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CLIMATE DYNAMICS IN THE BEGINNING OF NEOID GEOMORPHOLOGIC STAGE IN THE WEST CARPATHIAN MTS.

(Fig. 1)

Abstract: On the basis of knowledge about the generally northward movement of the Kreios micro-continent, or the Insubric-Carpathian Block System, and about the migration of North Pole during the last approx. 100 million years, an attempt was made to interprete dynamically the paleoclimatic conditions of the beginning of the Neoid geomorphologic stage in West Carpathians. The ideas on the position and movement of the micro-continent and North Pole and the thus following pertinence to a certain climate zone have been tested on the basis of the up to present known sedimentologic and geomorphologic paleoclimate indicators of the beginning of the Neoid geomorphologic stage.

Резюме: На основе данных о генерально северном перемещении микроконтинента Крейос или системы инсубрическо-карпатских блоков и миграции Северного полюса в течение последних около 100 миллионов лет была сделана попытка к динамической интерпретации палеоклиматической обстановки зачатков неоидного геоморфологического этапа в Западных Карпатах. Представления о положении и миграции микроконтинента и Северного полюса и вытекающая из этого принадлежность к определенному климатическому поясу проверялись на основе существующих седиментологических и геоморфологических индикаторов палеоклимата зачатков неоидного геоморфологического этапа.

Introduction

The solution of paleoclimate problems has a central position in the paleogeographic reconstruction of different evolution stages of the Earth crust. Together with paleogeomorphology, hydrology, pedology and biology, paleoclimatology attempts to result in a paleogeographic synthesis represented by a reconstruction of the natural environment of the given stage.

A paleoclimatologic analysis cannot be made separately. Besides very close relationships of the past climates to the surface forms, waters, soils, fauna and flora of the time, there is a very important connection between tectonics and climate, which has not always been appreciated sufficiently up to now. Tectonics influences climate often in a decisive way, either directly, by the distribution of continental megamorphostructures and ocean basins, or indirectly, through elevational gradation of the landscape which is a result of orogeny of the neotectonic stage.

In contrast to climatology, which evaluates measurable elements of atmospheric processes (air pressure, temperature, air humidity etc.), paleoclimatology is based on indirect indicators and using the method of actualism.

The results obtained in the paleoclimatology of West Carpathians are mostly based on paleobiologic indicators, only to a lesser extent on sedimentological

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results and even less on paleogeomorphologic analysis. Very positive results have been attained in climate reconstruction of variously long time intervals, even though they were not dynamic interpretations but methods more or less in accordance with fixistic ideas.

The data on paleoclimate illustrate often only the conditions in sedimentary basins or on their contacts with continent. Opinions on the paleoclimate of adjoining large continents could be often formulated only indirectly, on the basis of basin analyses. With the onset on the Neoid geomorphologic stage in the Earth crust evolution* the beginning of which for different regions can be considered as Cretaceous or Paleogene (Gerasimov — Meshcheriakov, 1964; Büdel, 1977), the extent of dry land gradually increased. From this fact follows also the increasing importance of geomorphologic paleoclimate indicators.

If we do not take into consideration astronomical and astrophysical influences, climate variations in the past are described not only to changes in the number, extent and mutual position of continents, but also to tectonic processes influencing to an important extent the radiation and thermal balance on Earth and thus also the circulation conditions.

The basis of our further considerations on climate dynamics in the beginning phases of the Neoid geomorphologic stage will thus be folowing:

1. movement of the micro-continents, or block systems;
2. changes in the position of the poles;
3. permanence of thermal and climate zoning;
4. sedimentological and geomorphological paleoclimate indicators.

Movement of micro-continents, or block systems, and climate dynamics

In paleogeographic and tectonic syntheses concerning Paleoalpine and Neoalpine development of European Alpides, horizontal movement of lithospheric micro-plates, or micro-continents, combined frequently also with their rotation, is accepted (Mahel', 1978, 1979, 1980; Krs — Roth, 1979; Roth, 1980; Kováč, 1981; Michalík — Kováč, 1982; Varga, 1978; and others).

Various opinions on the width of the West Carpathian space before Middle Albian deformation have appeared in palinspatic reocnstructions. Mahel' (1979, 1980) assumes a width of 500 km. Krs — Roth (1979) consider on the basis of paleomagnetic data the total width to have been 1200—1300 km. Similar width can be deduced also from the data of the 800—900 km width of the Magura Flysh Zone Klippen-belt and Tatricum (Vašíček — Michalík, 1981), if we take into consideration also the width of the more southern West Carpathian units.

The width of the West Carpathian space before and after the Middle Albian deformation as well as the position of the Kreios micro-continent (Tollmann, 1978; Michalík — Kováč, 1982), or of the system of Insubric-Carpathian

* Gerasimov — Meshcheriakov, 1964, use the term „geomorphologic stage", Büdel, 1977, „geomorphologic era". By the addition of the adjective „Neoid" we stress the pertinence to Paleo- or Neo-alpine subaeric evolution, in contrast to older ones.

Blocks (K r s — R o t h, 1979; R o t h, 1980), are facts which have considerable importance not only in tectonics but also for paleoclimates.

Great geographic changes caused by the movement of microcontinents had to be reflected also in the development and variations of climate. If any continent drifted hudreths or thousands of kilometres in the north-south, longitudinal direction, after a certain period of time dependent on the speed of the movement it would shift into a different climate zone. In the case of a west-east, latitudal movement of continents such a marked change in climate would not occur, because the continent would, in spite of the movement, preserve its position in certain geographic latitudes and thus with unchanged astronomical or astrophysical factors remaining in the same climate zone.

The generally northward direction of the movement of the Kreios microcontinent, or the Insubric-Carpathian Block System, beginning in Middle and continuing in Upper Cretaceous and Paleogene, is attributed to pressures caused by the convergence of the African craton and Paleoeuropean forefield (M i c h a l i k — K o v á č, 1982; K r s — R o t h, 1979; R o t h, 1980). Considerations on the amplitude of the horizontal movement are not simple and very few data are available for study.

The movement of the Insubric-Carpathian Block System in northern direction in West Carpathians after Oligocene is assumed to cover more than 100 km (K r s — R o t h, 1979). If we supposed purely mechanically that in four times longer time interval, i.e. in about 100 milion years the block system covered a four times larger distance, the total displacement in this period would be about 500 km. Even though the presumption of a regular movement does not correspond to reality, we shall consider this value as one of the possibilities in the model solutions.

From a schematic outline of the evolution of the Insubric-Carpathian Block System from Aptian, through Eocene and Carpathian to recent time it follows that the Carpathian — Pannonian sub-block, besides a general rotation of several hundred kilometres, shifted about 1000 km northwards (K r s — R o t h, 1979). We shall therefore take into account also this possibility in our further considerations. The displacement of 1000 km will be denoted as Model No. 1, and the distance of 500 km as Model No. 2.

For further considerations within the models, it is necessary to express at least schematically the velocity of the movement. An average speed of several cm in year is assumed for the movement of the Carpathian-Pannonian sub-block in Late Carpathian and Early Badenian (Early Styrian phase) — (K r s — — R o t h, 1979). No velocity is mentioned for other periods. We shall therefore use the several-cm velocity only as an aid for orientation in the model solutions.

If we considered the same average velocity for the needs of modelling and substituted the value of several cm in year by the values 2 or 3, the total displacement would exceed 2000 km and could reach as much as 3000 km. Both these values exceed considerably the limits of the assumed total width of the West Carpathian space.

Therefore we shall attempt to express the velocity for the needs of a schematic expression of the movement by the fraction of the 1000 km or 500 km distance covered in 100 milion years. In this case the velocity of displacement for Model No. 1 would be 1 cm/year, for Model No. 2 0.5 cm/year. The presumption of a roughly constant velocity can be accepted only for a model which should express climate dynamics dependent on horizontal displacement, and not for a real situation. Nevertheless, generally it can be stated that the model velocities do not disagree with the facts known about lithospheric plate movement (K u k a l, 1983). In spite of the fact that the obtained values of displacement amplitude and velocity are valid only for orientation they nevertheless indicate the way in which the displacement of the micro-continent could be reflected in climate variations in individual Paleoalpine stages, as well as during the Neoalpine stage.

Changes in the position of the poles

Besides the already proven northward displacement of the micro-continent, or the Insubric-Carpathian Block System, another important movement, which should be analysed, took place during Tertiary and Cretaceous. Shifting of the poles and of the Equator occured contrary to the northward movement of the micro-continent, in a generally opposite direction — towards south. For our further considerations it will be sufficient to follow the changes in the position of the North Pole during Cretaceous and Paleogene.

K r s (1969) places the North Pole of Cretaceous to 70°N and 180°, or 166°E. Very close to these data are also the coordinates of the Cretaceous North Pole for Europe and Russian Platform — 80°N, 162°E; for Siberia — 77°N 176°E; for China — 69°N 133°E (M c E l h i n n y, 1973). The North Pole coordinates for Cenomanian to Lower Turonian, obtained on the basis of measurements in outer Carpathians (Moravsko-sliezske Beskydy Mts.), are 64°N 36°W and 51°N 78°W (K r s — R o t h, 1979). The average value for all these data is about 70°N. This value shall be further considered to be the starting point for expressing the distance covered by the North Pole during its displacement since the beginning of the Neoid geomorphologic stage.

Several data exist as well on the position of the Lower Tertiary North Pole. The coordinates 75°N 164°E (M c E l h i n n y, 1973) are mentioned for West Europe and Rusian Platform. 75°N 170°E is the average value for the North European Platform Paleogene (K r s, 1979). The data on the Cretaceous (70°N) and Paleocene (75°N) position of the North Pole make possible the conclusion (on the basis of the distance covered in approx. 35 million years, from Middle Cretaceous to the beginning of Paleocene, i.e. 5° of latitude) — if a constant velocity of the displacement is pressumed for the model — that during Paleocene (approx. 17 milion years) the pole could travel approx. half distance, i.e. 2.5° of latitude and roughly at the beginning of Eocene it was lying between 77° and 78°N.

According to Model No. 1, the micro-continent covered from Middle Cretaceous until present time a distance of about 1000 km towards north; according to Model No. 2 about 500 km. The North Pole moved from approx. 70°N 180°E to its recent position — 90°N, what means a displacement of about 2000 km to south. The position of the micro-continent from the point of view of tectonics is sufficiently characterized by its northward movement. From the point of view of paleoclimate the situation of the micro-continent is nevertheless a result of an interference of two opposite types of movement. The northward drift of the micro-continent signified with its distance of 1000 km (approx. 9°), or 500 km (approx. 4.5°) a less important component than the southward movement of the pole and together with it, of course, also of the Equator and the climate zones.

On the basis of the recent position of the central West Carpathians which in present cross 49°N, the situation in the beginning phases of the Neoid geomorphologic stage can be characterized as follows:

The micro-continent moved in the time interval of approx. 100 milion years approx. 1000 km according to the Model No. 1, and 500 km acording to the Model No. 2, i.e. approx. 9°, or 4.5° of latitude respectively to north. That means that in the time of Middle Albian deformation the locations in central West Carpathians which are today crossed by 49°N were lying on 40°N, or approx. 44°N if we take into consideration the present net of coordinates. But as the Cretaceous North Pole lied on 70°N 180°E, or 166°E, the net of parallel coordinates was displaced by about 20 grades of latitude to north. That means that the Cretaceous Equator crossed the present 20°N. Therefore, present 40°N to 44°N were during Cretaceous lying approx. on 20°N to 24°N. From the abovementioned it follows that from the viewpoint of paleoclimate evolution the position of recent territories of the central West Carpathians belonging to Temperate Zone was during the beginning of the Neoid geomorphologic stage in subequatorial or Tropical Zone which we with right assume to lie on 20°, or about 24°N Middle and Upper Creaceous.

Permanence of thermal and climatic zoning

Thermal zoning of climates on the Earth surface is a reflection of the solar climate zoning. Therefore also the solar climate and the most frequent division of the Earth surface into three zones — polar, temperate and tropical — are based on the mutual position of Earth and Sun. The basic cause of latitudinal zoning on Earth surface are differences in radiation balance, i.e. actual solar radiation intake, while the radiation balance decreases from the Equator towards the poles. Atmospheric and ocean circulation, i.e. wind systems and sea currents cause differences in the course of annual isotherms and solar climate isotherms. This is nevertheless a case of secondary influences (B e r n a r d, 1963). Climate zones — recently as well as in Earth's past — have been caused by a decrease in solar radiation from the Equator to the poles. They thus reflect thermal zoning, but also general air circulation.

Thermal as well as climatic zoning which function basically according to the same laws that are generally accepted by modern climatology for the explanation of the present climate zoning was a characteristic trait also of the past geologic eras.

The features of zoning and gradation of biotas are assumed to exist in Cretaceous. Sharply defined climate zones are thought to be present in the Paleogene climate (D e m e k et al., 1976).

Polar regions were not covered by ice in Cretaceous and Paleogene and climate zoning was different from the present one with ice-covered polar regions, above all as to the internal course of boundaries between the Polar, Temperate and Tropical Zone (F a i r b r i d g e, 1963).

When trying to explain the existence of Temperate Zone flora in recent polar latitudes we cannot accept some opinions about a uniform thermal climate on the whole Earth surface. Warm climate with decreased seasonal variations can exist only in Tropical Zone (Bernard, 1963). Its boundaries can nevertheless change.

The position of the West Carpathian area on both sides of 20°, or 24° of northern latitude in the beginning phases of the Neoid geomorphologic stage points to the fact that the micro-continent was lying in subequatorial, or Tropical Zone. In the present time, with ice-covered polar territories, the Tropical Zone with a high radiation balance of 250—300 kJ extends as well into similar geographic latitudes.

An idea on the changes in thermal and climatic zoning and on the migration of the individual zones that can happen when the extent of polar ice changes can be obtained from semi-empirical climate models (Sellers, 1965; Budyko, 1969). Semi-empirical climate models have been elaborated especially in a consideration of future climate changes. They nevertheless permit a view back into the past on climate variations caused especially by the migration of individual climate zones in Mesozoic and Tertiary. One of the results of the models which can be applied also on the climatic conditions of Mesozoic and Paleogene in the West Carpathian region is the statement that a removal of ice from both poles could cause a marked warming of both polar regions. At the same time, only a slight temperature increase, approx. by 2 °C, would occur in the equatorial region.

On the basis of semi-empirical climate models we could thus consider for iceless periods in Cretaceous or Paleogene a slightly increased average temperature in comparison with present ones above continents, sea as well as in the surfatial layers of ocean in the regions lying about 20° to 24° of northern latitude.

As a result of a generally higher temperature, in comparison with recent times, on Earth surface in the beginning phases of the Neoid geomorphologic stage, no change occured in the basic symmetry of climate zones — cold, temperate and warm — about the Equator. A reflection of a higher average temperature was nevertheless a marked displacement of the boundaries of individual zones. Fairbridge (1963) assumed that this displacement could make as much as 1000 km, i.e. approx. 9—10 latitude grades.

The Tropical Zone is in present differentiated from the point of view of precipitation. It can be presumed that a differentiation, even though not so marked as today, existed also in the Tropical Zone of the beginning phases of the Neoid geomorphologic stage, in spite of the fact that the width of the Tropical Zone was much larger than today. The reason of the less marked precipitation differentiation was a more oceanic climate in comparison with the present times, and the absence of high mountain ranges.

In low geographic latitudes lying outside the equatorial region, a marked climate type is the savanna or trade wind climate, controlled by air masses flowing from the subtropical maxima to the Equator. Trade winds are mostly dry winds and they bring humidity on the Northern Hemisphere only to east coast. Only the monsoon circulation is strong enough to bring sufficient precipitation also to the region which according to its latitude belongs to the trade wind stream.

Each larger continent is capable of producing monsoons and similar winds if it can generate sufficient pressure differences between the continent and the adjoining sea.

Exceptionally good conditions for the origination of monsoon streams in the predecessor of the recent West Carpathian region existed in the Middle and Upper Cretaceous configuration of continents and oceans.

An extensive northern continent, Fennosarmatia, was washed on south by the waters of the ocean Tethys, in the northern part of which occured the micro--continent Kreios.

Sedimentological and geomorphological paleoclimate indicators of the beginning of the Neoid geomorphologic stage

The subaerial relief suggested by Mišík (1978) for the central West Carpathians in Middle Cretaceous, i.e. also for the time of the transportation of the subtatric nappes, was in its early phases probably tectonic. It was formed mostly on extensive carbonate rock complexes on which a gradual change of the primary tectonic relief into a karst relief can be assumed. High average temperatures and abundant precipitation could theoretically cause the origination of tropical karst in the beginning phases of the Neoid geomorphologic stage. Nevertheless, Middle Cretaceous karst has not been proved to occur in West Carpathians. The detritic-carbonate complex from the lower part of the bore GK-4 (Bzovík), which bears the signs of a rapid sedimentation (Vass et al., 1979; Vass — Čech, 1983) and forms sediments correlating with the early stages of tectonic relief destruction, points rather to a more varied local relief. The absence of crystalline material in the early molasse from Bzovík is an evidence of the fact that the denudation of the nappe relief in the source region did not yet make much progress.

The climate of the West Carpathian area was in the Middle and Upper Cretaceous determined above all by the position of the poles and of the micro-continent. Large sections of the micro-continent, which were lying on both sides of 20° or 24 °N occured in Tropical, or Subequatorial Zone. Their position indicates roughly the values of the most important climate elements. The high radiation balance in the tropical region is connected not only with high average temperatures but also with only slight seasonal variations. In connection with these conclusions following from the semi-empirical climate models we can suggest even a few degrees higher average temperature for the Middle to Upper Cretaceous Tropical, or Subequatorial Zone than they are in these zones in present time.

The high average temperatures and their only slight seasonal variations were probably supported also by a permanent flow of warm waters from the circumglobal equatorial sea current which crossed from east to west the Pacific Ocean, Sargasso Sea, Tethys and Carribean Sea and returned to the Pacific Ocean (Monin — Shishkov, 1979). The waters of this current flowed probably by one branch also northwards and they washed the coasts of the Kreios micro--continent.

The great differences in the temperatures of high and low latitudes existing today did not exist in Upper Cretaceous. This assumption is confirmed by the absence of polar glaciation, the functioning of a circumglobal equatorial current and an extensive Upper Cretaceous transgression. Stable and peneplenated continents permitted in this thalassocratic phase (F a i r b r i d g e, 1963) a deep penetration of warm seas and the forming of wide shelves. The climate of the continents was on large territories oceanic.

The extensive continent of Fennosarmatia warmed up in hot summers more rapidly than the water of the ocean Tethys due to its higher thermal conductivity. Relatively lower air pressures originated therefore during the summer months over the continent than over the ocean. Humid oceanic air flowed from equatorial and subequatorial ocean waters to such barometric minima; the air, due to intensive evaporation caused by high temperatures, brought summer clouds and ample precipitation.

The summer monsoon provided probably substantial precipitation not only to the southern coast of Fennosarmatia, but also to the slopes of the tectonic relief of the Middle and Upper Cretaceous micro-continent Kreios occuring in the northern part of Tethys. The assumption of a slightly varied tectonic relief of the West Carpathians in Middle and first phases of Upper Cretaceous (Senonian) is supported also by the fact that the central Carpathian area was not inundated by the Upper Cretaceous transgression; this can be said in spite of an occurence of marine Senonian near Šumiac. The absence of a greater amount of molasses in the Upper Cretaceous of central West Carpathians indicating a more significant elevation is on the other hand an evidence against a more varied mountaneous relief.

In winter time the pressure conditions changed. A pressure maximum originated over Fennosarmatia; from here air masses were flowing over the Kreios micro-continent towards the area of pressure minima over the ocean. Annual rainfall on the Middle and Upper Cretaceous micro-continent was evidently high, but precipitation was concentrated in the summer monsoon season, while the winter monsoon season was dry.

The river regime on the micro-continent probably corresponded also the distribution of the precipitation. The river system was evidently concentrated more on the rocks which were not influenced by karst processes. The water flow of the rivers varied considerably. They overflowed in summer and in the winter season their water level decreased very much. Sometimes the rivers also dried out or they could partly change into lakes.

Processes of deep and intensive chemical weathering took place on the micro-continent in the abovementioned conditions. Only sporadic remnants were preserved from the pedosphere covering the surface of the micro-continent in the beginning of the Neoid geomorphologic stage.

Bauxites of the central West Carpathians are the most significant remnants of the pedosphere of the beginning phases of the Neoid geomorphologic stage. Occurence of bauxite iron ore in the Slovak Karst decsribed by B o r z a — P o s p í š i l (1959) can also be considered to be the last redeposited remnants of a more extensive laterite crust.

The stratigraphic span of the formation of central West Carpathian bauxites has not been sufficiently clearly determined up to now. The bauxites are usually considered to be of Upper Cretaceous Paleocene, or pre-Eocene age (B o r z a — M a r t i n y, 1964; A n d r u s o v, 1965; M i š í k, 1978). Similar problems emerge also in the age determination of Hungarian, especially Transdanubian bauxites (B á r d o s s y, 1982), although several of them are older than the

Slovak occurences. It is also not clear whether bauxites originated in a single or more stages of Upper Cretaceous and Paleocene.

Due to the conditions of their formation in the decomposition sphere of the Tropical Zone on the micro-continent, certain analogues could be found recent laterites originating e.g. in the African tropical savanna climate approx. up to 15° of northern latitude and in Indian monsoon climate up to 25° and 30° of northern latitude (T r e w a r t h a, 1982; F r a k e s — K e m p, 1973). Recent bauxites almost always occur on recent or fossile levelled surfaces or in rock crevices of their decomposition spheres (B ü d e l l, 1977).

Bauxite occurences indicate in the West Carpathian Mts. the evolution trend of the relief in the beginning phases of the Neoid geomorphologic stage. The original tectonic relief, probably moderately varied, gradually changed in the warm, varyingly humid monsoon climate into an erosion-denudation relief which, as the bauxite occurences indicate, attained gradually the stage of a relatively advanced peneplenation.

The up to now oldest known manifestation of deep tropical weathering in the first phases of the Neoid geomorphologic stage in the central West Carpathians are related to the forming of laterite crusts older than Santonian—Campanian black schists which form the filling of cavities in the Gombasek quarry in the Slovak Karst region (M e l l o — S n o p k o v á, 1973). It is probable that in the time when the laterite crusts were being formed we can also attempt to find the beginning of the formation of cone carst the remnants of which — in the form of considerably altered mogotes — have been described from the Plešivec Plain and the Koniart Plain by L u k n i š (1962); they nevertheless considered the cone karst to be of Lower Pannonian and not of Upper Cretaceous age.

The Pre-Santonian/Campanian age of laterite crusts in the Slovak Karst suggests that the laterite crusts, by the redeposition of which the recently known bauxite occurences were formed, could also be of Pre-Santonian Campanian age.

The Mojtín bauxites which fill sink holes and open fissures and depressions on the surface of pure Triassic limestones and dolomites reflect not only the processes of deep weathering but also the following redeposition of the primary (laterite) crust. This assumption is supported also by the findings of pisolitic bauxite near Mojtín (B o r z a — M a r t i n y, 1964) because pisolitic texture is rather a sign of transportation than of the formation of residual concentration (P e t r á n e k, 1963).

The individual West Carpathian bauxite occurences differ one from another. While the Mojtín bauxite does not bear any signs indicating lower humidity of climate in the time of its formation, the Drieňovec bauxite indicate different facts. The Drieňovec bauxite is accompanied sometimes by approx. 20 cm thick layer of brown silicite which originated in hypergene conditions at the same time as the bauxite (M i š i k, 1978). Important is the suggestion of the hypergene origin of the silicite because in the same manner as bauxite indicates relatively high humidity, the forming of silicites indicates a more dry climate.

On the basis of a study of tropical red earths in Africa it is presumed that siliceous concretions can originate in red earths due to a stronger influence of dry seasons, while an extreme in their formation are the not very often occuring thick siliceous crusts — silcretes (B ü d e l, 1977). Silcretes originate probably in a little more humid climate than calcareous crusts, but, on the other hand, in a little more dry climate than laterite crusts, and in a landscape with very even relief (Bremer, 1967). The conditions of the formation of the Drieňovec bauxite were thus probably different from those of the Mojtín bauxite. This fact points to a possibility of different ages of both bauxites, nevertheless within Upper Cretaceous to Paleocene. The composition of the Drieňovec bauxite as well as of the Mojtín bauxite is an evidence that igneous, sometimes basic rocks were base rocks of the primary weathering crust (Borza — Martiny, 1964).

While the Bzovík Upper Cretaceous early molasse contains only carbonate material, from the Upper Cretaceous conglomerates of the Považský Inovec Mts. (Kullmanová — Gašpariková, 1982) are known as well pebbles of metamorphic and igneous rocks (phyllites, schists, granodiorites, diabases). The different composition of these Upper Cretaceous sediments suggests different depth of denudation of their source region. Deeper denudation can be also interpreted as a result of longer lasting denudation processes. The period of bauxite formation could be thus limited to the youngest phases of Upper Cretaceous and the following Paleocene, when the crystalline rocks were sufficiently exposed.

The climate of the Insubric-Carpathian Block System in the beginning of Paleogene was a result of an interference of the northward drift of the block system and the southward movement of the North Pole. The hypothetical position of the block system in the end of Cretaceous, or the beginning of Paleogene, can be determined according to the two proposed models in the following way:

According to the first model, the micro-continent moved in Cretaceous approx. 350 km, according to the second model, approx. 175 km northwards. The North Pole was lying in the beginning of Tertiary approx. on 75°N 164°E, in contrast to its Cretaceous position of 70°N.

The interference of these movements expressed in latitude degrees means (350 km = approx. 3.5°, 175 km = approx. 1.5° + 5° of the displacement of the pole) that the parts of the micro-continent lying during Cretaceous on 20°N, or 24°N, were in the beginning of Paleogene lying $3.5° + 5° = 8.5°$, or $1.5° + 5° = 6.5°$ to the north, approx. on 28.5°, or 30.5° of northern latitude.

The position on approx. 30° of northern latitude evaluated by present criteria means a position on the border of the Tropical Zone and Subtropical Zone. As a result of the fact that the poles were not glaciated in Paleocene and that the temperatures were higher the borderline of Tropical and Subtropical Zone was on the Northern Hemisphere probably lying more northwards. Thus it follows that the Insubric-Carpathian Block System was in the beginning of Paleogene still in Tropical Zone.

The Paleocene climate of the West Carpathian region was above all influenced by the following: 1. the position of the block system; 2. gradual narrowing of Tethys; 3. change in the character of sea currents; 4. gradual opening of middle and north Atlantic Ocean; 5. growth of continents.

The position of the Insubric-Carpathian Block in the Tropical Zone in Paleocene — even though already more on the north than in Cretaceous — ment a high radiation balance and high average temperatures over the continent as well as over sea. With a low temperature gradient between the Paleocene Equator and North Pole, the more northern position of the block system probably did not yet mean a more significant decrease of annual average temperature.

Gradual narrowing of the ocean was connected with deformations in the end of Cretaceous, caused by a new shortening of space in Tethys, while the western part of Mesogea closed completely (Michalík — Kováč, 1982). The function of marine currents as bearers of heat, including the circumglobal equatorial current, decreased by the closing of the western branch of Mesogea, or by the gradual opening of the north Atlantic Ocean, which ment an influx of colder waters from the north (Monin — Shishkov, 1979).

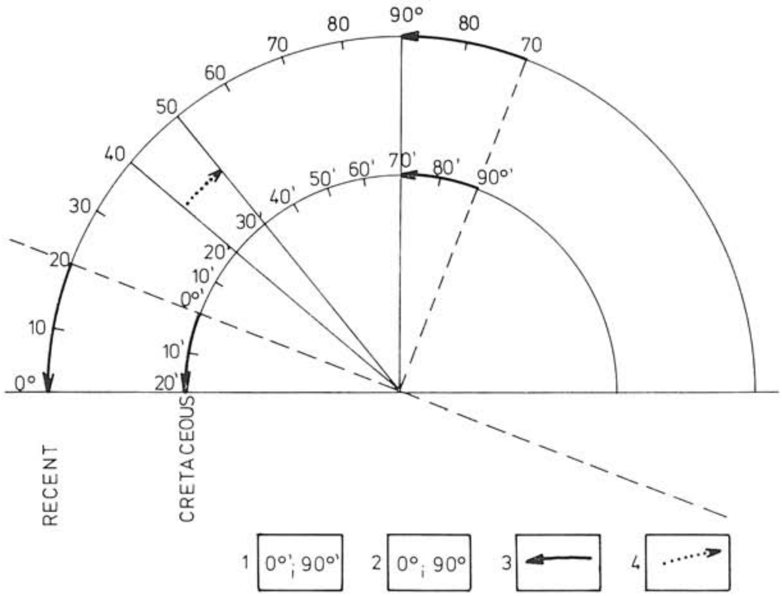

Fig. 1. Schematic representation of poles and the Kreios micro-continent migration from Cretaceous to Recent.
Explanations: 1 — coordinates network during Cretaceous; 2 — Recent coordinates network; 3 — migration of pole from Cretaceous to Recent; 4 — migration of the Kreios micro-continent from Cretaceous to Recent.

The inversion of Mesozoic sedimentation basins was generally connected with the formation of new parts of dry land to the detriment of water basins. This process went on progressively in the whole Neoid geomorphologic stage, which ment, as far as the climate was concerned, a gradual change of humid oceanic climates into continental, more dry climates. The mentioned climate changes took place only slowly and they point more to a general trend of Tertiary climate evolution in the West Carpathian region than to an intensive change, e.g. already in Paleocene.

Only few climate indicators exist from the Paleocene continent from the West Carpathian region. One of the most important sedimentological indicators of Paleocene climate are the sediments of the Kľuknava Formation which is noted for a varied rock association. Except boulder breccias, conglomerates and false-bedded sandstones, the formation contains near Markušovce in some places also lenses of impure bauxite, or in the surroundings of Štefanovská huta interbeds of high-caloric coal. Bauxites are developped on the base of the formation and the coal seams are as a rule also in the basal strata of the Kľuknava development (Andrusov, 1965).

The assumed Paleocene age of the formation does not necessarily mean also the time of the formation of the Markušovce bauxite. It can more probably be the time of their redeposition. Bauxite occurences in the material of low maturity grade and of local origin would be an evidence in favor of a not very large transportation distance from the primary weathering crust occurences of maybe Cretaceous, maybe Paleocene age.

Transportation and deposition of material was provided by mudflows and temporal rivers and gravitational slides bearing a great load of boulders and gravel, while the material on the base of the formation signalises a climate with occasional precipitation and cathastrophic torrents of clastic material. The effect of these transportation mechanisms is in higher horizons replaced by the activity of permanent flows (Marschalko, 1978).

Several signs of the Kľuknava Formation point to an increased aridity of climate, especially in the case if we admitted that the bauxites are older than the formation itself. It would be nevertheless premature to talk about typical arid desert conditions on the basis of the so far known indicators, although Andrusov (1965) believed that the red coating on pebbles could be considered to be a remnant of desert varnish. Other typical signs of fossile desert sediments, like e.g. evaporites eolic sandstones, wind-ripples, deflation residues, windkanters etc., are namely missing.

When trying to find analogues in the extent of fosille and recent deserts of low latitudes we should not forget the fact that the present climate is not a typical one for the geologic past, similarly as the present geomorphology with countless narrow isthmuses and channels, narrow shelves, is not a typical one as an example of paleogeomorphology of Cretaceous or of the beginning of Paleogene (Fairbridge, 1963). Even in the case when the bauxites would be older than the Kľuknava Formation itself, the coal occurences point to a certain grade of humidity on the base of the formation where Marschalko (1978) sees indications of a more arid climate.

Conclusion

On the basis of knowledge of the generally northward movement of the micro-continent Kreios, or of the Insubric-Carpathian Block System, and of the southward migration of the North Pole in the last approx. 100 million years, an attempt was made to interprete the paleoclimatic conditions of the beginning of the Neoid geomorphologic stage in central West Carpathian Mts. from the mobilistic point of view.

The assumptions about the position and movement of the micro-continent, or block system, and its belonging to a certain climate zone in the beginning of the Neoid geomorphologic stage are in accordance with the so far known sedimentological and geomorphological paleoclimate indicators in central West Carpathians.

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