Eur. J. Mineral.
2009, **21**, 1073–1080
Published online October 2009

The standardisation of mineral group hierarchies: application to recent nomenclature proposals

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Abstract: A simplified definition of a mineral group is given on the basis of structural and compositional aspects. Then a hierarchical scheme for group nomenclature and mineral classification is introduced and applied to recent nomenclature proposals. A new procedure has been put in place in order to facilitate the future proposal and naming of new mineral groups within the IMA–CNMNC framework.

Key-words: mineral group, supergroup, nomenclature, mineral classification, IMA–CNMNC.

Introduction

There are many ways which are in current use to help with the classification of minerals, such as: *Dana's New Mineralogy* (Gaines *et al.*, 1997), the *Strunz classification* (Strunz & Nickel, 2001), *A Systematic Classification of Minerals* (Ferraiolo, 2003) and the various volumes of Deer, Howie and Zussman (*Rock-forming Minerals* series), which use combinations of mineral structure and chemical composition to classify minerals. There is also *Fleischer's Glossary of Minerals* (Mandarino, 1999; Back & Mandarino, 2008) which lists 'groups' of minerals in the back section of the glossary. All are useful aids, however, there has been no systematic approach to mineral group naming or a definite hierarchical system put in place. There is also no system for the proposal and approval of mineral groups and group names.

In the past, some mineral groups have been referred to by different names and some mineral species have been proposed as members of more than one group. This proposal aims to standardise group nomenclature by introducing a hierarchy in which to classify mineral species (applied to recent nomenclature proposals) and to introduce a new procedure for the approval of new mineral groups. The following proposal has been approved by the IMA Commission on New Minerals and Mineral Names prior to publication (Voting Proposal 09–A).

** Deceased, July 18, 2009.

History

From time to time, the issue of how the names of groups have been applied and its consistency has been discussed by both the CNMMN/CNMNC and the Commission on Classification of Minerals (CCM)[1]. In 2004, a proposal was prepared by Drs Pushcharovsky, Pasero, Nickel and Ferraris which set out some definitions and criteria for establishing a standard set of group names. This document was circulated for comment at that time; however, there were many competing views. A revised version of this document was commented on by the CNMNC in 2008 and the definition of a mineral group in this scheme has been incorporated from that document.

Definition of a mineral group

Mineral species can be grouped in a number of different ways, on the basis of chemistry, crystal structure, occurrence, association, genetic history, or resource, for example, depending on the purpose to be served by the classification. However, if the classification is to adequately meet

[1] The Commission on New Minerals, Nomenclature and Classification (CNMNC) was formed in July 2006 by a merger between the Commission on New Minerals and Mineral Names (CNMMN) and the Commission on Classification of Minerals (CCM), at the request of both commissions (Burke, 2006).

DOI: 10.1127/0935-1221/2009/0021-1994
0935-1221/09/0021-1994 $ 3.60

the needs of the CNMNC, it is proposed that the grouping be based on chemical composition and crystal structure, as these are the two essential components in the characterisation of a mineral species. Consequently, the simplified definition of a mineral group is:

> *A mineral group consists of two or more minerals with the same or essentially the same structure, and composed of chemically similar elements.*

Structural aspects of a mineral group

The expression "the same structure" means isotypic structures, *i.e.*, structures belonging to one structural type. Crystal structures regarded as being 'essentially the same' can be encompassed by the term 'homeotypic'. As defined by the IUCr, "two structures are considered as homeotypic if all essential features of topology are preserved between them" (Lima-de-Faria *et al.*, 1990). In particular, homeotypic structures do not necessarily have the same space group. Therefore crystallographic variants such as superstructures, substructures and differences in the ordering of atoms that may give rise to multiple cells and/or different space groups, are considered to be homeotypic (*e.g.*, as in the recently defined labuntsovite (Chukanov *et al.*, 2002) and eudialyte (Johnsen *et al.*, 2003) groups). Some polymorphs, such as triclinic and monoclinic feldspars, can be regarded as homeotypic and can therefore be included in a group; others, such as the carbon polymorphs diamond and graphite, are topologically too dissimilar (*i.e.*, they are not homeotypic) and should not belong to the same group.

Homologous series (*e.g.*, lillianite and pavonite series), polysomatic series (*e.g.*, biopyriboles, heterophyllosilicates) and other structural categories that comprise modular structures (Ferraris *et al.*, 2008) go beyond the strict definition of a homeotype, and therefore are not to be regarded as groups. However, some mineral species in these categories may belong to groups if they meet the necessary criteria.

Polytypic variations within mineral species, as defined in Guinier *et al.* (1984), are not regarded as comprising groups.

Compositional aspects of a mineral group

"Chemically similar elements" is taken to mean elements that have similar crystal-chemical behaviour. Thus, isoconfigurational minerals composed of elements with dissimilar crystal-chemical behaviour, such as galena, periclase and halite, are not to be regarded as belonging to the same group. Unoccupied structural sites are to be treated in the same way as chemical elements for the purpose of group placement.

A hierarchical scheme for group nomenclature

The hierarchical scheme draws on the strengths of the various publications mentioned above. We have subdivided the scheme into six levels, however, because some of these levels are described differently in various texts, we provide the following definitions:

1. Mineral class.
2. Mineral subclass.
3. Mineral family.
4. Mineral supergroup.
5. Mineral group(s).
6. Mineral subgroup or mineral series[2].

Definitions of the group levels

1. At the highest level, mineral species can be classified primarily on the main *anion* (O^{2-}, S^{2-} etc.), *anionic complex* (OH^{-}, SO_4^{2-}, CO_2^{2-}, PO_4^{3-}, $B_xO_y^{Z-}$, $Si_xO_y^{Z-}$ etc.) or lack of an anion (native elements) to form classes. The most common mineral classes are: native elements, sulphides, sulphosalts, halides, oxides, hydroxides, arsenites (including antimonites, bismuthites, sulphites, selenites and tellurites), carbonates, nitrates, borates, sulphates, chromates, molybdates, tungstates, phosphates, arsenates, vanadates, silicates and organic compounds.
2. Mineral subclasses apply to the *borate* and *silicate classes*, where the configuration and bonding of tetrahedra are used to group structurally similar minerals. The subclasses are: neso-, soro-, cyclo-, ino-, phyllo- and tectosilicates(borates). Traditionally the borates are divided into monoborates, diborates, triborates, tetraborates etc. (*e.g.* Strunz & Nickel, 2001), however, enough structural data is known to base classification of borates on the polymerisation of the borate anion.
3. Mineral families apply to groups and/or supergroups having similar structural and/or chemical features that make them unique. A mineral family can also consist of two or more supergroups. An example of a mineral family established on the basis of structural criteria is the zeolite family, where all members are characterised by their framework structures containing cavities, but individual minerals themselves may also belong to different groups (and supergroups). The feldspathoid family also belongs to this type of 'structural' family. Other families are defined on the basis of chemical features, as for example the pyrite–marcasite family (which would consist of the pyrite and marcasite supergroups).
4. A mineral supergroup consists of *two or more* groups which have essentially the same structure and composed of chemically similar elements. Generally, a supergroup will contain members from the same mineral class (*e.g.* the epidote supergroup, Table 1c), however in rare cases a supergroup may also contain groups belonging to different classes, as for example in the alunite supergroup (Table 1a). A supergroup may also contain isolated mineral species which do not belong to any mineral group, as for example vanadinite, which is the only vanadate in the apatite supergroup.

[2] Due to the definition of a group as containing two or more minerals, it negates the need for a lower level classification. A mineral subgroup/series must also contain two or more members.

Table 1a. Group nomenclature for the alunite supergroup.

Alunite supergroup[1]			
Alunite group	**Beudantite group**	**Dussertite group**	**Plumbogummite group**
Alunite	Beudantite	Arsenocrandallite	Benauite
Ammonioalunite	Corkite	Arsenoflorencite-(Ce)	Crandallite
Ammoniojarosite	Gallobeudantite	Arsenogorceixite	Eylettersite
Argentojarosite	Hidalgoite	Arsenogoyazite	Florencite-(Ce)
Beaverite-(Cu)	Hinsdalite	Dussertite	Florencite-(La)
Beaverite-(Zn)	Kemmlitzite	Graulichite-(Ce)	Florencite-(Nd)
Dorallcharite	Svanbergite	Philipsbornite	Gorceixite
Huangite	Weilerite	Segnitite	Goyazite
Hydroniumjarosite	Woodhouseite		Kintoreite
Jarosite			Plumbogummite
Natroalunite			Springcreekite
Natroalunite-2R			Waylandite
Natrojarosite			Zaïrite
Osarizawaite			
Plumbojarosite			
Schlossmacherite			
Walthierite			

[1] References: Scott (1987), Birch *et al.* (1992), Jambor (1999), Scott (2000), Back & Mandarino (2008), Sato *et al.* (2008); Bayliss *et al.* (2009).

Table 1b. Group nomenclature for the astrophyllite group.

Astrophyllite group[2]
Astrophyllite
Magnesioastrophyllite
Hydroastrophyllite
Niobophyllite
Zircophyllite
Kupletskite
Kupletskite-(Cs)
Niobokupletskite

[2] Reference: Piilonen *et al.* (2003).

5. A mineral group consists of *two or more* minerals with the same or essentially the same structure and composed of chemically similar elements (see above).
6. A mineral subgroup or mineral series should be used for minerals of a homologous series (*e.g.*, the lillianite and pavonite series and other sulphosalt series, Moëlo *et al.*, 2008) or polysomatic series (*e.g.*, biopyriboles and heterophyllosilicates, Ferraris *et al.*, 2008), where they do not meet the strict definition of a mineral group.

The naming of the group and supergroup levels

It is desirable that the group name be that of the first mineral to have been adequately characterised. This will generally require full structural characterisation. However, in some cases it may be preferable to name a group by a particular chemical or structural attribute (*e.g.*, sodic-calcic amphiboles, Leake *et al.*, 2003) rather than by a specific species name. The historical name should be used as the group name wherever possible.

The supergroup name should also be taken from the first mineral to have been adequately characterised (*i.e.* the first group name) or a historically significant name which no longer defines a single mineral species, such as tourmaline.

In a few cases, a group or a supergroup name can be selected contrary to the precedence rule because the name of this group (supergroup) is very firmly established in the literature. For example, it would be confusing to refer to the alunite supergroup as the "plumbogummite supergroup", even though plumbogummite was described in 1819 and has precedence over alunite which was described in 1824.

Procedure for the introduction of mineral groups and supergroups

A mineral group (or supergroup) can be introduced in the following different ways:

1. If an author (or group of authors) is submitting a new mineral proposal to the CNMNC Chairman, whereby the new mineral would either become the second mineral of a new group, or a group has not been validated previously (and has more than two members), the author(s) can submit at the same time as the new mineral proposal, a proposal for the creation of a new group.
2. During a nomenclature report by a CNMNC subcommittee handled by the CNMNC Secretary.
3. In a proposal by an author (or group of authors) to the CNMNC Vice-Chairman (responsible for changes to

Table 1c. Group nomenclature for the epidote supergroup.

Epidote supergroup[3]		
Epidote group	**Allanite group**	**Dollaseite group**
Clinozoisite	Allanite-(Ce)	Dollaseite-(Ce)
Epidote	Allanite-(La)	Khristovite-(Ce)
Epidote-(Pb)	Allanite-(Y)	
Mukhinite	Dissakisite-(Ce)	
Clinozoisite-(Sr)	Dissakisite-(La)	
Piemontite	Ferriallanite-(Ce)	
Piemontite-(Sr)	Manganiandrosite-(Ce)	
Manganipiemontite-(Sr)	Manganiandrosite-(La)	
	Vanadoandrosite-(Ce)	

[3] Reference: Armbruster *et al*. (2006).

Table 1d. Group nomenclature for the eudialyte group.

Eudialyte group[4]
Carbokentbrooksite
Eudialyte
Feklichevite
Ferrokentbrooksite
Georgbarsanovite
Golyshevite
Ikranite
Johnsenite-(Ce)
Kentbrooksite
Khomyakovite
Manganokhomyakovite
Mogovidite
Oneillite
Raslakite
Rastsvetaevite
Taseqite
Zirsilite-(Ce)
Alluaivite
Andrianovite
Aqualite
Dualite
Labyrinthite

[4] References: Johnsen *et al*. (2003), Nickel & Nichols (2007), Back & Mandarino (2008).

Table 1e. Group nomenclature for the arrojadite group.

Arrojadite group[5]
Arrojadite-(KFe)
Arrojadite-(KNa)
Arrojadite-(PbFe)
Arrojadite-(SrFe)
Arrojadite-(BaFe)
Dickinsonite-(KMnNa)
Fluorarrojadite-(BaFe)
Fluorarrojadite-(BaNa)

[5] Reference: Chopin *et al*. (2006).

Table 1f. Group nomenclature for the joaquinite group.

Joaquinite group[7]
Bario-orthojoaquinite
Byelorussite-(Ce)
Joaquinite-(Ce)
Orthojoaquinite-(Ce)
Orthojoaquinite-(La)
Strontiojoaquinite
Strontio-orthojoaquinite

[7] Reference: Matsubara *et al.* (2001).

existing nomenclature) to create a new mineral group (or supergroup) based on data collected by those author(s).

Subgroup *vs.* Group in previous publications

The term ‘subgroup’ has been used in a number of different nomenclature proposals (*e.g.* the epidote nomenclature report, Armbruster *et al.*, 2006), which is the equivalent of ‘level 5 mineral group’ in the hierarchical system described above. The term ‘subgroup’ is often applied where ‘group’ has been used as the equivalent of ‘level 4 mineral supergroup’. Thus, there is a simple transformation between this style of mineral group naming and the one described here.

Family *vs.* Supergroup *vs.* Group in previous publications

The terms ‘family’, ‘supergroup’ and ‘group’ have been used interchangeably in several different schemes; in particular when referring to the alunite (jarosite) supergroup, which has been called the alunitejarosite family, alunite and jarosite supergroups, alunite–jarosite supergroup or the

Table 1g. Group nomenclature for the amphibole supergroup.

Amphibole supergroup				
Mg-Fe-Mn-Li group	**Calcic group**	**Sodic-calcic group**	**Sodic group**	**Na-Ca-Mg-Fe-Mn-Li group**
Anthophyllite	Actinolite	Aluminobarroisite	Arfvedsonite	Ferri-ottoliniite
Clinoferroholmquistite	Alumino-ferrotschermakite	Alumino-magnesiotaramite	Dellaventuraite	Ferriwhittakerite
Cummingtonite	Alumino-magnesiosadanagaite	Aluminotaramite	Eckermannite	Ottoliniite
Ferri-clinoferroholmquistite	Aluminotschermakite	Barroisite	Ferric-ferronybøite	Whittakerite
Ferri-clinoholmquistite	Cannilloite	Ferribarroisite	Ferricnybøite	
Ferripedrizite	Chloro-potassichastingsite	Ferrikatophorite	Ferro-eckermannite	
Ferro-anthophyllite	Chloro-potassicpargasite	Ferri-ferrobarroisite	Ferroglaucophane	
Ferrogedrite	Edenite	Ferri-magnesiotaramite	Fluoro-ferroleakeite	
Ferroholmquistite	Ferri-ferrotschermakite	Ferritaramite	Fluoro-magnesio-arfvedsonite	
Ferropedrizite	Ferritschermakite	Ferriwinchite	Fluoronybøite	
Fluoro-sodic-pedrizite	Ferro-actinolite	Ferrobarroisite	Fluoro-potassic-magnesio-arfvedsonite	
Gedrite	Ferro-edenite	Ferrorichterite	Glaucophane	
Grunerite	Ferrohornblende	Ferrowinchite	Kornite	
Holmquistite	Ferrokaersutite	Fluoro-alumino-magnesiotaramite	Kôzulite	
Manganocummingtonite	Ferropargasite	Fluoro-potassic-richterite	Leakeite	
Manganogrunerite	Ferrotschermakite	Fluororichterite	Magnesio-arfvedsonite	
Proto-anthophyllite	Ferrocannilloite	Katophorite	Magnesioriebeckite	
Protoferro-anthophyllite	Fluoro-edenite	Magnesiokatophorite	Nybøite	
Protomangano-ferro-anthophyllite	Fluoro-magnesiohastingsite	Magnesiotaramite	Obertiite	
Sodicanthophyllite	Fluoropargasite	Parvowinchite	Potassicarfvedsonite	
Sodic-ferri-clinoferroholmquistite	Fluoro-potassichastingsite	Potassic-fluororichterite	Potassicleakeite	
Socdic-ferri-ferropedrizite	Hastingsite	Richterite	Potassic-magnesio-arfvedsonite	
Sodic-ferripedrizite	Joesmithite	Taramite	Riebeckite	
Sodic-ferro-anthophyllite	Kaersutite	Winchite	Ungarettiite	
Sodic-ferrogedrite	Magnesiohastingsite			
Sodicgedrite	Magnesiohornblende			
	Magnesiosadanagaite			
	Pargasite			
	Parvo-mangano-edenite			
	Parvo-manganotremolite			
	potassic-aluminosadanagaite			
	Potassic-ferrisadanagaite			
	Potassic-ferropargasite			
	Potassic-hastingsite			
	Potassic-magnesiohastingsite			
	Potassic-magnesiosadanagaite			
	Potassicpargasite			
	Potassicsadanagaite			
	Sadanagaite			
	Tremolite			
	Tschermakite			

[8] References: Leake *et al.* (1997, 2003), Nickel & Nichols (2007), Back & Mandarino (2008). Only amphiboles found in nature are reported.

Table 1h. Group nomenclature for the labuntsovite supergroup.

Labuntsovite supergroup[9]				
Nenadkevichite group	**Vuoriyarvite group**	**Paratsepinite group**	**Lemmleinite group**	**Labuntsovite group**
Korobitsynite	Tsepinite-Ca	Paratsepinite-Ba	Lemmleinite-Ba	Labuntsovite-Fe
Nenadkevichite	Tsepinite-K	Paratsepinite-Na	Lemmleinite-K	Labuntsovite-Mg
	Tsepinite-Na			Labuntsovite-Mn
	Tsepinite-Sr			
	Vuoriyarvite-K			
Gutkovaite group	**Kuzmenkoite group**	**Organovaite group**	**Unassigned member of the labuntsovite supergroup**	
Alsakharovite-Zn	Gjerdingenite-Ca	Organovaite-Mn	Paralabuntsovite-Mg	
Gutkovaite-Mn	Gjerdingenite-Fe	Organovaite-Zn		
Neskevaaraite-Fe	Gjerdingenite-Mn	Parakuzmenkoite-Fe		
	Gjerdingenite-Na			
	Karupmøllerite-Ca			
	Kuzmenkoite-Mn			
	Kuzmenkoite-Zn			
	Lepkhenelmite-Zn			

[9] References: Chukanov *et al.* (2002) , Raade *et al.* (2004), Back & Mandarino (2008).

Table 1i. Group nomenclature for the sapphirine supergroup.

Sapphirine supergroup[10]			
Sapphirine group	**Aenigmatite group**	**Rhönite group**	**Unassigned member of the sapphirine supergroup**
Khmaralite	Aenigmatite	Dorrite	Surinamite
Sapphirine	Krinovite	Høgtuvaite	
	Wilkinsonite	Makarochkinite	
		Rhönite	
		Serendibite	
		Welshite	

[10] References: Grew *et al*. (2008).

Table 1j. Group nomenclature for the högbomite supergroup.

Högbomite supergroup[11]		
Högbomite group	**Nigerite group**	**Taaffeite group**
Ferrohögbomite-2*N*2*S*	Ferronigerite-6*N*6*S*	Magnesiotaaffeite-6*N*'3*S*
Magnesiohögbomite-2*N*2*S*	Magnesionigerite-6*N*6*S*	Ferrotaaffeite-6*N*'3*S*
Magnesiohögbomite-2*N*3*S*	Ferronigerite-2*N*1*S*	Magnesiotaaffeite-2*N*'2*S*
Magnesiohögbomite-6*N*6*S*	Magnesionigerite-2*N*1*S*	
Zincohögbomite-2*N*2*S*		
Zincohögbomite-2*N*6*S*		

[11] References: Armbruster (2002), Back & Mandarino (2008).

alunite supergroup. There have also been many different allocations of minerals into various groups within the 'supergroup' (Mills, 2007). In this case, the terms family and supergroup are equivalent to 'level 3 mineral supergroup' in the hierarchical scheme described above. The new scheme provides a way of simplifying large mineral groups so that confusing and inconsistent terms cannot be used to indicate the same thing.

Application of mineral group hierarchies to recent nomenclature proposals

As a test that the new hierarchical scheme can classify all minerals, we have applied it to recent nomenclature proposals (Table 1a to 1j). Here, we have created new groups and supergroups where they were previously 'subgroups' and

'groups', such as the new högbomite, labuntsovite, epidote and sapphirine supergroups.

In the case of the högbomite supergroup, the 'subgroups' that were established on the basis of Mg^{2+}, Fe^{2+} or Zn^{2+} by Armbruster (2002) have been combined so that they fall within the högbomite, nigerite or taaffeite groups. Likewise, the alunite supergroup has been simplified (from Scott, 1987; Birch *et al.*, 1992; Bayliss *et al.*, 2009), so that all members fall within the alunite (SO_4-dominant), dussertite (AsO_4-dominant), plumbogummite (PO_4-dominant), or beudantite (mixed SO_4-PO_4 and SO_4-AsO_4) groups.

In the sapphirine supergroup, surinamite is an unassigned member because there is no other member to allow a group to be established. Paralabuntsovite is also an unassigned member of the labuntsovite supergroup, for the same reason.

Conclusion

The new hierarchical scheme has been successfully applied to recent nomenclature reports in order to standardise the way in which minerals are organised into groups. A new procedure has been put in place in order to facilitate the future proposal and naming of new mineral groups within the IMA–CNMNC framework.

The next step is to apply the hierarchical scheme to all known minerals (via a CNMNC subcommittee) and to compile a list of mineral groups, supergroups, *etc.*, which should be published in an appropriate mineralogical journal and on the CNMNC website.

References

Armbruster, T. (2002): Revised nomenclature of högbomite, nigerite, and taaffeite minerals. *Eur. J. Mineral.*, **14**, 389–395.

Armbruster, T., Bonazzi, P., Akasaka, M., Beremanec, V., Chopin, C., Gieré, R., Heuss-Assbichler, S., Liebscher, A., Menchetti, S., Pan, Y., Pasero, M. (2006): Recommended nomenclature of epidote-group minerals. *Eur. J. Mineral.*, **18**, 551–567.

Back, M. & Mandarino, J.A. (2008): Fleischer's Glossary of Mineral Species 2008. Mineralogical Record Inc., Tuscon, 346 p.

Bayliss, P., Kolitsch, U., Nickel, E.H., Pring, A., Scott, K. (2009): Recommended nomenclature of the alunite supergroup. CNMNC proposal 07–D.

Birch, W.D., Pring, A., Gatehouse, B.M. (1992): Segnitite, $PbFe_3H(AsO_4)_2(OH)_6$, a new mineral in the lusingite group, from Broken Hill, New South Wales. *Am. Mineral.*, **77**, 656–659.

Burke, E.A.J. (2006): The end of CNMMN and CCM—LONG LIVE THE CNMNC! *Elements*, **2**, 388.

Chopin, C., Oberti, R., Cámara, F. (2006): The arrojadite enigma: II. Compositional space, new members, and nomenclature of the group. *Am. Mineral.*, **91**, 1260–1270.

Chukanov, N.V., Pekov, I.V., Khomyakov, A.P. (2002): Recommended nomenclature for labuntsovite-group minerals. *Eur. J. Mineral.*, **14**, 165–173.

Ferraiolo, J.A. (2003): A Systematic Classification of Minerals. 2206 Harwood Lane, Bowie, Maryland 20716–1107, U.S.A., 441 p.

Ferraris, G., Makovicky, E., Merlino, S. (2008): Crystallography of Modular Materials. Oxford University Press, 370 p.

Gaines, R.V., Skinner, H.C., Foord, E.E., Mason, B., Rosenzweig, A. (1997): Dana's new mineralogy. Wiley & Sons, New York, 1819 p.

Grew, E., Hålenius, U., Pasero, M., Barbier, J. (2008): Recommended nomenclature for the sapphirine and surinamite groups (sapphirine supergroup). *Mineral. Mag.*, **72**, 839–876.

Guinier, A., Bokij, G.B., Boll-Dornberger, K., Cowley, J.M., Ďurovič, S., Jagodzinski, H., Krishna, P., de Wolff, P.M., Zvyagin, B.B., Cox, D.E., Goodman, P., Hahn, T., Kuchitsu, K., Abrahams, S.C. (1984): Nomenclature of polytype structures. *Acta Crystallogr. A*, **40**, 399–404.

Jambor, J.L. (1999): Nomenclature of the alunite supergroup. *Can. Mineral.*, **37**, 1323–1341.

Johnsen, O., Ferraris, G., Gault, R.A., Grice, J., Kampf, A. R., Pekov, I.V. (2003): The nomenclature of eudialyte-group minerals. *Can. Mineral.*, **41**, 785–794.

Leake, B., Woolley, A.R., Arps, C.E.S., Birch, W.D., Gilbert, M.C., Grice, J.D., Hawthorne, F.C., Kato, A., Kisch, H.J., Krivovichev, V.G., Linthout, K., Laird, J., Mandarino, J.A., Maresch, W.V., Nickel, E.H., Rock, N.M.S., Schumacher, J.C., Smith, D.C., Stephenson, N.C.N., Ungaretti, L., Whittaker, E.J.W., Youzhi, G. (1997): Nomenclature of amphiboles: report of the subcommittee on amphiboles of the International Mineralogical Association, Commission on New Minerals and Mineral Names. *Eur. J. Mineral.*, **9**, 623–651.

Leake, B.E., Woolley, A.R., Birch, W.D., Burke, E.A.J., Ferraris, G., Grice, J.D., Hawthorne, F.C., Kisch, H.J., Krivovichev, V.G., Schumacher, J.C., Stephenson, N.C.N., Whittaker, E.J.W. (2003): Nomenclature of amphiboles: Additions and revisions to the International Mineralogical Association's 1997 recommendations. *Can. Mineral.*, **41**, 1355–1362.

Lima-de-Faria, J., Hellner, E., Liebau, F., Makovicky, E., Parthé, E. (1990): Nomenclature of inorganic structure types. Report of the International Union of Crystallography Commission on Crystallographic Nomenclature, Sub-Committee on the Nomenclature of Inorganic Structure Types. *Acta Crystallogr. A*, **46**, 1–11.

Mandarino, J.A. (1999): Fleischer's Glossary of Mineral Species 1999. Mineralogical Record Inc., Tuscon, 226 p.

Matsubara, S., Mandarino, J.A., Semenov, E.I. (2001): Redefinition of a mineral in the joaquinite group: Orthojoaquinite-(La). *Can. Mineral.*, **39**, 757–760.

Mills, S.J. (2007): The crystal chemistry and geochronology of secondary minerals from the Broken Hill deposit, New South Wales. Ph.D. thesis, University of Melbourne, Melbourne, Australia, 249 p.

Moëlo, Y., Makovicky, E., Mozgova, N.N., Jambor, J.L., Cook, N., Pring, A., Paar, W., Nickel, E.H., Graeser, S., Karup-Møller, S., Balic-Žunic, T., Mumme, W.G., Vurro, F., Topa, D., Bindi, L., Bente, K., Shimizu, M. (2008): Sulfosalts systematics: a review. Report of the sulfosalt sub-committee of the IMA Commission on Ore Mineralogy. *Eur. J. Mineral.*, **20**, 7–46.

Nickel, E.H. & Nichols, M. (2007): Minerals Database. MDI Minerals Data. California, USA.

Oberti, R., Della Ventura, G., Ottolini, L., Hawthorne, F.C., Bonazzi, P. (2002): Re-definition, nomenclature and crystal-chemistry of the hellandite group. *Am. Mineral.*, **87**, 745–752.

Piilonen, P.C., Lalonde, A.E., McDonald, A.M., Gault, R.A., Larsen, A.O. (2003): Insights into astrophyllite-group minerals. I. Nomenclature, composition and development of a general standard formula. *Can. Mineral.*, **41**, 1–26.

Raade, G., Chukanov, N.V., Kolitsch, U., Möckel, S., Zadov, A.E., Pekov, I.V. (2004): Gjerdingenite-Mn from Norway – a new mineral species in the labuntsovite group: descriptive data and crystal structure. *Eur. J. Mineral.*, **16**, 979–987.

Sato, E., Nakai, I., Terada, Y., Tstusumi, Y., Yokoyama, K., Miyawaki, R., Mastubara, S. (2008): Study of Zn-bearing beaverite $Pb(Fe_2Zn)(SO_4)_2(OH)_6$ obtained from Mikawa mine, Niigata Prefecture, Japan. *J. Mineral. Petrol. Sci.*, **103**, 141–144.

Scott, K.M. (1987): Solid solution in, and classification of, gossan-derived members of the alunite–jarosite family, northwest Queensland, Australia. *Am. Mineral.*, **72**, 178–187.

— (2000): Nomenclature of the alunite supergroup: discussion. *Can. Mineral.*, **38**, 1295–1297.

Strunz, H. & Nickel, E.H. (2001): Strunz mineralogical tables. Schweizerbart, Stuttgart, 869 p.

Received 6 October 2009
Accepted 6 October 2009