

NOMENCLATURE OF THE ALUNITE SUPERGROUP: REPLY

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It is gratifying that the paper on the nomenclature of the alunite supergroup stimulated sufficient interest to prompt the discussion by Scott (2000). Although Scott (2000) focuses only on compositional aspects, the nomenclature system suggested by Jambor (1999) involves two components, namely (1) structural, and (2) compositional, and it was the structural component that triggered the re-examination of the current system of classification. The situation arose because it became evident that, whereas most of the known minerals in the alunite supergroup are rhombohedral, with $a \approx 7 \text{ \AA}$ and $c \approx 17 \text{ \AA}$, space group $R\bar{3}m$, there are several unnamed species that would be entitled to new names if the precedents set within the current system remain unchanged. Scott (2000) mentions that other than for Pb-dominant minerals, only huangite would be eliminated from the supergroup if Jambor's (1999) proposals were accepted. The ideal situation would be to have no discreditations, as that presumably would ease the adoption of a ternary system. Scott (2000), however, has ignored the propos-

als concerning structural aspects and their resulting implications pertaining to nomenclature.

In Scott's (2000) first paragraph, he discusses the classification approved by the CNMMN and the utility of the grouping based on Fe or Al predominance. The latter was demonstrated by Botinelly (1976) and was used both by Scott (1987) and Jambor (1999), but it has no bearing on whether a ternary system based on TO_4 contents is preferable to the existing system. In the ternary TO_4 classification, the placement of a mineral is dependent on whether its TO_4 is predominantly sulfate, phosphate, or arsenate. Scott's (1987) system of classification, as approved by the CNMMN, is shown in Figure 1a. As is illustrated, no compositional boundary between the phosphate and arsenate members was established. For such a system to be functional, Jambor *et al.* (1996) and Jambor (1999) assumed that, in accordance with CNMMN recommendations for binary solid-solutions (*e.g.*, Nickel & Grice 1998), the AsO_4-PO_4 binary join should be divided at 50%; nevertheless, it

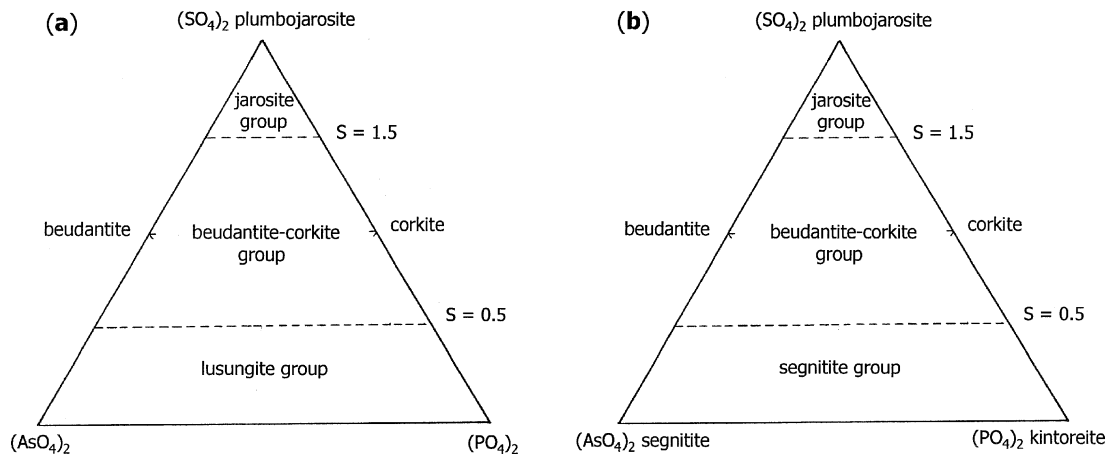


FIG. 1. (a) Classification of the Pb-Fe-dominant members of the alunite supergroup according to Scott's (1987) system, as approved by the CNMMN (after Birch *et al.* 1992). (b) Scott's (1987) system after the discreditation of "lusungite" and the naming of segnitite and kintoreite (from Pring *et al.* 1995).

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did not seem practical to extend this division to the SO_4 apex, thereby also dividing the small compositional field occupied by plumbojarosite (Fig. 1 in Scott 2000). Although both Scott (2000) and Jambor (1999) use this system (as in Scott's Fig. 1, left), and although both claim it to be the current system, it has not been approved, or to be more specific, has not been voted on by the CNMMN. Hence, when Birch *et al.* (1992) and Pring *et al.* (1995) named segnitite and kintoreite, respectively, the names were introduced only to specify the corners that had been opened as a consequence of the adoption of Scott's (1987) system of nomenclature. Neither Birch *et al.* (1992) nor Pring *et al.* (1995) specified a solid-solution limit on the PO_4 – AsO_4 join; hence, Scott's CNMMN-approved classification currently has the form shown in Figure 1b.

As is noted in Scott's (2000) second paragraph, there have been many more new names added to the alunite supergroup since his (1987) classification was adopted. Nevertheless, had a ternary system combined with structural notation been in place at that time (1987), only huangite, kintoreite, and segnitite would have been disallowed; as well, for both systems a decision is necessary concerning acceptance of arsenogoyazite as a replacement for kemmlitzite (Fig. 5 in Jambor 1999). Kintoreite and segnitite would not have been approved on the grounds that their compositional fields were within those occupied by corkite and beudantite (Fig. 1 in Scott 2000), whereas huangite similarly would have fallen within the compositional field occupied by woodhouseite. In its approval of huangite, the CNMMN simultaneously permitted the redefinition of minamiite, $(\text{Na,Ca,K})_2\text{Al}_6(\text{SO}_4)_4(\text{OH})_{12}$, which is compositionally equivalent to calcian natroalunite. Minamiite was retained on the grounds that order of the ions on the alkali site has led to a doubling of the c axis. In the general recommendations on nomenclature, however, two of the examples cited by the CNMMN (Nickel & Grice 1998) might be considered as germane:

1. "Analcime has a number of topologically similar polymorphs *e.g.*, cubic, tetragonal, orthorhombic, monoclinic, triclinic and possibly even trigonal, caused by relatively minor variations in symmetry due to different degrees of order of Si and Al with related different occupancies of the nearest Na structural site. Such polymorphs are not to be regarded as separate species."

2. "Pyrrhotite, Fe_{1-x}S , where x varies between 0 and 0.12, exists in a number of different crystallographic forms owing to variations in the degree of order of the Fe vacancies in the S lattice; because of the variable chemical composition, the different types of pyrrhotite can be regarded as polytypoids and are not regarded as separate species."

Although symmetry variations and order–disorder phenomena have been demonstrated for some members of the alunite supergroup (Jambor 1999), the topological similarity of all of the structures in the supergroup has made it difficult for crystallographers to characterize

with certainty the deviations from rhombohedral symmetry and space group $R\bar{3}m$ (*e.g.*, Hendricks 1937, Radoslovich & Slade 1980, Radoslovich 1982, Loiacono *et al.* 1982, Giuseppetti & Tadini 1987, Szymański 1985, 1998, Kolitsch *et al.* 1999). One might presume, therefore, that some degree of order of the alkali-site cations and its resultant effect of doubling the c -axis length, as is the case for minamiite, would be insufficient grounds for naming a mineral in the supergroup.

Let one be accused of being selective in citing examples from the CNMMN recommendations, the following from Nickel & Grice (1998) is also noted: "Orthoclase and microcline have essentially the same composition and topologically similar structures. According to current practice, these minerals would not be regarded as separate species, but their names are retained in the mineral lexicon for historical reasons." Thus, there might be retention of a mineral because of historical reasons, but segnitite, kintoreite, and huangite were named in the 1990s (Birch *et al.* 1992, Pring *et al.* 1995, Li *et al.* 1992), as was approval given for the retention of minamiite (Li *et al.* 1992). Thus, in a ternary compositional-structural classification system, there would be no need to approve, or no need to retain, these four names.

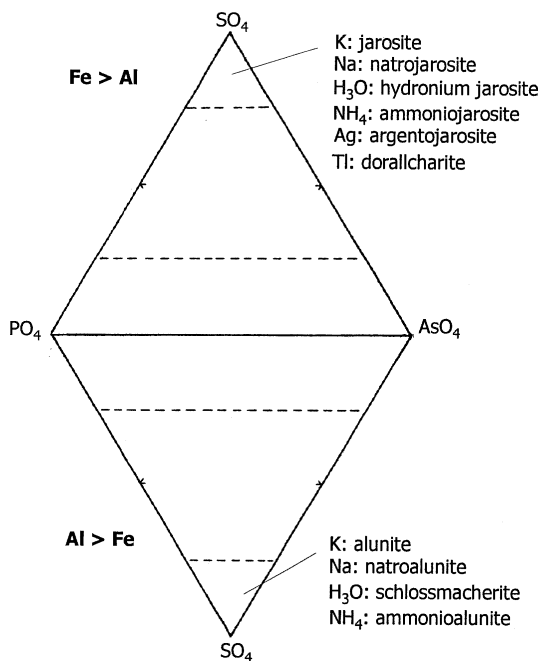


FIG. 2. Classification of the alunite-supergroup members containing monovalent ions in the alkali site, showing the TO_4 compositional limits according to the Scott (1987) system.

As Scott (2000) acknowledges, there have been significant additions (11 or 12) to the list of minerals in the supergroup since his 1987 classification was developed. The rate has been almost one new approved name annually, and several other potential candidates have already been discovered. Among the latter, some of the examples are “arsenowaylandite” (Scharm *et al.* 1994), “arsenoflorencite-(La)” and “arsenoflorencite-(Nd)” (Scharm *et al.* 1991), the benaite-related mineral described by Walenta *et al.* (1996), the unnamed Al-dominant analogue of plumbojarosite, and the structural variants given in Jambor (1999). The last-mentioned category is especially important because, if the precedent established with minamiite (*i.e.*, species status because its *c* length is twice that of natroalunite) is continued, additional names could be added even where the compositional fields are already occupied. Scott (2000)

does not address this issue; indeed, he seems not to have acknowledged it.

Scott (2000) chose to focus only on the Pb-dominant minerals, and in paragraph three he discusses protonation and the purported superiority of the Scott (1987) system in acknowledging protonation. The need for protonation arises because both AsO_4 and PO_4 are trivalent anions, whereas SO_4 is divalent. Thus, Scott (2000) chose corkite as one of the examples to illustrate the alleged merits of the 1987 system *versus* the proposed ternary system. In the ternary system, the composition of corkite extends from $\text{PbFe}_3(\text{PO}_4)_2(\text{OH}, \text{H}_2\text{O})_6$ to $\text{PbFe}_3(\text{PO}_4)(\text{SO}_4)(\text{OH})_6$, the latter the end-point at which protonation is no longer required to achieve charge balance. In Scott's (1987) system, there is no such end-member, and corkite compositionally straddles the protonated and non-protonated fields. Thus, it could

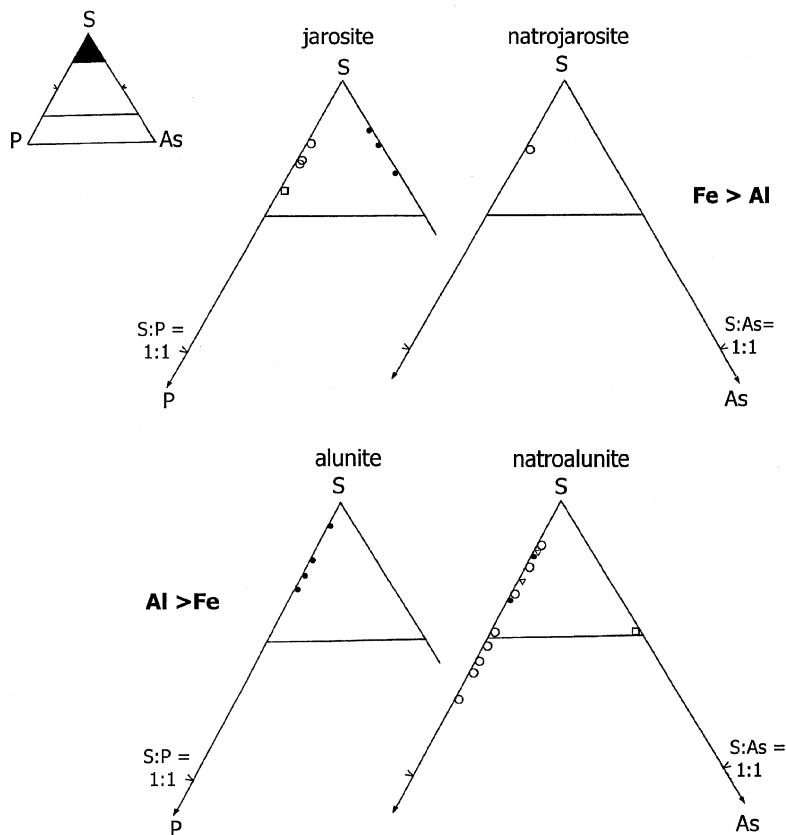


FIG. 3. Published compositional data for As and P substitutions in jarosite and related minerals. Data sources for jarosite and natrojarosite are: open square: Scott (1990), open circles: Horáková & Novák (1989), solid circles: Roca *et al.* (1999). Data for alunite are from Allibone *et al.* (1995), and sources for natroalunite are: open circles: Ripp *et al.* (1998) and Ripp & Kanakin (1998), triangles: Wise (1975), solid circles: Allibone *et al.* (1995). The open square represents the composition of type schlossmacherite (Schmetzer *et al.* 1980) rather than that of natroalunite. An As-free schlossmacherite has been reported by Khalaf (1990) but requires verification.

be deemed as unusual to have the lack of end-points claimed as a strength in the 1987 classification of corkite; others might perceive this feature as a significant weakness. Moreover, this apparent weakness is emphasized insofar as not only corkite, but all other minerals similarly positioned in the 1987 system, overlap the mid-point of the binary solid-solutions (*i.e.*, P versus S, and As versus S), thereby departing from current IMA guidelines on nomenclature.

In Scott's (2000) penultimate paragraph, he argues that the boundaries set in the 1987 classification, at least for SO_4 , "...may represent a real compositional break which is recognized by Scott's (1987) system but not by Jambor's (1999) proposed system (Fig. 2)." He then seems to dismiss the importance of his own argument by contending that, regardless of what the minerals might show, the Scott (1987) system is more informa-

tive about compositions. One could reduce the gist to "smaller is better". There is certainly ample precedent for smaller, non-standard partitioning. Systems such as those in use for the amphiboles and micas are IMA-approved, but the question is whether smaller is better for the nomenclature of the alunite supergroup.

Regardless of the different opinions, it is suggested that some decisions will have to be made by the CNMMN. First, should the PO_4 - AsO_4 boundary be set at 50%, as has been done by Jambor *et al.* (1996), Jambor (1999), and Scott (2000)? Second, should this boundary be extended to the SO_4 apex? Third, should the minor (in terms of topology) structural variations that have been documented for some of the minerals entitle them to species status? Fourth, is the Scott (1987) classification appropriate for now and the (even immediate) future? If the answers to these questions are

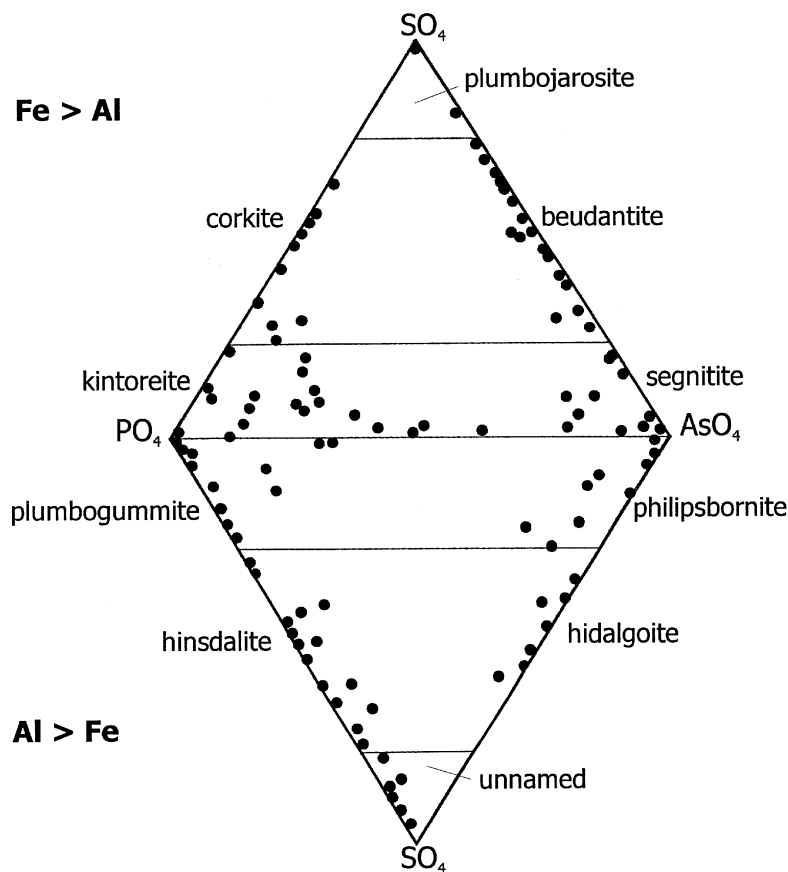


FIG. 4. Compositions of minerals within the Pb-dominant part of the alunite supergroup. Most of the data points are from Sejkora *et al.* (1998), with additions from Rattray *et al.* (1996), Matsubara & Matsuyama (1997), Roca *et al.* (1999), and Scott (2000). The nomenclature (updated) and boundaries are those of the CNMMN-approved system (Scott 1987). The unnamed field is shown by Scott (2000) as occupied by osarizawaite, but osarizawaite as currently defined is not the Al analogue of plumbojarosite.

affirmative, then some examples are illustrative of what may happen. Figure 2 shows the approved names in the jarosite and alunite groups and the boundaries according to the Scott (1987) system. Figure 3 shows some published compositions for jarosite, natrojarosite, and the Al-dominant analogues. It is evident that As-for-S and P-for-S substitutions occur, and that in the Scott (1987) system, the P-rich natroalunite shown in Figure 3 qualifies for another new mineral name on the basis of its composition. In a ternary system, the mineral is simply a phosphatian natroalunite.

Figure 4 is equivalent to Scott's (2000) Figure 2, but with additional data from compositions as noted in the caption. The uppermost As-bearing point is for jarosite or plumbojarosite with Pb:K = 1:1 (the analysis indicates a minute fractional predominance of Pb), but the point to be made is that the As-S solid solution has already been extended. Also within this diagram, IMA mineral No. 93-039 (Jambor 1999) is compositionally equivalent to Pb-Fe member kintoreite, but 93-039 has a doubled *c*-axis length and is entitled to a new name if the principle of the CNMMN ruling on minamiite is to be adhered to. As a last example, in their description of segnitite, Birch *et al.* (1992) noted that "...*beudantite shows anion disordering (AsO₄³⁻ and SO₄²⁻) (Szymański, 1988; Giusepetti [sic] and Tadini, 1989), whereas Giusepetti and Tadini (1987) suggest that corkite is anion ordered (PO₄³⁻ and SO₄²⁻). On these grounds, beudantite could be considered as the midpoint of a binary solid-solution series and, on the basis of recent IMA nomenclature rules, should not have species status. Corkite however, although a compositional midpoint, may be entitled to retain species status on structural grounds.*" The structural grounds alluded to in the preceding sentence refer to whether PO₄ and SO₄ are ordered, thus requiring that corkite have the space group *R3m* rather than *R3̄m*. In the ternary and structural system proposed by Jambor (1999), corkite and beudantite are end members in a solid-solution series, mineral 93-039 would not be entitled to a trivial name, and the outcome of ongoing discussions as to whether corkite has the space group *R3̄m* or *R3m* (*e.g.*, Kharisun *et al.* 1997) would not affect the basic nomenclature. Such a system of classification would be consistent with CNMMN rules and would seem to be a desirable improvement on the existing system.

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