

ADJECTIVAL ENDING OF CHEMICAL ELEMENTS USED AS MODIFIERS TO MINERAL NAMES*

WALDEMAR T. SCHALLER, *U. S. Geological Survey.*

This paper is concerned with the question, can a uniform, clearly understandable scheme of nomenclature be adopted to express a minor and variable isomorphous replacement of an essential chemical element of a mineral by another analogous element?

Take, for example, celestite, strontium sulphate. Suppose we are describing a variety containing several per cent of barium isomorphously replacing a minor part of the strontium. How should such a variety be designated? By present usage any one of several expressions could be used—baric celestite, baricelestite, bariferous celestite, baro-celestite, barium celestite, barium-bearing celestite. Most of such expressions can be interpreted by the reader in more than one way. They may be taken to mean either a minor replacement of strontium by barium or a major, almost complete, replacement, yielding a compound that is essentially barium sulphate.

To cite another example, what does an author mean when he refers to a sodium orthoclase, a soda orthoclase, a sodic orthoclase, a sodiferous or a soda-bearing orthoclase? Does he mean a partial or complete replacement of potash, a chemical or a mineralogic isomorphism, a mechanical mixture of two mineral species (such as an intergrowth), or something still different?

Taking Dana's *System of Mineralogy*, 6th edition, as a comprehensive example of mineralogic literature, we find various methods used to indicate such minor and variable isomorphous replacement. Thus Dana lists the following terms:

1. Using the suffix *iferous*:
 - Seleniferous sulphur (p. 10).
 - Argentiferous gold (p. 15).
 - Ferriferous sphalerite (p. 61).
 - Zinciferous rhodochrosite (p. 278).
 - Cupriferous smithsonite (p. 279).
 - Chromiferous pyromorphite (p. 770).
2. Using the suffix *ian*:
 - Magnesian magnetite (p. 225).
 - Manganesian titanite (p. 714).

* Published by permission of the Director, U. S. Geological Survey.

3. Using the suffix *al*:

- Antimonial arsenic (p. 12).
- Arsenical silver (p. 43).
- Mercurial sphalerite (p. 61).

A similar form is also used as a synonym for a mineral as antimonial silver for dyscrasite.

4. Using the suffix *eous*:

- Cupreous manganese (lampadite, var. psilomelane, p. 258).

5. Using the suffix *ic*:

- Bismuthic gold (probably not isomorphous, p. 15).

6. Running the adjective and mineral name together:

- Manganbrucite (p. 252).
- Baricalcite (p. 269).
- Ferrocaltcite (p. 269).
- Zincocalcite (p. 269).
- Plumbocalcite (p. 269).
- Manganpectolite (p. 374).
- Manganapatite (p. 766).
- Cuprodescloizite (p. 788).
- Celestobarite (p. 902).
- Calcioclestite (p. 906).

Similar compound names are used for mineral species, whose chemical composition is accurately expressed by the name, as manganotantalite, ferri-tungstite, natrojarsite.

Similar forms that do not express such a relationship are also used as names of mineral species, as arsenopyrite (should have been named arsenomarcasite, being orthorhombic like marcasite and not isometric like pyrite), which is not a pyrite containing some arsenic; ferronatrite, which is not a natrite (synonym of natron) containing some iron; bismutosphaerite, which is not a sphaerite containing bismuth.

7. Using a hyphen:

- Palladium-gold (p. 15).
- Ferro-goslarite (p. 939).

8. Adding the chemical name:

- Chromium mica (fuchsita, var. of muscovite, p. 617).
- Barium mica (oellacherite, var. of muscovite, p. 617).

The name of the replacing element (for some the Latin form) with the proper suffix added seems the most desirable of the several forms listed. The use of a suffix is indicated above in 1, 2, 3, 4, and 5. There is thus formed a two-word phrase, short, accurate, and, if used consistently, readily conveying its meaning. Before considering the question whether or not a single suffix can be applied for all elements, the remaining usages (6, 7, and 8) may be briefly considered critically.

Joining the adjective and mineral name together (6) is too

uncertain as to the meaning. The first example cited above, "manganbrucite," does not differentiate between (a) a brucite in which a minor and variable quantity of manganese replaces a small portion of the magnesium, and (b) a mineral analogous to brucite ($\text{MgO} \cdot \text{H}_2\text{O}$) with the formula $\text{MnO} \cdot \text{H}_2\text{O}$ (pyrochroite). The term "manganbrucite" may be interpreted by a reader as synonymous with pyrochroite. The same difficulty arises with the other examples and with any other term so formed. As a matter of fact, the running together of the names of a chemical element and of a mineral species has been used in the naming of individual species of an isomorphous group, as is well shown by the minerals analogous to jarosite—plumbojarosite, argentojarosite, natrojarosite, ammoniojarosite

The use of the hyphen (7) is very uncommon but is open to the same objection, perhaps even to a greater degree.

Adding the chemical name before the mineral name (8) leads to the same confusion as joining the adjective and mineral name together. Does "chromium mica" mean a mica in which a little chromium replaces a minor part of the aluminum or a mica in which chromium is one of the essential constituents? The term "chromium-bearing mica" would be much better than "chromium mica."

If a single suffix can be found that will apply to the names of all chemical elements and if it is used consistently, then a two-word phrase, in which the first word denotes the replacing element and the second word is the name of the mineral in which isomorphous replacement of a minor and variable extent has occurred, will partake of a definite meaning readily interpretable by all.

After considering the suffixes in use, as listed above, and also others, the writer has concluded that the ending *ian*, or *oan* if it is desired to indicate a lower valency, is the most satisfactory, and its consistent use is here advocated. A chromium muscovite, or a chromium-bearing muscovite, given the variety name fuchsite, would then be called chromian muscovite. Similarly the variety of brucite called manganbrucite would be called manganoan brucite. If the chemical element has only one valency or the author does not wish to bring up the question of valency, *ian* should be used. There is no chemical element whose name ends in *an*, *ian*, or *oan*.

The objections to the use of other suffixes are noted below. The

various suffixes have been tried out on all the names of chemical elements, but most of such endings yield a few unsatisfactory names. The sound of the spoken form must be considered, though the written form would deserve the greatest consideration. Any scheme proposed must be adaptable to the names of all the chemical elements, to allow for any possible mineral combination that may be found in the future.

The main objection to *ic* lies in the possible "confusion which would result, owing to the use of this ending by chemists in a definite technical sense."¹ Chemists use it technically to express high states of oxidation. Thus ferric, manganic, and others are well understood chemical terms, used by way of contrast to ferrous, manganous, etc. The ending *ic* is also so generally used in such terms as geologic, electric, and topographic, that it could not be confined to a definite meaning. It is also the termination of the names of most acids, as carbonic, sulphuric, and phosphoric. The form for cesium would become *cesic* (seasick!), clearly understood when written but perhaps confusing when spoken. Changing *ic* to *itic* might be clearer, but the terms would be cumbersome and some at least not very euphonious.

A similar objection applies to *ous*, a recognized chemical ending denoting a lower state of oxidation. Thus ferrous, manganous and sulphurous are common chemical terms. Neither *ic* nor *ous* allows any latitude to express different valencies.

The ending *al* is one of the best and has few objections. Some of the words with this ending would not be euphonious.

The ending *iferous* is commonly used in mineralogic literature. It was recommended in Topic 6, D (last page) by the Committee on Nomenclature and Classification of the Mineralogical Society of America for 1923. As clearly defined by Wherry,² "Varieties based on isomorphism are also described by adjectives, constructed by adding the suffix *iferous* to the names of the elements present in the lesser amounts.*** In minerals in which one element is clearly essential and others replace it isomorphously, in widely varying but never significant amounts, the plan adopted in the preceding paper is followed: the name of the replacing element, with the suffix *iferous*, is used as an adjective." Although most

¹ Wherry, E. T., personal communication.

² Wherry, E. T., The nomenclature and classification of sulfide minerals: *Washington Acad. Sci. Jour.*, vol. 10, p. 487, 1920.

commonly used by Dana and other writers, *iferous* is open to two objections. It is long, giving such cumbersome words as *magnesiferous*, *aluminiferous*, and it may be misleading. Thus, some students would interpret the ending as relating to iron on account of the *ferous*. Wherry³ now feels the weight of these objections and recommends the use of the ending *ian*.

The names of all the chemical elements would be placed in seven groups. In each of the first six groups all the names would have the same ending; the seventh group would include names with various endings. The adjectival ending of the names of all the chemical elements is formed according to the rules given under each group. Ordinary usage is followed in applying the suffix to the names. Latin names are used for copper, (*cuprum*), gold (*aurum*), iron (*ferrum*), lead (*plumbum*), silver (*argentum*), and tin (*stannum*). *Stibium* is optional for antimony, *natrium* for sodium, and *wolfram* for tungsten, but *hydrargyrum* is not used for mercury and *kalium* is not ordinarily used for potassium. If lower valency is to be expressed, use *oan* instead of *ian*, as in *ferroan* and *ferrian*.

GROUP 1. If the name ends in *um*, drop the *um*, and add *ian* (or *oan* if a lower valency is to be expressed).

Aluminum—aluminian.

Ferrum—ferroan and ferrian.

GROUP 2. If the name ends in *ium*, drop the *um*, and add *an*.

Barium—barian.

GROUP 3. If the name ends in *ine*, drop the *ne*, and add *an*.

Bromine—bromian.

GROUP 4. If the name ends in *on*, add *ian*, except for boron and silicon.

Carbon—carbonian.

For boron and silicon, drop the *on* and add *ian*.

Boron—borian.

Silicon—silician.

The abbreviated forms for boron and silicon follow the generally adopted usage, as the shorter forms *boric acid* and *silicic acid* are more commonly used in mineralogic literature than *boracic acid* and *siliconic acid*. For iron, the Latin name *ferrum* is used (Group 1).

GROUP 5. If the name ends in *gen* (three gases), add *ian*.

Hydrogen—hydrogenian.

³ Personal communication.

GROUP 6. If the name ends in *y*, drop the *y*, and add *ian* (or *oan*).

Antimony—antimonian

Mercury—mercuroan and mercurian.

GROUP 7. For the following names, use the form shown.

Arsenic—arsenoan and arsenian.

Bismuth—bismuthian.

Cobalt—cobaltian.

Manganese—manganoan and manganian.

Nickel—nickelian.

Phosphorus—phosphorian.

Sulphur—sulphurian.

Zinc—zincian.

Tungsten—tungstenian or wolframian.

The adjectival endings thus formed for the names of all the chemical elements are given below.

Aluminum—aluminian	Helium—helian
Antimony—antimonian	Holmium—holmian
Argon—argonian	Hydrogen—hydrogenian
Arsenic—arsenoan, arsenian	Indium—indian
Barium—barian	Iodine—iodian
Beryllium—beryllian	Iridium—iridian
Bismuth—bismuthian	Iron—ferroan, ferrian
Boron—borian	Krypton—kryptonian
Bromine—bromian	Lanthanum—lanthanian
Cadmium—cadmian	Lead—plumbian
Calcium—calcian	Lithium—lithian
Carbon—carbonian	Lutecium—lutecian
Cerium—cerian	Magnesium—magnesian
Cesium—cesian	Manganese—manganoan, manga- nian
Chlorine—chlorian	Mercury—mercuroan, mercurian
Chromium—chromian	Molybdenum—molybdenian
Cobalt—cobaltian	Neodymium—neodymian
Columbiun—columbian	Neon—neonian
Copper—cuproan, cuprian	Nickel—nickelian
Dysprosium—dysprosian	Nitrogen—nitrogenian
Erbium—erbian	Osmium—osmian
Europium—europian	Oxygen—oxygenian
Fluorine—fluorian	Palladium—palladian
Gadolinium—gadolinian	Phosphorus—phosphorian
Gallium—gallian	Platinum—platinian
Germanium—germanian	Potassium—potassian
Gold—aurian	Praseodymium—praseodymian
Hafnium—hafnian	

Radium—radian	Tellurium—tellurian
Radon—radonian	Terbium—terbian
Rhenium—rhenian	Thallium—thallian
Rhodium—rhodian	Thorium—thorian
Rubidium—rubidian	Thulium—thulian
Ruthenium—ruthenian	Tin—stannian
Samarium—samarian	Titanium—titanian
Scandium—scandian	Tungsten—tungstenian
Selenium—selenian	Uranium—uranoan, uranian
Silicon—silician	Vanadium—vanadian
Silver—argentian	Xenon—xenonian
Sodium—sodian	Ytterbium—ytterbian
Strontium—strontian	Yttrium—yttrian
Sulphur—sulphurian	Zinc—zincian
Tantalum—tantalian	Zirconium—zirconian

Where an element shows more than two valencies, the proper form can easily be made. Thus, for vanadium:

For vanadous vanadium, valency of 3, use vanadoan.

For vanadyl vanadium, valency of 4, use vanadylian.

For vanadic vanadium, valency of 5, use vanadian.

Some practical examples would then be:

Aluminian chromite for a chromite with a minor quantity of aluminum replacing part of the chromium.

Antimonian tennantite if the mineral contains a little antimony.

Barian celestite

Cadmian sphalerite

Calcian siderite

Cerian xenotime

Ferrian variscite

Manganoan siderite (manganous manganese)

Manganian spodumene (manganic manganese)

Rubidian lepidolite

Uranoan zircon (uranous uranium)

Uranian fergusonite (uranic uranium)

Tungstenian or wolframian powellite

Zincian tetrahedrite

The various forms given by Dana and listed in the earlier part of this paper, except for those of group 2 which remain unchanged, would then be changed as follows:

Seleniferous sulphur becomes selenian sulphur

Argentiferous gold becomes argentine gold

Ferriferous sphalerite becomes ferroan sphalerite

Zinciferous rhodochrosite becomes zincian rhodochrosite

Cupriferous smithsonite becomes cuprian smithsonite
 Chromiferous pyromorphite becomes chromian pyromorphite
 Antimonial arsenic becomes antimonial (or stibian) arsenic
 Arsenical silver becomes arsenian silver
 Mercurial sphalerite becomes mercurian sphalerite
 Cupreous manganese becomes cuprian manganese (psilomelane)
 Bismuthic gold becomes bismuthian gold
 Manganbrucite becomes manganoan brucite
 Baricalcite becomes barian calcite
 Ferrocalcite becomes ferroan calcite
 Zincocalcite becomes zincian calcite
 Plumbocalcite becomes plumbian calcite
 Manganpectolite becomes manganian pectolite
 Manganapatite becomes manganian apatite
 Cuprodescloizite becomes cuprian descloizite
 Celestobarite becomes strontian barite
 Calciocelstite becomes calcian celestite
 Palladium-gold becomes palladian gold
 Ferro-goslarite becomes ferroan goslarite
 Chromium mica becomes chromian mica
 Barium mica becomes barian mica

Some names of varieties of minerals would be abandoned, the two-word phrases being used instead, thus doing away with the uncertainty of determining whether a nondescriptive mineral name represents a species or only a variety of some species whose name bears no relation to the name of the variety. Thus

Marmatite becomes ferroan sphalerite
 Przibramite becomes cadmian sphalerite
 Tarnowitzite becomes plumbian aragonite
 Tawnawite becomes chromian epidote
 Danaite⁴ becomes cobaltian arsenopyrite
 Freibergite becomes argentian tetrahedrite
 Schwatzite becomes mercurian tetrahedrite
 Malinowskite becomes plumbian tetrahedrite
 Sandbergite becomes zincian tennantite
 Worobieffite becomes cesian beryl
 Actinolite becomes ferroan tremolite (as long as the molecular ratio of MgO is greater than that of FeO)
 Cuprogoslarite becomes cuprian goslarite
 Pisanite becomes cuprian melanterite or ferroan boothite, depending on whether iron or copper is in excess (molecularly)
 Nicholsonite becomes zincian aragonite
 Molybdosodalite becomes molybdenian sodalite
 Ferroprehnite becomes ferrian prehnite

⁴ This term is liable to be confused with danalite.

The two-word phrase would then be interpreted as referring to a minor and variable isomorphous replacement of an essential constituent. It would also mean that a *variety* of the mineral is being named.

Obviously, the scheme above set forth would apply only to single isomorphous replacement. If the essential element of the mineral is replaced by more than one element, then the name of the element whose replacing effect is the largest, or is for some reason to be emphasized, would be used. Thus if a brucite contains 5 per cent of MnO (molecular ratio 0.07), 2 per cent of ZnO (molecular ratio 0.02), and 1 per cent of FeO (molecular ratio 0.01), it would still be called manganian brucite. The determination as to which element has the largest replacing effect should be based on molecular ratios and not on chemical percentages. If more than one essential chemical element in a mineral is partly replaced by other elements, then the element showing the greatest replacement should be chosen for the adjectival name.

For many minerals (such as tourmaline) the question of isomorphous replacement is so complex that the problem of determining what scheme should be used for naming the varieties can well be left to the future. The number of varieties to which the plan herein suggested is applicable is sufficiently large to warrant its consideration. Perhaps the plan, if acceptable, will suffice as a beginning upon which decisions as to the more complex questions can be based.