From (1) it follows that antitoxin destruction may take place with or without protein splitting.

3. In solutions containing trypsin and 0.5% sodium carbonate the results were the same as in (2).

4. Tetanus antitoxin in 0.2% hydrochloric acid was completely destroyed in three or more days. During this time no significant chemical changes in the proteins were detected.

5. In neutral solutions pepsin did not affect the antitoxin.

6. In pepsin-hydrochloric acid, proteolysis and antitoxin destruction proceeded simultaneously.

These results tend to indicate that tetanus antitoxin is a substance of non-protein nature. But the stability of the antitoxin is so dependent upon that of the protein to which it is attached, that whenever the protein molecule is split, the antitoxin splits with it.

The experimental details are given in the *Journal of Agricultural Research*, 1918.

[1] Homer, A., *J. Hygiene, London*, **15**, 1916, (388–400).
[2] Rosenau, M. J., and Anderson, J. F., *Hygienic Lab. Bull.*, No. 43, 1908.

TESTS FOR FLUORINE AND TIN IN METEORITES WITH NOTES ON MASKELYNITE AND THE EFFECT OF DRY HEAT ON METEORIC STONES

By George P. Merrill

Department of Geology, United States National Museum, Washington

Communicated by E. W. Morley, April 29, 1918

The following is a partial report on results obtained in continuation of work under a grant from the J. Lawrence Smith Fund of the National Academy of Sciences.

1. On Fluorine in Meteoric Stones.—So far as I am aware the occurrence of fluorine has never been recognized in meteoric stones. Meunier[1] records its presence as doubtful. Fletcher in his Handbook does not mention it at all, nor is it mentioned by Cohen nor by Lockyer in his Meteoritic Hypothesis as one of the elements even recognizable by the spectroscope. Nevertheless, the occurrence of a calcium phosphate has often suggested its possible presence, and the wide distribution of this phosphate in meteoric stones, which I have shown of late[2] seemed to warrant further tests, particularly as new and more refined methods for its detection had been discovered. Opportunity for these tests was recently afforded by Dr. E. T. Wherry when engaged upon the investigation of some fossil bones for Dr. Hrdlička in the Museum laboratories. The method consists in the digestion of the material in concentrated sulphuric acid in a small flask heated to 200°C. in a paraffine bath, the process being continued for four to five hours. The gases evolved are bubbled through water, the fluorine being retained in water solution (in a U tube). In ordinary work it is customary to titrate the solution thus obtained with a standard alkali, but inasmuch as the meteoric samples tested contained both chlorides and sulphides, which would yield hydrochloric acid and sulphur dioxide, it was necessary to make the solution first alkaline with sodium hydroxide and evaporate nearly to dryness in a platinum dish on the water bath, the resulting concentrated solution being then added to a standard peroxidized titanium solution in a colorimeter. Fluorine has the power of decolorizing or at least reducing the intense yellow color of this titanium solution, even when present to an amount not exceeding 0.001%.

Three samples were tested—Bluff, Texas; Allegan, Michigan; and Waconda, Kansas, in each of which phosphoric acid (P_2O_5) to the amount of 0.25% has been recorded, and in all of which the phosphate had been recognized microscopically. Amounts of from 10 to 20 grams were used in the tests, and in not a single instance did the titanium solution show the least sign of the presence of fluorine. It would seem safe to assume, then, that in these cases at least the element was not present.

2. *Further Tests for Tin in Meteorites.*—It will be recalled that in my report on previous investigations, I stated that no traces of tin had thus far been found by us. Incited, however, by the work of Derby[3] I was led to follow up the matter still further. Derby, it will be remembered, reported 1.18% tin in the schreibersite of the Cañon Diablo iron. Concerning this, he states, "Tin has not been reported (i.e., previously) possibly because the solution has usually been made in aqua regia in which it would only appear through a special research. In the present case, the solution was made in plain nitric acid and the tin appeared as oxide and was verified by blowpipe tests."

Having obtained a considerable quantity of material, chiefly schreibersite and cohenite with some carbon from various digestions of the Cañon Diablo iron in dilute hydrochloric acid, I submitted it to Dr. Whitfield with the request that he examine the same with no other end in view than the determining of tin, if present. The results were negative. Two lots of 5 grams each were taken and dissolved in nitric acid as described by Derby. Not a trace of tin could be found, either in the first solution, as oxide, or by treating the solution with hydrogen sulphide, in the customary way.

On the assumption that there is no error in Derby's work, we must assume as suggested by him, that the tin does not belong to the schreibersite but to another mineral that is not generally distributed throughout the meteoric mass so that it only appears in certain portions of the residue.

3. *On Maskelynite.*—In a very large proportion of the stony meteorites I have described, or studied, mention is made of a colorless, interstitial material either quite isotropic or slightly doubly refracting, with rather low index of refraction, which, following Tschermak and others, I have called, though

often with mental reservations, maskelynite. The material first described under this name, it will be remembered, was found as a prominent constituent of the meteorite of Shergotty, and was sufficiently abundant to allow a satisfactory determination of all of its properties, including chemical composition. All occurrences since noted are of microscopic dimensions—mere interstitial areas of rarely more than two or three millimeters in diameter, and determinable properties so nearly negative that the referring of the mineral to maskelynite has been more in the nature of an acknowledgment to the quality of Tschermak's work than to actual determinations on the part of those describing it. This certainly was true in my own case,[4] and it was not until I was studying the stone of Holbrook, Arizona (1912), that I separated particles and by the recently introduced immersion method determined the index of refraction to be 1.51, which, according to Larsen's tables, is that of an oligoclase glass. Since that writing I have followed up the matter as systematically and thoroughly as time and opportunity will permit, and have reached the conclusion, pronounced without hesitation, that the mineral is in all cases feldspathic, ranging in composition from oligoclase to anorthite, and owes its condition to a fusion since the original crystallization of the stone, followed by a cooling too rapid to allow it to regain its normal properties.

These conclusions are based upon examinations of a large number of sections in which I have found the mineral in all stages from a glass essentially isotropic with the low index (1.51) mentioned above to one plainly biaxial but without crystal outlines, cleavage, or other recognizable properties, with indices of 1.543 and 1.545, and in one case (Ness Co.) 1.56. Also in forms where the mineral is largely isotropic but still retains, in places, traces of plagioclase twinning. It is this last feature, it should be stated, that causes me to consider it a re-fused feldspar, rather than a residual and original feldspathic glass.

These observations, it will be observed, are supplemental and corroborative of those of Tschermak.[5] The subject seems worthy of this extended notice, not merely on account of the new observations, but since Farrington in his recent *Meteorites* remarks concerning the mineral that "Its exact nature is yet to be determined."

Attention should be called, in this connection, that an elevation of temperature sufficient to fuse a feldspar without at least partial destruction of the olivine would be impossible but in an atmosphere completely devoid of all oxidizing gases. (See further under Effects of Heating, below.)

4. *Effects of Heating Meteoric Stones at Various Temperatures.*—The fact that Meunier had transformed meteoric stones of his aumalite group into tadjerites, by heating to redness, suggested the availing myself of opportunities offered by the Pennsylvania Zinc Company at their works at Palmerston, Pennsylvania. A series of prepared specimens, including two cubes, one each of the Estacado and Homestead meteorites, some 10 mm. in di-

ameter, were introduced into pits bored in fire-brick, and sealed up with fire-clay. These bricks were then placed on top of a gas-fucl zienc smelter, where they were allowed to remain for a period of four months, and in an atmosphere in which oxidizing influences were reduced to a minimum. The exact temperature could not be determined, but a cube of the Casas Grandes iron in one of the pits was completely fused and absorbed into one of the bricks, indicating a temperature not less than 1450°C. The results on the two stones were as follows:

Estacado, Texas.—This, a veined crystalline chondrite of a dark gray color, fine and compact texture, consists essentially of olivine and enstatite with smaller amounts of pyrrhotite and nickel-iron. Before heating, the silicates are colorless and limpid, and the metallic constituents scattered in small granules fairly uniformly throughout the mass. The roasting resulted in producing a slight glaze on the exterior surface of the cube. The color was much darkened, becoming uniformly dull black. Although remaining firm and hard, the stone became filled with fine vesicles. The thin section under the microscope seemed at first completely amorphous. In strong sunlight, however, the silicates, although nearly opaque and without action in polarized light, were of a deep dull red, indicating a certain amount of oxidation of the iron. The interstices were filled with a fine, dust-like, opaque and amorphous matter which is impossible of determination. The particles of metal had been fused and the material diffused throughout the ground to appear in the form of minute blue points in reflected light. With the exception of the metal not a single one of the original constituents was recognizable.

Homestead, Iowa.—This is a dark gray, homogeneous, hard and firm stone belonging to Brezina's brecciated gray chondrite group. The mineral composition, as determined by Wadsworth, is olivine, enstatite, pyrrhotite, iron, and base. Lasaulx is quoted as having noted the occurrence of a feldspar. I find, in addition, a polysynthetically twinned pyroxene and a calcium phosphate in small quantities. After the roasting, the color is dull black and the texture finely vesicular, although firm and hard. As was the case with the Estacado stone, it is so opaque in thin sections as to almost entirely obscure its original structure. The silicates are altered in the same manner, though the olivine is the most affected; the metal is likewise diffused, and attempts at making a photo-micrograph from the slides resulted in complete failure. As it was evident the experiment had been carried too far a second attempt was made in the museum laboratory at lower temperatures and for shorter periods.

Small pieces of the Homestead meteorite, of 2 or 3 grams weight, were roasted in a covered crucible at a low red heat for periods of one-half and one hour each, the gas flame playing freely up and around the crucible. The external manifestations of this heating were a change in color to dark gray and a fusion, on the outer surface, of the troilite granules. A thin section showed the nickel-iron to be unchanged, though the troilite had been broken up to a greater or less extent. The principal change lay in the finer siliceous material occupying the interstices of the other minerals which had turned, in part, black and amorphous. A like change had taken place along the borders of the chondrules and cleavage and fracture lines of the larger phenocryst, giving them the appearance of having been injected with some dark coloring fluid. The amount of change was proportional to the length of time in heating, as shown in figures 1, 2 and 3.

Figure 1 is from the unaltered stone and 2 and 3 from fragments heated for one half and one hour respectively. It will be noted that there is an increase in the amount of black opaque matter in 2 and 3 over that in 1. In the piece roasted for a full hour the fine interstitial silicates have become wholly changed to the black matter which penetrates the borders of the chondrules and other crystal aggregates, until a condition is reached so closely resembling that shown in sections of the McKinney (fig. 4) and Travis County (fig. 5) black chondrites as to apparently leave no doubt as to the correctness of Meunier's view to the effect that such are but phases of chondritic stones which have been altered through a re-heating subsequent to their first crystallization. It should be added that these roasted pieces are partially restored to their original color by digestion in hydrochloric acid and sodium carbonate, showing that the change is one that has influenced chiefly the olivine. Incidentally attention may well be called to the manner in which the blackening of the stone first manifests itself along cleavage and fracture lines in figure 5.

It should be noted further that it is doubtful if all of the dark color in these black chondrules is due to roasting, since some of them heated in a closed tube give evidence of the presence of a small amount of a hydrocarbon.

[1] *Encyclopédie Chimique*, **2**, appendix 2, Meteorites.

[2] *Amer. J. Sci., New Haven*, **43**, 1918, (322).

[3] *Ibid.*, **49**, 1895, (101–110).

[4] See my papers on the meteorites of Holbrook, Arizona, *Smithsonian Misc. Coll., Washington*, **60**, No. 9, 1912; Modoc, Kansas, *Amer. J. Sci., New Haven*, **21**, 1906, (356–360); Rich Mountain, North Carolina, *Proc. U. S. Nat. Mus., Washington*, **32**, 1907, (241–244); Thomson, Georgia, *Smithsonian Misc. Coll.*, **52**, 1909, (473–476); Fisher, Minnesota, *Proc. U. S. Nat. Mus.*, **48**, 1915, (503–506); and Coon Butte, Arizona, (Mallet), *Amer. J. Sci.*, **21**, 1906, (351).

[5] See Cohen's *Meteoritenkunde*, pp. 311–314, Figure 2 on plate 17 or Tschermak's *Die Mikroskopische Beschaffenheit der Meteoriten* will apply equally well to the majority of occurrences.

Fig. 1

Fig. 2

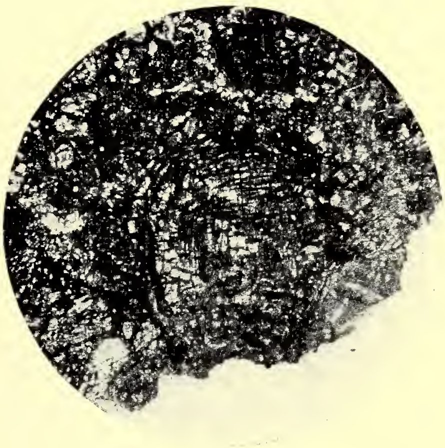

Fig. 5

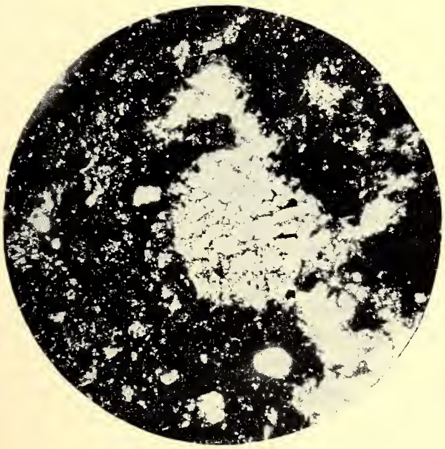

Fig. 3

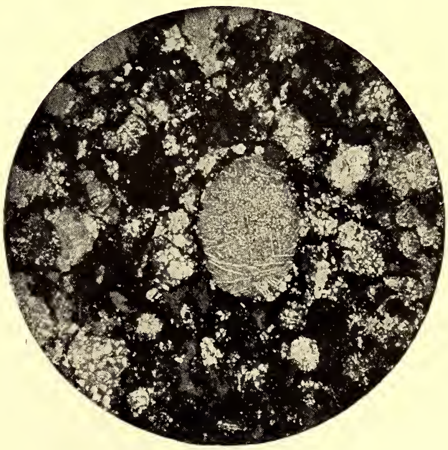

Fig. 4