

## NOTES

### Summary of national and international recommendations on clay mineral nomenclature

#### 1969–70 CMS Nomenclature Committee

(Received 23 October 1970)

BECAUSE of their small grain size and variable degree of crystal perfection, it is not surprising that clay minerals proved extremely difficult to characterize adequately prior to the development of modern analytical techniques. Problems in characterization led quite naturally to problems in nomenclature, undoubtedly more so than for the macroscopic, more crystalline minerals. The popular adoption in the early 1950's of the X-ray diffractometer for clay studies helped to solve some of the problems of identification. Improvements in electron microscopy, i.r. and DTA equipment, the development of nuclear and isotope technology, of high-speed electronic computers, Mössbauer spectrometers, and most recently of the electron microprobe and scanning electron microscope have all aided in the accumulation of factual information on clays. This, in turn, should facilitate eventual agreement on the nomenclature of clays.

Probably the earliest attempt by clay scientists to reach agreement on nomenclature and classification on an international basis was at the International Soil Congress held in Amsterdam in 1950 (Brindley *et al.*, 1951). Since that time national Nomenclature Committees have been established in many countries. Recommendations from these national groups have been considered every 3 yr at the International Clay Conferences, first by the Nomenclature Sub-Committee of CIPEA (COMITE INTERNATIONAL POUR L'ETUDE DES ARGILES) and since 1966 by the Nomenclature Committee of AIPEA (ASSOCIATION INTERNATIONALE POUR L'ETUDE DES ARGILES). These international committees in turn have worked closely with the Commission on New Minerals and Mineral Names of the IMA (International Mineralogical Association).

G. W. Brindley and R. E. Grim, from the United States, participated in the initial nomenclature meeting at Amsterdam in 1950, and have been active in national and international discussions since that time. A formal Nomenclature Sub-Committee was appointed in 1961 by the Clay Minerals Committee of the National Research Council. The title was changed slightly to the Nomenclature Committee in 1963 upon change of the parent Committee to The Clay Mineral Society (CMS). G. W. Brindley served as chairman of these committees during the period 1961–69. Much of the progress in resolving nomenclature problems at both the national and international levels is due to his continuing effort in this posi-

tion. Thanks are due also to the other committee members who served at various times during this period. These include S. W. Bailey, T. F. Bates, G. T. Faust, S. A. Forman, R. E. Grim, J. C. Hathaway, M. L. Jackson, A. A. Levinson, R. T. Martin, C. I. Rich, C. S. Ross and M. Ross.

The present CMS Nomenclature Committee has prepared the following summary of recommendations and agreements achieved to date in the national and international committees for the information of Society members. Agreements are annotated to allow consultation of the original references for further details. It is hoped that Society members will unite in using the agreed-upon terminology in their future publications, especially so in the Society publication *Clays and Clay Minerals*. The Committee also solicits the views of the membership on unresolved problems of clay classification and nomenclature.

#### Classification

Agreement was reached early in the international discussions that a sound nomenclature is necessarily based on a satisfactory classification scheme. For this reason, the earliest and most extensive efforts of the several national nomenclature committees have been expended on classification schemes. Existing schemes were collated and discussed (see Brown, 1955, Mackenzie, 1959, and Pedro, 1967, for examples), symposia were held at national meetings, and polls were taken of clay scientists in 32 countries as to their preferences. Armed with these data, the international representatives have been able to agree upon most features of a broadly based scheme for the phyllosilicates as a whole (Mackenzie, 1965a, b; Brindley, 1967b).

Table 1 gives the classification scheme in its present form. The phyllosilicates are divided into groups, each containing dioctahedral and trioctahedral sub-groups. Each sub-group in turn is divided into mineral species. This subdivision corresponds to successive stages of refinement in the identification process. It is intended that the precise definitions of the groups and sub-groups and their names will evolve and change with time. This intention is most noticeable in Table 1 in the group name for those 2:1 type phyllosilicates having charge per formula unit between 0.25 and 0.6. The decision on *smectite* or *montmorillonite-saponite* as the group name has been deferred due to lack of agreement, with the

Table 1. Proposed classification scheme for phyllosilicates related to clay minerals

Type	Group ( $x$ = charge per formula unit)	Sub-group	Species*
1:1	Kaolinite-serpentine $x \sim 0$	Kaolinites Serpentines	Kaolinite, halloysite Chrysotile, lizardite, antigorite
	Pyrophyllite-talc $x \sim 0$	Pyrophyllites Talc	Pyrophyllite Talc
	Smectite <i>or</i> Montmorillonite- saponite $x \sim 0.25-0.6$	Diocahedral smectites <i>or</i> montmorillonites	Montmorillonite beidellite, nontronite
2:1	Vermiculite $x \sim 0.6-0.9$	Diocahedral vermiculites Triocahedral vermiculites	Diocahedral vermiculite Triocahedral vermiculite
	Mica† $x \sim 1$	Diocahedral micas Triocahedral micas	Muscovite, paragonite Biotite, phlogopite
	Brittle mica $x \sim 2$	Diocahedral brittle micas	Margarite
		Triocahedral brittle micas	Clintonite
		Diocahedral chlorites Di, triocahedral chlorites Triocahedral chlorites	Donbassite Cookeite, sudoite Pennine, clinchlore, prochlorite

\*Only a few examples are given.

†The status of *illite* (or hydromica), *sericite*, etc. must be left open at present, because it is not clear whether or at what level they would enter the Table; many materials so designated may be interstratified.

expectation that the preferred term will emerge by popular usage. Table 1 represents international agreement. It has the backing of the CMS Nomenclature Committee, and compares favorably with the poll results of the views of the majority of U.S. clay scientists.

#### Definition of phyllosilicate

Table 1 assumes a specific definition of a phyllosilicate (or layer silicate). This definition was discussed most recently at the AIPEA Nomenclature Committee meeting held in Tokyo in 1969 (Pedro, 1970). There was general agreement that: (a) the tetrahedral sheet must be continuous, and (b) the layer structure must be evident in the nature of the interlayer bonding, which should be weaker than the bonding within the layers and give rise to characteristic properties, such as marked basal cleavage. The first criterion does not exclude layer structures in which the unshared\* tetrahedral apices alternate in direction. It does exclude "quasi-layer silicates", such as astrophyllite, lamprophyllite, bafertisite, and haradaite, in which 5-fold or 6-fold coordinated groups interrupt the continuity of the tetrahedral net. The second criterion is necessary in order to rule out minerals such as cristobalite, tridymite, and nepheline that could be and often are described in terms of layers.

#### Relation of palygorskite and sepiolite to phyllosilicates

The tetrahedral sheets in palygorskite and sepiolite are continuous, although arranged in bands with the apices in adjacent bands pointing in opposite directions. These minerals are more closely related to the layer silicates, therefore, than to the chain silicates. Pronounced layer characteristics such as basal cleavage are not developed, however, so that the second criterion of the definition of a layer silicate is not satisfied. The AIPEA Nomenclature Committee has recommended (Pedro, 1970) that a category of *pseudo-layer silicates* should be recognized, one subdivision of which will be *palygorskite-sepiolite*. The proposed name "hormite" for this subdivision has been rejected.

#### Interstratified materials

No general agreement has been reached yet as to preferred terminology for interstratified minerals. The 1962-63 CMS Nomenclature Committee (Brindley, 1966) approved in principle the suggestion of Brown (1955) for *irregularly interstratified* minerals, namely that the material should be described in terms of the component layers. The best descriptive terms for those layers are still in question. Brown suggested "chloritic-mica" for a small proportion of chlorite layers randomly interstratified with a major proportion of mica layers, or "chlorite-mica" for more nearly equal proportions of the two layers. The 1965-66 CMS Nomenclature

\*Unshared in the tetrahedral linkage.

Committee (Brindley, 1967a) criticized both terms on the grounds that "chloritic mica schist" and "chlorite-muscovite schist" are well established terms that imply macroscopic mixtures of minerals. The Committee recommended instead "irregular chlorite-mica interstratification", with the dominant component listed first. For comparable proportions of layers "irregular 1-1 (or 50-50) chlorite-mica interstratification" could be used. The CIPEA Nomenclature Sub-Committee at its Jerusalem meeting (Brindley, 1967b) recognized the advantages of the CMS proposals, but did not feel ready to endorse them internationally.

The 1962-63 Nomenclature Committee also recommended for *regularly interstratified* minerals that "regular" be used in the description, e.g. "regular chlorite-mica interstratification". Special names for interstratified minerals are not favored, though eventually the regular interstratifications may be given names.

#### Non-crystalline materials

The CIPEA Nomenclature Sub-Committee at its Jerusalem meeting (Brindley, 1967b) agreed unanimously that the term "non-crystalline" is preferable to the commonly used term "amorphous". It was recommended strongly that specific names not be given to newly discovered noncrystalline minerals, but that they be described so far as possible in terms of their chemical composition. Names may be chosen later if it becomes apparent that particular ranges of chemical composition exist for these minerals.

#### Clay mineral names

*Chamosite and berthierine.* The 1966-67 Nomenclature Committee (Brindley *et al.*, 1968) unanimously endorsed the recommendation of Orcel, Hénin and Caillère (1949) that the name "berthierine" has priority over "chamosite" for the 1:1 type layer silicate commonly found in ironstones. The name "chamosite" has priority for a 2:1:1 chlorite of similar composition.

*Diocahedral chlorite.* As more information has become available on dioctahedral chlorites, the nomenclature has changed. The latest recommendation is that of the AIPEA Nomenclature Committee (Pedro, 1970). It is recommended that the chlorite group be subdivided into the three sub-groups dioctahedral chlorite, ditriocahedral chlorite, and trioctahedral chlorite (Table 1). *Diocahedral* chlorite is dioctahedral in both the 2:1 layer and the interlayer hydroxide sheet. An example is *donbassite* (Lazarenko, 1940). A di, trioctahedral chlorite is dioctahedral in the 2:1 layer but trioctahedral in the interlayer hydroxide sheet. *Cookeite* and *sudoite* are examples. *Cookeite* contains significant  $\text{Li}_2\text{O}$  in its chemical composition.

*Anauxite.* The 1967-68 CMS Nomenclature Committee (unpublished report) recommended that the name "anauxite" be discredited. It has been shown to be a mixture of components, of which the kaolinitic component is true kaolinite (Langston and Pask, 1968; Allen, Fahey and Ross, 1969; Bailey and Langston, 1969).

*Kaolinite group minerals.* The AIPEA Nomenclature Committee at its meeting in Jerusalem (Brindley, 1967b) reconfirmed the recommendation reached at its 1963 meeting in Stockholm that kaolinite, dickite, and nacrite

should be renamed according to the principle of a single name followed by symbols expressing the stacking sequences of kaolin layers. The exact symbols to be used were left open pending further study. The question of the nomenclature to be used for the platy, rolled, and prismatic forms of kaolin, with and without water interlayers, has not been resolved. An extensive discussion has recently appeared by Douillet and Nicolas (1969).

*Clintonite.* The 1967-68 CMS Nomenclature Committee (unpublished report) endorsed the recommendation of Forman, Kodama and Maxwell (1967) that the name "clintonite" has priority over other species names (seybertite, xanthophyllite, brandisite, valuevite) for the Li-poor, Ba-poor trioctahedral brittle micas. All of these are so similar in crystallography, chemical composition, and mode of origin that only a single species name is justified.

*Palygorskite.* The 1967-68 CMS Nomenclature Committee (unpublished report) recommended that the name "attapulgitite" be relegated to the synonymy, as the name "palygorskite" is judged to have priority.

*Imogolite.* The AIPEA Nomenclature Committee at its Tokyo meeting (Pedro, 1970) approved the name *imogolite* for a hydrous aluminosilicate having a fine thread-like morphology and the diffraction characteristics described by Wada and Yoshinaga (1969) and by others.

#### Terminology

The CMS Nomenclature Committee (Brindley *et al.*, 1968) has recommended the following usages for terms that commonly are misused or intermixed in the literature.

*Lattice and structure.* A "lattice" is not synonymous with "structure", but is a uniform distribution of points in space (e.g. the 14 Bravais lattices). The term "layer lattice" clay mineral is incorrect and should not be used. Layer structure, layer silicate, and phyllosilicate are acceptable terms (Brindley, 1967b).

*X, Y, Z and a, b, c.* Strictly speaking, X, Y, and Z should be used to refer to crystallographic axes and a, b, c to the repeat distances along these axes (i.e. unit cell lengths).

*Plane, sheet, and layer.* Recommended usage is as a single *plane* of atoms, a tetrahedral or octahedral *sheet*, and a 1:1 or 2:1 *layer*. Thus, plane, sheet, and layer refer to increasingly thicker arrangements. A sheet is a combination of planes and a layer is a combination of sheets. In addition, layers may be separated from one another by various *interlayer* materials, including cations, hydrated cations, organic molecules, and hydroxide octahedral groups and sheets.

*Talc layer and brucite sheet.* These terms are not suitable for describing the component parts of the chlorite structure, because the minerals talc and brucite admit very little substitution of Mg by Al, which is an essential feature of trioctahedral chlorites. It is recommended that "2:1 layer" be used in place of "talc layer" and "hydroxide sheet" in place of "brucite sheet".

S. W. BAILEY (*Chairman*)  
G. W. BRINDLEY  
W. D. JOHNS  
R. T. MARTIN  
M. ROSS

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*Clays and Clay Minerals*, 1971, Vol. 19, pp. 132–133. Pergamon Press. Printed in Great Britain

**Clay Mineral Society**  
**Report of nomenclature committee**  
**1969–1970**

(Received 23 October 1970)

THE CMS Nomenclature Committee for 1969–70 has prepared a Summary Report of previous recommendations of this Committee and of the International CIPEA and AIPEA Nomenclature Committees. The report is designed to provide a convenient capsule summary for the Society membership of nomenclature recommendations that are scattered through the literature.

The Committee also has considered additional problems of nomenclature, for which the following recommendations are proposed.

1. In addition to our previous definitions of *plane*, *sheet*, and *layer* (Brindley *et al.*, 1968), the terms *unit* or *unit structure* are recommended for description of the

complete structural assemblage. A *unit* or *unit structure* contains one or more chemical formula units. Thus, a kaolinite unit structure consists only of a 1:1 layer, but a vermiculite unit structure consists of a 2:1 layer plus the interlayer hydrated cations. It is recommended further that the usage of 2:1:1 or 2:2 type layers for chlorite be discontinued. A chlorite unit structure consists of a 2:1 layer plus an interlayer hydroxide sheet. This emphasizes the similarity of chlorite to other clay minerals containing interlayer material.

2. Clay minerals belong to the larger family of phyllosilicates. The following structural and chemical definition of this family is suggested. *Phyllosilicates* contain