Mineralogical Magazine, April 2015, Vol. 79(2), pp. 243–246

Nomenclature for the laueite supergroup

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[*Received 17 August 2014; Accepted 17 September 2014; Associate Editor: A. Christy*]

ABSTRACT

A new nomenclature scheme has been set up for the laueite supergroup of minerals, which have the general formula $M1^{2+}M2^{3+}M3^{3+}(XO_4)_2(OH)_2{\cdot}8H_2O$, where $M1 = Fe^{2+}$, Mg^{2+} or Mn^{2+}; $M2/M3 = Al^{3+}$ or Fe^{3+}; and $XO_4 = PO_4$ or AsO_4. The laueite supergroup is divided into the laueite group ($XO_4 = PO_4$) and the maghrebite group ($XO_4 = AsO_4$). These groups are then subdivided into subgroups on the basis of the dominant atoms, Al^{3+} or Fe^{3+}, in octahedral sites $M2/M3$. The new nomenclature has been approved by the International Mineralogical Association Commission on New Minerals, Nomenclature and Classification, proposal 14-F.

KEYWORDS: laueite supergroup, laueite, maghrebite, crystal structure, group nomenclature.

Introduction

THE term 'laueite group' has come into common usage recently (Krivovichev, 2004; Meisser *et al*., 2012; Scholz *et al.*, 2014) to refer to minerals with structures based on so-called laueite-type heteropolyhedral sheets (Moore, 1965) and having the general formula $M1^{2+}M2^{3+}M3^{3+}(XO_4)_2(OH)_2{\cdot}8H_2O$, where $M1 = Fe^{2+}$, Mg^{2+} or Mn^{2+}; $M2/M3 = Al^{3+}$ or Fe^{3+}; and $X = P^{5+}$ or As^{5+}. The sheet motif, parallel to (010) is shown in Fig. 1. It comprises 7 Å kinked chains of *trans*-connected octahedra along [001] containing alternately *M*2 and *M*3. Adjacent chains are linked along [100] by corner connections with XO_4 tetrahedra. The sheets are connected along [010] by corner connections of the XO_4 tetrahedra with $M1O_2(H_2O)_4$ octahedra as shown in Fig. 2. The minerals generally have a divalent cation in *M*1, although there is also an oxidized species, sigloite (Hawthorne, 1988), with Fe^{3+} in the *M*1 site.

Nomenclature considerations

Following the recent description of new members with $XO_4 = PO_4$ (Segeler *et al*., 2012) and AsO_4 (Meisser *et al*., 2012; Scholz *et al*., 2014), there was a need to formalize the use of laueite as a supergroup, containing separate groups with $X = PO_4$ and AsO_4. Using the procedures developed by Mills *et al*. (2009) for standardization of mineral-group hierarchies, a grouping of laueite-related minerals was proposed to the International Mineralogical Association Commission on New Minerals, Nomenclature and Classification (IMA-CNMNC) and was accepted on August 7, 2014 (proposal 14-F). The assignment of minerals to the laueite supergroup is summarized in Table 1.

Laueite was the first mineral in Table 1 to have its structure determined by Moore in 1965, and the term 'laueite group' has been used frequently in publications to refer to the minerals in this list (e.g. Krivovichev, 2004; Meisser *et al*., 2012; Scholz *et al*., 2014). Consistent with Mills *et al*. (2009), laueite is the name to be used for the supergroup, which is divided at the highest level on the basis of the main anion, into the laueite group (phosphates) and the maghrebite group (arsenates). These groups are then subdivided into subgroups on the basis of the dominant cation, Al^{3+} or Fe^{3+}, in the octahedral sites $M2/M3$. This is analogous to the jahnsite group in which the minerals are subdivided into whiteites and jahnsites based upon the dominance of Al^{3+} or Fe^{3+}, respectively, in the *M*3 site (Moore and Ito, 1978).

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DOI: 10.1180/minmag.2015.079.2.02

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https://doi.org/10.1180/minmag.2015.079.2.02 Published online by Cambridge University Press

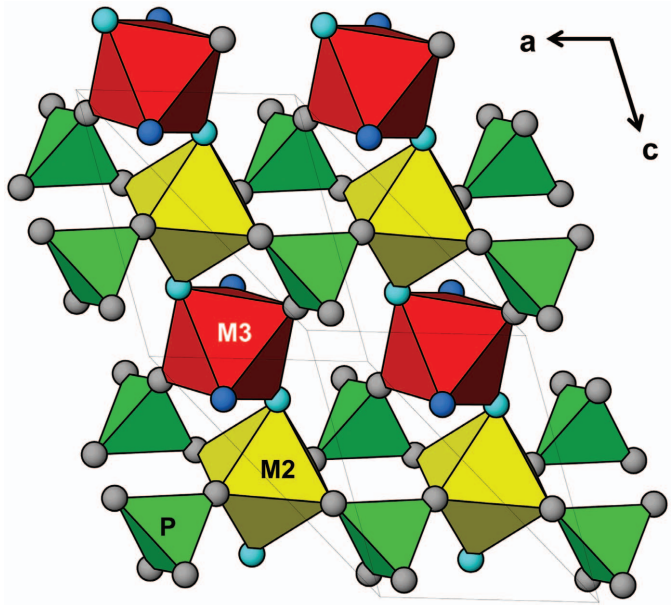


FIG. 1. Laueite heteropolyhedral sheet. Small grey, light blue and dark blue spheres are coordinated oxygen, hydroxyl and water, respectively.

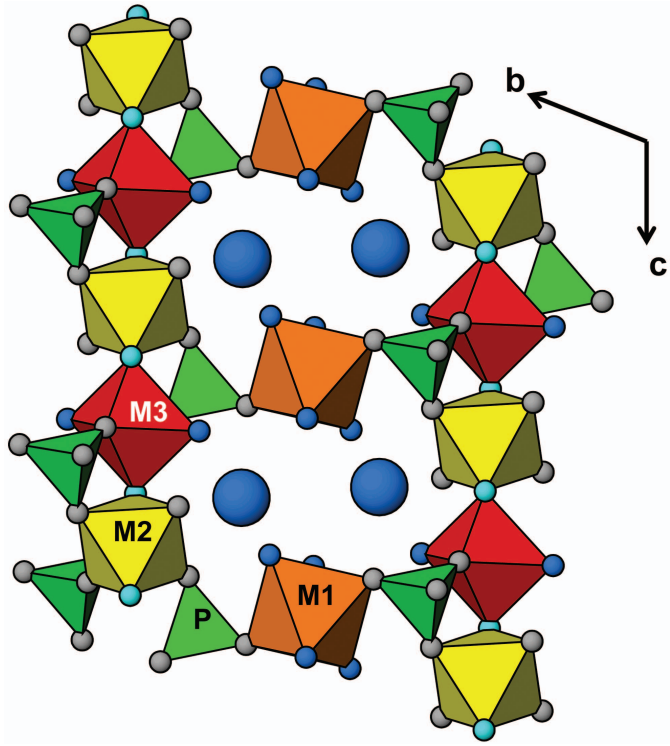


FIG. 2. Connectivity between laueite sheets. Small grey, light blue and dark blue spheres are coordinated oxygen, hydroxyl and water, respectively. Large blue spheres are interlayer water molecules.

https://doi.org/10.1180/minmag.2015.079.2.02 Published online by Cambridge University Press

TABLE 1. Hierarchy for the laueite supergroup.

Group name	Mineral name	*M*1*	*M*2	*M*3	*X*	Structure reference
Laueite group	laueite	Mn^{2+}	Fe^{3+}	Fe^{3+}	P^{5+}	Moore (1965)
	ushkovite	Mg^{2+}	Fe^{3+}	Fe^{3+}	P^{5+}	Galliski and Hawthorne (2002)
	ferrolaueite	Fe^{2+}	Fe^{3+}	Fe^{3+}	P^{5+}	Segeler *et al*. (2012)
	manganogordonite	Mn^{2+}	Al^{3+}	Al^{3+}	P^{5+}	Leavens and Rheingold (1988)
	gordonite	Mg^{2+}	Al^{3+}	Al^{3+}	P^{5+}	Leavens and Rheingold (1988)
	paravauxite	Fe^{2+}	Al^{3+}	Al^{3+}	P^{5+}	Baur (1969*b*)
	sigloite	Fe^{3+}	Al^{3+}	Al^{3+}	P^{5+}	Hawthorne (1988)
	curetonite	Ba^{2+}	Al^{3+}	Al^{3+}	P^{5+}	Cooper and Hawthorne (1994)
	unnamed	Mn^{2+}	Fe^{3+}	Al^{3+}	P^{5+}	Grey *et al*. (2015)
Maghrebite group	césarferreiraite	Fe^{2+}	Fe^{3+}	Fe^{3+}	As^{5+}	Scholz *et al*. (2014)
	maghrebite	Mn^{2+}	Al^{3+}	Al^{3+}	As^{5+}	Meisser *et al*. (2012)

* See text for explanation of differing coordinations for the *M*1 cations in sigloite and curetonite.

All currently accepted laueite-group minerals have the same dominant trivalent cation, Al^{3+} or Fe^{3+}, in both the *M*2 and *M*3 sites of the 7 Å chain; however, considering that the *M*2 and *M*3 sites have different coordinations, $M2O_4(OH)_2$ and $M3O_2(OH)_2(H_2O)_2$, there appears to be no reason why each site could not contain a different dominant cation. Indeed, two synthetic phases with heteropolyhedral sheets that are topologically identical to those in laueite, but with *M*2 and *M*3 sites containing different cations, have been reported by Wang *et al*., (2000): $(enH_2)NbFeOF(PO_4)_2(H_2O)_2$ [en = ethylenediamine] with Nb^{5+} in site *M*2 and Fe^{3+} in site *M*3 and $(enH_2)Ti(Fe,Cr)(F,O)(H_{0.3}PO_4)_2(H_2O)_2$ with Ti^{4+} in site *M*2 and Fe^{3+}/Cr^{3+} in site *M*3. We have also reported recently on intergrowths between laueite and mangangordonite at Hagendorf Süd, in which a single-crystal refinement on one of the compositions gave dominant Fe in site *M*2 and dominant Al in site *M*3 and would correspond to a new mineral species (Grey *et al*., 2015).

The mineral curetonite, $Ba(Al,Ti)(PO_4)(OH,O)F$ (Cooper and Hawthorne, 1994) is included in Table 1, even though it has a different symmetry (monoclinic) and a different arrangement of interlayer cations from the other laueite supergroup members. The reason for its inclusion is that its sheet is topologically identical to the sheet in laueite. In addition, although the sheets are cross-linked by Ba^{2+} cations rather than by $M^{2+}O_2(H_2O)_4$ octahedra, the valence-matching principle (Brown, 1981) is maintained in both cases, as described by Cooper and Hawthorne (1994).

In contrast to curetonite, the minerals stewartite (Moore and Araki, 1974) and kastningite (Adiwidjaja *et al*., 1999), which have similar compositions and symmetries to laueite-supergroup minerals, cannot be considered to belong to the laueite supergroup because their heteropolyhedral sheets are not topologically identical to those in laueite. In particular, the orientation of the PO_4 groups relative to the sheets differs from that in laueite, and they are classed as geometrical isomers (Moore, 1970, 1975; Krivovichev, 2004). Similarly, the structure layers of pseudolaueite (Baur, 1969*a*), metavauxite (Baur and Rao, 1967) and strunzite (Fanfani *et al*., 1978) have a topologically different connectivity between the octahedra and tetrahedra and are thus topological isomers, while geometrical isomerism further separates pseudolaueite from metavauxite and strunzite (Krivovichev, 2004).

https://doi.org/10.1180/minmag.2015.079.2.02 Published online by Cambridge University Press

Acknowledgements

We thank Tony Kampf and an anonymous reviewer for comments on the manuscript and members of the CNMNC for comments during the proposal process.

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