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Ocellar Mafic Rocks of I-Type and A-Type Plutonic Series (Adamello, Brittanny, Central Bohemian Pluton)

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24 Text-Figures, 2 Tables

Italy
France
Czech Republic
Adamello
Ploumanac'h
Central Bohemian Pluton
Granitoids
Ocelli
Petrography
Geochemistry

Contents

Ocelli-führende mafische Gesteine aus plutonischen Serien vom I- und A-Typus (Adamello, Bretagne, Zentralböhmischer Pluton)

Zusammenfassung

Wir beschreiben Ocelli-führende mafische Gesteine in Granitoidmassiven von zwei verschiedenen Gesteinsserien. Ocelli, d.h. subcentimetrische felsische „Äuglein“ mit mafischen Reaktionssäumen, werden heute für ein wichtiges gesteinstrukturelles Merkmal der Magmenmischung gehalten. Beispiele aus zwei granodioritisch-tonalitischen Massiven des I-Typus (das italienische Adamello-Massiv, der Mittelböhmische Pluton) und aus zwei granitischen Ringmassiven des A-Typus (das französische Massiv von Ploumanac'h, das Říāny-Massiv im Mittelbohmischen Pluton) werden vorgelegt. Die breite strukturelle und geochemische Mannigfaltigkeit der Ocelli-Wirtsgesteine wird gezeigt und die Tatsache wird betont, daß die Ocelli nicht nur in hybridisierten Gliedern, sondern auch in typischen Gabbroiden (Hornblende-Pyroxengabbros, Olivinbiotitnoriten) vorkommen. Die Zusammensetzung der Ocelli scheint durch die Zusammensetzung nicht nur der benachbarten granitischen Gesteine, sondern auch der Nebengesteine der Granitoidmassive beeinflußt zu werden.

Abstract

Ocellar mafic rocks of two different rock series are demonstrated. Examples of tow I-type granodiorite-tonalitic massifs (the Adamello batholith and the Central Bohemian Pluton), and two A-type granitic massifs (the Ploumanac'h body in Brittany and the Říāny ring body in the Central Bohemian Pluton) were chosen for illustration. The variously textured host rocks of ocelli and their various geochemistry are shown. Emphasis is given to the petrography of the host rocks of ocelli: ocelli occur not only in mafic enclaves and intermediate hybrids, but also in typical gabbroic members (hornblende-pyroxene gabbros, norite) of the series. Analogies and differences in ocelli development in both series are shortly discussed. The compositions of ocelli in mafic enclaves and bodies seem to reflect not only the compositions of the surrounding granitoids, but also that of the envelope of the plutonic massifs.

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1. Introduction

During the last ten years, King's (1964) view claiming that ocelli in the mafic/felsic rock associations represent a common phenomenon and that more informations on the subject will be put forward, has been confirmed.

The ocelli are small, mostly quartz or quartz/feldspar bodies (up to ½–1 cm in size), usually of rounded shapes and rimmed by mafic coronas. Before the publication of King's work, the ocelli were only occasionally reported in mafic hybrid rocks (particularly enclaves) of granitic complexes. They were considered to be rather exceptional, accidental and a genetically enigmatic phenomenon. The ocelli in enclaves represent a conflicting phenomenon similar to that of K-feldspar megacrysts because the quartz material is thought to be derived from the surrounding granitoids. In places, the quartz ocelli occur together with these K-feldspar megacrysts. In spite of this, they have not attracted such fervent attention as the latter (see in Vernon, 1986). The reason may be that they were often unnoticed. King (1964) and Walker & Skelhorn (1966) listed some examples of them.

In the literature, there is a considerable variety of interpretations trying to explain the existence of the quartz ocelli. We summarized the main examples of ocelli occurrences and their interpretations (Palivcová et al., in print). Some of these occurrences support, with more or less reliability, an idea of a heterogeneous origin of these textures in different geological environments. Recently, ocelli attracted new attention in the context of mechanical magma mixing (mingling) and in the context of the hybrid character of the host rocks (Vernon, 1990). The xenocrystic and microxenolithic derivation from the surrounding granitoids (e.g. Didier, 1987, p. 44; Frost & Mahood, 1987, p. 275; Zorpi et al., 1989, p. 318; Castro et al., 1990, p. 13; Sabatier, 1991, p. 77; Blundy & Sparks, 1992, p. 1056; Barnes et al., 1992, p. 123) is the most favoured explanation of the ocelli origin.

We noted some constraints to this interpretation concerning especially the mechanism of the ocelli incorporation into mafic rocks in plutonic environment (in print, op. cit.). We also pointed out that some identical examples of these textures have been explained variously and that they have prompted different interpretations about the origin of their host rocks. The terms ocelli, mixing, mingling, hybridization, enclaves etc. are used here as defined in the paper cited above.

There is yet a very insufficient knowledge about the variability of ocelli in various rock associations and in various types of the host rocks. This may be due to the fact that a more detailed insight into their features requires a great deal of time-consuming field and laboratory work. In particular, numerous large-sized thin-sections are needed to reveal some regularities.

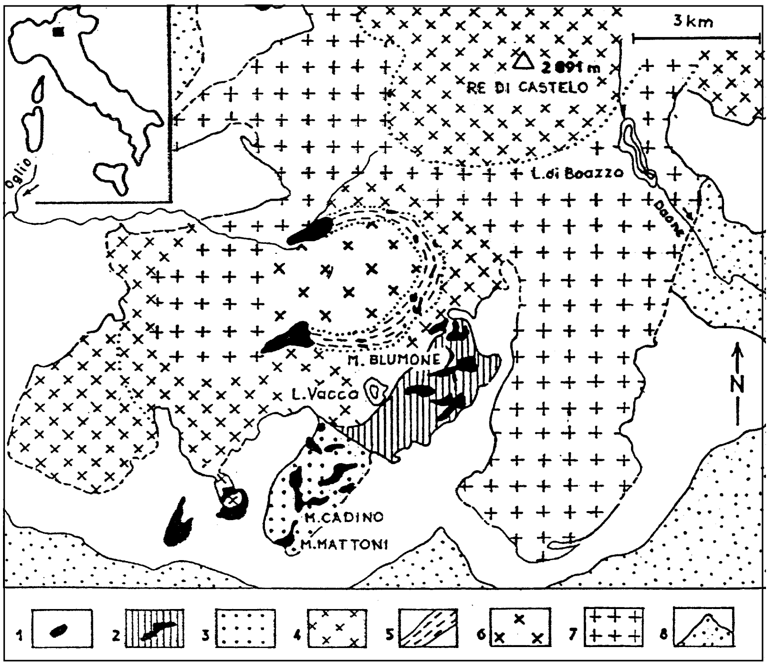
The aim of the paper is
1) to show the variability of the host rocks of ocelli on two examples in two different series, and
2) to summarize the analogies and differences found in them.

The attention is rather focused on the first point. The detailed description of the ocelli themselves will be dealt in another paper.

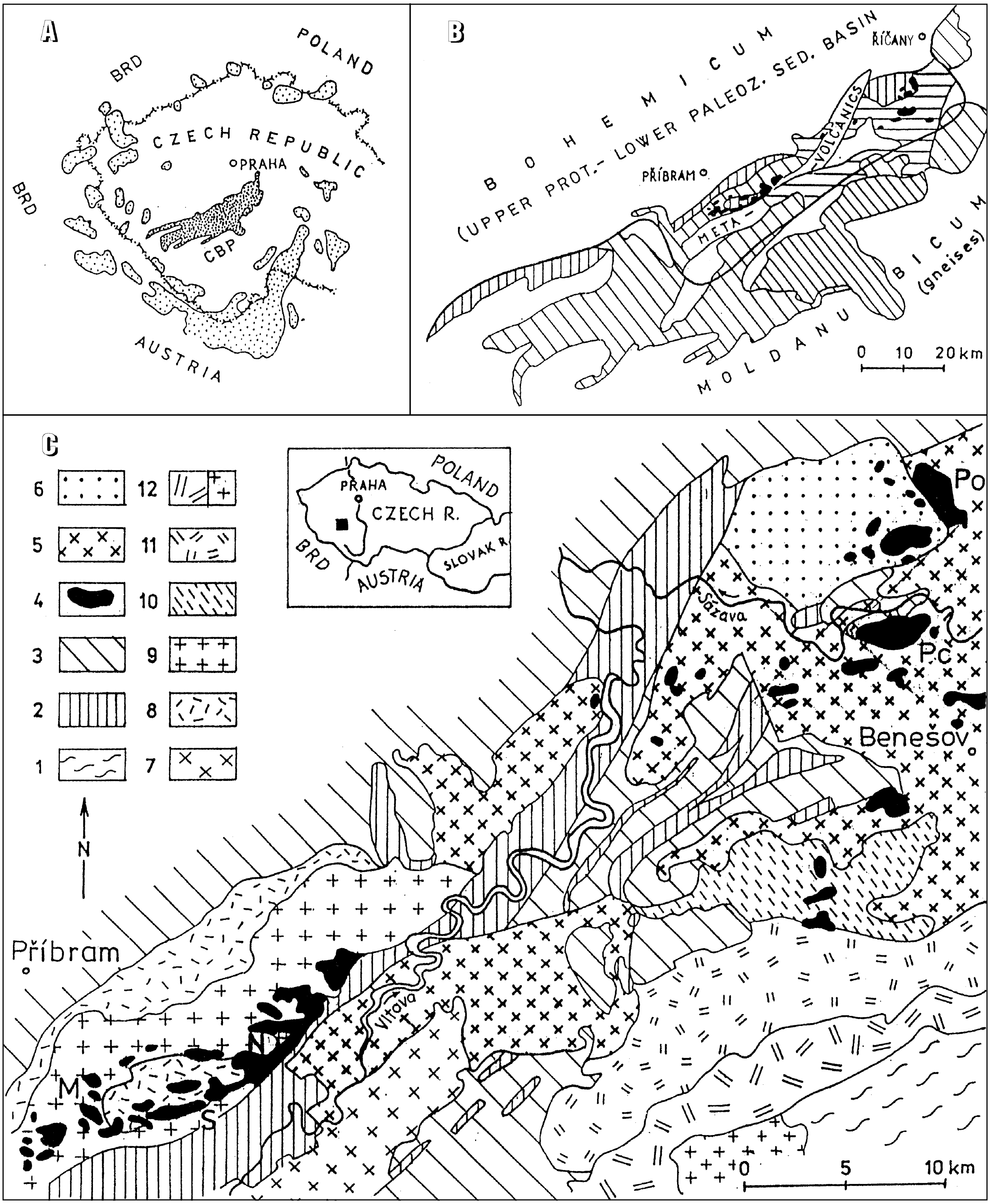
The study is based on several years systematic sampling of the ocellar rock material by workers of the Geological Institute of the Czechoslovak Academy of Sciences. About 500 large-sized and more than 1000 normal-sized thin-sections of these rocks are at disposal by the authors.

2. Ocellar Mafic Rocks in I-Type Granitoid Massifs

Two examples of I-type massifs of similar granitoids but of different ages are compared: the Variscan Central Bohemian Pluton (CBP) and the Neoid Alpine Adamello massif, the latter being recently called "batholith" by some authors (Brack, 1985; Ulmer et al., 1985). The rocks of granodiorite/tonalite I-type series are prominent members of both massifs. In the CBP, these rocks (so called "Sázava type" granitoids) occupy the area of about 710 km² (Svoboda ed., 1983). The Adamello massif (nearly 700 km² – Kagami et al., 1991, p. 14331) consists almost entirely of various types of these rocks. In both massifs, however, these granitoids contain minor or major additions of crustal material (Palivcová et al., 1989b and Callegari, 1985, Kagami et al., 1991, respectively). The areas discussed are those of the central to the northwestern part of the CBP (319–362 Ma, Bergner et al., 1988, p. 310), and the southernmost and the oldest unit of the Adamello massif (40 Ma, Del Moro et al., 1983) called Re di Castello massif (Text-Figs. 1 and 2). Some similarities of these



Text-Fig. 1.
Satellitic mafic bodies in the southern part of the Re di Castello massif of the southern part of the Adamello batholith. Simplified according to Brack (1985) and Ulmer et al. (1985), pp. 150, 174, respectively.
1 = gabbros and diorites; 2 = gabbros, diorites and tonalites of the Cornone Blumone complex; 3 = Val Fredda leucotonalite (trondhjemite); 4 = various types of tonalites of the Re di Castello massif; 5 = Listino ring structure; 6 = Listino granodiorite; 7 = various types of the granodiorites of the Re di Castello massif; 8 = Lower Permian to Lower Triassic (stippled) and Middle/Upper Triassic rocks (mostly marbles, dolomitic marbles: white) of the Southern Alps.



Text-Fig. 2.
a = Central Bohemian Pluton in the Bohemian massif; b = Steep gravimetric gradient – a geophysical boundary between two different plates (blocks), Bohemicum and Moldanubicum. Granitoids of the CBP are divided according to their geochemical features in four groups (PALIVCOVÁ, et al., 1989b), c = Satellitic mafic bodies in the Central Bohemian Pluton in the region between Benešov and Milín.
The scheme according to the Geological map of Czechoslovakia 1:200.000, sheet Tábor (1963). Some basic bodies known today are added.
1 = Moldanubian gneisses; 2 = Upper Proterozoic metavolcanics; 3 = Upper Proterozoic to Lower Palaeozoic sediments; 4 = basic bodies in the CBP; 5–9 = granitoids belonging to the Bohemicum according to their geochemistry (PALIVCOVÁ, et al., 1988b): 5 = Sázava type tonalites, 6 = light-coloured biotite granodiorite to trondhjemite (Požáry type), 7 = various hornblende-biotite granodiorites, 8 = coarse-grained porphyritic biotite (hornblende) granodiorite of “marginal type”, 9 = biotite-hornblendegranodiorite (Milín type, i.e. mineralogically, and geochemically distinct part of the Blatná type – see LEDVINKOVÁ, ed., 1994); 10–12 = granitoids belonging according to PALIVCOVÁ et al. (1989b) to the Moldanubian plate (block): 10 = cordierite-bearing granitoids and migmatites, 11, 12 = granodiorites, melagranodiorites, monzodiorites rich in biotite (lamproids). M = Milín; S = Smolotely; N = Nepřejov; Pc = Pecerady gabbroic body; Po = Popovice gabbroic body.

massifs, especially those of their basic rocks, are pointed out by the above authors and they are shortly summarized below. In the areas studied, the main differences between both massifs are in the character of their wall rocks: pelitic and psammitic metasediments with metavolcanics in the CBP, and predominantly calcareous cover lying on Permian metasediments and metavolcanics in the envelope of the southern part of the Re di Castello massif.

Basic series are characteristic features of both massifs. They form satellitic bodies. In the regions discussed, the basic bodies display the following features:

1) The satellites occupy a position at the periphery of the massif, at a close endocontact and exocontact between the granitoids and the envelope, or at the boundaries of granitoid intrusions. Such a geological setting is a general feature of satellitic basic bodies in granitoid complexes, and this is particularly obvious in the Adamello massif.
2) The satellitic bodies are characterized by a high degree of individuality, as far as the geological structure and petrography is concerned. They may be simple, but most often they are very complex and built by repeating basic to intermediate members of the series in various combinations. In some Adamello bodies, layered structure was found (ULMER et al., 1985).
3) The "wet" basic series, i.e. rich in hornblende, is a characteristic feature of these bodies. Entire differentiation series from ultramafic rocks (olivinehornblendite) through hornblende-pyroxene gabbro and hornblende diorites to quartzdiorites and melatonalites is developed (PALIVCOVÁ, 1984). This hornblende series is typical for basic bodies from the Val Fredda region (Mte Mattoni, Cadino, Frerone). ULMER et al. (1985) called this series "Mte Mattoni series" after the most characteristic rock type, hornblende-phyric pyroxene gabbro of the Mte Mattoni. PALIVCOVÁ ed. (1975) and PALIVCOVÁ (1982) pointed out the similarity of this rock with the Pecerady gabbro and other basic bodies in the Bene-ˇsov and Milín area of the CBP.
   The other, "dry" basic series, starting with pyroxene and olivine rich ultramafites, i.e. so called "Mte Blumone series" in the Adamello massif (ULMER et al., 1985) seems also to be present in the CBP, however, in a subordinate amount.
4) The satellitic bodies form morphological peaks, elevations, and hills. The position in higher levels above granitoids is probable in the Val Fredda region in the Re di Castello massif and was also observed in some bodies in the CBP (e.g. Stěžov body in the Milín area).
5) The shapes of satellitic bodies may be stocks, sheets, and sills. The bodies are often accompanied by consanguinic lamprophyres. On the other hand, large blocks of basic rocks are known from the CBP (Vran-ˇcice mine: PATOČKA, 1979; VLAŠÍMSKY, 1990; Teletín quarry: DUDEK & FEDIUK, 1956; LANG, ed., 1978). "Comagmatic" mafic enclaves (microgranular according to DIDIER, 1973, MME according to DIDIER & BARBARIN, 1991, p. 23) are widely distributed in granitoids of both massifs. Locally, thin intrusions of granitoids into basic rocks are known from the Adamello massif as well as from the CBP.
6) The above relations between basic bodies and granitoids lead to the controversial views on the age of the basic bodies. ULMER et al. (1985), like most authors in the CBP, assume a differentiation series with older basic members, whilst BLUNDY (in VILLA, 1985, p. 314) finds evidence of the opposite in the Val Fredda region. Recently, BLUNDY & SPARKS (1992) presented a new interpretation of mafic rocks on the basis of detailed mapping (1:5.000) of the Val Fredda region. They interpreted the mafic rocks in the area as small intrusions, synplutonic dykes, sills and mafic sheets (p. 1039, lit. cit.) emplaced into hot, but consolidated granitoid host. The sheets pass laterally into swarms of mafic enclaves in tonalites. The commonly accepted older age of basic bodies in the CBP was queried by PALIVCOVÁ (1978, 1984), see also TÁBORSKÁ et al. (1995) for similar Nasavrky Plutonic Complex in the Bohemian Massif.
7) The textural and mineralogical analogies in the basic rocks of both regions (as well as in the granitoids of both massifs) are striking. This can be seen from the papers of HANUŬS & PALIVCOVÁ (1971), FIALA et al. (1974), PALIVCOVÁet al. (1975) and was confirmed by CALLEGARI (1985) and ULMER et al. (1985). It is true that KARL (1967) described some differences between the rocks of the Adamello massif and those of the CBP, however, these differences are, in our view, insignificant. For instance, the Adamello gabbroic rocks have more pronounced Fe-Ti relics ("schiller") in hornblende, and a more fresh, nearly water-clear marginal zone of plagioclases with more pronounced Ca-cores. According to KARL (1967), the main difference is in higher ordering index of the K-feldspar in the CBP rocks. On the other hand, close similarities were shown using the mineralogical data of COCCO & DI PIERI (1981) and JOBSTRAIBIZER et al. (1985) from the Adamello massif, and the data reported by POUBOVÁ (1974), FIALA et al. (1974, 1975), PIVEC & MINARÍK (1975), ULRYCH (1975, 1985), LANG et al. (1975), LANG ed. (1978) from the CBP. Some differences shown by KARL (1967) seem to be well explained by younger age of the Adamello massif.
8) Some analogies in textural varieties of both the Mte Mattoni series and the CBP "basic series" with Scottish Caledonian appinitic series were pointed out by PALIVCOVÁ (1982, 1984).

The main granitoids of the Adamello massif and of the CBPare represented by several textural types of related hornblende-biotite granodiorites and tonalites. The Italian and Swiss geologists (Mem. Geol. Soc. It. 1985, 26) confirmed the polyphase, multistage architecture of the Adamello massif, built of individual closely related granodioritic and tonalitic intrusions in three main units as assumed by CALLEGARI & DAL PIAZ (1973). In the CBP, the main portion of the granodiorite/tonalite series was included into the so called Sázava type: see the geological map of Czechoslovakia 1 : 200.000, the sheet Tábor (1963). Indead, this type most probably also represents several separated individual phases, as can be deduced from their geochemical character (PALIVCOVÁ et al., 1989b; HOLUB, 1991).

In both massifs, the main types of granitoids are accompanied by the smaller bodies of younger light-coloured trondhjemitic (leucotonalitic) biotite granitoids (Val Fredda trondhjemite in the Re di Castello massif, the Požáry type in the CBP). Directly at the contact with these granitoids the main basic bodies occur (Mte Mattoni, Mte Cadino and Pecerady, Popovice, respectively), where ocellar textures were found. In the CBP, the best occurrences of ocellar rocks are in the Milín area near Příbram, where basic bodies are in contact with another type of light-coloured granitoids, the coarse grained porphyritic type, so called "marginal" type, of the CBP (see Text-

Text-Fig. 3.
Abnormal accumulation of ocelli in the host rock of hornblende quartz microgabbro to microdiorite composition – a common type of the host rock of ocelli. Endocontact of a small body, Draha near Smolotely, Central Bohemian Pluton.
The ocelli mostly consist of quartz + K-feldspar and display thin hornblend rims and rounded euhedral shapes.
Slightly reduced.
Photo V. MATEJKOVÁ.

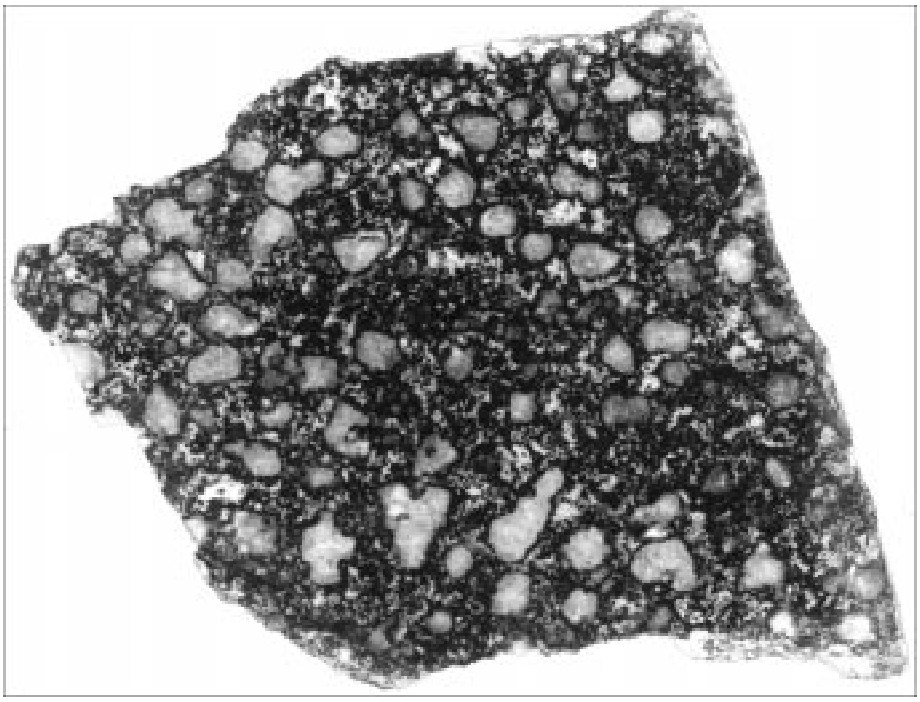


Fig. 2c). A porphyritic marginal granodiorite containing feldspar and quartz phenocrysts was recently described in the Adamello Val Fredda region, too (BLUNDY & SPARKS, 1992).

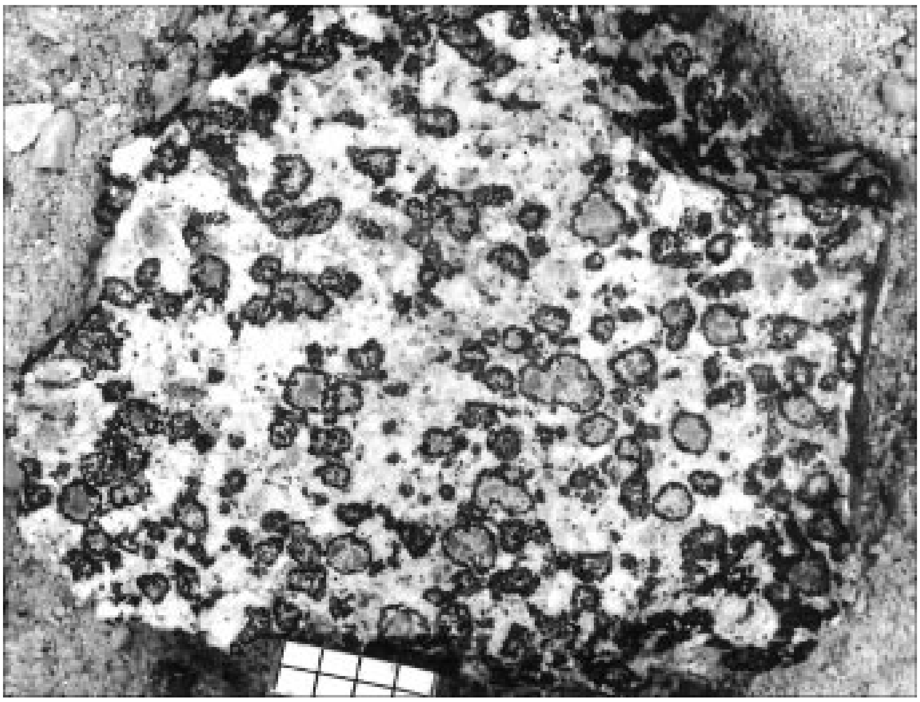
In the CBP, ocelli were first illustrated by HANUŠS & PALIVCOVÁ (1969, 1971a, 1978) in small elo gated basic bodies of gabbroic rocks in the Milín area, and by HANUŠS & PALIVCOVÁ (1971b) in the Pecerady gabbro which resembles the Mte Mattoni gabbro (PALIVCOVÁ, ed., 1975). PALIVCOVÁ (1978) described a special kind of ocellar quartz-leucogabbro (leucodiorite) from the Milín region.

All ocellar gabbroic rocks described hitherto from the Adamello massif come from the Mte Mattoni series as defined by ULMER et al. (1985). Although the Mte Blumone series was also studied by the latter authors, ocelli were not mentioned there, neither were they described in other bodies studied in detail (e.g. Cima Uzza – CALLEGARI, 1963).

Similarly, in the CBP ocelli were found mainly in the "wet hornblende series", equivalent to the Mte Mattoni series in texture and petrography. Only one small elongated body of the CBP, described by HANUŠS & PALIVCOVÁ (1970) as subvariolitic syenogabbro (microgabbro), differs in the high amount of pyroxene, sphene, and K-feldspar (Text-Fig. 12) from other hornblende-rich rock types.

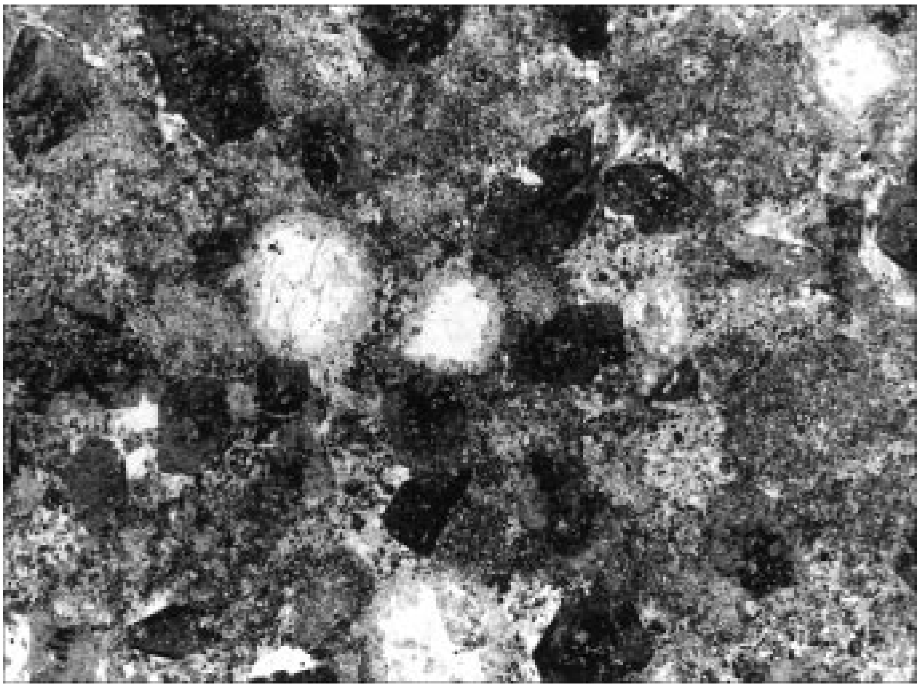
Ocelli were neither found in the Adamello Mte Mattoni hornblendite nor in the similar Kojetín hornblendite in the CBP despite the fact that they were looked for. They were found in the microdioritic rocks in the proximity of the latter. It should be noted, however, that not all mafic bodies in the Adamello massif nor in the CBP were studied in detail and only some of them were studied in particular with regard to ocelli occurrences.

As claimed above, ocelli in both massifs found up to now and illustrated below came directly from the contact of basic bodies with light-coloured trondhjemitic and granitic rocks or from the inner portions of basic bodies which occur in the vicinity of these light-coloured granitoids. Ocelli were not found at the contact of basic bodies with a "normal" grey granodiorite and tonalite, except for one case in pegmatoid schlieren in tonalites in the proximity of basic rocks (Teletín quarry, CBP). But ocelli may occur in mafic enclaves in these grey granitoids.



Text-Fig. 4.
Special type of ocellar rock (quartz leucogabbro to leuco-quartzdiorite).
The rock is composed of white zoned plagioclases and quartz + K-feldspar ocelli. Almost an entire amount of the mafic minerals is concentrated mainly in the rims of the ocelli. A block found at the contact of the gabbroic body (Pecerady type) and the porphyritic biotite granite at Dubeneck hora NE of Smolotely.
See also PALIVCOVÁ (1978).
Slightly reduced.
Photo: V. MATEJKOVÁ.

Text-Fig. 5.
Medium-grained porphyritic facies of a typical hornblende-phyric pyroxene gabbro of the Mte Mattoni (and also Pecerady) type (altered, saussuritized).
Porphyritic magnesiohornblende contains Fe-Ti opacites in brown hornblende relics. Small clinopyroxene grains are mostly concentrated in the anorthitic plagioclases. Andesine, accessory quartz and secondary minerals are in the matrix. Ocelli consist of quartz, altered plagioclase calcite and Mg-salitic rim. Mte Mattoni, near the contact with the Val Fredda trondhjemite, Adamello.
Analysis 1 in Tab. 1.
Thin Section O-334; parallel polars, 3×.
Photo: V. MATĚJKOVÁ.

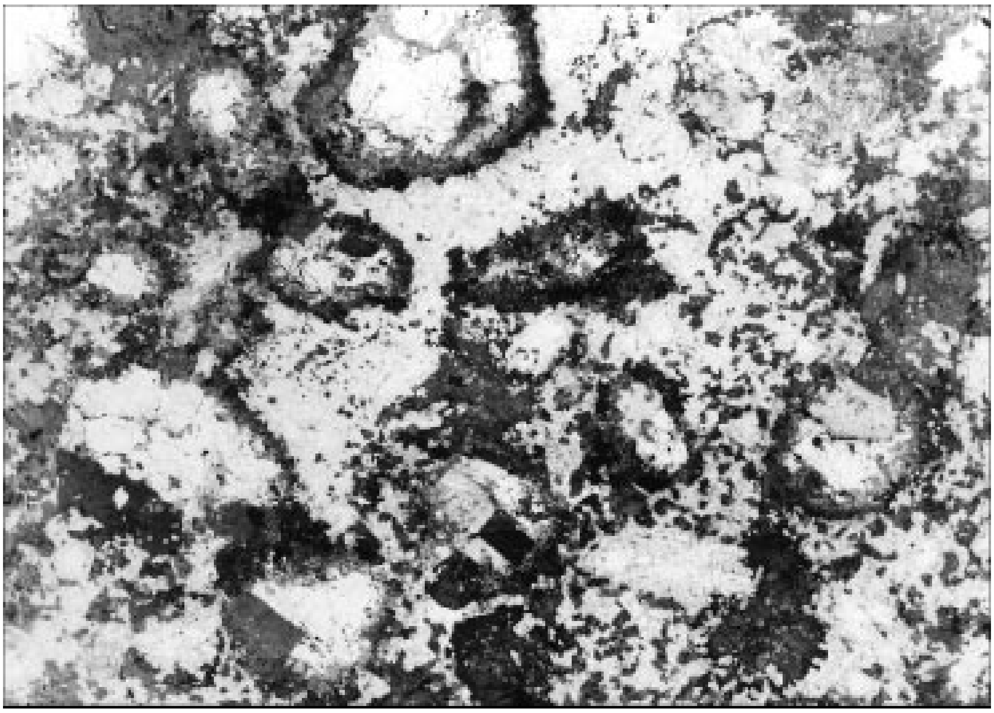


Ocelli in mafic rocks of the Adamello massif and the CBP display the same morphology (rounded, irregular and also euhedral shapes), the same narrow mafic rims (mostly of salite and/or hornblende, sometimes two-zoned), and analogical core compositions (consisting of several crystals of Ca-Al minerals – plagioclase, hornblende, epidote, and also calcite, sphene – in addition to the prevailing quartz and subordinate K-feldspar). Pure quartz-ocelli are frequent, especially in some dioritic rocks. Also monomineral feldspar ocelli were found in the thin sections of the mafic rocks of both massifs. Polymineral ocelli occasionally have the euhedral shapes similar to a single quartz crystal. There are some differences in the frequency of minerals. For example, in the Adamello massif, calcite is a frequent mineral in the ocelli, whilst in the CBP it is subordinate. On the other hand, K-feldspar is frequent in CBP ocelli and also the "primary" epidote was more often found there.

In the following text we present examples of the host rocks of ocelli. We cannot show the whole textural variability and analogies of both series due to limited space for figures in the paper. However, we would like to emphasize that for every type shown here from the CBP a perfect counterpart from the Adamello massif can be demonstrated (and vice versa – except for the mentioned photo 12). Some examples for comparison are referred to in the text of the figures, if they were published elsewhere.

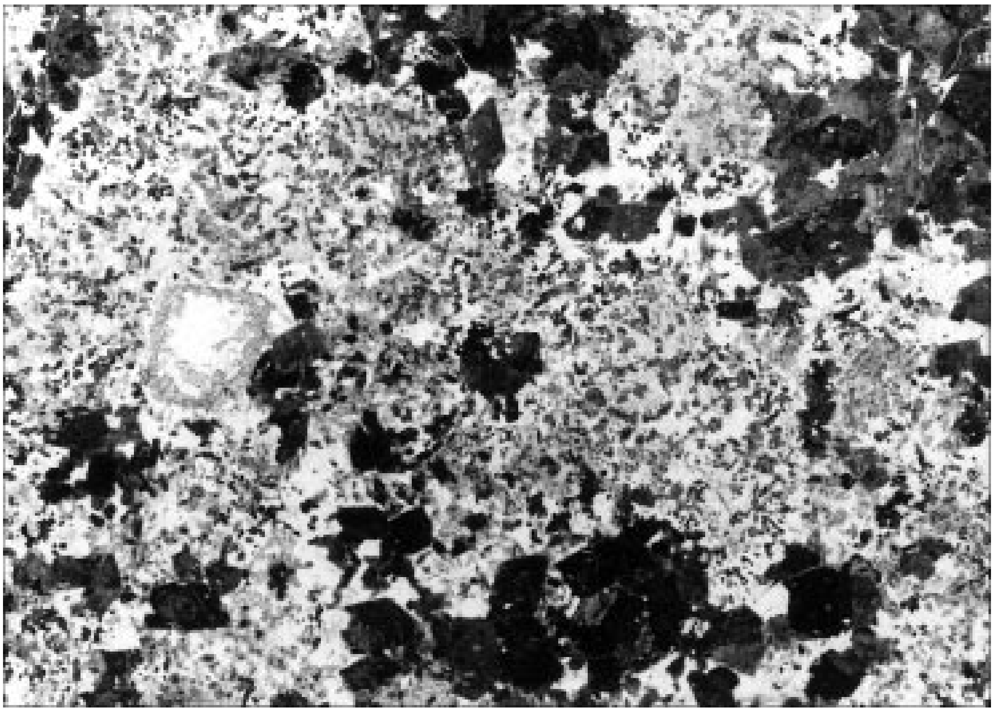
In Text-Figs. 3, 4 we show two examples of extreme ocelli accumulations in two typical fine-grained rocks from the marginal zones of quartz microdiorite and microgabbro bodies in the CBP. In the Adamello bodies, similar corresponding example was hithertoo not referred. However, the figures of ocelli in synplutonic dykes (CASTRO et al., 1990, p. 12), and those in mafic enclaves (BUSSELL, 1985, p. 148) show, that such accumulations are not exceptional.

The rock types in Text-Figs. 5–12 bear evidence that ocelli were found in rocks of various basicity, with SiO_2 from about 49 up to 57 % (in water-free analyses). They were found most often in the fine-grained marginal zones



Text-Fig. 6.
Plagioclase and micropegmatite bearing felsic portion from the endocontact of the gabbroic rock of the previous type (on Text-Fig. 5), rich in ocelli.
The ocelli have twofold rims (hornblende, uralitized pyroxene) and cores consisting of quartz, K-feldspar, hornblende, micropegmatite calcite.
Nepřejov near Dobříš, CBP.
Thin Section O-1052; parallel polars, 3×.,
Photo: V. MATĚJKOVÁ.

Text-Fig. 7.
Euhedral quartz ocellus (square) rimmed by salite in a subvariolitic type of the Pecerady body.
The structure is built of incomplete hornblende rings around zoned plagioclases with cores filled with clinopyroxene grains. Hornblende crystals in the rings are associated with andesine, quartz and some K-feldspar.
Svárov near Pecerady, CBP.
Thin Section 27–462; parallel polars, 6×,
Photo: V. MATĚJKOVÁ.

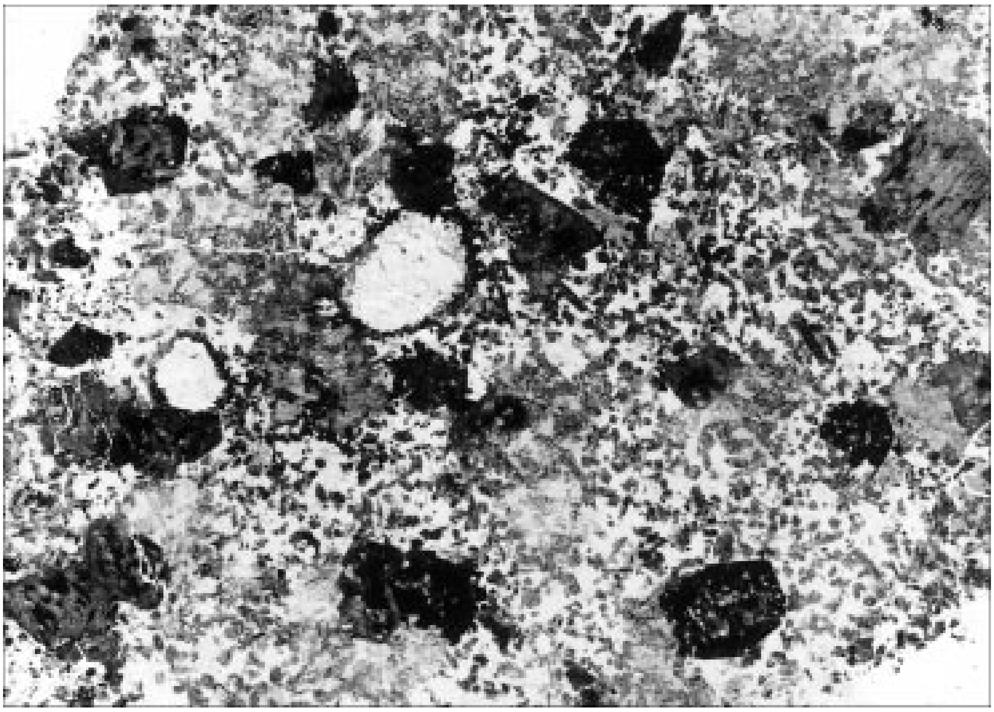


of the bodies ("chilled margins" against granitoids) but also unevenly dispersed in the inner part of the bodies. The examples on Text-Fig. 5 show the ocelli in the typical Mte Mattoni and Pecerady gabbro as well as in the pegmatoid accumulations in these gabbroic rocks (Text-Fig. 6). Fig. 7 represents textural types called by HANUŠS & PALIVCOVÁ (1970) variolitic or subvariolitic types (see also Text-Fig. 1 in FIALA et al. (1974). The small grained Mte Mattoni type with As the ocelli are often polymineral, and in the case of the Adamello massif rich in calcite, they were interpreted in both massifs as relict amygdules belonging to the parent rocks of present-day gabbroids (HANUŠS & PALIVCOVÁ, 1971a). In the case of the Adamello massif they were explained as vesicles (gas bubbles) of the late magmatic stage of the gabbroic rocks themselves (ULMER et al.1985, p. 212). However, the revision of a number of ocelli leads PALIVCOVÁ to the assumption that even typical "rounded amygdules" might have been rounded forms of originally euhedral pseudomorphosed crystals (Text-Fig. 2 in PALIVCOVÁ et al., in print).

The structure of the Mte Mattoni ocellar gabbro, shown as the hand specimen in BLUNDY & SPARKS (1992, Text-Fig. 3b), is the same as that in our microphoto Fig. 5. The two quartz ocelli in the needle-hornblende quartz-dioritic enclave on the Blundy and Sparks photo 7c are interpreted by them as xenocrysts. With some constraints to the mechanism of their incorporation (in PALIVCOVÁ et al., in print) we support the xenocrystic interpretation, too.

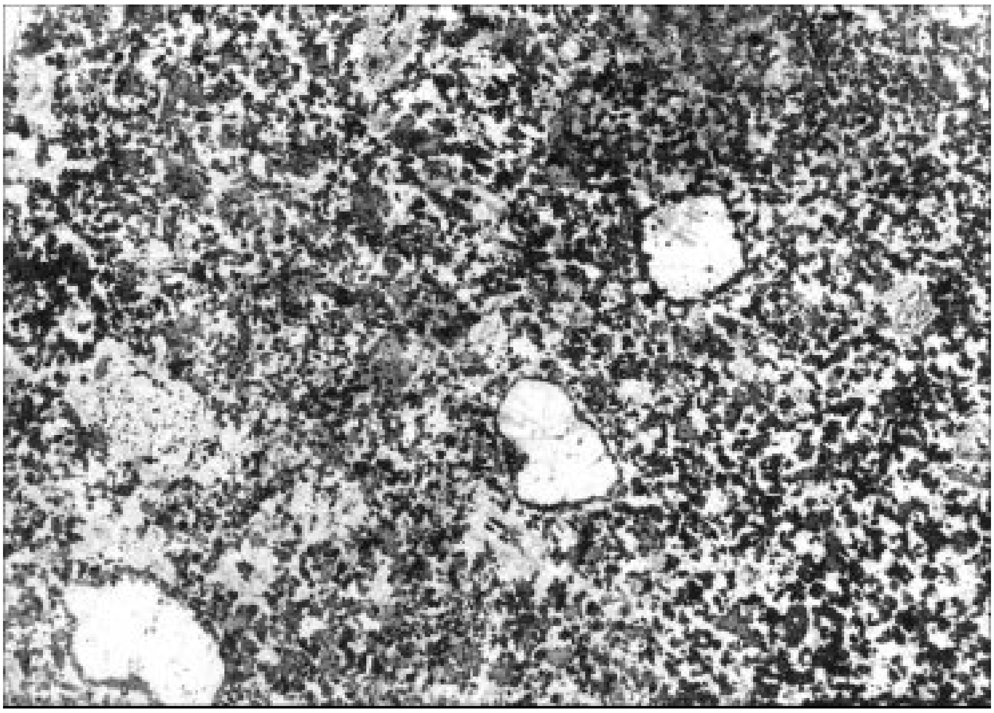
In Table 1 and Text-Fig. 13 we illustrate the chemical characteristics of the mafic host rocks of ocelli, ocelli-bearing enclaves and of those granitoids that are proposed as the source material of ocelli from the Adamello massif and the Central Bohemian Pluton.

In Table 1, selected pairs of analyses correspond to both typical gabbroic rocks (anal. 1–4), the analyses 5, 6 are acicular quartzdiorites, and analyses 9–12 correspond to "light-coloured granitoids". Also analyses of associ-



Text-Fig. 8.
Small-grained hornblende-pyroxene gabbro containing sporadic hornblende megacrysts (porphyroclasts?) and small rounded, originally euhedral quartz ocelli with salite rims.
This is a frequent type of ocelli in microdioritic and somedyke rocks. Calcite and plagioclase ocelli are also often present in this type of rock. These rocks may gradually pass into a fine-grained microgabbro to quartz microdiorite corresponding to the matrix without hornblende megacrysts (compare with Text-Fig. 9).
Mte Mattoni, Adamello.
Thin section O-298; without polars, 3×.
Photo: V. MATĚJKOVÁ.

Text-Fig. 9.
Fine grained equigranular ocellar hornblende quartzmelamicrodiorite, a chilled contact of a basic body.
Typical small euhedral quartz ocelli are fringed with a thin continuous hornblende rim. Frequent patchy plagioclase megacrysts are present.
Kaliště body near Nepřejov, CBP. Thin Section O-1080; parallel polars, 3×.
Photo: V. MATĚJKOVÁ.



main masses are shown (anal. 7, 8). The analyses represent pairs of the rock types whose textures are similar. Some small amount of microscopic ocelli in the analyzed mafic rocks cannot, however, be excluded.

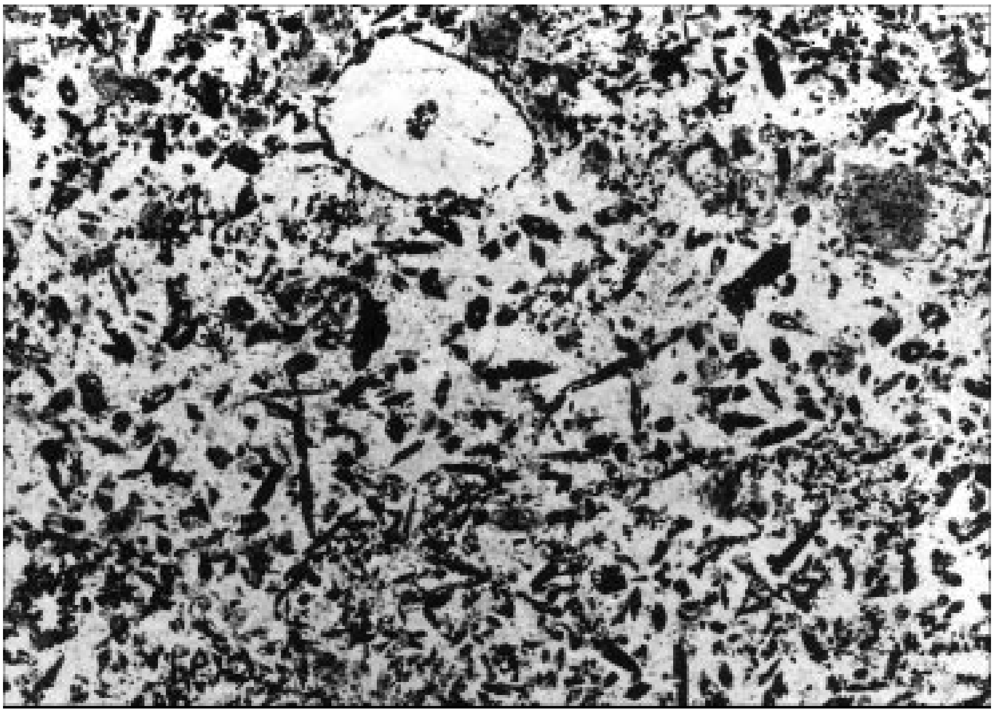
A comparatively high number of bulk analyses are at disposal for samples from both massifs, but only incomplete data are available for trace- and RE elements in the pertinent rocks. Therefore in Text-Fig. 13 we show the total alkali-silica diagram (TAS diagram, LE BAS et al., 1986) based on the major elements. The rocks of both massifs are mostly interpreted as attaining a state of melting. Such melts were able to differentiate and fractionate (ULMER et al., 1985; CALLEGARI, 1985; DUDEK & FEDIUK, 1956; HEJTMAN, 1949; LANG et al., 1975), therefore the use of the diagram for true-magmatic (i.e. volcanic) rocks is fully substantiated. In this way we can compare which relevant volcanics correspond to which of the discussed mafic rocks and granitoids.

The rock analyses from Table 1 are shown as numbered points in the diagram. The fields in Text-Fig. 13 are constructed from all data available in the literature, i.e. 152 analyses from the Adamello massif and 223 analyses from the CBP.

The rocks of both I-type massifs show well the similar trends from the basic rocks to the granitoids as well as the similar position of host mafic rocks of ocellar types in the diagram. In general, the rock series of the CBP is slightly richer in alkalies than the studied rock series of the Adamello massif.

The presence of the ocelli in the Adamello massif as well as in the CBP is interesting in the context of the genetic model of the massifs.

The Adamello massif as well as the main portion of the CBP are two outstanding examples of the calc-alkaline I-type series, petrographically similar to the Andean series. According to KAGAMI et al. (1991), three models of origin of the Adamello calc-alkaline series are discussed:
1) fractional crystallization of mantle-derived magma,
2) magma mixing, and
3) assimilation – fractional crystallization (AFC).



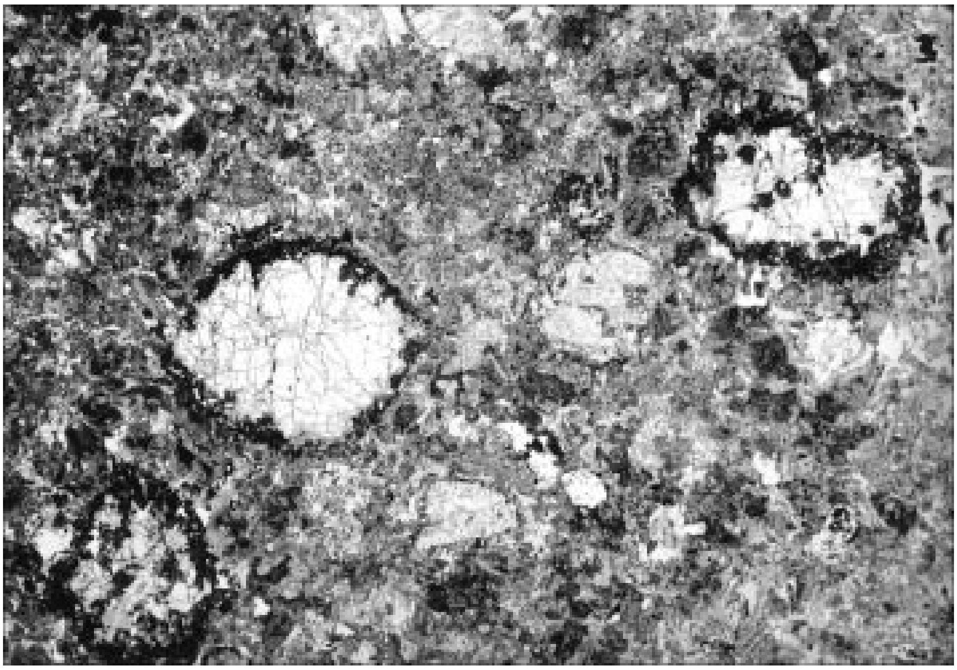
Text-Fig. 10.
Acicular hornblende quartzdiorite with a rounded quartz ocellus outlined by very thin fine-grained hornblende rim.
Rapidly crystallized quenched facies of mafic rocks with hollow hornblendes (compare with analysis 5 in Tab. 1).
Mte Cadino – Mte Frerone, Adamello.
Thin Section O-328, parallel polars, 3×.
Photo: V. MATĚJKOVÁ.

Table 1.
Chemical anlyses of ocelli-bearing rocks from the Adamello Pluton.
1 = Hornblende-phyric pyroxene gabbro, the Adamello massif, Mte Mattoni (DUPUY et al., 1982, an. 20); 2 = The similar rock type from the CBP, Pecerady quarry, main coarse grained type (PALIVCOVÁ, ed., 1975, an. P5); 3 = Medium grained equigranular hornblende pyroxene gabbro near to diorite, the Adamello massif, Mte Cadino (MACERA et al., 1985, A 77–15); 4 = The similar rock type from the CBP, Popovice quarry (VEJNAR, 1973, No. 243); 5 = Acicular hornblende gabbro to quartzdiorite, the Adamello massif, Mte Cadino (MACERA et al., 1985, A 77–13); 6 = The similar rock type from the CBP, Radětice mine (P 156, unpublished material of M.P., Geological Institute AS CR; 7 = Biotite-hornblende tonalite, Re di Castello type. The Adamello massif, Southern Re di Castello (DUPUY et al., 1982, an. 10); 8 = The similar rock type from the CBP, Sázava type, Teletín quarry (LANG, ed., 1978, p. 36); 9 = Biotite (+/-hornblende) trondhjemite (leukotonalite), the Adamello massif, Southern Re di Castello, Val Fredda (DUPUY et al., 1982, an. 14); 10 = The similar rock type from the CBP, Požáry quarry (POUBOVÁ, 1974, an. 394/65); 11 = Porphyritic "marginal granite", biotite granite with K-feldspar and quartz phenocrysts, the Adamello massif, Val Fredda type (BLUNDY & SPARKS, 1992, an. BO Vf); 12 = The similar rock type from the CBP, Bytíz near Příbram (an. 177/70, unpublished material of E. PIVEC, Geological Institute AS CR).

	1 A	2 CBP	3 A	4	5 A	6 CBP	7 A	8 CBP	9 A	10 CBP	11 A	12 CBP
	gabbroic rocks				diorites		tonalites		granodiorites, granites			
	Mte Mattoni	Pecerady	Mte Cadino	Popovice	Mte Cadino	Radětice	South R.C.	Teletín	South R.C.	Požáry	Val Fredda	Bytíz
	Dupuy 20	P5	A77-15	V243	A 77-13	P156	Dupuy 10	P36	Dupuy 14	394/ 65Pb	BoVf	177/70
SiO_2	47.95	48.96	53.24	52.74	55.74	56.22	60.81	64.57	70.27	69.90	71.15	71.28
TiO_2	0.84	0.80	0.93	0.45	0.91	0.80	0.77	0.63	0.37	0.28	0.27	0.21
Al_2O_3	11.51	14.36	18.96	15.86	18.44	17.60	17.54	17.06	15.91	15.06	15.05	13.87
Fe_2O_3	3.19	2.88	2.41	1.91	2.72	3.21	1.95	1.71	0.55	0.92	2.15^t	0.66
FeO	5.46	5.77	5.21	4.69	4.78	4.65	3.38	2.64	1.26	2.00	-	3.40
MnO	0.17	0.11	0.16	0.12	0.17	0.17	0.12	0.14	0.08	0.03	0.05	0.07
MgO	15.35	8.75	4.33	7.15	4.00	3.80	3.07	1.32	1.11	0.51	0.83	0.59
CaO	11.07	14.02	10.34	12.43	8.89	7.18	6.65	4.66	3.63	4.21	2.96	2.01
Na_2O	1.47	1.65	3.05	1.76	2.94	2.92	2.74	3.46	4.37	3.90	3.67	3.45
K_2O	0.55	1.16	0.61	0.75	1.10	1.90	1.79	2.90	1.82	2.28	2.74	3.71
P_2O_5	0.08	0.16	0.18	0.04	0.13	0.14	0.17	0.16	0.14	0.07	0.10	0.14
H_2O+	-	1.07	-	0.27	-	1.05	-	0.49	-	0.33	-	0.34
H_2O-	2.37*	0.22	0.46*	1.38	0.77*	0.16	1.01*	0.16	0.48*	0.07	0.70*	0.14
CO_2		n.d.		0.06		0.06		n.d.		0.03		0.29
Σ	100.01	99.91	99.88	99.61	100.59	99.86	100.0	99.90	99.99	99.59	99.67	100.16
La	5.87	6.2	21		22		22.6	25.6	30.5		28	
Ce	13.9	3.8	35		43		42.7	5.5	58.1			
Sm	2.03	3.6					3.92	3.5	3.24			
Eu	0.66	0.75					1.04	1.4	0.85			
Tb	0.40	0.65					0.58	<0.2	0.43			
Yb	1.26	<1					2.11	1.3	1.43			
Lu	0.2	-					0.33	0.19	0.23			
Rb	3	<56	0		24		53	58	51		82	
Ba	152		246		300		402		521		527	
Sr	218		416		386		388		395		328	
Y	3		11		14		20		4		14	
Zr	38		63		50		109		101		87	
Hf	1	<7.3					3	4.5	3			
Nb	3		7		9		10		14		13	
Th	2	2.9	6.68		4.62		10	7.2	17			
U			2.47		1.47		1.8	1.7	3.0			
Sc		80					17	14	<10		3	
Ni	233	31	13		5		12		7		2	
Cr	1118	105	24		13		24		10		6	
V	263	220	309		288		154		49		28	
Co	-	31.5	-		-		13	11.6	-			
Cu		33									8	
Ga											15	
Pb											20	
Zn											9	
Sb		0.9										

* LOI   t – Fe_2O_3 total

Text-Fig. 11.
Euhedral cracked quartz ocelli (K-feldspar in cracks) in hexagonal and rectangular sections in a nuralitized and amphibolized fine grained melagabbro. The distinct thin pyroxene rims are preserved in an entirely amphibolized rock.
Draha near Smolotely, CBP.
Thin Section O-193, parallel polars, 4,5×.
Photo V. MATĚJKOVÁ.



There are, however, diametrically different views on the extent of assimilation and especialy of mixing phenomena in the field. According to KAGAMI et al. (1991, p. 14342) "petrographic evidence of magma mixing is lacking". According to BLUNDY & SPARKS (1992, p. 1042) "mixing textures between tonalites and mafic magmas are apparent in the field".

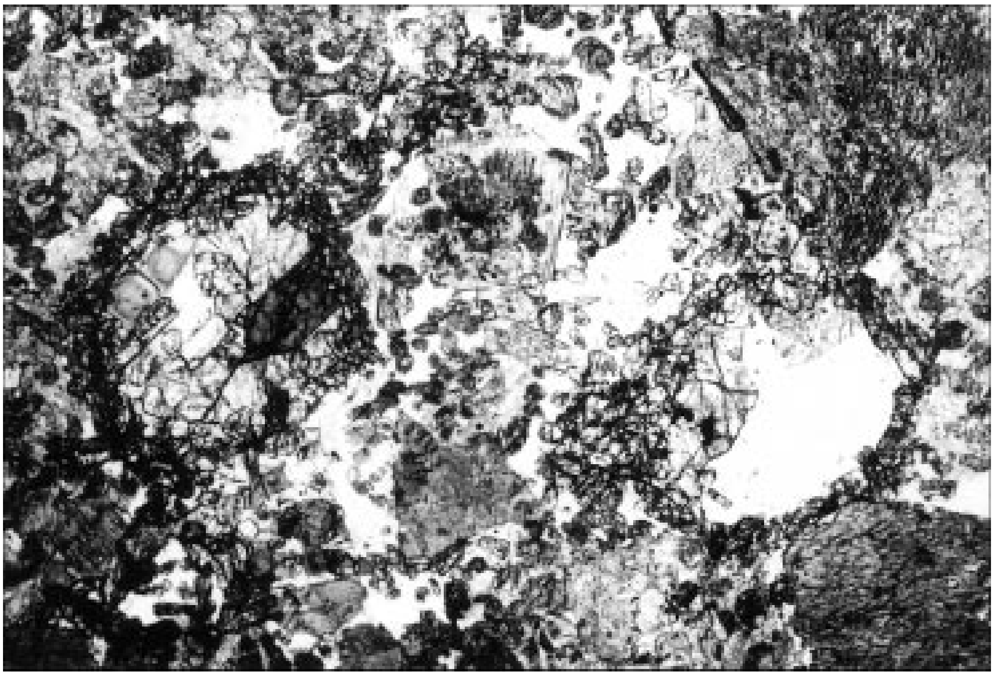
Xenocrystic origin of felsic ocelli in mafic rocks and enclaves as well as strongly patchy cored plagioclases and mafic minerals from mafic rocks in hybrid granitoids bear evidence of magma mixing (mingling) process (VERNON, 1992; CASTRO et al., 1990, 1991). These features are common in Adamello and CBP rocks. Therefore we concur with BLUNDY's and SPARKS's above observations and xenocrystic interpretation of ocelli. However, more knowledge of geological and petrographical features of ocelli occurrences are needed to solve the problem of their incorporation into both larger mafic bodies and enclaves as well as the mixing (mingling) process in plutonic conditions.

3. Ocellar Textures in Mafic Rocks of A-Type Granitoid Bodies

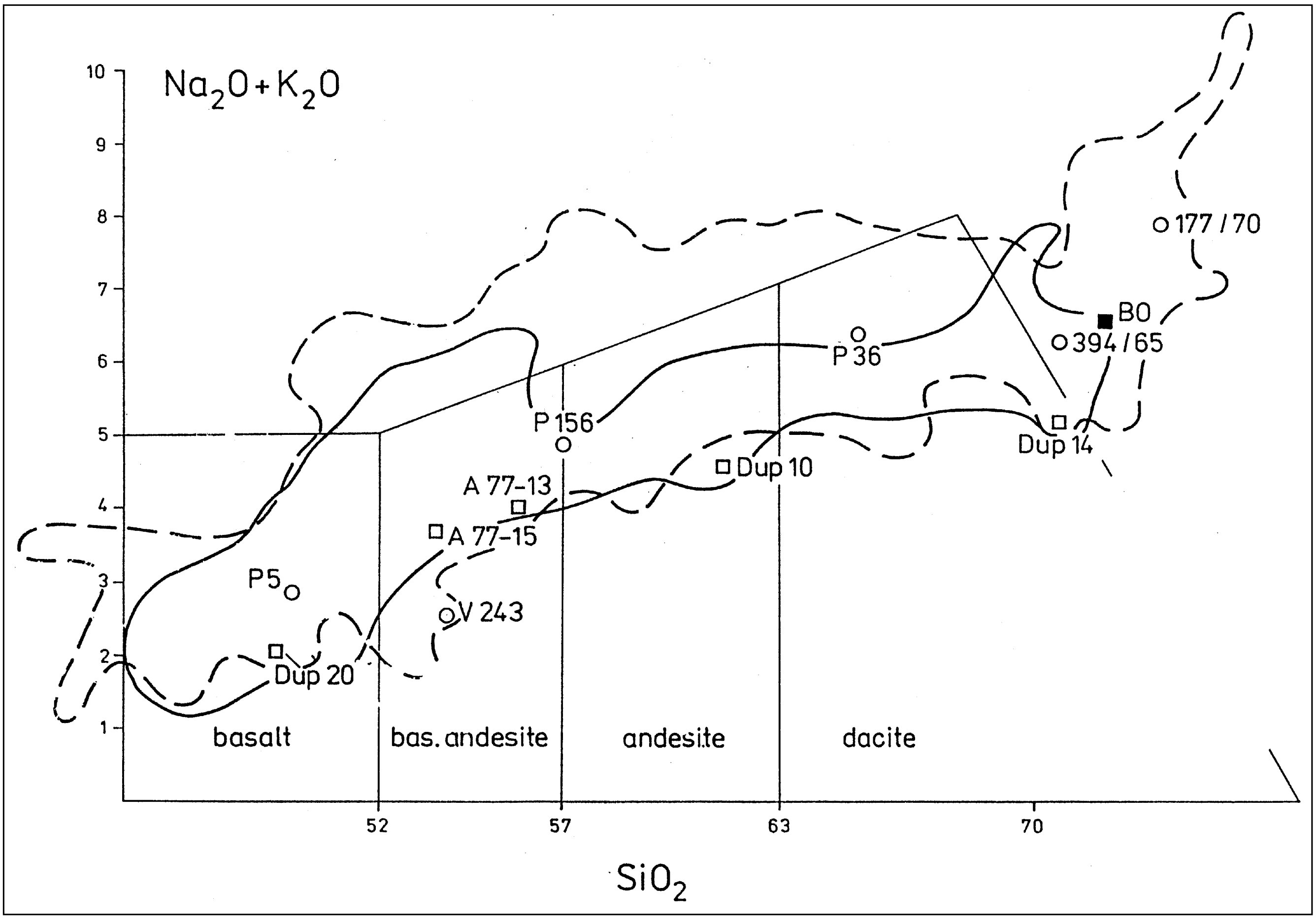
Two small A-type granitoid massifs were chosen for illustration of ocellar rocks, the famous Ploumanac'h massif of Brittany and the Říčany massif of the CBP. Both plutonic bodies are of Variscan age: Ploumanac'h 293±15 and 300±5 Ma (Rb-Sr, according to VIDAL, 1976, in BARRIÈRE, 1977b, p. 311), Říčany 338±15 and 351 Ma (K-Ar, BERGNER et al., 1988, p. 310).

Both bodies are similar in some features but differ in others. The Ploumanac'h massif (Text-Fig. 14) is the best described example of ocellar and hybrid rocks in the literature (THOMAS & SMITH, 1932; BARRIÈRE, 1972, 1977). It belongs to four small Armorican Paleozoic–late Hercynian massifs called "the cap of the red granites" (BARRIÈRE, 1980). The massifs are situated on the Icartian socle, the oldest part of the crystalline complexes of France (LAMEYRE & AUTRAN in: AUTRAN & DERCOURT, eds., 1980). According to the description of BARRIÈRE (198O, p. 60) these massifs are "ni anorogeniques, ni atectoniques, clairement rattachés à la compression hercynienne".

However, the geochemical and other features of the Ploumanac'h massif make it possible to classify it as the A-type granitoid (see CLARKE, 1992). The Říčany massif (Text-Fig. 15) in the complex of the CBP was also classi-

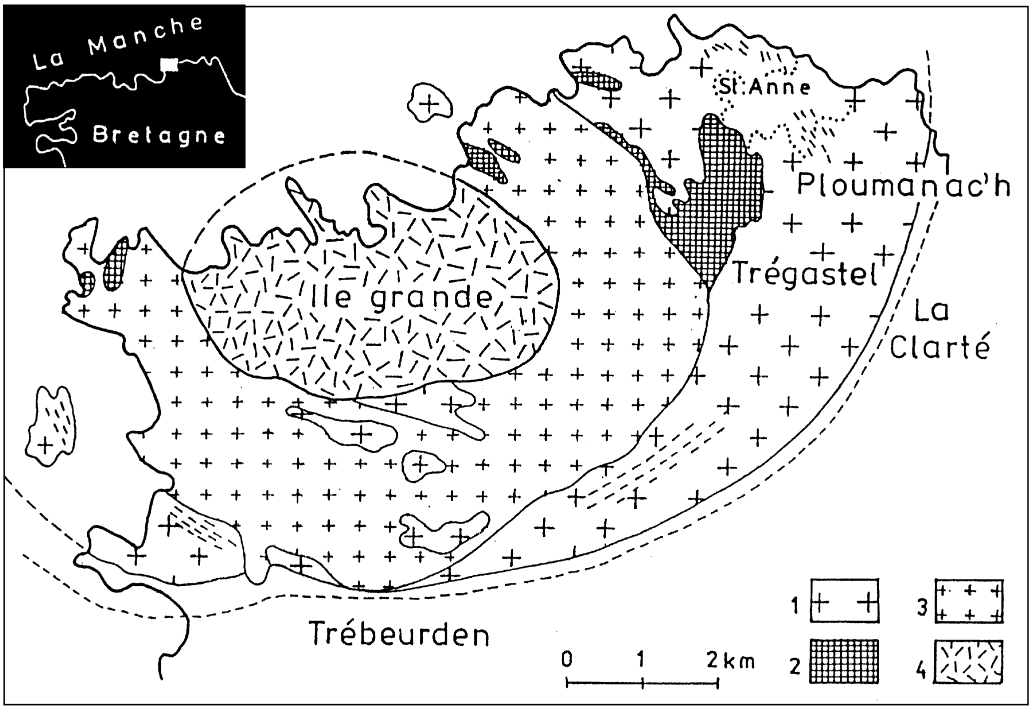


Text-Fig. 12.
Rounded ocelli with distinct pyroxene rims in a fine grained pyroxene hornblende monzogabbro.
Ocelli are characterized by the heteromineral composition (quartz, K-feldspar, sphene, epidote, actinolite, ore mineral). Perfectly euhedral ocelli were described in the same rock by HANUŪS & PALIVCOVÁ (1968, Text-Text-Fig. 6).
Draha near Smolotely, CBP.
Thin Section O-259, parallel polars, 16×.
Photo: V. MATĚJKOVÁ.

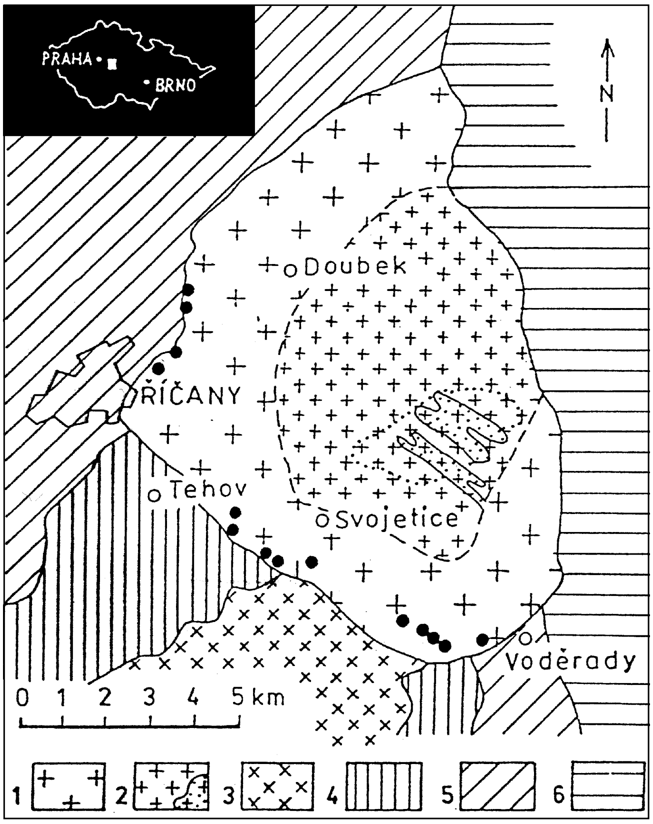


Text-Fig. 13.
Geochemistry of Adamello and CBP rocks. TAS diagram of the rock types of the Adamello massif, Southern Re di Castello – Val Fredda region and similar rock types of the CBP.
The full-line field (for the Adamello massif) and dashed-line field (for the CBP) summarize all data available in the literature.
Numbered points = analyses from Table 1; □ = Adamello massif (full square = an enclave); ○ = CBP.

fied as the A-type granitoid (JAKES & POKORNY, 1983). According to PALIVCOVÁ et al. (1989b), the Říčany body belongs to the continental Moldanubian plate (block) of the Bohemian Massif despite the fact that it is in contact with the Proterozoic and Lower Paleozoic sediments of Bohemicum.



Text-Fig. 14.
Ring structure of the Ploumanac'h granitic massif in Brittany.
After BARRIÈRE (1980, Text-Fig. 48).
1 = monzogranite to syenogranite ("coarse grained red granite"). Hatched = a strongly oriented structure; 2 = basic rocks; 3 = intermediate granite; 4 = granite of the Isle Grande.
Broken line around the massif outlines the contact aureole. The massif is set in felsic gneisses (Trebeurden) and Proterozoic to Paleozoic pelitic-psammitic metasediments (BARRIÈRE, 1977a). In the latter paper, the ring structure was refined (see the text on p. ***????***).



Text-Fig. 15.
Ring structure of the Říčany granitic body, in the NE tip of the CBP (after PALIVCOVÁ et al., 1992).
1 = coarse grained porphyritic granite. Heavy circles mark outcrops of tourmaline pegmatites; 2 = medium-grained biotite granite (porphyritic). Dotted field indicates the two-micaaplitic granite (Jevany type). Its probable outlines (dotted line) is after SPONAR & KOMÍNEK (1985); 3 = Sázava type tonalite; 4 = Lower Paleozoic metasediments; 5 = Upper Proterozoic volcanosedimentary complex; 6 = Permian cover (with pebbles of the granite).

The general significance of the alphabetic signature "A" has been, in fact, called in doubt in view of the new investigations (e.g. MARTIN et al., 1994 and references on p. 1012). In our view, both the Ploumanac'h and the Říčany massifs might have undergone two subsequent processes: an anorogenic emplacement of magma (as volcanics and/or subvolcanics) and then their P-T reworking during the Variscan orogeny.

The two massifs represent examples of ring-shaped bodies. The ring structure of the Ploumanac'h body is particularly pronounced. The architecture, the mode and the high level emplacement of the body was studied in detail by BARRIÈRE (1977b). The massif is interpreted as an example of a "forcible injection" in the form of a "poincon refoulant la croûte" (stamp pushing away the crust) that finished its emplacement in a solid state (BARRIÈRE, 1980, p. 61).

The Říčany massif is interpreted as a recrystallized volcanic-subvolcanic body (PALIVCOVÁ et al., 1992) belonging to the Moldanubian continental unit of the Bohemian massif.

In both massifs, the main granitoid type (the coarse-grained light-coloured porphyritic biotite granite) demonstrates the similar character not only by texture and mineralogy, but also by the distinct trend to the alkali-granite (BARRIÈRE, 1980; PALIVCOVÁ et al., 1992). Both massifs have the envelope of pelitic-psammitic metasediments and (in Ploumanac'h) also of felsic gneisses. Both bodies display similar hornfels contacts (biotite, andalusite, cordierite sillimanite). The main difference between the massifs appears in the fact that in the Ploumanac'h massif, a small body of mafic rocks is exposed at the contact of two types of granites, whilst in the Říčany massif, the mafic rocks occur only as mafic enclaves in the granite. From this, further differences result.

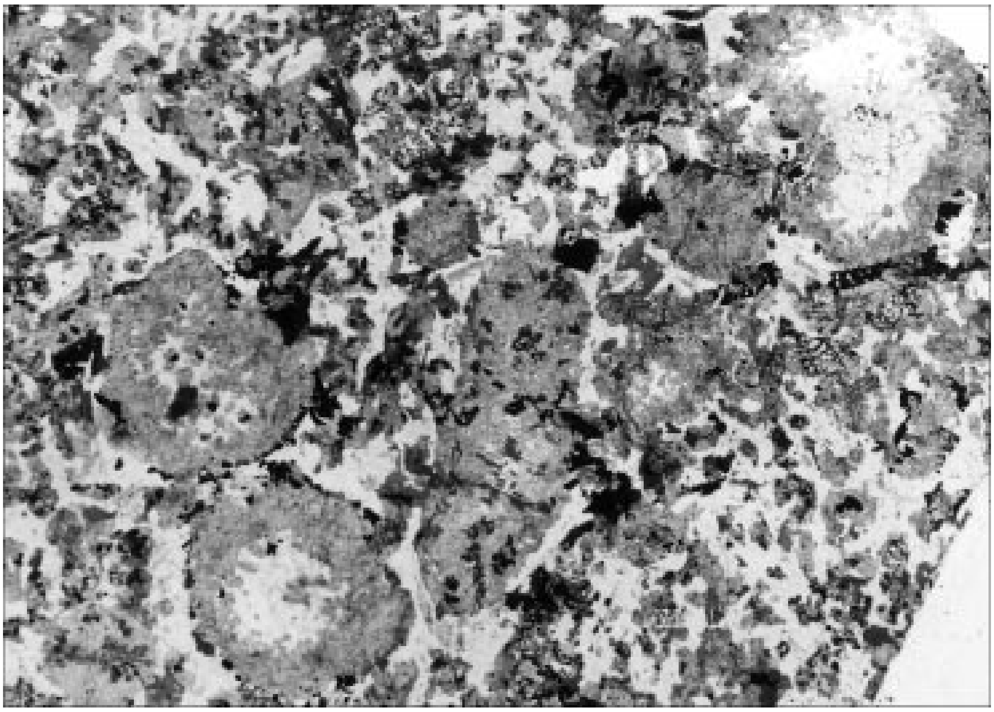
In the Ploumanac'h massif, a whole series of ocellar mafic rocks from the dark biotite-bearing olivine norite through pyroxene and biotite-bearing hornblende gabbroic and dioritic hybrids of various textures and compositions up to "light grey hybrids" (fine-grained porphyritic biotite quartz-microdiorite to microgranodiorite) is beautifully exposed. The hybrid rocks form more or less continuous masses and enclaves. The geological relations of basic and granitic rocks are, however, very complex. In spite of excellent exposure at the Ste Anne shore in Trégastel, two different explanation were offered. According to THOMAS & SMITH (1932), the basic rocks form here the roof of the underlying granite. They have spheroidal exfoliation. At the contact zone with the granite at this locality, mafic enclaves of various size and in various stages of hybridization originate "by separation of adjacent spheroids of basic rocks by the granite", and "various stages of their floating off into the main granite mass" may be observed (p. 280). According to BARRIÈRE (1972, p. 985) the basic rocks were emplaced in the depth, at the level, where granite magma was generated, or a little above, and were transported upwards by the granite intrusion. A long immersion of basic rocks in the granitic magma created favourable conditions for hybridization. The main rock types and their detailed geochemistry are at present well-known. According to BARRIÈRE (1977a) and FOURCADE (1981), the geochemistry supports the basic-acid magma mixing hypothesis.

In the Říčany granite, the ocellar enclaves were found in subvertical zones about 0.25 to 0.75 m in width that were unevenly distributed within the granite. The zones are enriched in patches of aplo-pegmatite material distributed between the enclaves. The enclaves range in composition from biotite-rich melaquartzdiorites to quartzmonzodiorites and melagranodiorites. The main difference from the Ploumanac'h rocks is the total absence of other mafic minerals apart from biotite. The dark mafic enclaves may be accounted for to the lamproitic rocks. The lamproitic series is typical for the SE part of CBP granitoids whose precursors are genetically connected with the Moldanubian continental plate (or block) according to PALIVCOVÁ et al. (1989b). HOLUB (1990) explains the origin of the main body of lamproitic series of the CBP (so called Čertovo břemeno "durbachites") on the basis of detailed geochemical studies by mixing of ultrapotassic magma close to primary melts from anomalous mantle and anatectic crustal normal granitic magma (p. 204–208). He describes scarce noritic rocks and illustrates two pyroxene rimmed ocelli in mafic enclaves of this series.

Some fine grained enclaves of the Říčany granite are very similar to the pale grey hybrids at the actual contact in Ploumanac'h, in which "all the hornblende disappears ... and the rock has a composition of plagioclase-rich biotite granite" (THOMAS & SMITH, 1932, p. 284). Similarly, the grey mica-microdiorite to mica-microgranite – the most evolved hybrids at the Ploumanac'h contact (Ste Anne) – represent also a type of enclaves in the surrounding and even more distant granite.

Rapakivi-type megacrysts represent a further similarity between granites and enclaves of the both massifs. In the

Text-Fig. 16.
Small-grained facies of olivine bearing biotite gabbronorite (biotite in black), rich in K-feldspar ocelli.
Four large ocelli display thick cpx-rims around the feldsparcore, often also thin discontinuous external biotite rims. Three small rounded ocelli are completely, and the large ellipsoidal ocellus almost completely filled by cpx (probably sections near the surface of the ocelli.
Trégastel (Ste Anne), Ploumanac'h massif, Bretagne.
Thin Section O-724, parallel polars, 3×.
Photo: V. MATĚJKOVÁ.

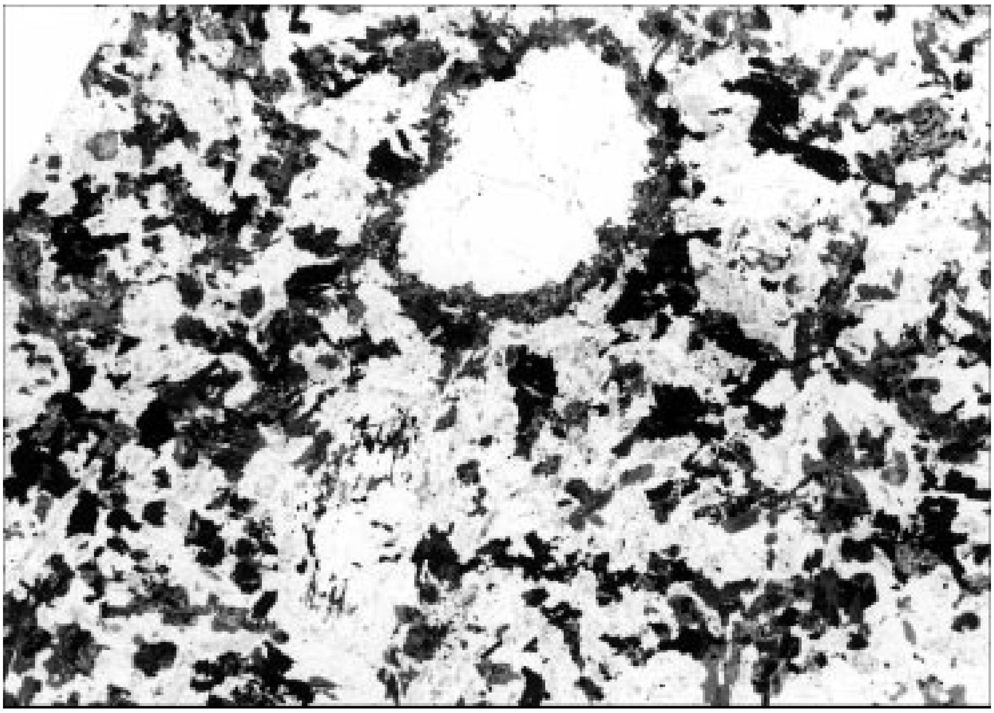


Říčany body, the feldspar grains are rather euhedral, in Ploumanac'h they have euhedral to rounded shapes. Thus more analogical features may be found between the two granitic massifs than it seems at the first sight.

Ocelli in Ploumanac'h hybrids were up to now shown on two figures only (THOMAS & SMITH, 1932, figs. 1a, b). One figure represents "an ovoid quartz-feldspar patch", the other its rim generating in the olivine gabbronorite.

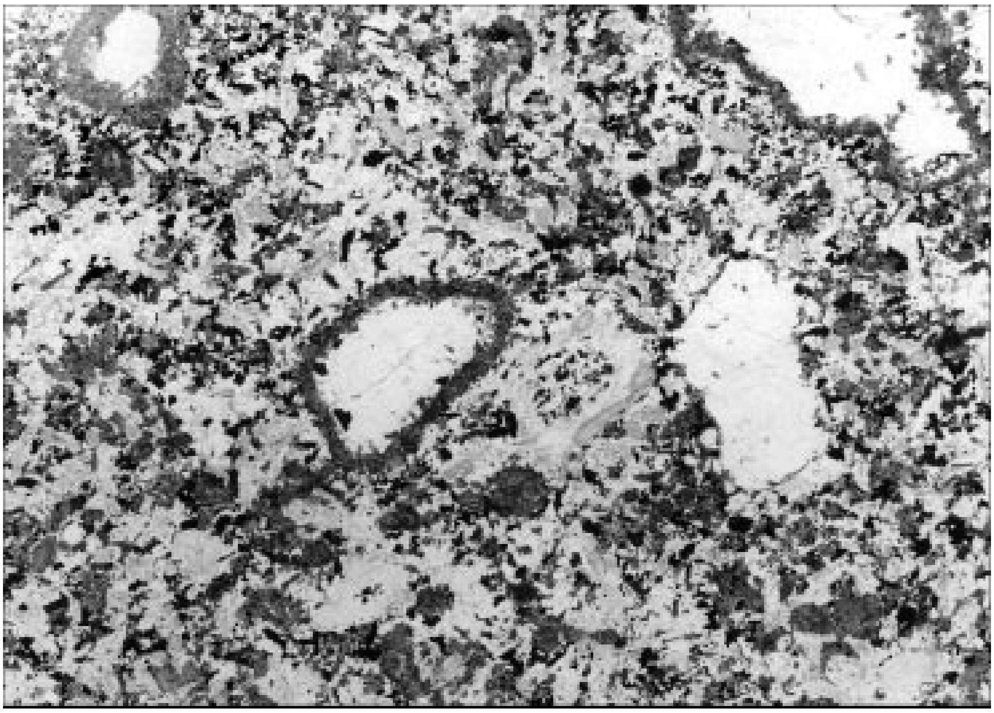
In this paper, examples of the main host rocks of ocelli (Text-Figs. 16–21) are illustrated from the same locality, Ste Anne shore in Trégastel. The most outstanding ocelli are those in the gabbronorite, though they may be easily overlooked in hand specimen due to the thick pyroxene rims (Text-Fig. 16). If weathered, small pink patches are seen in the dark rock. Some of them have euhedral shapes. Microperthite in addition to quartz is a common mineral in the cores. Hornblende-biotite (pyroxene) gabbro to quartz diorite (Text-Fig. 17) contain quartz ocelli with thin hornblende rims (after pyroxene rims), some in incipient stage of disintegration. The textures of both rock types are gabbroophitic, doleritic.

Other more common hybrids (Text-Figs. 18–21) are pyroxene-biotite-hornblende monzogabbro to quartz micromonzodiorite. In these rocks, conspicuous quartz ocelli of various shapes (euhedral up to deeply corroded, embayed) have thin, but nevertheless expressive, mostly zoned, compact, continuous rims. Origin from uralitized pyroxene rims is often recognized. Rim-free ocelli may be present together with rimmed ocelli (Text-Fig. 18). Similar ocelli and rims may be preserved in the fine-grained "light--grey" biotite hybrids (Text-Fig. 19). These hybrids are of microquartz-monzonitic to microgranodioritic compositions and are distinct due to a dramatic decrease in the grain size. They are distinguished by confuse and erratic microtextures (micromagmatic, microgranular, almost aphanitic portions alternate in the thin-sections). They display varying colour index (Text-Fig. 20). They contain feldspar megacrysts (rapakivi type or zoned oligoclase



Text-Fig. 17.
Hornblende-biotite (pyroxene) gabbro to quartzdiorite with common green hornblende.
The rounded irregular quartz ocellus displays a hornblende rim where some grains are well individualized small hornblende crystals, others are uralitized pyroxene grains. Megacrysts of patchy plagioclases are seen.
The same locality as in Text-Fig. 16, Ploumanac'h massif.
Thin Section O-709, parallel polars, 3×.
Photo: V. MATĚJKOVÁ.

Text-Fig. 18.
Hornblende-biotite pyroxene quartzmonzodiorite rich in ocelli. The ocelli are quartz and quartz-feldspar bodies with some small plagioclases at the inner rim. They may be perfectly euhedral or deeply embayed and irregular. They display distinct continuous thin two-zoned rims (of a clear-green hornblende or an uralite originating from pyroxenes, and an inner reaction rim with some biotite flakes). Rim-free ocelli (clasts) of quartz and alkali feldspars, with filled dusty and patchy cores or zones, are also seen (rapakivi type with oligoclase rims).
The same locality as in Text-Fig. 16, Ploumanac'h massif.
Thin Section 0–688, parallel polars, 3×.
Photo: V. MATĚJKOVÁ.

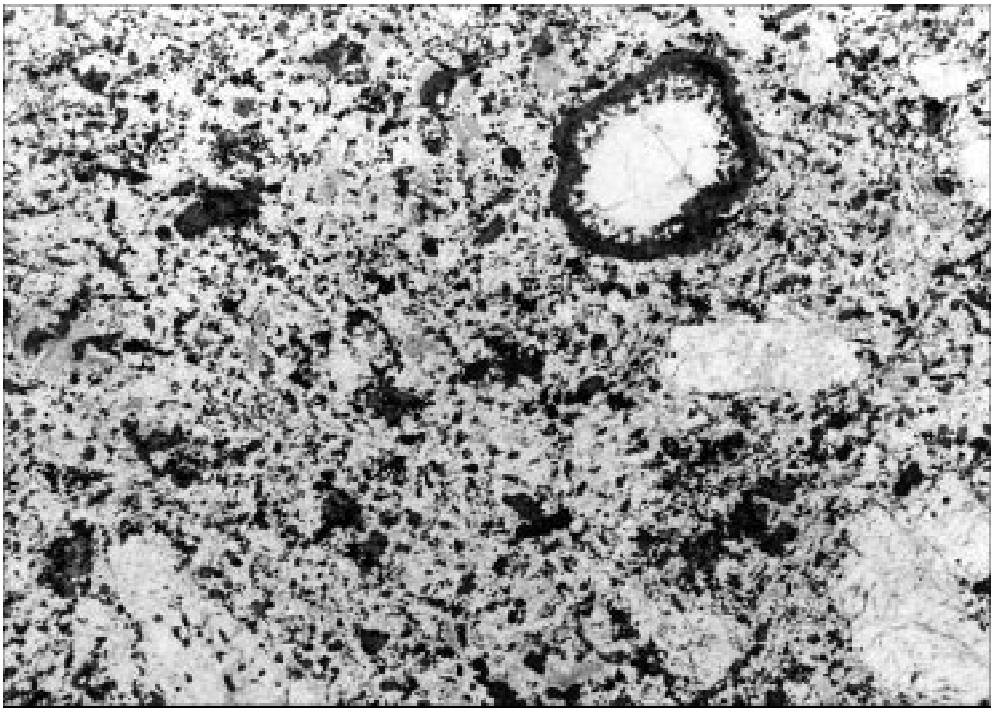


zones or cores) in a very fine-grained to aphanitic matrix, thus resembling dyke porphyries. The same rocks form enclaves in the granite (see also THOMAS & SMITH, 1932, p. 290–291). For more description see the figures.

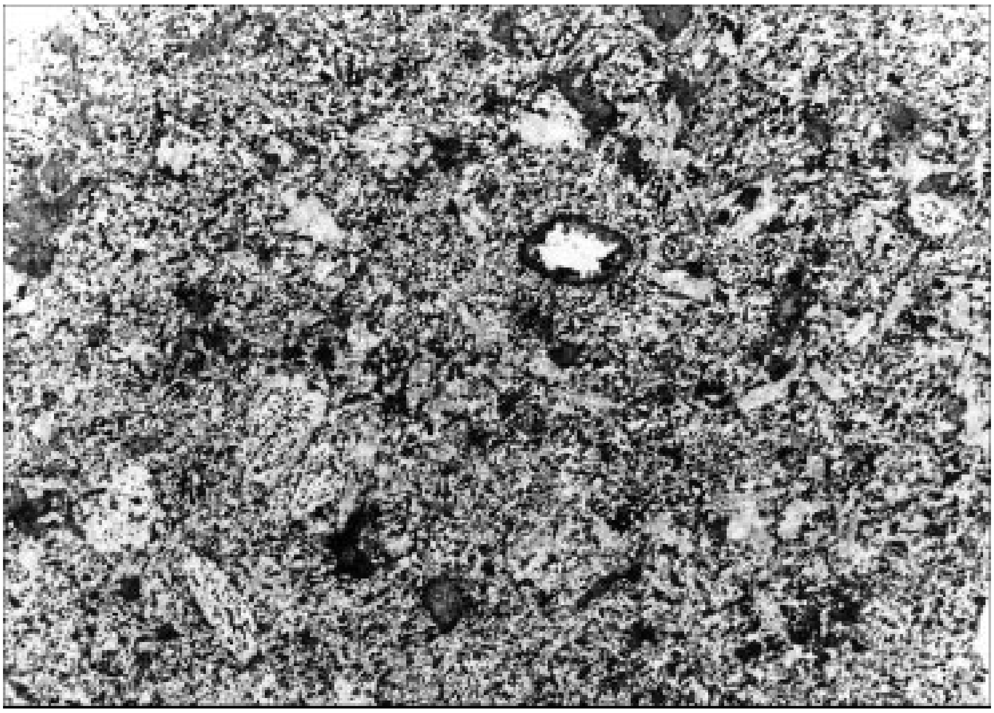
The texture of some grey finer-grained hybrids (biotite hornblende quartz monzonite) is very close to the lighter type of enclaves in the Říčany granite (compare Text-Figs. 21 and 23). The enclaves differ, however, in ocelli rims.

Ocellar enclaves in the Říčany granite and their host rocks were recently described by the present authors in more detail (PALIVCOVÁ et al., 1992). Therefore, we show two examples only, a more mafic (biotite melaquartzdiorite) host rock and a lighter-coloured one (biotite melagranodiorite), the two main types of mafic enclaves. As said above, the host rocks as well as the ocelli differ from those from the Ploumanac'h body in the absence of other Mg-Fe mineral except for biotite. In the more mafic type of the enclaves, euhedral quartz ocelli formed by a single or several grains were found. Their biotite rims may be designated as apposition rims (Text-Fig. 22). Biotite adheres tangentially to the surface of the quartz ocellus. In the lighter type of the enclaves (Text-Fig. 23), ocelli become less distinct and some of them have clear reaction rims. The rims are relict rims, where the ocellar quartz easily overgrows into the frame of the host rock and the rims gradually disintegrate. Such ocelli may be hardly discernible and they approach the rim-free ocelli known in alkaline rocks (POPOV & BORONIKHIN, 1981). Similarly to the Ploumanac'h enclaves, megacrysts of plagioclase and/or K-feldspar (with oligoclase rims) are present in the Říčany enclaves, too. The K-feldspar megacrysts are the same as in the granite. In the megacrysts, hour-glass structure was described by PIVEC (1969).

Text-Fig. 19.
Fine-grained type of ocellar hybrids of porphyritic hornblende-biotite-pyroxene micromonzonite to granodiorite composition contains a euhedral ocellus with a two-fold reaction rim of the preceeding type.
The inner vermicular reaction rim with minute biotite and hornblende is well developed. Megacrysts and clasts of feldspars are seen. Biotite probably is the only mafite in this type of the rock. Filled feldspars may be perfectly euhedral as well as rounded. (Comp. with Text-Fig. 14 in PALIVCOVÁ et al., 1989a).
The same locality as Text-Fig. 16, Ploumanac'h body.
Thin Section 0–694, arallel polars, 3×.
Photo: V. MATĚJKOVÁ.



Text-Fig. 20.
Extremely fine-grained "grey hybrid" from the contact with the granite.
The composition is that of a biotite microgranodiorite porphyry similar to a dyke rock. The rock contains strongly patchy, filled and dusted plagioclases, some euhedral small ocelli with pyroxene rims and some minute pyroxenes in the matrix.
The same locality as in Text-Fig. 16, Ploumanac'h massif.
Thin Section 0–690, parallel polars, 3×.
Photo V. MATĚJKOVÁ.



Chemical characteristics of the A-type bodies are shown in Table 2 and Text-Fig. 24. The analyses in Table 2 represent selected pairs of the similar rock types. The Ploumanac'h gabbronorite (No 1) is compared to the singular analyzed norite (No 2) from the vicinity of the CBP.

In Text-Fig. 24, very limited data available from both the Ploumanac'h and the Říčany small ring bodies are displayed. Numbered points correspond to the analyses in Table 2. The rocks of A-type massifs both lie in the rhyolite field, the alkaline character being better expressed in the Ploumanac'h rocks. However, both Říčany granitoids in Table 2 clearly tend to an alkali rhyolite composition.

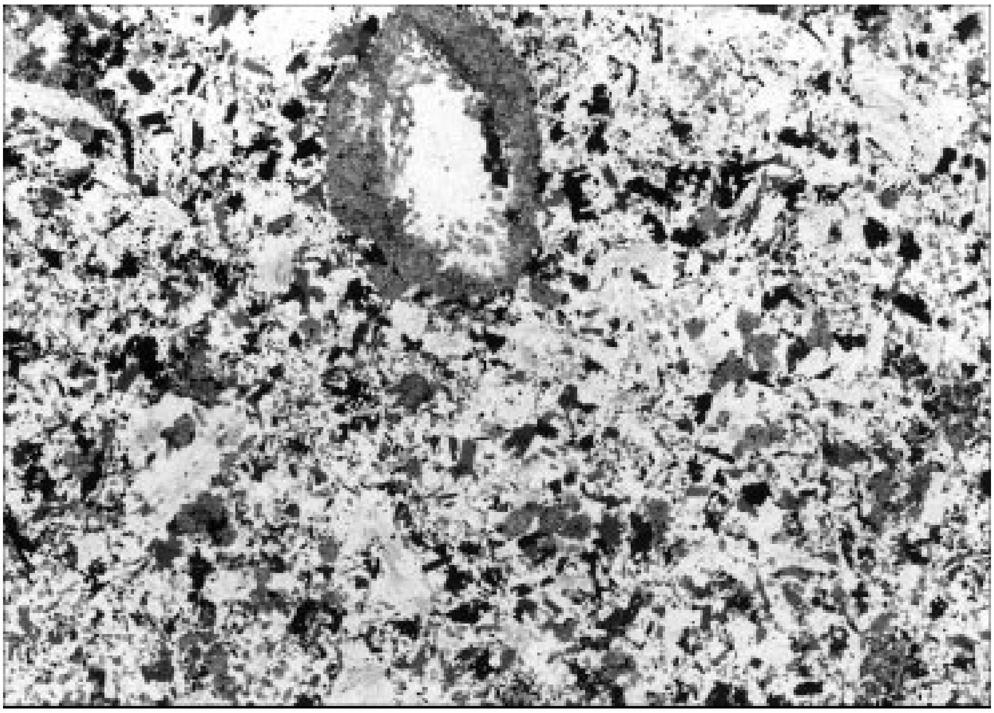
The difference between the A-type and the I-type massifs (Table 1 and 2) can be well seen on their REE contents. The magmatic source of the A-type rocks is more mature than that of I-type rocks. This is also confirmed by Rb and Th contents.

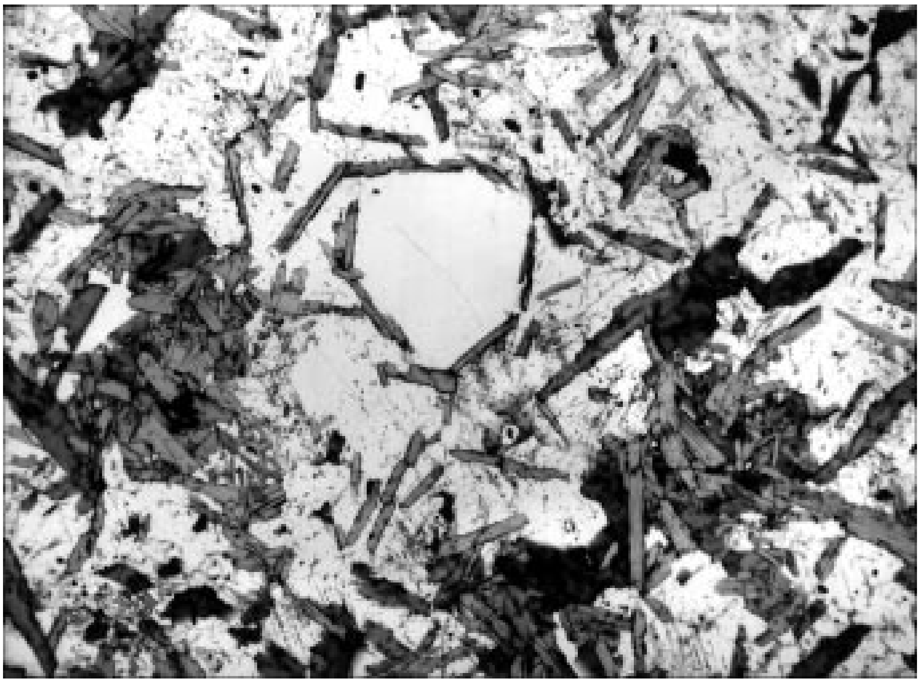
To summarize, most of the ocelli described here from the A-type massifs display simple quartz composition (monocrysts or several grains). However, in the most mafic hybrids in the Ploumanac'h norite, microperthite is much more common in the ocelli composition than in the typical intermediate hybrids. The same tendency was observed in some pyroxene-rich mafic rocks in the CBP (Text-Fig. 12).

In addition to rimmed ocelli, rim-free ovoids of quartz and also lithic ovoids (hololeucoquartzdiorites), both up to several centimeters in size, were also found in the Říčany granite. Rim-free "eyes" described by BARRIÈRE (1972), and consisting of quartz, feldspars and some mafic minerals may be brought to attention.

As mentioned above, ocelli in the Ploumanac'h massif were interpreted as crystallization products in the host rock due to mineral reactions and recrystallization processes during hybridization (THOMAS & SMITH, 1932). BARRIÈRE (1972) supported the idea of the hybrid character of the host rocks of the ocelli. He noticed, however, that "the

Text-Fig. 21.
Light-coloured fine-grained hybrid of biotite microquartz monzonite (hornblende) composition.
The light-grey rock (biotite "mica diorite" as described by THOMAS & SMITH, 1932) contains marked ocelli with originally pyroxene rims (now uralitized or amphibolized). These biotite hybrids are close in composition and texture to the lighter types of the enclaves in the Ríčany granite (See Text-Fig. 23).
The same locality as in Text-Fig. 16, Ploumanac'h massif.
Thin Section 3–787, parallel polars, 7×.
Photo V. MATĚJKOVÁ.





Text-Fig. 22.
Small euhedral quartz ocelli with appositional biotite flakes at the surface in a dark mafic enclave of the biotite melaquartzdiorite or monzodiorite of “lamproitic” character in Říčany granit.
Some clusters of biotite may be pseudomorphs after mafic minerals.
Doubek near Žernovka quarry, CBP.
Thin Section 10–353, parallel polars, 18×.
Photo: V. MATĚJKOVÁ.

case of ocelli with mafic coronas was uneasy to resolve“. The large rim-free quartz-feldspar eyes were connected with quartz-feldspathic veinlets. The “ocelli” were, however, of independent origin according to the author. Similar phenomenon (rimmed and rim-free ocelli) seems to be a frequent feature in the occurrences of ocellar rocks (e.g. WAGER et al., 1964; VORMA et al., 1975; CASTRO et al., 1990).

In the Říčany granite, the ocelli and the ovoids are suggested to be xenocrysts and microxenoliths, incorporated into the mafic enclaves during their volcanic history of development. These enclaves are interpreted as relics of pyroclastic material of a former volcanic activity in the Říčany body. The Říčany body can be explained as a volcanic/subvolcanic apparatus, that recrystallized during the Variscan orogeny (PALIVCOVÁ et al., 1992). JANOUSEK et al. (1995a, b) explain the Říčany body as reversely zoned peraluminous strongly fractionated intrusion, originated by partial melting of peraluminous lithologies, possibly of the adjacent Moldanubian unit.

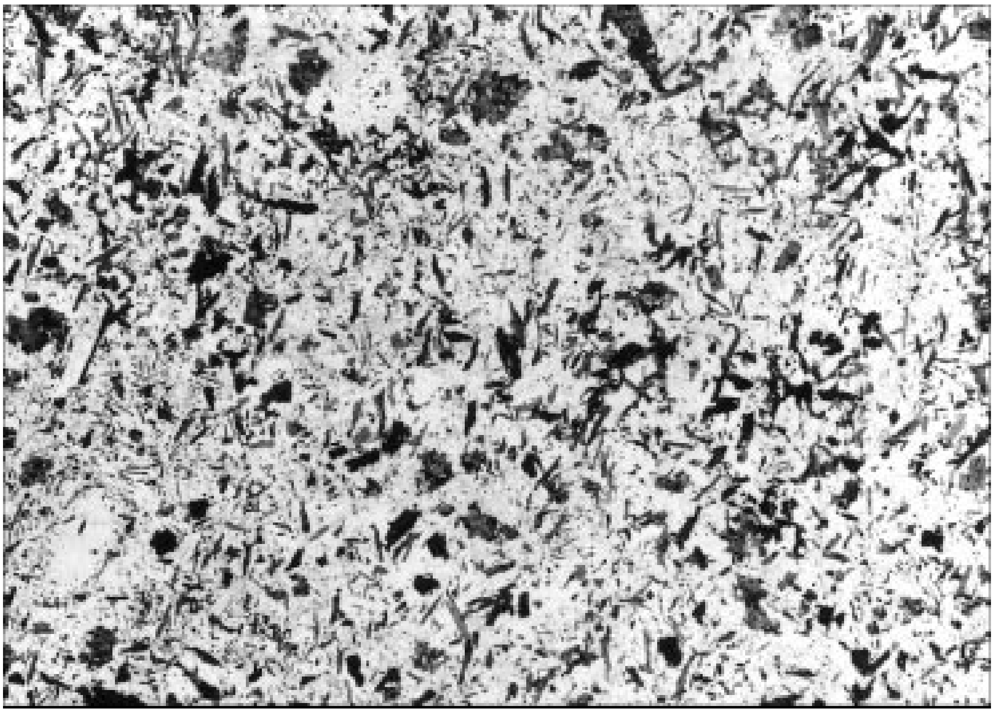
4. Summary and Conclusions

The aim of the paper is not a discussion about the origin of the ocelli. Such a discussion needs further knowledge about the variability in composition of the ocelli, particularly at the actual basic/acid contacts. Nevertheless, some conclusions which should be taken into consideration in all genetic interpretations, may be drawn from the study of the ocelli in two described associations.

Ocellar bodies in the studied associations of the I-type and A-type granitoids have many analogous and some different features.

Analogous features are:

1) In all massifs studied, host rocks of ocelli comprisemafic to intermediate rocks of various basicity, including typical basic rocks as Mte Mattoni hornblende pyroxenegabbro, Pecerady hornblende pyroxene gabbro or Ploumanac'holivine norite. If the presumption of LINDBERG & EKLUND (1989) is true, then the basic rocks under discussion had to suffer “some kind of mixing“, too.
2) Ocelli most often occur in the close proximity to or directly at the contact of basic/acid rocks, in the chilled endocontacts of basic bodies. They also occur in mafic (microgranular) enclaves in granitoids. They were,

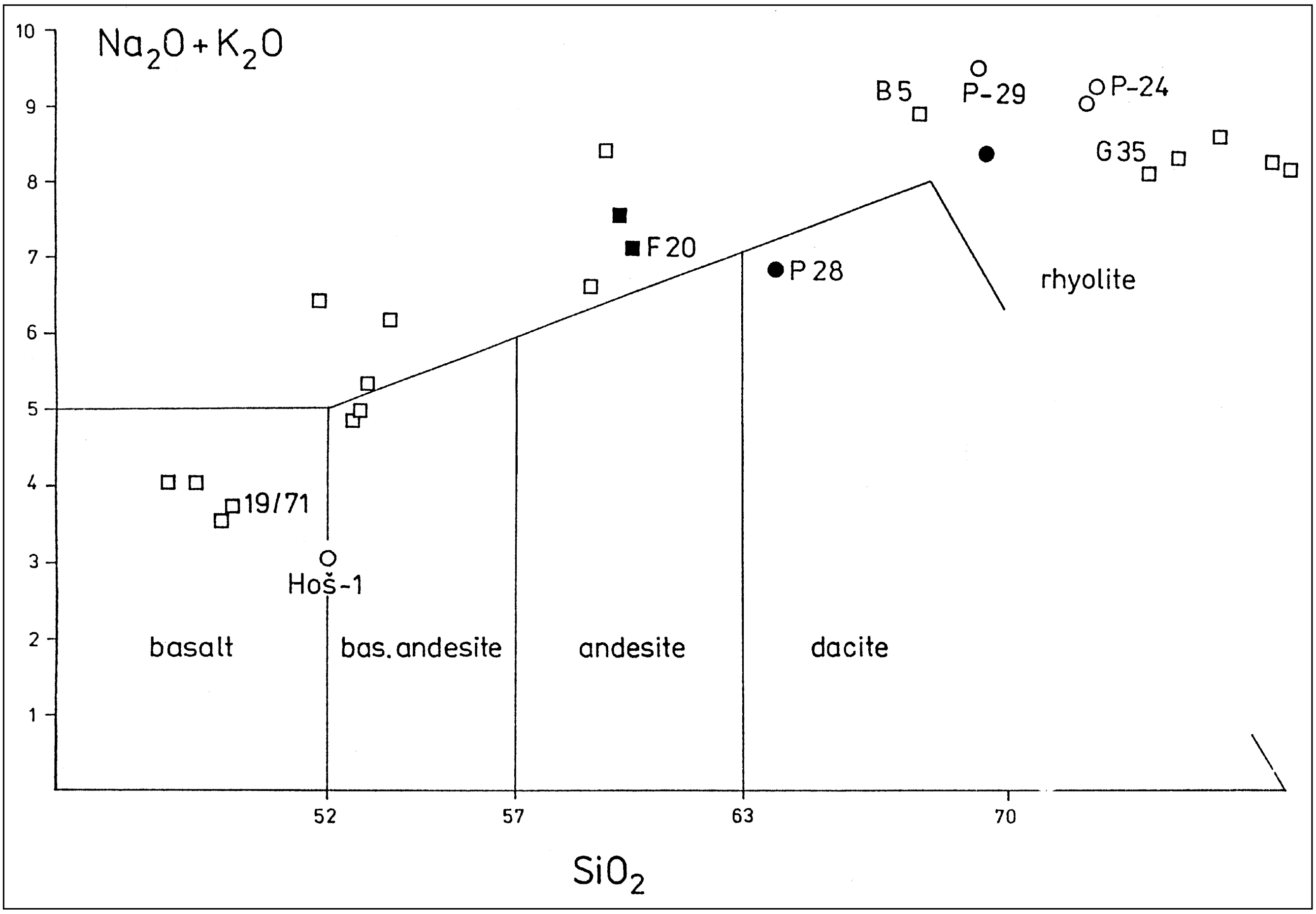


Text-Fig. 23.
Microtexture of a biotite enclave of biotite microgranodiorite composition (the lighter grey type) in theŘíčany granite.
Some indistinct ellipsoidal quartz ocelli display very fine discontinuous reaction rims (e.g. leftcorner below). The quartz overgrowing into the matrix of the host rock is common in this type of ocelli.
Compare analysis 4 in Table 2.
Svojetice-Srbín quarry, CBP.
Thin Section 0–494, parallel polars, 3×.
Photo: V. MATĚJKOVÁ.

Table 2.
Chemical anlyses of ocelli-bearing rocks from Brittanny and the Central Bohemian Pluton.
1 = Pyroxene-biotite gabbronorite, Ploumanac'h, Ste Anne (an. 19/71, unpublished material of M.P., Geological Institute AS CR; 2 = Pyroxene-biotite hornblende norite, Hoštice, Bohemian massif (ROSICKÝ & VESELÝ, 1922); 3 = Mafic enclave in the Traouieros granite, Ploumanac'h, Traouieros quarry (FOURCADE, 1981, F 20); 4 = Mafic enclave of biotite-microtonalitic composition in the Říčany granite, Svojetice quarry (PALIVCOVÁ et al., 1992, P28); 5 = Biotite granite, Ploumanac'h, Traouieros quarry (BARRIÈRE, 1977a; FOURCADE, 1981, B5); 6 = The similar rock type from the Říčany massif (non-porphyritic to slightly porphyritic type), Svojetice quarry (PALIVCOVÁ et al., 1992, P29); 7 = Porphyritic biotite granite (muscovite), Ploumanac'h, La Clarté quarry (BARRIÈRE, 1977a; FOURCADE, 1981, G35); 8 = The similar rock type from the Říčany massif, Doubek quarry (PALIVCOVÁ et al., 1992, P24).

	1	2	3	4	5	6	7	8
	P	H	P	Ř	P	Ř	P	Ř
	basic rocks		mafic enclaves		granite		porph. granite	
	gabbro norite	norite						
	19/71	Hoš-1	F20	P28	B5	P29	G35	P24
SiO_2	48.82	51.40	59.50	62.75	67.40	68.29	73.60	71.63
TiO_2	1.23	0.69	1.71	0.87	0.76	0.44	0.28	0.23
Al_2O_3	11.43	11.10	14.65	13.00	15.52	14.25	13.65	14.43
Fe_2O_3	1.99	1.23	8.26^t	1.17	3.65	2.08	1.99	0.52
FeO	9.02	8.45	–	4.14	–	1.27	–	0.78
MnO	0.15	0.70	0.09	0.08	0.07	0.05	0.02	0.03
MgO	14.32	4.79	3.75	5.73	1.06	1.08	0.52	0.46
CaO	8.01	16.84	3.63	2.91	2.20	1.61	1.0	1.61
Na_2O	2.00	0.83	3.77	3.14	3.72	3.45	3.09	3.71
K_2O	1.72	2.18	3.29	3.60	5.12	5.89	5.48	5.45
P_2O_5	0.21	0.40	n.d.	0.85	n.d.	0.30	n.d.	0.19
H_2O+	0.83	0.96	0.31	0.78	0.25	0.84	0.28	0.32
H_2O-	0.29	0.24	0.18	0.30	0.14	0.52	0.42	0.37
CO_2	-	0.41	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Σ	100.02	100.22	99.14	99.32	99.89	100.07	100.33	99.73
La					80		45.4	24.3
Ce					142		95.3	71.5
Nd					57.9		35.2	n.d.
Sm					10.2		4.95	4.6
Eu					1.53		0.72	0.92
Gd					5.1		4.0	–
Tb					0.85		0.35	0.35
Tm					0.38		0.14	–
Yb					2.07		0.86	<0.5
Lu					0.32		0.13	0.04
Rb					240	320	335	255
Ba			357		828	950	391	–
Sr			282		389	320	182	–
Hf					10.		5.65	1.3
Th					39.4		91.2	32.5
U					8.4		–	12.5
Sc					6.6		2.49	4.7
Ni			103	130	–	22	–	–
Cr			152	173	–	86	–	32
V			152	103	–	23	–	–
Co			78	26	7.4	32	1.66	3.6
Cu			<10	9	–	6	–	
Ta					2.4	–	0.88	
Cs					8.7	50	6.42	22
Sn						24		
B						51		
W						1.7		
Zn						42		
Pb						72		
Li						150		
Be						9.1		

t – Fe_2O_3 total



Text-Fig. 24.
Geochemistry of the Ploumanac'h and Říčany rocks. TAS diagram of the rock types of the Ploumanac'h massif (squares) and of the Říčany massif (circles).
All available analyses are displayed, the numbered points represent the analyses from the Table 2.
■, ● = enclaves.

however, found also irregularly distributed in the central parts of mafic bodies (e.g. Pecerady gabbro).

3) The occurrence of ocelli is closely related to the presence of light acid biotite granitoids, usually coarse-grained, often porphyritic (trondhjemites, porphyritic granites). The existence of these granitoids seems to be a prerequisite of the ocelli presence in the associated mafic rocks. Accumulations of ocelli as seen on Text-Figs. 3, 4 maybe found just at the contact.
4) At the mafic/felsic contact where granitoids are of "normal" type (i.e. equigranular grey granodiorites, tonalites) neither contact accumulation of ocelli such as referred sub 3, nor dispersed ocelli in the endocontact of the mafic body were observed. Ocelli may, however, be dispersed in the mafic enclaves of these granitoids and in aplopegmatoid accumulations at the mafic/felsic contact or in aplopegmatoid nests and schlieren in the granitoids (Hořejany and Teletín quarries, CBP). In the latter case, the ocelli, usually with a rim, seem to have been transported by this acid aplopegmatoid material (see also ANGUS, 1962).
5) The ocelli occur in similar morphological shapes (euhedral, rounded, resorbed, irregular) in all the massifs studied, regardless of the composition of the ocelli andregardless of the ages of the massifs. Euhedral pseudomorphosed ocelli were found, too.
6) In both, the I- and the A-type massifs studied, analogous relationships between the mafic rock composition and the ocelli rim composition can be traced. Usually, the rims correspond to the composition of mafites in the host rock. However, there are clear exceptions to this rule: inherited altered pyroxene rims were found in the most advanced hybridization products, i.e. biotite hybrids free of other mafic minerals in the Ploumanac'h body, pyroxene rims in hornblende diorites lacking pyroxene in the CBP.
7) The quartz ocelli and/or (rarely) feldspar ocelli are the most common compositional types of the ocelli. In both associations, the feldspar ocelli were more frequently observed in the more mafic members than in the less mafic ones: the Ploumanac'h olivine-bearing norite is a good example of this feature.
8) Rimmed as well as rim-free ocelli or ovoids may be present in the same host rock. Some of the rim-free ocelli exhibit euhedral shapes of the same type as the rimmed ocelli. Rim-free ocelli and ovoids are more common in A-type than I-type massifs.

There are not many differences in the development of the ocelli in the different rock series studied. However, the following essential point is of concern:

The compositions of the ocelli cores in different associations differ markedly in response to the petrographic character of the host association. In the I-type massifs, the mineral composition is more complex and more variable. The ocelli consist not only of quartz K-feldspar but they contain also the main Ca-Al rock-forming minerals and late- or postmagmatic minerals of the host rock (hornblende, intermediate plagioclase, minerals of the epidote group, and also sphene, ore minerals and calcite). In A-type massifs, only quartz and/or K-feldspar acid plagioclase (exceptionally accessory sphene and biotite) were found in the cores of ocelli.

Moreover, it seems that not only the composition of the host rocks, but also the composition of the massifs envelope might be reflected in the composition of the ocelli. For instance, Ploumanac'h and Říčany massifs are set mostly in metamorphosed pelitic-psammitic surroundings and felsic gneisses: here quartz- and/or K-feldspar ocelli are present. In the Adamello massif, calcareous rocks are the main rocks of the envelope in the region studied, and calcite together with plagioclase are frequent constituents of the ocelli. In the CBP, a metamorphosed pelitic-psammitic and metavolcanic environment is the most frequent one, whilst calcareous rocks are subordinate. In the ocelli composition, K-feldspar or epidote are frequent minerals in the cores, whilst calcite is scarcely observed.

The latter presumptions are naturally limited by the number of the ocellar rock samples and by the availability of the thin-sections of individual ocelli from different associations. The presumptions may be corrected by future research. E.g. Ploumanac'h – Ste Anne ocellar hornblende-biotite diorites should be studied in greater detail to confirm or disprove the above observations. We believe that this is the direction in which a further study of the ocellar rocks should be primarily oriented, i.e. to search for understanding of the ocelli variability in individual occurrences and in various host rocks.

5. Some Petrogenetic Remarks

The ocelli are small bodies in size but they are of great petrogenetic significance. No genetic interpretation of their existence can be made without an impact on the petrogenetic models of mafic-felsic series formation and no genetic interpretation of these series can omit them.

Two conclusions of general character which follow from the microtextural analogies of the studied rocks and their ocelli can be mentioned:

The first is the extreme similarity (up to minute details) in the ocelli development together with the extreme textural complexity of the granitoid rocks. This similarity in the range of microtextural varieties of rocks is independent of geological age, as is clearly seen from the study of the Adamello and the CBP rocks (see Palivcová, 1981 also for other regions).

The second conclusion follows from the first one. The raison of such complex similarity in the massifs of various ages can hardly be explained in a better way than by a true magmatic process occurring under similar geotectonic conditions, a view recently elaborated and emphasized e.g. by Pitcher (1993).

As for the origin of the ocelli, we suppose their xenocrystic (and microxenolithic) origin. The ocelli display similar coronas as the xenocrysts in the volcanics. Then the incorporation of the felsic country material into the younger mafic rocks by contamination and assimilation during their emplacement is the easiest geological interpretation. This also provides an explanation for the similarities between the ocelli in the gabbroic rocks and some of the ocelli in lamprophyres. The detailed mapping of basic satellitic bodies as sheets in the Adamello Val Fredda complex by Blundy & Sparks (1992) and remelting of the granitic material by these basic magmas can be used in favour of this view. These geological relations could also be a common feature of other similar mafic-felsic series (e.g. in the CBP) if mapped in as much of a detail as the Val Fredda complex of the Adamello massif.

However, the crucial problem of ocelli interpretation is that of their occurrence and incorporation into the mafic enclaves, i.e. the origin of the mafic enclaves themselves. This topic is outside the scope of the present study.

We mention only briefly that in the mafic microgranular enclaves, ocelli are recently interpreted as xenocrysts (and microxenoliths), too. They are thought to be incorporated into enclaves due to magma mixing during contemporaneous mafic/felsic intrusions (see references in the Introduction).

We do not call in doubt the xenocrystic (and microxenolithic) origin of ocelli in the mafic enclaves. Nevertheless, even the favoured model of the origin of the ocellar microgranular enclaves during magma mixing (such as pillows – e.g. Reid et al., 1983, quenched magma globules – Vernon, 1984, dismembered sheets by remelted granite – Blundy & Sparks, 1992) has its constraints (see also Frost & Mahood, 1987; Eberz & Nichols, 1988). In our view (Palivcová et al., in print), the most important constraints are those based on field geology. The mixing (mingling) model is difficult to understand on the scale of large geological dimensions in cases where the enclaves are dispersed in large granitoid massifs. We doubt the possibility of origin of mafic enclaves themselves by magma mixing under the deep seated, i.e. plutonic conditions. We suggest that the origin of the mafic enclaves and, in particular, the incorporation of the ocelli into them has not yet been satisfactorily explained.

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References

Angus, N.S.: Ocellar hybrids from the Tyrone igneous series, Ireland. – Geol. Mag., **99**, 19–26, Cambridge 1962.

Autran, A. & Dercourt, J.F. (eds.): Évolutions géologiques de la France. – Mém. du BRGM, 107, pp. 385, Orléans 1980.

Barnes, C.G., Barnes, M.A. & Kistler, R.W.: Petrology of the Caribou Mountain pluton, Klamath Mountains, California. – Journ. Petrology, **33**, 95–124, Oxford 1992.

Barrière, M.: Hybridization des roches basiques par un granite porphyroide dans le massif de Ploumanac'h (Cotes du Nord). – R.C. Acad. Sci. Paris, **274**, sér. D, 983–986, Paris 1972.

Barrière, M.: Le complexe de Ploumanac'h, Massif Armoricain (Essai sur la mise en place et l'évolution pétrologique d'une association plutonique subalcaline tardi-orogénique.) – These, Univ. de Bretagne Occ., pp. 290. Brest 1977a.

Barrière, M.: Deformation associated with the Ploumanac'h intrusive complex, Brittany. – J. Geol. Soc. London, **134**, 311–324, London 1977b.

Barrière, M.: Les granitoides paléozoiques armoricains. – In: A. Autran & J.F. Dercourt (eds.): Évolutions geologiques de France, Mém. du BRGM, **107**, 56–63, Orléans 1980.

Bergner, R., Hofmann, J., Dubansky, A., Gunia, T., Wojciechowska, Hofmann, J., Kohler, H., Povondra, P., Scharbert, S. & Zoubek, V.: Isotopic ages obtained from Precambrian complexes in the Bohemian Massif. – In: V. Zoubek (ed.): Precambrian in younger fold belts, 305–325, Chichester (Wiley) 1988.

Blundy, J.D. & Sparks, R.S.J.: Petrogenesis of mafic inclusions in granitoids of the Adamello Massif, Italy. – Journ. Petrology, **33**, 1039–1104, Oxford 1992.

Brack, P.: Multiple intrusions, examples from the Adamello batholith (Italy) and their significance on the mechanism of intrusions. – Mem. Soc. Geol. It., **26** (1983), 145–157, Roma 1985.

Bussell, M.A.: The centred complex of the rio Huaura: a study of magma mixing and differentiation in high-level magma chambers. – In: Pitcher, W.S. et al. (eds.): Magmatism at a plate edge, p. 128–155, Glasgow (Blackie) 1985.

Callegari, E.: La Cima Uzza (Adamello Sudorientale). Parte II. Studio petrografico e petrogenetico della massa femica. – Mem. Ist. Geol. Miner. Univ. Padova, **24**, 1–127, Padova 1963.

Callegari, E.: Geological and petrological aspects of the magmatic activity at Adamello (Northern Italy). – Mem. Soc. Geol. It., **26**, (1983) 83–103, Roma 1985.

Callegari, E., Dal, Piaz, H.: Field relationships between the main igneous masses of the Adamello intrusive massif (Northern Italy). – Mem. Ist. Geol. Miner. Univ. Padova, **29**, 1–39, Padova 1973.

Castro, A., Ross, J.D. & Stephens, W.E.: Magma mixing in the subvolcanic environment: petrology of the Gerena interaction zone near Seville, Spain. – Contr. Mineral. Petrol., **105**, 9–26, Heidelberg 1990.

Clarke, D.B.: Granitoid rocks. – Topics in the Earth Sciences, No. 8, 283 pp. (Chapmann and Hall) London 1992.

Cocco, L. & De Pieri, R.: Amphiboles from the igneous rocks of the Adamello massif (Northern Italy). – Neu. Jhb. Miner., Mh, **9**, 398–406, Stuttgart 1981.

Del Moro, A., Ferrara, G., Tonarini, S. & Callegari, E.: Rb-Sr systematic in rocks from the Adamello batholith (Southern Alps). – Mem. Soc. Geol. It., **26** (1983), 261–284, Roma 1985.

Didier, J.: Granites and their enclaves. – 393pp., Amsterdam (Elsevier) 1973.

Didier, J.: Contributions of enclave studies to the understanding of origin and evolution of granitic magmas. – Geol. Rdsch., **76**, 41–50, Stuttgart 1987.

Didier, J. & Barbarin, B.: Enclaves and granite petrology. – Development in Petrology, **13**, 625 pp., Amsterdam (Elsevier) 1991.

Dudek, A. & Fediuk, F.: Geology and petrography of the Hudčice quarry area. – Sbor. Ústř. úst. geol., Odd. geol., **23**, 159–213 (in Czech), Praha 1956.

Dupuy, C., Dostal, J. & Fratta, M.: Geochemistry of the Adamello massif (Northern Italy). – Contrib. Mineral. Petrol., **80**, 41–48, Heidelberg 1982.

Eberz, G.W. & Nicholls, I.A.: Microgranitoid enclaves from the Swifts pluton, SE Australia: textural and physical constraints of the nature of magma mingling process in the plutonic environment. – Geol. Rdsch., **77**, 713–736, Stuttgart 1988.

Fiala, J., Hanuǔs, V., Jurek, K. & Palivcová, M.: Pyroxene in spheroidal gabbro in the Central Bohemian Pluton – magmatic or metamorphic? – Krystalinikum, **10**, 101–112, Praha 1974.

Fiala, J., Ulrych, J., Lang, M. & Pivec, E.: Coexistence of the principal minerals of the Pecerady gabbro (In Czech). – Studie ČSAV, **12**, 141–160, Praha 1975.

Fourcade, S.: Geochimie des granitoides. – Dr.Sc. Thesis, University of Paris 1981.

Frost, T.P. & Mahood, G.: Field, chemical and physical constraints on mafic-felsic magma interaction in Lamarck granodiorite, Sierra Nevada, California. – Geol. Soc. Amer. Bull., **92**, 272–291, Boulder Co. 1987.

Hanuuš, V. & Palivcová, M.: Formation of gabbros from basalts stimulated by postvolcanic alteration. – 23. IGC, vol. 1, 221–232, Praha 1968.

Hanuuš, V. & Palivcová, M.: Quartz gabbros recrystallized from olivine-bearing volcanics. – Lithos, **2**, 147–166, Oslo 1969.

Hanuuš, V. & Palivcová, M.: Relic variolitic texture in basic plutonites. – Neu. Jb. Miner. Mh., **10**, 433–455, Stuttgart 1970.

Hanuuš, V. & Palivcová, M.: Ocellar texture of Pecerady gabbro in Central Bohemian pluton. – Acta Univ. Carol., Geol., **3**, 175–187, Praha 1971a.

Hanuuš, V. & Palivcová, M.: Presence and significance of amygdules in hornblende gabbros. – Krystalinikum, **8**, 27–43, Praha 1971b.

Hejtman, B.: Inclusions in the granodiorite of Kozárovice. – Bull. Intern. de l'Acad. tchèque de Sciences, **59**, 27, p. 1–25, Praha 1949.

Holub, F.V.: Petrogenetic interpretation of potassic lamproids of the European Hercynides. – Unpubl. PhD Thesis, 265 pp (in Czech). Charles University, Prague 1990.

Holub, F.V.: Contribution to petrochemistry of the Central Bohemian Plutonic Complex. – In: Souček, J. (ed.): Rocks in Earth Sciences, Charles University Prague, 117–140 (in Czech with English summary), Praha 1992.

Jakeš, P. & Pokorny, J.: The map of lithogeochemical complexes of the Bohemian Massif. – In: J. Vacek et al.: Perspective evaluation of metallic ore deposits in the Bohemian Massif, Unpubl. report, 32–33, Geofond, Praha 1983.

Janoušek, V., Rogers, G. & Bowes, D.R.: Sr-Nd isotopic constraints on the petrogenesis of the Central Bohemian Pluton, Czech Republic. – Geol. Rundsch., **84**, 520–534, Stuttgart 1995.

Janoušek, V., Rogers, G., Bowes, D.R. & Vaňková, V.: The generation and emplacement of the reversely-zoned Říčany granitoid intrusion in the Hercynian Central Bohemian Pluton. (Abstract). – J. Czech Geol. Soc., **40/3**, p. B-68, Prague 1995.

Jobstraibizer, P.G., De Pieri, R.C. & Callegari, E.: The main minerals of the Adamello massif, Northern Italy. – Mem. Soc. Geol. It., **26** (1983), 323–339, Roma 1985.

Kagami, H., Ulmer, P., Hansmann, W., Dietrich, V. & Steiger, R.H.: Nd-Sr isotopic and geochemical characteristics of the Southern Adamello (Northern Italy) intrusives: implications for crustal versus mantle origin. – Journ. Geophys. Res., **96**, B9, 14331–14346, Washington D.C. 1991.

Karl, F.: Ein Beitrag zum Vergleich von Tonaliten und Granodioriten im Mittelböhmischen Pluton und in den periadriatischen Intrusivmassen. – Verh. Geol. B.–A., 108–120, Wien 1967.

King, B.C.: The nature of basic igneous rocks and their relations with associated acid rocks. Part 4. – Science Progress, **52**, 282–292, London 1964.

Lang, M.: The An-content and ordering degree of the plagioclases in the Pecerady gabbro. – In: M. Palivcová (ed.): Pecerady gabbro – an example of the appinite type body in the Central Bohemian Pluton, Studie ČSAV, **12**, 107–123, Praha 1975.

Lang, M. (ed.): Rocks of the Teletín quarries. Petrology of the intrusive contact of tonalite near Teletín. (in Czech). – Studie ČSAV, **3**, 110 pp., Praha 1978.

Le Bas, M.J., Le Maitre, L.W., Streckeisen, A. & Zanettin, B.: Chemical classification of volcanic rocks based on the total alkali-silica diagram. – J. Petrology, **3**, 745–750, Oxford 1986.

Ledvinková, V. (ed.): Geological map 1:50.000, sheet 22–21 (Příbram). – Unpubl., Czech Geol. Survey, Praha 1994.

Lindberg, B. & Eklund, O.: Interaction between basaltic andgranitic magmas in a Svecofennian postorogenic granitic intrusion, Aland, Southwest Finland. – Lithos, **22**, 13–23, Amsterdam 1988.

Macera, P., Ferrara, G., Pescia, A. & Callegari, E.: A geochemical study on the acid and basic rocks of the Adamello batholith. – Mem. Soc. Geol. It., **26** (1983), 223–259, Roma 1985.

Martin, H., Bonin, B., Capdevilla, R., Jahn, B.M., Lameyre, J. & Wang, Y.: The Kuique peralkaline granite complex, SE China, petrology and geochemistry. – J. Petrology, **35**, 4, 983–1015, Oxford 1994.

PALIVCOVÁ, M.: Ocellar quartz leucogabbro (Central Bohemian-Pluton) and genetic problems of ocellar rocks. – Geol. Zbor. Geol. carpath., **29**, 43–66, Bratislava 1978.

PALIVCOVÁ, M.: Microtextures of gabbroic and dioritic rocks associated with intrusive granitoid complexes. – Geol. Zbor. Geol. carpath., **32**, 559–589, Bratislava 1981.

PALIVCOVÁ, M.: Petrogenetic significance of textural development of basic rocks in the southern Adamello massif (Mte Mattoni, Mte Cadino), Italy. – In: F.K. DRESCHER-KADEN & S.S. AUGUSTITHIS (eds.): Transformists' petrology, Theophrastus Publ., 149–175, Athens 1982.

PALIVCOVÁ, M.: Basic series of an "Andinotype" batholithic association in the Variscan Central Bohemian Pluton. – Geol. Zbor. Geol. carpath., **35**, 39–60, Bratislava 1984.

PALIVCOVÁ, M. (ed.): Pecerady gabbro – an example of the appinite type body in the Central Bohemian Pluton (in Czech). – Studie ČSAV, **12**, 166 pp. Praha 1975.

PALIVCOVÁ, M., WALDHAUSROVÁ, J. & LEDVINKOVÁ, V.: Granitization problem – once again. – Geol. Zbor. Geol. carpath., **40**, 423–452, Bratislava 1989a.

PALIVCOVÁ, M., WALDHAUSROVÁ, J. & LEDVINKOVÁ, V.: Precursors lithology and the origin of the Central Bohemian Pluton (Bohemian Massif). – Geol. Zbor. Geol. carpath., **40**, 5, 521–546, Bratislava 1989b.

PALIVCOVÁ, M., WALDHAUSROVÁ, J., LEDVINKOVÁ, V. & FATKOVÁ, J.: Říčany granite and its ocelli- and ovoid-bearing enclaves. – Krystalinikum, **21**, 33–66, Praha 1992.

PALIVCOVÁ, M., WALDHAUSROVÁ, J. & LEDVINKOVÁ, V. (in print): Ocelli in mafic rocks of granitic complexes. – Krystalinikum, **22**.

PATOČKA, F.: Granitization of the enclaves in granitoids fromthe Vrančice ore district (In Czech). – Čas. Min. Geol., **24**, 1, 39–50, Praha 1979.

PITCHER, W.S.: The nature and origin of granite. – 321 pp. London (Blackie Acad. Profess.) 1993.

PIVEC, E.: Potassium feldspars with hourglass structure in biotite adamellite and their genetic interpretation. – Acta Univ. Carol. Geologica, **1**, 25–30, Praha 1969.

PIVEC, E. & MINAŘÍK, L.: The potassium feldspars of the Pecerady gabbro. – In: M. PALIVCOVÁ (ed.): Pecerady gabbro – an example of the appinite type body in the Central Bohemian Pluton (in Czech), Studie ČSAV, **12**, 125–140, Praha 1975.

POUBOVÁ, M.: Composition of amphiboles and rock type subdivisions in the Central Bohemian Pluton. – Krystalinikum, **10**, 159–169, Praha 1974.

POPOV, V.S. & BORONIKHIN, V.A.: Quartz phenocrysts in melanocratic igneous rocks and their petrologic significance (In Russian.) – Zapiski Vsesojuzn. mineralog. obscestva, **110**, 5, 534–545, Moskva 1981.

ROSICKÝ, V. & VESELÝ, V.: Sur la norite biotitique et amphibolique de Hoštice en Boheme. – Publications Fac. Sci. Univ. Masaryk, **10**, 1–17, Brno 1922.

SABATIER, H.: Vaugnerites: special lamprophyre derived mafic enclaves in some Hercynian granites from Western and Central Europe. – In: J. DIDIER and J.B. BARBARIN (eds.): Enclaves and granite petrology, Developments in petrology, **13**, 63–81, Amsterdam (Elsevier) 1991.

SVOBODA, J. (ed.): Encyclopedic geological dictionary Vol. 1, 2, Praha (Academia) 1983.

SINE: Geological map of Czechoslovakia 1:200.000, sheet Tábor. – Ústř. úst geol., Praha 1963.

ŠPONAR, K. & KOMÍNEK, F.: Revision of heavy-mineral anomalies II. Říčany area. – Unpubl. report, Geofond, Praha 1985.

TÁBORSKÁ, Š., SCHULMANN, K. & HROUDA, F.: Multiphase intrusion in the Nasavrky Plutonic Complex as inferred from magnetic and mesoscopic fabric (Abstract). – J. Czech Geol. Soc., **40/3**, p. B-74, Prague 1995.

THOMAS, H.H. & SMITH, W.C.: Xenoliths of igneous origin in the Trégastel-Ploumanac'h granite. – Quart. Journ. Geol. Soc., **88**, 274–296, London 1932.

ULMER, P., CALLEGARI, E. & SONDEREGGER, U.G.: Genesis of the mafic and ultramafic rocks and their genetical relations to the tonalitic-trondhjemitic granitoids of the southern part of the Adamello batholith (Northern Italy). – Mem. Soc. Geol. It., **26** (1983), 223–259, Roma 1985.

ULRYCH, J.: The hornblendes of the Pecerady gabbro body. – In: M. PALIVCOVÁ (ed.): Pecerady gabro – an example of the appinitetype body in the Central Bohemian Pluton (in Czech), Studie ČSAV, **12**, 85–105, Praha 1975.

ULRYCH, J.: Development of chemical zoning of amphiboles in mafic rocks of the Central Bohemian Pluton (in Czech). – Acta Univ. Carol., Geologica, 25–48, Praha 1985.

VEJNAR, Z. 1973: Petrochemistry of the Central Bohemian Pluton. – Geochem. methods and data, 2, 116 pp., Ústř. úst. geol., Praha 1973.

VERNON, R.H.: K-feldspar megacrysts in granites-phenocrysts, not porphyroblasts. – Earth Sci. Rev., **23**, 1–63, Amsterdam 1986.

VERNON, R.H.: Crystallization and hybridism in microgranitoid enclave magmas: microtextural evidence. – Journ. Geophys. Res., **95**, No B 11, 17849–17859, Amsterdam 1990.

VERNON, R.H.: Interpretation of microtextures of microgranitoid enclaves. – In: DIDIER, J. & BARBARIN, B.: Enclaves and granite petrology, 277–291, Amsterdam (Elsevier) 1991.

VILLA, I.M.: 40Ar/39Ar chronology of the Adamello gabbros, Southern Alps. – Mem. Soc. Geol. It., **26** (1983), 309–318, Roma 1985.

VLAŠÍMSKÝ, P.: To the question of the Cambrian rocks enclosed in the NW part of the Central Bohemian Pluton (in Czech). – Čas. Mineral. Geol., **35**, 185–195, Praha 1990.

VOGEL, T. & WALKER, B.M.: The Tischka Massif, Morroco – an example of contemporaneous acidic and basic plutonism. – Lithos, **8**, 1, 29–38, Oslo 1975.

VORMA, A.: On two roof pendants in the Wiborg rapakivi massif, south eastern Finland. – Geol. Surv. Finland Bull., **272**, 86 pp., Espoo 1975.

WAGER, L.R., VINCENT, E.A., BROWN, G.M. & BELL, J.D.: Marscoite and related rocks of Western Red Hills complex, Isle of Skye. – Philos. Transact. Roy. Soc. London, ser. A, No 1080, **257**, 273–307, London 1965.

WALKER, G.P.L. & SKELHORN, R.R.: Some associations of acid and basic igneous rocks. – Earth Sci. Rev., **2**, 93–109, Amsterdam 1966.

ZORPI, M.J., COUTON, C., ORSINI, J.B. & COCIRTA, C.: Magma mingling, zoning and emplacement in calc-alkaline granitoid plutons. – Tectonophysics, **157**, 315–329, Amsterdam 1989.

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