

# THE AMERICAN MINERALOGIST

VOL. II

SEPTEMBER, 1917

No. 9

## GEL MINERALS (COLLOID MINERALS)

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A subject of growing importance to the mineralogist at the present time is that of the part colloids play in the formation of minerals. The application of colloidal chemistry to other branches of practical science has been extensive, but until very recently little work has been done from the mineralogical point of view. The existence of minerals which have had a colloidal origin has long been recognized, but our means of identifying them has been almost entirely from their external appearance and occurrence. The object of the work described in this paper was to secure some method for their identification. While no results of a positive nature were obtained, a few things of interest may be presented.

In order that the reader may obtain a rather clear conception of the subject of colloidal chemistry, a few definitions and descriptions of phenomena exhibited are given here:

*Colloid.* This refers to a condition or state of matter. As Wolfgang Ostwald points out<sup>2</sup> "we can speak of 'colloids' only as we speak of 'crystals,' 'amorphous substances,' 'soluble and insoluble' substances, or, better still, 'gaseous, liquid and solid' substances. *All substances can appear as colloids under appropriate conditions.*" In other words, any chemical compound may appear either as a colloid or as a crystalloid.

There is no relation between chemical composition and colloidal condition. However, what Ostwald characterizes<sup>3</sup> as a law governing the relation is "The more complex chemically the compound, the greater the probability that it is in a colloidal state." As an example he gives gelatin, a compound the formula of which has never been definitely determined.

*Phase.* By a phase is meant any homogeneous part of a system different from the other parts of the system and separated from these by abrupt transitions. Dispersed phase is the finely divided, discontinuous phase. Dispersion-means is defined as the continuous or closed phase. In the case of colloidal suspensions the dispersed phase is a solid and the dispersion-means a liquid.

<sup>1</sup> Thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in the Faculty of Pure Science of Columbia University, 1916.

<sup>2</sup> Ostwald (Fischer) Handbook of Colloid-Chemistry. [1st English edition.] P. Blakiston's Son & Co.: Philadelphia, 1915; p. 2. <sup>3</sup> *ibid.*, p. 2.

When dealing with emulsoids the dispersed phase is a liquid and the dispersion-means a liquid. As Ostwald points out<sup>4</sup> the dispersed phase and dispersion-means are geometrically and structurally different.

*Sol.* A term introduced by Thomas Graham, which means a colloidal solution, or, as Ostwald states<sup>5</sup>, is a special name for spatially homogeneous systems.

*Gel.* A gel he defines<sup>6</sup> as a system in the course of passing to or from a condition of spatial homogeneity.

*Hydrosol.* In the case of the hydrosol the dispersion-means is water and the dispersed phase is the substance in the colloidal condition. In addition there are alcosols (alcohol sols), sulfosols (sulfuric acid sols), organosols (in which the dispersion-means is an organic liquid). Corresponding to these we have hydrogels, sulfogels and organogels. In nature the most widely distributed sols are no doubt hydrosols, but sulfosols and organosols may play an important part. The reactions which go on are by no means simple.

*Adsorption.* A property which gels possess to take up foreign material from solution. Example: the barium and potassium content of psilomelanite.

When a change in state of a colloid may be reversed by reversing the conditions which produce that change, it is said to be reversible. In Colloidal Chemistry we have both reversible and irreversible colloids. Among minerals the only reversible colloid is said to be ilsemannite.<sup>7</sup>

*Isocolloid.* When the dispersed phase and the dispersion means have the same chemical composition, the system is known as an "isocolloid."

*Tyndall Ray Phenomena.* It is a common experience to observe the dust particles in the air when a beam of sunlight is admitted to a darkened room. These particles are made visible by unequal illumination. This is the basis of the Tyndall ray effect.

A strong arc with a suitable system of lenses produces a beam of light which makes visible fine particles dispersed in a liquid or other medium. It is upon this principle that the ultra-microscope depends.

A useful apparatus for producing a Tyndall ray can be made by using a small arc light placed behind a camera box. By removing the lens and substituting a low-power objective from a microscope, a very fair light cone is produced for rough work. The adjustable diaphragm on the camera makes it possible to obtain a suitable sized cone. The solution to be tested can be placed on the stage of a microscope, in a thin-walled glass vessel,

<sup>4</sup> *ibid.*, p. 25.

<sup>5</sup> *ibid.*, p. 24.

<sup>6</sup> *ibid.*, p. 24.

<sup>7</sup> The nature of this mineral has been, however, misinterpreted: see Schaller, *J. Wash. Acad. Sci.* 7, 417, 1917. [Editor.]

and the light cone directed thru it. By focussing on the narrow part of the ray very good effects are produced.

*Brownian Movements.* All dispersoids that have a liquid or gaseous dispersion-means and a sufficiently great degree of dispersion show certain movements. This phenomenon was discovered by Brown, an English botanist, and named after him. Zsigmondy has described the movement in colloidal solutions as "hopping, skipping and dancing."

In the case of microscopic particles the movement is along a curved path, while smaller particles move in straight lines and change their direction suddenly.

Brownian movements may be observed in metal hydrosols, metal sulfide hydrosols, animal and vegetable milks, also in tobacco smoke and cooling ammonium chloride vapors. The movements can be observed satisfactorily only under high magnification.

Since colloidal solutions are merely a special case of dispersoids, Ostwald<sup>3</sup> has classified the dispersoids by taking the three states of matter—solid, liquid, and gas, and has obtained the following nine possibilities:

1. Solid + solid. 2. Solid + liquid. 3. Solid + gas. 4. Liquid + solid. 5. Liquid + liquid. 6. Liquid + gas. 7. Gas + solid. 8. Gas + liquid. 9. (Gas + gas).

*Examples:*

1. *Solid + solid.* Intercalations of foreign particles in minerals (microliths, etc.), carbon particles in iron, of coloring matter in mineral salts and precious stones, "solid" colloid solutions, mixed crystals, solid solutions.

2. *Solid + liquid.* Liquid intercalations in many minerals; water of occlusion, inclusion, and crystallization.

3. *Solid + gas.* Gaseous inclusions in many minerals (meerschäum, pumice stone, lava, tufa), solutions of gases and solids (hydrogen in iron, etc.).

4. *Liquid + solid.* Suspensoids.

5. *Liquid + liquid.* Emulsoids.

6. *Liquid + gas.* Foams.

7. *Gas + solid.* Smoke, for example, tobacco smoke; condensing metallic vapors; cooling vapors of ammonium chloride; cosmic dust, etc.

8. *Gas + liquid.* The fog formed at the liquefaction point of gases or in the condensation of steam, atmospheric fogs, clouds, Tyndall photo-chemically produced liquid fog, etc.

9. *Gas + gas.* Since gases are completely miscible in each other in all proportions, no examples are known.

Of these the ones of most importance are Nos. 4 and 5 to the colloidal chemist in general, while to the mineralogist the one of primary importance is the fourth, namely, "suspensoids."

<sup>3</sup> Handbook of colloid-chemistry, p. 43.

(To be Continued)