GEOLOGICKÝ ZBORNÍK — GEOLOGICA CARPATHICA, 40, 4, BRATISLAVA, AUGUST 1989,
Pp. 423—452

MARIE PALIVCOVÁ* — JARMILA WALDHAUSROVÁ** — VLASTA LEDVINKOVÁ**

GRANITIZATION PROBLEM — ONCE AGAIN

(16 Figs.)

Abstract: In the present paper some considerations (based on the research and documented by the examples from the Central Bohemian Pluton) stimulated by the paper of Mehnert (1987) on the revisited granitization are presented. In accordance with Mehnert the authors demonstrate some further examples that can be misinterpreted in the granitization process, eventually need reinterpretation, in spite of the fact that they belonged to the crucial arguments in favour of the granitization (e.g. feldspathization). The authors summarize further the examples of so-called contrasting, contradictory phenomena, especially in the CBP, the most of which were the subjects of a grave controversy between magmatists and transformists and that have remained unresolved till now. It was pointed out that the whole set of these phenomena is to be taken in account in the models of the plutonic rocks origin.
In conclusion, the authors express an agreement with the rejection of the geological significance of the s.s. granitization (i.e. metasomatic granitization); on the contrary they emphasize the usefulness of a modified term of the granitization s.l. in the process of the granitoids formation in orogenic belts.

Резюме: В работе приводятся рассуждения (на основе исследований и иллюстрированы примерами из Среднечешского плутона) вызванные статьей Менерта (1987) о ревизованной гранитизации. Согласно Менерту авторы показывают примеры, которые могут быть неправильно интерпретированы в процессе гранитизации, или они требуют новую интерпретацию, несмотря на то что они были одни из основных аргументов для гранитизации (напр. фельдшпатизация). Далее авторы резюмируют примеры целого ряда тнз. противоположных явлений прежде всего в Среднечешском плутоне, большинство которых было темой споров между магматистами и трансформистами и которые не были до сих пор разрешены. Подчеркивается что эти явления должно принимать во внимание в моделях возникновления плутонитов. В заключении соглашается с отвержением геологического значения представлений о гранитизации s.s. (т. зн. метасоматической гранитизации), с другой стороны подчеркивается значение термина и процесса гранитизации «sensu lato» при возникновении гранитоидов орогенных зон.

Introduction

All the three outstanding experts — doyens of granitology — E. Raguin, W. S. Pitcher and K. R. Mehnert preferred the idea of the granitization process for the explaining of the granite origin in some of their previous works. Raguin holds to his idea still in 1976 when suggesting the terms "milieu mobilisé" and "état mixte" instead of "intrusion" and "magma".

* RNDr. M. Palivcová, CSc. Institute of Geology and Geotechnics, Czechoslovak Academy of Sciences, V Holešovičkách 41, Praha 8.
** RNDr. J. Waldhausrová, RNDr. V. Ledvinková, Geological Survey, Malostranské nám. 19, 118 21 Praha 1.

Pitcher uses the term "granitic magma" even more often though with a certain confinement (e.g. 1978, 1987). Mehnert (1987a, b) called newly in question the geological importance of the granitization process at all. Some differences lie in the different definition of the term "granitization" (see discussion in conclusions of this article). Nevertheless such trend from the granitization model to the magmatic model is not too usual in the history of the granite research. More often an opposite case happened among geological petrologists due to their increasing experience in the field work.

Hence it seems substantiated that the protagonists of the magmatic models can be satisfied: a high renaissance of magmatic theories — sometimes of the classic orthomagmatic (newly e.g. Schermerhorn, 1987), more often of the anatectic magmatic or magma mixing theory (e.g. Didier, 1987) — becomes recently evident. In the present paper the authors would like to call in question whether this negation of the granitization model is not one-tracked, whether it is justified.

The following considerations have been stimulated by Mehnert's paper on "granitization-revisited" mentioned above. We would like to express our agreement with many Mehnert's precise and excellently documented observations as well as deductions drawn by him from the comprehensive number of new references concerning this problem. In addition to those of Mehnert some further examples in favour of the conservative compositional character of metamorphism are presented. Nevertheless we would like to defend the usefulness of the term granitization and its geological importance. We briefly discuss three main controversiae arguments of granitization and bring evidence of some other contrasting features in plutonic complexes, especially from the Central Bohemian Pluton. The significance of these phenomena for the models of the granite origin and for our conclusions on the granitization process is emphasized.

Our considerations are mostly based on many years' experience in the Central Bohemian Pluton (later CBP). This complicated Variscan massif of the batholitic character (Palivcová, 1984) is unique in the Bohemian Massif as well as in the whole European Variscan belt. Due to its variability it provides an occasion to study many types of the plutonic rocks from the basic to acid members in different rock series in their mutual relations as well as in relations to different surrounding rocks (Upper Proterozoic—Lower Proterozoic volcanosedimentary complexes and various Moldanubian gneisses).

Problem of the compositional persistence during metamorphism

We deeply concur with Mehnert that the metamorphic process is usually — if not always — a highly conservative one. This is obviously a very important conclusion with respect to granitization sensu stricto (see Meh-

Fig. 1. Stretched and folded metaconglomerates of pyroclastic origin (from Devonian of Moravosilesian unit of the Bohemian Massif). The layers correspond to deformed pebbles. Figs. a and b are perpendicular sections of the same rock. Růžová stráň near M. Morávka, Hrubý Jeseník Mts. Material of P. Rajlich and J. Synek.

Fig. 1a.

Fig. 1b.

n e r t' s definition 1987b, p. 286), which is, in principle, a metamorphic process. Our experience led us to the same conclusion, xthat there are no distinct, if any, examples of the metamorphic differentiation. On the contrary the material transport may happen due to the rock deformation. Examples of the extremely stretched and folded conglomerates (M e h n e r t, 1987), which can be mistaken for metamorphic differentiation, are clear and convincing. The significance of the tectonic deformations such as the stretching in the shear zones or crushing in the mylonitic zones was probably underestimated in the metamorphism as well as in the plutogenesis. These deformations in the Bohemian Massif are presented in the papers of R a j l i c h (1987) and R a j l i c h et al. (1988). Flattening examples like those shown by M e h n e r t occur in the Bohemian Massif (Fig. 1) similarly as everywhere in the world in analogous geological conditions. Fig. 2 illustrates another deformation example that can be misinterpreted as porphyroblastesis. Figs. 3a, b and 4 demonstrate two examples from Belomoridy (Kola peninsula) where even the mineral composition remained preserved despite of the strongest deformation. In the first case (Fig. 3a, b, c) the granulite-looking rocks originate from coarse-grained noritic

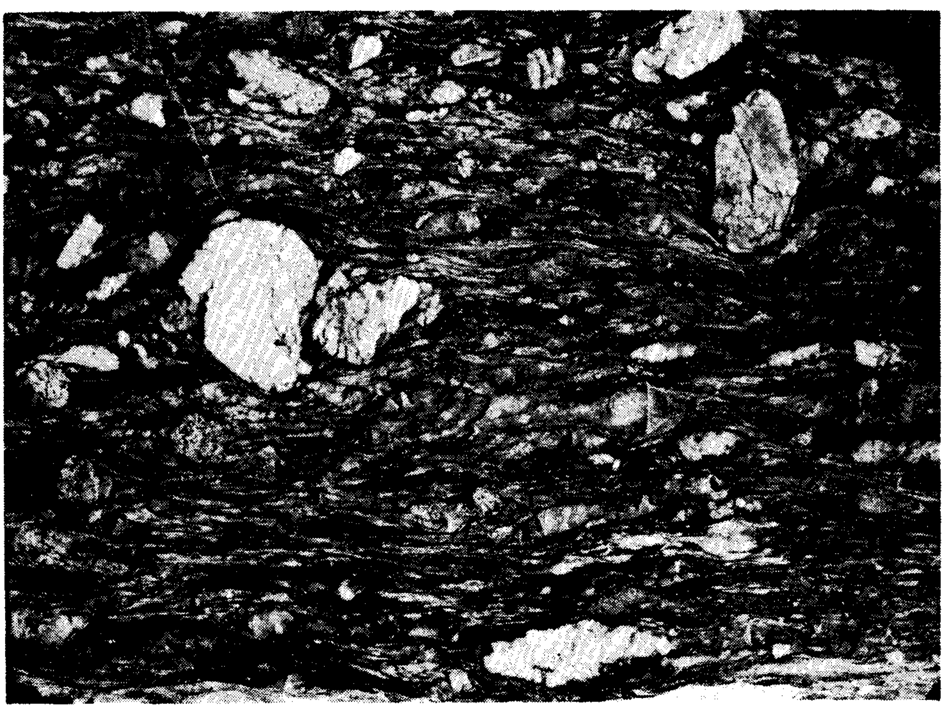

Fig. 2. Cambrian metaconglomerate from Železný Brod-crystalline complex, NE Bohemia of similar character as in Fig. 1. Some preserved pebbles and grains of Na-rhyolite, quartz and albite may be macroscopically mistaken for porphyroblasts. Lišný, W. of Železný Brod. Natural size. Material of J. C h a l o u p s k ý.

rocks in anorthositic complexes (the zones can be followed in hundreds meters length and one to several meters thickness). Fig. 4 illustrates the initial deformation of the endocontact around a metaporphyrite boudin in strongly migmatized gneisses. The flattening of the porphyritic feldspars is rather abrupt and in an extreme case banded rocks of leptynitic appearence originate. The deformed endocontact around the boudin is about 5—20 cm thick. Opposite examples of the preservation of compositional, textural as well as structural features in metamorphic complexes during the regional metamorphism are well-known and very common. E.g. the preservation of cross-bedding was described in Moldanubian gneisses (Vajner, 1966). The statement of Mehnert in a discussion concerning the migmatization should be pointed out: "Many uncertainties lie in the fact that the original differences are often underestimated". Fiala (1986) clarified that the metatect in Moldanubian migmatites had to be explained not by addition from the outside and not by

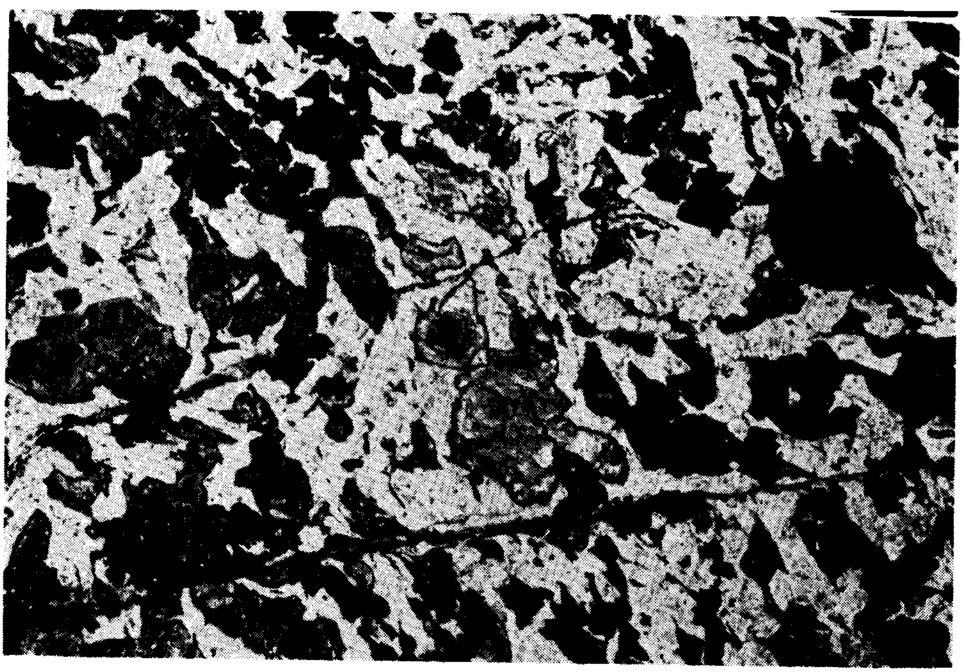

Fig. 3a.

Fig. 3a, b, c. Gradual increasing deformation in Precambrian norites from anorthositic massifs. Coarse-grained norites consisting of hypersthene and plagioclase are stretched into finely laminated leptynite-looking rocks. Belomoridy crystalline complex, Kola Peninsula, U.S.S.R., Kataranga promontory.

Fig. 3b.

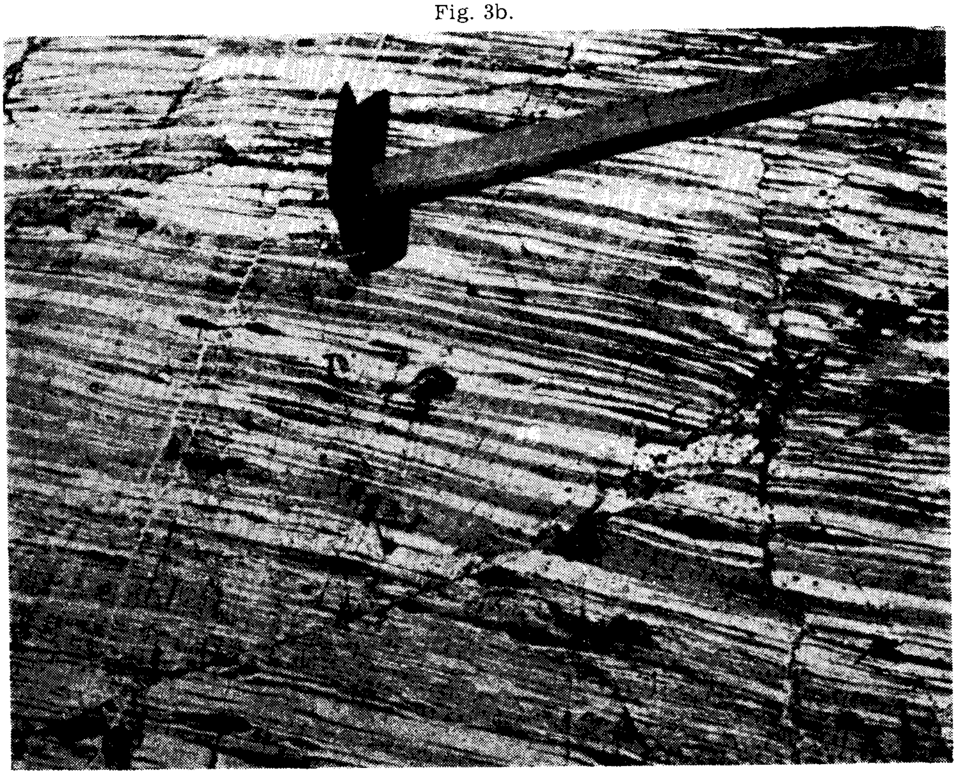

Fig. 3c.

melt segregation but by selective melting of the original light laminae in the rock. The difference in the alkali content (mainly K) could represent the variations of the parent rocks.

Another example of persistence which could be of great importance in the formation of the metamorphic as well as of plutonic rocks is the stability of the chemical composition of volcanic rocks not only during the metamorphism but also during the volcanic process itself. The dependence of geochemistry as well as petrology on the tectonomagnetic conditions regardless their stratigraphy is well known. E.g. Condie (1981) has demonstrated that the tholeiites of the ocean floor are practically identical in the Archaean as well as in the recent time. Thus the original conditions of the tectonic environment could be estimated from the chemistry of metavolcanics more detailed than hitherto assumed in the evolution of the metamorphic and plutonic complexes.

In Fig. 5 an example from the CBP granitoids is illustrated which reveals the original shape of a rounded enclave. Such observations necessarily provoke the question: „Do we not underestimate the preservation of the bodies shapes (e.g. of the basic bodies, of the mylonitized and crushed zones etc.), i.e. their premetamorphic original features in the metamorphic or plutonic complexes?"

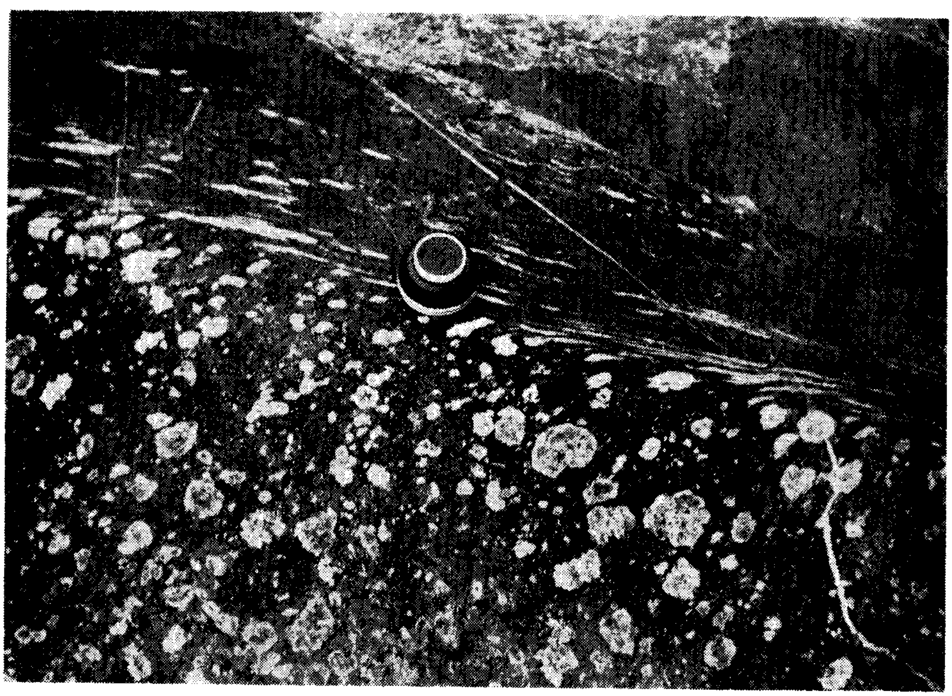

Fig. 4. Stretched feldspar phenocrysts at the margin of a metaporphyrite boudin which is enclosed in migmatites. Belomoridy crystalline complex, Kola Peninsula, U.S.S.R., Konchiniy promontory.

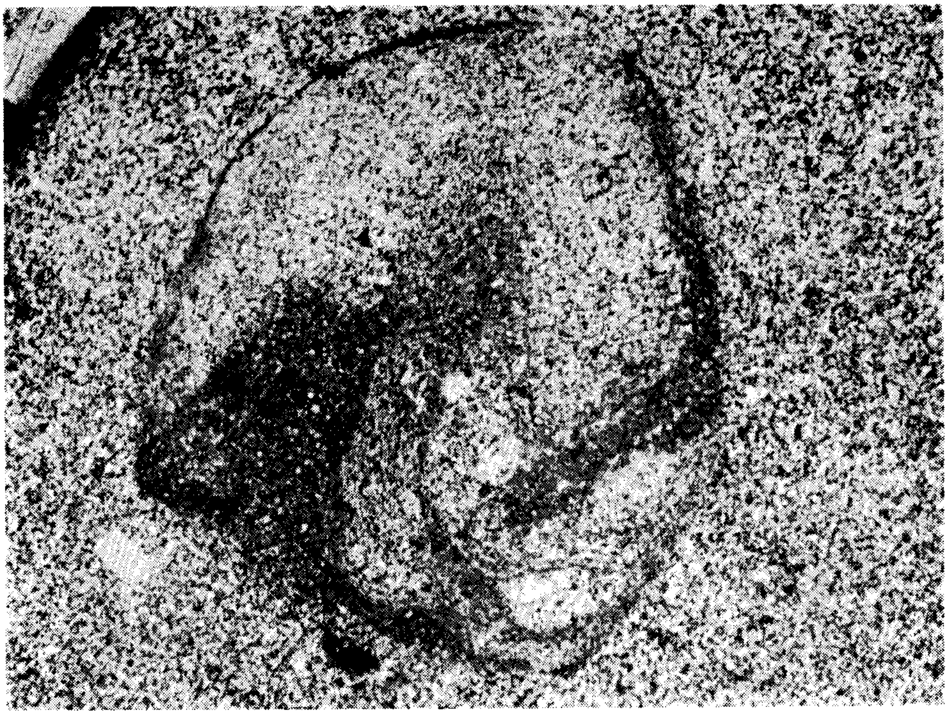

Fig. 5. Relict outlines of the shape of an original mafic enclave in Hudčice granodiorite. The size of enclave is about 1/4 m in diameter. Hudčice quarry near Březnice, Central Bohemian Pluton.

Three main arguments in favour of the granitization process

As summarized by Mehnert the three most discussed questions of granitization are as follows: a) feldspathization of granites and their wall rocks, b) the Sederholm's effect, c) ghost stratigraphy and the problem of active-passive (violent-nonviolent, forcible-permissive) amplacement. We would like to call attention to the fact that these phenomena belong to the group of the so-called "contradictory, conflicting, contrasting, controversial, antipathetic" phenomena or "antinomies" in the granite geology which evoke intricate "struggles" on it. There are many other such phenomena in addition to the three main problems mentioned above. Some further examples from the CBP will be given in the next chapter. The role of many of them is not appreciated enough. We attribute to these contrasting phenomena a decisive importance for the models of the granite origin.

Mehnert argues that the three phenomena may be explained in an other way than in favour of the granitization. Some granitization can occur to a limited degree only.

a) *Feldspathization.* The same what experiences Mehnert in Black and Bavarian Forest (Mehnert, 1987b, p. 294) also happened to one of the authors

(P a l i v c o v á, 1965, 1966) in CBP. The feldspar megacrysts, best developed in so-called durbachitic (i.e. lamproitic) CBP rocks, were explained as porphyroblasts and therefore as an argument in favour of a large scale feldspathization (the durbachitic complex has the extent of about 220 km^2). Instructive figures of "porphyroblastic" growth described by R ö h l i c h o v á (1964) were even mentioned by M a r m o (1971) as a proof of porphyroblastesis (Fig. 6). Later experience led us to a magmatic explanation (P r o k h o r o v et al., 1983); however, recrystallization of this magmatic feldspar was emphasized by one of the authors (P a l i v c o v á). In these K-feldspar megacrysts not only hidden oscillatory zoning (as mentioned by M e h n e r t in Black Forest,

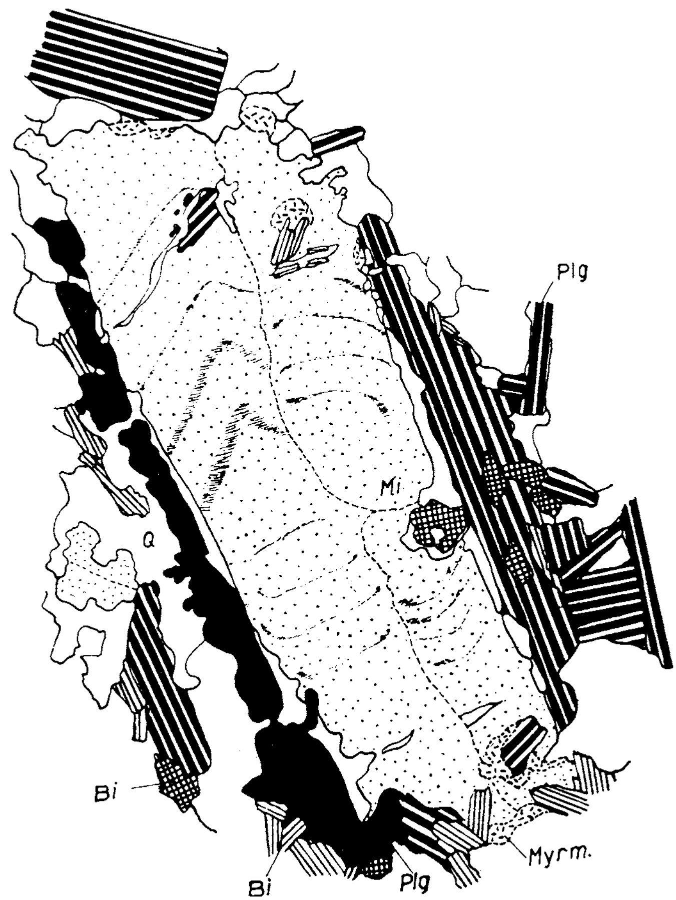

Fig. 6. Relict zoning in microcline megacryst which originated by recrystallization of magmatic orthoclase phenocrysts in durbachites of the Čertovo břemeno type. Quarry „V Logrech" near Písek. Small bodies at southern margin of the Central Bohemian Pluton. Enlarg. 10×. M. R ö h l i c h o v á, 1964 (the author explained the feldspar as a porphyroblast).

p. 294) occurs but also optically visible relic oscillatory zoning — in different stages of recrystallization and ordering of original orthoclase to microcline — was stated. Microcline forms irregular outmost rims of feldspars which make them to appear like porphyroblasts. Without doubts, feldspars are magmatic in origin, they "already existed in the rocks" (Mehnert, p. 294) and recrystallized. Many special inhomogeneities described earlier in the feldspars were newly interpreted as deformation effects of magmatic phenocrysts in a shear zone (Lobkovic, 1987). The point of crucial significance for the granitoid genesis lies in the fact that (like in other cases known from the literature) the same magmatic and recrystallized feldspars are disseminated in the wall rocks, layers and enclaves of the Moldanubian gneisses which abundantly occur in durbachitic rocks. This phenomenon was erroneously taken for one of the starting points of the classic metasomatic granitization.

Analogous conspicuous K-feldspar megacrysts as shown by Mehnert from Alpine Albigna granite (p. 293) are present in the similar coarse porphyratic granite of Liberec type in the Krkonoše Massif (NE Bohemia, Klomínský, 1969; Tab. VI, 1). The best and very frequent examples of this "feldspathization" in the dark schlieren and enclaves can be observed in the present time on the polished blocks of this granite in several stations of the Prague underground (Flora, Pavlova, Sokolovská, Leninova). Here the same character of the feldspar megacrysts in the granite and the enclaves is well distinguishable because the feldspars have similar features like the rapakivi feldspars, i.e. white macroscopic rims. Many others examples, where the authors stress a perfect analogy of both feldspars (especially the study of Spencer) can be found in the book of Didier (1973). It follows from the book that the problem of the feldspar megacrysts is not yet resolved.

Another example of the magmatic feldspars which were mistaken for the porphyroblasts are the feldspars in the dioritic rocks and their enclaves considered as the products of the metabasites dioritization (Palivcová, 1966). Krupička (1948) was right in interpreting the rocks of the metabasite quarry as cataclased porphyrites with the plagioclase phenocrysts. The dioritization is here a metamorphic, not a metasomatic process. The exact analogy of the intricately zoned and sometimes filled plagioclases in the metabasites and tonalites should be particularly stressed (i.e. their recrystallization from the original more basic feldspars by acid to very acid-albitic plagioclases). This was the cause of the misinterpretation. Some typical plagioclase phenocrysts which can be compared with those of the andesitic volcanics were found in the microdioritic enclaves of the tonalites and granodiorites (Fig. 7). The same case are the feldspars of some basic rocks described by Patočka (1979, Fig. 2) as porphyroblasts.

It is possible to sum up that the feldspar megacrysts discussed here have the features of both the primary magmatic formation and recrystallization, regardless whether they occur in the granitoids or in the enclaves or in the surrounding rocks. Of course, the recrystallization in the granitoids can be explained in terms of deuteric phenomena. In gneisses, sedimentary and volcanogenic material such an explanation is more difficult. We are inclined to the conclusion in agreement with Spencer (1938) that due to the markedly intricate structure of the feldspars (e.g. rapakivi structure etc.) such a deuteric explanation outside the granite is impossible. According to our opinion there is but one

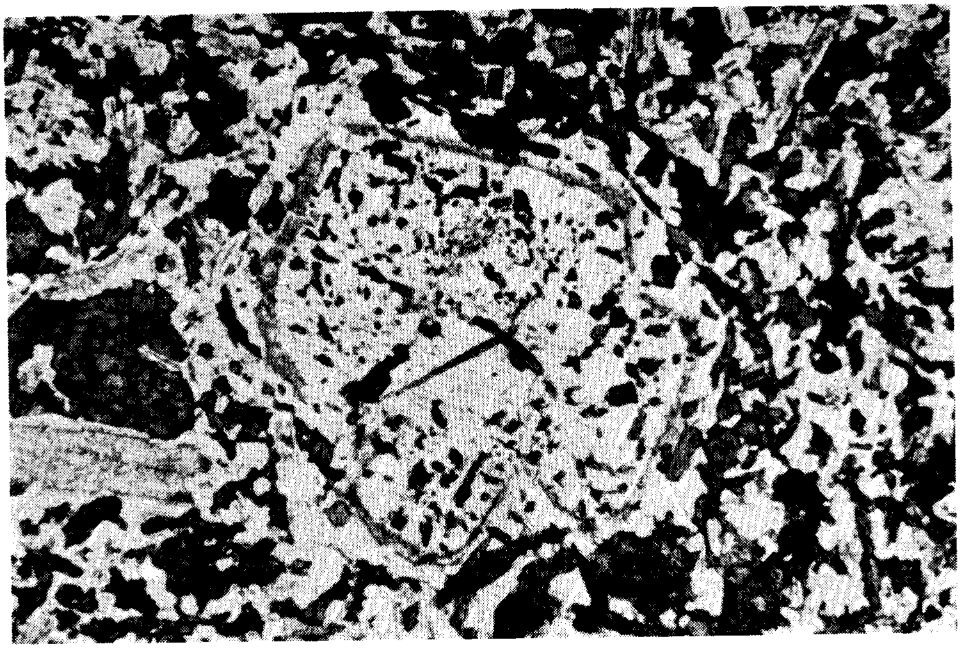

Fig. 7. Zoned and filled recrystallized volcanic-subvolcanic phenocryst (andesine to oligoclase with minute hornblende grains) in hornblende ± biotite ± quartz microdioritic enclave from the granite (of s.c. marginal type of the Central Bohemian Pluton). The grey margin outlines the original zone of basic plagioclase. Radětice mine near Milín, Příbram district. Microphoto without polarizer, enlarg. 30×, photo V. Matějková.

way from this dilema: the magmatic feldspars "already existed in the rock" (Mehnert, 1987b, p. 294) before recrystallization. Volcanogenic and volcanoclastic origin of the feldspars may be the most plausible explanation. The coarse-grained and monotonous character of pyroclastics (crystaloclastics) in large areas is an underestimated feature of the volcanic process (Waldhausrová). Thus we concur with Mehnert that a large scale metasomatic feldspathization with long-distance import of material is an improbable process.

The above statement does not mean that we vould deny the metasomatic process at all. It obviously occurs in relation with magmatic i.e. volcanic, subvolcanic events, with their volatile components (preferentially water) and hydrothermal solutions providing that necessary components were present in the complex. Their higher mobility, however, requires open transporting ways (faults) and is usually of limited regional scale. Many metasomatic processes present in metamorphic and plutonic complexes may be overprinted changes from preexisting evolution stages of the rocks.

b) *Sederholm's effect.* Though originally described and better understandable in the high metamorpphic Precambrian complexes (see in Mehnert's Fig.

Fig. 8. Platty mafic enclave (disrupted dyke?) of hornblende ± biotite quartz-microdioritic composition in tonalitic rocks. Teletín quarry 20 km S of Prague, Central Bohemian Pluton. From Dudek — Fediuk (1956).

12) Sederholm's effect is not an unusual feature in the Phanaerozoic granitoids too. Here, however, it can be more controversial. It occurs especially in those of tonalite-granodiorite lithology where bosses of basic rocks are associated with. This so nicely called "petrified nonsense" — i.e. injection of a granitoid (or its aplopegmatitic material) into a more or less continuous dyke which penetrates into the same granitoid has a strict analogy, in principle, in different regions. Various explanations were assumed, as summarized by Didier (1973): the dykes were considered to be older (relict dykes), contemporaneous (synintrusive, synplutonic) or younger dykes (evoking anatexis) of the sourrounding granite). Also some zones of angular enclaves were interpreted as fragments of the dyke rocks.

One questionable example of this kind is shown in Fig. 8, in the tonalitic and dioritic rocks from the well-known Teletín quarry (CBP). According to Dudek — Fediuk (1956) the platty bodies are enclaves. However, an interpretation of a disrupted dyke in the sense of the Sederholm's effect cannot be excluded, especially if chilled edges (fine-grained dark margins with chilling phenomena — see next chapter) along the boundaries of the dyke (not around the whole enclaves margins) are developed. The chilled character of the margins is often discernible only microscopically.

Another very enigmatic case of a lamprophyre dyke (minette) in durbachitic rocks from the Velká mine in CBP can be unfortunately documented schematically only (Fig. 9). The dyke ends abruptly on one dislocation; the continuation of the same rock, however, can be observed behind the dislocation in the smaller and smaller slowly disappearing sphaeroids. The "ball shape" was checked in the mine; the sphaeroids were entirely surrounded by the durbachitic rocks without any connection with the dyke. The explanation is not clear.

The Sederholm's effect, if present, is one of the best and clear examples of the contrasting phenomena in plutonic as well as metamorphic rocks; it cannot be satisfactorily explained by an one-stage of the surrounding rock.

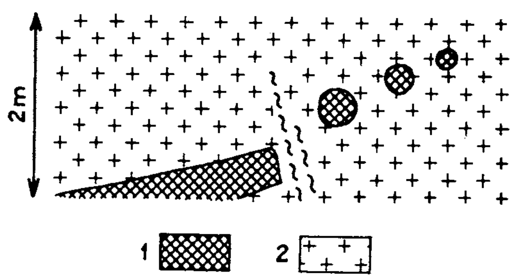

Fig. 9. Schematic picture of an interrupted lamprophyric dyke (minette) and its continuation in spheroids in durbachites. Velká mine near Milevsko, Central Bohemian Pluton.

c) *Ghost-stratigraphy, active and passive emplacement.* According to M e h n e r t, ghost stratigraphy "was stressed by the advocates of the granitization theory, because from such evidence it seemed safe to conclude, that granites can be formed by non-violent emplacement". However, this convincing "vestige" for granitization can be seen exceptionally only and in a limited scale, mostly not far from the contact. M e h n e r t discusses then the classic example of "ghost stratigraphy" from the migmatite granodiorite in Donegal and remembers the reinterpretation of P i t c h e r (p. 297), who confines the idea of ghost stratigraphy. Some arguments of this reinterpretation are persuading, some are uneasy to understand (e.g. the preservation of the disrupted pieces in the horizons "in spite of the still existing melt between them").

The statement of M e h n e r t that the examples of preserved ghost stratigraphy are exceptional, seems to be true for the CBP, too. We have not been successful in finding some examples (continuation of metabasites layers into granitoids) mentioned by U r b a n (1931) in CBP. Some layers of Moldanubian metamorphites can be traced at the durbachite endocontacts; they lose, however, quickly their continuity and become enclaves (Fig. 10).

The present authors suggest that one example of ghost stratigraphy can be shown in the case of a nebulitic granodiorite of CBP (P a l i v c o v á et al.,

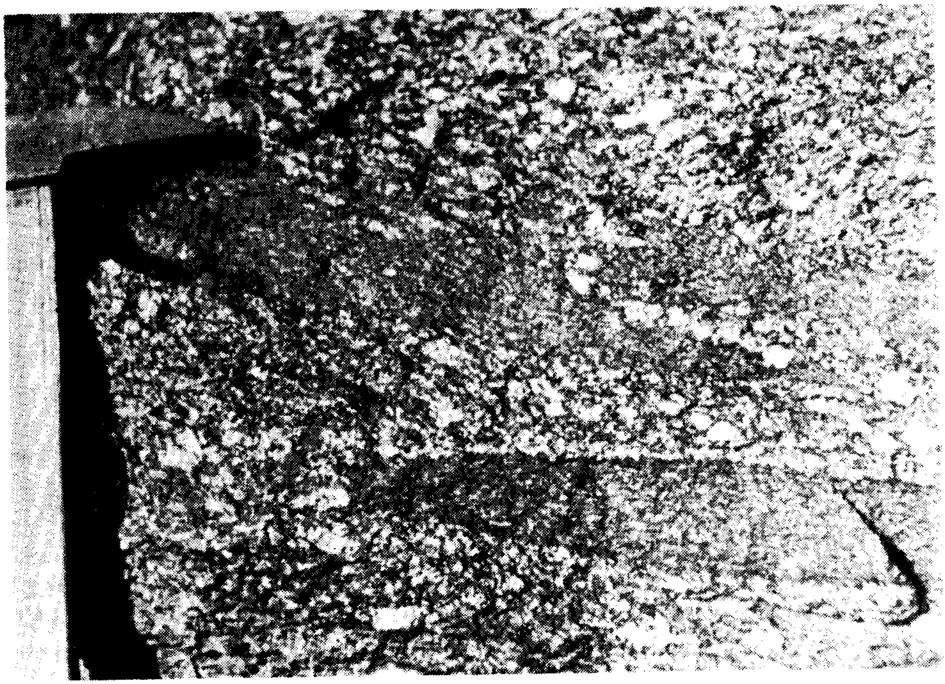

Fig. 10. Disjoined and displaced layers (now xenoliths) of fine-grained originally continuous Moldanubian pearl-gneisses in durbachites of Čertovo břemeno type. Votice quarry, Central Bohemian Pluton.

1988); the relics of Cambrian conglomerate layers may be traced in it in the form of the quartz pebbles and digested hornfels pebbles. New examinations of long sections in the mines of Příbram district by Vlašímský (in print, oral communication) seem to support the above interpretation. We came to the conclusion that this granodiorite formed in situ or almost in situ — i.e. the same and almost contemporaneous conclusion with that of Wickham (1987a) in Pyrenees. For the reasons discussed at the end of this paper, we indicated this process as "granitization" — whilst "anatexis in situ" is assumed by Wickham in Pyrenees. Regardless the mode of the granite formation we find much important that in the both distant regions the same in situ or almost in situ origin and almost of the same Lower Palaeozoic sediments (Ordovician in Pyrenees, Cambrian in CBP) has been considered for some Variscan granitoids.

A more detailed discussion on granite emplacement is beyond the aim of this paper and we are not familiar with this problem. Nevertheless we would like to note that the ideas of the granite emplacement in the CBP similarly as currently in most other massifs — are hardly unanimous. The reason is that, on the one hand, in one and the same body the features can be found which support an active, violent emplacement (such as discordant contacts, apophyses into surrounding rocks, enclaves of the country and older rocks etc.);

on the other hand, B e n e š (1971) demonstrated two different geological fabrics corresponding to the geological position of intrusions (Moldanubian structures in the peri-Moldanubian zone and Proterozoic structures in the peri--Proterozoic zone of CBP). A passive, non-violent emplacement of granitoids is repeatedly emphasized by some authors, most readily recently from the detailed mapping and careful documentation in the mines (V l a š í m s k ý, 1986a, see above); intrusion apophyses to a small distance only are adopted.

We can summarize that, obviously, all the three above mentioned phenomena used in favour of the granitization process remain controversial, if the one-stage magmotic model of the granitoid genesis is accepted. Another model of the formation of granitoids is necessary which would enable to explain the presence of both — magmatic as well as non-magmatic features in the same body and in the same rock.

Contrasting phenomena in the Central Bohemian Pluton

A series of other contrasting phenomena exists in the CBP, especially in the relations of the basic to acid rocks. As seen below, most of these features were separately described and vigorously discussed in many analogous as well as different plutonic complexes, mainly in the forties and fifties, between magmatists and transformists. Many of them are quoted in the book of D i d i e r (1973) who succeeded in collecting examples of many of these phenomena and other puzzles of the ranite problems in an excelent manner and underlined their more or less sucessful solution in the works of many authors. The CBP is an example where almost all contrasting phenomena occur alltogether in one and the same complex. The common, current, simultaneous occurrence of all of them in one complexx together, all in all, was not enough emphasized up to now.

The same more or less complete set of contrasting features occurs in analogous geological conditions in all the other plutonic complexes where basic rocks are intimately associated with granitoids. Hence the contrasting features are best developed in tonalite-granodiorite series where hornblende-gabbroic basic series prevails. They occur however also in other granitic complexes where the basic rocks are e.g. of noritic composition. It seems that the presence at least of two types of granitic rocks (usually of a coarse porphyritic granite and of a medium to fine-grained normal granodiorite) is the precondition of the phenomena described below. The processes of assimilation, contamination, hybridization, newly magma mixing, are currently noted in them.

The most common contrasting features in CBP are as follows:

Forms and shapes of basic bodies. This problem can be denoted as the S e d e r h o l m's effect of a higher order. Geological forms of basic bodies in CBP often remember sills, dykes, stocks in spite of the supposed earlier age of basic rocks than that of the surrounding granitoids. Fine-grained darker chilled contacts of basic bodies (called therefore "antichilled, pseudochilled" — see below) may be observed commonly in them. On the other hand large blocks and enclaves of basic rocks occur in granitoids (see e.g. P a t o č k a, 1979, his Fig. 7) — of the same basic bodies which have chilled contacts. Netveining may be developed in these basic rocks. Therefore, it is very difficult to determine the geological age of the basic rocks in relation to the granitoids (only K/Ar values are at disposal which usually give the same age like surrounding granitoids, in an interval 330 to 340 Ma). These difficulties have been pointed out also by Vlašímský (1973) who described mafic intrusive stocks similar to the basic rocks in the pluton in the close sedimentary exocontact. Some of them are shallow (subvolcanic? — author's interrogation) intrusions and manifest themselves by a variable lithology. The position of the most larger (first km^2 and less) satellitic basic bodies along the peri-Barrandian contact or directly on some other discontinuities in CBP, e.g. on boundaries between granitoid intrusions, was already pointed out (Palivcová, 1984). The geological position in the exocontact as well as close endocontact and the complex lithology of some bodies demonstrably remember the position of the Scottish appinites.

Mafic enclaves (microgranular after Didier, 1973) and their swarms. They occur preferentially (though not exclusively) in the tonalite-granodiorite series for which they are common all over the world. They occur in zones which are often subparallel with the contacts. They are of various shapes often discoid and elongated — sharply angular as well as well rounded, "hard" as well as "plastic" in the same subhorizontal or subvertical zone. Teletín quarries (Fig. 11) — an analogy of occurrences in the Adamello or Californian-Andean Massifs — offer the best exposures of them as seen already in Dudek's and Fediuk's paper (1956) and recently of Palivcová (1984 in this journal). The texture of these mafic mostly microdioritic microgranular enclaves is always finer-grained than that of the larger basic masses. One type of them is shown in Fig. 7. As mentioned above the enclaves often correspond to the chilled margins of these larger bodies (see also Vlašímský, 1976). However the problem of the microgranular enclaves is a complex one as many of them have often their own endocontact chilled margins around their whole shapes. Not groundlessly, Didier (1973) characterized the microgranular enclaves as enigmatic rocks. He collected many examples of their interpretations by various authors. The discussion is not in the framework of the present paper. Here we would only to state the existence of this contrasting phenomenon in connection with the others. In principle, the problem is similar to the following one.

Petrographical (especially textural) analogy of some young lamprophyric dykes with mafic enclaves. Geologically it concerns the same problem discussed in petrology as Harker's marscoite, i.e. the same rock as a dyke as well as an enclave in a granitoid. This phenomenon was first considered in CBP by Fiala (1943), recently by Palivcová (in print). Subvolcanic character and analogy of lamprophyres and enclaves has been recently evidenced by Barnes (1987) in some Californian massifs (nor ocellar hybrids are missing in this association — see following point). This problem represents again a variety of the Sederholm's effect. It should be noted that this case does not concern "relict dykes" (though such events also occur in CBP) nor the analogy with the dyke-looking bodies described by Ramsay (1967) in the Alpine granitoids which originate by extreme shear stretching of the mafic enclaves

Fig. 11. A swarm of various microgranular (hornblende ± biotite ± quartz microdioritic) mafic enclaves in tonalites (granodiorites) of the Sázava type. Teletín quarry, Central Bohemian Pluton. The same loc. as Fig. 8.

(we thank for notice to Dr. R a j l i c h). The case in CBP concerns typical young mafic dykes; having a similar mineralogical as well as textural character, the dykes and the enclaves differ in deuteric alteration, which is much greater in younger dykes than in the fresh (recrystallized) enclaves.

"Antichilled" contacts (margins, edges, selvedges) of mafic rocks in granitoids and their special textures. The problem concerns fine-grained, usually darker thin zones at the endocontact of mafic bodies and mafic enclaves in granitoids. It entered into the history of the granite problem as a well-known and strongly discussed problem of "chilled and baked edges" between magmatists and transformists (especially B a i l e y, 1947; M c I n t y r e — R e y n o l d s, 1947; W a g e r — B a i l e y — R e y n o l d s, 1953 and many others). There exist various mafic margins of various origin in endocontacts as well exocontacts of mafic rocks and microgranular enclaves in granitoids (B i s h o p, 1963). (E.g. ultramafic almost monomineral margins consisting of hornblende and/or biotite which were often referred to in favour of a "basic front" may very probably represent recrystallized zones of deformation at the boundaries of the enclave). Here, we shall deal only with these margins which have the signs of chilling. Because the mafic margins occur at the endocontacts of the basic

rocks and enclaves and not at the endocontact of the granitoids where we would expect them, the term "antichilled, pseudochilled" was used by some authors. We shall speak about "chilled margins, chilled contacts" since we assume that their textures prove the chilling. These current textures and features of chilling in the chilled margins are especially the following: the *needle-like texture* (often with skeletal and hollow crystals), *subvariolitic (fine spheroidal) texture, poikilitic texture, ocellar texture* and *textures with patchy and melted plagioclases.* Some of them have been shown and will be shown in separate papers. Attention will be paid here to the ocellar texture and patchy plagioclases which are assumed by us to be of prime importance for the considerations of the basic-acid plutonic rocks relations. Both phenomena are highly controversial, not clear and sometimes enigmatic. Some hypotheses led to questionable conclusions (see e.g. Hanuš — Palivcová, 1969, 1971; comments of Angus, 1971) on their origin though the geological process deduced from them (i.e. the original volcanic-subvolcanic character of basic rocks) seems to be highly justified. Some problems of these intricate phenomena will be shortly illustrated in some figures.

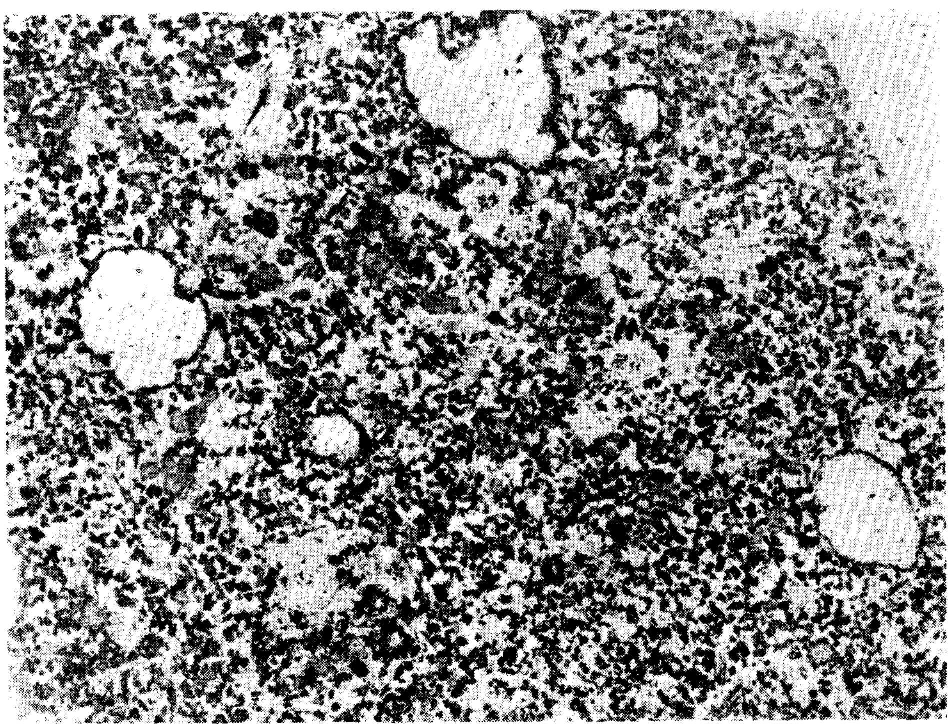

Fig. 12a. Fine-grained ocellar hornblende microdiorite from the outmost marginal chilled edge of a hornblende gabbroid body close to the contact with coarse-grained granite. Kaliště E of Milín, Central Bohemian Pluton. Note small and large, irregular and idiomorphic quartz ocelli as well as irregular filled plagioclases with dark hornblende cores. Without polarizer, enlarg. 3×, photo V. Matějková. Thin section 0-1081.

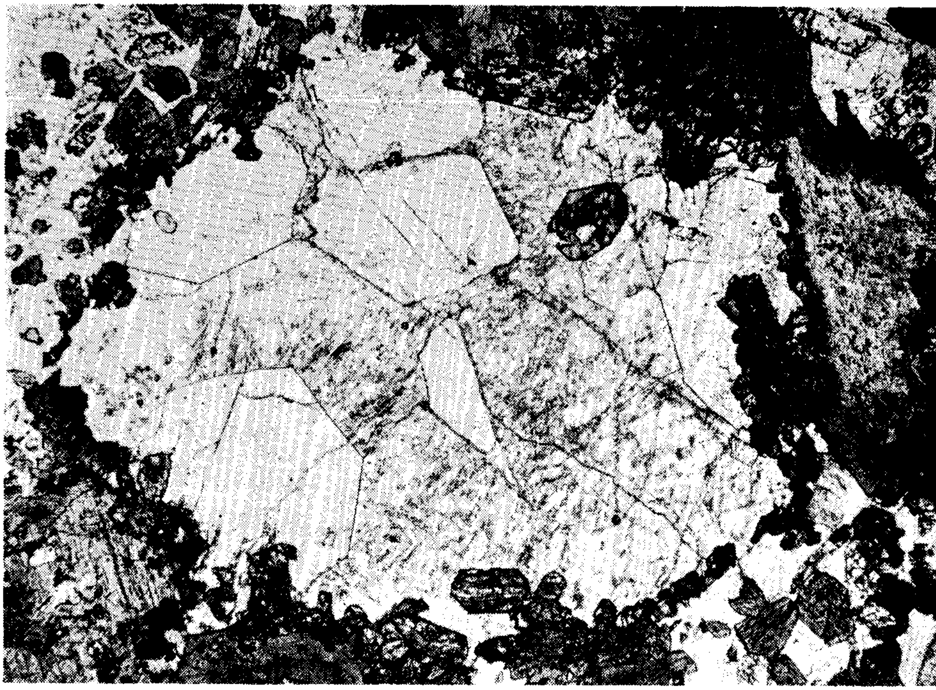

Fig. 12b. Detail of an ocellus from an analogous chilled rock as in Fig. 12a. Hexagonal shape is outlined by thin (dark) pyroxene rim, the pseudomorphose consists of idiomorphic quartzes in microcline (micropegmatite). Dubenecká hora near Smolotely E of Milín, Central Bohemian Pluton. Without polarizer, elarg. 14×, photo V. Matějková. Thin section 27-439.

Ocellar texture can be well seen in Fig. 12a in a very fine-grained microdioritic chilled zone of a small basic body. Former, they were noted as "bird's eyes". The accumulation of ocellar quartz which is the dominant mineral in ocelli, may attain about 25 % of the rock (see Fig. 2 in Palivcová, 1978). These quartzes are often similar to those of the surrounding granite in size and shape. Quartz ocelli are a foreign material in the mafic rock. Reaction margins of mafic minerals (consisting often of pyroxene in otherwise hornblendic rock) irregular shapes as well as crystallographic forms of quartzes are well visible. The genetic problem of them is best seen in Fig. 12b. The pseudomorphous character of the ocellus is here evidenced: aplopegmatitic material as well as hydrothermal minerals in other cases (calcite, epidote, sphene, pyrite etc.) may fill the crystallographic shape of the ocellus. Some other examples of ocelli were described and discussed in the papers of Hanuš, Palivcová, and Palivcová cited above. Best developed ocellar hybrid rocks occur at the norite-granite contact from Ploumanac'h (Thomas—Smith, 1932; Barière, 1972). An example from Ploumanac'h is demonstrated in Fig. 14. The authors explain the ocellar rocks as product of hybridization of basic rocks by the granite.

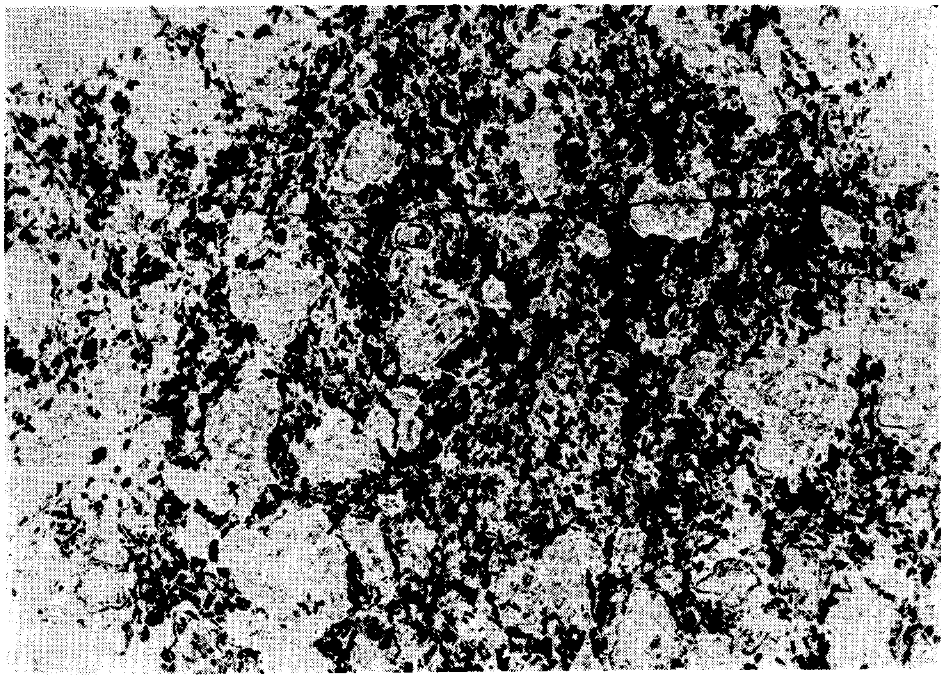

Fig. 13a.

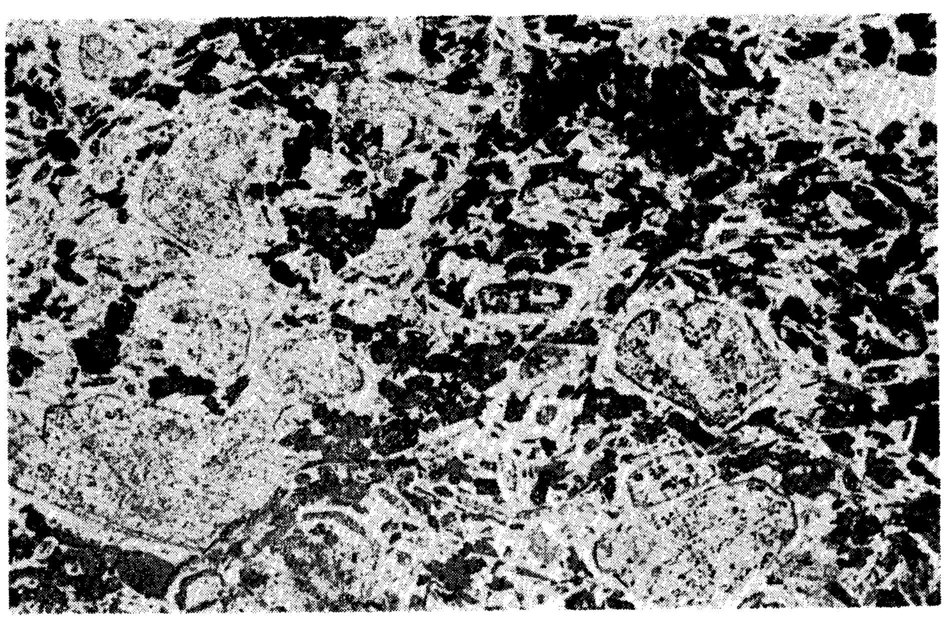

Fig. 13b.

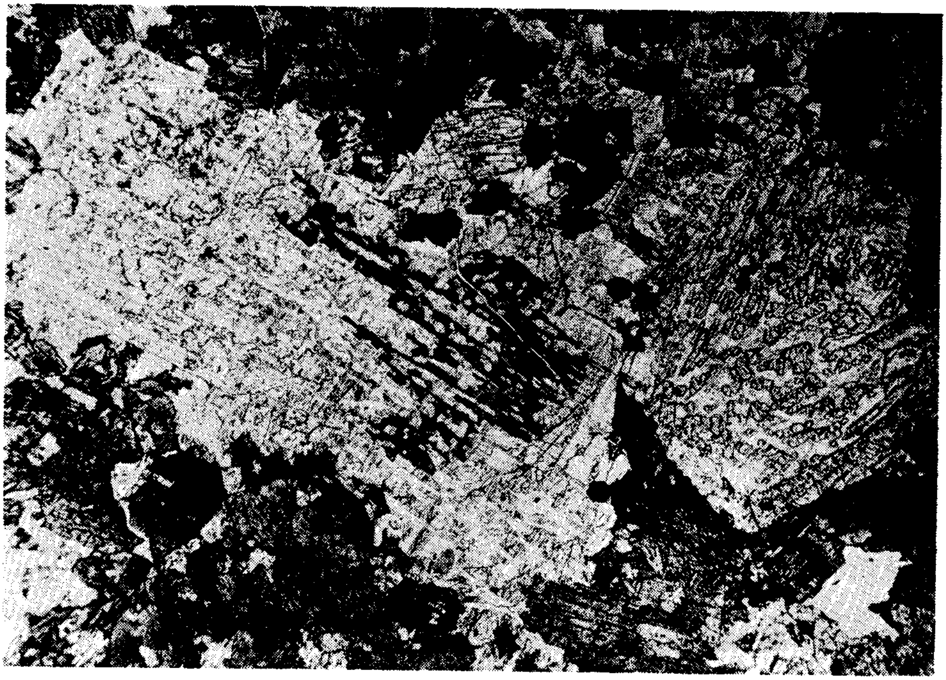

Fig. 13c.

Fig. 13a. Accumulation of patchy plagioclase phenocrysts in a fine-grained microdioritic chilled edge. The plagioclases are partly porphyritic like in Fig. 13b, partly rounded, especially in basic cores (see Fig. 13c). They are interpreted as melted and recrystallized phenocrysts. Draha near Smolotely, E of Milín, Central Bohemian Pluton. Without polarizer, enlarg. 3×, photo V. Matějková. Thin section 0-220.

Fig. 13b. Strongly patchy plaggioclase phenocrysts in a fine-grained chilled margin of small gabbroic body. A minute intergrown of basic plagioclase (bytownite to anorthite - grey) and clear andesine-oligoclase (to albite) is well seen. On the place of andesine, common hornblende (dark) may develop in the plagioclase. Nepřejov area, E of Milín, Central Bohemian Pluton. Without polarizer, enlarg. 30×, photo V. Matějková. Thin section 27-448.

Fig. 13c. Detail of melted plagioclases from Fig. 13a. Without polarizer, enlarg. 15×. Thin section 27-127.

Patchy plagioclases are the constant feature at the immediate contact of the chilled zone. They may accumulate here similarly as the ocellar quartz (Fig. 13a). Their association with ocellar texture and large very fine-grained poikilitic hornblende is frequent. They may be perfectly or less perfectly idiomorphic and then they remember some phenocrysts of intermediate volcanics in this case. Their structure may be very intricate as seen in Fig. 13b. These plagioclases may also be irregular or well-rounded. The latter stimulated once the discussion on s.c. "amygdaloidal gabbros" or "white gabbros" (Bailey — Reynolds, 1952). The plagioclases are often filled with minute

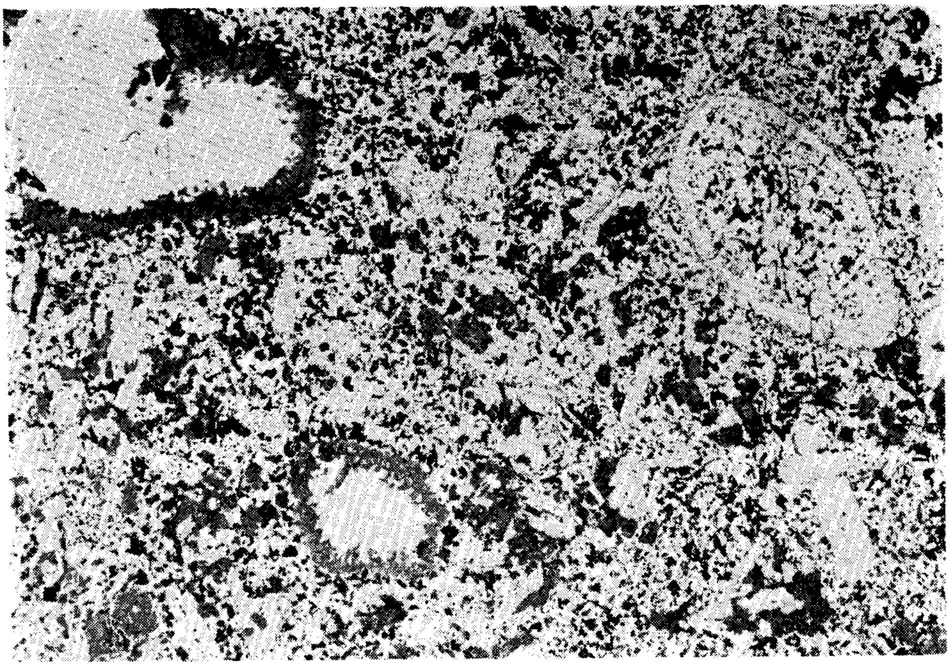

Fig. 14. Ocellar quartz and a rounded patchy filled plagioclase phenocryst in a very fine-grained rock of granodiorite porphyrite composition. Note irregular as well as idiomorphic form of quartz and rounded (melted) form of plagioclase phenocrysts. The rock corresponds to the finest facies of the ocellar hybrids from the norite-granite contact closest to the granite. The enclaves in the granite are of the same character. Trégastel-Ploumanac'h, Bretagne, Côte du Nord (Grève St. Anne). Without polarizer, enlarg. 7×, photo V. Matějková. Thin section 3-778.

mafic minerals or mafic cores (see Fig. 12a, 13b). The study of many chilled contacts with patchy and rounded plagioclases led us (Palivcová) to the conclusions that they are not amygdales but most probably melted megacrysts ("fritted" phenocrysts? cf. e.g. Braker, 1983; p. 269) of basic rocks. Their patchy structure may probably be due to the same less advanced melting process for their idiomorphic shape may remain preserved. An example of melted plagioclases is given in Fig. 13c, from Ploumanac'h locality in Fig. 14.

Didier (1973) paid rightfully much attention to the chilled contacts. He tried e.g. to explain the analogy of some microgranular enclaves with the chilled facies of the granite by breaking up of this consolidated chilled margin by a new portion of the granite magma. In the cases described above we cannot apply such an explanation: chilled contacts belong to the mafic rocks, not to the granite. We cannot discuss here the problem more thoroughly. We would like to note only, that we do not presume that the surrounding granite was able to melt the basic rock.

Contemporaneous crystallization of the main minerals in both mafic enclaves and surrounding granitoids. In magmatic conceptions the simultaneous crystallization and the analogous mineralogy is explained as the effect of surrounding granitoids on mafic enclaves. However the tonalitic and mafic granodioritic rocks are themselves interpreted as the assimilation product of mafic enclaves the dissolution of which in granitoids was many times described in the petrological papers. In situ contamination, hybridization of granitoids is emphasized (e.g. Vlašímský, 1986a). It is clear that the same rock cannot be simultaneously the cause and the product of the same process. Moreover there is a discrepancy between geological relations and crystallization of the mafic enclaves and granitoids. Geological relations indicate an age interval between these rocks, their crystallization process on the contrary their contemporaneity.

The relation of durbachitic rocks to Moldanubian migmatites and other granitoids of CBP. This is an other example of the contrasting relations which are not explainable providing one-stage evolution of durbachitic rocks. The relation concerns an other rock series than described above, i.e. lamproitic (syenite-monzonitic) series, shortly called durbachites. Two figures, one scheme according to Beneš (in Palivcová et al., 1968; Fig. 15) the other

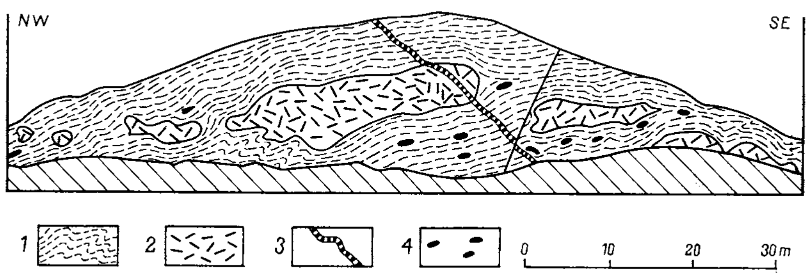

Fig. 15. Scheme of a geological exposure of durbachites enclosed in Moldanubian nebulites.
Explanation: 1 — Moldanubian nebulite; 2 — durbachite; 3 — aplitic dyke; 4 — mafic enclaves. According to Beneš (in Palivcová et al., 1968).

according to Holub—Žežulková (1978, Figs. 16a, b) clearly demonstrate the problem. In the first scheme, the durbachitic rocks (which are Variscan in age) were found in the form of large enclaves, blocks in Moldanubian (older) nebulites — a further new example of "petrified nonsense". On the other hand, dykes of durbachitic rocks penetrate into granodiorites of the CBP (Figs. 16a, b). These relations were the reason of a controversial interpretation of the relative age of durbachites which is repeated several times in the literature. Some authors even exclude the durbachites from the CBP due to their close relations to Moldanubicum (newly e.g. Zoubek ed., 1988, p. 242). The case of the durbachitic rocks is not easy to explain and is not answered satisfactorily. We note that Tauson et al. (1979) pointed out the analogy of the

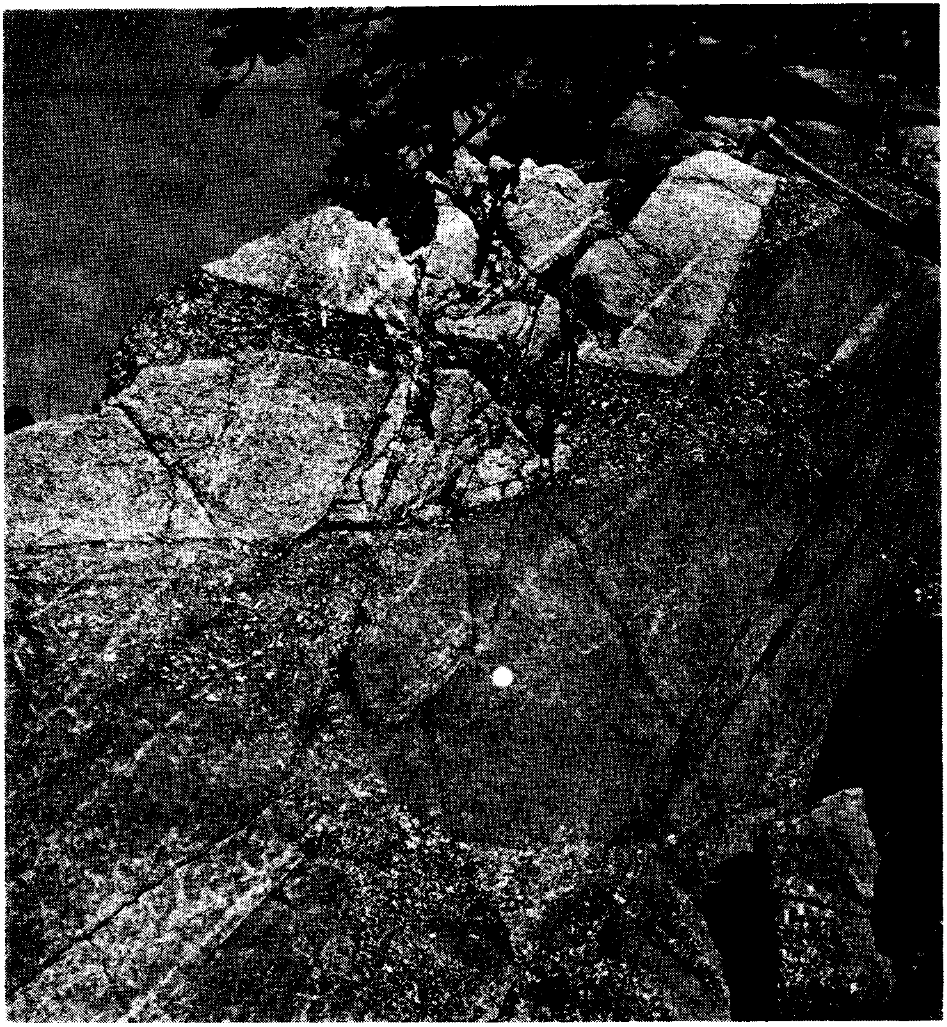

Fig. 16a. Intrusion of durbachites into Blatná granodiorites (light). In durbachites large dark fine-grained rounded enclaves are seen. They are often of the same composition as the groundmass of durbachites. From H o l u b — Ž e ž u l k o v á (Fig. 2, 1978). 3 km S of castle Zvíkov, Central Bohemian Pluton.

geochemistry of trace elements with alkalic volcanics. H a m e u r t (1967) interpreted durbachites of Vosges (vaugnerites) as hypabyssal transformed basic stocks.

In the similar inexplicable cases many authors like to search the way out in the convergency principle. Although it is certainly not possible to reject such an access in some cases, this principle should not hinder further research, especially if the rocks seem to be identical.

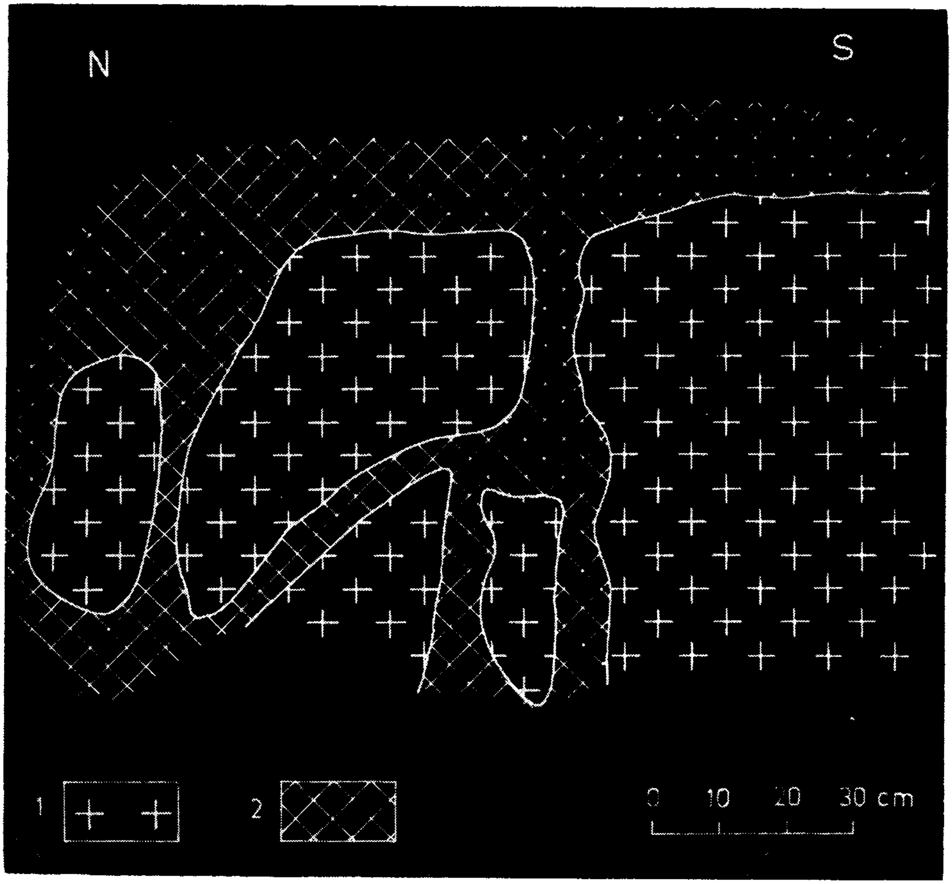

Fig. 16b. Scheme of a similar situation from an other exposure of the same locality. *Explanation:* 1 — Blatná granodiorite, 2 — durbachite. The same authors, Fig. 3.

It can be concluded that these intricate relations described above cannot be obviously explained during the simple and one-stage geological process of the surrounding granitoid formation. All the three possibilities were expressed as the explanation of the relations of granitoids to the basic rocks in magmatic models: the basic rocks are older, younger as well as contemporaneous with the acid rocks, in spite of the close similarily of all these basic rocks. Each of these possibilities can explain but some of these controversial features. A model is to be found which enables to elucidate simultaneously the majority of the controversial features described above. According to our opininon, in the CBP it is the following model: volcanic and subvolcanic rocks pierced an older rock complex; subvolcanic rocks formed chilled margins at their endocontacts. The older rock complex consisted of sediments as well as of volcanics (lavas, pyroclastics). Older intrusive as well as metamorphic rocks could be also present. We assume that coarse-grained basic rocks mostly represent subvolcanic intrusive members of this pre-Variscan complex, which could intrude in the form of dykes and stocks. During Variscan orogeny the whole complex was subjected to the granitization (definition see at the end of this paper).

Conclusions

As seen grom the foregoing chapter we are inclined to the model of the CBP origin by *reworking of really magmatic. i.e. volcanic-subvolcanic precursors with their sedimentary and volcanosedimentary surroundings* and with all features belonging to such a complex, especially *with intrusive subvolcanic members.* Almost all contrasting phenomena discussed above can be explain in this model. Some phenomena which have been hitherto explained due to effects of granitoids on basic rocks may be also explained in an opposite, more understandable direction, i.e. by the effects of basic rocks on the acid rocks (e.g. "antichilled" edges and their special complex textures etc.). There is no great difficulty to recognize the previous magmatic, i.e. volcanic-subvolcanic nature of basic rocks. It is, however, very difficult to find out the criteria for distinguishing the parent lithology of granitoids. An attempt to do this was newly presented by us on the example of CBP (in print).

Let us now to turn to the purpose of this paper, *to the term and definition of granitization.* From the reasons given in the examples of the CBP we are inclined to the idea that most granitoid bodies have never attained the state of advanced palingenic magma which would be able to differentiate, accumulate, assimilate or mix. If such features are present in plutonic complexes they can be regarded as overprinted features and effects of previous volcanic-subvolcanic rocks. Palingenic magma is a product of an advanced anatexis which is an abrupt process (see references in Mehnert, 1987b, p. 295). Advanced anatexis leads to volcanism and not to plutonism. The segregation of an anatectic magma in plutonic dimensions during orogeny when large open fractures hardly exist is an insuperable problem (Wickham, 1987).

Thus we prefer the model of the metamorphic recrystallization leading to the incipient anatexis. According to Hovorka — Suk (1981) only 10 % of the melt (according to other authors even less) is sufficient to acquire intrusive ability. From the point of view of this activity the rock will be a magmatic rock in magmatic models. From the point of view of 90 % of its recrystallization history, the rock is a metamorphic product. The term magmatic-metamorphic granite is clearly a question of a conventional definition which criterion will be prefered. Such a rock with a small amount of the melt will hardly be able to move to long distances. Moreover our knowledge of initial anatexis of massive magmatic rocks are unsufficient up to now according to our opinion. Moreover it is difficult to distinguish the state of the crystallization. Mehnert characterizes this problem in following words (1987b, p. 286): "All attempts to apply this principle (i.e. solid state crystallization against melt crystallization — authors' note) as discriminating proof have until now failed, since a crystallized melt bear the same characteristics as completely recrystallized solid rock" or better on p. 301: "The rocks formed by crystallization of *initial melt* (our italics) and those formed by transformation of solid rocks are primarily indistinguishable from each other, on principle".

This is the reason why we applaud for the term granitization, i.e. "granitization sensu lato", however in a definition slightly modified between those two given by Mehnert. According to Mehnert 1) granitization sensu stricto is a metasomatic process by which previous rocks are converted into granite (or granite looking rocks) without departing from the predominantly solid state; 2) granitization sensu lato is a comprehensive term for processes by which previous rocks are converted into granite — including melting, resolution or fluidization. According to us 3) granitization is a term for a metamorphic process and/or incipient stages of anatexis leading to formation of granitic rocks from pre-existing rocks. We point out "incipient anatexis"; advanced anatexis should not range with the term granitization. Neither the term "selective mobilization" (which accentuates migration) nor the term "ultrametamorphism" (which remembers high-grade metamorphism) are the suitable description of the process of granitoid formation. Shallow levels (in situ or almost in situ) and low degrees of isochemical medium-grade metamorphism together with deformation effects during orogeny are probable the most favourable conditions for this process. In this respect and with this restriction — i.e. granitization as in principle isochemical predominantly metamorphic process in orogenic conditions, in high levels (in situ or almost in situ) and with short-distance displacements — our conception of granitization differs from the most general most large definition of Raguin (1976, p. 9); i.e. "l'évolution d'un espace qui est devenu, à partir d'une certaine époque, un massif de granite, quelque soit le processus suivi, sur place ou avec certain déplacements, d'une partie plus ou moins importante de la matière."

If we admit initial stages of anatexis, the question obviously arises where are the limits to advanced anatexis. Chapell et al., 1987 made recently an attempt to solve the problem by aid of the idea of so called "restite model", an idea previously formulated by Mehnert in European petrology. In the model of the authors, relatively homogeneous "clean" granites may represent progressive stages of "clearing" from restite by advanced anatexis. The authors summarize ten interesting criteria for distinguishing more or less advanced anatexis. However, we find an other conclusion and observation of the authors more important and decisive for the granite origin: the same restite model is applied by them for the origin of associated related volcanics. If so, this analogy may be explained in our view in two following ways: granites that originated by advanced anatexis — i.e. from the melt — may be a) hypabyssal parts of feeders, necks of volcanics, subsequently recrystallized or not, b) recrystallized volcanogenic products. Thereby, at least for the second case, the term "granitization" is once more desirable.

To sum up: We deeply agree with Mehnert that long distance metasomatic granitization (with long distance import and migration)i.e. granitization s.s. according to him should be rejected in the formation of granitic complexes. We defend however the geological significance of large scale granitization s.l. in the third definition given above. Large scale isochemical metamorphic granitization should not be rejected. On the contrary, it may be presumably the most important process in granitoid genesis of most plutonic complexes in orogenic belts. Obviously we are aware of the fact that no one model of granite origin could be deprived of subjective views. We would like to replace it by an other one if it will enable to explain the phenomena shown in the preceding chapter more credibly.

Acknowledgements: The authors would like to express their sincere thanks to academician B. Cambel for his critical discussion and comments. Further they thank to their colleagues Dr A. Dudek DrSc., Dr J. Chaloupský CSc., Dr F. Holub, Dr P. Rajlich and Dr J. Synek for their readiness to lend the photos and to Dr A. Špačková CSc. for the translation.

Translated by Dr. A. Špačková, CSc.

Note in print. A paper of Ebertz — Nicholls (1988) (Geol. Rdsch. 77, 3, pp. 713—736) deals newly with analogous phenomena at the basic - acid plutonic contact as described above. The authors try to explain ocellar quartzes and feldspar megacrysts in microgranular enclaves in favour of "magma mingling" model. Accordingg to our view, the difficulties and constraints on this explanation are wel seen from the paper: the granite that consolidated up to the quartz phase would hardly be able to mix with the basic magma.

REFERENCES

ANGUS, N. S., 1971: Comments on the origin of ocellar quartz gabbros. Lithos (Oslo), 4, pp. 381—388.

BAILEY, F. B., 1947: Chilled and "baked" edges as criteria of relative age. Geol. Mag. (Hertford), 84, pp. 126—128.

BAILEY, F. B. — REYNOLDS, D. L., 1952: So-called amygdaloidal gabbro Skye. Geol. Mag. (Hertford), 89, pp. 369—375, 376—379.

BARKER, D. S., 1983: Igneous petrology. Prentice Hall Inc., New Jersey, 417 pp.

BARNES, C. G., 1987: Mineralogy of the Wooley Creek Batholith, Slinkard Pluton and related dykes, Klamath Mountains, northern California. Amer. Mineralogist, (Washington D.C.), 72, pp. 879—901.

BARRIÈRE, M., 1972: Hybridisation de roches basiques par un granite porphyroide dans le massif de Ploumanac'h (Côtes du Nord). C.R. hebd. Séanc. Acad. Sci., Sér. D. Sci. natur (Paris), 274, pp. 983—986.

BENEŠ, K., 1971: Flow and fracture fabrics and their relationship in some granitic bodies of the Bohemian Massif. Krystalinikum (Praha), 8, pp. 149—166.

BISHOP, A. C., 1963: Dark margins at igneous contacts. Proc. Geologists Assoc. (Colchester), 74, 3, pp. 289—300.

CONDIE, K. C., 1981: Archean greenstone belts. Developments in Precambrian geology. Elsevier, Amsterdam, 3, 434 pp.

CHALOUPSKÝ, J., 1989: Geological evolution of the Krkonoše—Jizerské hory crystalline complex in the Precambrian and Early Palaeozoic. In: Chaloupský, et al. (eds.) — Geologie Krkonoš a Jizerských hor. Prague.

CHAPPELL, B. W. — WHITE, A. J. R. — WYBORN, D., 1987: The importance of residual source material (restite) in granite petrogenesis. J. Petrology (Oxford), 28, pp. 1111—1138.

DIDIER, J., 1973: Granites and their enclaves. Elsevier, Amsterdam, 393 pp.

DIDIER, J., 1987: Contribution of enclave studies to the understanding of origin and evolution of granitic magmas. Geol. Rdsch. (Stuttgart), 76, pp. 41—50.

DUDEK, A. — FEDIUK, F., 1957: Bazické pecky a fluidální jevy v granodioritu při okraji středočeského plutonu u Teletína. Sbor. k 80-tinám akad. F. Slavíka, (Praha), pp. 97—111.

FIALA, F., 1943: Kontaktní a intruzivní horniny silničního profilu u Zbořeného Kostelce. Věst. Král. Čes. Společ. Nauk (Praha), 1.

FIALA, J., 1986: Ověření prognózy zlata v Českém masívu — Kašperské hory. Geologická zpráva. Závěrečná zpráva HS pro Geoindustrii Praha. Manuscript, Praha 33 pp.

HAMEURT, J., 1967: Les terrains cristallins et crystallophylliens du versant occi-

dental des Vosges moyennes. Mém. Serv. Carte géol. Alsace-Lorraine, (Strassbourg), 26, pp. 1—402.
HANUŠ, V. — PALIVCOVÁ, M., 1969: Quartz gabbros recrystallized from olivine bearing volcanics. Lithos (Oslo), 2, pp. 147—166.
HANUŠ, V. — PAVLICOVÁ, M., 1971: Presence and significance of amygdules in hornblende gabbros. Krystalinikum (Praha), 8, pp. 27—43.
HOLUB, F. — ŽEŽULKOVÁ, V., 1978: Relativní stáří intruzivních hornin ve středočeském plutonu na Zvíkovsku. Věst. Ústř. Úst. geol. (Praha), 53, pp. 289—297.
HOVORKA, D. — SUK, M., 1981: Geochémia a genéza eruptívnych a metamorfovaných hornín. Acta Univ. Comen., (Bratislava), 163 pp.
KLOMÍNSKÝ, J., 1969: Krkonošsko-jizerský granitoidní masív. Sbor. geol. Věd, Geol. (Praha), 15, 119 pp.
KRUPIČKA, J., 1948: Petrologická studie ze severovýchodního okraje středočeského plutonu. Sbor. Ústř. Úst. geol. (Praha), 15, pp. 259—338.
LOBKOVIC, M., 1987: Střižné postižení hornin pestré skupiny a středočeského plutonu v okolí Votic. Manuscript PFUK, Praha.
MARMO, V., 1971: Granite petrology and the granite problem. Elsevier, Amsterdam, 244 pp.
McINTYRE, D. B. — REYNOLDS, D. L., 1947: Chilled and "baked" edges as criteria of relative age. Geol. Mag. (Hertford), 84, pp. 61—69.
MEHNERT, K. R., 1987a: 50 Jahre Granitforschung. Geol. Rdsch. (Stuttgart), 76, pp. 1—14.
MEHNERT, K. R., 1987b: The granitization problem — revisited. Fortschr. Mineral. (Stuttgar), 65, pp. 285—386.
PALIVCOVÁ, M., 1965: The Central Bohemian Pluton — a petrographic review and an attempt at a new genetic interpretation. Krystalinikum (Praha), 3, pp. 99—131.
PALIVCOVÁ, M., 1966: Dioritization of metabazites of the spilit-keratophyre association in the north-eastern contact of the Central Bohemian Pluton, the Islet Zone and the Moldanubicum. Paleovolcanites of the Bohemian Massif. Praha, pp. 61—74.
PALIVCOVÁ, M., 1978: Ocellar quartz leucogabbro Central Bohemian Pluton and genetic problems of ocellar rocks. Geol. Zbor. Geol. carpath. (Bratislava), 29, pp. 19—41.
PALIVCOVÁ, M., 1984: Basic series of an "Andinotype batholitic association" in the Variscan Central Bohemian Pluton. Geol. Zbor. Geol. carpath. (Bratislava), 35, pp. 39—60.
PALIVCOVÁ, M., in press: Mikrostruktury bazických uzavřenin a žilných hornin v okrajovém typu středočeského plutonu (šachta Radětice na Příbramsku). Sborník Příbramska. Příbram.
PALIVCOVÁ, M. — BENEŠ, K. — ZOUBEK, V., 1968: Guide to excursion 29AC: Genesis of granitoids in the Bohemian Massif. Intern. geol. congr. XXIII sess. Prague.
PALIVCOVÁ, M. — LEDVINKOVÁ, V. — WALDHAUSROVÁ, J. — ŽEŽULKOVÁ, V., 1988: Kambrické slepence jako substrát kozlovického granodioritu a přilehlého moldanubika (sz. od Kasejovic). Čas. Mineral. Geol. (Praha), 33, pp. 171—186.
PATOČKA, F., 1979: Granitizace v uzavřeninách z granitoidů vrančického rudního revíru. Čas. Mineral. Geol. (Praha), 24, pp. 39—50.
PROKHOROV, K. V. – KRASIVSKAYA, I. S. – PALIVCOVÁ, M. – BORONIKHIN, V. A., 1983: Genezis vkraplennikov kalinatrovogo shpata v durbakhitakh Srednecheskhogo plutona. Sborn.: Korrelyatsiya magmaticheskikh porod Chekhoslovakii i nekotorykh rayonov SSSR. Nauka, Moscow, pp. 79—90.
RAUGIN, E., 1976: Géologie du granite. Masson, Paris 3eme ed. 276 pp.
RAJLICH, P., 1987: Variszische duktile Tektonik im Böhmischen Massiv. Geol. Rdsch. (Stuttgart), 76, 3, pp. 775—786.
RAJLICH, P. — SYNEK, J. — ŠARBACH, K. — SCHULMANN, K., 1986: Hercynian thrust-related shear zones and deformation of the varied group on the contact of granulites (southern Moldanubicum, Bohemian Massif). Geol. Rdsch. (Stuttgart), 75, pp. 665—683).
RAJLICH, P. — SCHULMANN, K. — SYNEK, J., 1988: Strain analysis of conglomerates in the Central Bohemian shear zone. Krystalinikum (Praha), 19, pp. 119—134.
RAMSAY, J. G., 1967: Folding and fracturing of rocks. McGraw Hill, New York.

RÖHLICHOVÁ, M., 1964: Petrographie und Genese der durbachitischen Gesteine (Typus Čertovo břemeno) in der Umgebung von Písek. Acta Univ. Carol., Geol. (Praha), 1964, pp. 207—221.

SCHERMERHORN, L. J. G., 1987: The Hercynian gabbro-tonalite-granite-leucogranite suite of Iberia: Geochemistryy and fractionation. Geol. Rdsch. (Stuttgart), 76, pp. 137—145.

SPENCER, F., 1938: The potash-soda-feldspars, II: Some applications to petrogenesis. Mineral. Mag. (London), 25, pp. 87—118.

TAUSON, L. V. — KOZLOV, V. D. — PALIVCOVÁ, M. — CIMBÁLNÍKOVÁ, A., 1977: Geokhimicheskiye osobennosti granitoidov srednecheshskogo plutona i nekotoryie voprosy ikh genezisa. Sbor.: Opyt korrelyatsii magmaticheskikh i metamorficheskikh porod. Nauka, Moscow, pp. 145—161.

THOMAS, H. H. — SMITH, W. C., 1931: Xenoliths of igneous origin in Trégastel-Ploumanac'h granite, Côte du Nord, France. Quart. J. Geol. Soc. (London), 88, pp. 274—296.

URBAN, K., 1931: Geologické poměry území na soutoku Otavy a Vltavy. Sbor. St. geol. Úst. Čs. Republ., Odd. geol. (Praha), 9, pp. 109—187.

VAJNER, V., 1966: Nález reliktní sedimentogenní textury v moldanubických pararulách. Čas. Mineral. Geol. (Praha), 11, pp. 47—49.

VLAŠÍMSKÝ, P., 1973: Pně bazických a tonalitových hornin v exokontaktní zóně středočeského plutonu na Příbramsku. Acta Univ. Carol., Geol. (Praha), pp. 179—195.

VLAŠÍMSKÝ, P., 1976: Petrogeneze a geochemie hornin v příbramské rudní oblasti. Manuscript, Geofond, Praha.

VLAŠÍMSKÝ, P., 1986: Stavba středočeského plutonu v důlních dílech v okolí Milína. Zp. geol. výzk. v r. 1984 (1), Praha, pp. 220—222.

VLAŠÍMSKÝ, P., 1986: Příspěvek k diskusi o karbonských arkózách a hloubce denudace variských plutonů. Čas. Mineral. Geol. (Praha), 31, 4, pp. 429—434.

VLAŠÍMSKÝ, P., 1989: Příspěvek k otázce kambrického substrátu v sz. části středočeského plutonu. Čas. Mineral. Geol. (Praha), (in press).

WAGNER, L. R. — BAILEY, E. B. — REYNOLDS, D. L., 1953: Basic magma chilled against acid magma. Nature (London), 172, pp. 68—70.

WICKHAM, S. M., 1987a: Crustal anatexis and granite petrogenesis during low-pressure regional metamorphism: The Trois Seigneurs massif, Pyrenees, France. J. Petrology (London), 28, pp. 128—169.

WICKHAM, S. M., 1987b: The segregation and emplacement of granitic magmas. J. Geol. Soc. (London—N. Ireland), 144, pp. 281—297.

ZOUBEK, V. et al. (ed.), 1988: Precambrian in younger fold belts. Wiley, Chichester, 885 pp.

Manuscript received March 2, 1989.