LADISLAV KAMENICKÝ*

RELATION OF THE CRYSTALLINE OF THE CENTRAL WEST CARPATHIANS TO THE ADJACENT AREAS

(Fig. 1)

Abstract: In the article many polemic and hypothetic views on relation of the crystalline of the West Carpathians to that of the Bohemian Massif, Alps, Carpathians of Roumania and Balkanides, to the Pannonian Massif and partly also to the Dinarides and the East-European platform are mentioned. Their objective is to renew discussion about the above mentioned problems in the time of intense geological mapping of the key areas of the West Carpathian crystalline (of the Veporides). This work is in continuation from another article devoted to lithological study and structural reconstruction of the crystalline of the Central West Carpathians, presented in the same number of the journal „Geologický zborník". A generalized sketch of relations of the crystalline of the Central West Carpathians to the adjacent areas is attached to the article.

Резюме: В статье приводятся многие полемические и гипотетические взгляды на взаимоотношения между кристаллическими массивами Западных Карпат и Чешского массива, Альп, румынских Карпат, балканид, панонского массива, а также частично динарид, и восточноевропейской платформы. Целью данной статьи является обновление дискуссии о вышеприведенной проблематике во время интенсивного геологического картирования ключевых областей кристаллических массивов Западных Карпат (веперид). Работа связана с другой статьей, посвященной литологическому изучению и структурной реконструкции кристаллического массива центральных Западных Карпат (см. этот же номер Геологического журнала). К статье прилагается схема соотношений между кристаллическим массивом центральных Западных Карпат и соседними областями.

Relation of the crystalline of the West Carpatians or also relation of the Slovak block crystalline to adjacent areas is not only a very interesting problem but also an unavoidable condition for knowledge of position, sedimentation, magmatism and orogenes of this area in the region of central Europe..

Solving of this relation always met with objective difficulties because there is almost no place, where this relation can be studied at the surface. The greatest difficulties lie in knowing the relation to external crystalline since the area of the supposed contact, the so called exotic ridge and the adjacent territory are hidden below thick series of younger formations, which, moreover, are intensely tectonically reworked and so represent a zone of several phases of sial shortening, also in the latest periods.

The situation in the area of eastern continuation of the Slovak block, although not characterized by such a complicated structure and depth of covering formations, has also not been clear since in continuation are the East and South Carpathians of Roumania including the Transylvanian block, not only with a different lithology of formations but also with different structural pattern and in which no suitable equivalents could have been found. This situation was also supported by the circumstance that in contrast to the general trend of the vergency of structures in the West Carpathians (northwestern, northern) the structures of the Roumanian Carpathians display other strikes of vergency, often also in opposite direction (east, southeast). Another com-

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* RNDr. L. Kamenický, Geological Institute of the Slovak Academy of Sciences, Bratislava, Obrancov mieru 41.

plication is in arcuate course of mountain ranges, which only after the bend west of the Iron Gate pass to the Balkan and Rhodope, also to the Serbian-Macedonian Massif with essentially southeastern orientation.

The western continuation of the Slovak block was usually sought in the Eastern Alps and recently also in the Western Alps by some authors. In this case the complication was not as much caused by the existence of younger covering formations but mainly by the complicated nappe structure of the Alps, which reached not only the Mesozoic but also the underlying crystalline and Paleozoic. After Alpine tectonic reworking, of course, the appearance of crystalline schists was changed and died not permit easy correlation, also because not all lithological members of stratigraphic and tectonic units might have been incorporated in the nappes.

The contact with the Pannonian Massif was unclear for several reasons. The character and structure of the Pannonian Massif were not known sufficiently as it is weakly uncovered only. On the other hand it was difficult to interpret its function in this region, because its equivalents in the adjacent regions were not clearly known, where the structure can be better exposed and analogically the character, structure and function of the Pannonian Massif might be considered. In the last period several works came out, in which the authors supposed continuation of the Pannonian Massif in the basement of the Eastern Alps as far as almost to the area of the Hohe Tauern inlier.

It is in the first place the task of Czechoslovak and Slovak geologists to solve relation of the Slovak block because they can be based on detailed study of the crystalline of the Central West Carpathians and Bohemian Massif. Under the situation when the contact areas are generally covered, one may be mainly based on a detailed analysis of these nearest crystalline areas.

In order to know this relation I directed my work in the last years from the need to get more familiar with the regularities of distribution, character and genesis of the volcanics in Slovakia, which I have studied.

As important I consider to focus attention on these problems now, also for the reason that in the last period more detailed geological mapping works and investigations were carried out in the crystalline, so it is suitable to trace all their important aspects, which, although not so evident in detailed scale of mapping, are of a great importance in general reconstruction of geological structure. When the views are not confirmed and expressed in maps, they loose their importance and function. One cannot reckon with new mapping in near future. For the above mentioned reasons some ideas and affirmations are given in the work, which have not been worked out in full extent. They have chiefly to serve for polemics on the raised problems. They represent only the first approach to knowledge of the structure based on my studies, not finished yet.

Giving a summary of the studied problems, the following fundamental relations of the Central West Carpathian crystalline to the adjacent areas can be outlined. The Slovak block has a common boundary with continuation of the Bohemian Massif in the area of the Outer Flysch zone, in the so called exotic ridge. The Bohemian Massif has a two-sided structure, which continues in the basement of the outer flysch to the Transylvanian block and Marmaros crystalline and farther to the Danube autochthon, Rodope Massif including the Serbo-Macedonian Massif and Srednogorje.

The Slovak block continues in eastern direction in the Montii Apuseni and the Vardar zone of the Dinarides. The exotic ridge continues from the Klippen Belt to the eastern margin of the Montii Apuseni and the Serbo-Macedonian Massif. In western direction the continuation of the exotic ridge may be sought in the Helvetic zone. The western continuation of the Slovak block corresponds to the whole extent of the Eastern and Western Alps from the Helvetic zone to the Drava Line.[1]

The contact with the Pannonian Massif, between the Slovak block and the proper Pannonian Massif, is situated on the line and/or zone of the folded out Mesozoic South Gemeride geosyncline. Eastward continuation is covered below the overthrust Pannonian Massif and farther we can see it along the western periphery of the Vardar zone. The Pannonian Massif has its equivalent in the Pelagonic Massif and to the West its reduced continuation can be seen in the reduced crystalline of the Ivrea zone.

A more detailed division of these large units and linking with neighbouring areas is also possible, however, in placing the boundaries misrepresentation of real conditions will surely appear as the individual tectonic basement units need not take the course of the preceding facies developments of geosynclinal sedimentation: also the newly founded geosynclinal facies developments may exceed the boundaries of older tectonic elements and on the other hand need not be developed in the whole extent of older tectonic units, but in spite may have various facies development in their course or in elevations sedimentation might not have taken place.

For these reasons the scheme indicated in the attached sketches and maps (fig. 1) is of an informative character in general and does not precisely reflect real relations. Conditions in nature reflect the function of all factors, which influenced development of a certain area, developed, acted and disappeared as in historical development. Our knowledge cannot grasp this complicatedness of factors and processes by far. It is only a simplified, schematic outline of known and supposed regularities.

In this conception it can be possible to seek continuation of the Sudetic crystalline including the zone with development of the Algonkian and Earlier Paleozoic of the Barrandien and of the area between the Sudetes and Železné hory Mts. in the external units of the outer flysch: the exotic ridges supplying material for Upper Paleogene and Cretaceous conglomerates (e. g. in the Subsilesian and Silesian unit and at the boundary of the Magura and Silesian unit) may correspond to the East and West Sudetic and Železné hory crystalline including the Svratka vault, the Moravic. Further eastward continuation of these zones may be sought in the crystalline of Maramures, the Getic nappe, Balkan and then in the Crimea and northern Caucasus. In the Carpathians of Yugoslavia and on the territory of Bulgaria the tectonically overthrust units of the Carpathians in Yugoslavia and Stara Planina, also of the Srednogorje and in the Sofia amphitheatre even overthrust units of the Kraistid zone area may belong there. Linking to the crystalline of western Europe is more evident (see for instance, the work of M. G. R u t t e n, Geology of western Europe).

Continuation of the Moldanubic crystalline can be the crystalline of the original basement of a large part of the Magura zone and its eastern continuation may be sought in the crystalline of the Transylvanian block, Danube autochthon, Rhodope Massif and possibly the Srednogorje. The western continuation is in the Schwarzwald, Central Massif of France, in Portugal and western Spain. The great bend of this zone almost to opposite direction in Spain and oblique cutting by the Alpine orogene in the south of the Iberian Peninsula may be explained by its rotation with the advance of the African continent in southeastern to eastern direction. Contemporaneous was also rotation of the Apenninic Peninsula and of the blocks of Sardinia and Corsica.

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[1] After public defence of my work (at the beginning of this year) was published H. K o z u r's and R. M o c k's work. Their work points out to dinaridinic development of the south-gemeridic Triassic (Meliata-Series) from a completely different point of view.

South of the Moldanubic crystalline we may suppose an analogous zone as north of it in the area of the foredeep of the Alps north of the Helvetic zone as far as the Moldanubic. An equivalent of this zone may be sought in the original basement of the northern Peri-klippen Paleogene of the Outer Carpathians north of the exotic ridge. As a boundary between the Moldanubic and this zone can be considered the Moravic of the Dyje vault. The eastern continuation can be found at the western periphery of the Transylvanian block in Poiana Rusca, in the eastern part of the Serbo-Macedonian Massif of Yugoslavia and in the Kraistid zone of Bulgaria.

The southern boundary of the above mentioned zone is formed by an exotic ridge extending between the Variscan and strongly Alpide folded zone of the Alps and Carpathians and the mentioned zone in the external region of the Helvetic zone and the Klippen Belt with continuation of the Preluca crystalline, the Muntii Traseaui and then in the proper Serbo-Macedonian Massif.

The external zone of the Tatrides, the internal zone of the Tatrides and the interzone with development of coal-bearing Upper Paleozoic (Briançon zone, occurrences of coal in the underlier of the internal Paleogene and Upper Cretaceous in the Váh Valley, Paleozoic of the Zemplín „Island") corresponds to the Helvetic and Ultrahelvetic zone, the Valais and Briançon zones and the eastern continuation of the eastern part of the crystalline of the Muntii Apuseni and the Vardar zone.

The northern zones of the Veporides most probably correspond to the Piemont zone of the Pennides (crystalline). The eastern continuation we can see in the northern part of the Sfubica, Čierna Hora crystalline and near Byšta, in the central part of the Muntii Apuseni and Vardar zone crystalline.

The Kohút zone of the Veporides has probably its equivalent in the lower Eastern Alpine nappes (crystalline) in the basement of the Gemerides and of young formations west of the Muntii Apuseni.

The Gemeride crystalline has its equivalent in the crystalline of the upper nappe of the Eastern Alps and the eastern continuation is probably hidden below the overthrust Pannonian block. In the Pannonian Massif it may be possible to distinguish the proper pre-Cambrian block, bordered by the Caledonian crystalline on both sides. The western continuation of the Pannonian Massif might be seen in the highly compressed crystalline of the Ivrea zone and of the adjacent zones and its eastern continuation in the Pelagonic Massif. The crystalline of the Pannonian Massif and/or of the primary more continuous pre-Cambrian crystalline is reduced in extensive sections as visible in the Ivrea zone and the section of the western periphery of the Vardar zone

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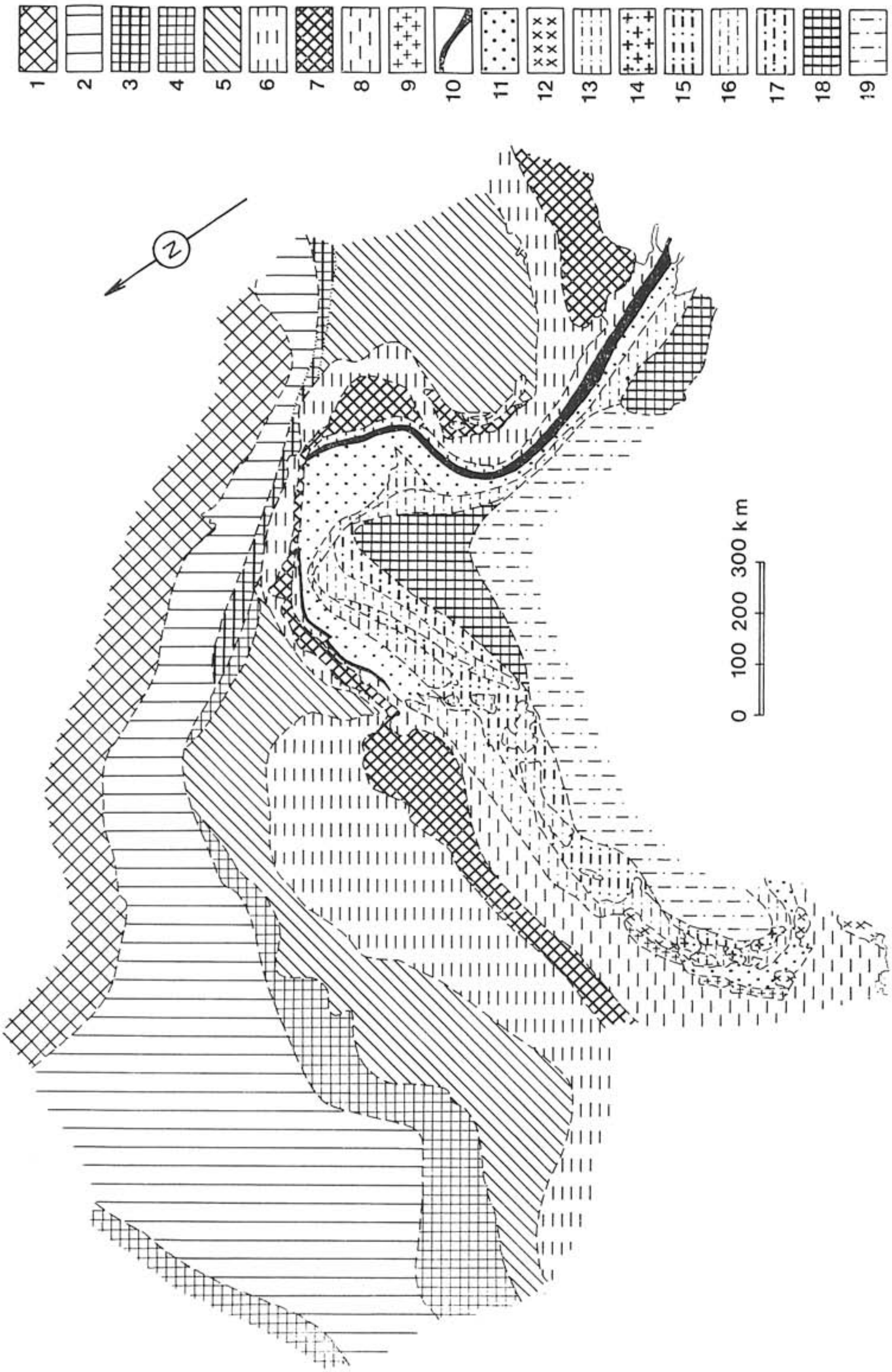
Fig. 1. Outline of relation of the West Carpathian crystalline to adjacent areas (compiled according to modified generalized maps of H. K ö l b e l 1968, M. G. R u t t e n 1969, M. M a h e ľ 1971, A. T o l l m a n n 1965, T. H ü g i 1963 and other authors). Explanations: 1 — East European platform, 2. Zone of pre-Cambrian massives, 3 — Zone of Holy Cross-North Dobrudzha crystalline, 4 — Zone of Caledonides, 5 — Zone of Rhynian-Silesian--Mysian crystalline, 6 — Zone of Sudetic-Železné hory-Marmaroš-Balkan crystalline, 7 — Zone of Moldanubic-Transylvanian-Rodope crystalline, 8 — Zone of fore-Alpine-Carpathian-Dinaric crystalline, 9 — External massives of the Helvetic zone, 10 — Central Helvetic Pieninic-Serbian-Macedonian crystalline ridge, 11 — Zone of Inner Helvetic-Briançonnais-Tatride crystalline, 12 — Inner massives of the Helvetic zone, 13 — Zone of Penninic-North Vepor crystalline, 14 — Granitoid massives of the Penninic zone, 15 — Zone of crystalline of lower Eastern Alpine and South Vepor nappes, 16 — Zone of the crystalline of the upper Eastern Alpine nappe and Gemerides, 17 — Zone of Balaton crystalline, 18 — Zone of Ivrea-Pannonian-Pelagonic crystalline, 19 — Zone of South Alpine-Dinaric crystalline.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from the northern environs of Beograd to the proper Pelagonic Massif. Similar pre-Cambrian crystalline may be also seen in the ridge extendig and the lower course of the Labe river through the Holy Cross Mountains to the northern Dobrudzha and from there to the Crimea and northern Caucasus.

Recapitulating the above mentioned structure we arrive some symmetrical structure with the oldest ridge in the central zone, on both sides bordered by areas with successively younger Variscan orogenes. On both sides of these linear symmetric structures are platforms, the East European and African. The linear structures of this area continue also farther eastward, where they take a more or less equatorial course. In the European part of these structures we may also consider a primarily less vaulted arc of the oldest orogene, which has got distinct, modified and complicated with later orogenes only. A different picture would appear if we unfolded the tectonically reduced and shortened zones. The strongest reduction is just in the area between the Western Alps and Balkan, where the strongest modification of the individual parts of linear structural units is to be seen as, for instance, of the pre-Cambrian Pannonian-Pelagonic ridge, of the strongly Alpine- and Variscan-folded Alpine-Carpathian-Vardar region (mainly in one part of the Alps and the Vardar zone) and, on the contrary, of the more external zone in the region of the West Carpathians. Similarly also the Moldanubic zone was most strongly reduced in the West Carpathian region and partly also on the western periphery of the Mysian platform. In the latter section the more external zones were most strongly reduced too. Thus this area is a section, in which maximum tangential forces compensated between the northern and southern platform. The Subvariscides including the Brunia and Cracow monocline, the Mysian platform and North Caucasian monocline represent equivalent parts with locally different development and representation of orogenes.

A problem often discussed is the origin of the Carpathian arc. According to the given reconstruction this arc seems to have developed gradually. As early as the Moldanubic orogeny modification of the orogene into slight arcs took place. These arcs got more distinct mainly as we may expect from the Assyntian orogenic phase when the Moravic structures were in accordance with the mighty Assyntian wedge of Brunia and so conspicuous arc structures were already present. The arcs, adapted to shortening of areas by preceding modelling, were made distinct as weak sections also during the Caledonian and Variscan orogeny when namely uparching of the Roumanian part of the Carpathians took place. In the course of the Cretaceous orogeny this process was still more intense. On the contrary, in the time of the last stronger orogeny the Carpathian arc was completed in its present-day form as one unit. During this process the isolated Pannonian Massif and underthrusting of the East European platform below the Carpathians played an important part.

Development of the Central European geological structure continued also afterwards with formation of deep grabens in the region of the Mediterranean and Black Sea in the Pliocene and Quaternary. Various assumptions of this process were expressed, explaining it as contemporaneous geosynclinal area or grabens formation of which was evoked by other processes. Recently M u r a t o v has dealt with this question.

Generalizations resulting from the structure of the crystalline of the West Carpathians and adjacent areas

The foregoing chapter has shown that orogenes in central Europe are of linear character with irregular morphology containing isometric (block) and linear elements (proper orogenes): the course of linear elements adapted to closed blocks so that a typical element are arcs of various curvature and direction of symmetry axis. It may be even inferred that also the oldest orogene had already these irregularities although being of east-western, equatorial or Tethys direction.

Another characteristic of these Paratethys geosynclines and orogenes is their course parallel to the directions of preexisting orogenes and symmetric pattern, of course, with local preformation.

The third sign is the evolution of the geological structure, showing an equal character of the pre-Cambrian stage essentially in its whole extension, as we may observe, typical with a strong and wide-spread, prevailingly acid syngenetic volcanism in the older phase. In the later stage of the pre-Cambrian, on the contrary, basic volcanism is characteristic. This acid volcanism indicates that the existence of sial crust may be rather supposed in the whole area in essential.

In the whole area of central Europe we find more distinct discordancies only in younger stages of development (in older stages known only locally) and therefore also in the last time many authors arrive the conclusion that a cycle terminated by the Hercynian folding (Mesoeurope) is concerned there. On the other hand we see in the Carpathian region and more southerly continuation of the development also in younger stages until the present time and so the conclusion can be deduced that in this region regeneration of development has always been taking place. This is in contrast to conditions known from the platforms. According to the results of several authors similar conditions may be also found in farther course of these equatorial orogenes.

Continued regeneration in the equatorial belt indicates a permanent phenomenon resulting from the same reason to be concerned. With each orogeny evidently movement of platforms toward the equator, their underthrusting below the orogenes folded out from geosynclinal areas took place; the central massives, as usually, displayed not the same tendency but, on the contrary, folding was sometimes of a vergency outward from the massives. However, this is not a rule, as depending on the age of the orogene central massives were of various character, their sizes were different and the geosynclinal zones between them were folded out in dependence on their relative size or relation to the platform. A force continuously acting on the platforms could have been the centrifugal force, tangential phase of which is greatest in regions more remote from the equator and, on the contrary, in the equatorial belt the vertical component predominates. The primary cause is thus the rotation of earth, action of which is stable in relation to the sial. The post-orogenic stage, on the other hand, is more influenced by isostatic readjustment of individual sialic blocks.

In geosynclines and orogenes of Tethys orientation underthrusting and/or thrusting of the sial appears to have taken place. Whether this underthrusting or thrusting corresponds to the ideas of plate tectonics requires more consideration because the existence of oceanic crust in this region of greater dimensions has evidently not been proved so far although there is enough evidence of areas with extensive ultrabasic and basic bodies mainly in younger orogenes; the origin of these bodies from the mantle is not doubtful. In older orogenes are also known areas with enormous representation of basic volcanism, which could be put into connection with dismantling of oceanic crust. A massing of volcanics in narrow elongated zones, on the other hand, may rather testify to fissures of the sial of smaller dimensions when compared with extensive oceans and their oceanic crust.

Geosynclines of Tethys orientation show essentially different conditions of formation than marginal geosynclines at the boundary between continents and oceans.

When the processes of folding out of geosynclinal zones between the central massif and external zones (for instance, in the region of the West Carpathians) are observed more thoroughly a tendency to formation of arc with zonal structure may be seen. In the zone nearest to the central massif overthrusting of the folded zone on the foreland is visible, which retains its structure and shows deformation of rocks concordant with the thrusting plane, mainly near the overthrust unit. Present are also numerous steeper dislocation lines (Kohút zone). More externally is the zone of intense shortening and causal swallowing of the sial. Dynamic metamorphism penetrates the whole area and dislocation lines are evidently more numerous (Kraklova zone). The neighbouring more external zone is characterized by blocks structure and numerous more or less vertical faults and more subordinate zones with dynamic metamorphism (Tatrides). Taking into account the Klippen Belt Mesozoic, we see an extremely developed block character. The exotic ridge and more northern zones, on the contrary, were evidently underthrust and consequently probably block structure has not formed.

Considering the orogenes, their asymmetry and general vergency with the polarity of individual stages of folding are emphasized. Regarding from this view usually registration of symmetry elements is losing and the features of vergency and polarity are overestimated. Proper sedimentation in the basin bears elements of symmetry and the vergency may be changed in dependence on the existence and character of the central massives on the other hand. In general it may be said that also opposite directions of vergency are possible, depending on the shape of the arcs and mutual relations of the central massives and platform. Vergency and polarity depend on these causes. On the other hand, in one arc a vergency conformable to the radius axes in direction from the centre toward the arc usually predominates.

As it is apparent from the above mentioned, also in the region of central Europe, i. e. between two platforms, the existence of a sialic crust as early as prior to the Middle pre-Cambrian may be supposed; the distinct block structure represented by numerous central massives, modified into more or less elongated lenticular forms during the orogenetic processes, permits to infer the existence of agglomeration of primary sialic blocks joined by geosynclinal zones. Such a structure of the southwestern platform margin was observed and characterized by E. Znosko — S. Kubicki — B. Ryka (1972) in northeastern Poland. A similar picture can be also accepted for the remaining part of the pre-Middle-Cambrian sial (pre-Carelian) of central Europe.

The idea raises that in the first period of sial formation when equal conditions of primary differentiation had existed on the whole earth surface (regarding to the fact that in the equatorial belt might have been preconditions for more intense differentiation processes) the protocrust had formed on the whole earth surface and with regard to the inhomogeneity, to more stormy geological processes, this protocrust broke up, the individual blocks and their agglomerations were concentrated into a protocontinent and protooceans formed. This process could obviously have been of very long duration and as a result the Pangea (according to H. Stille) of ellipsoidal shape, with symmetric distribution around the equator, could have formed. Only after formation of this complex (agglomeration) of heterogeneous blocks and joining folded geosynclinal zones, due to rotation of earth the centrifugal forces manifested probably more intensively, having induced formation of equatorial geosynclines and subsequently also of orogenes of equal orientation. Thus this process represents continuation of concentration of the sial in a smaller area distributed along the equator. In the (quasi)equatorial belt the thickest plates of sial should be expected, apart from the subcrustal erosion of the sial.

The marginal geosynclines, on the contrary, were influenced by intensive sedimentation on the margins of extensive continents, by isostatic forces and movement enforced on the continent and the original cause of phenomena, rotation of earth.

The Tethys geosynclines and orogenes are properly said intracontinental. Beside equatorial geosynclines also such of meridional or other orientation may be observed, however, the latter are of not such a great extension and importance.

Some time ago S. Bubnoff derived the regularity of alteration of equatorial and meridional orogenes. It may be observed that some meridional zones consisted of more stages than other ones. On the other hand it may be mentioned that beside linear orogenes also other areas with mosaic structure exist as stated by A. V. Pejve et al. for the region of central Siberia.

A question very often discussed is that of sialization or simatization of the earth crust. Already with regard to the before mentioned I am inclined to the view that the process of differentiation in the mantle and earth crust is a durable process leading to formation of the sial formerly and at present. This results also from the circumstance, as many authors assume, that also magmatism actually represents differentiation of the mantle if we accept selective remelting of the original substance. Oceanization of the sial in the geosynclines appears to be locally a contradictory process.

In this connection very interesting are relations of volcanism and plutonism to the geological structure of the corresponding area and to contemporaneous tectonic processes. Nowadays the opinion is being accepted that many ultrabasic and basic bodies may be compared with the mantle substance. As already has been mentioned in orogenes these bodies are concentrated in narrow zones and mainly in zones, where the central massives are observed to die out. On the other hand manifestations of volcanism are noticed in wide areas, where evidently the sialic crust was present in the basement of geosynclinal sediments. Since long ago many regularities in distribution of geosynclinal volcanics, synorogenic plutonites, late-orogenic plutonites and volcanics have been known. It seems that it will be difficult to explain thoroughly the full variety of volcanism character by the analysis of conditions because obviously several factors cooperate here, the intensity and mutual relation of which as well as the local structure of the mantle and crust influence mutually and it is beyond human possibilities to judge the details of these conditions. The general features of volcanism, on the contrary, can be rather established. I believe that beside the structure of mantle and earth crust also the amplitude and intensity of vertical crustal movements and the character of contemporaneous tangential forces have an influence.

Conclusion

As has already been mentioned in the introduction of the article, many polemic and also hypothetic views and ideas are given here. The objective of the work, as a matter of fact, was the endeavour to point out some discussible problems of the geological structure of the West Carpathian crystalline because from the mode of its occurrence in isolated crystalline cores without directly observable linking to the crystalline of adjacent areas various conceptions can be well understood. In the time of intensive geological mapping of key areas (Veporides) it is rational to renew discussion on this theme.

Closing I should very like to express my deep thanks to the authors of all works and maps, which I made use of when writing this article: it is not possible to give their full list for their great extent. They were for me a source of knowledge of this complicated problem. Especially I should like to express my thanks to those who gave me kindly the opportunity to get familiar with the geological structure of various areas, to Academician A f a n a s j e v for getting acquainted with the geological structure of the northern Caucasus, to Academician S e m e n e n k o and his co-workers for introduction into the problems of the Vendian, the Ukrainian shield and Rachov Massif, to professor Š u r k i n for introduction into the problems of the Belomorides, Dr. S a v u and co-workers for the possiblity of undertaking a very instructive excursion to the Carpathians of Roumania, Professor K a r a m a t a and others from the Federal Republic of Yugoslavia for several well-chosen excursion in the Carpathians and Dinarides of Yugoslavia. A great source of information were for me also the synthetic works of Academician A n d r u s o v and Academician Z o u b e k. Particularly I am indebted to professor J. K a m e n i c k ý, who some time ago introduced me into the mapping of crystalline areas and to Academician C a m b e l for directing and support during research works and critical remarks.

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Review by B. CAMBEL.