SUMMARY OF RECOMMENDATIONS OF THE AIPEA NOMENCLATURE COMMITTEE

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INTRODUCTION

Because of their small particle-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 perfectly crystalline minerals. The popular adoption in the early 1950s of the powder X-ray diffractometer for clay studies helped to solve some of the problems of identification. Improvements in electron microscopy, electron diffraction and oblique texture electron diffraction, infrared and DTA equipment, plus the development of nuclear and isotope technology, high-speed electronic computers, Mössbauer spectrometers and most recently, the electron microprobe and scanning electron-microscope all have 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 occurred 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 three years at the International Clay Conference, first by the Nomenclature Subcommittee of CIPEA (Comité International pour l’Étude des Argiles) and since 1966 by the Nomenclature Committee of AIPEA (Association Internationale pour l’Étude des Argiles). These international committees in turn have worked closely with the Commission on New Minerals and Mineral Names of the I.M.A. (International Mineralogical Association).

This summary of the recommendations made to date by the international nomenclature-committees has been prepared in order to disseminate more widely the decisions reached and to aid clay scientists in the correct usage of clay nomenclature. Some of the material in the present summary has been taken from an earlier summary by Bailey et al. (1971a).

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 committees on nomenclature have been expended on classification schemes. Existing schemes were collated and discussed (e.g., Brown 1955, Mackenzie 1959, Pedro 1967), 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 1967).

Table 1 gives the classification scheme in its present form. The phyllosilicates are divided into groups, each containing dioctahedral and trioctahedral subgroups. Each subgroup in turn is divided into mineral species. This subdivision corresponds to successive stages of refinement in the identification process. It is anticipated that the precise definitions of the groups and subgroups and their names will evolve and change with time. This table differs from previously published versions in two respects. Smectite has now been accepted as the group name for clay minerals with layer charge between 0.2 and 0.6 per formula unit. This decision, made at the 1975 Mexico City meeting (Brindley & Pedro 1976), was based on an

### TABLE 1. CLASSIFICATION SCHEME FOR PHYLLOSILICATES RELATED TO CLAY MINERALS

<table>
<thead>
<tr>
<th>Layer Type</th>
<th>Group</th>
<th>Subgroup</th>
<th>Species*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>Kaolinite-serpentine</td>
<td>Kaolinite</td>
<td>Kaolinite, dickite, halloysite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Serpentine</td>
<td>Chrysotile, lizardite, amesite</td>
</tr>
<tr>
<td></td>
<td>Pyrophyllite-talc</td>
<td>Pyrophyllite</td>
<td>Pyrophyllite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Talc</td>
<td>Talc</td>
</tr>
<tr>
<td></td>
<td>Smeectite</td>
<td>Dioctahedral smectite</td>
<td>Montmorillonite, beidellite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trilobahedral smectite</td>
<td>Saponite, hectorite, sauconite</td>
</tr>
<tr>
<td></td>
<td>Vermiculite</td>
<td>Dioctahedral vermiculite</td>
<td>Dioctahedral vermiculite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trilobahedral vermiculite</td>
<td>Trilobahedral vermiculite</td>
</tr>
<tr>
<td></td>
<td>Mica#</td>
<td>Dioctahedral mica</td>
<td>Muscovite, paragonite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trilobahedral mica</td>
<td>Phlogopite, biotite, lepidolite</td>
</tr>
<tr>
<td></td>
<td>Brittle mica</td>
<td>Dioctahedral brittle mica</td>
<td>Margarite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trilobahedral brittle mica</td>
<td>Clintonite, anandite</td>
</tr>
<tr>
<td></td>
<td>Chlorite</td>
<td>Dioctahedral chlorite</td>
<td>Donbassite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trilobahedral chlorite</td>
<td>Cookeite, sudolite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trilobahedral chlorite</td>
<td>Clinohlore, chamosite, nimite</td>
</tr>
</tbody>
</table>

* 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.

Increased world-wide usage of this name as opposed to the alternate dual name montmorillonite–saponite for the group. Dual names still exist for the kaolinite-serpentine and pyrophyllite-talc groups. Suggested names of kandite and septechlorite for the kaolin and serpentine minerals, respectively, have not been approved by the AIPEA Committee and should not be used. The second change is to treat chlorite as consisting of a 2:1 layer plus an interlayer hydroxide sheet, rather than as a 2:1:1 or 2:2 layer type. This emphasizes the similarity of chlorite with other clay minerals containing interlayer material (Brindley & Pedro 1972).

### 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 Madrid in 1972, at which a 1969 definition was modified. The present definition (Brindley & Pedro 1972) states: “Clay minerals belong to the family of phyllosilicates and contain continuous two-dimensional tetrahedral sheets of composition \( T_2O_5 \) \((T = Si, Al, Be, \ldots )\) with tetrahedra linked by sharing three corners of each, and with the fourth corner pointing in any direction. The tetrahedral sheets are linked in the unit structure to octahedral sheets, or to groups of coordinated cations, or individual cations.” The present definition is based on the nature of the silicate parts of the structure, and does not include previous requirements of weaker interlayer bonding or of certain resultant physical properties. Thus, it does not require a category of “pseudolayer silicates” for minerals such as palygorskite and sepiolite that do not possess marked basal cleavages. The criterion of a continuous tetrahedral sheet does exclude “quasilayer silicates” such as astrophyllite, lamprophyllite, bafertisite and haradait, in which 5- or 6-fold coordinated groups interrupt the continuity of the tetrahedral net.

### STANDARDIZATION OF STRUCTURAL TERMS

At the 1975 Mexico City meeting the AIPEA Nomenclature Committee noted that lattice and structure continue to be misused by authors and speakers. A lattice is not synonymous with structure; it is a uniform distribution of points in space (e.g., the 14 Bravais lattices). The terms “layer lattice” and “Schichtgitter” are incorrect and should not be used. Layer structure, layer silicate and phyllosilicate are acceptable terms (Brindley 1967, Brindley & Pedro 1976).

In 1972 the Committee agreed upon usage of the terms plane, sheet, layer, unit structure and their equivalents in other languages (Brindley & Pedro 1972). Recommended usage of these is: 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. The total assembly of a layer plus interlayer
Table 2 lists the equivalent terms in other languages, as modified at the 1978 Oxford meeting.

The terms “talc layer” and “brucite sheet” are not suitable descriptions of the component parts of the chlorite structure because the minerals talc and brucite permit very little substitution of Mg by Al, and such substitution is an essential feature of trioctahedral chlorites. It is recommended that 2:1 layer be used in place of “talc layer” and hydroxide sheet or interlayer sheet in place of “brucite sheet” (Brindley & Pedro 1972). It is permissible to write brucite-like or brucitic or gibbsite-like or gibbsitic if one wishes to specify the trioctahedral or dioctahedral nature of the interlayer.

Attention is drawn also to the report of the I.M.A.-I.U.Cr. Joint Committee on Nomenclature (Bailey 1978); the following recommendations, approved by the AIPEA Nomenclature Committee, will be of special interest to clay scientists.

1. Polytypism is defined as “the phenomenon of the existence of an element or compound in two or more layer-like crystal structures that differ in layer stacking sequences. The layers need not be crystallographically identical, but should be similar. Polytypism differs from polymorphism (in the present and strict definition of the latter term) in permitting small differences in chemical composition between structures, not to exceed 0.25 atoms per formula unit of any constituent element. Layer structures that differ from one another by more than this amount are to be called polytypoids rather than polytypes.”

2. “In general, polytypes should not receive individual mineral names. Instead, a set of related polytypes should be designated by a single name followed by a structural symbol suffix that defines the layer stacking differences.” A recommended system of structural symbols is described in the report.

3. “Polytype mineral names already in existence that have international acceptance and serve a useful function need not be discarded. Decision on retention of individual names should be the responsibility of the I.M.A. Commission on New Minerals and Mineral Names.”

4. “It is recommended that X, Y, Z or [001], [010], [001] be used for directions of crystallographic axes and a, b, c for the repeat distance along these axes.”

### INTERSTRATIFICATIONS AND NONCRYSTALLINE MATERIALS

No general agreement has been reached yet regarding the preferred terminology for interstratified minerals, except that (1) the material should be characterized fully as to degree of regularity or irregularity of the interstratification and (2) it should be described in terms of the nature and ratios of the component layers. The best descriptive terms for those layers are still in question. At the 1972 Madrid meeting the Committee recommended that specific names not be given to poorly defined materials such as irregularly interstratified systems, to imperfect structures (e.g., deweylite and aquacreptite) or to noncrystalline constituents. Special names can be given to regularly interstratified minerals subject to acceptance by the AIPEA Nomenclature Committee and the I.M.A. Commission on New Minerals and Mineral Names (Brindley & Pedro 1972). Names already in the literature at that time were rectorite for a regular 1:1 interstratification of dioctahedral paragonite–smectite (Brown & Weir 1963), corrensite for a regular 1:1 interstratification of trioctahedral chlorite–“swelling chlorite” (Lippmann et al. 1973).
specific phyllosilicate names

dioctahedral chlorite

The Committee has recommended (Brindley & Pedro 1970) that the chlorite group be subdivided into the three subgroups dioctahedral chlorite, di,tri-octahedral chlorite and trioctahedral chlorite (Table 1). Dioctahedral chlorite is dioctahedral in both the 2:1 layer and the interlayer hydroxide sheet. An example is donbasite (Lazarenko 1940). Tri-octahedral chlorite is tri-octahedral in both octahedral sheets. A di,tri-octahedral chlorite is dioctahedral in the 2:1 layer but trioctahedral in the interlayer sheet. Cookeite and sudoite are examples, with cookeite being Li-rich and sudoite Li-poor. No examples are yet known of chlorites with trioctahedral 2:1 layers but dioctahedral interlayers.

trioctahedral chlorite

At the 1978 Oxford meeting the AIPEA Nomenclature Committee adopted the suggestion of Bayliss (1975) for simplification of chlorite nomenclature. Trioctahedral chlorites should be named according to the dominant divalent octahedral cation present. Recommended species-names are clinochlore [Mg dominant, end member (Mg$_2$Al)(Si$_4$Al)O$_{10}$(OH)$_x$], chamosite [Fe$^{3+}$ dominant end member (Fe$^{3+}$Al) (Si$_4$Al)O$_{10}$(OH)$_x$], nimite [Ni dominant, end member (Ni$_3$Al)(Si$_4$Al)O$_{10}$(OH)$_x$] and penannlite [Mn$^{2+}$ dominant, end member (Mn$^{2+}$Al)(Si$_4$Al) O$_{10}$(OH)$_x$]. All other species and varietal names should be discarded, because arbitrary subdivisions according to octahedral and tetrahedral compositions have been shown to have little or no structural significance. Tetrahedral compositions and trivalent octahedral cations are not considered in the recommended species-names, nor is the distribution of octahedral cations between the 2:1 layer and the interlayer. Adjectival modifiers, such as those of Schaller (1930), may be used to indicate either important octahedral cations other than the dominant cation or unusual tetrahedral compositions. Bayliss (1975) gives modifiers appropriate for many of the chlorite species listed in other nomenclature systems.

imogolite

At its 1969 Tokyo meeting (Brindley & Pedro 1970) the Committee approved the name imogolite for a hydrous aluminosilicate having a fine, thread-like morphology and the diffraction characteristics described by Wada & Yoshinaga (1969) and others.

halloysite

The 1975 AIPEA Nomenclature Committee reviewed the several terminologies in use for the less hydrous and the more hydrous forms of halloysite. The terms halloysite(7Å) and halloysite(10Å) were recommended for general usage as being least ambiguous (Brindley & Pedro 1976). The term endellite should not be used.

celadonite

The 1978 AIPEA Nomenclature Committee has defined celadonite as a dioctahedral mica of ideal composition KMgFe$^{3+}$SinO$_{10}$(OH)$_x$ but allowing a range in tetrahedral Al (or Fe$^{3+}$) of 0 to about 0.2 atoms per formula unit. Substantial octahedral variations from this formula can be described by adjectival modifiers, such as aluminian celadonite or ferroan celadonite. Further characteristics of celadonite are d(060) < 1.510 Å and sharp infrared spectra, as described by Buckley et al. (1978). There is an area of potential overlap between celadonite and glauconite in the range of Al$^{IV}$ = 0.17 to 0.20 atoms. For compositions near this boundary and...
for cases in which analytical errors or impurities are suspected, application of the other identification criteria are especially important.

**Glaucocnite**

Buckley *et al.* (1978) have shown that with careful purification and modern analytical techniques there is little or no overlap between celadonite and glauconite compositions and that the two minerals also can be differentiated by *d*(060) values and infrared spectra. The 1978 AIPEA Nomenclature Committee has defined glauconite as an Fe-rich dioctahedral mica with tetrahedral Al (or Fe*) usually greater than 0.2 atoms per formula unit and octahedral R* correspondingly greater than 1.2 atoms. A generalized formula is K*(R*B+r*)(R'*o.ur)* (Si'0.2Alo.8r')O'O(OH), with Fe* + Al and Mg > Fe* (unless altered). Further characteristics of glauconite are *d*(060) > 1.510 Å and, usually, broader infrared spectra than celadonite, as described by Buckley *et al.* (1978). The species glauconite is single-phase and ideally is not interstratified. Mixtures containing an iron-rich mica as a major component can be called glauconitic. Specimens with expandable layers can be described as randomly interstratified glauconite-smectite. Mode of origin is not a criterion, and a green fecal pellet in a marine sediment that meets the definition for celadonite should be called celadonite.

**Miscellaneous**

Attention is drawn here to recommendations made by other nomenclature committees, although not specifically considered by the AIPEA Nomenclature Committee.

The name berthierine has priority for the Fe-rich 1:1-type layer silicate having appreciable tetrahedral Al and commonly found in ironstones and iron formations. Brindleyite is the Ni-analogue of berthierine. The name chamosite has priority for a 2:1 chlorite of composition similar to berthierine (Orcel *et al.* 1949).

The name clintonite has priority over other species names (xanthophyllite, seybertite, brandisite, valuevite) for the Li-poor, Ba-poor trioctahedral brittle mica. All of these are so similar in crystallography, chemical composition and mode of origin that only a single species name is justified (Forman *et al.* 1967). Bityite (Li, Be-rich), anandite (Ba, Fe-rich) and kinoshitalite (Ba, Mg-rich) appear to be other valid trioctahedral brittle-mica species (Schaller *et al.* 1967, Pattiaratchi *et al.* 1967, Yoshii *et al.* 1973). Ephesite, described originally as a Li-Na brittle mica (Schaller *et al.* 1967), is more accurately described as a true mica with a layer charge per formula unit of unity.

The name palygorskite has priority over attapulgite for the mineral with a ribbon-like structure in which the ribbons have a width of two pyroxene-like chains (Bailey *et al.* 1971b).

The name anauxite has been discredited. It is a mixture of components, of which the kaolinite component is true kaolinite (Langston & Pask 1968, Allen *et al.* 1969, Bailey & Langston 1969).

Medmontite is a mixture of chrysocolla and mica; the name should be discarded (Chukhrov *et al.* 1968, 1969, Fleischer 1969a).

Nimite is the preferred term for the trioctahedral chlorite with Ni dominant (Hiemstra & de Waal 1968a). Specimens previously termed *schuchardtite* have Ni < Mg (Fleischer 1969b) and should be called nickeloa clinoclore. Brindley & De Souza (1975) also have shown that some "schuchardites" are transitional between chlorite and vermiculite.

Caryopilite is the preferred term for a 1:1 layer-type mineral that is the Mn⁺⁺ analogue of greenalite. The name bementite, sometimes used for the former mineral, has priority for a Mn-rich mineral that belongs to the friedelite group of minerals and is not a layer silicate (Kato 1963).

The name rectorite has priority over allevardite for a regular 1:1 interstratification of paragonite-smectite (Brown & Weir 1963).

Sungulite and kolskite are mixtures of lizardite and sepiolite; the names should be discarded (Ivanova *et al.* 1973).

Alushrite is a mixture of dickite and hydrous mica; the name should be discarded (Logvinenko & Frank-Kamenetskii 1955). Some specimens that have been called alushite have been identified later as tosudite (Frank-Kamenetskii *et al.* 1963).

Deweylite is a mixture in variable proportions of a disordered form of talc (kerolite) and a disordered form of serpentine. Both components have excess water, probably associated with unbalanced surface bonds. The name is useful only as a field term (Bish & Brindley 1978).

Kerolite is a varietal name for a mineral close to talc in composition and structure but with highly random layer-stacking and an enlarged basal spacing of about 9.6 Å due to misfitting layers; R⁺⁺ₙ(SiO₄)₉(OH)ₙ₊ₙH₂O with *n* ~ 0.8–1.2 (Brindley *et al.* 1977).
Pimelite is a Ni-analogue of kerolite with Ni > Mg (Maksimović 1966, Brindley et al. 1979).

Nepouite is a Ni-analogue of lizardite (Glasser 1907, Maksimović 1973, Brindley & Wan 1975).

New names for layer silicate minerals approved recently by the I.M.A. Commission on New Minerals and Mineral Names are listed below:

hendricksite, a trioctahedral Zn-rich mica (Frondel & Ito 1966, Frondel & Einaudi 1968)

willemseite, a Ni-analogue of talc (Hiemstra & de Waal 1968b)

pecoraite, a Ni-analogue of clinochrysotile (Faust et al. 1969)

Mn–sepiolite, Mn–palygorskite, Mn–ferrositepilite, Mn–ferropalygorskite (Semenov 1969)

chernykhite, a dioctahedral V, Ba, Na-rich mica (Ankinovich et al. 1972)

kellyite, a Mn⁺⁺-analogue of amesite (Peacor et al. 1974)

swinefordite, a Li,Al,Mg-rich smectite intermediate between dioctahedral and trioctahedral (Tien et al. 1975)

baumite, a Mn,Fe,Zn-rich serpentine (Frondel & Ito 1975)

masutomilite, a Mn⁺⁺⁺-analogue of zinnwaldite (Harada et al. 1976).

yofortierite, a Mn⁺⁺-analogue of palygorskite (Perrault et al. 1975)

falconoidite, a Ni-analogue of sepiolite with Ni > Mg (Springer 1976)

ferripyrophyllite, a Fe⁺⁺⁺-analogue of pyrophyllite (Chukhrov et al. 1979).

Several layer silicates incorporating interlayer metallic elements have been recognized recently. Chapmanite and bismutoferrsite have 1:1 layers with Si in the tetrahedral sheet and Fe³⁺ in the octahedral sheet. The surface hydroxyl groups of the octahedral sheet are replaced by oxygens, and Sb and Bi (in chapmanite and bismutoferrsite, respectively) are in the interlayer space (Zhukhlistov et al. 1974, Zhukhlistov & Zvyagin 1977). Surite is a smectite having a defect, cerussite-like lead carbonate interlayer (Haysase et al. 1978).

REFERENCES


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