

## A systematic nomenclature for metamorphic rocks:

### 4. HIGH P/T METAMORPHIC ROCKS

Recommendations by the IUGS Subcommittee on the Systematics of Metamorphic Rocks:  
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### INTRODUCTION

The Subcommittee for the nomenclature of Metamorphic Rocks (SCMR), a branch of the IUGS Commission on the Systematics in Petrology, aims to publish international recommendations on how metamorphic rocks and processes are to be defined and named, as was previously done for igneous rocks by the Subcommittee on the Systematics of Igneous Rocks (Le Maitre et al., 1989, 2002). The principles used by the SCMR for defining and classifying metamorphic rocks are outlined in SCHMID et al. (2004).

A Study Group under the leadership of J. DESMONS was set up to prepare the nomenclature of rocks which form at high P/T. Questionnaires were sent to a world-wide panel of specialists on high P/T metamorphism. Twenty-two agreed to cooperate. This paper summarizes the results of the discussions and presents the recommended definitions.

### ECLOGITE (term created by HAÜY in 1822)

The SCMR defines eclogite as

*«Plagioclase-free metamorphic rock composed of  $\geq 75\%$  vol. of omphacite and garnet, both of which are present as major constituents, the amount of neither of them being higher than  $75\%$  vol.».*

In this definition omphacite is taken as defined by the IMA Subcommittee on pyroxene nomenclature (MORIMOTO et al., 1988; FLEITSCHER and MANDARINO, 1991, see also CARSWELL, 1990), that is, based on its chemical composition, which, in the field, can be more or less inferred from its colour.

The wording of the above definition resulted from the many comments given by members of the Study Group and the Subcommittee. Here follow a few explanatory comments.

1. 'Major constituent' means, according to the SCMR rules, present in an amount of  $\geq 5\%$  vol. This percentage may be considered to be too low, especially for omphacite. However, together with the  $\geq 75\%$  vol. amount of both omphacite and garnet it is intended to allow enough, and not too much, flexibility to the term.
2. Rocks in which either omphacite or garnet is present in an amount exceeding  $75\%$  vol., have to be called, according to the SCMR rules, garnet omphacitite or omphacite garnetite (see the use of the suffix '-ite' in SCHMID et al., 2004).
3. K-feldspar can be present in an eclogite (hence plagioclase-free, not feldspar-free)
4. The basaltic composition (which in the field is only inferred from the mineral composition), or basic to ultrabasic composition does not need to be mentioned because it is implicitly given by the mode specified in the definition
5. The colour term 'melanocratic' is not used in the definition of eclogite because :
  - (i) The SCMR recommends that colour terms for metamorphic rocks are not used, owing to the greater variability of colours in such rocks compared to igneous rocks (SCHMID et al., 2004).
  - (ii) 'Melanocratic' implies a lower boundary of  $65\%$  of mafic and related minerals (LE MAITRE et al., 1989, p. 6), which is too low an amount for eclogite.

6. Consistent with IMA recommendations (FLEISCHER and MANDARINO, 1991), the discredited Na-pyroxene chloromelanite has now been included under omphacite and its name does not therefore appear in the definition of eclogite.

7. The SCMR defines rocks, as far as possible, on their properties visible to the eye, that is, as they appear in the field. The amount of  $\geq 75\%$  has, therefore, to be taken as roughly three quarters or more of the rock as seen in hand specimen. From a rapid literature survey it appears that a majority of eclogites has modal compositions consistent with the above definition. However, there is a tendency to put the stress on the presence of eclogite minerals by naming the rock eclogite even when the amount of the characteristic minerals are lower than that required by the definition. The SCMR recommends that the term eclogite should not apply to such rocks but that another rock term preceded by the adjective eclogitoid should be used (as long as both omphacite and garnet are present, see the next section).

8. The additional presence of rutile may be mentioned as complementary information, as also may the names of other possible additional phases, for example, paragonite, kyanite, etc. These minerals are not essential in the definition of eclogite. According to the SCMR rules (SCHMID et al., 2004), the following style should be used: 'kyanite-paragonite eclogite' (if both minerals are major constituents, i.e., present as  $\geq 5\%$ , and where paragonite is more abundant than kyanite), or 'rutile-bearing eclogite' (if rutile is a minor constituent, i.e., present as  $\leq 5\%$ ). The SCMR will propose a list of abbreviations of rock forming minerals to allow easier prefixing of rock names with component mineral names.

9. The SCMR defines rocks primarily according to their appearance in hand specimen. Therefore, classifications of eclogites based on garnet and/or whole rock chemical compositions, or with respect to their environment of formation (K. SMULIKOWSKI, 1964, 1972, 1989; COLEMAN et al., 1965; BANNO, 1970) are beyond the scope of the SCMR.

10. Rocks consisting of pyrope-rich garnet and Cr-rich Ca-clinopyroxene, associated with ultrabasic rocks have been called eclogites in the past (ESKOLA, 1939). The correct name for these rocks is pyrope pyroxenite or pyroxene garnetite (see also griquaitite below).

## NAMES FOR ROCKS RELATED TO ECLOGITES

There are two different groups of rocks related to eclogites. Terms referring to them should be clearly distinguished.

(i) Various suffixes have been proposed, such as '-oid', '-oidic', and '-ic', for unaltered rocks that contain omphacite and garnet, but in a smaller amount than required by the definition for eclogite, owing to an unsuitable bulk composition.

The Study Group members felt that the most appropriate use of the suffix '-ic' is to form an adjective the meaning of which is strictly related to the noun from which it derives. Eclogitic, thus, means: «Applying to eclogite». The suffix '-oid', commonly used in igneous nomenclature (LE MAITRE et al., 1989, 2002), rather loosely means, 'in some way related to the noun', including the noun itself (see, e.g., the use of granitoid, syenitoid, etc.).

Accordingly, an eclogitoid would be a metamorphic rock containing both omphacite and garnet.

It may be noted, for example, that the Eclogitic Micaschists ('Micaschisti eclogitici') of the Sesia-Lanzo zone in the Western Alps thus would remain as a formation name only. The omphacite-garnet rocks contained in this formation would encompass, on the above definitions, both 'eclogitoids' and 'eclogites'.

(ii) Eclogites that have experienced a later metamorphism and which now contain omphacite and garnet as abundant relics in an amphibolite groundmass have been given a long list of names. These include amphibolitized eclogite, post-eclogite amphibolite, retro-eclogite amphibolite, eclogitogene amphibolite, etc. Among the Study Group members, no one term emerged as favourite and acceptable to the SCMR. For the time being, it is left to each author to use their personally preferred term and to define it clearly.

## ECLOGITE FACIES, ECLOGITE FACIES ROCKS

Eclogite is also the name of a facies, which was established by ESKOLA (1915, 1921). As is the case with the other metamorphic facies, not all rocks metamorphosed in the eclogite facies are called eclogites (for example, 'whiteschist', as defined below). For referring to all such rocks, the term 'eclogite facies rocks' or 'rocks in eclogite facies' may be used. The definition of 'metamorphic facies' and a diagrammatic representation of metamorphic facies are given in SMULIKOWSKI et al. (2004).

## **GLAUCOPHANE SCHIST, GLAUCOPHANE-SCHIST FACIES AND GLAUCOPHANE-SCHIST FACIES ROCKS**

According to the rules of the SCMR (SCHMID et al., 2004) the term 'glaucophane schist' is used for a schist having only one major constituent, i.e., glaucophane or ferroglaucophane ('major' meaning present, in a modal proportion  $\geq 5\%$ ). If additional minerals are present, as major or minor constituents, they have to be given as prefixes, e.g., jadeite-bearing glaucophane-phengite schist, epidote-glaucophane schist, etc. Therefore the definition of 'glaucophane schist' is covered by the SCMR rules and no further special definition is required.

The term, however, has evolved to cover all rocks belonging to the glaucophane schist facies (ESKOLA, 1915, 1921), commonly called by the synonym 'blueschist facies' (see below). This ambiguity and such a genetic meaning are things that the SCMR wishes to avoid. Accordingly, the SCMR recommends that the term 'glaucophane schist' as a rock name is used in the manner given above, and that rocks in the glaucophane-schist facies are explicitly called '*glaucophane-schist facies rocks*'. If a more specific name than 'rocks' is required, then one of the structural root terms (schist, gneiss or granofels) may be used (SCHMID et al., 2004; BRODIE et al., 2004), and reference to the glaucophane schist facies can be made by adding 'in glaucophane schist facies'.

## **GLAUCOPHANITE**

The term glaucophanite can be, or has been, used in three different ways.

1. As stated above, the SCMR proposes to use the suffix '-ite', appended to a mineral name, for metamorphic rocks which consist of  $\geq 75\%$  of that mineral (SCHMID et al., 2004). Following this proposal, glaucophanite is a general name for a rock consisting of  $\geq 75\%$  of glaucophane or ferroglaucophane. Thus, the term does not need any further definition under the SCMR rules.
2. For Japanese and Russian geologists, among others, glaucophanite is a gneiss or granofels consisting of  $\geq 50\%$  glaucophane.
3. The terms 'glaucophanite' and 'glaucophane schist' are used by some scientists as synonyms, in spite of the structural connotation of glaucophane schist. The SCMR, therefore, recommends the use as defined under 1 (above).

## **BLUESCHIST, BLUESCHIST FACIES AND BLUESCHIST FACIES ROCKS**

The name 'blueschist' was established by BAILEY in 1962. At that time doubts had arisen whether glaucophane was only stable at elevated pressures or also under greenschist facies conditions. Jadeite and/or lawsonite were considered to be more reliable pressure indicators and the term 'blueschist' was introduced. It has now become clear that glaucophane requires a high P/T for its formation. ESKOLA's term glaucophane schist has, therefore, regained its former significance, but in the meantime 'blueschist' has become well entrenched both as a rock and a facies term.

As a rock name, blueschist is currently defined by the SCMR in a loose descriptive way with a recommendation to replace it by other terms if a more precise description of the rock is required. The proposed SCMR definition is as follows:

*«Schist whose bluish colour is due to the presence of alkali amphibole».*

The definition is complemented by:

1. *«More precise terms should be used wherever possible (e.g., jadeite-bearing glaucophane schist)».*

A schist containing blue amphibole is more explicitly called glaucophane schist, with the addition of the names of main or critical minerals, e.g. jadeite-bearing glaucophane-phengite schist, or epidote-glaucophane schist, etc.

2. *«This term is also used as a facies name and if used in this sense the facies context should be made clear (by saying 'blueschist-facies rock')».*

As stated above, the terms 'glaucophane schist facies' and 'blueschist facies' are regarded as synonyms (SMULIKOWSKI et al., 2004).

### **WHITESCHIST (SCHREYER, 1973)**

Whiteschist is defined by the SCMR in a loose descriptive manner, in a similar way to blueschist:

*«Light-coloured schist containing kyanite and talc. More precise rock terms should be used wherever possible (e.g., kyanite-talc-phengite schist)».*

complemented with:

*«Whiteschists represent Al-rich rocks metamorphosed under the conditions of the eclogite facies».*

### **ULTRAHIGH-PRESSURE METAMORPHISM**

The discovery of coesite and diamond in rocks of crustal origin showed that these rocks had been subject to pressures equivalent to those found in the mantle. This increased the range of metamorphic conditions considered to have operated on crustal rocks. The additional field of metamorphism was termed ultrahigh-pressure metamorphism or UHPM for short (COLEMAN and WANG, 1995).

The SCMR defines UHPM as follows:

*«That part of the metamorphic P-T field where pressures exceed the minimum necessary for the formation of coesite. Pressure may be sufficient for the formation of diamond».*

### **ULTRAMAFIC ROCK NAMES**

As stated in SCHMID et al. (2004), the SCMR definition of the ultramafic rocks, such as harzburgite, lherzolite and websterite should follow those given by LE MAITRE ET AL. (1989, 2002), without implication to the genesis of the rock. If it is desirable to emphasise the metamorphic nature of the rock, mineral-structural root names should be used, for example, pyroxene-olivine gneiss. The presence of garnet or other accessory minerals should be indicated by the appropriate prefix.

### **RESTRICTED AND UNNECESSARY ROCK NAMES: GRIQUAITE, GROSPYDITE, MUCRONITE, ALKREMITTE.**

The SCMR regards the three terms griquaitte, grosphydite and alkremite as restricted terms and mucronite as an unnecessary term (sensu Schmid et al., 2004) Their further use in international journals is not recommended, although the restricted names may be given if qualified with a full, unambiguous definition. A widely accepted equivalent term is preferable (see below).

**Griquaite** (BECK, 1907):

«Rock composed of pyrope-rich garnet, diopside ± orthopyroxene. It may contain diamond». An equivalent term is, for example, orthopyroxene-bearing garnet-diopside gneiss.

**Grospydite** (BOBRIEVICH et al., 1960):

«Plagioclase-free rock mainly composed of Ca-Al clinopyroxene and calcic garnet together with some kyanite». An equivalent term is, for example, kyanite-bearing grossular-clinopyroxene gneiss.

**Alkremite** (PONOMARENKO, 1975):

«Ultramafic rock composed of about 75% of spinel and pyrope-rich garnet, both of which are present in a large proportion». An equivalent term is, for example, spinel-pyrope granofels.

**Mucronite** (REINSCH, 1977):

«Metamorphic rock mainly composed of jadeitic clinopyroxene, garnet, phengite, quartz ± K-feldspar». An equivalent term is, for example, jadeite-garnet-phengite schist.

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## References

- BAILEY E.H., 1962. Metamorphic facies of the Franciscan Formation of California and their geologic significance. *Geol. Soc. Amer. Spec. Pap.* **68**, 4-5 (abstract).
- BANNO Sh., 1970. Classification of eclogites in terms of physical conditions of their origin. *Phys. Earth Planet. Interiors* **3**, 405-421.
- BECK, R., 1907. Untersuchungen über einige südafrikanische Diamantenlagerstätten. *Z. Deutschen Geol. Ges.* **59**, 275-307.
- BOBRIEVICH A.P., SOBOLEV V.S. and SMIRNOV G.I., 1960. Mineralogii xenolitov grossular-piroxen-distenovoï porodi (grosspydita) iz kimberlitov Yakutii. *Sibirskoye otdelenie Akademii Nauk CCCP, Geologiya i Geofisika* **3**, 18-24.
- BRODIE K., FETTES D., HARTE B., SCHMID R., 2004. A systematic nomenclature for metamorphic rocks: 3. Structural terms, including fault rock terms. Recommendations by the IUGS Subcommittee on the systematics of metamorphic rocks. SCMR website ([www.bgs.ac.uk/SCMR](http://www.bgs.ac.uk/SCMR)).
- CARSWELL D.A., 1990. Eclogites and the eclogite facies: definitions and classification. In: D.A. Carswell (Ed.), *Eclogite facies rocks*. Blackie, Glasgow and London, 1-13.
- COLEMAN R.G., LEE D.E., BEATTY L.B. & BRANNOCK W.W., 1965. Eclogites and eclogites: their differences and similarities. *Geol. Soc. Amer. Bull.* **76**, 483-508.
- COLEMAN R.G. & WANG X., 1995. *Ultrahigh pressure metamorphism*. Cambridge Univ. Press, 528 p.
- DESMONS J., SMULIKOWSKI W. and SCHMID R., 1997. High-P/T rock terms: Definitions proposed by SCMR. *4<sup>th</sup> Intern. Eclogite Conf., Ascona*.
- DESMONS J., SMULIKOWSKI W. and SCHMID R., 2001. High-P/T rock terms: definitions proposed by SCMR. *Mineralogical Society of Poland – Special papers* **19**, 36-38
- ESKOLA P., 1915. Om sambandet mellan kemisk och mineralogisk sammansättning hos Orijärvitraktens metamorfa bergarter. *Bull. Comm. géol. Finl.* **44**.

- ESKOLA P., 1921. The mineral facies of rocks. *Norsk Geologisk Tidsskrift* **6**, 143-194.
- ESKOLA P., 1939. In : BARTH T.F.W., CORRENS C.W. & ESKOLA P. Die Entstehung der Gesteine. Springer, Berlin, 422 p.
- FLEISCHER M. & MANDARINO J.A., 1991. Glossary of mineral species. The Mineralogical Record Inc., Tucson, U.S.A., 256 p.
- HAÜY R.J., 1822. Traité de minéralogie (2d ed.). Bachelier, Paris **4**, 604 p.
- LE MAITRE R.W. (Ed.) et al., 1989. A classification of igneous rocks and glossary of terms. Blackwell Scientif. Publ., 193 p.
- LE MAITRE R. W. (Ed.) et al., 2002. A classification of igneous rocks and glossary of terms. Cambridge University Press, Cambridge, 236 p.
- MORIMOTO, N., FABRIES, J., FERGUSON, A.K., GINZBURG, I V., ROSS, M., SEIFERT, F.A., ZUSSMAN, J., AOKI, K. and GOTTARDI, G., 1988. Nomenclature of pyroxenes. *Miner. Mag.* **52**, 535-550.
- PONOMARENKO A.I., 1975. Alkremite, a new variety of aluminous ultramafic rock in xenoliths from the Udachnaya kimberlite pipe. *Transl. Dokl. Akad. Nauk S.S.S.R.* **225**, 155-157.
- REINSCH D., 1977. High pressure rocks from Val Chiusella (Sesia-Lanzo zone, Italian Alps). *N. Jb. Mineral. Abh.* **130**, 89-102.
- SCHMID R., FETTES D., HARTE B., DAVIS E., DESMONS J., MEYER-MARSILIUS H-J. and SIIVOLA J., 2004. A systematic nomenclature for metamorphic rocks: 1. How to name a metamorphic rock. Recommendations by the IUGS Subcommittee on the systematics of metamorphic rocks. SCMR website ([www.bgs.ac.uk/SCMR](http://www.bgs.ac.uk/SCMR)).
- SCHREYER W., 1973. Whiteschist: a high-pressure rock and its geologic significance. *J. Geol.* **81**, 735-739.
- SMULIKOWSKI K., 1964. An attempt at eclogite classification. *Bull. Acad. Polonaise Sci., Sér. sci. géol. géogr.* **12**, 27-33.
- SMULIKOWSKI K., 1972. Classification of eclogites and allied rocks. *Krystalinikum* **9**, 107-130.
- SMULIKOWSKI K., 1989. In: D.R. BOWES (Ed.), The encyclopedia of igneous and metamorphic petrology. Van Nostrand Reinhold, New York, 137-142.
- SMULIKOWSKI W., DESMONS J., FETTES D., HARTE B, SASSI F.P. and SCHMID R., 2004. A systematic nomenclature for metamorphic rocks: 2. Types, grade and facies of metamorphism. Recommendations by the IUGS Subcommittee on the systematics of metamorphic rocks. SCMR website ([www.bgs.ac.uk/SCMR](http://www.bgs.ac.uk/SCMR)).