GEOLOGICKÝ ZBORNÍK — GEOLOGICA CARPATHICA, 37, 2, BRATISLAVA, APRIL 1986, Pp. 225—243

MARIAN PUTIŠ*

CATACLASTIC METAMORPHISM OF METAPELITIC AND METABASIC ROCKS IN THE MALÉ KARPATY MTS.

(Figs. 4, Tabs. 10)

Abstract: Under the influence of mostly subhorizontal movements in the crystalline complexes, several horizons of cataclastic metamorphic rocks, of protomylonite, schistose mylonite, mylonite breccia and blastomylonite (with chlorite and sericite) character, originated from the primary metapelitic and metabasic rocks, which had been the products of Hercynian regional-periplutonic and contact metamorphism.

Резюме: Под влиянием альпийских, прежде всего субгоризонтальных, движений в кристаллиникуме возникло несколько горизонтов катакластически метаморфизованных пород характера протомилонитов, сланцеватых милонитов, милонитовых брекчий и бластомилонитов (с хлоритом и серицитом) из исходных метапелитических и метабазических пород, которые были продуктами герцинского регионально-периплутонического и контактового метаморфизма.

Introduction

Alpine cataclastic metamorphism of the granitoid rocks of the Malé Karpaty Mts. is characterised in the works of Cambel (1956) and Cambel — Valach (1956). As a result of more recent geological investigations of the author in the years 1982—1984 (basic geological mapping of the crystalline complexes in the scale 1 : 10 000; lithological and structural analysis; microscopical petrography — Putiš, in press), thin (mostly 0.5—3 m) discontinuous horizons of cataclastically metamorphosed metapelitic and metabasic rocks have been discovered in the region north of Podbaba valley, east of Pernek and in the region of the valleys Vývrať, Modra creek and Švancpošská, east of Kuchyňa.

At the same time, similar clastic rocks in the same geological position have been discovered also amid the metapelites south of Podbaba valley (B. Klukan, in press); these are presumed nevertheless to be of sedimentary origin, however, this author does not consider their origin to be explained satisfactorily.

Geological situation

On geological maps (Figs. 1—3) and schematic litological profiles of the field (Fig. 4) is presented the geological position of cataclastically metamorphosed metapelitic and accompanying metabasic rocks. In all cases they are the same rock types, with predominant tectonic breccias and blastomylonites. The texture forms are reflection of lithology changes, differences in the basic mineral

* RNDr. M. Putiš, CSc., Department of Petrography of the Faculty of Natural Sciences of the Comenius University, Mlynská dolina, Bratislava.

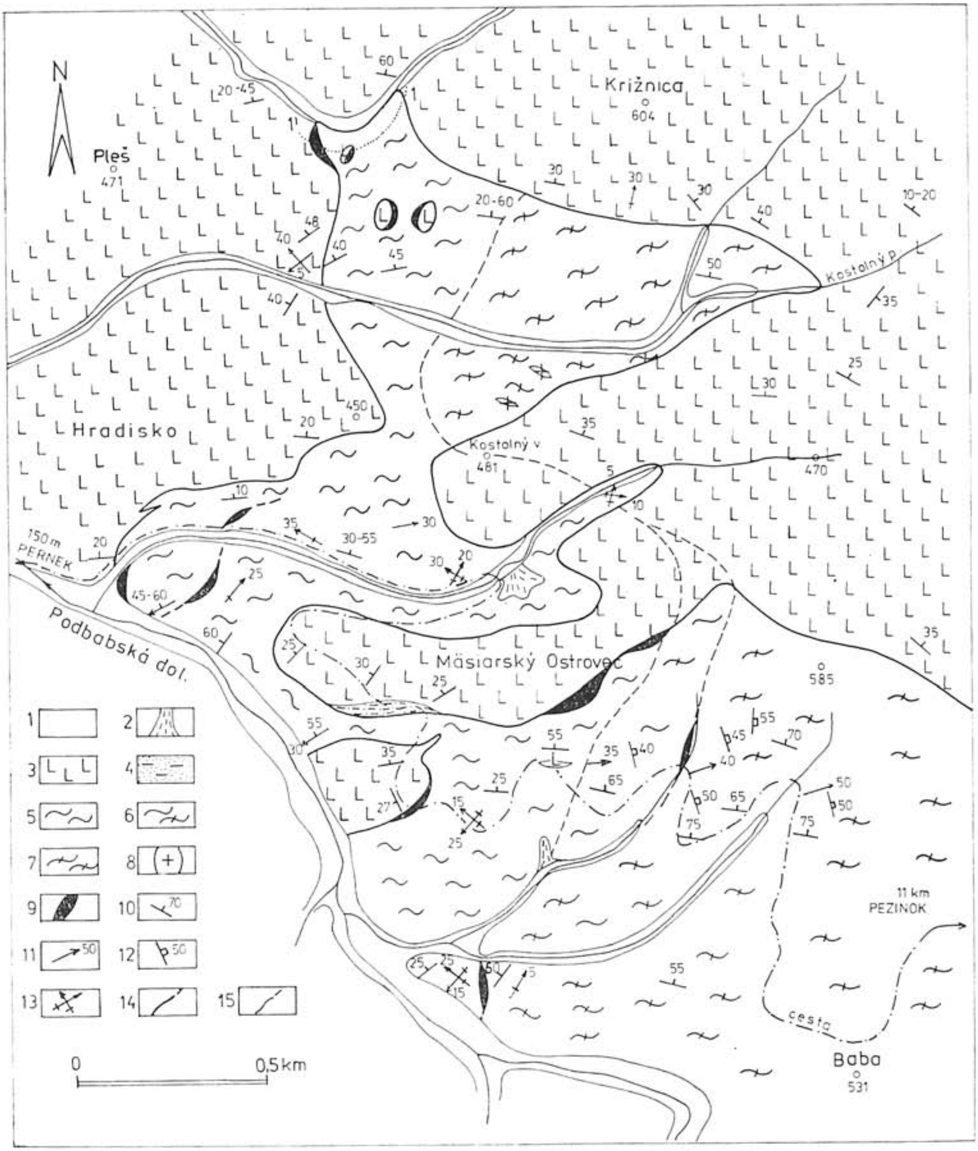


Fig. 1. Geological map of crystalline complexes east of Pernek.

Explanations: 1 — Quarternary, alluvium; 2 — Quarternary, dejection cone; 3 — metabasic rocks (metadiabases) and their metatuffs; 4 — graphite quartzites; 5 — biotite phyllites (± chlorite, garnet); 6 — biotite-garnet schist-gneisses; 7 — biotite-garnet paragneisses (± staurolite, andaluzite, sillimanite); 8 — aplite-pegmatite granite; 9 — cataclastically metamorphosed metapelites of blastomylonite character (thickness mostly 0.5–3 m), with accompanying schistose mylonites, brecciated mylonites and protomylonites of varying thickness (several metres); 10 — Hercynian metamorphic foliation; 11 — Hercynian metamorphic lineation; 12 — Alpine fold cleavage; 13 — B-axes of "kink folds" (kink bands); 14 — tectonic contact; 15 — geological boundaries.

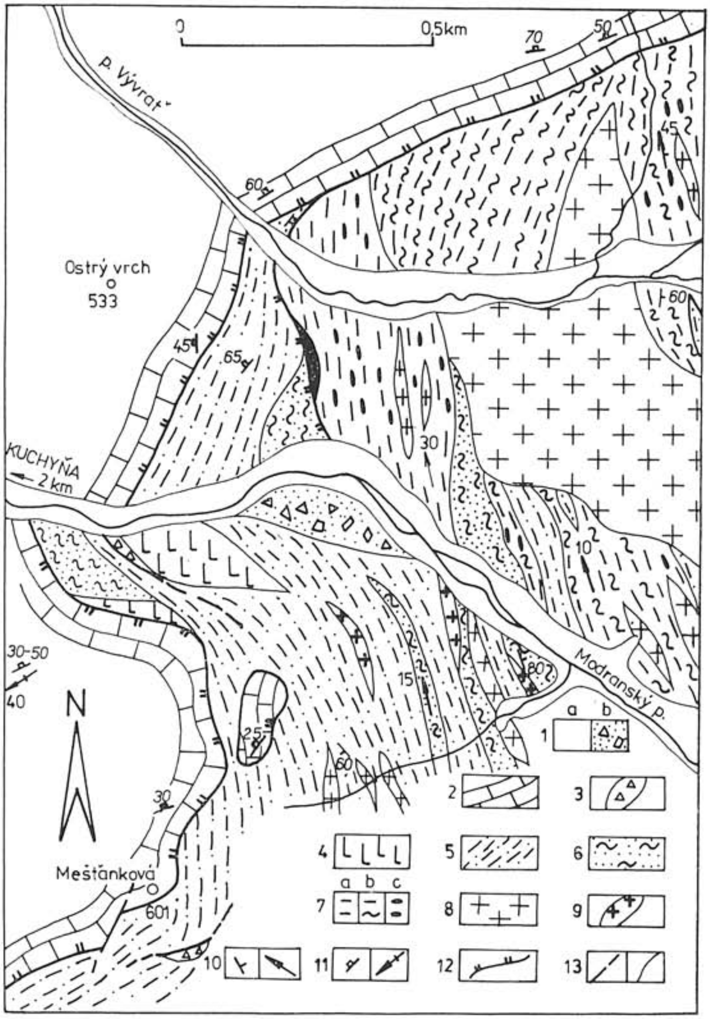


Fig. 2. Geological map of crystalline complexes east of Kuchyňa.
Explanations: 1 — Quarternary a - alluvium, b - delluvium; 2 — Mesozoic; 3 — breccias (sedimentary) from metabasic rocks and their metatuffs, cemented by carbonate matrix (J_1?); 4 — metabasic rocks and their metatuffs; 5 — graphite metaquartzites; 6 — muscovite-biotite metaquartzites with graphite and ore pigment; 7 — a - chlorite-biotite phyllites, b - laminated (mostly fine-grained to very fine-grained quartzitic) biotite phyllites to schist-gneisses, c - spotted and nodular phyllites to schist-gneisses (with cordierite); 8 — a - biotite granodiorite (Modra type), b - hornblende-biotite quartz-diorite; 9 — aplite; 10 — Hercynian a - metamorphic foliation, b - metamorphic lineation; 11 — a - bedding and oblique (to bedding) cleavage in Mesozoic rocks, Alpine cleavage in crystalline complexes, b - B axes of Alpine meso-folds; 12 — thrust planes; 13 — a - tectonic contact, b - geological boundaries, (tectonic breccias — as Figs. 1, 9).

composition of the primary metamorphic rocks as well as of the intensity of the tectonic effects.

The blastomylonites and tectonic breccias form the most distincitive horizon on the contact of the biotite — garnet phyllite, schist-gneisses and paragneisses

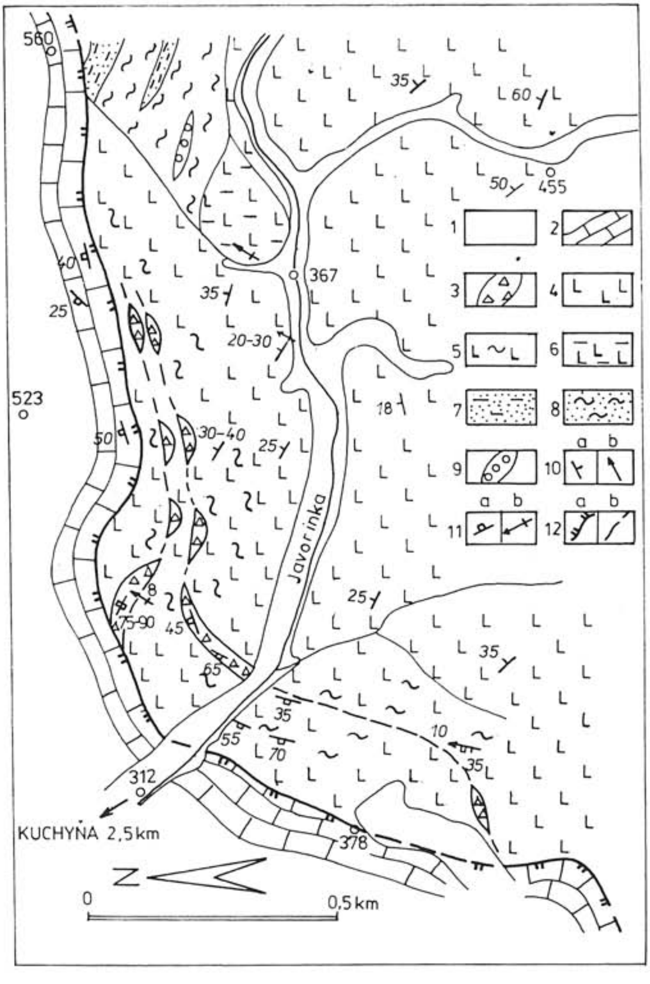


Fig. 3. Geological map of crystalline complexes SE of Kuchyňa.
Explanations: 1 — Quarternary, alluvium; 2 — Mesozoic; 3 — breccias (sedimentary) from metabasic rocks and their metatuffs cemented by carbonate matrix (J_1?); 4 — metabasic rocks and their metatuffs; 5 — mylonitised to phyllonitised metabasic rocks and their metatuffs; 6 — chlorite-calcite metatuffs; 7 — graphite metaquartzites; 8 — muscovite-biotite metaquartzites with graphite and ore pigment; 9 — intraformational conglomerates; 10 — Hercynian a - metamorphic foliation, b - metamorphic lineation; 11 — a - bedding and oblique (to bedding) cleavage in Mesozoic rocks, Alpine cleavage in crystalline, b - B-axes of Alpine meso-folds; 12 — a - thrust planes, b - geological boundaries.

complex with the overlying complex of metabasic rocks, their metatuffs and graphite metaquartzites. The second (deeper), comparatively distinctive horizon are the blastomylonites and tectonic breccias (pseudoconglomerates) on the contanct of phyllites with schist-gneises and paragneisses. Eventually, blastomylonites and tectonics breccias occur, even if only in limited quantities, amid phyllites, schist-gneisses and paragneisses (Fig. 1).

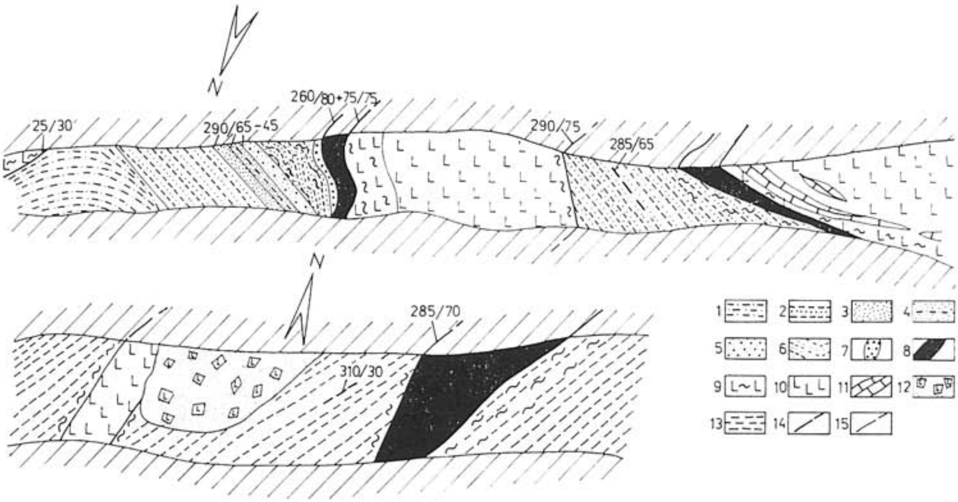


Fig. 4. Lithological profiles (1—1'; another one 50 m to the south) of crystalline complexes NE of Pernek (Fig. 1).
Explanations: 1 — biotite phyllites to schist-gneisses; 2 — layered (quartz and biotite) phyllites (thickness in the profile approx. 4 m); 3 — light-coloured metaquartzites (0.5 m); 4 — quartzitic phyllites with sporadic biotite lamines (0.2 m); 5 — dark metaquartzites (0.4 m); 6 — mylonitised phyllites, folded in detail, with broken quartz layers (1 m); 7 — vein of secretion quartz (0.2 m); 8 — blastomylonites ($\pm$ schistose mylonites) of phyllites (0.6 m in the profile 1—1', in the next profile 2.5 m); 9 — mylonites of metabasic rocks and their metatuffs (1.5 m); 10 — metabasic rocks and their metatuffs (10 m); 11 — calcite-quartz vein with siderite (metasomatic rim of the vein border in the contact with metatuffs), chalcopyrite and pyrite; 12 — delluvium with metabasic rock fragments; 13 — biotite phyllites to schist-gneisses (as a unit); the values e. g. a - 290/65-45, b - 290/75, c - 25/30, signify the direction of dip/dip of a - metamorphic foliation of phyllites, b - mesodislocations, c - contact planes of phyllites (schist-gneisses, paragneisses) with the overlying complex of metabasic rocks and their metatuffs.

From the above mentioned data it follows that a major part of the cataclastically metamorphosed rocks is bound to inhomogenity planes between complexes of different mechanical properties, which were later, during the Alpine orogeny, tectonically emphasised, mostly by subhorizontal movents in crystalline complexes.

Petrography of the cataclastic rocks

By a study of the primary metapelites and the tectonically derived rocks in profiles a succession of texture as well as structure types of intermediate rocks has been discovered.

The lowest grade of cataclastic metamorphism is represented by protomylonites (sensu Higgins, 1971) with brecciated structure, in which the cataclasis is limited to irregular fissure systems in the metapelites (Tab. I — Figs. 1, 2; Tab. III — Figs. 1, 2; Tab. IV — Figs. 1, 2) and metabasic rocks (Tab. III — Fig. 4; Tab. VI — Fig. 4), while the character of the primary rock is well preserved in the individual segments.

With increasing intensity of differential movements in quartzite types metapelites, brecciated structure comes into being where the proportion of porphyroclasts is lower than of crushed matrix (Tab. III — Figs. 1—3).

For the more plastic members of the metapelites, dynamofluidal structure is characteristic (Tab. II); here the crushed matrix dominates over the elongated, flattened lenticular porphyroclasts of the original rock. The boundary-line between porphyroclasts and the crushed matrix is often not sharp (Tabs. V, VII). Such rocks are distinguished by banded structure (Tab. I — Figs. 3, 4; Tab. IV — Figs. 3, 4; Tab. V — Figs. 1—3) with interchanging bands of different cataclasis intensity. Above this, the more rigid (more competent) bands are segmented and transported (shifted) along several systems of fold and shear cleavage into more plastic (non-competent) bands (Tab. I — Fig. 4; Tab. II — Figs. 3—4; Tab. V); like this, even pseudo-conglomerate structure is formed, so that these rocks macroscopically resemble (as well as in some micro-domains) very much sedimentary conglomerates (Tab. VI — Figs. 1—3; Tab. VIII — Figs. 2, 3).

Predominant in the cataclastically metamorphosed metabasic rocks is brecciated structure (Tab. III — Fig. 4; Tab. VI — Fig. 4; Tab. VIII — Fig. 4).

The texture of the (crushed) matrix of the tectonic breccias is clastic, of cataclastic origin. The texture of megaporphyroclasts, i. e. segments of well-preserved original rock in protomylonites (without a more significant mutual rotation of segments) is mostly granolepidoblastic (Tab. IV — Fig. 1; Tab. I — Figs. 1, 2). In porphyroclasts of schistose mylonites mortar texture dominates (Tab. VII, Tab. VIII — Fig. 1) over the original granoblastic and granolepidoblastic texture. In blastomylonites, the relicts of original textures are almost destroyed and besides mortar texture, neoblastic texture is also present in significant proportion (Tabs. VII, VIII).

The mineral composition of megaporphyroclasts (i. e. individual rock fragments rotated on the cataclastic foliation planes and rounded to different grades by tectonic transport) corresponds with biotite and garnet-chlorite-biotite phyllites, schist-gneisses to garnet-biotite paragneisses. In the area east of Pernek, transversal biotite$_2$ in association with garnet and porphyroblastic chlorite$_2$ — which are the products of periplutonic metamorphism under the influence of Bratislava granite intrusion (Кориковский — Цамбел et al., 1984) — takes also part in their mineral composition. In the region east of Kuchyňa (Fig. 2), the megaporphyroclasts have the character of laminated (mostly quartzitic) biotite phyllites to schist-gneisses, frequently they are of spotted to nodular schist character (on the contacts of vein bodies of Modra granodio-

Table I

Fig. 1 — Protomylonite (kakirite) of biotite phyllite, loc. SW of Krížnica; reduced to 1/3 of the original size (author of photography of all Figs. on Tabs. I—III L. Osvald, Tabs. IV—X M. Putiš); Fig. 2 — as Fig. 1, another view; Fig. 3 — schistose mylonite of schist-gneiss, loc. Mäsiarsky Ostrovec, reduced to 2/3; Fig. 4 — blastomylonite of biotite phyllite, loc. SW of Krížnica, reduced to 1/2.

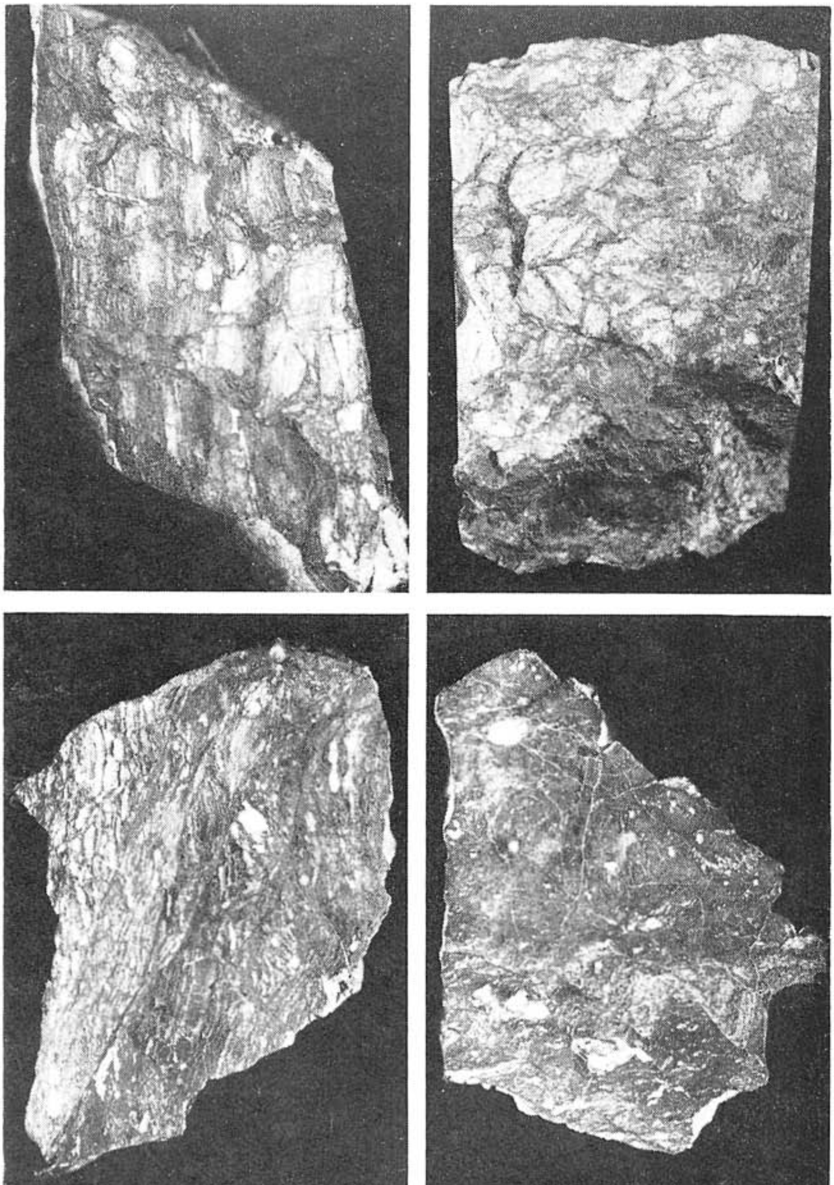


Table II

Fig. 1 — Schistose mylonite of paragneiss, loc. Podbaba valley, real size; Fig. 2 — blastomylonite of paragneiss, loc. Podbaba valley, real size; Fig. 3 — blastomylonite of schist-gneiss, loc. Mäsiarsky Ostrovec, reduced to 1/2; Fig. 4 — blastomylonite of phyllite, loc. SW of Krížnica, reduced to 1/2.

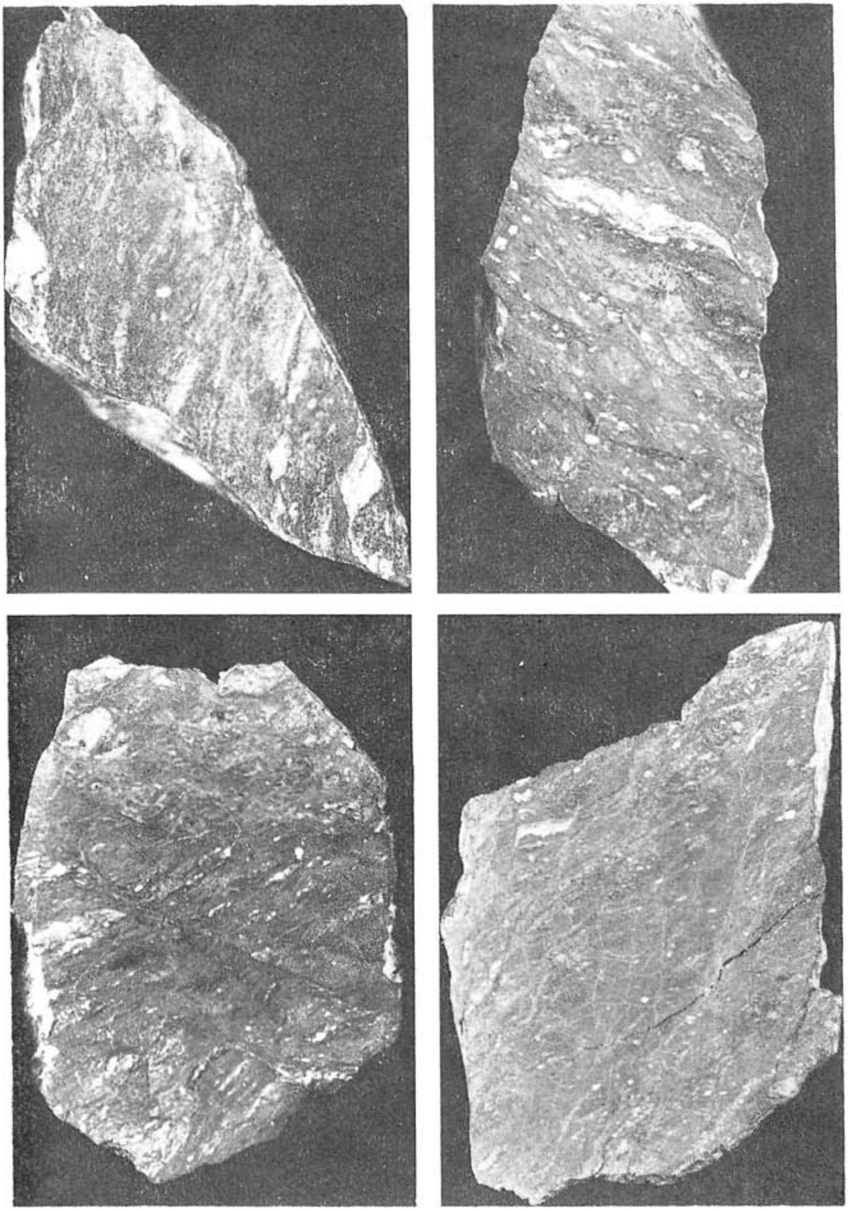
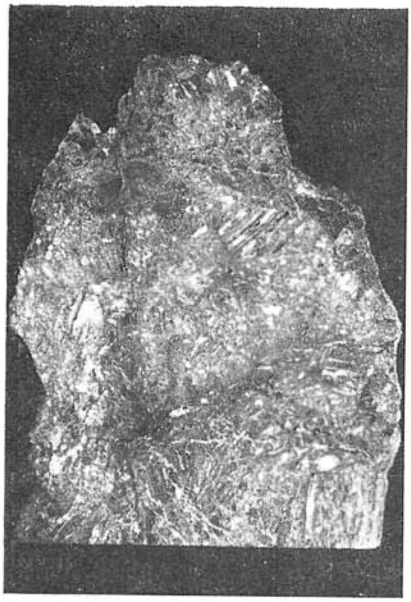
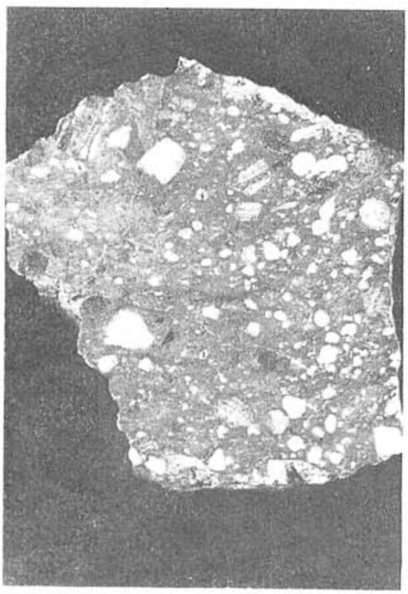


Table III

Fig. 1 —Brecciated mylonite with a predominance of megaporphyroclasts of quartzitic laminated biotite phyllites over crushed matrix, loc. SE of Ostrý hill, reduced to 2/3; Fig. 2 — as Fig. 1 — another view; Fig. 3 — brecciated mylonite with a predominance of fine-grained crushed matrix over megaporphyroclasts of layered quartzitic biotite phyllite, loc. Mäsiarsky Ostrovec, reduced to 2/3; Fig. 4 — brecciated mylonite of metabasalt, loc. SW of Mäsiarsky Ostrovec, real size.





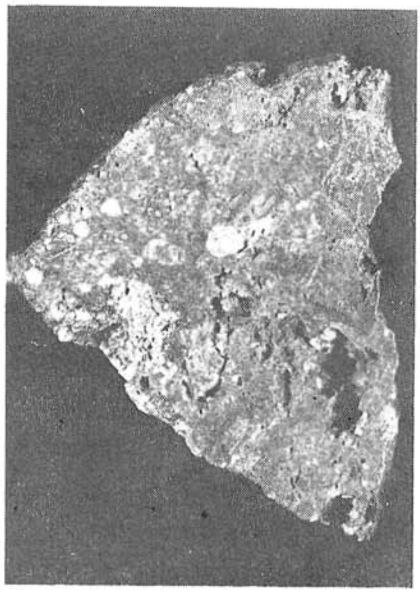


Table IV

Figs. 1—4 — Gradual evolution of cataclastic foliation planes through several systems of slip and shear cleavage, loc. Podbaba valley, // nicols, 20 ×.

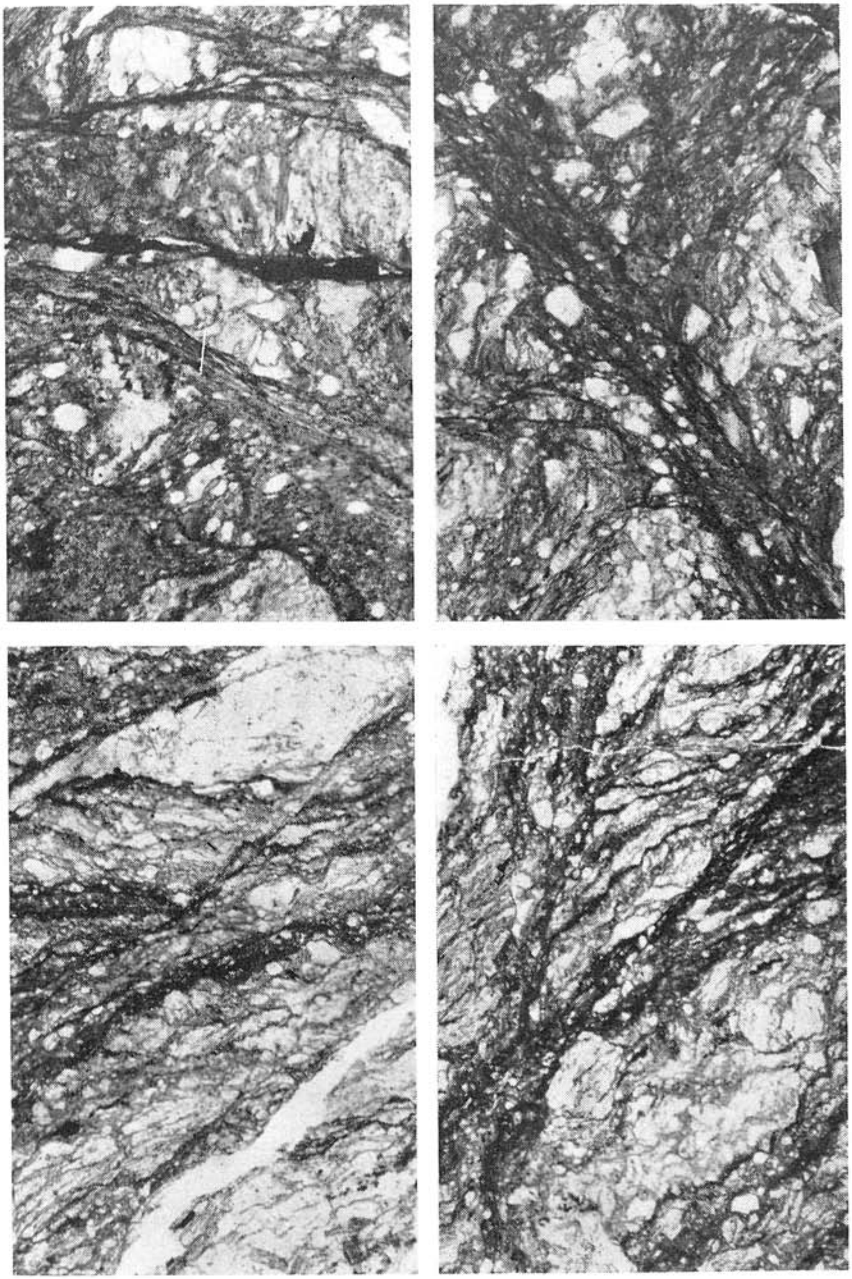


Table V

Figs. 1—4 — Cataclastic texture in schistose mylonite of biotite phyllite with interchanging bands of weaker and stronger cataclasis (cataclastic foliation), loc. E of Pernek, in a road-cut on Baba, // N, 20 ×.

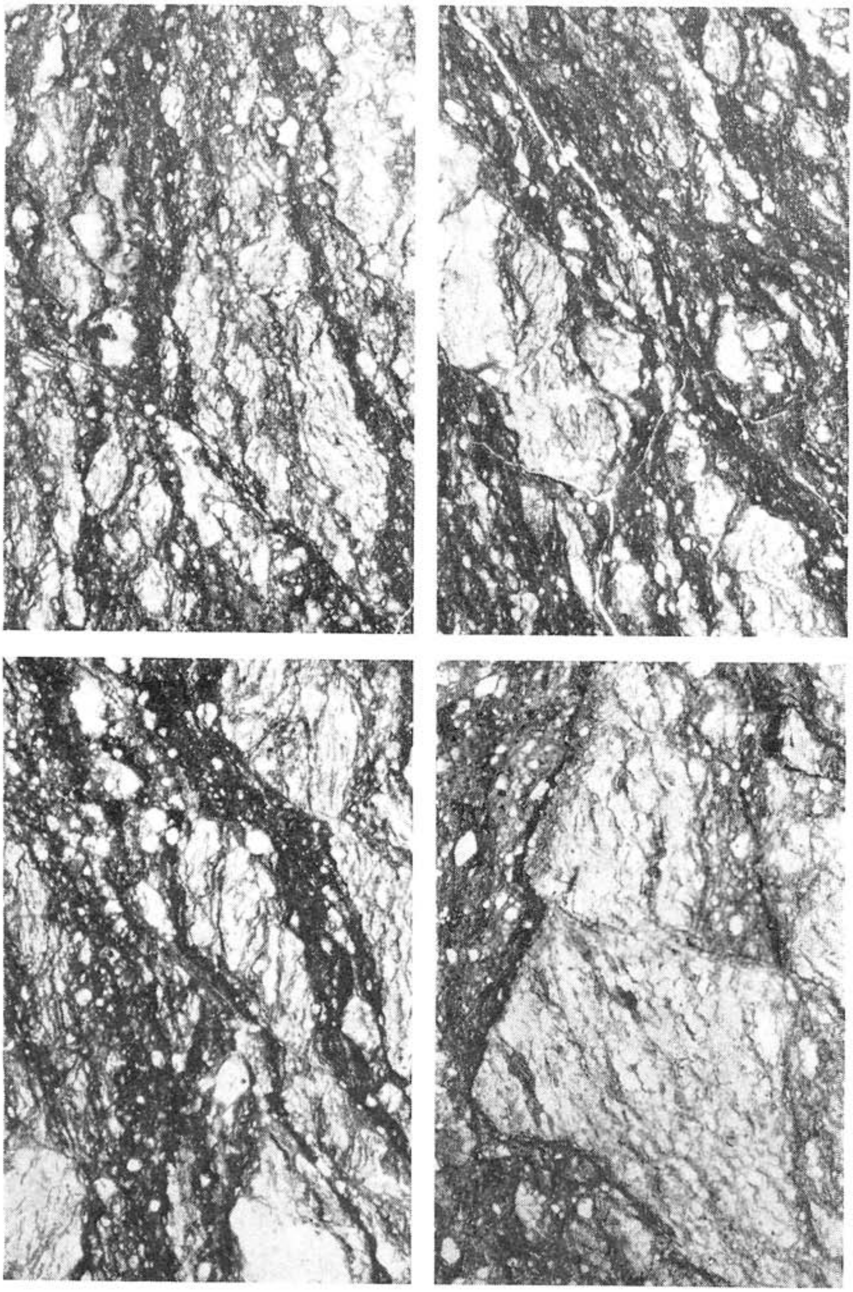
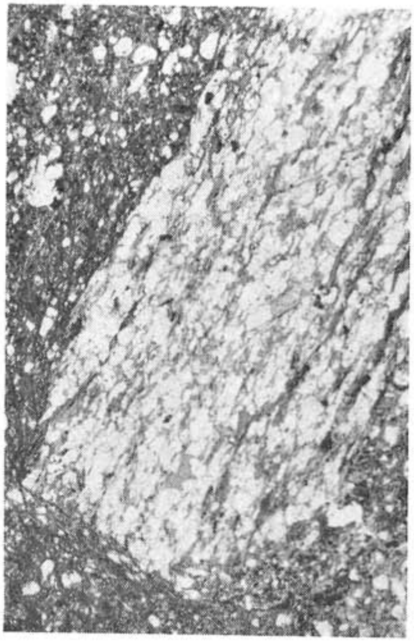
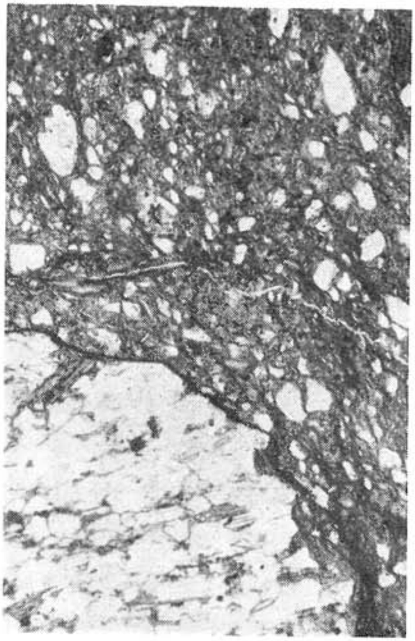


Table VI

Figs. 1—3 — Pseudoconglomerate texture in blastomylonite of biotite phyllite, loc. SW of Krížnica, // N, Figs. 1 and 3 - 20 ×, Fig. 2 - 40 ×;
Fig. 4 — cataclastic texture in metabasalt, loc. SW of Krížnica, // N, 20 ×.





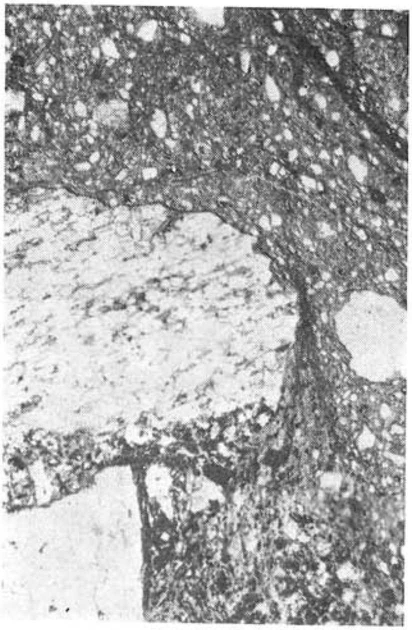


Table VII

Figs. 1, 2 — Cataclastic (mortar) texture in protomylonite of biotite phyllite, loc. SW of Krížnica, X N Fig. 1 - 20 ×, Fig. 2 - 40 ×;
Figs. 3, 4 — cataclastic (mortar) texture in schistose mylonite of biotite phyllite, loc. SW of Krížnica, X N, 20 ×.

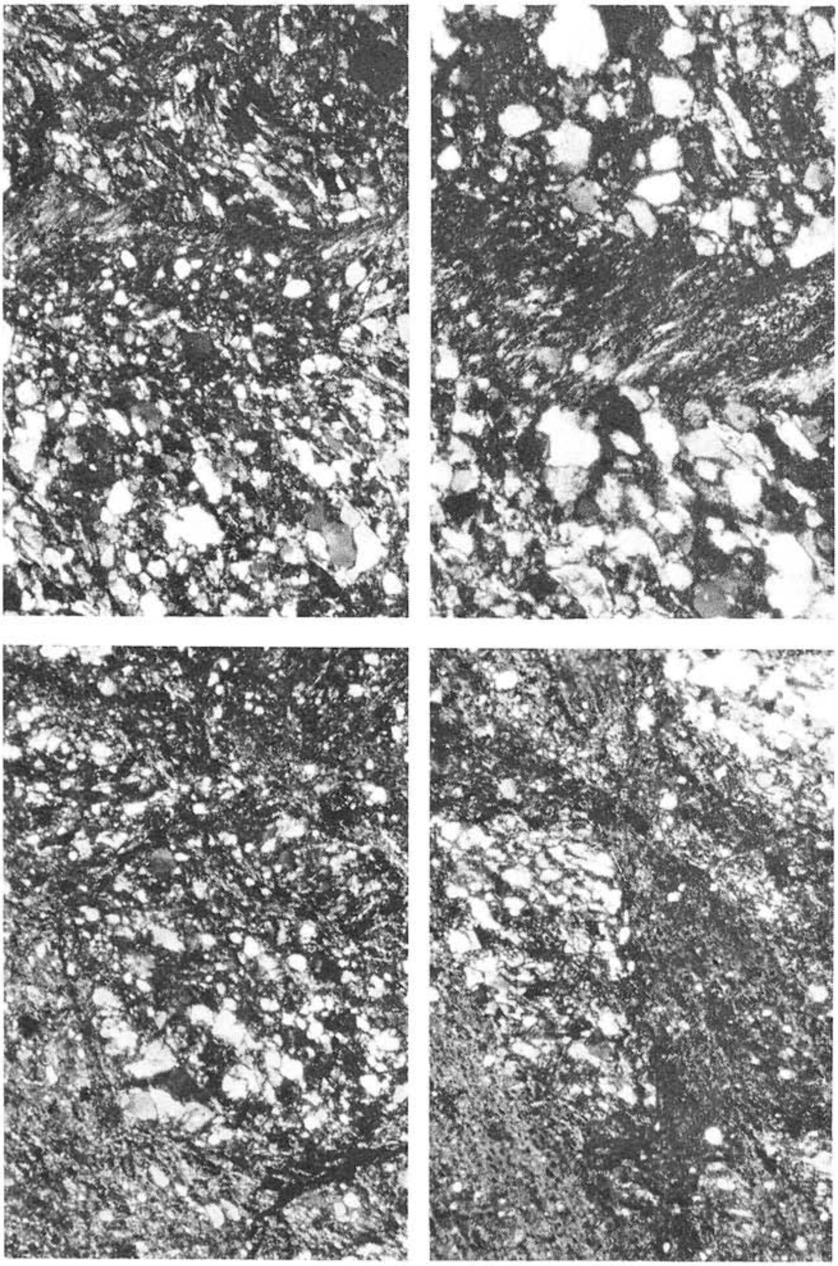
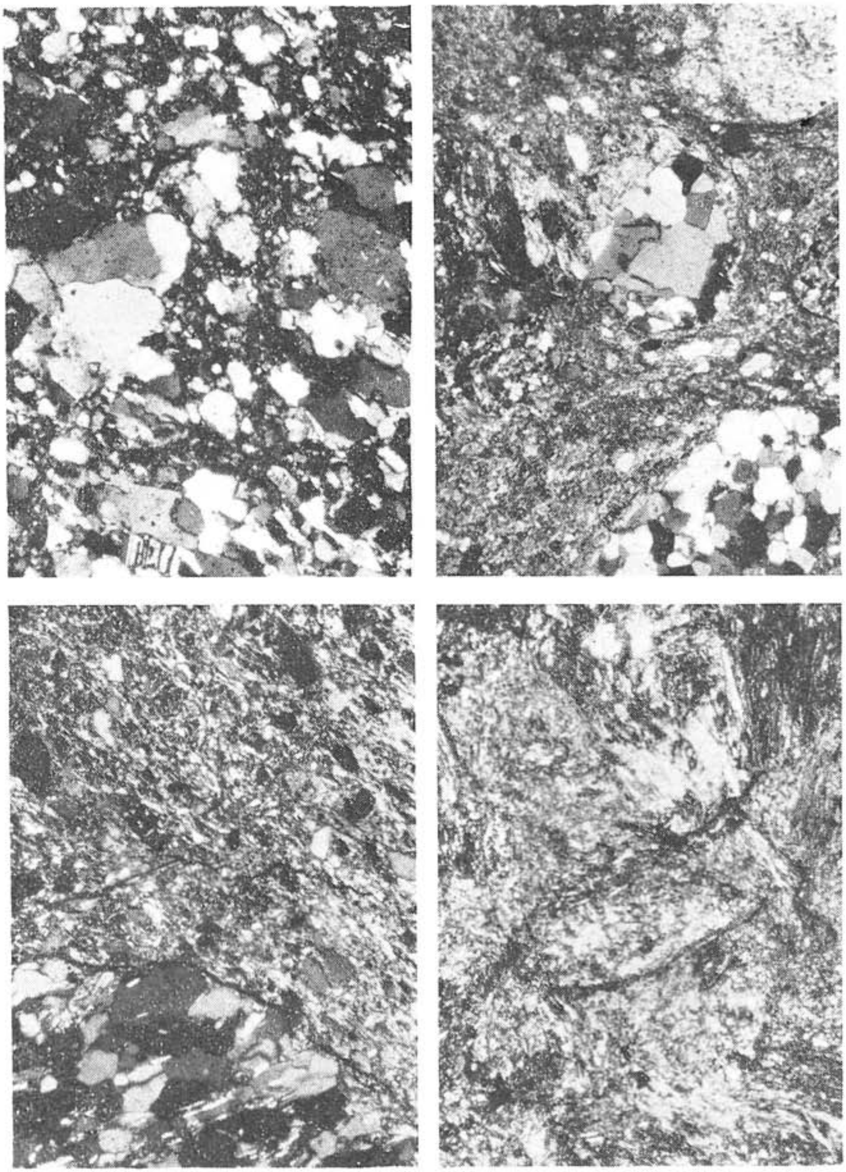


Table VIII

Fig. 1 — Cataclastic (mortar) texture of (mega) porphyroclasts in blastomylonite of biotite-quartzitic phyllite, loc. SW of Krížnica, X N, 60 ×;
Figs. 2, 3 — pseudoconglomerate texture in blastomylonite (with neoblastic texture of the crushed matrix) of quartzitic biotite phyllite, loc. SW of Krížnica, X N, Fig. 2 — 20 ×, Fig. 3 — 40 ×;
Fig. 4 — cataclastic texture of brecciated mylonite of metabasalt, loc. SW of Krížnica, X N, 20 ×.



rite). The megaporphyroclasts of these metamorphosed rocks contain besides fine-grained oriented regionally metamorphic biotite$_1$ ($\pm$ chlorite$_1$) also transversal biotite$_2$, porphyroblastic chlorite$_2$ in association with garnet and cordierite (Putiš in Mahel' et al., 1983; Кориковский et al., l. c.).

The monomineral porphyroclasts are formed by: quartz, plagioclase, biotite, garnet, muscovite, zircon, rutile, iron oxides.

In the time scale, the cataclastic metamorphism followed thus the (Hercynian) regional-periplutonic and contact metamorphism of crystalline schists.

In the cataclastically metamorphosed metabasic rocks, cataclastic texture dominates over relict nematoblastic texture (Tab. VI — Fig. 4; Tab. VIII — Fig. 4). In the Švancpošská valley region east of Kuchyňa (Fig. 3), conglomerates with carbonate matrix with slightly rounded fragmental material of metabasic rocks are also folded into mylonitised to phyllonitised metabasic rocks and metatuffs; the fragments of metabasic rocks are not affected by cataclasis. When presuming that these are Lias mantle conglomerates, the age of the cataclastic metamorphism of the metabasic rocks as well as of the contacting metapelites is Post-Lias.

The (crushed) matrix of the cataclased metapelites is distinguished on one hand by a very low grade of recrystalisation of the porphyroclasts, on the other hand by a quite distinct neoblastesis of very fine-grained chlorite and sericite on the planes of cataclastic foliation.

The cataclastically metamorphosed rocks can be thus characterised as protomylonites (kakirites), schistose (banded) mylonites, mylonite breccias (tectonic breccias) and blastomylonites.

Table IX

Figs. 1, 2 — Psammitic-pelitic (clayi-arenaceous-graywacke) sediments of Emsian from the uppermost part of the clastogene (flysch) formation A of the Harmónia segment of the crystalline with preserved sedimentary structures as well as textures (bedding — S_0 planes, sedimentary porphyroclastic texture). Sedimentary porphyroclastic texture is in the resulting blastoporhyroclastic texture distinctive, besides blastic texture. Metamorphic foliation S_1 (with biotite) is concordantly (mimeticaly) superimposed on bedding planes S_0.
Loc.: North of Malá cajlanská (pezinská) homola; // N; 20 ×;
Figs. 3, 4 — more coarse-grained arenaceous graywackes with porphyroclasts (size up to 3 mm) of quartz, metaquartzites and plagioclose with Hercynian metamorphic sericite, chlorite and biotite. The porphyroclasts are on rims slightly recrystallized (dented rims).
Loc.: North of Malá cajlanská homola, X N; 20 ×.

Table X

Figs. 1, 2 — Fragment (megaporphyroclast, size 3 mm) of a rock composed of quartz and plagioclase (paragneiss?; replacement of plagioclase by quartz along reaction rims — migmatitised gneiss?, granitoid?) in Hercynian metamorphosed arenaceous graywacke (with biotite) of the Lower Devonian — Emsian part of the formation A of the Harmónia segment of the crystalline.
Loc.: righ-hand slope of the Hrubá valley; X N; Fig. 1 — 20 ×, Fig. 2 — 60 ×;
Figs. 3, 4 — fragments (1—3 mm) of undulatory quartz and plagioclase (from Early Palaeozoic, or even Precambrian?, source rocks) in Hercynian metamorphosed arenaceous graywacke (with biotite) of Emsian age (age determined by Dr. E. Planderová, Dionýz Štúr Geological Institute, Bratislava, written information).
Loc.: righ-hand slope of the Hrubá valley, X N; Fig. 3 — 20 ×, Fig. 4 — 40 ×.

Table IX

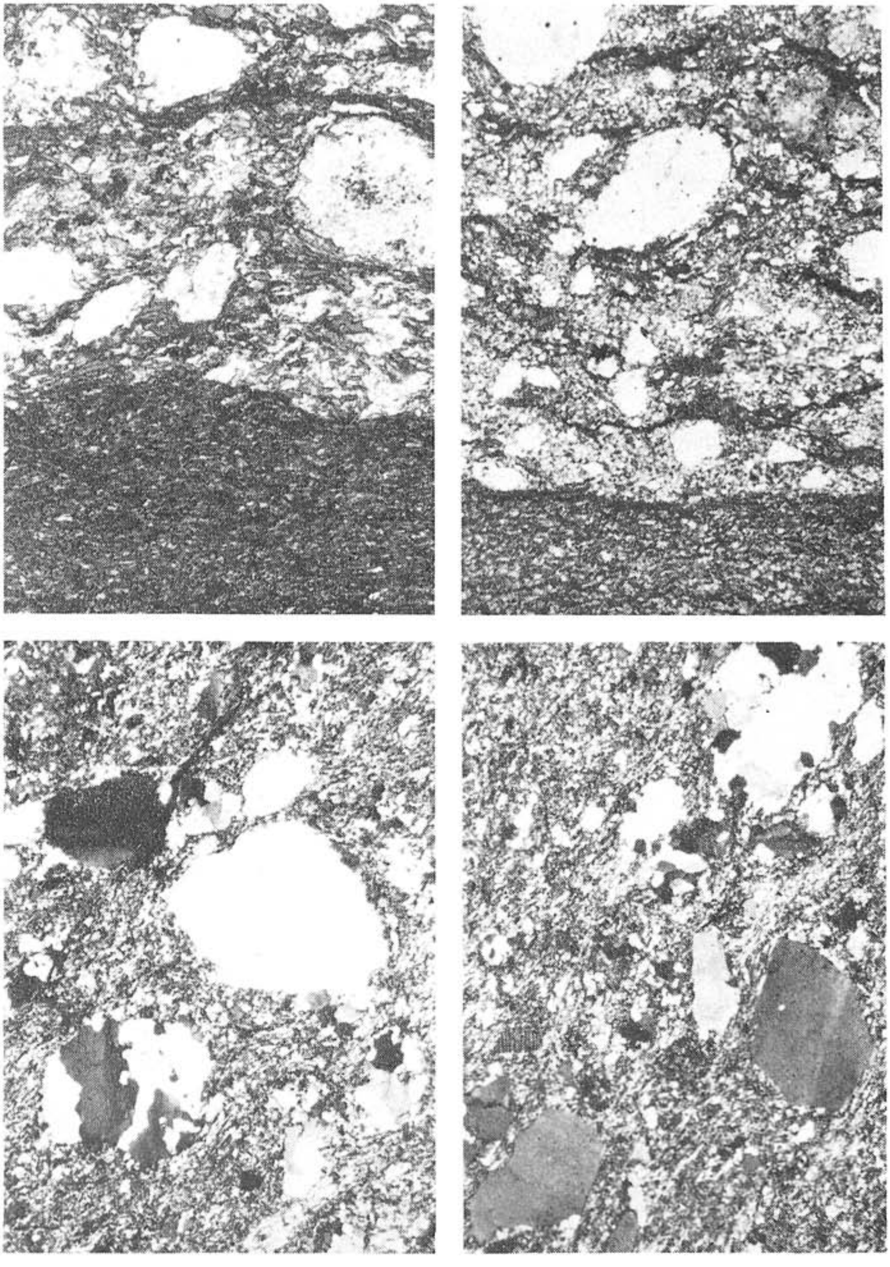
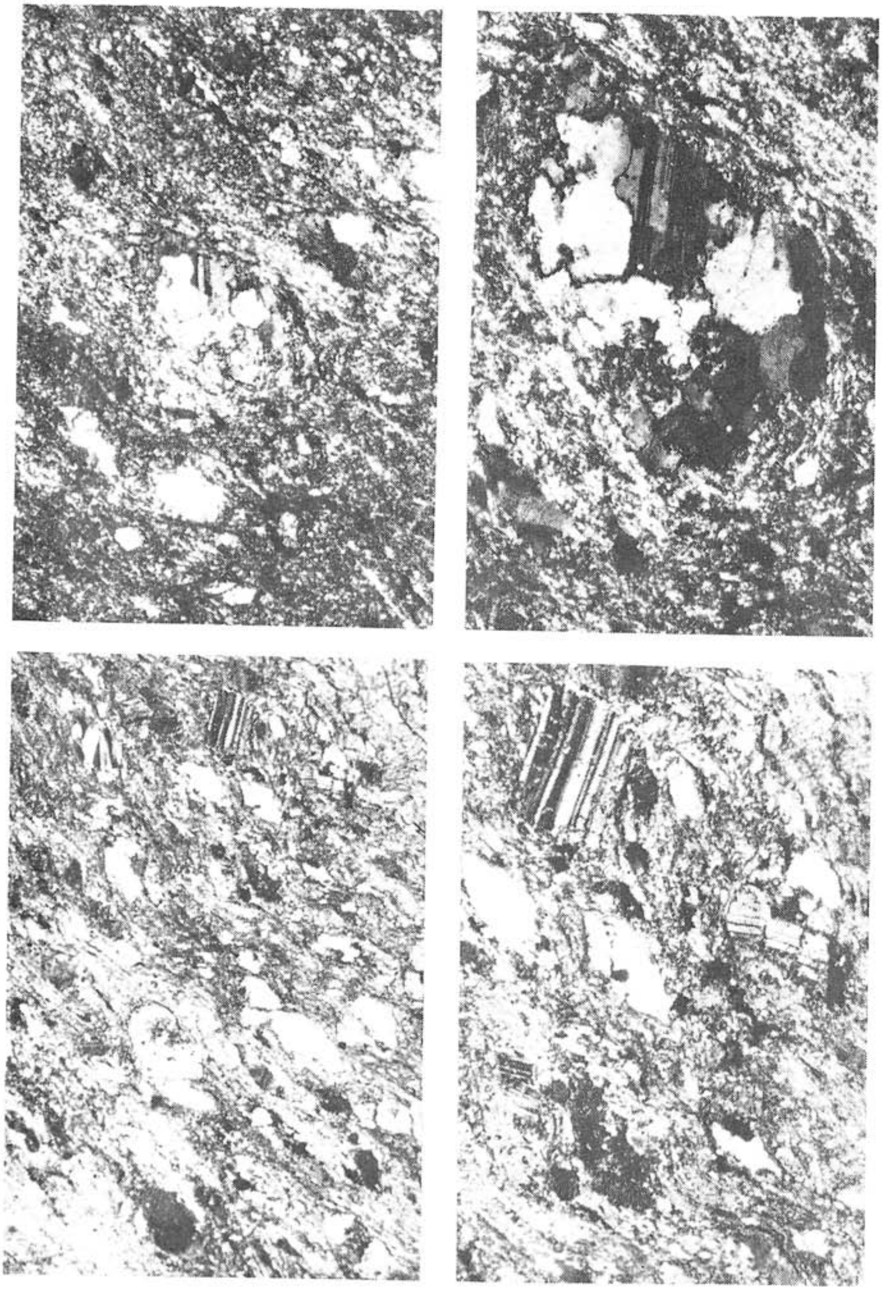


Table X



The low-grade metamorphism of the cataclased metapelites and metabasites is comparable with the alpine metamorphic mineral association in the Mesozoic mantle, where e. g. quartzites and arkoses of Lower Triassic have in some areas even the properties of sericite schists.

Discussion and conclusions

1. The problematic clastic rocks (protomylonites, schistose mylonites, mylonite breccias and blastomylonites) of the crystalline complex in the mentioned geological position (Figs. 1, 2, 4) with tectonically reduced thickness of mostly 0.5—5 m, in some areas even more, are a product of cataclastic metamorphism of metapelitic and metabasic rocks, in connection with Alpine, mostly subhorizontal motions in the crystalline complexes.

2. The cataclastic metamorphism (only locally with metamorphic sericite and chlorite in blastomylonites) is superimposed on higher-temperature Hercynian regional-periplutonic and contact metamorphism, the manifestations of which (biotite$_{1,2}$, sericite, muscovite$_{1,2}$, chlorite$_{1,2}$, garnet) are well preserved in porphyroclasts (in clastic particles of individual minerals with a size of up to 0.3 mm) and megaporphyroclasts (in clastic particles of original metamorphic rocks, mostly in the size of several mm to 3 cm, sporadically up to 10 cm) of tectonites.

3. No relicts of blastoporphyroclastic texture (Tabs. IX, X), which is (in the mentioned example from the Harmónia series) an evidence of the superimposition of blastic texture (with metamorphic biotite) on sedimentary porphyroclastic texture, have been found in the studied problematic clastic rocks.

4. Cataclastic (especially mortar) texture (Tabs. IV, V, VII, VIII) of the megaporphyroclasts, which are frequently not sharply separated from the "matrix", is a characteristical accompanying phenomenon of these rocks. The unsharp limitation of megaporphyroclasts in the more fine-grained matrix is an evidence of the matrix originating from the primary metamorphic rocks by the process of cataclasis (Tabs. IV, V, VII); on the other hand, the matrix is formed exclusively from the material of the surrounding (cataclased) metamorphic rocks. The lithological variability of the original sediments as well as different grades of their metamorphism are frequently the cause of their being "polymictic". The clastic (cataclastic) texture does not bear any distinctive signs of recrystallisation (no superimposed metamorphic biotite) as an effect of later metamorphism (as in the examples in the Tabs. IX, X).

5. In the marked geological profiles (Fig. 4) and localities (Figs. 1, 2, 3), no occurence of sedimentary coarsely-clastic (conglomerate) rocks with superimposed Hercynian metamorphism has been found, nevertheless this problem remains topical in the Malé Karpaty Mts. The evidence of this are the more coarsely grained clastogene sediments (Tabs. IX, X) of arenaceous graywacke character in the upper — clastogene — part of the Harmónia series, where the size of the clastic particles of minerals as well as rocks (Lower Palaeozoic?, Pre-Cambrian?) in a majority of cases nevertheless does not exceed 3 mm. These Lower Devonian (Emsian — P l a n d e r o v á, written information) psammitic (or psammitic — pelitic) sediments are affected by Hercynian metamorphism (with metamorphic biotite). They form the uppermost part of the clastogene (flysch) formation A (clayi-arenaceous-graywacke rythmical sediments) of the Harmónia

segment of the crystalline complexes and the direct base of the upper B formation (dark metaquartzites, graphite quartzitic phyllites, carbonate inlays, basaltes and their tuffs); the basalt flows of this formation (with accompanying tuffs and penetrating veins of gabbrodiorites) end in its uppermost part the rythmical sedimentation (flysch) of the lower formation A and the lower part of the formation B (in the sense of the lithological composition of the Harmónia and the northern part of the Bratislava segments — P u t i š im M a h e ľ et al., 1983; P u t i š in press).

Translated by K. Janáková

REFERENCES

CAMBEL, B., 1956: Tektonity malokarpatských granitoidných hornín. Geol. Sbor. (Bratislava), VII, pp.

CAMBEL, B. — VALACH, J., 1956: Granitoidné horniny v Malých Karpatoch, ich geológia, petrografia a petrochémia. Geol. Práce, Zoš. (Bratislava), 42, pp.

HIGGINS, M. W., 1971: Cataclastic rocks. Geol. Surv. profess. Pap. (Washington), 687, pp. 1—97.

KLUKAN, B.: Klastické horniny v kryštaliniku Malých Karpát. (Paper in Smolenice, March 13, 1984), in press.

PUTIŠ, M., 1983: in MAHEĽ, M. et al.: Tektonická mapa Malých Karpát. Mierka 1 : 100 000. Správa, archív GÚDŠ.

PUTIŠ, M.: Príspevok k litológii, metamorfóze a tektonike kryštalinika strednej a severnej časti Malých Karpát. (Paper in Smolenice, March 13, 1984). In: Maheľ, M. ed.: „Problémy geologickej stavby juhozápadných častí Západných Karpát vo vzťahu k perspektívam ropy a zemného plynu". Zborník GÚDŠ, Bratislava, in press.

PUTIŠ, M.: Litológia a tektonika juhozápadnej, strednej a severozápadnej časti kryštalinika Malých Karpát. Miner. slov. (Bratislava), in press.

КОРИКОВСКИЙ, С. П. — ЦАМБЕЛ, Б. — МИКЛОШ, Я. — ЯНАК, М., 1984: Метаморфизм кристаллиникума Малых Карпат: этапы, зональность, связь с гранитоидами. Geol. Zbor. Geol. carpath. (Bratislava), 35, 4, pp. 437—462.

КОРИКОВСКИЙ, С. П. — ЦАМБЕЛ, Б. — БОРОНИХИН, В. А. — ПУТИШ, М. — МИКЛОШ, Я., 1985: Фазовые равновесия и геотермометрия метапелитовых роговиков вокруг Модранского гранитного массива (Малые Карпаты). Geol. Zbor. Geol. carpath. (Bratislava), 36, 1, pp. 51—74.

Manuscript received, May 16, 1985.