

## THE IMA COMMISSION ON NEW MINERALS AND MINERAL NAMES: PROCEDURES AND GUIDELINES ON MINERAL NOMENCLATURE, 1998

ERNEST H. NICKEL\*

*Division of Exploration and Mining, CSIRO, Private Bag, P.O. Wembley, W.A., 6014, Australia*

JOEL D. GRICE\*\*

*Mineral Sciences Division, Canadian Museum of Nature, P.O. Box 3443A, Station "D", Ottawa, Ontario KIP 6P4*

### INTRODUCTION

The Commission on New Minerals and Mineral Names (hereafter abbreviated as CNMMN) of the International Mineralogical Association was established in 1959 for the purpose of controlling the introduction of new minerals and mineral names, and of rationalizing mineral nomenclature. Since that time, the work of CNMMN has gained overwhelming support from the international mineralogical community. The CNMMN consists of representatives appointed by national mineralogical bodies, and an executive committee consisting of chairman, vice-chairman and secretary. A list of current members is given in Appendix I.

The activities of the CNMMN, and its various recommendations for mineral nomenclature, have been widely published in a substantial number of mineralogical journals over a number of years; there is a clear need to consolidate these reports to provide an up-to-date account of the procedures currently followed by the CNMMN and updated guidelines on mineral nomenclature. In this paper, which represents a consensus of CNMMN members, and which has benefitted from their suggestions, we attempt to do that. It incorporates material from previous reports on mineral nomenclature and procedures of the CNMMN, including general papers such as those by Hey *et al.* (1961), Fleischer (1970), Donnay & Fleischer (1970), Dunn & Mandarino (1988), Mandarino *et al.* (1984) and Nickel & Mandarino (1987), as well as papers on more specific topics, which will be referred to in the body of this paper. This paper is therefore a revised update of the procedures employed by the CNMMN and of general guidelines for mineral nomenclature.

It must be understood that the CNMMN does not wish to impose an arbitrary set of rigid rules on the mineralogical community, but rather to provide a set of

coherent guidelines that provide a reasonably consistent approach to the introduction of new minerals and the application of mineral nomenclature. The guidelines presented herein probably apply reasonably well to the great majority of cases, but inevitably situations arise that do not conform so readily. As is mentioned several times in the text, each case must be judged on its own merits.

### CRITERIA FOR A NEW MINERAL SPECIES

#### *General considerations*

A mineral substance is a naturally occurring solid that has been formed by geological processes, either on earth or in extraterrestrial bodies (Nickel 1995a). A mineral species is a mineral substance with well-defined chemical composition and crystallographic properties, and which merits a unique name. General criteria for defining mineral species are given below. In practice, most mineral species conform to these criteria, but exceptions and borderline cases inevitably arise, and ultimately each proposal to introduce a new mineral species or to change mineral nomenclature must be considered on its own merits.

#### *The concept of a mineral species*

A mineral species is defined mainly on the basis of its chemical composition and crystallographic properties, and these must therefore be the key factors in determining whether the creation of a new mineral species and a new mineral name is justified. If a mineral is found whose composition or crystallographic properties (or both) are substantially different from those of any existing mineral species, there is a possibility that it may be a new species. A general guideline

\* Vice-chairman, IMA Commission on New Minerals and Mineral Names. *E-mail address:* ernien@per.dem.csiro.au

\*\* Chairman, IMA Commission on New Minerals and Mineral Names. *E-mail address:* jgrice@mus-nature.ca

for compositional criteria is that at least one structural site in the potential new mineral should be predominantly occupied by a different chemical component than that which occurs in the equivalent site in an existing mineral species.

---

*Example 1:* Hydroxylapatite and fluorapatite both crystallize in the hexagonal system, with the same space group, and have similar unit-cell parameters. They are considered as separate species because the relevant structural site is predominantly occupied by OH in hydroxylapatite, and by F in fluorapatite.

*Example 2:* Sphalerite (ZnS) and "marmatite" ([Zn,Fe]S) are both cubic, with the same space group and similar unit-cell parameters, but they are not regarded as separate species because the cationic structural site is predominantly occupied by Zn in both cases. "Marmatite" is regarded as a ferroan variety of sphalerite.

---

#### *Substances formed by human intervention*

Anthropogenic substances, *i.e.* those made by Man, are not regarded as minerals. However, there are other cases in which human intervention in the creation of a substance is less direct, and the borderline between mineral and non-mineral can be unclear. One such case is the occurrence of new substances that owe their origin, at least in part, to human activities such as mining or quarrying. If such substances are formed purely as a result of the exposure of existing rock or minerals to the atmosphere or to the effects of groundwater, they can generally be accepted as minerals. However, if their occurrence is due, at least in part, to the interaction of existing minerals with substances of non-geological origin such as blasting powder, corroded human artifacts or industrially contaminated water, then such products are not to be regarded as minerals.

Substances formed by combustion are not generally regarded as minerals. A contentious issue is the occurrence of substances in the combustion products of coal mines, waste dumps or peat bogs. The origin of a particular fire is often difficult to determine, and therefore the possibility of human intervention cannot be entirely eliminated, nor can the possibility of human artifacts contributing to the combustion products. It has therefore been decided that, as a general rule, products of combustion are not to be considered as minerals in the future.

Another contentious issue is whether substances formed by the action of air or water on anthropogenic substances should be regarded as minerals. A well-known example is that of the Laurium "minerals" formed by the reaction of seawater with ancient metallurgical slags. A potential problem with accepting

similar products as minerals in the modern age is that a multitude of unusual substances could be created purposely by exposing exotic Man-made materials to the influence of weathering agents, and it would not be appropriate to give such substances the same status as minerals formed entirely by geological processes. It was therefore decided that substances formed from Man-made materials by geological agents should not be accepted as minerals in the future (Nickel 1995a). However, the exclusion of such substances from the mineral lexicon does not preclude their description as artificial substances.

Substances that would not be accepted as minerals according to the above criteria, but which have been accepted in the past are not to be automatically discredited as a result of the new rulings, as it is not our intention to roll back the clock but rather to establish guidelines for the future.

#### *Biogenic substances*

It is not always possible to draw a sharp distinction between biogenic substances, *i.e.* those produced by biological processes, and minerals, which are normally produced by geological processes. For instance, it is becoming increasingly clear that many of the processes associated with diagenesis are influenced, to some extent, by bacterial action, and the biosphere is commonly regarded as an integral part of the geochemical cycle. Nevertheless, it is necessary to make a formal distinction so as to prevent a host of purely biological materials being incorporated into the world of minerals. Some biogenic substances, such as hydroxylapatite in teeth, whewellite in urinary calculi or aragonite in the shells of molluscs, also exist as minerals formed by geochemical processes, and therefore are regarded as valid minerals. However, purely biogenic substances that have no geological counterparts, or whose origin owes essentially nothing to geological processes, are not regarded as minerals.

However, substances formed by the action of geological processes on organic material, such as the chemical compounds crystallized from organic matter in shale or from bat guano, can be accepted as minerals.

#### *Amorphous substances*

Amorphous substances are non-crystalline, and therefore do not meet the normal requirements for mineral species. The term "crystalline", as generally used in mineralogy, means atomic order on a scale that can produce a regular array of diffraction spots when the substance is traversed by a wave of suitable wavelength (X-ray, electrons, neutrons, *etc.*). However, some geologically derived substances such as gels, glasses and bitumens are non-crystalline. Such substances can be divided into two categories: amorphous, those substances that have never been

crystalline and do not diffract, and metamict, those that were crystalline at one time, but whose crystallinity has been destroyed by ionizing radiation. Some mineralogists are reluctant to accept amorphous substances as mineral species because of the difficulty of determining whether the substance is a true chemical compound or a mixture, and the impossibility of characterizing it completely; the term "mineraloid" is sometimes applied to such substances. However, in the past some amorphous substances (e.g., georgeite, calcio-uranoite) have been accepted as mineral species by the CNMMN.

With modern techniques, it is possible to study amorphous phases more effectively than was possible in the past. Spectroscopic methods associated with a complete chemical analysis can in many cases identify an amorphous phase unequivocally. In fact, appropriate spectroscopic techniques (e.g., IR, NMR, Raman, EXAFS, Mössbauer) can reveal the three-dimensional short-range structural environment (chemical bonds) of each atom in the structure. Of course, without the possibility of obtaining a complete crystal-structure analysis, which can give the coordinates and the nature of the atoms, the need for a complete chemical analysis is more stringent with amorphous material than with a crystalline phase.

The basis for accepting a naturally occurring amorphous phase as a mineral species could be a series of complete quantitative chemical analyses that are sufficient to reveal the homogeneous chemical composition of a substantial number of grains in the specimen, and physicochemical data (normally spectroscopic) that prove the uniqueness of the phase.

Metamict substances, if formed by geological processes, are accepted as mineral species if it can be established with reasonable certainty that the original substance (before metamictization) was a crystalline mineral of the same bulk composition. Evidence for this includes the restoration of crystallinity by appropriate heat-treatment and the compatibility of the diffraction pattern of the heat-treated product with the external morphology (if any) of the original crystal, e.g., fergusonite-(Y).

#### *The matter of size*

The main criteria for defining a mineral species are its composition and crystal structure; with the development of modern analytical techniques, it is now possible to perform complete chemical and crystal-structure analyses on nanometric volumes, i.e., on the scale of a few Ångström units. Should such submicroscopic domains be accepted as valid mineral species? There is a wide range of opinions on this subject. On the one hand, it is argued that if a mineral substance can be characterized in terms of composition and crystallography, then it should be regarded as

a valid mineral species. On the other hand, it is contended that the other properties traditionally reported for minerals, such as color, hardness, optical properties, etc., cannot be determined on an area of that size, and that the description is therefore incomplete. Furthermore, the size of the described particle should be sufficiently large so that sufficient type material can be retained to enable a later independent examination to confirm the original characterization. Another argument against the acceptance of nanometric specimens as valid mineral species is that such substances cannot be adequately displayed in mineral museums. It has not been possible to reach agreement on a minimal acceptable size for a mineral substance to be regarded as a species, and therefore each case must be decided on its own merits.

#### *Stability under ambient conditions*

Many minerals were formed under conditions of high temperature or pressure (or both) and are metastable under ambient conditions; others may tend to hydrate or dehydrate when removed from their place of origin. Such minerals may require special procedures to prevent their decomposition before the investigation is complete. The use of special procedures in the investigation does not preclude the acceptance of a metastable substance as a mineral species if it can be adequately characterized and if it meets the other criteria for a mineral.

#### *Polymorphs*

Polymorphic minerals are those that have essentially the same chemical composition, but different crystal structures. The polymorphic forms of a mineral are regarded as different species if their structures are topologically different. However, if the crystal structures of the polymorphs have essentially the same topology, differing only in terms of a structural distortion or in the order – disorder relationship of some of the atoms comprising the structure, such polymorphs are not regarded as separate species. The names of such topologically similar polymorphs can be distinguished by the addition of crystallographic suffixes to the mineral name, as discussed in a later section.

Although the formal definition of polymorphism is restricted to substances with identical chemical compositions, this strict limitation is broadened somewhat to include relatively minor chemical variations when the topology of the structure is retained.

---

*Example 1:* Graphite and diamond are polymorphs of crystalline carbon; both have the same composition, but their structures are topologically different, and therefore minerals such as these are regarded as separate species.

*Example 2:* Analcime has a number of topologically similar polymorphs, *e.g.*, cubic, tetragonal, orthorhombic, monoclinic, triclinic and possibly even trigonal, caused by relatively minor variations in symmetry due to different degrees of order of Si and Al with related different occupancies of the nearest Na structural site. Such polymorphs are not to be regarded as separate species.

*Example 3:* Orthoclase and microcline have essentially the same composition and topologically similar structures. According to current practice, these minerals would not be regarded as separate species, but their names are retained in the mineral lexicon for historical reasons.

### *Polytypes and polytypoids*

Polytypes are substances that occur in several different structural modifications, each of which may be regarded as being built up by the stacking of layers of (nearly) identical structure and composition, and with the modifications differing only in their stacking sequence (Guinier *et al.* 1984). Polytypoids are substances that do not fit the strict definition of a polytype, and include minerals with the same topology and with somewhat different compositions. Polytypes and polytypoids are not regarded as separate species and, like topologically similar polymorphs, they can be distinguished by the addition of a crystallographic suffix to the mineral name, as indicated in a later section.

*Example 1:* Högbonite exists in a number of different hexagonal and rhombohedral polytypes owing to variations in the stacking of the basic structural layers. These polytypes are not regarded as separate mineral species, and can be distinguished by appropriate suffixes (see later).

*Example 2:* Pyrrhotite,  $\text{Fe}_{1-x}\text{S}$ , where  $x$  varies between 0 and 0.12, exists in a number of different crystallographic forms owing to variations in the degree of order of the Fe vacancies in the S lattice; because of the variable chemical composition, the different types of pyrrhotite can be regarded as polytypoids and are not regarded as separate species.

### *Regular interstratifications*

Regular interstratifications of two or more minerals are accepted as separate species if the kinds of layers, their relative proportions, chemical compositions, and regularity of interstratification in three dimensions on a micrometric or nanometric scale have been well documented. Such information can commonly be obtained by transmission electron microscopy (TEM)

using lattice-imaging techniques. However, if the evidence for regularity of stratification is based on X-ray diffraction data, then the criteria of Bailey (1981) should be applied.

*Example:* A regular interstratification of talc and a trioctahedral smectite qualifies as a separate mineral species, *aliottite*.

### *Polysomatic series*

Homologous structures are those that consist of structural units built on common structural principles; these structures contain the same chemical elements, although in different proportions, and differ with respect to the size of the units. A homologous series is a series of structures that can be derived from one type of basic structural unit using one type of recombination principle. Homologous series can be classified into two categories, accretional and variable-fit; combinations of the two types are known also to occur.

An accretional homologous series, also known as a polysomatic series, is one in which the types of building blocks (rods, layers, *etc.*) and the principles that define their mutual relationships remain preserved, but in which the sizes of these blocks vary incrementally (Veblen 1991). A member of an accretional homologous series can be regarded as a distinct species if it has the following properties: a) unique size of the fundamental building block, b) unique crystallographic unit-cell, and c) unique composition or a limited compositional range (Makovicky 1989).

*Example 1:* The structures of the sulfosalt minerals lillianite, eskimoite, vikingite, ourayite, gustavite and heyrovskyite can all be interpreted as consisting of alternating galena-like modules twinned on (131) of the galena motif (Makovicky & Karup-Møller 1977). The sizes of the modules, the unit-cell parameters, and the chemical compositions of these minerals are all different, which justifies their existence as separate species.

*Example 2:* Composite structures of members of the cylindrite group are formed of two kinds of layers, pseudo-hexagonal (H) and pseudotetragonal (Q). Cylindrite and franckeite have the same Q–H–Q–H sequence of stratification, but in franckeite the width of the Q layer is twice that of the Q layer of cylindrite. The two minerals are therefore regarded as separate species.

A variable-fit homologous series can also be regarded as coupled homeotypes forming a composite structure. Such a series is one in which the structure consists of two kinds of alternating, mutually non-commensurate building blocks. Each kind of

building block has its own short-range periodicity, and it takes  $m$  periods of one block and  $n$  periods of the other block before they meet in the same configuration as was observed at the preselected origin. The non-commensurability of the building blocks may be one- or two-dimensional, and is usually connected with geometrical and compositional long-range modulation of both layer types (Makovicky & Hyde 1981). The period of the long-range match may vary within certain relatively broad limits because of incremental changes in the value of  $m$  or  $n$ . Because of this, the structures are infinitely adaptive, and a great number of possible variants can result. For this reason, individual members of variable-fit homologous series should not be regarded as separate species (see a later section for suggestions in the nomenclature of this group of minerals).

---

*Example:* The cylindrite structure has been interpreted as consisting of incommensurate alternating layers of pseudotetragonal and pseudo-hexagonal symmetry. Several different coincident lattices have been reported for this mineral (Makovicky & Hyde 1981), but these do not qualify for separate species status.

---

#### *Modulated structures*

Misfits between structural units can also be accommodated by structural perturbations. If these perturbations are of a periodic nature, the resultant structures are termed modulated structures, and are generally manifested in diffraction patterns by the appearance of superstructure reflections. Modulated variants of an existing mineral species do not warrant separate species status.

---

*Example:* In the antigorite structure, a misfit between the octahedral and tetrahedral layers is resolved by structural adjustments that result in the formation of structural waves with different periodicities. The various modulations are not regarded as separate species.

---

#### *Solid-solution series*

In a continuous binary solid-solution series, only the two end-members are regarded as species, and the compositional range of the species is taken to apply from that of the end member to 50 mol% of the series; this is generally known as the "50% rule". If a binary solid-solution is incomplete, and the composition of one of the end members exceeds 50 mol% by a small amount, then, strictly speaking, that part of the series exceeding the 50% mark could be regarded as a separate species. However, for practical purposes, it may not be desirable to create a new species defining only a very short compositional range, and therefore such cases should be considered on their individual merits.

In multiple solid-solution series, the 50% rule is interpreted to mean predominant occupancy of a particular structural site. Thus, if there are two types of atom in a structural site, the species is to be defined by the atom comprising at least 50% of that site. If there are more than two substituting atoms in the site, the species is defined by the predominant atom occupying the site. For the purpose of species definition, site vacancies, commonly shown as  $\square$  in chemical formulae, are to be regarded as atoms.

In minerals with complex structures and a multiplicity of structural sites that can accommodate a variety of different elements, the 50% rule may be difficult to apply, and authors of new-mineral proposals that rely on this rule for a particular structural site should substantiate their designation by a crystal-structure analysis.

The problem of applying the 50% rule to members of a complex group is exemplified by the amphibole minerals. The example given below shows that the 50% rule should not be applied too rigorously, and that a certain degree of latitude must be permitted when dealing with complex minerals.

---

*Example:* With a generalized amphibole composition expressed by the formula  $AB_2C_5T_8O_{22}(OH)_2$ , the  $C$  "site" actually comprises 5 different sites, and the  $T$  "site" actually comprises 8 sites. With the  $C$  sites able to accommodate Mg,  $Fe^{2+}$ ,  $Mn^{2+}$ , Li, and a number of less common elements, there is a great opportunity for the proliferation of mineral species if the 50% rule for each structural site were strictly adhered to. Added to this is the difficulty of accurately determining site-populations for elements with similar scattering powers. The Amphibole Subcommittee therefore decided to regard the different  $C$  sites as one composite site, and to apply the 50% rule to it. The  $T$  sites, normally occupied by Si and Al, presented a different problem, as petrologists had long regarded the partial replacement of Si by Al as being of petrological significance. The 8  $T$  sites were therefore not considered as one composite site, and smaller increments in the Si:Al ratio were taken as the effective boundaries between species.

---

In some cases, solid-solution series do not extend to either end member, but instead, the compositions cluster around the 50% mark. For practical reasons, it may not be appropriate to denote the compositions on the two sides of the 50% mark as separate species. Such cases should be considered on their own merits.

---

*Example:* In pentlandite,  $(Fe,Ni)_9S_8$ , Fe and Ni substitute for each other to a limited extent, with compositions centered around  $Fe_{4.5}Ni_{4.5}S_8$ . It has not been found necessary to divide pentlandite into two species, an Fe-dominant one and a Ni-dominant one.

---

Some additional details applying to multiple and partial solid-solution series are given in Nickel (1992).

#### REQUIREMENTS FOR THE APPROVAL OF NEW MINERALS

Before a new mineral and its name can be accepted into the literature, they must be approved by the CNMMN. To obtain this approval, the senior investigator should submit a proposal to the chairman of the CNMMN (see Appendix I), either directly, or through a national new-minerals committee, if appropriate; at present, national committees perform this function in Russia and China.

It is important that a new-mineral proposal be submitted for approval **before** publication. Such a submission should contain as much information as possible so that the CNMMN can adequately judge the validity of the proposal. Ideally, a new-mineral proposal should contain the following information:

Proposed name and reason for its selection.

Description of the occurrence (geographic and geological occurrences, paragenesis, and a list of associated minerals, particularly those in apparent equilibrium with the new mineral).

Chemical composition and method of analysis.

Chemical formula, empirical and simplified.

Crystallography: crystal system, crystal class, space group, point group, unit-cell parameters, unit-cell volume, number of formula units per unit cell, and X-ray powder-diffraction data.

Crystal structure: general description, site populations, structural formula, reliability factor.

General appearance and physical properties: grain or crystal size, morphology, type of aggregate, color, streak, luster, transparency, hardness, tenacity, cleavage, parting, fracture, density, both measured and calculated (Mandarino 1981a).

Optical properties

a) Non-opaque minerals: optical character (isotropic or anisotropic; uniaxial or biaxial), optical sign, indices of refraction, 2V, dispersion, orientation, pleochroism and absorption. The compatibility index using the Gladstone – Dale relationship (Gladstone & Dale 1864) should also be calculated (Mandarino 1981b, Bloss *et al.* 1983).

b) Opaque minerals: color in reflected plane-polarized light, internal reflections, reflectance, bireflectance, pleochroism and anisotropy. The reflectance must be measured relative to a reflectance standard approved by the IMA Commission on Ore Microscopy (IMA-COM), ideally from 400 to 700 nm at intervals of 20 nm. The **minimum** requirement is for reflectance data at the wavelengths 470, 546, 589 and 650 nm. Where data are supplied for measurements in oil, the oil used should conform to the German standard DIN 58.884; this and other recommendations of the IMA-COM are contained in Criddle & Stanley (1993).

Other data: Thermal behavior, infrared spectrum, response to chemical tests, *etc.*

Type material: The type material should be designated according to the criteria published by Dunn & Mandarino (1987) and deposited as permanent reference material in at least one major museum or a nationally recognized mineral collection (Dunn 1988).

Relationship to other species.

Relevant references

Any other data that will clarify difficult parts of the description.

It is recognized that it may not always be possible to obtain all the above data; in such cases, the author should give reasons for the omissions. Of particular importance is the calculation of H<sub>2</sub>O content where it has not been determined analytically. If H<sub>2</sub>O is reported by difference, the method of calculation should be clearly stated and, if possible, evidence for the presence of H<sub>2</sub>O should be provided. Also, ample justification should be given for the allocation of hydrogen to H<sub>2</sub>O, OH or H<sub>3</sub>O.

Because of great differences in the amount and type of information that can be obtained from the study of a particular mineral specimen, it is not practical to specify the irreducible minimum of information required for a mineral to be approved; each proposal must be considered on its own merits.

A general outline of the procedures involved in establishing a new mineral species is given by Dunn (1977). To assist potential authors of new-mineral proposals, a check-list has been drawn up (Mandarino 1987) and should be submitted as part of the proposal. Copies of an official check-list can be obtained from the chairman of the CNMMN or from one of the national representatives (Appendix I). Guidelines on some aspects of new-mineral proposals are given below.

To assist scientists who do not have all the technical facilities to obtain some important data for the complete definition of a new mineral, the CNMMN (*via* its chairman or secretary) may ask some of its members, or specialists of some subcommittees, to collaborate with these scientists in order to improve their proposal.

It happens in some cases that non-mineralogical specialists such as crystallographers or chemists publish a crystal-structure description of a new mineral that has not been officially approved by the CNMMN. Such descriptions should not include a name for the mineral.

If the entire mineral specimen has been consumed during the course of the investigation, and consequently nothing of the specimen remains to be deposited in an appropriate collection, approval for the new mineral will not be given; this is because some material should always remain for possible later re-examination.

## TREATMENT OF A NEW-MINERAL PROPOSAL

When the chairman of the CNMMN receives a new-mineral proposal from authors, either directly or *via* the national new minerals committee in the country of origin, he will acknowledge receipt of the proposal, and may write to the authors asking for more information if he considers this desirable, or he may point out possible objections either to the mineral or to the name. If the authors so desire, the chairman is required to submit a proposal to the CNMMN whether or not he approves of it. In such cases, the chairman will inform the authors that he will give his reasons as to the unsuitability of the proposal under "Chairman's Remarks". The chairman's abstract of a proposal is sent by air mail to each member of the CNMMN, and approximately 60 days are allowed for receipt of voting papers.

Members of the CNMMN are urged, not only to vote, but also to comment in detail. The chairman is authorized to suspend voting on a proposal to enable more information to be obtained, or he may call for a second vote on a proposal if, in his opinion, important comments made by members should be seen by all the members. Second votes have the same voting periods (about 60 days) and require the same majorities as those for original proposals (see below). Any member of the CNMMN who objects to a proposal may ask the chairman to suspend voting or to call for a new vote, but the final decision to do so rests with the chairman.

Abstracts of proposals dealing with opaque minerals may be sent to some members of the IMA-COM at the discretion of the Chairman. Similarly, the chairman may submit abstracts of any proposals to other specialists for advisory opinions. Such advisors do not vote, but their comments are considered by the chairman. Serious objections raised by any advisors are to be treated by the chairman as specified above.

Proposals dealing with minerals belonging to mineral groups for which subcommittees have been organized by the CNMMN may be sent to the appropriate subcommittee chairman for circulation among the subcommittee members if the CNMMN chairman thinks such action is advisable. Subcommittee members are invited to submit opinions, and serious objections raised by them are to be treated as specified above.

If two or more proposals for the same new mineral are received by the chairman, the proposal that arrived first in the chairman's office will have priority. Exceptions can be made if the new-mineral proposal has been submitted *via* a national new-mineral committee and if the CNMMN chairman has been given prior notification of the receipt of the proposal by the national committee.

A proposed new mineral will be considered approved if more than half (1/2) of the members of the CNMMN vote on the proposal, and if more than

two-thirds (2/3) of these members have voted "yes". A proposed name will be considered approved if more than one-half (1/2) of the members who vote on the proposal vote "yes". In assessing the voting results, an abstention is regarded as a negative vote, as it suggests that additional information is required. After the voting on a proposal is completed, the chairman sends the results to the CNMMN members and to the author of the proposal. He includes the comments of the voting members, but the votes of individual members are not disclosed. Reconsideration of adverse votes can be requested by an author at any time if **significant new data or new interpretations** are obtained. If a mineral is approved, but not the name, a new name should be requested by the chairman when he notifies the author of the voting results. In cases of repeat voting, approvals of the mineral and the name require the same majorities as in the original voting.

Authors who have described new minerals without names do not have any priority rights on the subsequent naming of such minerals. However, as a matter of courtesy, it is recommended that a person proposing a name for a previously unnamed mineral communicate with the original authors of the unnamed mineral. Any new names proposed subsequently have to be approved by the CNMMN, as do the minerals for which the names are proposed.

The publication of a non-approved name or the publication of a name for a non-approved mineral is not acceptable, and journal editors should guard against the introduction of such names.

## MINERAL GROUPS

The nomenclature of mineral groups is generally dealt with by subcommittees comprising specialists in the group under consideration, and including at least one member of the CNMMN. The following subcommittees have been established in the past: Pyrochlore, Amphiboles, Pyroxenes, Sulfosalts, Micas, Zeolites, Platinum-Group Minerals, Nomenclature, and Unnamed Minerals.

The creation of a subcommittee, and the composition of its membership, must be approved by the CNMMN. The subcommittee is expected to formulate recommendations for the nomenclature of minerals in the group under consideration, and these recommendations are submitted to the CNMMN for approval by a voting procedure. The recommendations of a group subcommittee are regarded as being of an advisory nature, with the final decision regarding the adoption of the recommendations resting with the CNMMN.

Proposals for the creation of new subcommittees should be submitted to the chairman of the CNMMN. If the establishment of a new subcommittee is approved, the CNMMN secretary (see Appendix I) is authorized to deal with procedural matters involving the subcommittee.

## CHANGES TO EXISTING NOMENCLATURE

*General*

Changes to existing mineral nomenclature, including the redefinition or discreditation of existing mineral species, the renaming of minerals, or the revalidation of discredited or obsolete mineral names, must be approved by the CNMMN **before** publication. Toward this end, a suitable proposal should be submitted to the vice-chairman of the CNMMN (see Appendix I).

A list of changes in nomenclature approved by the CNMMN since 1987 is given in Appendix II.

*Redefinition*

Advances in knowledge such as those resulting from structure refinements or new chemical knowledge extending known ranges of solid solution do not, in general, need to be referred to the CNMMN. However, approval of the CNMMN is required if it is proposed to redefine a mineral a) on structural grounds, b) by adding or deleting one or more chemical components regarded as essential to the definition, or c) by proposing compositional limits in a solid-solution series that are not compatible with the existing definition of the 50% rule (or its equivalent in multicomponent systems). In case of doubt, the authors are invited to consult with the vice-chairman of the CNMMN.

If a mineral is shown to be a mixture and one of the components is otherwise new, the name should usually be transferred to the new phase.

Redefinition of a mineral species requires a review of the literature on the mineral to be redefined, a re-examination of the type specimen (see below), a comparison of the new data with the original, and justification for the redefinition.

*Discreditation*

A mineral or mineral name may be discredited if it can be shown that the mineral is identical to another one that has priority, or if the name is misleading. Requirements for discrediting a mineral species or name are similar to those for redefinition (above), and have been outlined by Dunn (1990).

*Revalidation*

A mineral that has been discredited or fallen into disuse may be revalidated if a re-examination shows that the mineral meets the normal criteria for a distinct mineral species or that it is a mixture containing a new mineral species. Requirements for revalidating a mineral species are similar to those for redefinition, as given above.

*Type specimens*

Wherever possible, the redefinition, discreditation or revalidation of a mineral should be based on a study of type material. If a type specimen exists and if the original description, though faulty, represents a reasonable approximation to material on the specimen, the mineral is to be defined by reference to the type material rather than to the original description. This means that errors in the original description cannot be held to discredit a mineral unless the original description was so grossly inaccurate that, in the words of J.D. Dana (1868), "a recognition of the mineral by means of it is impossible".

If type material cannot be obtained for study, the investigator may propose a neotype to the CNMMN, clearly stating the efforts made to seek the original type-specimen, and providing satisfactory evidence for the identity of the neotype with the original. Both the acceptance of the neotype and approval of the proposal are within the authority of the CNMMN.

*Preparation of a nomenclature proposal*

A proposal to change mineral nomenclature should include all relevant information, including a summary of the original description of the mineral, a review of subsequent reports, the submission of new data, and recommendations for change.

If one or more of the original authors of the mineral to be discredited or redefined are alive, the author of the discreditation or redefinition proposal should write to the original authors asking them to comment on the proposal, and these comments should accompany the submission to the CNMMN.

A proposal for a change of nomenclature should be sent to the vice-chairman of the CNMMN, who is authorized to write to the author pointing out possible deficiencies in the proposal and making suggestions for its improvement. The proposal, modified if necessary, is then submitted to members of the CNMMN as a draft proposal, with an invitation for them to comment. Such comments, if any, are forwarded to the authors of the draft proposal, who are asked to respond to the comments, amend the proposal, or withdraw it, as appropriate. If the proposal is not withdrawn, the amended proposal is submitted to the CNMMN membership for a formal vote, together with the comments on the draft proposal and the authors' responses. The voting procedure is similar to that followed in the case of new-mineral proposals, and at least a two-thirds majority is required to approve such proposals.

## GENERAL GUIDELINES FOR MINERAL NOMENCLATURE

*Choice of a new mineral name*

The responsibility for the choice of a name for a new mineral rests primarily with the author(s) of the



original description, although the name must ultimately be approved by the CNMMN. A mineral is commonly named for the geographical locality of its occurrence, for the discoverer of the mineral (although not if he or she is the author), for a person prominent in the field of mineralogy, or for a particular property of the mineral.

The naming of minerals after commercial organizations or groups that have made no specific, worthwhile contributions to mineralogy is to be discouraged, to prevent inappropriate commercialization of the nomenclature.

If the mineral is to be named after a geographical occurrence, care must be taken to ensure that the spelling conforms to that in use at the locality; the spelling should not be taken from translations.

If the mineral is to be named after a living person, that person's permission must be obtained by the author, and this should be done prior to the submission of the proposal to the CNMMN. When deciding to name a mineral after a person, it is well to recall J. D. Dana's (1854) precept: "It should be remembered that the use of names of persons eminent in other sciences, or of such as are ignorant of all science, is wholly at variance with good usage and propriety; moreover, an attempted flattery of the politically distinguished is degrading to science, and cannot be too strongly discountenanced". If the mineral is named after a person with a space or a capital letter in the name, the name should be modified to eliminate them, *e.g.*, *mcnearite*, **not** *mcNearite*; *joesmithite*, **not** *joe smithite*. Otherwise, the original spelling of the person's name should be retained.

Although the CNMMN does not have a fixed policy on the use of compounded personal names, some members feel that they should be discouraged, particularly where they become cumbersome or cacophonous, or where they unnecessarily distort the true names of the individual who is supposedly being honored.

Mineral names proposed in languages that use other than the Latin alphabet should be transliterated into the Latin alphabet by the author of the name according to the prevalent system operative in the country of origin. Such transliterated names should be reported, in national journals, for example, when the name of the mineral is written according to other alphabets or phonetic rules. Diacritical marks should be retained wherever possible, but it is recognized that not all printing establishments have the necessary facilities for printing all types of diacritical marks; in such cases, diacritical marks may be omitted.

Re-use of a discredited or obsolete name for a new or redefined mineral is to be discouraged, except when the new mineral is a component of a mixture originally described as a single mineral; in such a case, the original name may be transferred to the new phase. Re-use of a discredited name may also be permitted if there is a good reason why the discredited name is particularly appropriate for the mineral in question, and the discredited or obsolete name has not appeared in

the active literature (except for the report of its discreditation) for **fifty years**. A proposal to re-use an obsolete name must be accompanied or preceded by a proposal to discredit the obsolete name. If the CNMMN does not approve a proposal to re-use a discredited name, the author of the proposal has no priority for the use of the discredited name, although he is free to propose the name again at a future time.

The re-use of an obsolete or discredited name is not permitted if the name has been used to a significant extent outside the field of mineralogy (*e.g.*, in petrography, metallurgy, palaeontology, *etc.*), or to indicate two or more minerals.

If an artificial substance has been given a name, and a mineral corresponding to that substance is subsequently discovered, the name given to the artificial substance does not necessarily have to be applied to the mineral.

The name must be sufficiently different from existing ones to prevent confusion, both in the author's language and in others. Existing mineral nomenclature already displays a number of examples of unfortunate names that are easily confused; names such as *celadonite* and *caledonite*, or *mallardite* and *malladrite* can easily be misspelled; names such as *rhodesite*, *rhodizite* and *rhodusite* are euphonically very similar. Introduction of new names that can create similar problems must be avoided.

If the new mineral is clearly and simply related to an existing one, it is very desirable that this relationship be indicated in the new name, *e.g.*, *clinoenstatite* for the monoclinic dimorph of enstatite, or *magnesiocopiapite* for the Mg analogue of copiapite. Such a name should consist of one word only (*e.g.*, *magnesiocopiapite*, **not** *magnesium copiapite*).

Efforts should be made to choose a simple name rather than an excessively complicated one that may be difficult to read or pronounce. The use of excessively long names should be avoided, as these may cause difficulties in pronunciation, tabulations, and computer databases.

### *Rare-earth minerals*

The name of a mineral with essential rare-earth elements (*REE*), or the chemically related elements Y or Sc, must have a suffix indicating the dominant rare-earth element, *e.g.*, *bastnäsite*-(Ce); if a new mineral is discovered with the same structure and analogous composition, but with a different dominant rare-earth element, it should be given a name that is analogous to that of the existing mineral, *e.g.*, *bastnäsite*-(Y). A suffix of this type is known as a **Levinson modifier** after the person who introduced this procedure (Levinson 1966). A subsequent clarification (Bayliss & Levinson 1988) specifies that more than one chemical symbol may be appended only if the elements occupy different crystal-structure sites. A compilation of

rare-earth minerals, appropriately suffixed, was given as an Appendix to Nickel & Mandarino (1987).

An example of a situation that may arise is one in which a mineral with a particular structural site is occupied by both Ca and REE, and the sum of REE elements (in molar proportions) is greater than that of Ca, but individual REE elements are subordinate to that of Ca. In such a case, the mineral is regarded as a rare-earth mineral, with a Levinson modifier specifying the predominant REE.

#### *Extended Levinson modifiers*

As noted above, Levinson modifiers are used primarily in the nomenclature of rare-earth minerals. In a few cases, however, the procedure has been extended to other mineral groups that can contain different substituting elements in one or more structural sites, e.g., *jahnseite* and *pumpellyite*. In zeolites, such modifiers are used without parentheses to indicate exchangeable cations. In general, the use of extended Levinson modifiers is acceptable in cases where only one substituting element is suffixed, but suffixes consisting of multiple elements are conditionally acceptable in cases where the structure is complex, and use of such suffixes simplifies the nomenclature.

#### *Adjectival modifiers*

In mineralogical nomenclature, it is important to distinguish the name proper from adjectival modifiers that may precede the name and are not connected to it. An adjectival modifier is not considered to be part of the mineral name, and is normally used to indicate a compositional variant, e.g., *ferroan manganotantalite*, where *ferroan* is the adjectival modifier that indicates the presence of some ferrous iron, and *manganotantalite* is the name proper. It is recommended that Latin-derived adjectives should be used wherever possible (Hey & Gottardi 1980), e.g., *natrian versus sodian*, and *kalian versus potassian*. The adjectival modifiers recommended by Schaller (1930) have found general acceptance, and they have been augmented by additional ones in the more comprehensive list of adjectival modifiers published by Nickel & Mandarino (1987). In constructing an adjectival modifier that is not in the list, the ending *oan* is to be used for the ion with the lower valency, and *ian* for the higher. If the valency of an element in a particular mineral is not known, the adjectival modifier derived from the more likely, or more common, valence state of the element should be used.

As adjectival modifiers are not considered to be a part of the mineral name, they should be ignored in the preparation of alphabetical indexes. Occasionally an adjectival modifier is given in the form of a hyphenated chemical prefix, e.g., *Li-tosudite*, rather than *lithian tosudite* or *lithium-bearing tosudite*. Such usage is incorrect and should be avoided.

#### *Varietal names*

The existing names of mineral varieties such as *amethyst*, *kunzite*, etc., which are not regarded as species, do not come under the jurisdiction of the CNMMN, and are therefore unregulated. The introduction of new varietal names, however, is to be discouraged, as it tends to create confusion in the mineralogical literature.

#### *Nomenclature of mineral groups*

As noted above, subcommittees have been established for a number of complex mineral groups. Some of these subcommittees have produced reports that have been approved by the CNMMN, and these reports have been published in a number of different journals. The reports, which include guidelines for the nomenclature of minerals comprising these groups, are too complex to be summarized adequately here; readers are advised to consult the published reports of these subcommittees, as follows: pyrochlore: Hogarth (1977), pyroxenes: Morimoto *et al.* (1989), platinum-group minerals: Harris & Cabri (1991), amphiboles: Leake *et al.* (1997), zeolites: Coombs *et al.* (1997) and micas: Rieder *et al.* (1998).

In general, names of less complex mineral groups are well established in the mineralogical literature, and frequently one of the species names of the minerals comprising the group is used for this purpose. The use of such group names is not regulated by the CNMMN, but the creation of a new name must have the approval of the CNMMN.

#### *Nomenclature of polytypes, polytypoids and polymorphs*

The approved system for denoting polytypes is the modified Gard notation recommended by the International Mineralogical Association and the International Union of Crystallography (Bailey *et al.* 1978, Guinier *et al.* 1984, Nickel 1993). It consists of the mineral name followed by a hyphenated, italicized suffix comprising an alphabetical character to indicate crystal system, preceded by a numerical symbol to indicate multiplicity of the structural unit, as first proposed by Ramsdell (1947). This system can also be used for topologically similar polymorphs and for polytypoids. The alphabetical characters to be used in the suffixes are as follows: cubic: *C*, tetragonal: *Q* (for *Quadratic*), hexagonal: *H*, trigonal: *T*, rhombohedral: *R*, orthorhombic: *O*, and triclinic: *A* (for *Anorthic*).

*Example 1:* Muscovite-1*M* is the monoclinic polytype of muscovite with  $c = 10 \text{ \AA}$ ; muscovite-2*M*<sub>1</sub> is the monoclinic polytype of muscovite with  $c = 20 \text{ \AA}$ , and muscovite-3*T* is the trigonal polytype of muscovite with  $c = 30 \text{ \AA}$ .

*Example 2:* Analcime has a number of topologically identical polymorphs caused by different degrees of order of Al and Si in the tetrahedral structural sites. The different polymorphs are distinguished by the suffixes  $-1C$ ,  $-1Q$ ,  $-1M$ , etc.

### *Nomenclature of nanometric domains*

If a domain of nanometric dimensions in a larger mineral grain has a unique composition or crystal structure but is not sufficiently large to qualify as a mineral species, it should not be given a distinctive mineral name. If it is deemed necessary to refer to such a domain by name, it should retain the name of the host mineral, with the addition of an appropriate suffix to indicate the crystallographic or compositional nature of the domain. Such suffixes do not require approval by the CNMMN.

### *Nomenclature of variable-fit homologous series*

Individual names should not be given to members of variable-fit homologous series (see a previous section). Instead, an optional descriptive modifier may be appended, describing the match between the building blocks. The contents of the appended symbol will vary according to the precision required or the method used, should contain the word "homologue", and should be enclosed by  $\langle \rangle$  brackets. An example is "*cyindrite*  $\langle$ homologue (19,13)Q/(30,12)H $\rangle$ " for a homologue of the cyindrite series with a tetragonal (quadratic) building block of 19 by 13 units that is commensurable with a hexagonal block of 30 by 12 units.

### *Prefixes in mineral names*

In applying compositional prefixes to mineral names, it is recommended that Latin-derived prefixes be used instead of other linguistic derivatives (Hey & Gottardi 1980), e.g., *ferro-* instead of *eisen-*, *natri-* instead of *soda-*, or *stanno-* instead of *olovo-*.

Prefixes are an integral part of the mineral name, and should generally be treated as such in the preparation of alphabetical compilations or indexes. However, an exception can be made in the case of prefixed symbols such as Greek letters or their spelled-out Latin equivalents, which may be positioned after the main name in alphabetical listings; e.g.,  $\beta$ -*roselite* may be written as *roselite- $\beta$*  or *roselite-beta*.

The prefix *para* should be used only for names of dimorphs or polymorphs of known minerals. The prefix *meta* should be used only for names of lower hydrates of known minerals.

### *Hyphens in mineral names*

Hyphens are used in mineral names to connect suffixed symbols, such as polytype suffixes and

Levinson modifiers. The use of a hyphen to distinguish a prefix from the root name is to be discouraged, but where an unhyphenated name is awkward and a hyphen assists in deciphering the name, it may be used, e.g., *bario-orthojoaquinite*.

### *Mineral names for synthetic substances*

Unmodified mineral names should not, in general, be used for synthetic substances corresponding to existing minerals, chemical analogues of existing minerals, or hypothetical minerals. However, synthetic substances that correspond to existing minerals may be given mineral names if such names are suitably modified to clearly indicate their synthetic origin (Nickel 1995b), or if the synthetic origin of such substances is clearly stated.

## PUBLICATION OF THE DESCRIPTIONS OF APPROVED MINERALS

The published paper describing the new mineral should include sufficient information, comparable to that given in the proposal to the CNMMN. Publication in a brief abstract in which only some of the data are given should be avoided.

Authors of approved proposals should publish descriptions of the minerals covered by these proposals **within two years** of being notified of the approval by the chairman or vice-chairman. If new-mineral descriptions, discreditations, redefinitions or revalidations are not published within that time, the proposals are no longer considered as approved. Any extensions of this deadline must be approved by the chairman or vice-chairman, as appropriate.

## ADVICE TO EDITORS

Journal editors will do a service to the earth science community if they cooperate fully with the CNMMN. All aspects of the nomenclature in submitted manuscripts should be evaluated according to the guidelines given here, and assurance should be sought from authors that they have submitted all matters dealing with mineral nomenclature to the CNMMN, and that their proposals have been approved. Unless they have definite proof of approval, editors should consult with their national representatives on the CNMMN, or with members of the CNMMN executive. Editors should be particularly cautious about the final acceptance of a paper bearing phrases like "has been submitted" or "will be submitted" to the CNMMN. Acceptance of such papers should be delayed until evidence is produced that the nomenclature **has been approved** by the CNMMN.

In the case of new minerals, editors should insist on evidence that a type specimen of the new mineral has been lodged in at least one major museum or a

nationally recognized mineral collection. This information should be included in the published paper.

It would be appreciated if all journals that publish mineralogical papers include the following statement in their instructions to authors: **This journal follows the rules of the Commission on New Minerals and Mineral Names of the IMA in all matters concerning mineral names and nomenclature.**

## REFERENCES

- ALLEN, F.M. (1992): Mineral definition by HRTEM: problems and opportunities. In *Minerals and Reactions at the Atomic Scale: Transmission Electron Microscopy* (P.R. Buseck, ed.). *Rev. Mineral.* **27**, 289-333.
- BAILEY, S.W. (1981): A system of nomenclature for regular interstratifications. *Can. Mineral.* **19**, 651-655.
- \_\_\_\_\_, FRANK-KAMENETSKII, V. A., GOLDSZTAUB, S., KATO, A., PABST, A., SCHULZ, H., TAYLOR, H.F.W., FLEISCHER, M. & WILSON, A.J.C. (1978): Report of the International Mineralogical Association (IMA) – International Union of Crystallography (IUCr) joint meeting on nomenclature. *Can. Mineral.* **16**, 113-117.
- BAYLISS, P. & LEVINSON, A.A. (1988): A system of nomenclature for rare-earth mineral species: revision and extension. *Am. Mineral.* **73**, 422-423.
- BLOSS, F.D., GUNTER, M., SU, SHU-CHUN & WOLFE, H.E. (1983): Gladstone–Dale constants: a new approach. *Can. Mineral.* **21**, 93-99.
- COOMBS, D.S. *et al.* (1997): Recommended nomenclature for zeolite minerals: report of the Subcommittee on Zeolites of the International Mineralogical Association, Commission on New Minerals and Mineral Names. *Can. Mineral.* **35**, 1571-1606.
- CRIDDLE, A.J. & STANLEY, C.J., eds. (1983): *Quantitative Data File for Ore Minerals* (3rd ed.). Chapman & Hall, London, U.K.
- DANA, J.D. (1854): *A System of Mineralogy* (4th ed.). John Wiley & Sons, New York, N.Y.
- \_\_\_\_\_. (1868): *A System of Mineralogy* (5th ed.). John Wiley & Sons, New York, N.Y.
- DONNAY, G. & FLEISCHER, M. (1970): Suggested outline for new mineral descriptions. *Am. Mineral.* **55**, 1017-1019.
- DUNN, P.J. (1977): From unknown to known: the characterization of new mineral species. *Mineral. Rec.* **8**, 341-349.
- \_\_\_\_\_. (1988): Protocols for scientists on the deposition of investigated mineral specimens. *Am. Mineral.* **73**, 1480.
- \_\_\_\_\_. (1990): The discreditation of mineral species. *Am. Mineral.* **75**, 928-929.
- \_\_\_\_\_. & MANDARINO, J.A. (1987): Formal definitions of type mineral specimens. *Am. Mineral.* **72**, 1269-1270.
- \_\_\_\_\_. & \_\_\_\_\_ (1988): The Commission on New Minerals and Mineral Names of the International Mineralogical Association; its history, purpose and general practice. *Mineral. Rec.* **19**, 319-323.
- FLEISCHER, M. (1970): Procedures of the International Mineralogical Association Commission on New Minerals and Mineral Names. *Am. Mineral.* **55**, 1016-1017.
- GLADSTONE, J.H. & DALE, T.P. (1864): Researches on the refraction, dispersion, and sensitiveness of the liquids. *Phil. Trans., R. Soc. London* **153**, 317-343.
- GUINIER, A. *et al.* (1984): Nomenclature of polytype structures. Report of the International Union of Crystallography *ad-hoc* Committee on the Nomenclature of Disordered, Modulated and Polytype Structures. *Acta Crystallogr.* **A40**, 399-404.
- HARRIS, D.C. & CABRI, L.J. (1991): Nomenclature of platinum-group-element alloys: review and revision. *Can. Mineral.* **29**, 231-237.
- HEY, M.H. & GOTTARDI, G. (1980): On the use of names, prefixes and suffixes, and adjectival modifiers in the mineralogical nomenclature. *Can. Mineral.* **18**, 261-262.
- \_\_\_\_\_, GUILLEMIN, C., PERMINGEAT, F. & DE ROEVER, J.P. (1961): Sur la nomenclature minéralogique. Décisions de la Commission des Nouveaux Minéraux et des Noms de Minéraux de l'Association Internationale de Minéralogie. *Bull. Soc. fr. Minéral. Cristallogr.* **84**, 96-105.
- HOGARTH, D.D. (1977): Classification and nomenclature of the pyrochlore group. *Am. Mineral.* **62**, 403-410.
- LEAKE, B.E. *et al.* (1997): Nomenclature of amphiboles: report of the Subcommittee on Amphiboles of the International Mineralogical Association Commission on New Minerals and Mineral Names. *Can. Mineral.* **35**, 219-246.
- LEVINSON, A.A. (1966): A system of nomenclature for rare-earth minerals. *Am. Mineral.* **51**, 152-158.
- MAKOVICKY, E. (1989): Modular classification of sulphosalts: current status. Definition and application of homologous series. *Neues Jahrb. Mineral., Abh.* **160**, 269-297.
- \_\_\_\_\_. & HYDE, B.G. (1981): Non-commensurate (misfit) structures. *Structure and Bonding* **46**, 103-176.
- \_\_\_\_\_. & KARUP-MØLLER, S. (1977): Chemistry and crystallography of the lillianite homologous series. *Neues Jahrb. Mineral., Abh.* **130**, 264-287.
- MANDARINO, J.A. (1981a): Comments on the calculation of the density of minerals. *Can. Mineral.* **19**, 531-534.
- \_\_\_\_\_. (1981b): The Gladstone–Dale relationship. IV. The compatibility concept and its application. *Can. Mineral.* **19**, 441-450.

- \_\_\_\_\_ (1987): The check-list for submission of proposals for new minerals to the Commission on New Minerals and Mineral Names, International Mineralogical Association. *Can. Mineral.* **25**, 775-783.
- \_\_\_\_\_, NICKEL, E.H. & CESBRON, F. (1984): Rules of procedure of the Commission on New Minerals and Mineral Names, International Mineralogical Association. *Can. Mineral.* **22**, 367-368.
- MORIMOTO, N. *et al.* (1989): Nomenclature of pyroxenes. *Can. Mineral.* **27**, 143-156.
- NICKEL, E.H. (1992): Solid solutions in mineral nomenclature. *Can. Mineral.* **30**, 231-234.
- \_\_\_\_\_ (1993): Standardization of polytype suffixes. *Can. Mineral.* **31**, 767-768.
- \_\_\_\_\_ (1995a): Definition of a mineral. *Can. Mineral.* **33**, 689-690.
- \_\_\_\_\_ (1995b): Mineral names applied to synthetic substances. *Can. Mineral.* **33**, 1335.
- \_\_\_\_\_ & MANDARINO, J.A. (1987): Procedures involving the IMA Commission on New Minerals and Mineral Names and guidelines on mineral nomenclature. *Can. Mineral.* **25**, 353-377.
- RAMSDELL, L.S. (1947): Studies on silicon carbide. *Am. Mineral.* **32**, 64-82.
- RIEDER, M. *et al.* (1998): Nomenclature of the micas. *Can. Mineral.* **36**, 905-912.
- SCHALLER, W.T. (1930): Adjectival ending of chemical elements used as modifiers to mineral names. *Am. Mineral.* **15**, 566-574.
- VEBLEN, D.R. (1991): Polysomatism and polysomatic series: a review and applications. *Am. Mineral.* **76**, 801-826.

Received May 4, 1998.

#### APPENDIX I. MEMBERS OF THE IMA COMMISSION ON NEW MINERALS AND MINERAL NAMES (as of August, 1998)

##### EXECUTIVE

**Chairman:** Dr. Joel D. Grice, Mineral Sciences Division, Canadian Museum of Nature, P.O. Box 3443, Station "D", Ottawa, Ontario, CANADA K1P 6P4. *E-mail:* jgrice@mus-nature.ca

**Vice-Chairman:** Prof. Giovanni Ferraris, Dip. di Scienze Mineralogiche e Petrologiche, Università di Torino, Via Valperga Caluso 35, 210125 Torino, ITALY. *E-mail:* ferraris@dsmp.unito.it

**Secretary:** Dr. William D. Birch, Department of Mineralogy, Museum of Victoria, 285 Russell Street, Melbourne, Vic. 3000, AUSTRALIA. *E-mail:* bbirch@mov.vic.gov.au

**WEB site:** <http://www.dst.unipi.it/ima/>

##### NATIONAL REPRESENTATIVES

**Australia:** Dr. Allan Pring, Department of Mineralogy, South Australian Museum, North Terrace, Adelaide, S.A. 5000, AUSTRALIA. *E-mail:* apring@geology.adelaide.edu.au

**Austria:** Prof. Dr. Franz Pertlik, Institut für Mineralogie und Kristallographie, Universität Wien, Althanstrasse 14, A-1090 Wien, AUSTRIA. *E-mail:* Franz.Pertlik@univie.ac.at

**Belgium:** Dr. Michel Deliens, Section de Minéralogie, Institut royal des Sciences naturelles, rue Vautier, 29, B-1000 Bruxelles, BELGIUM.

**Brazil:** Dr. Daniel Atencio, Instituto de Geociências, Universidade de São Paulo, Caixa Postal 11348, 05422-970 São Paulo, SP, BRASIL. *E-mail:* datencio@usp.br

**Bulgaria:** Prof. Ivan Kostov, National Natural History Museum, Bulgarian Academy of Sciences, Boul. Tsar Osvoboditel 1000, Sofia, BULGARIA. *E-mail:* rikostov@staff.mgu.bg

**Canada:** Mr. Andrew C. Roberts, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, CANADA K1A 0E8. *E-mail:* aroberts@nrcan.gc.ca

**China:** Dr. Huang Yunhui, Institute of Mineral Deposits, Chinese Academy of Geological Sciences, Baiwanzhuang Road 100037, Beijing, CHINA

**Croatia:** Dr. Vladimir Bermanec, Mineral.-Petrogr. zavod PMF-a, University of Zagreb, Demetrova 1/1, HR-41000 Zagreb, CROATIA.

**Czech Republic:** Dr. Milan Novák, Dept. of Mineralogy and Petrology, Moravian Republic Museum, Zelný trh 6, 659 37 Brno, CZECH REPUBLIC. *E-mail:* mineral@mzm.anet.cz

**Denmark:** Dr. Ole Johnsen, Geologisk Museum, Øster Voldgade 5, DK-1350 Copenhagen K, DENMARK. *E-mail:* oj@savik.geomus.ku.dk

**Finland:** Prof. Ragnar Torarsoo, Department of Geology, University of Helsinki, PO Box 11 (Snellmaninkatu 3), FIN-00014 University of Helsinki, FINLAND.

**France:** Dr. Yves Moëlo, Institut des Matériaux de Nantes, Laboratoire de Chimie des Solides, 2, rue de la Houssinière, B.P. 32229, F-44 332 Nantes Cedex 03, FRANCE. *E-mail:* Yves.Moelo@cims-irm.fr

**Germany:** Dr. Paul Koller, Institut für Mineralogie und Kristallchemie, Universität Stuttgart, Pfaffenwaldring 55, D-7000 Stuttgart, GERMANY.

**Hungary:** Dr. Gábor Pepp, Hungarian Natural History Museum, Department of Mineralogy & Petrology, Budapest, Pf.: 137, H-1431, HUNGARY. *E-mail:* pappmin@udens.elte.hu

**Israel:** Dr. Hanan J. Kisch, Department of Geology and Mineralogy, Ben-Gurion University of Negev, PO Box 653, Beer-Sheva 84105, ISRAEL.

**Italy:** Prof. Giovanni Ferraris, Dip. di Scienze Mineralogiche e Petrologiche, Università di Torino, Via Valperga Caluso 35, 210125 Torino, ITALY. *E-mail:* ferraris@damp.unito.it

**Japan:** Dr. Satoshi Matsubara, Department of Geology, National Science Museum, 3-21-1 Hyakunin-cho, Shinjuku, Tokyo 160. JAPAN. *E-mail:* matsubara@kahaku.go.jp

**The Netherlands:** Dr. Ernst A.J. Burke, Faculteit Aardwetenschappen, Vrije Universiteit, De Boeleaan 1085, 1081 HV Amsterdam, THE NETHERLANDS. *E-mail:* bure@geo.vu.nl

**New Zealand:** Prof. Douglas S. Coombs, Department of Geology, University of Otago, PO Box 56, Dunedin, NEW ZEALAND. *E-mail:* doug.coombs@stonebow.otago.ac.nz

**Norway:** Dr. Gunnar Raade, Mineralogisk-Geologisk Museum, Sars' Gate 1, N-0562 Oslo, NORWAY. *E-mail:* gunnar.raade@toyen.uio.no

**Poland:** Prof. Dr. A. Manecki, Academy of Mining and Metallurgy, Institute of Geology and Mineral Deposits, al. Mickiewicza 30, 30-059 Krakow, POLAND

**Romania:** Dr. Gheorghe Udubasa, Institute of Geology and Geophysics, Str. Caransebes No. 1, 78344 Bucuresti-32, ROMANIA. *E-mail:* udubasa@igr.sftos.ro

**Russia:** Prof. Andrei G. Bulakh, Department of Mineralogy, St. Petersburg University, Universitetskaya nab., 7/9, St. Petersburg 199034, RUSSIA. *E-mail:* bulakh@mineral.geol.pu.ru

**Slovakia:** Dr. Pavel Uher, Geological Institute, Slovak Academy of Sciences, Dúbravská cesta 9, 842 26 Bratislava, SLOVAKIA. *E-mail:* geoluh@savba.savba.sk

**South Africa:** Dr. J.P.R. de Villiers, Mineralogy Division, Council for Mineral Technology, Private Bag X3015, Randburg 2125, SOUTH AFRICA.

**Spain:** Prof. Dr. Purificación Fenoll Hash-Alá, Departamento de Mineralogía y Petrología, Avda. Fuente Nueva s/n, Universidad de Granada, Granada 28002, SPAIN. *E-mail:* pfenoll@goliat.ugr.es

**Sweden:** Dr. Ulf Hålenius, Department of Mineralogy, Naturhistoriska Riksmuseet, Box 50007, S-104 05 Stockholm, SWEDEN.

**Switzerland:** Prof. Stefan Graessner, Naturhistorisches Museum, Augustinerstrasse 2, CH-4051 Basel, SWITZERLAND. *E-mail:* graessner@ubach.unibas.ch

**United Kingdom:** Dr. Alan Criddle, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K. *E-mail:* a.criddle@nhm.ac.uk

**U.S.A.:** Dr. Pete J. Dunn, Department of Mineral Sciences, Smithsonian Institution, Washington, D.C. 20560, U.S.A.

## APPENDIX II. CHANGES IN NOMENCLATURE, 1987–1997

### DISCREDITATIONS

Andrewsite (= hentschelite)	Dunn: <i>Am. Mineral.</i> 75 (1990), 1197
Anosovite (= arnalcobite)	Bowles: <i>Am. Mineral.</i> 73 (1988), 1377
Ashanite (= idiolite)	Pending
Baumite (= impure serpentine)	Guggenheim & Bailey: <i>Am. Mineral.</i> 75 (1990), 705
Bravoite	Bayliss: <i>Am. Mineral.</i> 74 (1989), 1168
Calciocelesian (= armenite)	Mason: <i>Mineral. Mag.</i> 51 (1987), 317
Calcium pharmacosiderite (= barium pharmacosiderite)	Pending
Caratite (= pipyrite)	
Filatov & Vergasova: <i>Zap. Vses. Mineral. Obshchest.</i> 118(3) (1989), 88	
Chaveseite (= monesite)	Kampf & Dunn: <i>Am. Mineral.</i> 79 (1994), 385
Csikovite (= tetradyomite)	Bayliss: <i>Am. Mineral.</i> 76 (1991), 257
Cuprocassiterite (= murchisonite)	Dunn & Roberts: <i>Mineral. Rec.</i> 17 (1986), 383
Donatite (= magnetite + chromite)	
Burns <i>et al.</i> : <i>Neues Jahrb. Mineral., Monatsh.</i> (1997), 163	
Ferrazite (= gorceixite)	Atencio & Clark: <i>Mineral. Mag.</i> 60 (1996), 841
Ferropseudobrookite (= pseudobrookite)	Bowles: <i>Am. Mineral.</i> 73 (1988), 1377
Herschelite (= chabazite)	Coombs <i>et al.</i> : <i>Can. Mineral.</i> 35 (1997), 1571
Iridosmine (= osmium)	Harris & Cabri: <i>Can. Mineral.</i> 29 (1991), 231
Kennedyite (= arnalcobite)	Bowles: <i>Am. Mineral.</i> 73 (1988), 1377
Laubmannite (= impure dufenite)	Dunn: <i>Am. Mineral.</i> 75 (1990), 1197
Leonhardite (= starkeyite)	Coombs <i>et al.</i> : <i>Can. Mineral.</i> 35 (1997), 1571
Lewisite (= roméite)	Pending
Lusungite (= goyazite)	Pring <i>et al.</i> : <i>Mineral. Mag.</i> 59 (1995), 143
Mauflite (= interstratified lizardite – chlorite)	Pending
Nioboloparite [loparite-(Ce)]	Mitchell <i>et al.</i> : <i>Can. Mineral.</i> 34 (1996), 991
Osmiridium (= iridium)	Harris & Cabri: <i>Can. Mineral.</i> 29 (1991), 231
Platiniridium (= iridium)	Harris & Cabri: <i>Can. Mineral.</i> 29 (1991), 231
Polymignite (= zirkelite)	Bayliss <i>et al.</i> : <i>Mineral. Mag.</i> 53 (1989), 565
Portite (= natrolite)	Franzini & Perchiazzi: <i>Eur. J. Mineral.</i> 6 (1994), 351
Protoastrakhanite (= konyaite)	
van Doesburg & van der Plas: <i>Am. Mineral.</i> 74 (1989), 1382	
Rezhanyite (= mixture with hammarite)	
Žák & Mumme: <i>Neues Jahrb. Mineral., Monatsh.</i> (1994), 314	
Rutheniridosmium (= iridium)	Harris & Cabri: <i>Can. Mineral.</i> 29 (1991), 231
Selen-tellurium (= selenium + tellurium)	Bayliss: <i>Am. Mineral.</i> 76 (1991), 257
Sismondine (= chloritoid)	Chopin <i>et al.</i> : <i>Eur. J. Mineral.</i> 4 (1992), 67
Starignite (= cassiterite + ferrotapiolite)	Groat <i>et al.</i> : <i>Mineral. Mag.</i> 58 (1994), 271
Sulrhodite (= bowieite)	Bayliss <i>et al.</i> : <i>Mineral. Mag.</i> 56 (1992), 125
Svetozharite (= dachiardite)	Coombs <i>et al.</i> : <i>Can. Mineral.</i> 35 (1997), 1571
Tetranatrolite (= gonardite)	Pending
Warrenite (= jamesonite)	Pending
Wellsite (= phillipsite)	Coombs <i>et al.</i> : <i>Can. Mineral.</i> 35 (1997), 1571

### REDEFINITIONS

Agularite	Pending
Arnalcobite	Bowles: <i>Am. Mineral.</i> 73 (1988), 1377
Attakolite	Grice & Dunn: <i>Am. Mineral.</i> 77 (1992), 1285
Berndite polytypes	Bayliss & Clark: <i>Mineral. Mag.</i> 54 (1990), 137
Gartrellite	Krause <i>et al.</i> : <i>Eur. J. Mineral.</i> 10 (1998), 179
Georgeite	Pollard <i>et al.</i> : <i>Mineral. Mag.</i> 55 (1991), 163
Kegeite	Dunn <i>et al.</i> : <i>Am. Mineral.</i> 75 (1990), 702
Khademite	Ceshron & Bayliss: <i>Mineral. Mag.</i> 52 (1988), 133
Plumbotellurite	Pending
Pseudobrookite	Bowles: <i>Am. Mineral.</i> 73 (1988), 1377
Rutheniridosmine	Harris & Cabri: <i>Can. Mineral.</i> 29 (1991), 231
Tengerite-(Y)	Miyawaki <i>et al.</i> : <i>Am. Mineral.</i> 78 (1993), 425
Villamaninite	Bayliss: <i>Am. Mineral.</i> 74 (1989), 1168
Xitieshanite	Li Jiaju <i>et al.</i> : <i>Sci. Geol. Sinica</i> (1989), 106
Zircanolite polymorphs	Bayliss <i>et al.</i> : <i>Mineral. Mag.</i> 53 (1989), 565
Zirkelite	Bayliss <i>et al.</i> : <i>Mineral. Mag.</i> 53 (1989), 565

### RENAMINGS

Ferridravite (= povondraite)	Grice <i>et al.</i> : <i>Am. Mineral.</i> 78 (1993), 433
Fiedlerite polytypes	Merlino <i>et al.</i> : <i>Mineral. Mag.</i> 58 (1994), 69
Hiortdahlite polymorphs	Merlino & Perchiazzi: <i>Mineral. Petrol.</i> 37 (1987), 25
Magnesium orthite [= dollaseite-(Ce)]	
Peacor & Dunn: <i>Am. Mineral.</i> 73 (1988), 838	
Natroautunite (meta-natroautunite)	
Chernikov & Organova: <i>Dokl. Akad. Nauk</i> 338 (1994), 368	
Penkivskite polytypes	Merlino <i>et al.</i> : <i>Am. Mineral.</i> 79 (1994), 1185

### REVALIDATIONS

Aerinite	Azambre & Monchoux: <i>Bull. Minéral.</i> 111 (1988), 39
Barium pharmacosiderite	Walenta: <i>Aufschluss</i> 45 (1994), 73
Fernandinite	Evans <i>et al.</i> : <i>Can. Mineral.</i> 32 (1994), 339
Prismatine	Grew <i>et al.</i> : <i>Mineral. Mag.</i> 60 (1996), 483
Pseudorutile	Grey <i>et al.</i> : <i>Mineral. Mag.</i> 58 (1994), 597

Note that a large number of additional changes in nomenclature have been formalized in IMA reports on pyroxenes (Morimoto *et al.* 1989), amphiboles (Leake *et al.* 1997), zeolites (Coombs *et al.* 1997) and micas (Rieder *et al.* 1998).