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HOW SHOULD CHARNOCKITIC ROCKS BE NAMED?

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ABSTRACT

The IUGS Subcommission on the Systematics of Igneous Rocks, at its meeting of Montreal, agreed to Recommendations (1972) for plutonic rocks, which were published in various reviews. Charnockitic rocks were not included, as their nomenclature was still under review by a special working group. This paper outlines the results reached at present.

Charnockitic rocks are classified and named according to their positions in the QAP diagram. General and special names may be used in an optional manner. Definitions of special names are given. Only special names of current usage are recommended: charnockite, opdalite (or charno-ederbite), enderbite, mangerite, jotunite; the use of farsundite is debated. A classification scheme of charnockitic rocks is presented.

The attribution of perthitic felspar to alkali feldspar or plagioclase is discussed. It is recommended that perthitic feldspars are distributed over A and P according to the actual (modal) content of their K-feldspar and plagioclase phases. As albite is considered as an alkali feldspar, perthites are attributed to A.

It is suggested that the terms anorthosite, norite (including leuconorite), and monzonorite be used for rocks of any An content.

A list of terms which should be abandoned is annexed.

INTRODUCTION

Charnockitic rocks constitute a genetic suite that is characterized by the presence of hypersthene (or fayalite + quartz), and by that of perthitic feldspars (perthite, mesoperthite, antiperthite) in many of its rocks. They are commonly associated with norites and anorthosites and seem to be restricted to Precambrian terranes. According to mineral contents, charnockitic rocks have formed in a deep-seated "dry" environment of granulite facies and are, therefore, considered as plutonic rocks. In places, however, plutonic masses with comparable mineralogical composition may rise to levels of lower metamorphic grade. Charnockitic rocks often show deformation and recrystallization phenomena, signs of metamorphic overprinting. Their origin, whether magmatic or metamorphic, is debated; it may be assumed that there are "charnockites and charnockites." Because of their phaneritic texture, they belong to "igneous and igneous-looking rocks"

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and are, thus, included in considerations of the nomenclature of igneous rocks.

With respect to the peculiar characters of the suite, special names have been introduced for many of its members. de Waard (1969*a*, 1969*b*) and Tobi (1971) have given useful reviews of charnockite nomenclature. In order to discuss the connected problems and to reach agreement on appropriate recommendations, the IUGS Subcommission on the Systematics of Igneous Rocks formed a Working Group (WG) on charnockitic rocks, in which a number of interested colleagues took part. The present paper outlines the results that have been reached.

These colleagues have taken part in the discussions: P. C. Bateman (USA), P. G. Cooray (Zambia), E. A. Dahlberg (Suriname), J. C. Duchesne (Belgium), A. Dudek (CSSR), A. F. Laurin and K. N. M. Sharma (Canada), O. H. Leonardos, Jr. (Brazil), J. Martignole (Canada), K. R. Mehnert (FRG), J. Michot (Belgium), W. Pälchen (GDR), H. Pichler (FRG), H. de la Roche (France), E. W. F. de Roever (Suriname), S. K. Sen (India), V. M. Shemyakin and S. K. Shurkin (USSR), K. Smulikowski (Poland), A. Streckeisen (Switzerland), A. C. Tobi (Netherlands), T. Torske (Norway), D. de Waard (USA), A. Watznauer (GDR), A. F. Wilson (Australia), H. G. F. Winkler (FRG) and H. P. Zeck (Denmark).

NOMENCLATURE OF PLUTONIC ROCKS

At its meeting of Montreal, the IUGS Subcommission (1972) agreed upon recommendations on plutonic rocks, i.e., rocks with phaneritic texture that are presumed to have crystallized at considerable depth, irrespective of their origin. Plutonic rocks are classified and named according to their modal mineral content (in volume percent). For nomenclature, the following minerals and mineral groups are considered: Q quartz, A alkali feldspars (including albite An 00-05), P plagioclase An 05-100, F feldspathoids, M mafic and related minerals (including accessories). Rocks with M less than 90 are named according to their positions in the QAPF double triangle, the light-colored constituents being calculated to the sum 100. The limits of the fields, on which agreement has been reached, are shown in figure 1. The prefixes leuco- and mela- are suggested to designate the more felsic and mafic types of each rock group, in comparison with normal types (see IUGS Recommendation 1972, figs. 6*a* and 6*b*). Rocks with M = 90-100 are named according to their mafic minerals.

The Recommendations of 1972 did not provide suggestions for charnockitic rocks, as their nomenclature was still under review. Based upon a report by A. C. Tobi (1971), the WG discussed the application of the general scheme to charnockitic rocks. The main topics were as follows: (1) How should the scheme be subdivided for charnockitic rocks? (2) How should perthitic feldspars be treated with respect to A and P? (3) Which names should be used for charnockitic rocks?

GRAPHICAL REPRESENTATION OF CHARNOCKITIC ROCKS

There was no doubt that the QAP diagram should serve also for classifying charnockitic rocks. However, the number of fields and their limits were subject to discussion.

In order to reduce the number of fields, it was considered whether either the limit at $Q = 5$ or that at $Q = 20$ could be eliminated, or whether a single limit should be drawn at $Q = 10$. Opinions were divided, as some considered the limit at $Q = 5$ more important, others that at $Q = 20$. On the other hand, a limit at $Q = 10$ would have resulted in a difference to the general scheme, which was considered unsuitable. Further suggestions in order to eliminate the boundaries between fields 6 and 7, or 9 and 10, have likewise been rejected. Thus, the WG decided to retain the subdivisions of the general scheme (fig. 1) also for charnockitic rocks.

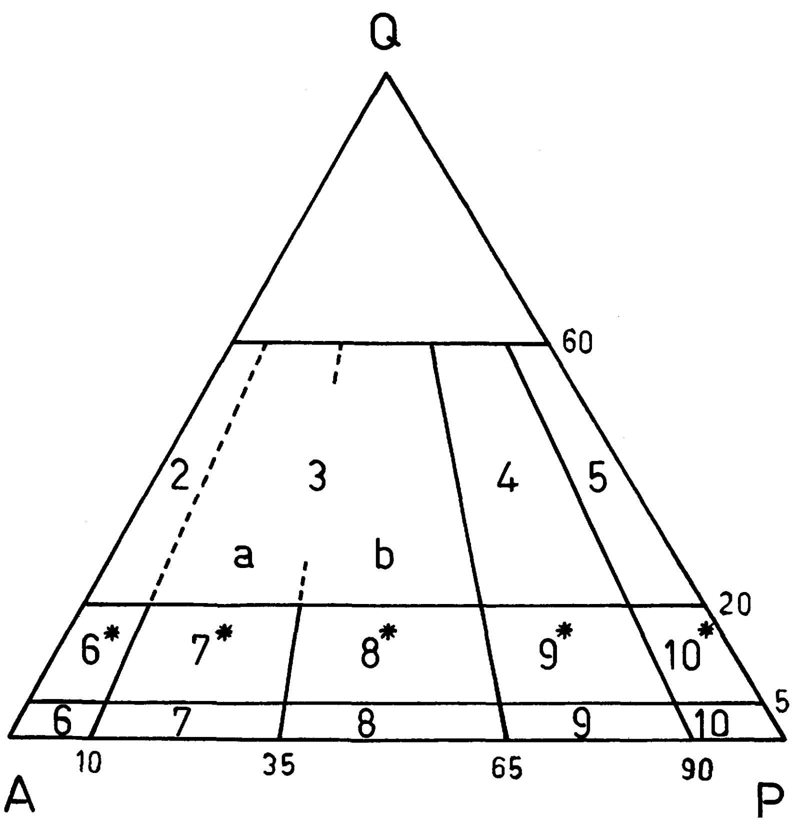

FIG. 1. — *QAP diagram for classifying charnockitic rocks (see table on p. 355).*

PERTHITIC FELDSPARS

Many perthitic feldspars are transitional in composition between alkali feldspar and plagioclase. Therefore, their attribution either to A or to P had be discussed. Johannsen (1939, p. 148) suggested attributing microperthite to A, antiperthite to P. The problem was complicated by the discovery of Na-K feldspars that consist of stringers of K-feldspar and plagioclase phases of nearly equal size and in nearly equal amounts, and for which P. Michot (1951, p. 270) created the term *mesoperthite*. His stimulating description (P. Michot, 1964, p. 968) is as follows: "La mésoperthite est une association entre plagioclase et feldspath K analogue à celle des microperthites et antiperthites, mais qui s'en distingue par le fait que les deux feldspaths associés se présentent en lamelles parallèles identiques, s'interpénétrant mutuellement, et en proportions sensiblement égales au point qu'on ne peut pas définir lequel de ces feldspaths enrobe l'autre. La mésoperthite résulte de la démixtion d'un feldspath homogène Na-K-(Ca) conditionné chimiquement par une teneur suffisamment basse en Ca feldspathisable, et une teneur en potasse suffisamment élevée pour que le paramètre de Niggli K atteigne dans la roche la valeur 0,45-0,50."

Consequently, attributing mesoperthite entirely to A *or* to P would not convey an accurate picture of the real situation.

For treating perthitic feldspars, two possibilities were taken into consideration:

(*a*) For reasons of simplicity, perthites and mesoperthites could be attributed to A, antiperthites to P. This would be reasonable for perthites and antiperthites, but questionable for mesoperthites.

(*b*) All perthitic feldspars could be distributed over A and P according to their actual content of K-feldspar and plagioclase phases, as approximately determined by optical investigation or diffractometry.

As such determinations are now possible, the WG decided by majority for solution (*b*), which was favored by all those especially concerned with charnockitic rocks.

The consequences are as follows:

Perthites, as occur, e.g., in one-feldspar granites and syenites, are to be considered as alkali feldspars (IUGS Recommendations 1972), because the exsolved phase is commonly albite, which is considered as an alkali feldspar.

Mesoperthites are to be distributed over A and P, in many cases in nearly equal amounts. The ratio K-feldspar: plagioclase may vary from 60:40 up to 30:70. In the Labrieville massif (Anderson, 1966, p. 1681 f. and 1692 f.), e.g., the composition of the K-feldspar phase is about Or 90 Ab 7, while the plagioclase phase may vary from An 20 Or 0.2 up to An 34 Or 1.8.

Antiperthites have mainly the composition of andesine (An 30-35, according to Dahlberg, 1969). The K-feldspar phase, Or 90 Ab 7 at Labrieville (Anderson, 1966, p. 1682), is subordinate in amount and makes commonly up no more than 10 percent (Dahlberg). Accordingly, the major part of the antiperthites is to be attributed to P.

MESOPERTHITIC ROCKS

Rocks that contain mesoperthite constitute the *mangeritic facies* of P. Michot (1948, p. 183; 1964, p. 968). The Belgian school (communication by J. C. Duchesne and J. Michot) suggested to designate corresponding rocks by the prefix *mangero-*, as follows:

— mangerite: contains mesoperthite as the only feldspar;
— mangerosyenite: contains mesoperthite besides K-feldspar;
— mangeronorite: contains mesoperthite besides plagioclase;
— mangeromonzonite: contains mesoperthite besides K-feldspar and plagioclase;
— mangerocharnockite: contains mesoperthite and about more than 20 percent quartz.

The WG does not support the term mangeritic facies, as its rocks belong anyhow to the granulite facies of Eskola. On its place, it suggests the comprehensive term "*mesoperthitic rocks.*"

Again, the terms mangerosyenite, mangeromonzonite, mangeronorite and mangerocharnockite are not recommended, because they erroneously would suggest rocks intermediate between mangerite and the fields to which the prefix mangero- is attached. Following a proposal by Tobi (1971), the WG suggests the prefix *m(esoperthite)-* on the place of mangero-; e.g., mesoperthite-charnockite or m-charnockite, hypersthene m-syenite, etc.

NOMENCLATURE OF CHARNOCKITIC ROCKS

As all suggestions put forward in the discussion cannot be presented here, only the more important ones are included.

For naming charnockitic rocks two possibilities were taken into consideration:

(*a*) Names of the general system could be used by adding the qualifier hypersthene; e.g., hypersthene granite for field 3, hypersthene tonalite for field 5, hypersthene monzonite for field 8, etc.; see p. 355.

(*b*) Special names could be applied, as are in current usage; e.g., charnockite, enderbite, mangerite, etc.; see p. 355.

The WG was divided as to which possibility preference should be given. It decided, therefore, that both possibilities may be used in an optional manner. In its opinion, however, only special names of current usage should be applied, in order not to burden nomenclature with terms that are poorly known. A useful review of special names has been given by de Waard (1969*b*), to which the reader is referred; it contains definitions and re-definitions in the following manner: "charnockite is defined here as a plutonic rock, magmatic or metamorphic, which has the composition of a granite and contains hypersthene." A large number of special names originate from Norway.

Names have been provided for fields 2-5 and 6-10 (see p. 351). The names of fields 6*-10* are those of fields 6-10 by adding the prefix quartz; e.g., hypersthene-quartz syenite for field 7*, quartz norite for field 10*, etc.

As mentioned above, it is suggested that mesoperthitic rocks are designated by the prefix m(esoperthite)-. The synonymous terms that were used by the Belgian school are mentioned at p. 353.

Special names that have been discussed are as follows:

Charnockite (Holland, 1900). St. Thomas' Mount, Madras, India. Applied to hypersthene granite (field 3) according to common usage.

Birkremite (Kolderup, 1904). Birkrem, Egersund area, Norway. Kolderup introduced the term for alkali-feldspar charnockites (field 2). New research revealed that the feldspar is mesoperthite (Dahlberg, 1969), which conforms with the chemical analysis given by Barth (1936). Thus, the type rock is a m-charnockite (field 3). The term is ambiguous and should be abandoned.

Farsundite (Kolderup, 1904). Farsund, Egersund area, Norway. The term was introduced for hypersthene adamellite, i.e., charnockite of field 3*b*. Barth (1960) and Middlemost (1968) pointed out that the name is frequently used as a comprehensive term for the granitic rocks of the Farsund area, i.e., biotite-hornblende granites and, more subordinate, hypersthene granites. The WG, by majority, recommends avoiding the term. It should be noticed, however, that the term is used by various authors (de Waard, Martignole, etc.) for charnockites of field 3*b*.

Charno-enderbite (Tobi, 1972*a*). See opdalite, field 4.

Opdalite (Goldschmidt, 1916). Opdal Inset, Trondheim area, Norway. Field 4. The term was introduced for hypersthene granodiorites. Tobi objects to its inclusion into charnockite nomenclature that the opdalites of Opdal area are not associated with charnockites and anorthosites, but with noritic intrusions in an amphibolite facies environment, and with biotite trondhjemites of Goldschmidt's trondhjemite-opdalite stem. They do not take part of the charnockite Bergen-Jotun stem of Goldschmidt and belong clearly to the Caledonian orogeny. Therefore, Tobi (1972*a*, 1972*b*) suggests replacing opdalite by charno-enderbite, which means a rock intermediate between charnockite and enderbite. The WG was divided as to which term preference should be given and decided that both may be used in an optional manner.

Enderbite (Tilley, 1936). Enderby Land, Antarctica. Applied to hypersthene tonalite (field 5).

Ankaranandite (Giraud, 1964). Betafo-Ankaranando, Madagascar. The term was introduced for hypersthene-alkalifeldspar syenites and hypersthene syenites of fields 6 and 7. Although no other special name is provided for these fields, the WG rejects the term as it is complicated and not of current usage.

Mangerite (Kolderup, 1904). Manger, Bergen area, Norway. The term was introduced for mesoperthitic rocks of field 8. P. Michot (1957, p. 156; 1964, p. 968) and J. C. Duchesne (1972, p. 321) use the term for rocks of field 8 which contain mesoperthite as the only feldspar, regardless of the nature of the accompanying ferromagnesian constituents. This conforms with the original definition, as recorded by Kolderup and Kolderup (1940, p. 89). On the other hand, de Waard (1969*b*) generally uses the term for hypersthene monzonite whether mesoperthite is present or not. No agreement could be reached as to whether definition preference should be given, but there exists agreement that the term be restricted to rocks of field 8.

Jotun-norite (Goldschmidt, 1916) or *Jotunite* (Hødal, 1945). Jotunheim area, Norway. Field 9. According to its original definition, the term jotunite will be used synonymously for hypersthene monzodiorite, or for monzonorite as defined on p. 357. The type rock contains K-feldspar besides the more frequent plagioclase which is andesine (An 35-45, commonly antiperthitic).

The considerations presented result in the following scheme of names which, as mentioned above, may be used in an optional manner (see fig. 1):

Field	General terms	Special terms
2	Hypersthene alkali-feldspar granite	Alkali-feldspar charnockite
3	Hypersthene granite	Charnockite (3b farsundite)
4	Hypersthene granodiorite	Opdalite or charno-enderbite
5	Hypersthene tonalite	Enderbite
6	Hypersthene alkali-feldspar syenite	
7	Hypersthene syenite	
8	Hypersthene monzonite	Mangerite (according to definition)
9	Monzonorite (hypersthene monzodiorite)	Jotunite
10	Norite (hypersthene diorite) Anorthosite (M < 10)	

To designate *textural features,* terms such as gneiss, granulite, granofels, etc., may be used in relation to the corresponding rock names; e.g., charnockite gneiss (or gneissose charnockite), charnockite granulite (or granulitic charnockite), etc.

ANORTHOSITES AND NORITES

Anorthosites and norites are frequently associated with rocks of the charnockitic suite. Anorthosites are transitional into norites, and arbitrary limits according to color index are used to define the various types of the anorthosite-norite suite:

M (color index)		
0–10		anorthosite
10–22.5	noritic anorthosite	leuconorite
22.5–35	anorthositic norite	leuconorite
35–65		norite
65–90		melanorite
90–100		hypersthenite

Anorthosite was introduced by Hunt (1862) and more fully explained by Logan *et al.* (1863) as rocks "composed chiefly of a lime-soda feldspar, varying in composition from andesine to anorthite, and associated with pyroxene or hypersthene" (cited by de Waard, 1969*a*, p. 4). Kolderup (1897, 1904) used the synonymous term "Labradorfels". It was only later that anorthosite was restricted to rocks containing calcic feldspar (labradorite to anorthite), and that rocks carrying andesine were excluded (Johannsen, 1937, p. 196). While anorthosites of layered intrusions (Bushveld, Stillwater, etc.) contain mainly basic labradorite and bytownite, those associated with charnockitic rocks (Norway, the Adirondacks, Quebec, etc.) consist commonly of andesine and sodic labradorite; e.g., An 40-45 in anorthosites of Egersund area, Norway, according to P. Michot (1955, p. 282) and J. Michot (1961); see also Anderson (1966, p. 1092) and J. Michot (1972, p. 15). It has now become customary to call anorthosites all rocks that consist mainly of plagioclase (from anorthite down to andesine, and even oligoclase); see Turner and Verhoogen (1960, p. 322), Wilkinson (1967, p. 178), the AGI Glossary (1972), and IUGS Recommendations (1972).

Norite was introduced by Esmark (1823) for rocks of the Norvegian anorthosite-gabbro formation, which he called "Norit-Formationen" (derived from Norway). As most textbooks distinguish diorite and gabbro by An content of their plagioclase (at the limit An 50) and norite is considered as the hypersthene-bearing equivalent of gabbro, norite is usually restricted to rocks with An content more than 50, while hypersthene-bearing rocks of lower An content are commonly described as hypersthene diorites.

However, this usage seems unsuitable, and the limit at An 50 is fully arbitrary. Norites and leuconorites of Norway, the Adirondacks, Quebec, etc., that grade into anorthosites (with An 40-45) show similar feldspars; e.g. An 40-45 in the norites of the Haaland-Helleren massif, Egersund area, Norway (P. Michot, 1955; J. Michot, 1961); An 43-54 (av. 44.4) in the norites of the Snowy Mountain dome,

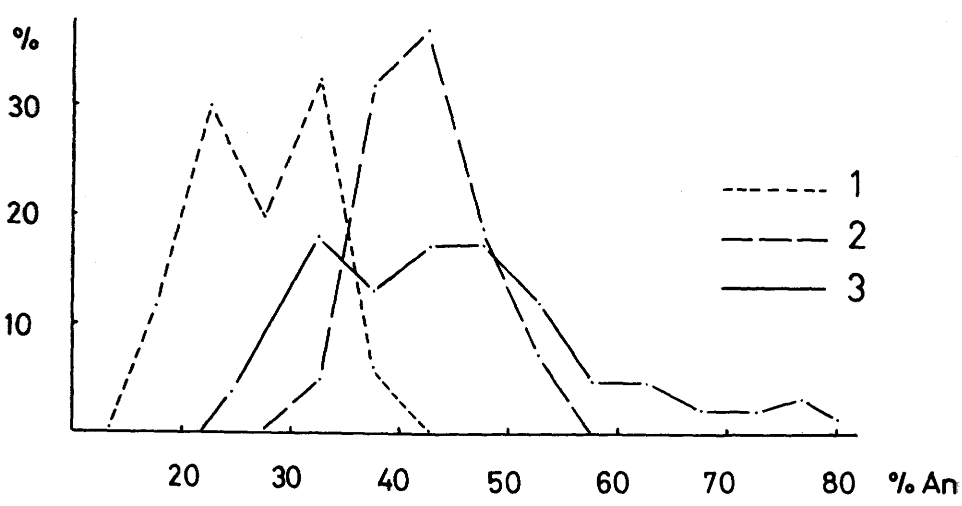

FIG. 2. — *An contents of basic rocks from Rogaland, SW Norway, according to A. C. Tobi. (1) 44 monzonorites, (2) 60 leuconorites, (3) 62 norites.*

Adirondacks (de Waard and Romey, 1969), etc. A convincing diagram (fig. 2) is here presented by kindness of A. C. Tobi, which shows the An contents of norites, leuconorites, and monzonorites of Rogaland, southwestern Norway. Anorthosites grade into norites, and it is not understandable why anorthosite may contain andesine, while the term norite should be restricted to rocks with An contents more than 50. The rocks in question have always been described as leuconorites and norites and will continue to be so described.

The WG examined whether the limit between norite and hypersthene diorite could possibly be set at An 45 or 40. But all those especially concerned with corresponding rocks plead unequivocally for eliminating any limit. We agree, therefore, to de Waard (1969*b*) who defines norite as follows: "norite is here defined as a plutonic rock, magmatic or metamorphic, which has the composition of a gabbro *or diorite*, and in which hypersthene is a major dark constituent." Colleagues who like to respect the An 50 limit may continue to use the term hypersthene diorite.

The same holds true for *monzonorite*. According to P. Michot (1964, p. 968), the plagioclase of his monzonoritic phase shows An contents from An 40 down to An 25. Similar An contents are recorded in the corresponding jotunites by de Waard and Romey (1969), de Waard (1970), and de Waard and Wheeler (1971). Therefore, it is recommended that monzonorite and jotunite be used synonymously for rocks that have the composition of a monzodiorite or monzogabbro and contain hypersthene.

The IUGS Recommendations (1972) suggest that norite be used for rocks mainly composed of plagioclase and hypersthene, while gabbroic rocks that contain clinopyroxene and orthopyroxene (each more than 5 percent) be termed *gabbronorite*. However, as the common usage of norite is larger, the Subcommission recently decided that the term gabbrodiorite be used as a comprehensive term for *clinopyroxene norite* (more orthopyroxene than clinopyroxene) and *orthopyroxene gabbro* (more clinopyroxene than orthopyroxene), in agreement to Wilkinson (1967, p. 174).

GLOSSARY OF TERMS WHICH SHOULD BE ABANDONED

(References to Tröger [1935, 1938] are indicated by Tr and the corresponding number)

Akoafimite (Schüller, 1949). Akoafim, Southern Cameroons.
Leuco-quartz norite, hornblende-bearing. Field 10*.

Amherstite (Watson and Tabor, 1913). Amherst Co., Virginia. Tr 294.
Leuco-quartz jotunite (with andesine-antiperthite). Field 9*.

Ankaranandite (Giraud, 1964). Betafo-Ankaranado, Madagascar.
Fields 6-6* and 7-7*. See p. 354.

Arendalite (Bugge, 1940). Arendal, Norway.
Comprehensive term for charnockitic rocks of Arendal area.

Bauchite (Oyawoye and Makanjuola, 1972). Bauchi, Northern Nigeria.
Fayalite-bearing rocks of fields 3, 7* and 8* (fayalite + quartz besides hypersthene).

Birkremite (Kolderup, 1904). Birkrem, Egersund area, Norway. Tr 15.
m-charnockite. Field 3. See p. 354.
Bugite (Bezborodko, 1931): Bug River area, Podolia. Tr 131 1/2.
(Charno-)enderbite with andesine-antiperthite. Fields 4-5.
Epibugite (Bezborodko, 1931). Bug River area, Podolia. Tr 129 1/2.
Leuco-enderbite with andesine-antiperthite. Field 5.
Grimmaite (Ebert, 1968). Grimma, Saxony.
Effusive charnockite porphyry to quartz mangerite porphyry. Fields 8*-3b.
Ivoirite (Lacroix, 1910). Mt. Marny, Ivory Coast.
Clinopyroxene norite. Field 10.
Katabugite (Bezborodko, 1931). Bug River area, Podolia. Tr 308 1/3.
Jotunite or norite with andesine-antiperthite. Fields 9-10.
Sabarovite (Bezborodko, 1931). Sabarovo, Bug River area, Podolia. Tr 130 1/2.
Leuco-charno-enderbite with andesine-antiperthite. Field 4.

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