

MINERALOGY.—*Variations in the compositions of minerals.*

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With the advance of scientific knowledge it becomes necessary from time to time to revise some of our most fundamental conceptions and definitions. In chemistry, for instance, the old view is being abandoned that mixtures differ from compounds in that the former can be separated into their constituents by "mechanical means" while the latter cannot.²

Most of our text-books of mineralogy are largely based on Dana's System of 1892, and ignore the important advances which have taken place since that time. In particular, the writer believes that the conception of mineral species which permeates them is in need of revision, for, in the light of recent work, variability of composition must apparently be recognized as a fundamental principle of mineralogical chemistry. It is therefore proposed that a species be defined as *a natural inorganic substance whose chemical and physical properties are constant only within certain limits*, these limits varying widely from one case to another. The possible ways in which variations in the chemical composition of minerals can occur are through adsorption, isomorphous replacement, and solid solution.

Adsorption. While most minerals exemplify the crystalloidal state of matter, colloids are also not infrequently represented. As has been pointed out by several writers,³ all minerals appearing wax- or gum-like, or with botryoidal, dendritic, globular, mammillary, nodular, reniform, or stalactitic structures, and at the same time showing an amorphous character under the microscope, are to be regarded as gels, or solid colloids.

¹ Read at the Rochester meeting of the American Chemical Society, September, 1913.

² W. Lash Miller, *Science*, **34**: 257 1911.

³ F. Cornu, *Centr. Min. Geol.*, **1909**: 324; R. Marc, *Fortschritte Min. Kryst. Petr.*, **3**: 11; A. Himmelbauer, *ibid.*, **3**: 32 (including a 6-page bibliography), 1913.

My excuse for treating this subject so fully at this place is that American mineralogists appear to have underestimated the importance of these contributions: in six recent text-books I have been unable to find the word colloid.

One of the most striking features possessed by gels is their power of adsorbing foreign substances. For instance, the ability of the sesquioxides, when precipitated with ammonia, to take up considerable amounts of phosphoric acid, boric acid, etc., has long been recognized, and analytical methods modified in the presence of these substances. The amounts so adsorbed bear in general no relation to the molecular weights of the substances concerned—that is, the law of definite proportions is not obeyed—except that “the composition of many [natural] gels agrees frequently quite exactly with the corresponding formulas of crystallized minerals.”⁴

The extent to which adsorption causes variations in the compositions of colloid minerals becomes evident when the analyses of bauxite, psilomelane, wad, the clays, chrysocolla, etc., are inspected. It is not so certain, however, which constituents should be regarded as united and which as adsorbed in these minerals. Is an amorphous clay containing silica, alumina and water to be regarded as an adsorption product of SiO_2 gel, Al_2O_3 gel, and water, or as kaolinite gel ($\text{H}_4\text{Al}_2\text{Si}_2\text{O}_9$) containing an excess of one or the other constituents adsorbed? It will be necessary to develop methods for the proximate analysis of colloidal minerals—staining, fractional solution, plotting dehydration curves, etc.—before such questions can be settled, a problem that will keep mineralogical chemists busy for some time to come. But meanwhile we should face the issue squarely, and in stating the composition of such minerals admit their variable character instead of attempting to assign them definite formulas, as is done in text-books.

Then there is a whole series of minerals whose superficial appearance is that of colloids, but whose fibrous or foliated internal structure betrays their crystallinity, such as chalcedony, limonite, malachite, serpentine, dufrenite, etc. As there appears to be no single descriptive term⁵ in use for these, the word *meta-colloid* is here proposed. A *meta-colloid* is to be defined as a substance which, though originally colloidal in character, has be-

⁴ Cornu, op. cit., p. 336.

⁵ Himmelbauer, op. cit., p. 39, calls them “gealterte Gelen.”

come more or less crystalline, for this has evidently been the history of most of this class of minerals.

If the original colloids have compositions approaching those of definite crystallizable compounds, then the change to a meta-colloid may be regarded as a simple molecular rearrangement. But if adsorbed constituents are present in excess over the requirements for such compounds, what becomes of them? Observations bearing directly on this point are lacking, but some analyses of meta-colloid minerals are certainly on record in which the presence of foreign material is shown. It is only necessary to turn to garnierite (Dana, System, p. 677), chloropal (*ibid.*, p. 701) and dufrenite (*ibid.*, p. 797), all of which often look crystalline (cryptocrystalline) and homogeneous under the microscope, to find examples of this. It would therefore seem that in some cases, at least, adsorption may occur even in meta-colloids, so that *it can not be regarded as safe to consider crystallinity alone of minerals, whose features are those of meta-colloids, as a certain proof of their definiteness of composition.*

Solid solution. Especially in substances appearing in distinct crystals it is quite generally assumed that, except for isomorphous replacement,⁶ the composition is fixed, constant, and definite. Yet even here there is evidence that some variation may occur. Two cases have recently been discussed elaborately: nephelite, which often contains 2 per cent more SiO_2 than is required by its simple formula without evident effect on its crystallographic constants, optical properties, or any other features;⁷ and pyrrhotite, in which the amount of sulphur can vary from 36.3 per cent corresponding to FeS , to over 40 per cent, with only slight changes in axial ratio and specific gravity, and without loss of crystallinity or characteristic properties.⁸

But other well crystallized minerals have yielded analytical results exhibiting even greater variability in the amounts of con-

⁶ The subject of isomorphous replacement is fully treated in the text-books, and need not be discussed here. In one sense it is, of course, only a special case of solid solution, but this term is here used only for non-isomorphous combinations.

⁷ Foote and Bradley, *Amer. Jour. Sci.*, **31**: 25, 1911; **33**: 439, 1912.

⁸ Allen, Crenshaw, Johnston and Larsen, *Amer. Jour. Sci.*, **33**: 169, 1912.

stituents, especially the columbates, tantalates and titanates, but also some sulfo-salts (binnite, tetrahedrite), halides (fluocerite, yttrocerite), oxides (strüverite, uraninite), silicates (some pyroxenes and amphiboles, to account for the composition of which the conception of isomorphous replacement has to be made unreasonably broad), etc.

It is customary at the present time to consider this variability as due to "solid solution." Of course, the mere giving a phenomenon a name does not explain it, but whatever may be its significance its existence cannot be denied and should not be overlooked. Consequently, *even crystallinity cannot fairly be regarded as a certain criterion of the absence of "solid solution" or accordingly of the definite chemical composition of a mineral.*¹

In conclusion, it may be urged that in future text-books and writings dealing with the establishment of mineral species, notice be taken of these relations, and that there be included along with the simple, essential formula of each mineral, in so far as one can be recognized, a statement of the extent to which variations in its composition occur.

BOTANY.—*A hybrid between Tripsacum and Euchlaena.* G. N. COLLINS and J. H. KEMPTON, Bureau of Plant Industry.²

In connection with studies in the heredity of maize and related plants a fertile hybrid has been secured between *Tripsacum dactyloides* L. and *Euchlaena mexicana* Schrad.

Euchlaena mexicana or teosinte is an annual grass, native in Mexico, often grown for forage. The variety grown in the United States requires a long season to mature and the only place where seed is produced is in southern Florida. *Tripsacum dactyloides* is a perennial grass, native in many parts of eastern United States. The plant is of no economic importance.

The genera *Euchlaena* and *Tripsacum* are placed in separate groups of the tribe Maydeae and the plants are so different that

¹ This is in no way intended as a denial of the definite molecular structure of crystals; and that it is quite possible to reconcile the latter conception with the existence of solid solution will be shown in a later paper.

² Presented before the Botanical Society of Washington, February 3, 1914.