A NEWLY FOUND METEORITE FROM NEAR CULLISON, PRATT COUNTY, KANSAS.[1]

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The stone described below was found by Mr. A. J. Oshel, who writes that "it struck the earth December 22, 1902, on the northeast corner of section 25, township 28, range 15, in Pratt County." As it was not found until 1911 we are confronted with the usual doubt as to whether the stone is actually the one seen to fall on the date given. The oxidized condition of its crust leaves no doubt as to its having lain for a considerable time in the ground, but for how long there is no means of estimating. Excepting for the natural feeling of caution that exists in the mind of every man experienced in such matters, there is no apparent reason for not accepting the date given.

The general appearance of the stone is shown in figures 1 and 2 of plate 54. It is a very complete individual, a chip of a few grams weight only having been broken from one edge. There exists no large, recently broken surface to suggest that it became broken after reaching our atmosphere, or that the one stone may not constitute the entire fall.

The crust, which extends practically over the entire surface, is very thin and has suffered to such an extent through oxidation that nothing of value can be learned from its study. Except for an occasional slightly protruding metallic point where it has been rubbed, and for the pittings, the appearance of the stone is so like that of a weathered bowlder of a dense, fine-grained trappean rock that for some time there existed a doubt as to its true nature, a doubt which was, however, immediately dispelled on viewing a thin section through the microscope. On a broken surface the stone is nearly black and without structural features or metallic points recognizable to the unaided eye. Characteristic pittings are present, particularly on the broad end shown at the lower right in the figures of plate 54. Both of the views on this plate, it should be stated, are somewhat diagonal in order to bring into view as much of the surface as possible, and hence fail to show the full size of the stone. The maximum

[1] Catalogue No. 430, U. S. National Museum.

dimensions are as follows: 21 cm. by 25 cm. by 12 cm.; weight, 10.10 kilograms.

As mentioned above, the stone is so dense and fine-grained that nothing of its mineral nature can be learned from an examination of a broken surface by the unaided eye. A sawn and polished surface is, however, abundantly specked with small metallic points and numerous chondrules. In the main the distribution of the metallic constituents is fairly even, but diversified by stringers of either metal alone or metal and metallic sulphide together, which seem for the most part to have a general trend; that is, their longer axes show a tendency toward parallelism as though developed along lines of weakness caused by shearing. (Pl. 55, fig. 2.)

In the thin section the meteoric nature of the stone is at once apparent. Everywhere it presents a dense aggregate of small chondrules, sometimes mere fragments or again remarkable for their sharp and circular outline, imbedded in a fragmental and tuff-like ground. In its mineral composition the stone presents nothing new; olivine, orthorhombic and monoclinic pyroxenes and fragmentary plagioclase feldspars, together with metallic iron and iron sulphides, make up the entire recognizable constituents. As noted later (p. 330), there seems a possibility of the one-time presence of oldhamite.

The stone is of interest, however, from the diversity of the chondritic forms which it carries. There are the common monosomatic, barred, grate-like and porphyritic forms composed wholly of olivine; the radiating fan-like forms composed of enstatite; also porphyritic forms composed of enstatite in a smoky or felt-like glass, and still further chondrules composed wholly of twinned, monoclinic pyroxenes. These last sometimes display a structure which is new to me, the outer rim consisting of crystals somewhat curved to conform to the outline of the chondrule and elongated in the direction of their vertical axes, so that sections in other than the orthopinacoid zone show more or less distinct striations. Interiorly this type of chondrule is a mass of imperfectly outlined granules some of which show twin striæ, but the structure as a rule is very obscure and no attempt has been made to reproduce it in detail by photograph or drawing. An occasional form is met with in which the interior is wholly of a yellowish glass while the rim is of a fibrous pyroxenic (?) material radiating from a common center. Several minute and very nearly circular chondrules were noted, like a slightly brownish, wine-tinted homogeneous glass traversed by numerous cracks into which secondary iron oxides had penetrated. Between crossed nicols this glass proves not absolutely isotropic, but a portion remains light, the dark cloud sweeping over it as the stage is revolved, in a manner to suggest a condition of mechanical stress. Occasional faintly bluish-gray forms occur which are apparently comparable with those described by Tschermak in the stone of Tipperary.

In slicing this stone the saw passed through the larger diameter of a nodular mass some 10 by 17 mm. of a distinctly lighter, somewhat greenish-white color, which from its sharp boundaries at once excited interest, and steps were taken to secure a thin section without wholly destroying the material. (See pl. 55, figs. 1 and 2.) This section, when placed under the microscope, was found to be composed, with the exception of a few grains of troilite, wholly of the twinned pyroxene noted as occurring sporadically in the body of the meteorite. It is to be noted, however, that the structure is not chondritic, but the entire mass is made up of granular and columnar forms elongated parallel with the vertical axes, all closely interknit, with no residual glass, forming the *hypidiomorphic granular* structure of Rosenbusch. Though an abundant constituent of the surrounding mass, no metallic iron could be detected in the body of the nodule. The dark points shown in the photograph are of iron sulphide.

Incidental to this inclosure attention should be called to another structural feature of even greater import. This is a somewhat indistinct wavy banding visible only on a polished surface. Close inspection shows this to be due to elongated, illy defined areas of a dark greenish color with intervening wavy, narrower bands, sometimes mere lines, of a darker hue. The wider greenish bands are thickly studded with rounded spots caused by chondrules, which are much less abundant in the dark bands. The metallic particles, both sulphide and native iron, seem to be disseminated through all portions alike. The effect is of a nature that might be produced by a shearing force exerted on a body already solidified but still capable of yielding; in other words, it corresponds apparently with the *schlieren* structure of terrestrial rocks. That this structure is actual is further shown by the tendency of the larger metallic sulphides to be elongated in this same general direction. It is further to be noted that minute rifts which have opened in the stone since its fall, and are obviously due to exposure, all tend in the same general direction. Indeed it seems probable that the shape of the mass as found is due to a natural tendency to exfoliation along these lines, the maximum dimensions given on page 326 being those parallel with the schlieren lines mentioned.

This structure is brought out somewhat obscurely in figure 2 of plate 55 from a photograph of a polished slice, and reproduced about two-thirds of the actual size. In the upper left is shown the pyroxene inclosure already described. An irregular band some 10 mm. in width is conspicuous, extending entirely across the surface from left to right just below this inclosure, and shorter areas again below this. An attempt was made to bring out this structure still more clearly in figure 1 of this plate from a photographic enlargement of about five diameters. The inclosure is here seen imbedded in a darker ground displaying structures which to my mind can be explained only on the supposition that it was imbedded in a finer ash-like ground which, on being subjected to a shearing movement, had yielded, giving results closely simulating the flow structure produced under similar conditions in terrestrial rocks.

A brecciated structure is not uncommon in meteorites. Indeed, the mineral constituents of stony meteorites are more common in a fragmental condition than otherwise. A true breccia structure produced by rock fragments imbedded in a finer ground, as is the case of the stones of St. Mesmin and Soko Banja, or the Mount Joy iron, is much more rare, and I have not seen, either in the stone itself nor in written descriptions, anything comparable to the structure I have attempted to describe above. If I am right in my interpretation of what is shown, it of course means that this stone was once a portion of a vastly larger mass in which stresses were operative as in the moderately deep-seated portions of the crust of our own earth. The occurence differs from that of Chattonay, as described by Tschermak, in that iron is very uniformly distributed throughout the ground, while only the sulphide is apparent in the inclosure. From the Orvinio stone it differs in that the inclosure is not of the same mineral nature as the matrix, containing no olivine nor metal, but consisting wholly of the pyroxene and iron sulphides.

A word with reference to the iron sulphide. This is distributed very generally throughout the stone both in small particles, as is the metallic portion, and also in larger forms, the section shown in figure 2, plate 55, which is some 15 cm. by 10 cm. in dimension, showing seven sulphide areas varying from 5 to 10 mm. in length besides innumerable smaller forms. These are so closely associated with the metallic particles as to be practically, and in some cases actually, in contact with them. In one instance an area of sulphide about 3 mm. in length and 1 mm. broad is capped, as it were, at either end, with the native metal. (Pl. 55, fig. 3.) In other cases metal and sulphide appear mutually intergrown. The matter is mentioned in detail as having some bearing upon the mineral nature of the sulphide, it being usually conceded that the form found in metallic meteorites is the monosulphide troilite, and in the stony forms, pyrrhotite. Recent work by Dr. E. T. Allen,[1] of the Carnegie Geophysical Laboratory, shows that in the presence of an excess of iron only the monosulphide is possible, and it would hence seem probable that it must so exist in the stone here described. It is possible, however, that there may be a gradual change in the character of the sulphide as the distance from the point of contact increases, the monosulphide (FeS) forming at the immediate contact and this grading into compounds conforming to the formula Fe_nS_n+1. Separation of the material for analysis in order to determine this point is obviously impossible.

[1] Amer. Journ. Sci., vol. 33, 1912, p. 212.

Chemical and mechanical analyses of the stone, by Dr. J. E. Whitfield, yielded results as below.[1]

A separation by means of an electromagnet and treatment of the residue with iodine yielded—

	Per cent.
Troilite (?)	6.00
Metallic iron	19.40
Silicate minerals	74.50
Schreibersite	.10
	100.00

The metallic portion yielded—

	Per cent.
Silicon	.129
Sulphur	Trace.
Phosphorus	.071
Nickel	9.207
Cobalt	.507
Copper	.040
Chromium	.160
Carbon	.088
Manganese	.080
Iron	89.700
	99.982

No traces found of molybdenum, tungsten, or vanadium.

The silicate portion yielded—

	Per cent.
Silica	47.36
Alumina	5.67
Ferric oxide	.10
Ferrous oxide	11.25
Lime	.84
Magnesia	31.72
Manganese protoxide	.36
Soda	2.42
Potash	.23
Titanic oxide	.00
	99.95

Combining the metallic and nonmetallic portions and recalculating after making the very unsafe assumptions that the material called troilite is all the monosulphide, and that the schreibersite conforms to the formula Fe_2NiP, the following figures are obtained, representing the composition of the stone in mass or bulk:

	Per cent.
Silica (SiO_2)	35.30
Alumina (Al_2O_3)	4.24
Ferric iron (Fe_2O_3)	.75
Ferrous iron (FeO)	8.38
Lime (CaO)	.62

[1] This analysis is one of several made by Doctor Whitfield for the present writer under a grant from the National Academy of Sciences, to which body he is indebted for the privilege of utilizing the same here.

	Per cent.
Magnesia (MgO)	23.631
Manganese oxide (MnO)	.268
Soda (Na_2O)	1.804
Potash (K_2O)	.171
Sulphur (S)	2.184
Phosphorus (P)	.0138
Nickel (Ni)	1.80
Cobalt (Co)	.098
Copper (Cu)	.008
Chromium (Cr)	.029
Carbon (C)	.017
Manganese (Mn)	.015
Iron (Fe)	21.270
Total	100.5988

Specific gravity, 3.65.

None of the rarer elements sometimes reported as occurring in meteorites were found, although very carefully looked for.

Should we refer all the soda and lime to the feldspar it is evident that it belongs to an acid type nearer albite than oligoclase. That all the *lime* can not be so referred is, however, rendered doubtful by the following:

An attempt was made to isolate some of the component minerals by the usual process of crushing, washing, and use of heavy solution. The results were complete failures. In the course of the attempt, however, the water, in which a finely pulverized sample had been standing for some 24 hours, was tested and gave distinct reactions for lime and sulphuric acid. Three independent tests, two by myself and one by Mr. Chester Gilbert, yielded similar results, Mr. Gilbert getting 0.0052 grams of CaO from 9.2495 grams of the pulverized stone after digesting in distilled water for 24 hours. Mr. Andrew A. Blair, at my request, digested a powdered sample for 24 hours in dilute hydrochloric acid, 1 part acid to 50 parts water. The solution yielded 0.28 per cent CaO, 0.05 per cent SO_3, and 1.14 per cent MgO, the last named undoubtedly derived from the olivine. These results led to a very careful search for oldhamite, the rare calcium sulphide. With one possible exception nothing could be found in the slides that could with any degree of certainty be thus referred, and one is forced to conclude that if such existed it has gone over to an earthy or perhaps ocherous gypsum and is no longer recognizable. It will perhaps be remembered that I was driven to a similar conclusion in the case of the Hamblen (Morristown), Tennessee, siderolite, described some years ago.[1] It is of course possible that the minute quantity of lime found may have come from an easily decomposed feldspar.

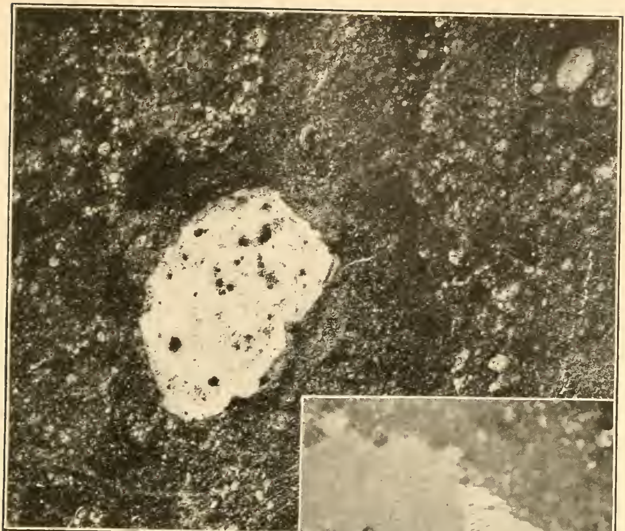
[1] Amer. Journ. Sci., vol. 2, Aug., 1896, p. 149.

1

2

THE CULLISON METEORITE, PRATT COUNTY, KANSAS.

Two views of stone as found.



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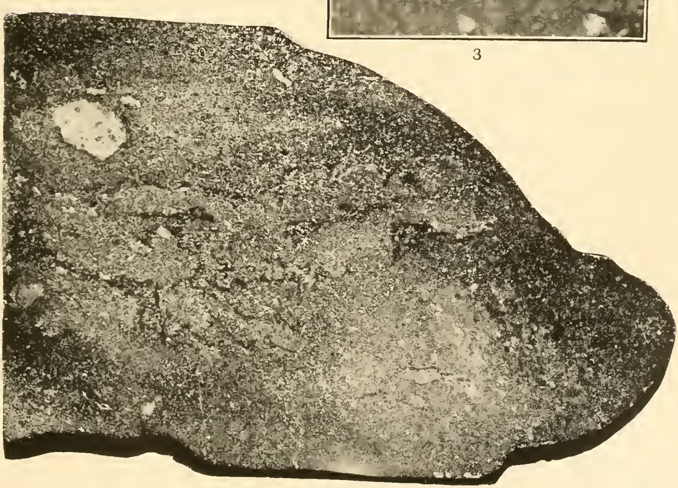

2

THE CULLISON METEORITE, PRATT COUNTY, KANSAS.

Fig. 1.—Polished slice enlarged about 5 diameters. Fig. 2.—Polished slice, about two-thirds natural size. Fig. 3.—Iron sulphide capped at right by metallic iron.