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BASIN OPENING IN THE LOWER MIOCENE STRIKE-SLIP ZONE IN THE SW PART OF THE WESTERN CARPATHIANS

(Figs. 27, Tabs. 2)

RCMNS

Abstract: Development of the Lower Miocene sedimentary areas in the SW part of the Western Carpathians was affected by palaeostresses generated by collision of the Eastern Alps and the Western Carpathians with the Bohemian massif. Longitudinal intramountain basin was opened in palaeo-Alpine-consolidated part of the mountain chain. Its origin and character of sedimentation document basin opening in wide left-lateral strike-slip zone. Tectonic regime reflects palaeostress orientation changes which can be connected with movement of the Western Carpathian segment to the N, NE and formation of the Carpathians arc-shape in the Neogene.

Резюме: На развитие нижнемиоценовых бассейнов в ЮЗ части Западных Карпат оказали влияние палеодавления, которые возникли коллизией Восточных Альп и Западных Карпат с Чешским массивом. В палеоальпийски консолидированной части орогена был образован продольный внутригорный бассейн. Его образование и характер осадконакопления подтверждают существование зоны левого горизонтального смещения. Тектонический режим отражает направления палеодавлений, связанные с движением западнокарпатского сегмента к С, СВ и с окончением формирования карпатской дуги в неогене.

Formation of wide shear zone in palaeo-Alpine consolidated SW part of the Western Carpathians in the Lower Miocene was caused by collision of the North-European platform and Alpine—Carpathian orogene. Denudation remnants of the filling of the sedimentary area occurring there form now a component of various geological structures. They are known from the Vienna basin, Malé Karpaty Mts., Myjavská pahorkatina Mts., Brezovské Karpaty Mts., northern margin of the Danube lowlands, Čachtické Karpaty Mts., Váh river valley and Bánovská kotlina basin (Fig. 1). Reconstruction of development of the Lower Miocene sedimentary area is based on ecostratigraphic, sedimentological, tectonic research and paleomagnetism.

Character of sedimentation

The Eggenburgian sedimentary area has a character of shallow epicontinental sea divided by archipelagos of islands into individual depressions. Basal clastic sediments overlie transgressively and discordantly the pre-Neogene basement

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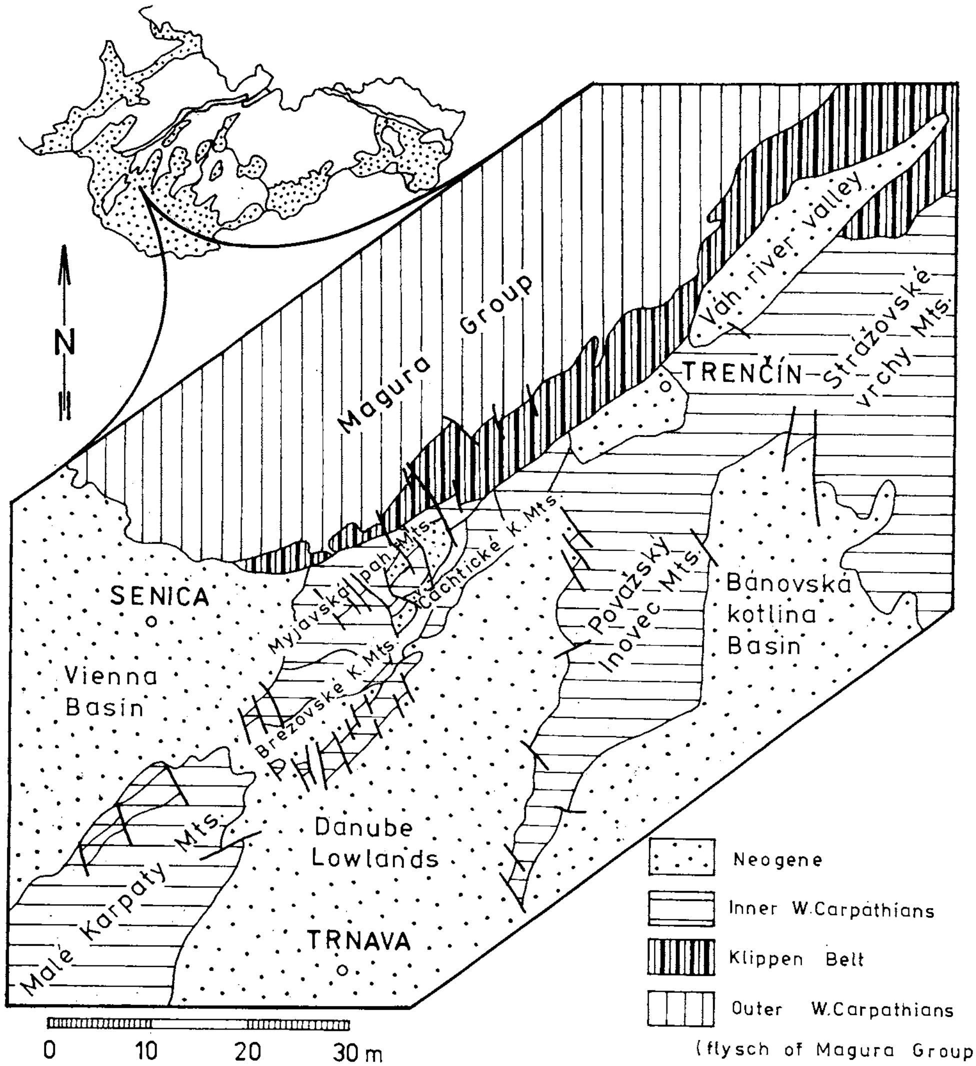


Fig. 1. Geological structures of the SW part of the Western Carpathians.

built up of the Outer Carpathian flysch units, Klippen Belt, nappes of the Northern Limestone Alps and the Inner Western Carpathian units. Pebbles of conglomerates from the majority of exposures are composed of rocks from the local sources (B u d a y et al., 1963). On the basis of textural features of the sediments, orientation of pebbles, morphometric analysis and palaeoecological indicators, the clastic material was formed under shallow littoral conditions of sandy-gravel beach (K o v á č et al., 1988). From here it was trans-

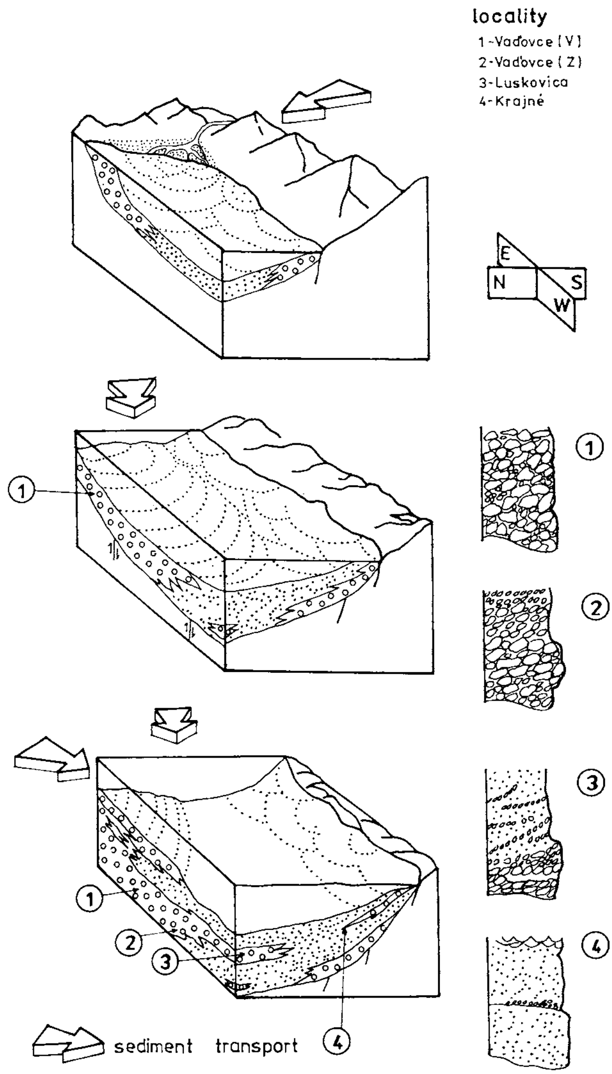


Fig. 2. Block diagram representing development of sedimentation and clastic material transport direction during the Eggenburgian in the region of Vaďovce depression (Myjavská pahorkatina Mts.).

ported by a system of fans from the margins to deeper parts of the basin. Two main directions of transport were distinguished. Transport of material from the S to the N, i.e. from the region of the Central Western Carpathians, was originally prevailing. Transport of clastic material parallel with axis of individual depressions of WSW-ENE direction prevailed during the Eggenburgian (Figs. 2, 12, 13, 14, 15, 16). Depositional flow formed fans trending WSW along the both sides of elevation structure of the Klippen Belt. Source area of pebbles from the Triassic limestones and dolomites is represented by subtatric nappes from the region of the present-day Brezovské Karpaty Mts., Čachtické Karpaty Mts. and Strážovské vrchy Mts. Majority of the Jurassic and Cretaceous limestone pebbles is supposed to originate from the Klippen Belt, in some localities also from the nappes of the Central Western Carpathians. Pebbles of Senonian and Palaeogene clastic rocks are derived from the periklippen zone and flysch belt. Exotic rocks, volcanites and granites were redeposited from older conglomerates (B a r á t h — K o v á č, 1988).

Study of heavy minerals in the Eggenburgian sediments proved our presumption of source areas established on the basis of petrographic study of clastic material. Heavy minerals were redeposited from older sediments mainly of the Upper Cretaceous and Palaeogene age (S a l a j — P r i e c h o d s k á, 1987). Typical is high content of stable minerals, such as tourmaline, rutile, zircon, garnet, apatite accompanied with epidote, chrome-spinels, chlorite and glauconite (Tab. 1). High ilmenite content in the localities of the Čachtické Karpaty Mts. and Myjavská pahorkatina Mts. indicates supply of volcanoclastic material. Increased contents of garnet and of less stable minerals - staurolite, disthene and titanite in middle Váh river valley region caused by presence of primary sources of metamorphites are present. Differences in association of heavy minerals from the SW part of the Western Carpathians indicate division of the sedimentary area into partial depressions and, at the same time, they prove an assumption of larger areal distribution of the Cretaceous and Palaeogene sediments in the Lower Miocene.

The Eggenburgian sediments from the SW part of the Western Carpathians are characterized by frequent presence of angular discordances and rapid facial changes (Figs. 17, 18, 19). Clastic sediments from the studied area were deposited in proximal and central parts of submarine fans. Conglomerates and sandstones are massive to bedded, often with gradational, diagonal, cross and ripple bedding (Figs. 20, 21, 22, 23). Intraclasts formed during erosion of feeder channel margins were found in sandstones. Synsedimentary activity of faults is suggested by presence of debris flows and slumps. Tectonic activity of reverse faults in the region of the Malé Karpaty Mts., Brezovské Karpaty Mts. and Čachtické Karpaty Mts. is supported by talus cones bound to these dislocations in which poorly rounded debris of rocks was accumulated. Breccia are alternating here with beds of well rounded conglomerates and sandstones which were formed under beach conditions during the period of tectonic quiescence. Marginal conglomerates and sandstones pass to "schlier" siltstones and claystones towards the basin. Thickness of preserved Eggenburgian sediments on the Central Carpathian basement does not exceed 200 m.

In the Ottnangian, sedimentation retreated from the Klippen Belt region. Continuous sedimentation is known only from the Vienna basin and Bánovská kotlina basin.

Increase of tectonic activity in the Karpatian caused formation of alluvial-delta fan of Jablonica conglomerates and sandstones (B u d a y et al., 1963). They are distributed in the NE part of the Vienna basin, Malé Karpaty Mts., Brezovské Karpaty Mts. and northern part of the Danube lowlands (Figs. 13, 14). They are massive to heavy-bedded, horizontal-, diagonal-, cross- and ripple-beddings are common. Conglomerate and sandstone body has textural

Table 1

Mineralogical evaluation of heavy fractions from the selected type localities

LOCALITY \ MINERAL		ZIRCON	RUTILE	TOURMALINE	SPINEL	GARNET	STAUROLITE	TITANITE	EPIDOTE	APATITE	PYROXENE	HORNBLENDE	ILMENITE	ANATASE	KYANITE	MONAZITE	CHLORITOID	LEUCOXENE	MICA	CHLORITE	QUARTZ	GLAUCONITE	Fe-OXIDES
LOPAŠOV	EGGENBURGIAN	+	1.0	+	—	2.1	—	—	+	+	—	—	—	1.0	—	—	+	—	—	1.0	—	+	92.8
BUKOVEC	EGGENBURGIAN	3.6	3.6	5.5	7.4	—	—	—	1.5	—	—	—	—	1.2	—	—	—	7.3	—	—	—	—	69.2
HRADIŠTE P. V.	EGGENBURGIAN	36.7	16.6	13.4	—	16.7	—	2.1	—	—	—	—	6.7	+	—	—	—	6.6	1.1	—	—	—	—
DOBRÁ VODA	EGGENBURGIAN	—	—	4.0	1.0	3.0	—	—	—	—	—	—	—	—	—	—	—	12.0	—	—	—	—	80.0
ŠÍPKOVÉ	EGGENBURGIAN	6.8	6.7	20.2	13.4	14.3	—	6.7	—	—	—	—	6.7	—	—	—	2.6	15.8	—	—	—	—	6.6
ČACHTICE	EGGENBURGIAN	—	11.8	11.7	17.6	23.5	—	2.1	3.7	—	—	—	5.9	—	—	—	—	—	—	—	—	—	23.6
VAĎOVCE	EGGENBURGIAN	2.5	9.3	23.1	11.5	7.0	—	2.3	—	4.7	4.7	—	6.9	—	—	—	—	11.6	—	—	—	—	16.4
KOSTOL-NÍK	EGGENBURGIAN	8.2	20.5	24.7	6.9	6.8	—	1.4	—	2.7	—	—	13.7	—	—	—	—	—	—	—	—	—	14.1
VISOLAJE	EGGENBURGIAN	1.2	9.8	19.5	7.7	30.5	—	7.3	1.2	3.7	—	—	6.1	1.6	+	—	—	11.0	—	—	—	—	—
SVEREPEC	EGGENBURGIAN	3.1	16.1	25.3	2.1	20.4	2.0	2.6	4.1	3.1	—	—	8.2	2.0	—	—	+	10.2	—	—	—	—	—
VLASÁČ-KA	KARPATIAN	0.9	3.8	4.3	3.6	25.8	6.9	9.9	0.5	1.9	1.8	—	9.8	0.5	—	—	+	14.4	—	0.8	1.8	—	13.3
PRIETRŽ	KARPATIAN	0.6	0.7	2.7	1.0	4.1	0.5	3.5	0.3	17.5	0.7	—	14.4	—	—	0.4	0.2	4.5	0.6	3.5	—	—	44.8
PUSTA-TINA	KARPATIAN	1.2	1.9	6.1	0.7	26.2	3.9	8.7	—	2.3	0.5	—	1.5	0.5	—	—	+	27.1	—	0.9	1.2	—	17.2

+ mineral present in sporadic grains

features of fluvial and basinal sedimentation (K o v á č, 1985).

Proximal part of alluvial fan has a character of braided river sedimentation with transport of clastic material from the SW, from crystalline complexes, paraautochthone, nappes of the Malé Karpaty Mts. and basement of the present Danube lowlands. Middle and upper part of the conglomerate body has a character of basinal facies deposited due to current from the NW, from the Vienna basin region and partly from the SE, from the region of the northern part of the Danube lowlands. Lateral and vertical distribution of the rock types documents gradual exposure of the source area by erosion (from younger to older rocks). Triassic carbonates from the highest subtatric nappes, i. e. rocks from the close surrounding are prevailing in pebble material. In addition to carbonates, transport from the SW, from more remote sources, is supported also by clastic rocks and basic volcanites of the Malužiná Formation, granites, crystalline schists, Lower Triassic quartzites and dynamometamorphic limestones from the tatric units. Cretaceous and Palaeogene sediments being a component of Jablonica conglomerates pebbles occur nowadays N, NE of the Malé Karpaty Mts. Their source is supposed from the NE, as well as from the SW where they were more spread before erosion in the Lower Miocene (K ö h l e r — B o r z a, 1984). Some, for this region exotic types of rocks, such as quartz porphyries, Norian pelagic limestones, shallow-water Malm and fresh-water Senonian limestones (M i š í k, 1986) were redeposited from the older conglomerates. Deltaic fan of Jablonica conglomerates and sandstones prograded towards the NE. Retreat of coast line to the SW was observed. Sedimentation was affected by synsedimentary activity of the faults (K o v á č, 1985).

Heavy minerals (Tab. 1) from Jablonica conglomerates and sandstones, as well as from "schlier" claystones to which they pass laterally and vertically document change of the source area of clastic material when compared with the Eggenburgian sources. The following less stable minerals prevail in the association: garnet, titanite, staurolite, ilmenite and apatite where enclosures of dark minerals often occur. In addition to the above-mentioned minerals, there are also tourmaline, zircon, spinel, rutile and minerals of pyroxene group, chlorite, epidote, leucoxene and anatase occur sporadically. Representation of heavy minerals, their idiomorphic shape or only poor rounding support a presumption of close primary source of metamorphic rocks from the crystalline complex in the SW part of the Western Carpathians. Such source was represented by the Malé Karpaty Mts. region and the present-day basement of the Danube lowlands.

Karpatian sediments from the SW part of the Western Carpathians overlie discordantly and transgressively the Eggenburgian and Ottnangian sediments and the pre-Neogene basement. In the beginning of the Karpatian, marine sedimentation was concentrated to original, Lower Miocene depressions in the region of flysch nappes, Klippen Belt and on the basement formed by the Northern Limestone Alps and Central Western Carpathians nappes. In the Upper Karpatian, brackish Šaštín sands were deposited with slight angular discordance in the northern part of the Vienna basin, upwards changing into marine facies (J i ř í č e k — T o m e k, 1981). In the southern part of the basin, Karpation transgression started with fresh-water Gänsendorf conglomerates and sandstones (K r ö l l, 1980). They are overlain by fresh-water aderklaa beds passing northwards to brackish Láb ostracode beds. In comparison with the

Eggenburgian, Karpatian depocentres migrated to the south. Synsedimentary activity of the faults is documented by sedimentation rate increase in the northern part of the Danube lowlands and Vienna basin (Fig. 3). Sedimentation is characterized by presence of angular discordances, rapid facial transitions, changes in sediments thickness, presence of fluxoturbidites, slump bodies (Buday — Cicha — Čtyroký, 1959), increase of terrestrial material supply. Marginal conglomerates and sandstones pass vertically and laterally to sands and clays of basinal facies reaching 2000 m in thickness (Buday et al., 1963) (Figs. 15, 16).

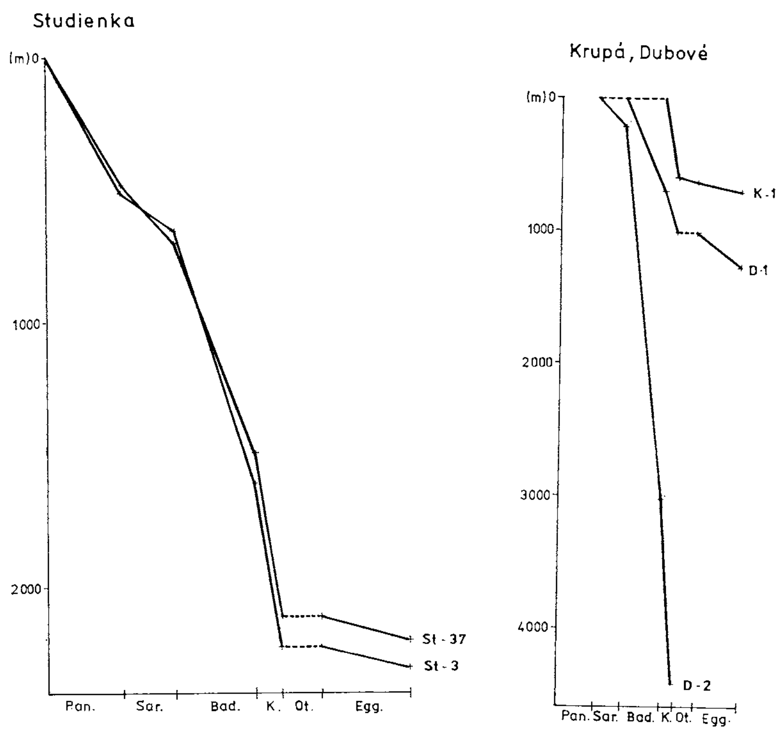


Fig. 3. Subsidence rate in the NE part of the Vienna basin (3 a — Studienka) and in the Danube lowlands (3 b — Krupá, Dubové).

Palaeostresses and tectonic activity

Collision of platform and overthrusting Carpathian—Pannonian system of blocks (Krs — Roth, 1979) generated a distinct palaeostrees field during the Neogene. Direction of main compression can be identified with direction of the Western Carpathian segment movement. Dating of palaeostress field orientation changes in the Neogene and of movement direction in the SW part of the

Western Carpathians was solved by tectonic analysis of five structural levels, namely in rocks of the pre-Neogene basement (Mesozoic, Palaeogene) and Eggenburgian, Karpatian and Badenian sediments. Supposing that stress field had a regional character in the mentioned stages and it was homogeneous in whole analyzed segment, we arrived at the oldest stresses registered only in the oldest rocks by means of the method of gradual elimination of younger stresses established in younger formations. Besides elimination method, in some localities we succeeded in direct determination of probable succession of tectonic movements caused by palaeostress changes.

Real faults were used in tectonic analysis of the region (Fig. 4), whereby data on kinematic characteristics of dislocations and, in ideal cases, also succession and amplitude of movements were taken into consideration. Study of disjunctive structures of lower order (tectonic mirrors and tension gashes) and of minor structural elements (Riedel shears, slicken-side lineations and flower structures) having exactly defined spatial and kinematic relation to the main stresses in which they were generated provided us information on regional stress field (Anderson, 1951). Movement direction along the faults was established on the basis of mirror morphology and relation of displacements to flower structures. Direction of main compression or traces of all three components of the regional stress field were determined by known descriptive methods (Price, 1981; Chernyshev, 1973; Gzovsky, 1975; Wilson, 1985; etc.).

In addition to normal faults, formation of the Lower Miocene basins was controlled by horizontal displacements. We came out from an assumption that tectonic regime of regional faults important for the basin opening was affected by the same stress field as minor structural elements, i.e. their kinematic regime was adapted to the given stress field. This resulted in kinematic fluctuation of inhereted dislocations acting in different stages of development as dislocations of different kinematic type in dependence on stress field change and character (Montenat et al., 1987).

Main compression of N-S direction (Fig. 5) determined by tectonic analysis of minor structural elements in Mesozoic rocks underlying Eggenburgian sediments seems to be the oldest one. It is considered a manifestation of the Savian orogenetic movements. This stress generated and activated regionally significant faults which were opening the Eggenburgian sedimentary basins in the palaeo-Alpine consolidated SW part of the Western Carpathians. They were:

— left-lateral strike-slip faults of ENE - WSW and NE - SW direction,

— normal faults of N - S direction along which blocks subsided and depressions were formed.

Prograding collision of the Eastern Alps and the Western Carpathians with the Bohemian massif caused palaeostress field whose axis of main compression started to turn to the NW - SE. This is closely connected with movement orientation change of the SW part of the Western Carpathian segment. This compression generated or activated regional significant dislocations during the Eggenburgian and Ottnangian:

— left-lateral strike-slip faults of N - S direction along which extensive displacements took place in the Malé Karpaty Mts.; this follows also from geological map, e.g. Limbach, Lošonec, etc. faults,

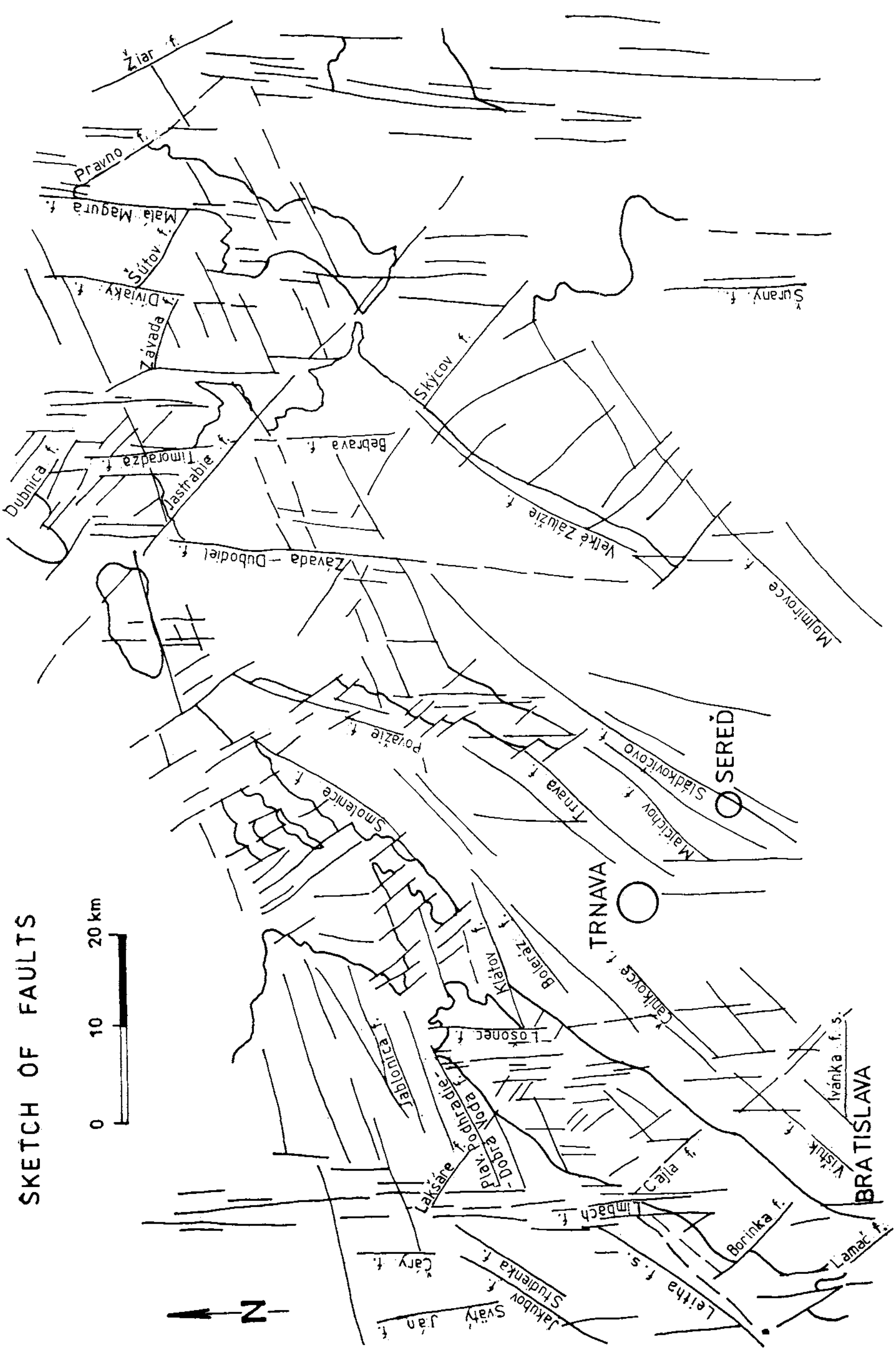


Fig. 4. Network of real faults in the SW part of the Western Carpathians.

— normal faults of NW - SE direction,

— reverse faults of ENE - WSW direction, connected mostly with vergency inward the Carpathians; they were established in the N part of the Malé Karpaty Mts., Čachtické Karpaty Mts., on the N margin of the Strážovské vrchy Mts.,

— right-lateral strike-slip faults of ESE - WNW (or E-W) sporadically occurring in the field.

Styrian orogenetic movements were accompanied with main compression of NW - SE direction (Figs. 6, 7). In this phase mainly left-lateral strike-slip faults on NE - SW direction, opening the Karpatian sedimentary area were activated. N - S compression was registered at the end of the Karpatian and tectonic regime whose culmination was observed in the Lower Badenian started. Regional significant faults took place:

— left-lateral strike-slip faults of NW - SE direction which can be expected also from the present general direction of elongation of the Neogene basins in the western part of the Western Carpathians,

— right-lateral strike-slip faults of NW - SE direction,

— normal faults of N - S direction.

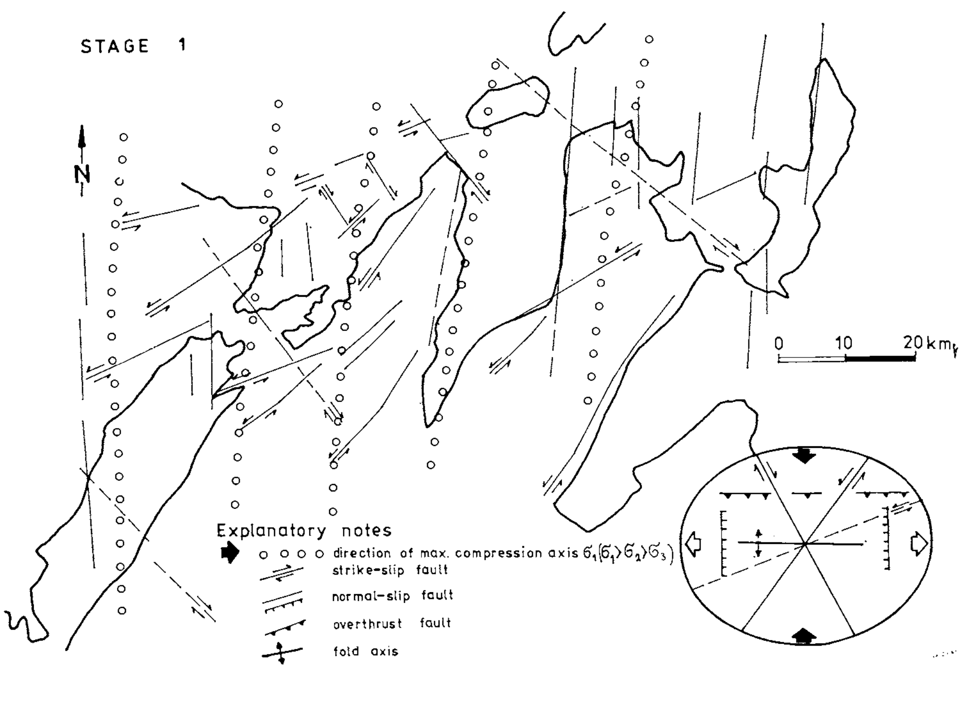


Fig. 5. Stage 1 — dislocations active in the beginning of the Miocene (Savian orogenetic movements).

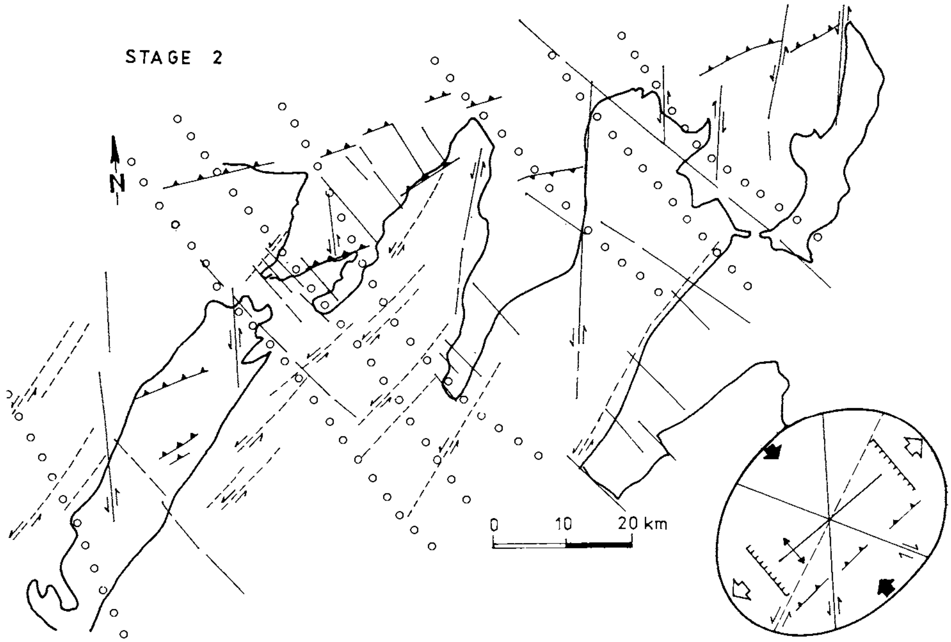


Fig. 6. Stage 2 — dislocations active at the Eggenburgian and Karpatian (Savian and Styrian orogenetic movements).

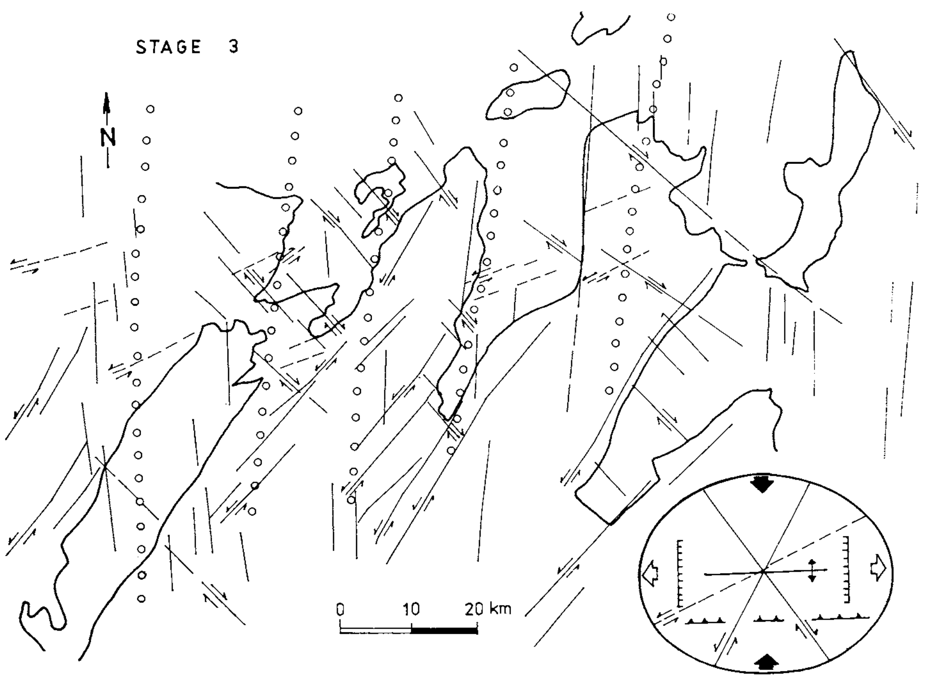


Fig. 7. Stage 3 — dislocations active in the end of the Lower Miocene — beginning of the Middle Miocene (Styrian orogenetic movements).

Palaeomagnetic study

Derivation of palaeodirections in the Lower Miocene sediments was preceded by the tests of palaeomagnetic stability by alternating demagnetizing field, Graham's test and test by use of converging remagnetization circles. The tests proved that the rocks are slightly magnetic, but suitable for palaeomagnetic purposes after cleaning by alternating field up to the value of $200 \cdot 10^3 / 4 \pi$ A/ m (Túnyi — Kováč, 1988).

Main results are presented in Tab. 2 and Fig. 8 where palaeodirections

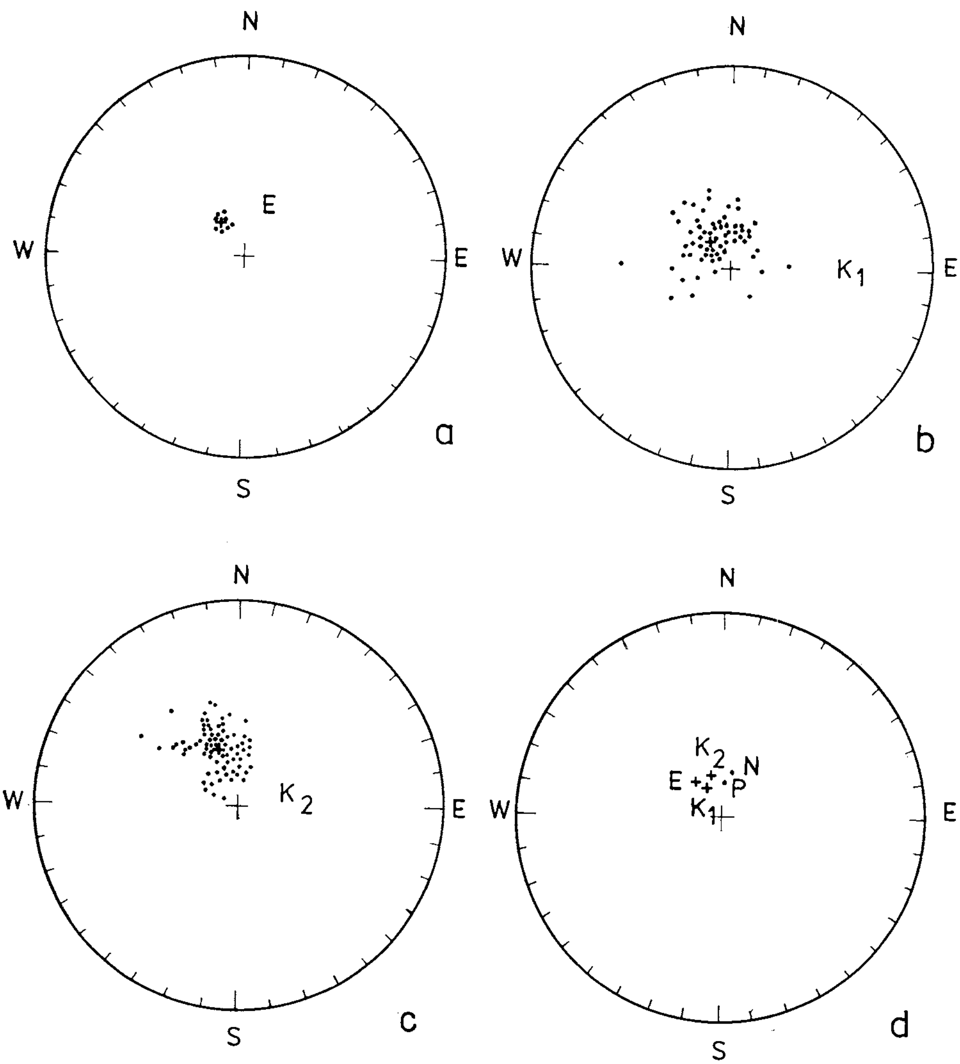


Fig. 8. Main results of palaeomagnetic study (for explanatory notes see the text).

Table 2

Palaeomagnetic directions in the Eggenburgian and Karpatian derived from the sediments in the region of Malé Karpaty Mts. and Brezovské Karpaty Mts.

Locality	φ [°]	α [°]	Stage / age	sign.	n	D_s [°]	I_s [°]	k	α [°]
1 — Hradište pod Vrátnom	17.49 E	48.62 N	Eggenburgian 21—20 MY	E	8	325.79	67.28	576.31	2.31
2 — Dobrá Voda-Vlasáčka	17.51	48.54	Karpatian 18.5—16.8 MY	K_1	63	329.90	71.01	16.04	4.61
3 — Naháč-Dvor Prekážka	17.56	48.58		K_1					
4 — Cerová—Lieskové	17.48	48.63	Karpatian 18.5—16.8 MY	K_2	74	341.24	58.62	25.89	3.30

Explanatory notes: φ, λ — geographic coordinates of the locality, n — number of samples, D_s, I_s — average direction of palaeomagnetic field, k — precision parameter, α — semiangle of reliability cone where average direction with probability of 95 % lies.

of geomagnetic field are derived for the Eggenburgian basal clastics and littoral sands (denoted by index E), Karpatian conglomerates and sandstones (denoted by index K_1) and clays of basinal facies of the Karpatian "schlier" (denoted by index K_2). Obtained results show anti-clockwise deviation of geomagnetic field palaeodirections, i.e. westward to northwestward when compared with statistically established direction for the Neogene on the territory of central Europe (Krs, 1979). (Index N denotes statistically established direction for the Neogene, index P — for the present). Rotation of the Malé Karpaty Mts. block in the period from the Eggenburgian till today expressed in deviations is cca. 43° for the Eggenburgian, 39° for Jablonica conglomerates and sandstones and 37° for Karpatian claystones.

Our results of palaeomagnetic study supporting northwest rotation of the Malé Karpaty Mts. in the period from the Eggenburgian till today correspond well with the results of palaeomagnetic study from the region of the East Slovak and Central Slovak volcanites (Pagáč, 1968; Orlický et al., 1970, 1974), as well as with Balla's study (1987) who summarized data on palaeomagnetic research from the Western Carpathian and Pannonian regions. Established NW rotation enables us to comprehend palaeotectonic regime of the Lower Miocene. Palinspastic reconstruction of sedimentary areas (Fig. 9) comes out from original position of active faults in the Lower Miocene which can be obtained by reverse (clockwise) rotation of their present-day position (e.g. faults nowadays of N - S orientation were obtained in deviations is cca. 43° for the Eggenburgian, 39° for Jablonica conglomerates

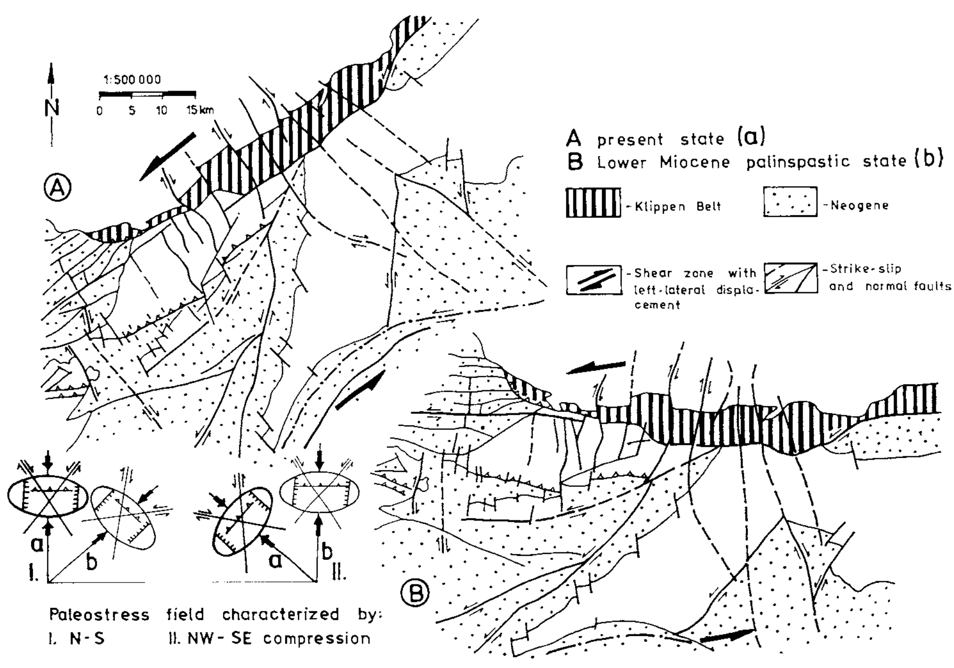


Fig. 9. Palinspastic situation in the Lower Miocene with respect to rotation of the SW part of the Western Carpathians to the NW after the Lower Miocene.

Lower Miocene geodynamics of the SW part of the Western Carpathians

Left-lateral strike-slip zone development in palaeo-Alpine consolidated SW part of the Western Carpathians may be well correlated with development of the outer units (K o v á č et al., 1986).

In the beginning of the Miocene, Oligocene flysch sedimentary area disintegrated in front of the Carpathians. During the Egerian, flysch sedimentation changed to molasse one in the sedimentary area of Waschberg—Ždánice unit (C i c h a — P í c h a, 1964). Uplifted fronts of the Magura Group nappes were source of clastic material, similarly as in the flysch basins of Silesian, Subsilesian and Skola units (here also intrabasin sources were present). Due to N - S compression in the Eggenburgian, Silesian and Subsilesian units were overridden through their foreland. Flysch sedimentation changed to molasse one in the sedimentary area of Skola and Borislav-Pokut units (O s z- c z y p k o — Ś l ą c z k a, 1986).

Transgression of sea in the Eggenburgian (Fig. 10) in the SW part of the Western Carpathians from the foredeep and Waschberg—Ždánice sedimentary

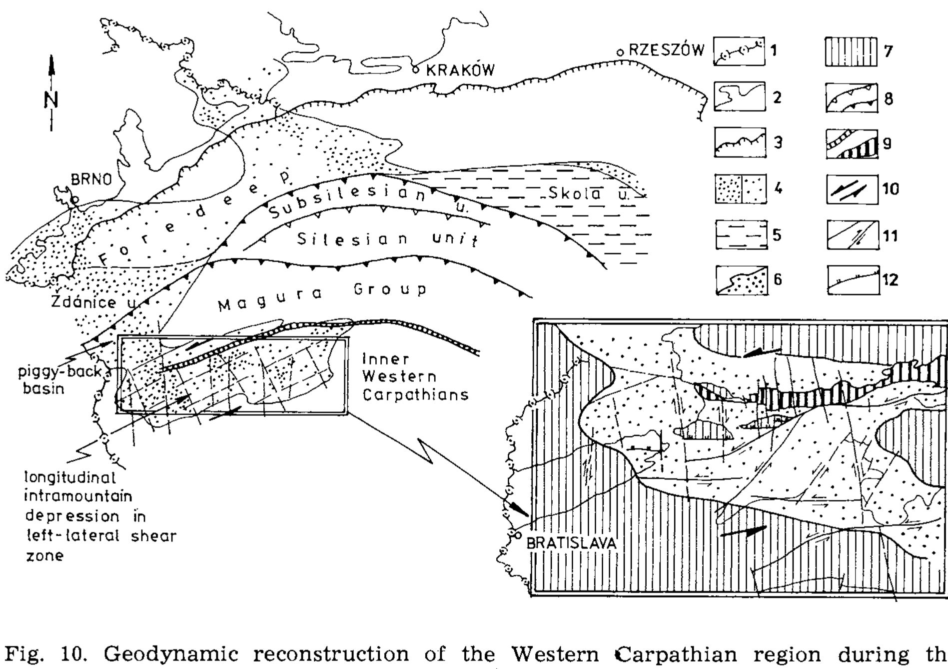


Fig. 10. Geodynamic reconstruction of the Western Carpathian region during the Karpathian.

Explanatory notes: 1 — state border; 2 — Western Carpathian foredeep; 3 — present front of the Western Carpathian nappes; 4 — distribution of the Eggenburgian molasse sediments: a — real, b — presupposed; 5 — distribution of the Eggenburgian flysch sediments; 6 — presupposed Eggenburgian sedimentary area; 7 — presupposed extent of source areas in the SW part of the Western Carpathians in the Eggenburgian; 8 — active nappe fronts; 9 — Klippen Belt; 10 — shear zone, 11 — presupposed activity of faults (normal and strike-slip); 12 — reverse overthrusts.

area extended on the fronts of thrusting nappes of the Magura Group. Lužica and Štefanov depressions of WSW - ENE direction were formed here due to longitudinal (WSW - ENE) and transversal (NW - SE) tectonics (J i ř í č e k — T o m e k, 1981) considered as basins of piggy-back type (O r i — F r i e n d, 1984). Continuation of the sedimentary area on Central-Carpathian basement was represented by longitudinal intramountain basin opened owing to N - S and NW - SE compression. Its shape and development of partial depressions were controlled by zone of left-lateral strike-slip faults of ENE - WSW direction.

In the Ottnangian, Eggenburgian sedimentary areas disintegrated, sea retreated from large part of the foredeep and periklippen region. Continuous sedimentation of Eggenburgian—Ottnangian cycle is known from the western part of the Vienna basin (Lužice Fm.) and Bánovská kotlina basin (B r e s t e n s k á, 1980). In front of the Carpathians, sedimentation took place in the southern part of the foredeep in Moravia and in its eastern part in Poland (Sucha Fm.). Sedimentary area of Stebnic unit continued eastward in the sedimentary area of Sambor-Rozniatov unit (O s z c z y p k o — T o m a ś, 1985). At the end of Ottnangian, Skola unit was separated and overthrust on Borislav—Pokut unit (O s z c z y p k o — Ś l ą c z k a, 1986).

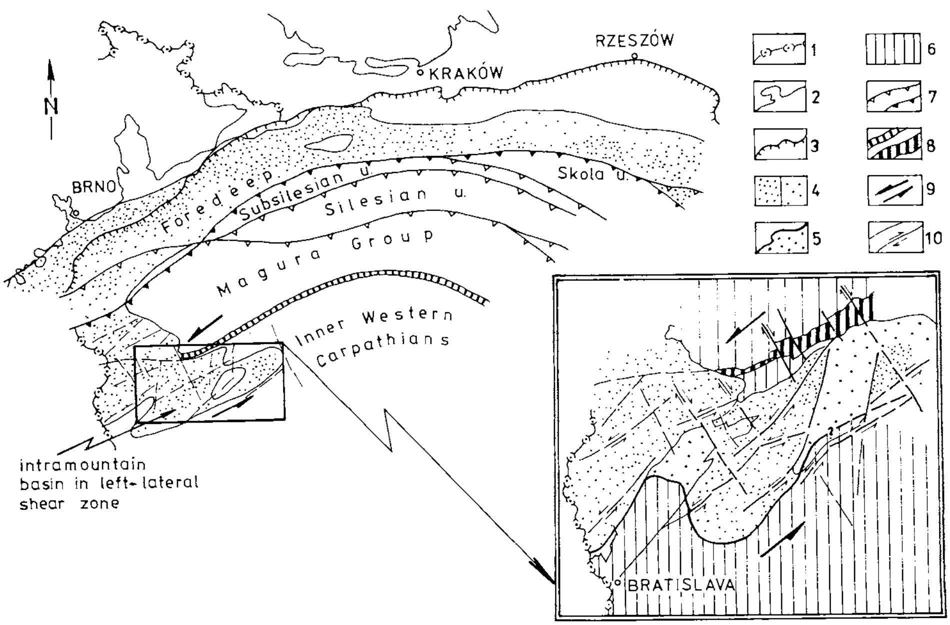


Fig. 11. Geodynamic reconstruction of the Karpatian in the Western Carpathian region.

Explanatory notes: 1 — state border; 2 — Western Carpathian foredeep; 3 — present front of the Western Carpathian nappes; 4 — distribution of the Karpatian molasse sediments: a — real, b — presupposed; 5 — presupposed Karpatian sedimentary area; 6 — presupposed extent of source areas in the SW part of the Western Carpathians in the Karpatian; 7 — active nappe fronts; 8 — Klippen Belt; 9 — shear zone; 10 — presupposed activity of faults during the Karpatian.

In the Karpatian, sedimentary area of the foredeep was spread before the whole front of the Western Carpathians (Fig. 11). Prograding overthrust of the Magura Group nappes caused folding and thrusting of the sediments from Waschberg—Ždánice unit. Advancement of the nappes to the foredeep during the Karpatian is documented by flysch material in conglomerate bodies before the front of nappes in central and northern Moravia (Krystek, 1983) and by olistolites of Zamarov Formation in Poland (Oszczypko — Tomaś, 1985). At the end of Karpatian, Pouzdřany and Waschberg—Ždánice units were overthrust on foredeep in the SW part of the Western Carpathians. In northern Moravia and Poland, Silesian and Subsilesian units were overthrust too and a part of foredeep sediments was folded and created Stebnic unit nappe (Ney et al., 1974).

In the Lower Badenian, overthrusting movements of the Western Carpathian front continued only in northern Moravia and Poland, what can be connected with change of main compression axis orientation from NW - SE to N - S.

Change of main compression from NW - SE to N - S direction is reflected also in development of intramountain basin in the SW part of the palaeo-Alpine consolidated Central Western Carpathians. Extension of the sedimentary area, as well as character of sedimentation in the Karpatian were controlled by left-lateral strike-slip zone of NE - SW direction. In contrast to the Eggenburgian, depocentres migrated to the south, sedimentation rate reached maximum of 7.3—22 cm/100 years (Vass, 1987).

Conclusions

Geodynamic development of the SW part of the Western Carpathians in the Lower Miocene is characterized by:

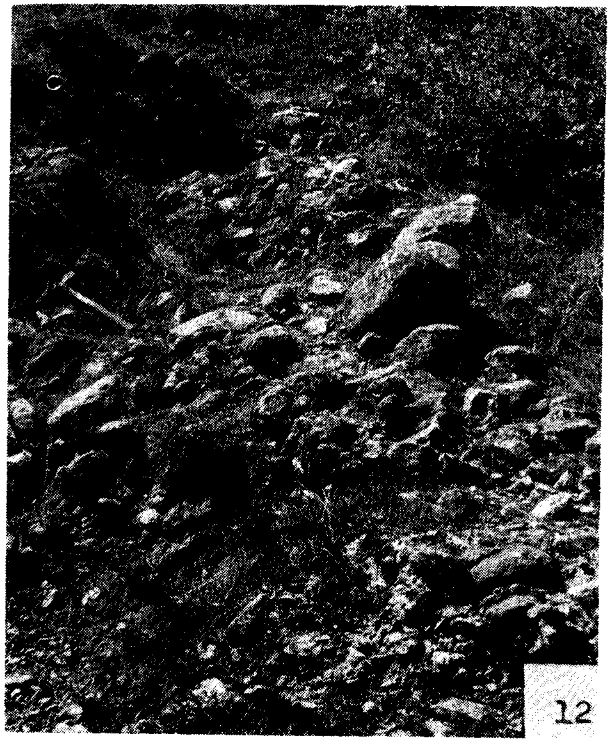
— disintegration of flysch sedimentary areas, change of flysch sedimentation to molasse one,

— formation of foredeep and basins of piggy-back type on fronts of overthrusting nappes,

— folding and thrusting of nappes of the Outer Western Carpathians,

— formation of left-lateral strike-slip zone in palaeo-Alpine consolidated part of the Central Western Carpathians.

Shear zone was formed in palaeostress field between the Eastern Alps and Western Carpathians segments caused by subsequent overthrust of the Western Carpathian segment to the N, NE. Change of palaeostress direction is connected with partial movements of the Western Carpathians and completion of the mountain chain arc formation. Periods of culmination of tectonic activity and changes in development of intramountain basin in the shear zone coincide with development of sedimentary areas, folding and thrusting of the nappes in front of the Carpathians. Last overthrusting movements of the nappes on the foredeep in the SW part of the Western Carpathians in the end of the Karpatian are identical with main period of palaeomagnetically established rotation of the Malé Karpaty Mts. to the NW. Reconstruction of geodynamic development of the Lower Miocene sedimentary area in the Western Carpathians, as well as results of several authors dealing with the study of basins formed in shear zones of collision areas, such as the Gulf



Figs. 12, 13. Character of sedimentation in the region of Vaďovce depression (Myjavská pahorkatina Mts.). Basal conglomerate with boulders and cobbles; proximal part of the fan, loc. Horné Jazero/Vaďovce).

Fig. 14. Character of sedimentation in the region of Vaďovce depression (Myjavská pahorkatina Mts.). Alternation of sandstones and conglomerates; proximal to central part of the fan, loc. Luskovica (direction of clastic material transport from the NE, i.e. from Vaďovce to Luskovica).

Fig. 15. Character of sedimentation in the region of Vaďovce depression (Myjavská pahorkatina Mts.). Laminated sandstones with diagonal bedding; central part of the fan, loc. Piesky.

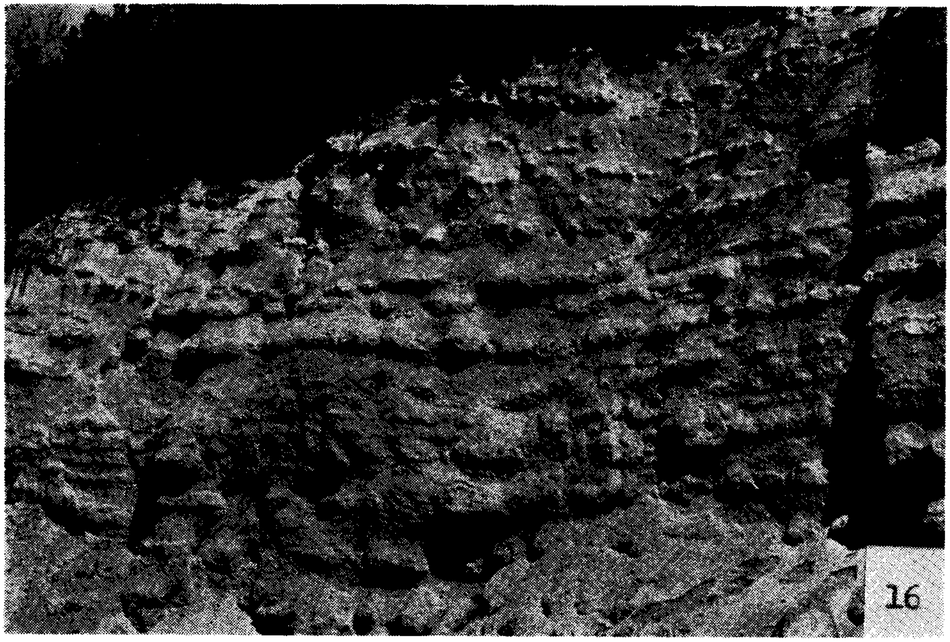
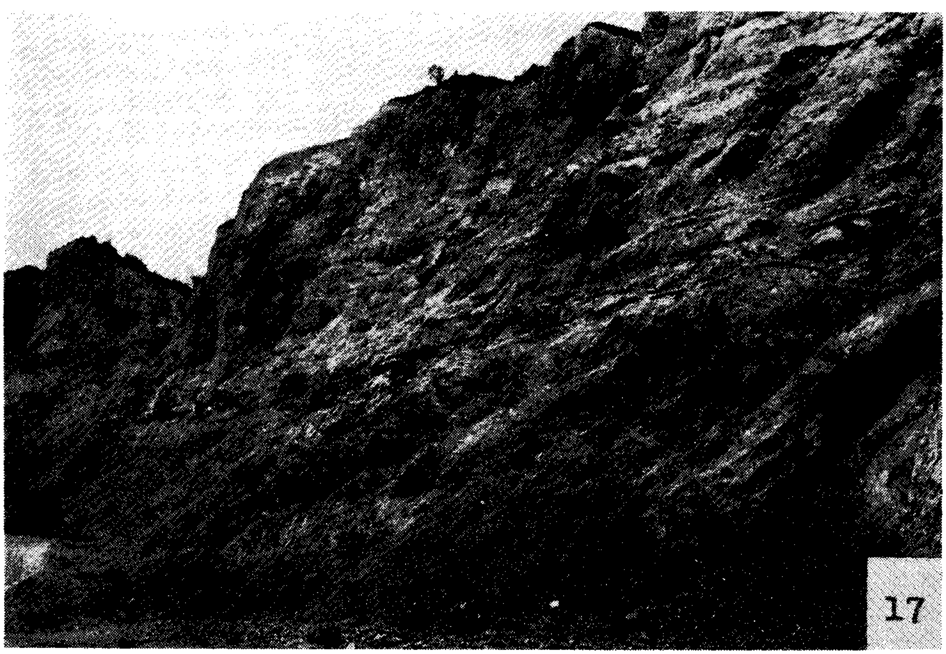
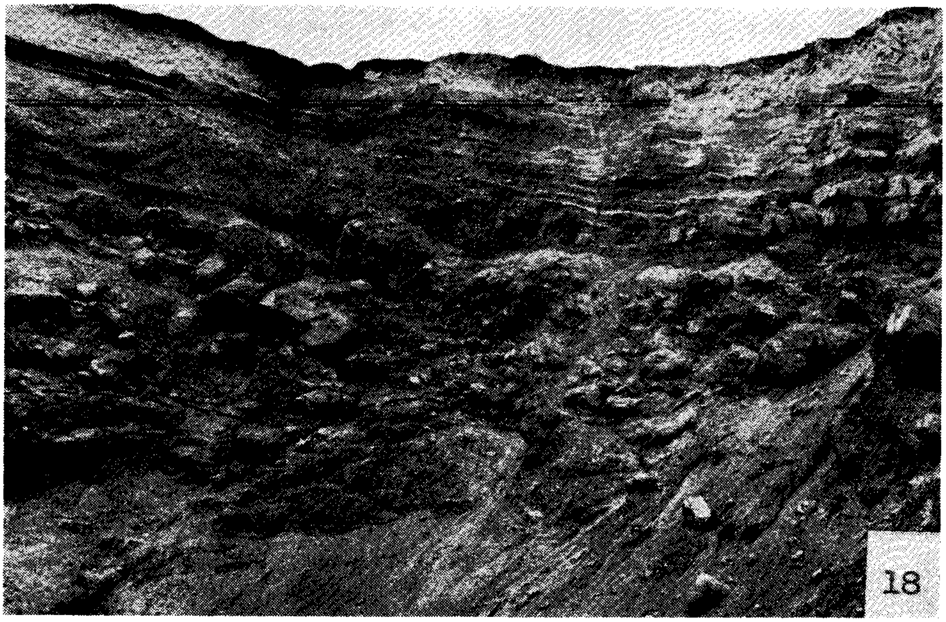
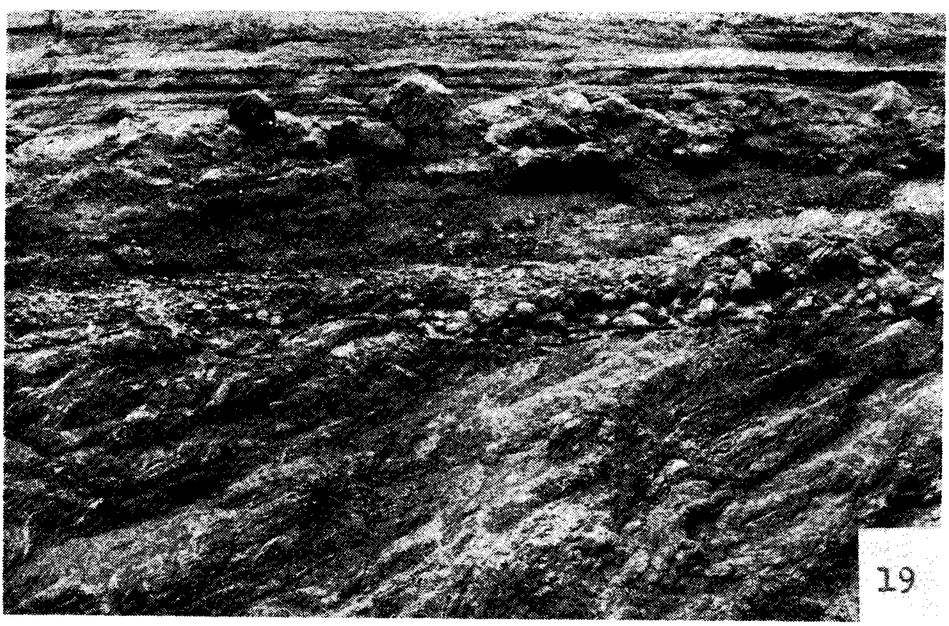


Fig. 16. Character of sedimentation in the region of Vaďovce depression (Myjavská pahorkatina Mts.). Massive to heavy-bedded sandstones; central part of the fan, loc. Krajné.







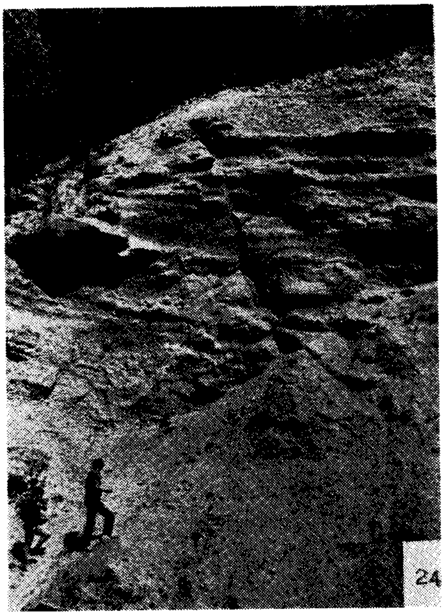
Figs. 17, 18, 19. Transgression of the Eggenburgian in the NE part of the Vienna basin, loc. Hradište pod Vrátnom. Dashed line indicates transgression area where the Eggenburgian sediments overlie the Upper Triassic dolomites of the highest subtatric nappes (Jablonica nappe) with angular discordance.

Fig. 20. Character of sedimentation during the Eggenburgian. (Brezovské Karpaty Mts.). Conglomerates forming the filling of erosion channel in sandstones, loc. Dobrá Voda.

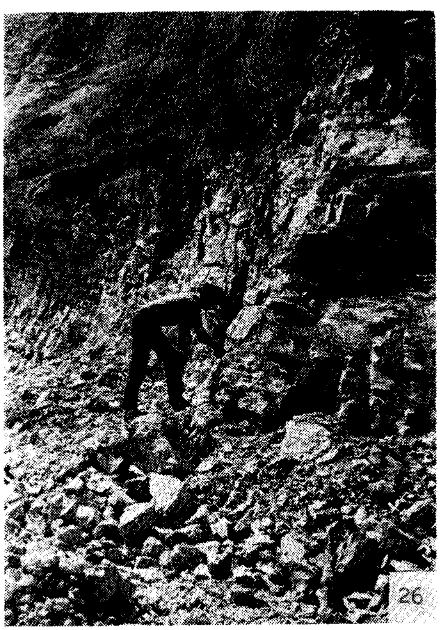
Fig. 21. Character of sedimentation during the Eggenburgian (Brezovské Karpaty Mts.). Diagonal and cross bedding of sandstones, loc. Dobrá Voda.

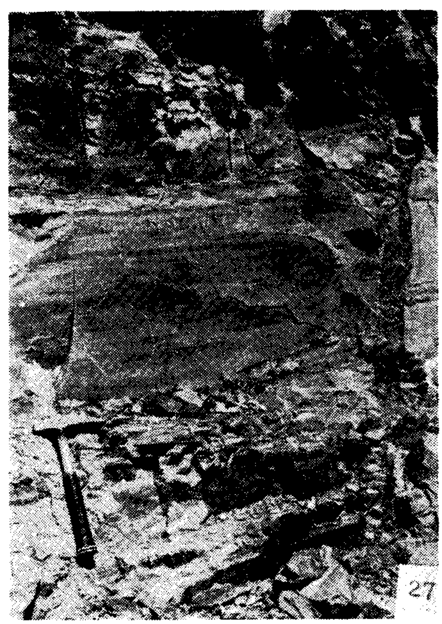
Fig. 22. Character of sedimentation during the Eggenburgian (Brezovské Karpaty Mts.). Ripple bedding of sandstones, loc. Dobrá Voda.

Fig. 23. Character of sedimentation during the Eggenburgian (Brezovské Karpaty Mts.). Diagonal bedding of conglomerates, loc. Štverník.



Figs. 24, 25. Character of sedimentation during the Karpatian. Alternation of Jablonica conglomerates and sandstones; central part of deltaic-alluvial fan, loc. Naháč (Malé Karpaty Mts.).





Figs. 26, 27. Character of sedimentation during the Karpatian. "Schlier" clays of basinal facies, loc. Cerová-Lieskové (NE part of the Vienna basin).

of California, transform zone between Saone and the Rhine graben, shear zone in SE Spain, etc. (Angelier — Bergerat, 1983; Biddle — Christie-Blick, 1985; Montenat et al., 1987) enable to characterize their tectonic regime and sedimentation in more detail.

Translated by O. Mišániová

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