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EVOLUTION OF PALEOCENE — LOWER EOCENE TROUGH ON CONTACT BETWEEN PIENINY KLIPPEN BELT AND CENTRAL WEST CARPATHIAN BLOCK (ON EXAMPLE OF SÚĽOVSKÉ VRCHY HILLS)

(Figs. 1—4)

Abstract: The Paleocene — Lower Eocene trough extended in at least 400 km length in the front of the Central West Carpathian block. The substratum consisted of the Manín structures. In the early phase the trough was filled with olistolites of Montian — Thanetian reefs from the northern exotic island arc, and later (Lower Eocene) with dolomite clastics rocks derived from southern fronts of the Choč and Strážov nappes. The trough was deformed during its development. Its terminal stage proceeded in the Upper Eocene — Lower Oligocene and its most part faded out. Its origin and history were controlled by hypersubsidence of a zone on the contact of the block margin with the Pienides. So the trough got features typical of a mobile continental margin.

Резюме: Палеоцен-низнеэоценовый желоб в лобу блока центральных Западных Карпат распространялся длиной не меньше чем 400 км. Основу образовали манинские структуры. Выполнением в раньшей фазе служили олистолиты монтско-танетских рифов из северной экзотической цепи островов и позже (нижний эоцеп), доломитовые кластические осадки, происходящие из южнолежащих лобовых частей хочского и стражовского покрова. Желоб деформировался в течение развития. Его окончательная стадия осуществилась в верхнем эоцене — нижнем олигоцене, когда его значительная часть исчезла. Его происхождение, историю и развитие обусловило гипероседание пояса на контакте окраины блока с пиенидами. У желоба были поэтому все особенности мобильной окраины континента.

The Paleocene — Lower Eocene formation on the periphery of the Central West Carpathian block (Fig. 1) are a regional phenomenon and so they were paid adequate attention. D. Andrusov (1965) denoted the sequences as the Myjava — Hričov — Žilina facies, and O. Samuel (1973) — as the Považie — Hanušovce belt including the Hričov — Žilina — Varín facies. In East Slovakia the formations form the Proč beds (B. Leško, 1960) in the Beňatina — Chmelov — Radvaňovce — Haligovce belt (B. Leško — O. Samuel, 1960; R. Marschalko, 1975; A. Matějka, 1960; E. Scheibner, 1968; Fig. 1). All the authors prove that individual facies are rests of a trough affected by intensive tectonic activity. Great thickness and stratigraphical range (Paleocene — Lower Eocene) of the flysch filling, types of proximal facies with mostly dolomite detritus originating from the frontal parts of the Choč nappe, are characters of a marginal trough in the frontal part of a mobile block. So it is called the frontal trough (R. Marschalko, 1975). It is the stage of a periklippen zone characterized by M. Mahel' on the basis of the Manín unit, the frontal parts of the Krížna nappe, the Upper Cretaceous of the Myjava facies and the Paleogene of a particular type (M.

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M a h e ľ, 1967, p. 169). Reconstruction of the through is important because its oldest members are partly connected with the Upper Cretaceous formation of the Pienides and the youngest members pass into the Central Carpathian flysch. This is emphasized in the term „periklippen Paleogene".

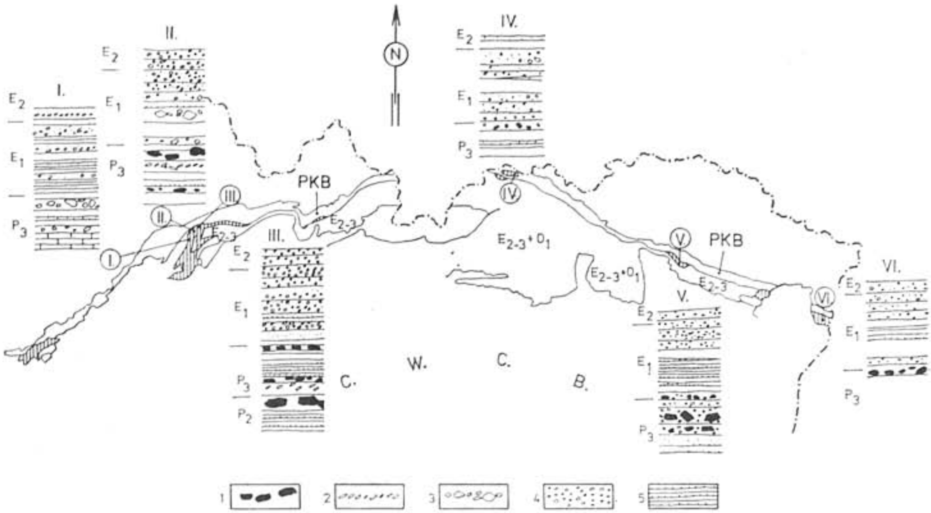

Fig. 1. Extension and localization of Paleocene — Lower Eocene sediments on the contact between the Central West Carpathian block (C.W.C.B.) and the Pieniny Klippen Belt (P.K.B.). The sediments are most extensive in the area of the Súľovské vrchy hills. 1 — reef limestone olistolites, 2 — operculina turbidite sandstones, 3 — blocky breccias, 4 — conglomerates, 5 — carbonate sandstones.

The Hričov — Žilina and the Inner Carpathian Paleogene

A part of the frontal trough is best preserved between Pružina (Mojtín) and Žilina. It is a morphologically distinct conglomerate-sandstone belt beginning at Ovčiarsko, divided by the Súľov depression into two branches connected again at Bodina, and ending at Pružina and Podskalie. Detailed geological maps (D. A n d r u s o v — M. K u t h a n, 1944; D. A n d r u s o v, 1951, 1958; R. M a r s c h a l k o, 1962; R. M a r s c h a l k o — J. K y s e l a, 1980), stratigraphical research (D. A n d r u s o v — E. K ö h l e r, 1973) and sedimentological analysis of the sequences showed rapid facies changes in intricate structures. The researches revealed Paleocene reefs in flysch facies of the western branch, and facilitated stratigraphical assignment of the Súľov conglomerates stratotype between the Illerdian and Lower Lutetian. R. M a r s c h a l k o (1967, 1968) postulated the nontransgressive character of conglomerates in the western branch and described them as marginal (proximal) in flysch.

Tectonics of the Paleogene and its relation to basement structures

The Paleogene is divided by the Súľov depression and a fault running from Zemianska Závada through Prečín, Bodina, Súľov to Paštiná Závada into two branches (Fig. 2.). The external belt is intensively folded, straight to reversed with gradually aging beds toward Jablonovo and Hričovské Podhradie. Between Podskalie and Praznov the contact between the Paleogene and the Mesozoic is transgressive, partly tectonic, cutting the Krížna and Koste-

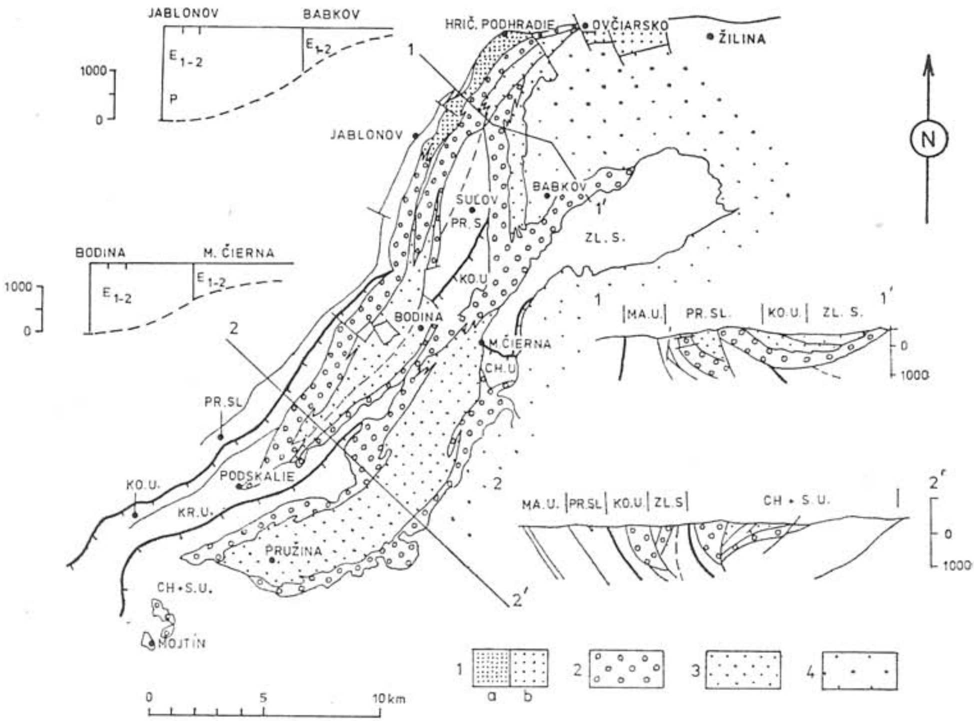

Fig. 2. Geological map of the paleogene of the Súľovské vrchy hills between Pružina and Žilina. — 1 a. Flysch with breccias, conglomerates, carbonate graded sandstones (alodapic limestones) and reef limestone olistolites (Mont — Cuisian). — 1 b. Flysch with reef limestone olistolites, graded sandstones and conglomerates (Dan — Lutet). — 2. Blocky breccias and conglomerates (Cuisian — Lutetian). — 3. Carbonate conglomerates, breccias, sandstone and shales — Flysch (Lower and Middle Lutetian). — 4. Graded sandstones (lithic arenites) and shales — Flysch (Middle Lutetian-Priabonian. At the left: spatial change in thickness of sediments in the Paleocene-Lower Eocene, partly Lower Lutetian).

lec units and the Praznov — Jablonovo slice at an angle 20°—30°. The contact between the Paleogene and the Upper Cretaceous is tectonic from Hlboké, Hričovské Podhradie, Ovčiarsko to Žilina. There it passes into the Upper Cretaceous (J. Salaj — J. Kysela — V. Gašparíková — A. Began, 1978). The external belt (Fig. 2) has a form of truncated syncline and the beds get younger toward the inside. It is separated by a fault from the internal partly folded belt. The fault is SE-dipping and the internal belt is thrust over the external belt along the fault in the form of a block. By the overthrust of the southern branch the basement structures were exposed in the so — called Súľov „window". The Paleogene structures are diagonal (Fig. 2) to older lines of the Manín unit, Praznov—Jablonovo slice, Kostelec and Krížna units in the basement, and unconformable to Mesozoic structures. So it is with the southern belt at Pružina: its northwestern part is in transgressive contact with the Choč and Strážov dolomite and it is straight to reversed The. NW and N — dipping flysch sequence of the Domaniža — Pružina depression is underthrust and forms a false SE — dipping syncline (Fig. 2 cross-section 2—2') with WE to SW—NE dipping axis. The southern belt is tectonically confined by the fault Sádočné, Kardošova Vieska, Čierna continuing over the NW slope of a Mesozoic ridge to Lietava. There it is transgressive. Near Babkov it submerges beneath younger flysch filling of the Žilinská kotlina (depression) in the form of t sycline.

Age, types of filling and origin of clastic rocks

The oldest facies (Montian-Thanetian, Ilerdian) are in the external branch running from Žilina through Hričovské Podhradie, Hlboké to Jablonovo. The facies were described as the Žilina and the Hričov beds (O. Samuel, 1973). Basical types are organodetrital turbidites and isolated Montian-Thanetian reef blocks. Turbidite sandstones consist of detrital components (extrabasinal: dolomites and limestones) and of organic remains (lithotamnians 50 %, algae, skelets) indicative of benthic shallow-water origin. Turbidites are associated with graded bedding and current-ripple lamination. Organo detrital beds are surrounded by fine-grained basinal sediments containing plentiful foraminiferal assemblages (O. Samuel — K. Borza — E. Köhler, 1972). According to these characters the Montian-Thanetian beds may be ranged among carbonate flysch, allodapic limestones of Meischner (1964) — equivalents of turbidite facies. They are reef debris of platform margins, resedimented by turbidite currents.

Thick bodies and blocks (40 cm — 4m — 100 m) of Montian-Thanetian reefs enter in the lower and middle parts of the facies. According to their presence in marlstones, in breccia bodies and in graded conglomerates and according to their poor roundness and disorganized arrangement they are olistolites and not primary bioherms. Conglomerates and breccia — although comprising disintegrated reefs — were produced by various gravity flow mechanisms and so they are no shalow-water transgressive formations but slumps from adjacent platforms. There were no platform (reef) facies nor unconformity between the flysch and the platform in the profiles studied, so we do not know how far was the platform. The distance must have been shorter — as indicated by organization of beds in the flysch megacycles with fining upwards and by disorganized structures in coarse breccias.

There also are some indication that platforms and their unstable slopes, supplying slumps and reef olistolites were on the place of the Pieniny Klippen Belt and inclined inside the Carpathian area. It can be so, because there are no algal coral reefs in the facies of basal conglomerates transgressing on the front of the Choč nappe (e.g. in the Cuisian). Extension of reefs on the margin of the West Carpathian continent drained by rivers and in places of the transport of detritus into the trough was hardly possible. First the reefs formed isolated outer arcs in the foreland of the Carpathian block because there were constant physical and chemical conditions of their development and very slight continental influences. The arcs separated by faults from the Carpathian block were tectonically amputated during Paleogene phases. This is why the primary platforms are not preserved and the Montian-Thanetian flysch is thrust over the Upper Cretaceous structures. Since the Upper Cretaceous belt did not supply clastic material in the Paleocene time, the frontal parts of platforms could not extend to the Upper Cretaceous facies of the Manín unit. Canibalism of the basin proceeded from the Klape unit. There are olistolites of Montian-Thanetian reefs with exotic Maastrichtian orbitoid limestones in the Ilerdian (Makovec). It also proves that the subduced arcs must have been considerably extensive. Thickness of the flysch (Montian-Thanetian, Ilerdian) ranging from 800—1200 m indicates that the trough was open to the north and northwest and amputated on its contact with Upper Cretaceous structures of the Manín unit.

Another significant group of facies consists of conglomerates and breccia at the base of the flysch or in the flysch. Their lithosomes are in the middle part of the flysch (the western branch) or in the lower part of the formation in the eastern branch (Praznov and Pružina), (Fig. 1, 2). They are characterized by great thickness of bodies (2—10—25 m) and lateral stability (3—5 km). The bodies are separated by fine-rhythmical series of sandstones and sandy siltstones. The conglomerates are fine-grained to blocky, composed excludingly of fragments of Middle Triassic dolomites (like micrites, pellets — 90—98 %) with slight admixture of Jurassic — Lower Cretaceous (Upper Aptian) and Middle Cretaceous (Lower Albian) limestones. Dolomite clasts are 3—10 cm in average size. Their size only varies laterally with the type of bedding. Blocks of 2 m size are frequent (Fig. 3), exceptional are 4 m blocks mainly in the eastern branch. They are poorly rounded. Flat pebbles are unknown. Conglomerates are characteristized by irregular and unordered fabric with blocks supported by matrix (20—40 %) of gravel. Another type is represented by massive, non graded conglomerate and breccias with blocks and sheets of sandstone intraclasts imbricated upcurrent. Less frequent are graded conglomerates with normal grading of fragments in the whole bed, and with transition into sandstones. According to these features especially poor sorting, the absence of cross-bedding and of macroorganic remains, the sediments may be classified among deposits of submarine grain, debris flows and less by turbidity currents of low maturity. Imbrication of higher degree (28°) is typical of turbidity currents and partly sandflows and of other gravity transport mechanisms of sedimentary matter.

Paleocurrents and tectonosedimentary characters of trough

Mapping of directional elements e.g. linear structures and orientation and imbrication of intraclasts pebbles (Fig. 3) showed that the regional paleocurrent direction in conglomerates (Cuisian) was slightly rotated. In the northern part of the region (Roháč—Ovčiarsko) the paleocurrent direction was from E to W and in the southern part (Bodina, Pružina) from NE to SW and SSW. The direction was constant during the whole accumulation period of the very thick (850 m) conglomerate lithosome. So the slumps and mass flows were controlled regionally by paleoslope from E to NW—W—SW. The Cuisian basin deepend in that direction and opened to the west and south-west. Conglomerate lithosomes of the western branch wedge-out from the source to the trough or they pass down current into sandstone facies. The analysis revealed the following tectonosedimentary characters of the trough:

1. Stratigraphical range and volume of conglomerate facies (200—250 km^3), poor sorting of bouldery breccias, predominant dolomite fragments in clastic material are indicative of destruction of great masses of dolomite rocks from the frontal part of the Choč and Strážov nappes. The Choč nappe confined the trough on the southeast in the form of a truncated rocky cliff and it was tectonically active, declined and destructed.

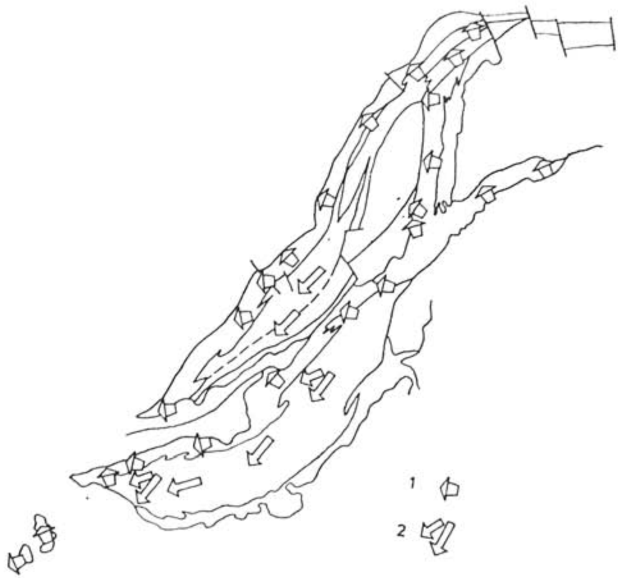

Fig. 3. Directional structures and dispersed coarse clastic rocks (Cuisian and Lower Lutetian breccias and conglomerates). 1. Measured were 50 clasts with evident primary imbrication. 2. Current lineations on bed surfaces and tractional structures. The size of the arrow is proportional to the number of measurements (smaller: 1—3 larger: 4—10 measurements).

2. Conglomerates represent submarine fans formed at the base of the nappe front (Middle Cretaceous) reactivated tectonically in the Paleocene.

3. The termination of the Paleocene — Lower Eocene formation at the NW, W and SW is secondary (tectonical) as proved by the current system in the conglomerates of the western branch near Pružina (Fig. 4), and by the remains of basal members near Mojtín.

4. Bathymetric and structural axes of the trough were diagonal to the members of the Manín unit and cut them at an angle of 20°—30°. The maximal subsidence of the trough began on the structures of the Manín unit and partly advanced along them. A comparison of conglomerate thicknesses on the Choč dolomite (200—400 m) and on the Manín structures (500—850 m) shows a difference caused by subsidence and by collapse of substratum.

It follows that extensive subsidence of the Manín structures into the substratum of the trough in the Paleocene — Lower Eocene and its thick filling (2000 m) in a short time resulted from hypersubsidence characteristic of marginal troughs.

Othe basins in structural position between West Carpathian block and Pienides

Intensive tectonic deformation of the edge of the West Carpathian block on its contact with the Pieniny Klippen Belt and its backward overthrust

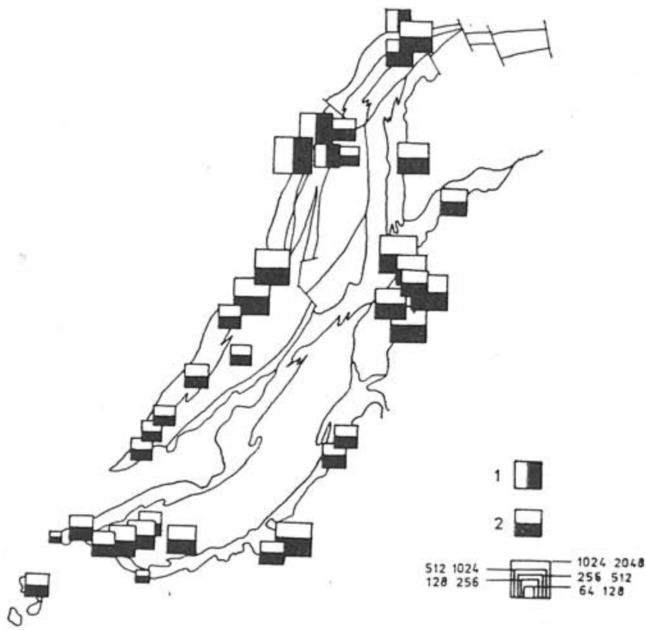

Fig. 4. Map of distribution of clasts of maximum size in basal member and in flysch conglomerates, and in blocky breccias. Distribution of reef olistolites is not estimated. Diminishing of clasts in the Cuisian from E to NW and from NE to SW is in accordance with directional structures.

caused extinction of most sediments of the trough in Orava and Pieniny. There are rests of the trough in East Slovakia between Chmeľov and Hanušovce, near Humenné, and between Jasenová and Beňatina (Fig. 1). Thickness (1200 m), age (Paleocene—Lower Eocene—Lutetian) and petrographical filling of flysch formations resemble the Hričov—Žilina Paleogene. In the lower part are plentiful exotic granites, quartzites with reef blocks of algal-coral type and of Montian-Thanetian age. Conglomerate bodies with reef blocks alternate with hemipelagic marls, turbidites and variegated marls.

In the upper part are conglomerates with excludingly dolomite detritus (the so-called Proč conglomerates). They range variably from 100 to 250 m in thickness. Conglomerate megarhythms of the Chmeľov — Hanušovce —

Beňatina are big lenses intercalated in the flysch. Structures of the coarse clastic rocks are indicative (R. M a r s c h a l k o, 1975) of „quick" beds of high concentration sediment gravity flows from adjacent slopes into deeper parts of the sea. Exotic rocks with reef blocks were transported from outside — from the klippen belt and the coarse dolomite detritus of higher members was transported from the central block and rotated into the trough axis parallely with its margin (SE—NW). The Paleocene—Lower Eocene flysch near Chmelov, Hanušovce, Beňatina and near Haligovce show anologous arrangement of structures. Areas of about 800—1200 m thick sequences including reef blocks and conglomerates incline inside the Central West Carpathian block and have a tectonic contact with the Cretaceous klippen belt and with higher (Lutetian—Priabonian) members of the Central Carpathian flysch. There are occasional minor fold structures and parallel synclinal forms which prove that the trough was compressed and thrust over the Klippen Belt from inside. The substratum crops out only near Haligovce and belongs to the Manín unit (D. A n d r u s o v, 1960; A. M a t ě j k a, 1961).

Conclusions

The frontal trough ran along the edge of the central West Carpathian block on the contatct with the Pieniny Klippen Belt over the length of at least 400 km. It is proved that the trough formed on the structures of the Manín unit in the Paleocene — Lower Eocene and it had all features of a mobile marginal trough in the frontal part of the arched block. It was filled by plentiful dolomite clastic material from the Choč and higher nappes. The nappes confined the trough on the south all over its length. For a short time (Ilerdian) it received coarse material and blocks from an unstable northern island arc comprising reef platforms. On its northern side the trough was tectonically reduced during its evolution. The width of the amputated part is estimated to 10—15 km. The trough underwent final destruction in the Pyrenean (the West Slovakian—Hričov—Žilina segment) or in the Savian phase (the East Slovakian—Haligovce—Beňatina segment). Then the most part of the trough faded out and there are only fragments of the frontal trough in places with no signs of the backward overthrust of the Pienid structures.

Translated by E. Assingerová

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