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## Solid solutions in mineral nomenclature

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### Introduction

Guidelines for mineral nomenclature recommended by the Commission on New Minerals and Mineral Names (CNMMN) of the International Mineralogical Association were summarized by NICKEL and MANDARINO (1987–1989) and published in most of the international mineralogical journals.

One aspect of mineral nomenclature that was not covered in the guidelines was the question of how members of solid-solution series should be named. This matter was initially discussed by the Nomenclature Subcommittee of the CNMMN, and the recommendations of that body were subsequently considered and modified by the full CNMMN membership. These deliberations culminated in a general consensus that is embodied in this paper. Although similar to brief recommendations published by the Commission on New Minerals and Mineral Names of the All-Union Mineralogical Society of the USSR Academy of Sciences (Zap. Vses. Min. Ob. 106 [1977], 686–687), it is considered appropriate to publish this paper because it covers the subject more comprehensively and because it has the approval of the CNMMN.

Mineralogists wishing to give names to members of known solid-solution series are advised to adhere to the recommendations in this paper. However, to avoid confusion, mineral names or definitions already in the literature that contravene the recommendations should not be changed unless there are compelling reasons to do so, and then only if approved by a formal vote of members of the CNMMN.

Although general guidelines are recommended, readers will note that a certain degree of flexibility is permitted in the case of partial solid-solution series. Proposals for mineral names in this category will be judged by members of the CNMMN on the merits of each particular case.

Solid solutions can be considered in terms of three categories: complete solid solutions without structural ordering, solid solutions with structural ordering, and partial solid-solutions. Mineral nomenclature in each of these categories is discussed below.

### I. Complete solid-solutions without structural ordering

For purposes of nomenclature, a complete solid-solution series without structural ordering of the ions defining the end members is arbitrarily divided at 50 mole %, and the two portions are given different names, with each name applying to the compositional range from the end member to the 50% mark. For the sake of brevity this will be called the "50% rule". In figure 1, one name applies to the range A–c, and the other to the range c–B. A mineralogical example of this is the forsterite-fayalite

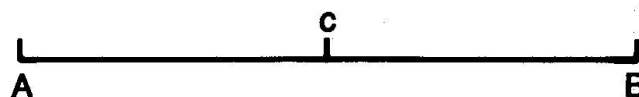


Fig. 1 Diagrammatic representation of a complete binary solid-solution series. A and B represent the two end members, and c represents the mid-point (50%).

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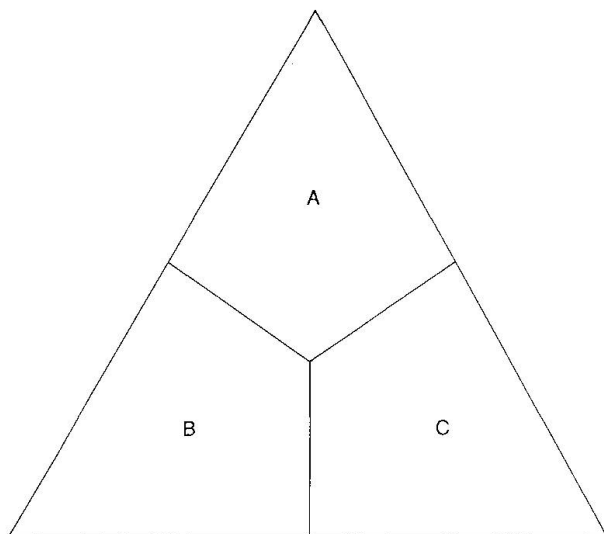


Fig. 2 Diagrammatic representation of a complete ternary solid-solution series. A, B and C represent the three compositional fields, each of which merits a mineral name.

series,  $(\text{Mg,Fe})_2\text{SiO}_4$ , in which the name forsterite applies to the compositional range from  $\text{Mg}_2\text{SiO}_4$  to  $\text{MgFeSiO}_4$ , and the name fayalite applies from  $\text{Fe}_2\text{SiO}_4$  to  $\text{MgFeSiO}_4$ .

Analogously, the 50% rule applied to members of ternary solid-solution series implies that mineral names should be given only to the three end members; each name should apply to the compositional range from the end member to the nearest right bisectors of the sides of the composition triangle, as shown in figure 2.

For example, in the apatite series,  $\text{Ca}_5(\text{PO}_4)_3(\text{F,OH,Cl})$ , the apices of the compositional triangle (Fig. 2) can be represented by F, OH and Cl, respectively, making A = fluorapatite, B = hydroxylapatite, and C = chlorapatite.

According to the same principle, in a multi-component solid-solution series different mineral names can be given to isostructural or isotypic phases that have different chemical elements dominant in specified structural sites. An example of this is provided by minerals of the monazite series in which a number of different rare-earth elements can predominate in the cation structural site. The dominant element then specifies the appropriate "Levinson" suffix, e.g. monazite-(La).

## 2. Solid solutions with structural ordering

If there is structural ordering of the ions that define the end members within an otherwise disordered solid-solution series, the ordered phase may be given a mineral name different from those of the end members. An example is provided by dolo-

mite,  $\text{CaMg}(\text{CO}_3)_2$ , in which ordering of the Ca and Mg ions results in a crystal structure distinct from those of calcite and magnesite, the Ca and Mg end-members, respectively, of the  $(\text{Ca,Mg})\text{CO}_3$  series. It is recommended that the name of a newly-described ordered phase discovered in an existing solid-solution series be derived from, or related to, the name of the solid solution or one of the end members, although the author of the name is not obligated to do so.

## 3. Partial solid-solution series

If there is limited solid solution at one or more of the end members, and the solid solution does not extend to the 50% mark, the 50% rule is generally applied. Therefore, in figure 3, the name of end-member A applies to the compositional range A-c

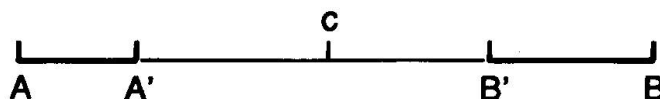


Fig. 3 Diagrammatic representation of a partial binary solid-solution series in which A'-B' represents the miscibility gap.

and the name of end-member B applies to the range c-B, even if known compositions extend only to A' or B'; this is to allow for the possibility of new chemical data extending compositions toward c. For purposes of nomenclature, it does not matter whether or not A and B are isostructural.

If the miscibility gap is to one side of the 50% mark, as in figure 4, and if the phases represented by A-A' and B-B' are not isostructural, a separate

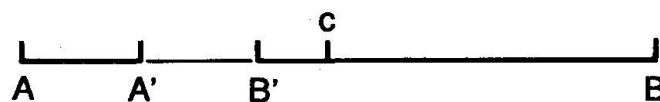


Fig. 4 Diagrammatic representation of a partial binary solid-solution series in which A'-B' represents the miscibility gap, and the range B-B' encompasses the midpoint, c.

name should not be given for the range B'c if it is very small, but if it is of substantial extent, then a separate name might be justified. The dividing line between a "small" range and a "substantial" one, in this case and others given below, can be taken as about 10 mole %, although each situation should be regarded on its own merits.

Similar considerations should apply to ternary or higher-order partial solid-solution series. Therefore, in a situation like that depicted in figure 5, the field defined by composition FGED does not warrant a separate name if it is very small, but may be given a separate name if it is of substantial size.

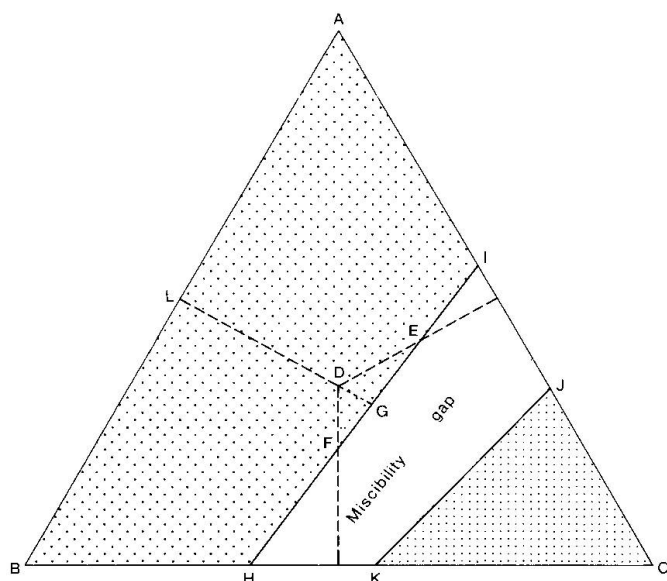


Fig. 5 Diagrammatic representation of a partial ternary solid-solution series in which the area HXJI represents the miscibility gap, and D represents the mid-point of the triangle.

If the known compositions embrace the 50% mark, but do not appear to extend to either end member (Fig. 6), only one name should apply to the compositional range. However, here again, the compositional range should be taken into account; if it is very small, then only one name should be

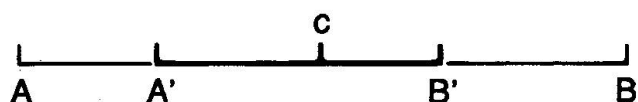


Fig. 6 Diagrammatic representation of a partial binary solid-solution series in which the solid solution is limited to the region A'–B'.

given, but if it is large, consideration may be given to two names. An example of a mineral in this category is pentlandite,  $(\text{Ni,Fe})_9\text{S}_8$ , the composition of which centres around  $\text{Ni:Fe} = 1:1$ , and compositions near the Ni and Fe end-members are not known.

The analogous situation in a ternary solid solution can be represented by figure 7, in which known compositions cluster about a geometric boundary

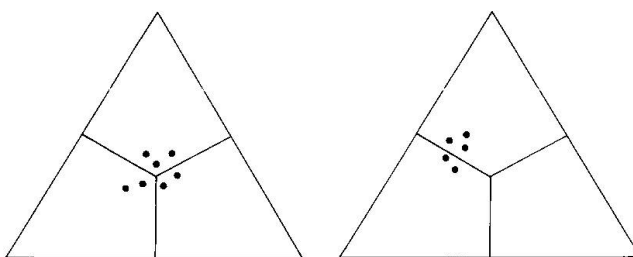


Fig. 7 Diagrammatic representation of ternary solid solution series in which known compositions cluster about geometric boundaries.

or boundaries. If the scatter of compositional points is small, only one name should be given to the cluster, but if the scatter is large, consideration can be given to more than one name.

In cases such as those illustrated by figures 6 and 7, one particular composition of a type specimen should be nominated as the type, because later work might well reveal a wider range of compositions justifying two (or more) names. One of these should be the name already in existence.

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