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NOMENCLATURE OF THE TRIOCTAHEDRAL CHLORITES

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ABSTRACT

Trioctahedral mineral species within the chlorite group have the end-member compositions as follows: clinochlore $(Mg_5Al)(Si_3Al)O_{10}(OH)_8$, chamosite $(Fe_5^{++}Al)(Si_3Al)O_{10}(OH)_8$, nimite $(Ni_5Al)(Si_3Al)O_{10}(OH)_8$, and pennantite $(Mn,Al)_6(Si,Al)_4O_{10}(OH)_8$. The varietal names of brunsvigite, corundophilite, daphnite, delessite, diabantite, grovesite, kämmererite, kotchubeite, leuchtenbergite, orthochamosite, pennine, pseudothuringite, pycnochlorite, ripidolite, sheridanite, talc-chlorite and thuringite should be discarded. The varieties between these end-member compositions should be described by chemical element adjectives. At present the polytype symbols of Brown & Bailey (*Amer. Mineral.* 47, 819) should be used.

INTRODUCTION

Compilations and classifications of the trioctahedral chlorites have been made by Orcel *et al.* (1950), Serdyuchenko (1953), Hey (1954), Brindley & Gillery (1956), Lapham (1958), Foster (1962), Phillips (1964), Strunz (1970), and Fleischer (1971). Problems have arisen because different names have been given in the original descriptions for similar compositions, and then the same name has been used for different compositional ranges in various classifications. Each of these classifications is based upon different arbitrary divisions within a complex solid-solution series. Some authors avoid nomenclature problems by the use of the group name chlorite instead of a species name, which is also undesirable as there are a number of valid species. There seems to be no adequate reason, as suggested by Albee (1962), to continue the use of a large number of ill-defined varietal names, especially as only the end-member compositions are accepted as species by the Commission on New Minerals and Mineral Names, International Mineralogical Association.

The powder diffraction data of trioctahedral chlorites are similar, as shown by a comparison of data in *Selected Powder Diffraction Data for Minerals* (1974). Therefore, to ascertain the approximate chemical composition of a trioctahedral chlorite, one must use cell constants or reflection intensities rather than simple comparison. For example, the curves of Shirozu (1958) relate the (001) spacing to the $Mg^{VI}Si^{IV} \rightleftharpoons Al^{VI}Al^{IV}$ substitution, and the *b*-axis length to the $Mg \rightleftharpoons Fe^{++}$ substitution. Also, the intensity ratio of $(002 + 004)/(003)$ reflections has been related to $Mg \rightleftharpoons Fe^{++}$ substitution by Petruk (1964). The accuracy of these methods is discussed by Bailey (1972). In addition, Brown & Bailey (1962) recognized four different one-layer poly-types (II*b*, I*b* orthorhombic, I*b* monoclinic, and I*a*), which cut across all the arbitrary nomenclature divisions established for different compositions. Therefore the nomenclature needs re-evaluation and simplification.

DISCUSSION

Both Foster (1962) and Brown & Bailey (1962) have plotted a diagram from numerous natural samples to indicate the extent of substitution with respect to $Mg \rightleftharpoons Fe$ and $(Mg, Fe)^{VI}Si^{IV} \rightleftharpoons Al^{VI}Al^{IV}$ in the chlorite group. The number of samples recorded that are either manganese- or nickel-rich is limited. Therefore it appears unnecessary to give tabulated compilations or compositional diagrams in this paper.

Initially the chlorite series was described with serpentine $Mg_3Si_2O_5(OH)_4$, and amesite $(Mg_2Al)(SiAl)O_5(OH)_4$ as the end-members, but later both of these minerals were found to belong to the kaolinite-serpentine group (7Å or 1:1 layer) rather than the chlorite group (14Å or 2:1 layer plus an interlayer sheet). In order to fit together the tetrahedral and octahedral sheets in chlorite to produce a stable structure, some Al substitution is essential to produce tetrahedral and octahedral sheets of similar *a*- and *b*-axis dimensions. This limits the composition to approximately the center of this series. This composition of $(Mg_5Al)(Si_3Al)O_{10}(OH)_8$ is most commonly used to describe the mineral species clinochlore. The tetrahedral composition of (Si_3Al) has been used for the end-member, as it represents the mid-point of the series and is fairly simple, although the average tetrahedral composition of natural samples is near $(Si_{2.7}Al_{1.3})$. A common type of

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*On leave from Department of Geology, University of Calgary, Alberta T2N 1N4 substitution in clinochlore is $Mg^{VI}Si^{IV} \rightleftharpoons Al^{VI}Al^{IV}$. Varietal names that should be discarded include leuchtenbergite which is a clinochlore, pennine (often misspelled as penninite) which is a magnesian siliconian clinochlore, and sheridanite which is an aluminian clinochlore. The varietal name of talc-chlorite with a composition similar to serpentine should be discarded because it falls considerably outside the compositional range of the trioctahedral chlorite group.

Complete substitution of magnesium by ferrous iron in clinochlore produces the end-member composition $(Fe_5^{++}Al)(Si_3Al)O_{10}(OH)_8$. For this composition, chamosite appears to be the most logical name as it is the most often used name in the literature for approximately this composition. The substitution of $Fe^{++}Si$ by $Al^{VI}Al^{IV}$ is frequent; the reverse substitution is rare, although it frequently occurs in clinochlore. In some chamosites, ferric iron results from oxidation of ferrous iron with a loss of hydrogen, but Foster (1962) considers ferric iron as a normal constituent unless there is other evidence of secondary oxidation. The classification of Hey (1954) into orthochlorites (unoxidized ferrous) and leptochlorites (oxidized ferric) on the arbitrary division of 4% Fe_2O_3 is rejected by Foster (1962), because ferric iron commonly substitutes for aluminum in many chamosites. Varietal names that should be discarded include daphnite which is a chamosite, orthochamosite which is the polytype chamosite I*b*, pseudothuringite which is an aluminian chamosite, and thuringite which is a ferric aluminian chamosite.

Varietal names have been given to compositions in the magnesium-ferrous iron solid-solution series between clinochlore and chamosite. Varietal names that should be discarded include brunsvigite which is a magnesian chamosite, corundophilite (often misspelled as corundophyllite) which is an iron aluminian clinochlore, delessite which is an iron clinochlore, diabantite which is a magnesian siliconian chamosite, pycnochlorite which is an iron clinochlore, and ripidolite which is either an iron-aluminian clinochlore or a magnesium-aluminian chamosite.

Minor substitution of aluminum by chromium in clinochlore occurs in the varieties kämmererite and kotchubeite. These names should be discarded in favour of chromian clinochlore. A proposal to redefine these varieties on an arbitrary division of 2% Cr_2O_3 minimum was made by Lapham (1958), who suggested that the chromium occupies octahedral positions in kämmererite but tetrahedral positions in kotchubeite. This subdivision is extremely unlikely, because the crystal field stability energy of chromium is very large compared to aluminium (Burns 1970), which means that chromium strongly prefers octahedral sites. Therefore until conclusive evidence is presented for tetrahedral chromium, it should be taken to occur only in octahedral sites.

The end-member composition of $(Ni_5Al)(Si_3Al)O_{10}(OH)_8$ is produced by complete substitution of magnesium in clinochlore by nickel. A nickel-rich trioctahedral chlorite has been described by De Waal (1970) with the name of nimite.

Complete substitution of magnesium in clinochlore by manganese produces the end-member $(Mn,Al)_6(Si,Al)_4O_{10}(OH)_8$. The first occurrence of this manganese-rich trioctahedral chlorite was described by Smith *et al.* (1946), who called it pennantite. Initially grovesite was described by Bannister *et al.* (1955) as a member of the kaolinite-serpentine group, but later it was decided by Peacor *et al.* (1974) to be a one-layer polytype Mn trioctahedral chlorite, whereas pennantite is a two-layer polytype Mn trioctahedral chlorite. Because a polytype has only varietal status, the name of grovesite should be discarded and replaced by pennantite plus polytype stacking symbol.

Frondel (1955) has described the mineral gonyerite $(Mn_{3.25}Mg_{1.95}Fe_{.64}Zn_{.04}Pb_{.02}Cu_{.01})_{5.91}(Si_{3.75}Fe_{.17}Al_{.08})_4O_{10.20}(OH)_{7.80}$ as a trioctahedral chlorite. However the *x*-ray diffraction powder data of this mineral shows that it is not a chlorite. This has been confirmed with single crystals from the type material of Frondel by Bailey (personal communication).

CONCLUSIONS

There are descriptions at present for four distinct chemical species within the trioctahedral chlorite group. With the use of chemical element adjectives, the complete range of chemical varieties may be described, so that all special varietal names should be discarded. In addition, the polytype symbol should be stated if it can be determined. Until the symbol nomenclature is agreed upon by the joint committee of the International Mineralogical Association and the International Union of Crystallography, the symbols of Brown & Bailey (1962) may be used. The use of prefixes such as ortho in front of chamosite instead of suffixed symbols to indicate the polytype must be avoided. The general formula for the trioctahedral chlorite group is $[(Mg,Fe^{++},Mn,Ni)_{6\text{-}X\text{-}Y}(Al,Fe^{+++},Cr)_Y]\ [(Si_{4\text{-}Z})(Al)_Z]O_{10}(OH)_8$. Foster (1962) gives the range of Z as $1.6 > Z > 0.6$, and states that the number of octahedral cations which is normally 6.0 may drop to as low as 5.6 with X number of vacant octahedral sites.

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