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Revised nomenclature of högbomite, nigerite, and taaffeite minerals

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Abstract: Minerals of the högbomite, nigerite, and taaffeite groups form polysomatic series composed of spinel (*S*) and nolanite (*N*) modules. The idealised formula of a spinel module is $T_2M_4O_8$ where T and M represent tetrahedrally and octahedrally coordinated cations. The nolanite module in nigerite and högbomite minerals has the formula $TM_4O_7(OH)$ whereas the nolanite module in the Be-bearing taaffeite minerals is modified (*N*') and has the formula $BeTM_4O_8$. The modules are normalised to two closest-packed oxygen layers situated parallel to (001) in hexagonal setting. The composition of these minerals thus depends: (1) on the composition of the nolanite module, (2) on the composition of spinel module, (3) on the number of spinel and nolanite modules forming the structure. Högbomite- and nigerite-group minerals are distinguished by the dominant tetravalent cation in the nolanite module. If the molar concentration of Ti > Sn, the group name is högbomite. If the molar concentration of Sn > Ti, the group name is nigerite. Taaffeite-group minerals have a nolanite module without OH groups but with additional tetrahedral Be.

In the new nomenclature, approved by the *IMA CNMMN*, the subgroup name is chosen according to the composition of the aluminium-spinel module. If the spinel module is dominated by the gahnite component, $ZnAl_2O_4$, the prefix 'zinco' is used. If the spinel module is dominated by the hercynite component, $FeAl_2O_4$, the prefix 'ferro' is used. If the spinel module is dominated by the spinel component, $MgAl_2O_4$, the prefix 'magnesio' is used.

To characterise the various polysomes found for each subgroup a hyphenated suffix composed of the total number of nolanite (*N*) and spinel (*S*) modules is attached. The module symbols (*N*, *S*) are italicised and given in the sequence first *N* and then *S*. According to this new nomenclature pengzhizhongite-6*T* and pengzhizhongite-24*R* are replaced by magnesionigerite-2*N*1*S* and magnesionigerite-6*N*6*S*, respectively. Furthermore, magnesiotaaffeite-6*N*'3*S* and ferrotaaffeite-6*N*'3*S* replace musgravite and pehrmanite, respectively.

Key-words: högbomite, nigerite, taaffeite, polysomatism, crystal structure, chemistry, nomenclature.

Högbomite- and nigerite-group minerals

Historical background

Högbomite was originally described by Gavelin (1916) as a rhombohedral rock-forming mineral from the Routevaara area, Lapland, Sweden. A simple chemical formula was not given but the chemical analyses (after correction for intergrown ilmenite and pleonast) yielded the composition (wt.%): TiO_2 = 5.53, Al_2O_3 = 61.19, Fe_2O_3 = 17.41, Cr_2O_3 = 0.29, MnO = 0.14, MgO = 15.44. A sum of 100.00 % was assumed and all iron was analysed as Fe_2O_3. The name högbomite was chosen in honour of Professor Arvid Gustaf Högbom (University of Uppsala, Sweden).

Nigerite was originally described by Jacobson & Webb (1947) as a new tin mineral from the tin-bearing pegmatites of Kabba, central Nigeria. The name is after the type locality. Chemical analyses yielded (wt.%): SnO_2 = 25.33, Al_2O_3 = 50.91, Fe_2O_3 = 11.90, ZnO = 4.51, sum = 92.65. Independent of the true oxidation state all iron was analysed as Fe_2O_3. Additional data on the same nigerite sample were provided by Bannister *et al.* (1947) reporting the mineral as trigonal with a = 5.72 and c = 13.86 Å.

McKie (1963) restudied nine specimens of högbomite from seven of the fifteen recorded occurrences at that time. He used Weissenberg and rotation photographs to identify cell dimensions and lattice type (*H* and/or *R*). Among his studied samples were also specimens originally studied by Gavelin (1916). McKie (1963) found that the dimensions of the hexagonal unit cell for all specimens are a = 5.72 Å and c a multiple of 4.6. He introduced a series of **polytypes**, to each of which a symbol of the form *nH* or *nR* was attached in form of a hyphenated suffix (n is given by $c = n \times 4.6$ Å). The sample of Gavelin (1916) became högbomite-4*H*. In addition, McKie (1963) found in other samples the **polytypes** 5*H*, 6*H*, 15*H*, 15*R*, and 18*R*. At this time the crystal structure of högbomite was not known and the suggestion of **polytypism** was based on the varying c dimensions ($n \times 4.6$ Å) and the 'similar' chemical compositions. Furthermore, McKie (1963) has pointed out the relation between nigerite, taaffeite, and the högbomite polytypes, all of which have similar values of a, and c which are multiples of 4.6 Å.

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There is considerable confusion about the correct usage of polytype suffixes indicating the crystal system. The *IMA CNMMN* (Nickel, 1993) recommended polytype symbols are: *C* (cubic), *H* (hexagonal), *R* (rhombohedral), *T* (trigonal), *Q* (tetragonal), *O* (orthorhombic), *M* (monoclinic), and *A* (triclinic). Structures having 6, 6_1, 6_2, 6_3, 6_4, 6_5, or $\overline{6}$ as principal axis are hexagonal (*H*). The trigonal structures with 3, 3_1, 3_2 or $\overline{3}$ as principal axis are subdivided into those with a primitive lattice (*T*) and into those with a rhombohedral Bravais lattice (*R*). For hexagonal axes the *R* lattice is centred at 2/3, 1/3, 1/3 and 1/3, 2/3, 2/3. In this paper, hexagonal axes are used for *H*, *T*, and *R* lattices. McKie (1963) and several other authors did not distinguish between *T* and *H* crystal systems but used the *-H* suffix for both of them. The *R* lattice can simply be identified on the basis of systematic extinctions in the diffraction pattern and was therefore recognised and distinguished by most authors.

Peacor (1967) identified nigerite and högbomite as structures with a closest-packed oxygen array and for this reason introduced a nomenclature (in analogy to other polytypic systems) where *n* referred to the thickness of one oxygen layer (2.3 Å; half of the value used by McKie (1963)). From then on the confusion started because according to Peacor (1967) the original högbomite-4*H* became högbomite-8*H*. In the same study Peacor (1967) described nigerite-24*R* from the Kabba pegmatite (Nigeria) in addition to the 6*T* polytype from the same locality (Bannister *et al*., 1947).

The structural principles of högbomite and nigerite were unravelled by Grey & Gatehouse (1979) who described the structure of nigerite-24*R* (Peacor nomenclature) as composed of different modules, the nolanite module and the spinel module, where the nolanite module is associated with one oxygen sheet with a stacking environment corresponding to hexagonal closest-packing. The term **polysomatism** was not used by Grey & Gatehouse (1979) but their description conforms with the modular structure of **polysomes**. The modular concept was confirmed (Gatehouse & Grey, 1982) for the structure of högbomite-8*H* (Peacor nomenclature) and all other subsequent structural studies on members with different **c** translations.

Short description of polysomatism

Minerals of the högbomite and nigerite group form polysomatic series composed of spinel (*S*) and nolanite (*N*) modules. The idealised formula of a spinel module is $T_2M_4O_8$ where T and M represent tetrahedrally and octahedrally coordinated cations. The nolanite module has the formula $TM_4O_7(OH)$. Note that the spinel module has twice the T sites of the nolanite module. Both modules are normalised to two oxygen layers. The closest-packed oxygen sheets in högbomite and nigerite minerals are parallel to (001) in hexagonal setting. The composition of högbomite- and nigerite-group minerals thus depends: (1) on the composition of the nolanite module, (2) on the composition of spinel module, and (3) on the number of spinel and nolanite modules forming the structure.

It seems that the presence of tetravalent cations (mainly Sn and Ti) in octahedral coordination is responsible for the formation of nolanite modules. Members of the högbomite group have octahedral Ti^{4+} and members of the nigerite group have octahedral Sn^{4+} in the nolanite module. Published analyses of various nigerite and högbomite specimens indicate *ca*. 0.5-1 Ti^{4+} per nolanite module in högbomite minerals and *ca*. 1 Sn^{4+} in nigerite minerals. A review of the literature on this subject is given by Petersen *et al*. (1989), Armbruster (1998), and Hejny & Armbruster (2002). Up to now, all known högbomite- and nigerite-group minerals are composed of spinel modules belonging to the aluminium-spinel subgroup.

More recent findings on polysomatism

Armbruster (1998) discussed the common nomenclature for högbomite and stated that the members of the högbomite and nigerite groups are not necessarily polytypes, depending on the ratio of nolanite (*N*) and spinel (*S*) modules. Similar arguments may be derived from the work of Neiva & Champness (1997) who found for nigerite from the Cabanas pegmatite (Portugal) that the rim of nigerite crystals is Sn-rich nigerite-6*H* (correct name: nigerite-6*T*) whereas the core is depleted in Sn and consists of nigerite-24*R*. Two types of nigerite, one Sn-rich (with low Zn) and the other Sn-depleted (with high Zn) were also reported by Tindle & Breaks (1998) from a granitic pegmatite in northwestern Ontario. The latter authors tentatively assigned the two chemically distinct nigerite varieties to nigerite-6*H* (correct name: nigerite-6*T*) and nigerite-24*R*.

The structural principles discussed by Armbruster (1998) imply that nigerite-24*R* has a *N*/*S* ratio of 1/1 whereas nigerite-6*T* has a *N*/*S* ratio of 2/1. As stated above, all structural analyses have shown that Sn is confined to the nolanite module which agrees with the different Sn concentration found in both 'varieties'.

Modular structures as found for högbomite and nigerite minerals should be treated as **polysomes**. Notice that here a **polysomatic series** (Thompson, 1978) is equivalent to Mackovicky's (1997) **homologous accretional series**. Because each of these polysomes has a different chemistry or/and different topology they should formally have species status provided they occur as well defined minerals and not as small domains (few unit cells wide) only detectable by transmission electron microscopy.

There are hexagonal (*H*) and/or (primitive) trigonal (*T*) nigerite and högbomite minerals with the same *N*/*S* ratio as the corresponding members of this group with an rhombohedral (*R*) Bravais lattice (identical *N*/*S* ratios have: 6*T* = 18*R*, 8*H* = 24*R*, 10*T* = 30*R*, 12*H* = 36*R*). Structural study of högbomite and nigerite minerals with 6, 10, and 14 oxygen sheets yielded trigonal (Hejny & Armbruster, 2002) but not hexagonal symmetry (thus the suffix *H* must be changed to *T*). Members with the same *N*/*S* ratio within each group (högbomite or nigerite) but different stacking sequence of the *N* and *S* modules may be considered **polytypes** according to Guinier *et al.* (1984). There are only scarce chemical data available to decide whether 'stacking variants' with the same *N*/*S* ratio have also 'identical' chemical composition (as required for polytypes). It could well be that clustering

Table 1. Oxygen stacking sequence and modular composition of högbomite- and nigerite-group polysomes and related structures. Notice: altered names suggested in this proposal are given in bold in the right column. All other högbomite and nigerite names given in this table require an independent new mineral proposal. The additional data are only presented to give a perspective of the nomenclature system.

nomenclature (Peacor, 1967)	space group / periodicity along c_h (Å)	sequence of cubic '*c*' and hexagonal '*h*' closed- packed oxygen layers	sequence of spinel (*S*)* and nolanite (*N*)* modules	sum of spinel (*S*) and nolanite (*N*) modules	theoretical composition	new names (in bold) for högbomite and nigerite group minerals
6*C*	*Fd*3*m* / 13.8	*cccccc*	*SSS*	3*S*	$3 \times T_2M_4O_8$	spinel
4*H*	$P6_3mc$ / 9.2	*chch*	*NN*	2*N*	$2 \times TM_4O_7(OH)$	nolanite[1]
6*T*	$P\bar{3}m1$ / 13.8	2 × (*c* + *ch*)	*NNS*	2*N*1*S*	$2 \times T_2M_6O_{11}(OH)$	**ferronigerite-2*N*1*S*** [2] zinconigerite-2*N*1*S* [3] **magnesionigerite-2*N*1*S*** [4]
8*H*	$P6_3mc$ / 18.4	2 × (*cc* + *ch*)	*NSNS*	2*N*2*S*	$2 \times T_3M_8O_{15}(OH)$	**magnesiohögbomite-2*N*2*S*** [5] ferrohögbomite-2*N*2*S* [6] **zincohögbomite-2*N*2*S*** [7]
10*T*	$P\bar{3}m1$ / 23.0	2 × (*ccc* + *ch*)	*NSSNS*	2*N*3*S*	$2 \times T_4M_{10}O_{19}(OH)$	**magnesiohögbomite-2*N*3*S*** [8]
12*H*	$P6_3mc$ / 27.6	2 × (*cccc* + *ch*)	*NSSNSS*	2*N*4*S*	$2 \times T_5M_{12}O_{23}(OH)$	structure modeled [8] observed for högbomite group but no chemical analysis given
14*T*	$P\bar{3}m1$ / 32.2	2 × (*ccccc* + *ch*)	*NSSSNSS*	2*N*5*S*	$2 \times T_6M_{14}O_{27}(OH)$	structure modeled [9]
16*H*	$P6_3mc$ / 36.8	2 × (*cccccc* + *ch*)	*NSSSNSSS*	2*N*6*S*	$2 \times T_7M_{16}O_{31}(OH)$	**zincohögbomite-2*N*6*S*** [10]
18*R*	$R\bar{3}m$ / 41.4	3 × (*cc* + *chhc*)	3 × (*NNS*)	6*N*3*S*	$6 \times T_2M_6O_{11}(OH)$	known for taaffeite group[11] given for consistency
24*R*	$R\bar{3}m$ / 55.2	3 × (*cccc* + *hcch*)	3 × (*NNSS*)	6*N*6*S*	$6 \times T_3M_8O_{15}(OH)$	**ferronigerite-6*N*6*S*** [12] zinconigerite-6*N*6*S* [3] **magnesionigerite-6*N*6*S*** [4] **magnesiohögbomite-6*N*6*S*** [13]
30*R*	$R\bar{3}m$ / 69.0	3 × (*cccccc* + *hcch*)	3 × (*NNSSS*)	6*N*9*S*	$6 \times T_4M_{10}O_{19}(OH)$	structure predicted [8] observed for högbomite group but no chemical analysis given
36*R*	$R\bar{3}m$ / 82.8	3 × (*cccccccc* + *hcch*)	3 × (*NNSSSS*)	6*N*12*S*	$6 \times T_5M_{12}O_{23}(OH)$	ferrohögbomite-6*N*12*S* [14] structure predicted

* $N = TM_4O_7(OH)$, $S = T_2M_4O_8$

[1]Gatehouse *et al*., 1983; [2]Jacobson & Webb (1947), Bannister *et al*. (1947), Arakcheeva *et al*. (1995); [3]Neiva & Champness (1997); [4]Chen *et al*. (1989); [5]Gavelin (1916), McKie (1963); [6]Gatehouse & Grey (1982); [7]Ockenga *et al*. (1998), Armbruster (1998); [8]McKie (1963), Hejny & Armbruster (2002); [9]Hejny & Armbruster (2002); [10]Armbruster *et al*. (1998); [11]Nuber & Schmetzer (1983); [12]Burke *et al*. (1977), Grey & Gatehouse (1979); [13]Schmetzer & Berger (1990), Hejny & Armbruster (2002), [14]Nel (1949), McKie (1963).

of nolanite modules as found by crystal-structure analysis of rhombohedral stacking variants (Table 1) is actually favoured for specific chemical compositions. At least for högbomite-24*R* and högbomite-8*H* strong differences in the Ti concentration have been observed (*e.g*., Gatehouse & Grey, 1982; Schmetzer & Berger, 1990; Hejny & Armbruster, 2002). This seems to be sufficient ground to assign **species status** to all members (also to those with the same *N*/*S* ratio). An additional argument is that **polysomes** with the same *N*/*S* ratio are distinct by their different structural topology.

Existing nomenclature

Högbomite group

The following högbomite 'polytypes' have been reported according to the Peacor (1967) nomenclature: -8*H*, -10*T*, -12*H*, -30*H*, 24*R*, -30*R*, -36*R* (Table 1). Notice that Fe^{2+}- and Mg^{2+}-dominant högbomite 'species' were hitherto not distinguished by different (*CNMMN*-accepted) names, although various papers show that both 'species' exist.

For zincohögbomite -8*H* and -16*H* 'polytypes' were described according to the Peacor (1967) nomenclature.

Nigerite group

According to the Peacor (1967) nomenclature -6*T*, and -24*R* 'polytypes' have been reported**.** Notice that Fe^{2+}- and Zn^{2+}-dominant nigerite 'species' were hitherto not distinguished by different (*CNMMN*-accepted) names although various papers show that both 'species' exist.

The name pengzhizhongite describes the Mg-dominant form of nigerite (reported 'polytypes' according to the Peacor (1967) nomenclature: -6*T*, -24*R*).

General ideas of a new nomenclature

Accepting that each ordered stacking 'variety' of högbomite and nigerite has **species status**, an unwanted large number of independent new mineral names could arise which would rather confuse than clarify the subject. For this reason a unified nomenclature is favoured. Continuing the existing **polytype** nomenclature is also not desirable because most ordered '**polytypes**' of nigerite and högbomite reveal (1) different stoichiometry, (2) different ratios of octahedrally and tetrahedrally coordinated cations, and (3) different degrees of hydroxylation (OH groups are associated with the nolanite module) and therefore do not conform with the definition of **polytypism** (Guinier *et al.*, 1984). Furthermore, the presently used ambiguous polytype nomenclature (McKie, 1963; Peacor, 1967) gave rise to confusion about the 'true' stacking periodicity.

New nomenclature accepted by IMA CNMMN

The group name (högbomite or nigerite) is determined by the dominant tetravalent cation in the nolanite module. If the molar concentration of Ti > Sn, the group name is högbomite. If the molar concentration of Sn > Ti, the group name is nigerite.

Högbomite group

The subgroup name is chosen according to the composition of the aluminium-spinel module. If the spinel module is dominated by the gahnite component, $ZnAl_2O_4$, the prefix 'zinco' is used. If the spinel module is dominated by the hercynite component, $FeAl_2O_4$, the prefix 'ferro' is used. If the spinel module is dominated by the spinel component, $MgAl_2O_4$, the prefix 'magnesio' is used. A corresponding choice of prefixes is required if högbomite minerals with other spinel modules are discovered.

If only chemical analyses are available, the dominant divalent cation determines the subgroup. A special problem occurs for iron without specified valence. In general, the valence of iron can not be estimated from the bulk Fe composition if the polysome is unknown. If the polysome is known (see Appendix), the minimum amount of Fe^{2+} can be calculated by assuming that all T sites of a spinel $T_2M_4O_8$ module are occupied by $Zn + Mg + Mn^{2+} + Co^{2+} + Ni^{2+} + Fe^{2+}$. At first all well-defined divalent cations are assigned to the spinel T sites and then the T occupancy is completed with Fe^{2+}.

To characterise the **various polysomes** found for each subgroup (zincohögbomite, ferrohögbomite, magnesiohögbomite) a hyphenated suffix composed of the total number of nolanite (*N*) and spinel (*S*) modules is attached. The module symbols (*N*, *S*) are italicised and given in the sequence first *N* and then *S*. Table 1 shows how the Peacor (1967) polytype nomenclature is transformed to the new polysome nomenclature. Notice that each polysome has species status and thus requires approval by *CNMMN*.

Magnesiohögbomite subgroup: The original högbomite described by Gavelin (1916) and restudied by McKie (1963) is a magnesiohögbomite-2*N*2*S*, other magnesiohögbomites are: magnesiohögbomite-2*N*3*S* (McKie, 1963; Hejny & Armbruster, 2002), magnesiohögbomite-6*N*6*S* (Schmetzer & Berger, 1990; Hejny & Armbruster, 2002).

Ferrohögbomite subgroup: Potential members of the ferrohögbomite subgroup, -2*N*2*S* (Gatehouse & Grey, 1982) and -6*N*12*S* (Nel, 1949; McKie, 1963), are not subject of the new nomenclature but need acceptance as new minerals and require an independent proposal. These examples are only given to provide a more complete view of the subject. Members of this subgroup were hitherto named högbomite. Thus Mg- and Fe^{2+}-dominant members were not distinguished.

Zincohögbomite subgroup: Zincohögbomite-2*N*6*S* (Armbruster *et al*., 1998) and zincohögbomite-2*N*2*S* (Ockenga *et al*., 1998, Armbruster, 1998) have recently been described.

Nigerite group

The subgroup name is chosen according to the composition of the aluminium-spinel module. If the spinel module is dominated by the hercynite component, $FeAl_2O_4$, the prefix 'ferro' is used. If the spinel module is dominated by the gahnite component, $ZnAl_2O_4$, the prefix 'zinco' is used. A corresponding choice of prefixes is required if nigerite minerals with other spinel modules are discovered. If the spinel module is dominated by the spinel component, $MgAl_2O_4$, the new name is magnesionigerite replacing pengzhizhongite.

To characterise the **various polysomes** found for each subgroup (zinconigerite, ferronigerite, magnesionigerite) a hyphenated suffix composed of the total number of nolanite (*N*) and spinel (*S*) modules is attached. The module symbols (*N*, *S*) are italicised and given in the sequence first *N* and then *S*. Table 1 shows how the Peacor (1967) polytype nomenclature is transformed to the new polysome nomenclature. Notice that each polysome has species status and thus requires approval by *CNMMN*.

Ferronigerite subgroup: The original nigerite described by Jacobson & Webb (1947) and Bannister *et al.* (1947) is ferronigerite-2*N*1*S*, the other polysome is ferronigerite-*6N*6*S* (Burke *et al*., 1977; Grey & Gatehouse, 1979)**.**

Magnesionigerite subgroup: This subgroup comprises magnesionigerite-2*N*1*S* and magnesionigerite-6*N*6*S* (Chen *et al*., 1989).

Zinconigerite subgroup: Potential members of the zinconigerite subgroup -2*N*1*S* and -6*N*6*S* (Burke *et al.*, 1977; Čech *et al*., 1978; Neiva & Champness, 1997) are not subject of the new nomenclature but need acceptance as new minerals and require an independent proposal. These examples are only given to provide a more complete view of the subject. Members of this subgroup were hitherto named nigerite. Thus Zn- and Fe^{2+}-dominant members were not distinguished.

Additional advantages of the new nomenclature

Considering that nolanite (*N*) and spinel (*S*) modules have the simplified compositions $TM_4O_7(OH)$ and $T_2M_4O_8$, respectively, the simplified formula of each polysome can be determined by adding the modular formulas (examples are given in Table 1). Each module is normalised to two oxygen layers or in other words each module along the *c* axis (hexagonal setting) is 4.6 Å thick. Thus the total number of modules given in the suffix multiplied by 4.6 Å yields the length of the *c* axis (in hexagonal setting). Structural systematics of högbomite- and nigerite-group polysomes (Hejny & Armbruster, 2002) have indicated that polysomes with even numbers of modules are hexagonal, those with odd numbers of modules are trigonal. An exception are polysomes where both the number of *N* and of *S* modules can be divided by three, those polysomes are rhombohedral (Table 1).

Taaffeite-group minerals

As already noted by McKie (1963) taaffeite, $Mg_3BeAl_8O_{16}$, (Anderson *et al*., 1951) is a Be mineral structurally related to högbomite and nigerite. The name taaffeite is for Count Edward Charles Richard Taaffe (1898-1967), a gemologist from Dublin, Ireland, who noted the first specimen. According to McKie's (1963) nomenclature musgravite, $Mg_2BeAl_6O_{12}$, was originally described as a 9*R* polytype of taaffeite (Hudson *et al*., 1967) and only years later *IMA CNMMN* approved the name musgravite (Schmetzer, 1983). Pehrmanite, also a 9*R* polytype (McKie's (1963) nomenclature), is the Fe^{2+} analogue of musgravite (Burke & Lustenhouwer, 1981). Taprobanite (Moor *et al*., 1981) was found to be identical with taaffeite (Schmetzer, 1983).

Structural study of taaffeite-4*H* and musgravite-9*R* (Peng & Wang, 1963; Moor *et al*., 1981; Nuber & Schmetzer, 1983) showed that these minerals are also composed of spinel and nolanite modules with the difference that the nolanite module is modified. Be occupies a tetrahedral position close to the site occupied by hydrogen in the nolanite module of nigerite- and högbomite-group minerals, making taaffeite- group minerals anhydrous. If this modified nolanite module is labelled *N*' the suggested nomenclature for högbomite- and nigerite-group minerals can also be extended to the taaffeite-related Be minerals.

New nomenclature accepted by IMA CNMMN

The taaffeite group is newly defined for minerals composed of spinel and modified nolanite modules where Be occupies a tetrahedral site close to the hydrogen position in the nolanite module. The modified nolanite module has the composition $BeTM_4O_8$.

The subgroup name is chosen according to the composition of the aluminium-spinel module. If the spinel module is dominated by the spinel component, $MgAl_2O_4$, the prefix 'magnesio' is used. If the spinel module is dominated by the hercynite component, $FeAl_2O_4$, the prefix 'ferro' is used.

Table 2a. New names for högbomite-group minerals defined in this paper.

old name	**reference**	**new name** space group, cell dimensions
högbomite-8*H*	Gavelin (1916), McKie (1963)	magnesiohögbomite-2*N*2*S* $P6_3mc$, a =5.73, c = 18.39 Å
högbomite-10*T*	McKie (1963), Hejny & Armbruster (2002)	magnesiohögbomite-2*N*3*S* $P\bar{3}m1$, a =5.72, c = 23.0 Å
högbomite-24*R*	Schmetzer & Berger (1990), Hejny & Armbruster (2002)	magnesiohögbomite-6*N*6*S* $R\bar{3}m$, a =5.70, c = 55.8 Å
zincohögbomite-8*H*	Ockenga *et al*. (1998), Armbruster (1998)	zincohögbomite-2*N*2*S* $P6_3mc$, a =5.71, c = 18.33 Å
zincohögbomite-16*H*	Armbruster *et al.* (1998)	zincohögbomite-2*N*6*S* $P6_3mc$, a =5.73, c = 37.10 Å

Table 2b. New names for nigerite-group minerals defined in this paper.

old name	**reference**	**new name** space group, cell dimensions
nigerite-6*T*	Jacobson & Webb (1947), Bannister *et al.* (1947), Arakcheeva *et al*. (1995)	ferronigerite-2*N*1*S* $P\bar{3}m1$, a =5.72, c = 13.69 Å
nigerite-24*R*	Burke *et al.* (1977), Grey & Gatehouse (1979)	ferronigerite-6*N*6*S* $R\bar{3}m$, a =5.73, c = 55.60 Å
pengzhizhongite-6*T*	Chen *et al.* (1989)	magnesionigerite-2*N*1*S* $P\bar{3}m1$, a =5.69, c = 13.78 Å
pengzhizhongite-24*R*	Chen *et al*. (1989)	magnesionigerite-6*N*6*S* $R\bar{3}m$, a =5.69, c = 55.12 Å

Notice that nigerite-6*T* and pengzhizhongite-6*T* were originally named nigerite-6*H* and pengzhizhongite-6*H*, however, the space-group symmetry is trigonal, thus in the existing Peacor (1967) nomenclature the correct suffix must be –6*T* (Nickel, 1993).

Table 2c. New names for taaffeite-group minerals defined in this paper.

old name	**reference**	**new name** space group, cell dimensions
taaffeite	Anderson *et al.* (1951), Nuber & Schmetzer (1983)	magnesiotaaffeite-2*N*'2*S* $P6_3mc$, a = 5.69, c = 18.34 Å
musgravite	Hudson *et al.* (1967), Nuber & Schmetzer (1983)	magnesiotaaffeite-6*N*'3*S* $R\bar{3}m$, a = 5.68, c = 41.10 Å
pehrmanite	Burke & Lustenhouwer (1981)	ferrotaaffeite-6*N*'3*S* $R\bar{3}m$, a = 5.70, c = 41.16 Å

A corresponding choice of prefixes is required if taaffeite minerals with other spinel modules are discovered.

To characterise the **various polysomes** found for each subgroup (magnesiotaaffeite and ferrotaaffeite) a hyphenated suffix composed of the total number of modified nolanite (*N*') and spinel (*S*) modules is attached. The module symbols (*N*', *S*) are italicised and given in the sequence first *N*' and then *S*.

Magnesiotaaffeite subgroup

Taaffeite-8*H* (nomenclature according to Peacor (1967)) becomes magnesiotaaffeite-2*N*'2*S*, as it is composed of two spinel $Mg_2Al_4O_8$ modules and two modified nolanite modules of $BeMgAl_4O_8$ composition. Correspondingly, musgravite-18*R* (nomenclature according to Peacor (1967)) becomes magnesiotaaffeite-6*N*'3*S*.

Ferrotaaffeite subgroup

Pehrmanite-18*R* (nomenclature according to Peacor (1967)) with spinel modules of $Fe_2Al_4O_8$ composition becomes ferrotaaffeite-6*N*'3*S*.

Summary and consequences

The names in the left column of Tables 2a-c are in use in literature (according to the Peacor (1967) nomenclature) and the names given in the right column are the new names accepted by *IMA CNMMN*. The relation between crystallisation of a specific polysomatic member of the högbomite, nigerite, and taaffeite group on one hand and the formation conditions on the other hand, are up to now not understood. This lack of knowledge should encourage petrologists not only to estimate formation conditions and to analyse chemical compositions but, most important, to determine the polysome by diffraction methods. Either structure determinations or structure models leading to atomic coordinates are referenced in Table 1. Cell dimensions and atomic coordinates allow the calculation of powder diffraction data for almost all polysomes using a computer program like LAZY-PULVERIX (Yvon *et al*., 1977).

Appendix

Example for naming nigerite-group polysomes

Burke *et al.* (1977) described Fe-rich nigerite from the Rosendal pegmatite and aplites, Kemiö island, southwestern Finland (Table 3). At the time of their study the polysome was not known but according to the reported X-ray powder reflections the polysome is 'nigerite-6*N*6*S*', leading to a bulk composition of $6 \times T_2M_4O_8 + 6 \times TM_4O_7(OH)$. In the next step, the formula is normalised on 66 cations (18T + 48M). Based on the resulting formula (Table 3) 12 tetrahedral sites (in the spinel modules) are occupied by divalent cations. Thus samples 1 and 2 in Table 3 have $(Mn_{0.09}Mg_{0.53}Zn_{3.28}Fe^{2+}_{8.10})_{\Sigma=12}$ and $(Mn_{0.09}Mg_{0.53}Zn_{2.60}Fe^{2+}_{8.78})_{\Sigma=12}$, respectively, that leads to ferronigerite-6*N*6*S*, whereas sample 3 has $(Mn_{0.21}Mg_{0.63}Zn_{6.25}Fe^{2+}_{4.91})_{\Sigma=12}$ and would be named 'zinconigerite-6*N*6*S*'. The same procedure can be applied to the Bohemian nigerite, sample 4 in Table 3 (Čech *et al*., 1978), yielding $(Mn_{0.50}Zn_{6.29}Fe^{2+}_{5.21})_{\Sigma=12}$ which classifies the sample as 'zinconigerite-6*N*6*S*'. Furthermore, samples 5 and 6 in Table 3 become ferronigerite-6*N*6*S* and 'zinconigerite-6*N*6*S*', respectively. Notice that the suggested new name 'zinconigerite-6*N*6*S*' requires separate approval by *CNMMN*.

Table 3. Electron microprobe analyses of 'nigerite-6*N*6*S*' from Rosendal (1-3) (Burke *et al*., 1977), from Bohemia (4) (Čech *et al.*, 1978), (5) from northern Queensland (Grey & Gatehouse, 1979), (6) from northern Portugal (Neiva & Champness, 1997); all Fe assumed as Fe^{2+}.

	(1)	(2)	(3)	(4)	(5)	(6)
MnO	0.15	0.15	0.35	0.80	0.34	0.09
MgO	0.50	0.50	0.60	-	-	-
ZnO	6.30	5.00	12.00	11.55	7.75	20.79
FeO	16.28	18.10	10.09	9.81	13.51	2.40
Al_2O_3	55.80	55.85	56.15	53.82	52.47	54.00
TiO_2	0.15	0.35	0.15	1.07	-	0.25
SiO_2	0.10	0.05	0.30	0.51	0.56	0.48
Nb_2O_5	0.30	0.45	0.15	0.37 (Ta_2O_5)	-	-
SnO_2	21.00	18.85	21.30	18.16	22.37	20.77
Sum	100.58	99.3	101.9	96.09	97.00	98.78
normalised on 66 cations						
Mn	0.09	0.09	0.21	0.50	0.21	0.06
Mg	0.53	0.53	0.63	-	-	-
Zn	3.28	2.60	6.25	6.29	4.26	11.25
Fe	9.60	10.68	5.95	6.05	8.41	1.47
Al	46.36	46.44	46.54	46.78	46.05	46.72
Ti	0.08	0.19	0.08	0.59	-	0.13
Si	0.07	0.04	0.21	0.38	0.42	0.36
Nb	0.10	0.14	0.05	0.07 (Ta)	-	-
Sn	5.90	5.30	5.99	5.34	6.64	6.08

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