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THE CARPATHIANS AND PLATE TECTONICS

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It is generally assumed that the Carpathians as a folded orogen were formed in result of a complex geosyncline evolution. However, the mechanism of the folding of geosyncline formations, and particularly the development of the Carpathian nappes of a high amplitude of thrusts, and as well as the relation of the Carpathians to their foreland have been the subject of various interpretations (D. Andrusow 1960, 1964—65; S. Dżułyński 1953; M. Książkiewicz 1956, 1972; J. Nowak 1927; W. Teissyere 1921; K. Tołwiński 1956; H. Świdziński 1971, and others).

The Carpathians being a part of the European Alpine system stretch for 1500 km from the Neogene Vienna Basin — where they make a prolongation of the Eastern Alps — to the Danube rift in Iron Gate in Romania. Further east they pass into the Balkan belt (Fig. 1).

The Carpathians are a typical mountain belt in the shape of an arc. Together with the Balkans they make two arcs, a bigger, typical Carpathian arc bent NE, and a smaller one, Carpathian-Balkan, bent westward. The Carpathians thrust onto their forefield, which makes a typical foredeep filled with the Neogene molasse sediments. The Carpathian foredeep developed on a Paleo-Mesosoic Euroasiatic plate surrounding them from the outside of the arc.

Three basic zones are distinguished in the Carpathian arc: an outer zone, the so called Outer Carpathians (externides); a transition zone, made by the Pieniny Klippen Belt; and an inner zone, or Inner Carpathians (internides). The Outer Carpathians are built up from Cretaceous and Paleogene Flysch nappes of strongly developed inner fold tectonics. The Pieniny Klippen Belt presents a kind of megabreccia of rocks — mainly Jurassic and Cretaceous — intensly faulted and fractured. On the surface, it makes a zone a few hundred metres to several kilometres wide (occasionally over 10 km.) stretching for 550 km. from Marmorosze in the Eastern Carpathians up to Vienna. Further west, already in the Eastern Alps, the Pieniny Klippen Belt passes into Gresten klippens. In the East, the Rachów—Marmorosze formations — further passing into Getic Nappe — take over the role of the Pieniny Klippen Belt.

The Inner Carpathians (Flysch sediments included) are also characterized by a folded structure. With this zone are connected Neogene volcanic formations concentrated mainly along the northern edge of the Pannonian microplatform and the eastern frame of the Transylvanian block, Both elements were plunged at the end of evolution of the Carpathians; Neogene internal (in relation to the Carpathian orogen) depressions developed on their area.

The folding of the Carpathian orogen occurred first in the Inner and then in the Outer Carpathians. The Inner Carpathian formations were folded from the Jurassic till Late Cretaceous period, whereas Outer Carpathian flysch formations folded during the Neogene; there are also indications of Quaternary folding in this area. Thus, it can be seen that the Carpathians are an orogen of a complex structure.

As it had been assumed that Flysch sediments of the Carpathian nappes are of a thrust nature (which was confirmed by borehole data) and it had been stated that Flysch formations widely cover the northern Carpathian foreland, it has been difficult so far — taking into account the known hypotheses of folded mountain formations — to elucidate clearly and thoroughly the relationship between the folding movements and the structure and evolution of the crust on which the Carpathian geosyncline developed.

The traditional explanation of the Carpathian tectogenesis considered mainly vertical crust movements. This, however, did not meet the need for a complex explanation of both the cause of the Carpathian formations folding and the origin of the regional thrusts of amplitudes of a few dozens kilometres.

A possibility of a new explanation of the folded mountain tectogenesis and of the development of their geosynclines occurred after a new theory of the globe tectonics, the so called plate tectonics, had been put forward (W. J. Morgan 1968, Le X. Pichon 1968). According to this theory, the globe litosphere consists of six plates being in a permanent movement in relation to each other. J. F. Dewey and J. M. Bird (1970b) recognize within the area of the plates a series of blocks distinct, to some extent, in their structure and in their limited independent movement. The phenomenon of plate tectonics is based both on subsidence in movement, i.e. a subduction of a part of the crust of some of the plates under the others, and on the process of plate accretion by spreading the ocean crust in the rift zone (J. Coulomb 1972). This phenomenon has been recognized due to the exhaustive investigations of the ocean floor (R. S. Dietz 1961; H. H. Hess 1962). The plate tectonics accepting the movement of particular crust plates refers to the theory of continent drift, sensu A. Wagener (1924), assuming convection currents to be the force effecting movement of the plates (A. Holmes 1945).

The plate tectonics formulated above was then used to explain tectogenesis of folded mountains (J. M. Bird; J. F. Dewey, 1970; P. J. Coney 1970; J. F. Dewey, J. M. Bird 1970a, b; J. F. Dewey, B. Horsfield 1970; J. F. Dewey at all. 1973, and others). According to J. F. Dewey and J. M. Bird (1970a, b) it is assumed that there are basically two types of orogens. An orogen of Cordilleran type originated through breaking and subduction of the crust of the oceanic type in the zone of deep ocean trench in the proximity of continental edge. Thermal agents played a remarkable part in the formation of such orogen. The Andean mountains may serve as an example here. The second type includes orogens formed in result of the so called collision of continents. An example here is the belt of the European Alpides which comprise the Carpathians. The orogen of the collisional type is characterized by a complex fold system resulting from extensive compression, large-distance tectonical transportation, etc. The origin of such orogens is primarily connected with the action of mechanical stresses resulting from the collision of continental plates.

In recent years there appeared some papers presenting attempts to interpret tectogenesis of the European Alpides in the light of the plate tectonics. The Alps were discussed from that point of view by J. Dercourt (1971), K. J. Hsü (1971) and H. Laubscher (1969) and others, and the Carpathians — by G. Szénás (1972a) and D. P. Radulescu and M. Sandulescu (1973). Interesting data concerning the plate tectonics of the western Mediterranean Sea were given by K. Hinz (1972).

Recently the present author made an attempt to reconstruct the tectogenesis of the Carpathians from the point of view of the plate tectonics, taking into account the borehole and geophysical data and regional comparative analyses (R. Ney 1973, 1975). This paper presents a wider discussion of that problem.

THE CARPATHIANS IN THE SYSTEM OF THE EUROPEAN ALPIDES

The Carpathians represent the most northerly belt of a complex system of the European Alpides connected with the Mediterranean zone on the west

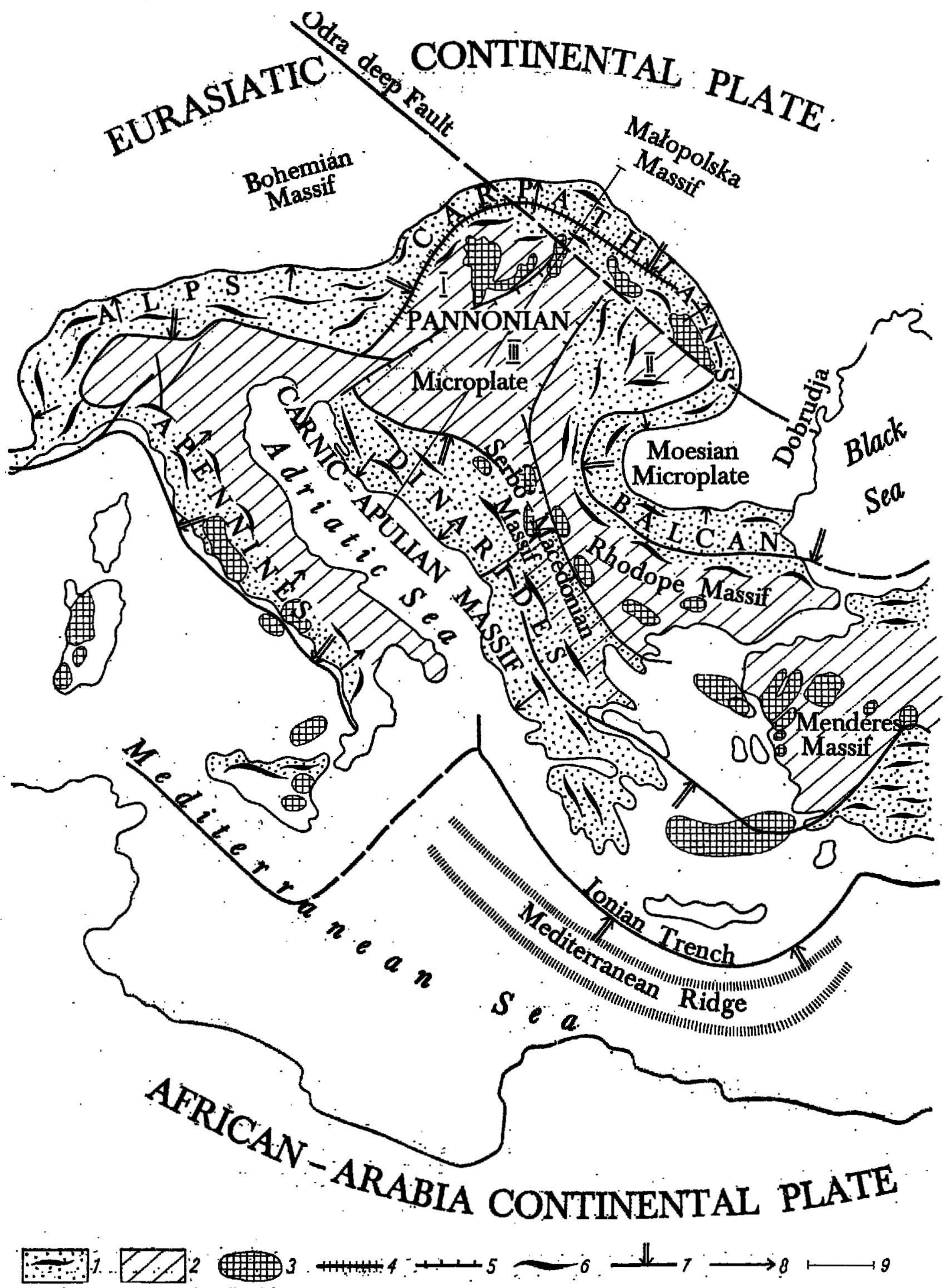

Fig. 1. Structural outline of Mediterranean Alpides (after J. F. Dewey and J. M. Bird, 9 — simplified).

1 — Alpine folding zones, 2 — Microcontinents (Massives and inner Microplatforms), 3 — Neogene vulcanites, 4 — Pieniny Klippen Belt, 5 — Alföld Depression limiting faults, 6 — other main faults, 7 — crust subduction zones and directions of the plates, 8 — directions of the structural polarization in folded Alpine formations, 9 — line of paleogeografic sections (Fig. 2, 3). I — Slovakian block, II — Transylvanian block, III — Alföld Depression.

Ryc. 1. Szkic strukturalny Alpidów Śródziemnomorskich (wg J. F. Deweya i J. M. Birda; 9 — uproszczony).

1 — strefy fałdowań alpejskich, 2 — mikrokontynenty (masywy i mikroplatformy wewnętrzne), 3 — wulkanity neogeńskie, 4 — pieniński pas skałkowy, 5 — uskoki ograniczające depresję Alföldu, 6 — inne uskoki główne, 7 — strefy subdukcji skorupy i kierunki pogrążania się płyt, 8 — kierunki polaryzacji strukturalnej w sfałdowanych utworach alpejskich, 9 — linia przekrojów paleogeograficznych (ryc. 2, 3). I — blok słowacki, II — blok transylwański, III — depresja Alföldu

and passing into the Alpide system of the southern Asia on the east (see R. Stoneley, 1974, and B. K. Rastogi, 1974, for an analyses of the latter in terms of the plate tectonics). According to the idea assuming modification of the Earth surface by continental drift, the Mediterranean zone played an important part in the break-up of Pangea and the formation of the Tethyan Ocean from the very beginning (J. F. Dewey and J. M. Bird, 1970b, J. F. Dewey et all. 1973, R. S. Dietz and J. C. Holden 1970). The

Mediterranean zone is situated between African and Eurasian plates; that is why it underwent a complex evolution during the continental drift. Therefore, in the framework of the Alpine geosynclinal system a number of geonsynclines were formed in the Mediterranean Europe. The geosynclines were separated by continental blocks acting as microcontinents, according to the classis scheme of J. F. Dewey and J. M. Bird (1970a).

The Alpine-Carpathian geosyncline, arched along the southern edge of the Eurasian plate is the most northerly element of the system. The Małopolska and the Bohemian massifs from the edge of that plate acted as resistance massifs in respect to the geosyncline. The Bohemian massif acted as some kind of a bar, which is most probably responsible for regional southward bend of the northern margin of the geosyncline (Fig. 1). Continental blocks also occur south of the Alpine-Carpathian geosyncline; this is the case of the Pannonian microplatform formed of the Slovakian and Transylvanian blocks separated by Alföld depression of a rift origin. The Rhodope massif is situated south of the Balcan geosyncline, and Serbian-Macedonian massif — north-east of the Dinaride geosyncline. The Dinaride and Apennine geosynclines are separated by Carnic-Apulian massif, in place of which the Adriatic depression originated in the Neogene.

Some of the above mentioned microcontinents, that is continental blocks, drifted in their own way in times of formation of the Mediterranean Alpine system. Geosynclines were developing in zones of crust weakness, possibly related to melting of the crust from below by convection currents. In these zones continental crust drifted away and the crust of the oceanic or transitional type was formed. It follows that continental blocks drifted away from the axes of the geosynclines during the pre-orogenic stage. Afterwards, in consequence of a reverse movement (i.e. movement towards the geosynclinal axes) of continental blocks deposits entrapped in the geosynclines were folded, and finally regional overthrusts developed. In the Mediterranean zone the convergent movement of the Afro-Arabian and Eurasian plates was of primary importance for the development of these processes.

At the edges of the converging plates a number of small continental blocks originated. These blocks acted as separate microcontinents (Pannonian microplatform) or they plunged into the astensphere initially creating deep trenches. The African plate displays some losses which now infill a system of trenches stretching south of the Aegean Arc. On of such trenches is the Yonian trench surrounded by the zone of formation of the crust of the transitional type. These movements of plates and blocks, leading to the narrowing of the Mediterranean Alpine zone, were accompanied by subduction of a part of the crust. The amplitude to regional overthrusts appears to be directly proportional to the rate of subduction. An analyses of the structure of the crust of the Mediterranean Alpine zone has shown that the subduction of the North-European continental plate surrounding the Alpides from the north was the most intense. Structural polarity in orogenic sedimentary series of geosynclines is oriented in accordance with the direction of crust subduction.

In the Carpathians the overthrusts are directed to the north; from here the subduction of the crust of the northern forefield of the Carpathians proceeded under the Pannonian microplatform crust. Outer and inner massifs played a remarkable part in the development of the Mediterranean Alpine zone, as they created a framework for the tectonics of particular orogens. In the case of the Carpathians especially important is the influence of the Pannonian microplatform and, to some extent, of the Serbian-Macedonian massif which acted as inner massifs, as well as the Bohemian and Małopolska massif which acted as resistance outer massifs.

Igneous rocks played a remarkable part in the development of the Mediterranean Alpine system. Basic and ultrabasic Late Mesozoic rocks known from the Metaliferi Mts evidence growth of the Pannonian microplatform, similarly as the basic and ultrabasic rocks found in Transsylvanian nappes. These rocks may be also treated as relics of an oceanic crust, presumably located within an oceanic rift. Ultrabasic rocks alterated into serpentinites, known from the Gemerid units, might have also been related to the oceanic rift.

Basic rocks, mainly represented by diabase tuffs, also occur in the Transcarpathian Ukraine. The Neogene volcanism is also connected with the margins of the Pannonian microplatform. Early Cretaceous teschenites occur in the Flysch Carpathians, and andesite volcanites along the Pieniny Klippen Belt; the latter may represent products of crust melting in the zone of subduction. Tatric granites may also be connected with a deep reconstruction of the Carpathian geosyncline, and they evidence a movement of magma in its basement. Igneous rocks present in the Mediterranean Alpine system evidence the existence of deep crustal fractures delineating microplatforms and massifs; they also reflect a movement of crustal blocks in subduction zones which were favourable routes for the migration of magma.

There still remains the problem of a south-eastern extension of a great regional zone of deep crustal fracture, so called Odra fault. According to A. Guterch et all. (1973) the Odra fault is connected with a 3-km translocation of Moho surface, and bears a decisive influence on the structure of SW Poland. J. Oberc (1972) interpreted this as a Laramie tensional fault which surely underwent partial rejuvenation during the Tertiary. Basalt intrusions are related to that fault. Andesite intrusions from the Pieniny, Vrancea seismic zone from the Eastern Carpathians, and its presumable extension from the area of the Transylvanian block are presumedly situated along the south-eastern extension of the Odra fault. This great regional zone of deep crustal fracture seems to end at the Dobrogea dislocation zone on the south-east. The last SE section of this deep crustal fracture seems to represent, at the same time, a zone of contact and subduction of the Moesian microplatform and Euroasiatic plate. The reconstruction of the north-western extension of the Odra fault appears to be highly important for the knowledge of the tectonics of Europe; however, further studies are necessary for elucidating this problem.

MAIN STAGES OF THE FORMATION OF THE CARPATHIANS

It is possible to distinguish three main stages in the complex evolution of the Carpathians, the most northerly part of the Mediterranean Alpine system. The first two: geosynclinal (Fig. 2), and subsequent orogenic (Fig. 3) stages may be further subdivided into a number of evolutionary cycles. These are constructional stages, that is, leading to the formation of the orogen. The third stage, which may be called denudational, still continues leading to the destruction of the orogen, that is, to planation of these mountains to the level of their surroundings (Fig. 4). Particular stages are not sharply delineated but they rather interfinge. For example, the geosynclinal and orogenic stages markedly interfinge, as the folding of the internal Carpathians started long before the end of geosynclinal development of the external Carpathians (Fig. 3A). The denudational stage was initiated along with the uplift of some parts of the Carpathian arc; the material from degradation of uplifted parts of that arc situated further to the south was supplied to northern sedimentary basins of the Flysch geosyncline.

The main stages and cycles of complex evolution of the Carpathian orogen are illustrated on the enclosed sketch paleogeographic sections through the Carpathians and Dinarides (Figs. 2—3).

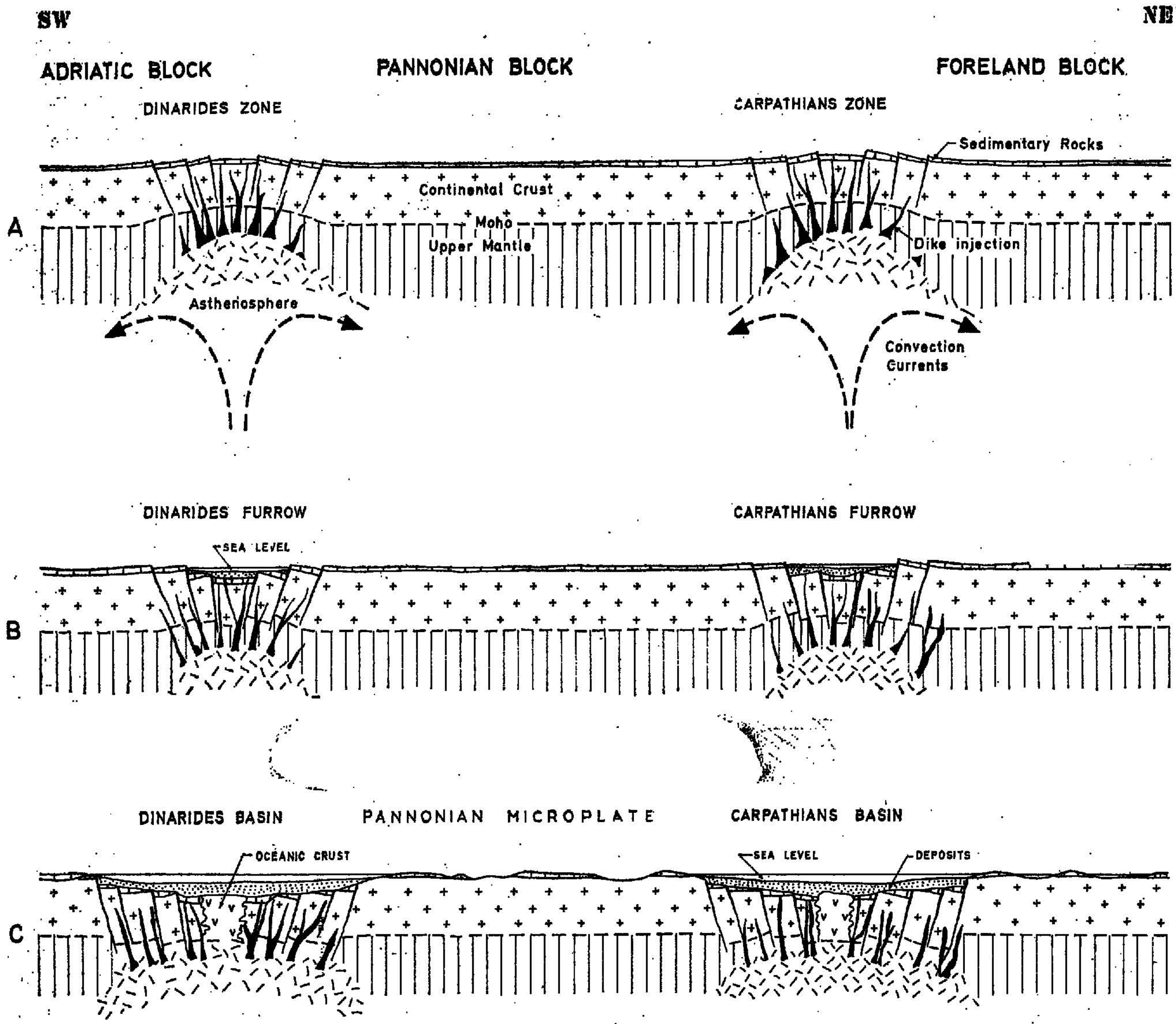

Fig. 2. Outline of formation of the Carpathians and Dinarides geosynclines basement.

A — stage of origination of deep fault zones, B — stage of origination of geosynclines basement as furrows, C — stage of origination of the sedimentation basins and the expanision of oceanic crust.

Ryc. 2. Schemat formowania się założeń geosynklin Karpat i Dynarydów.

A — stadium powstania stref wgłębnych rozłamów, B — stadium powstania założeń geosynklin w postaci rynien (rowów), C — stadium powstania basenów sedymentacyjnych i ekspansji skorupy oceanicznej.

At the end of the Hercynian orogeny the area of the present Carpathians and Balcan Alpides represented a consolidated region in which sialic crust was covered by various, usually epicontinental Paleozoic series. However, there is some evidence for the Hercynian foldings, but their strength and extent are difficult to establish. (G. Szénás, 1972a) .

During the Late Paleozoic or, more precisely, the Late Carboniferous, after the complition of major phases of Hercynian foldings, the southern part of the Eurasian plate was dismembered by several large-scale crustal fractures genetically related to it. This breakage resulted in the division of that part of the Eurasian plate into a number of crustal blocks, which was accompanied by tensional movements connected with the beginning of the separation of the two large continental plates: Afro-Arabian and Eurasian.

The zone in which the fractures originated were presumably partly melted from below by convection currents from the stenosphere (Fig. 2A). Two of the major zones of fractures originated in the area covered by the cross-section (Fig. 2A): the Carpathian on the north and the Dinaride zone on the south-west. The zones, although presented in the same section, differ in age. The zone of fractures and breaks, connected with the Dinarides, is presumably of the Early Carboniferous age, whereas that connected with the Carpathians did not originate before the end of Carboniferous or even Permian.

North of the Carpathian zone of fractures streched Eurasian plate, monolitic at that time, which comprised the block of the Carpathian forefield. The Pannonian block originated between the Carpathian and Dinaride zones, and the Adriatic block — south-west of the Dinaride zone; the latter was delineated by the zone of fractures connected with the Apennines. The fractures represented the zones of complex crustal fractures into which ultrabasic magma of the astenosphere origin was injected.

Granite magma originating from the melting of basal parts of the continental crust became activated, in some places giving rise to granite intrusions. This is the case of granite of the Tatra Mts which is surrounded by crystalline schists metamorphosed and folded in the course of the Late Variscan orogenic cycle and covered by transgressive Permo-Mesozoic deposits. Similar granite intrusions are known from the Slovakia (Lower Tatra Mts, Nitra massif, Small Carpathians, Small Fatra, etc.).

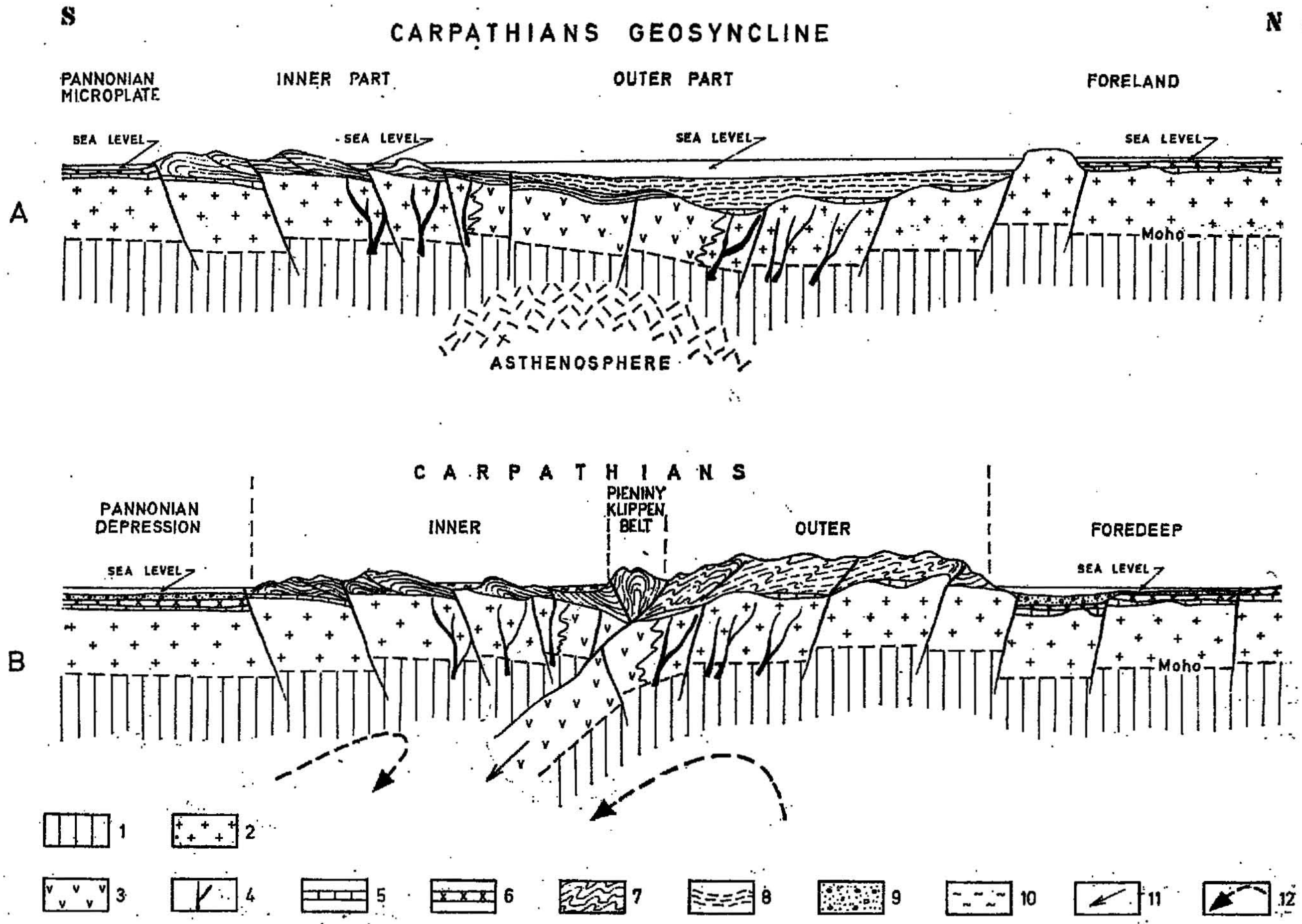

Fig. 3. Outline of the development of Carpathian orogen in the Tertiary.

A — partial folding of the Carpathian inner zone and further development of Flysch sedimentation in the outer zone (Oligocene); B — folding and uplifting of the Carpathian orogen caused by the crust subduction (Miocene). 1 — upper mantle, 2 — continental crust, 3 — oceanic crust, 4 — veins of magma injection, 5 — Palaeozoic formations, 6 — platform type Mesozoic formations, 7 — inner Carpathian formations, 8 — outer Carpathian formations, 9 — Miocene Carpathian foredeep sediments, 10 — Miocene sediments of inner Carpathian basins, 11 — direction of the crust subduction, 12 — directions of convection currents.

Ryc. 3. Schemat rozwoju orogenu Karpat w okresie trzeciorzędu.

A — częściowe sfałdowanie wewnętrznej strefy Karpat i dalszy rozwój sedymentacji fliszowej w strefie zewnętrznej (oligocen), B — sfałdowanie i wydźwignięcie orogenu karpackiego spowodowane subdukcją skorupy (miocen). 1 — górny płaszcz, 2 — skorupa kontynentalna, 3 — skorupa oceaniczna 4 — żyły iniekcyjne magmy, 5 — utwory paleozoiku, 6 — utwory mezozoiku typu platformowego, 7 — utwory Karpat wewnętrznych, 8 — utwory Karpat zewnętrznych, 9 — osady miocenu zapadliska przedkarpackiego, 10 — osady miocenu karpackich niecek wewnętrznych, 11 — kierunek subdukcji skorupy, 12 — kierunek prądów konwekcyjnych.

The successive cycle in the evolution of the Carpathians is connected with the origin of a trench in the zone of the crustal fractures in the latest Permian and Triassic (Fig. 2B). Similar trench originated in the Dinarides in the Carboniferous. Deposits originating in the Carpathian trench, which are partly preserved up to now, were injected with ophiolites. In the course of subsequent reconstructions of the Carpathians the oldest deposits were usually so deeply buried that at present they may be only occasionally found in the internides. The Carpathian trench may be interpreted as an embryonic geosyncline.

There are two major reasons for the formation of regional crustal fractures in the Carpathian zone in the Late Carboniferous, and of their subsequent transformation into a trench in the Permian and Triassic. The divergent movement of the Eurasian and Afro-Arabian plates was of primary importance here, while the orientation of convention currents outwards of the zones of the Carpathians and Dinarides had some influence on the location of fracture zones and, therefore, on the location of descendant troughs.

During the third, Jurassic cycle of the geosynclinal stage of the formation of the Carpathians a distinct sedimentary basin originated in the place formerly occupied by the trench (Fig. 2C). Transformation of the trench into a basin was connected with decay of the continental crust and sea-floor spreading between the Pannonian microplatform and Eurasian plate. The Pannonian microplatform originated as an independent microcontinent in result of breaking-off of the Eurasian plate and shifting in SW direction. Accretion of the oceanic crust in the Dinaride basin started earlier, in the Late Triassic. The classic development of the Carpathian geosyncline proceeded in the Late Jurassic, Cretaceous and Tertiary. During that period a number at the second-order sedimentary basins were formed and then geosyncline became polygeosyncline. The axis of sedimentation gradually shifted outwards, towards the Eurasian plate. In that direction younger sediments succesively appear; the youngest, Miocene and Pliocene sediments which were formed after the complition of the folding of the Carpathian orogen occur in the Carpathian Foredeep.

During the Middle-Tertiary cycle of the geosynclinal stage the Carpathian geosyncline was clearly divided into two zones: external, partly folded before the end of the Cretaceous, and outer, in which intensive sedimentation was still continuing (Fig. 3A).

Intensive folding of the whole Carpathian orogen and especially of its outer zone took place in the Neogene (Fig. 3B). This resulted in the uplift of the

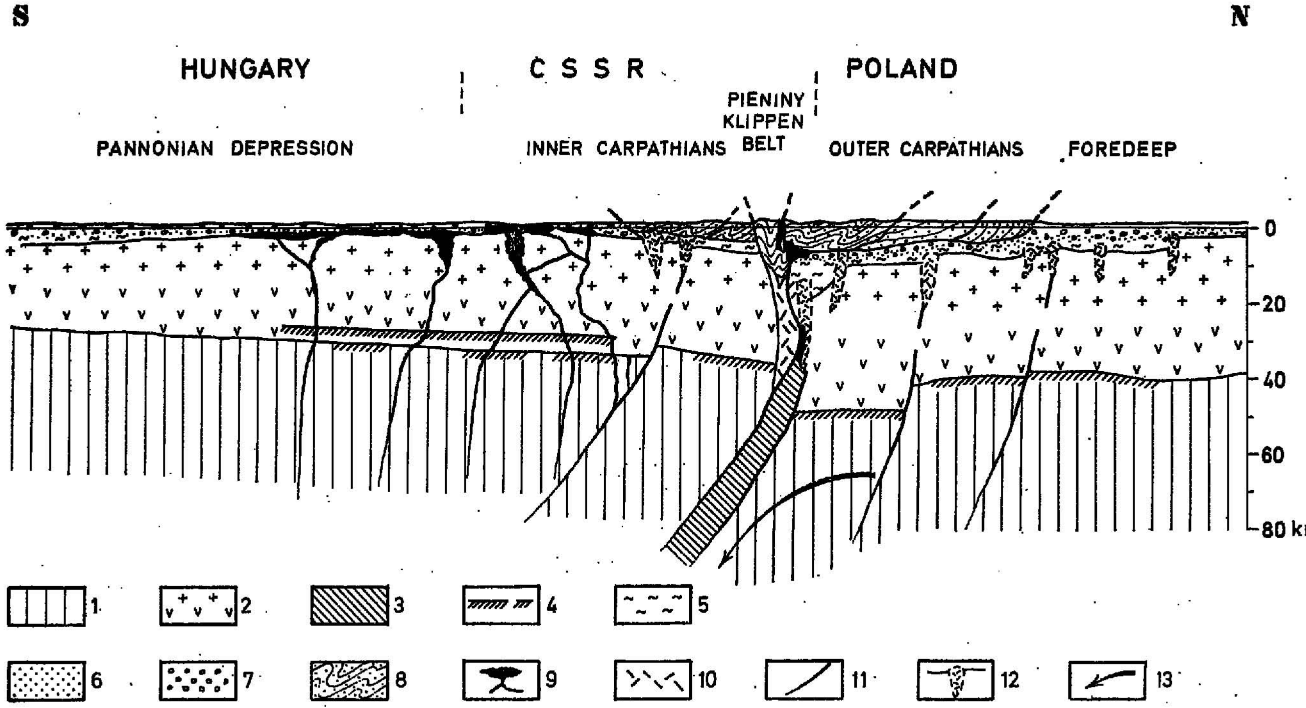

Fig. 4. Schematic geological section through the Carpathians along profile V GSS.

1 — upper mantle, 2 — crust, 3 — subduction zone, 4 — Mohorovičić surface, 5 — metamorphic and sediment basement rocks, 6 — Neogene sandy-mudstone formations, 7 — Neogene molasse, 8 — folded Carpathian formations, 9 — volcanic rocks, 10 — metamorphosed rocks in deep fault of Pieniny Klippen Belt, 11 — deep faults in the crust and in upper mantle, 12 — deep faults in upper crust zone, 13 — direction of the crust subduction.

Ryc. 4. Schematyczny przekrój geologiczny przez Karpaty wzdłuż V profilu GSS.

1 — górny płaszcz, 2 — skorupa, 3 — strefa subdukcji, 4 — powierzchnia Mohorovicića, 5 — skały metamorficzne i osadowe podłoża, 6 — utwory piaszczysto-mułowcowe neogenu, 7 — molasa neogenu, 8 — sfałdowane utwory Karpat, 9 — skały wulkaniczne, 10 — skały zmetamorfizowane we wgłębnym rozłamie pienińskiego pasa skałkowego, 11 — wgłębne rozłamy w skorupie i górnym płaszczu, 12 — wgłębne rozłamy w górnej strefie skorupy, 13 — kierunek subdukcji skorupy.

Carpathians and later in the formation of large-scale regional overthrusts. The subduction of the crust in the southern, direction, that is beneath the Pannonian microplatform, started during this orogenic stage of the evolution of the Carpathians. On that microplatform a Pannonian depression originated in the Tertiary (Neogene). Marginal parts of the Eurasian plate, dismembered by deep fractures, were plunged beneath this microplatform. Almost the whole of the oceanic crust previously formed was consumed. The author's studies (R. Ney, 1975) have shown that this zone of subduction was passing beneath the sedimentary basin of the Pieniny Klippen Belt. A part of sediments which originated in that basin were dredged deeplly into that zone or even underwent melting at still greater depths. The subduction of the crust was accompanied by intensified volcanic activity and andesite intrusions in that zone.

The geophysical studies (and primarily deep seismic soundings), carried outin the Carpathians and Dinarides, have shown a fairly sharp downthrust of the Mohorovičić surface, from about 30 to 50 km, in the zones of inferred crust subduction (W. B. Sollogub et al., 1970, G. Szénás, 1972b). According to the present author this is connected with some thickening of the crust, resulting from the pushing of some of the blocks under the others. It is important to note that the morphology of Mohorovičić surface appears to be similar in all the studied profiles of these zones; all the profiles display a deep crustal fracture presumably representing structural suture connected with the subduction.

The subduction of the crust resulted in reduction of the width of the Carpathian geosyncline of at least 230 km at the meridian of Cracow. The contraction calculated from straightening of folds for the section from the Pieniny Klippen Belt to the northern margin of the Carpathians equals 133 km (R. Ney 1975). In the course of the subduction the northern forefield of the Carpathians was pushed beneath the Flysch series at a considerable distance.

The recent studies have shown that Miocene deposits from the Carpathian Foredeep reach the Pieniny Klippen Belt beneath the Flysch cover (Fig. 4). This conclusion, based on seismic surveying data, needs to be confirmed by borehole data. Boreholes hitherto made have shown the occurrence of Miocene deposits beneath the Flysch 25 km south of the northern margin of the Carpathians.

The denudational stage of the evolution of the Carpathians continues from the folding and the orogenic uplift of that orogen up to the present (Fig. 4). It is connected with gradual erosion of the rocks building the orogen. The sub-Silesian unit from the Polish western Carpathians is an excellent example of an advanced erosion of Flysch series and the resulting peneplanation of the mountains.

An attempt of synthetic approach to the tectogenesis of the Carpathians from the point of view of the plate tectonics, presented here, should be further tested through an accurate analyses of all the data. Results of geophysical surveys of the crust from the zone of the Carpathian orogen and borehole data revealing internal structure of the mountains are of primary importance here.

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STRESZCZENIE

W artykule przedstawiono pogląd na formowanie się orogenu karpackiego przy uwzględnieniu zasad tektoniki płyt. Karpaty potrakowano jako składową część śródziemnomorskiego systemu Alpidów, w których poszczególne pasma orogeniczne są genetycznie ściśle związane ze sobą (ryc. 1). Oddzielające je masywy oraz mikroplatformy są częściami dawnej, jednolitej platformy euroazjatyckiej i odgrywają rolę mikrokontynentów.

W rozwoju Karpat wyróżniono trzy podstawowe etapy, na które składają się cykle rozwojowe, dwa pierwsze, to etap geosynklinalny (ryc. 2) i orogeniczny (ryc. 3). Są one etapami konstruktywnymi, ponieważ rozwój ich prowadził do zbudowania Karpat w postaci gór. Trzeci etap (przebiegający współcześnie) można nazwać etapem denudacyjnym, ma on znaczenie destruktywne, gdyż prowadzi do zrównania tych gór z otaczającymi je obszarami (ryc. 4). Poszczególne etapy nie są ostro rozgraniczone, a nawet wyraźnie zazębiają się ze sobą; z etapem geosynklinalnym zazębia się etap orogeniczny. W czasie gdy Karpaty wewnętrzne były już częściowo fałdowane w Karpatach zewnętrznych trwał jeszcze rozwój geosynkliny. Etap denudacji rozpoczął się z chwilą wydźwignięcia wewnętrznych partii łuku karpackiego, z którego do północnych basenów donoszony był materiał pochodzący z erozji tych części gór.

Etap geosynklinalny związany jest z rozsuwaniem się poszczególnych płyt i mikropłyt. Ogólnie chodzi tu o rozsuwanie się płyty euroazjatyckiej oraz afrykańsko-arabskiej i powstanie w tym czasie eocenu Tetydy. Złożona geosynklina Tetydy nie miała jednolitego charakteru, ale składała się z szeregu basenów sedymentacyjnych oddzielonych mikropłytami i masywami. Każdy z takich basenów tworzył oddzielną geosynklinę, również o złożonej budowie. Najbardziej północna z nich była geosynklina karpacka, którą od geosynkliny Dynarydów oddzielała mikroplatforma pannońska.

Etap orogeniczny w Karpatach nastąpił z chwilą rozpoczęcia się ruchu płyt kontynentalnych skierowanego do wewnątrz geosynkliny Tetydy, wówczas nastąpiła subdukcja skorupy płyty kontynentu europejskiego pod płytę pannońską. Strefa subdukcji skorupy w Karpatach przebiegała wzdłuż pienińskiego pasa skałkowego, co odbiło się w ogólnej tektonice tego elementu orogenicznego. Ruch ten wyrażający się także w cyklach nie wygasł zupełnie do dziś, stąd obserwowane w Karpatach przejawy neotektoniki. Z chwilą wydźwignięcia się Karpat rozpoczął się silny proces denudacji, który doprowadził już w niektórych ich partiach do znacznego spłaszczenia tych gór.