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A NEW METEORIC STONE FROM JOHNSTOWN, WELD COUNTY, COLORADO

BY EDMUND OTIS HOVEY[1]

WITH SUPPLEMENTAL NOTES BY GEORGE P. MERRILL AND EARL V. SHANNON

On the 6th of July, 1924, the inhabitants of western Weld County, Colorado, were treated to a sight which was a new one in the history of Colorado, and which is rare in any part of the world. At 4:20 in the afternoon of a cloudless day, four terrific explosions were heard. Then came a series of minor bursts, like the crackling of a machine gun. Other accounts describe the noises as resembling "shrill screeches," "whistling" and "the exhaust of an aëroplane." Grayish blue "smoke" puffs are described as accompanying the explosions, and then the missiles struck with a "thud," a "thug," or a "thump"; a meteorite, strange visitor from space, had fallen to the earth. At least four of the largest fragments were seen to fall, and although they were separated by considerable distances the course of each was marked by a trail of "light gray smoke."

The first piece unearthed fell in the highway about thirty feet from the doors of a little church at Elwell. At the time, a funeral service was being held in the yard behind the church, and the fall was witnessed and heard by not fewer than two hundred persons. Superstitious minds attached sinister meanings to the fall, and many persons felt that a religious explanation was to be given to the phenomenon. Immediately following the service, the local undertaker, Mr. H. A. Clingenpeel, began digging where the meteorite had fallen and found the mass at a depth of "slightly less than two feet" below the surface of the ground. It was "quite cold, forty-five minutes after it struck," and was considerably broken by impact. Some small bits were not found, being mingled with gravel and not recognized, but the mass recovered weighed 241 ounces (6832 grams).

[1]A report of the discovery was sent in to the Colorado Museum of Natural History at Denver, and Director J. D. Figgins made immediate and thorough investigations. To his prompt activity is due the exceptionally full and exact eyewitness reports of this fall. He also enlisted without delay the coöperation of The American Museum of Natural History in the investigation, and with his approval Doctor Merrill later kindly undertook to complete the study initiated by our lamented associate and friend, Doctor Hovey.—[EDITOR.]

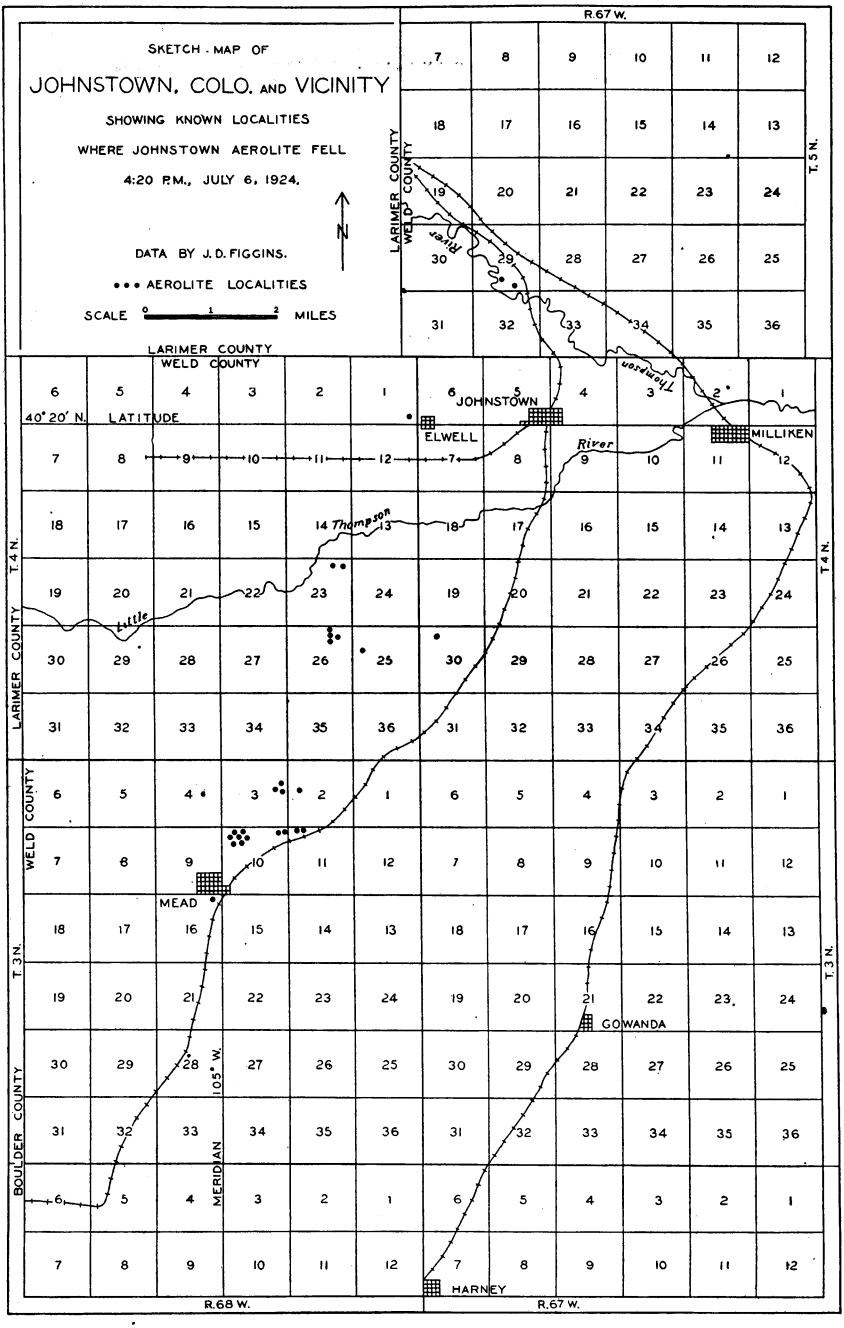

Fig. 1. Sketch map of Johnstown, Colorado, and vicinity.

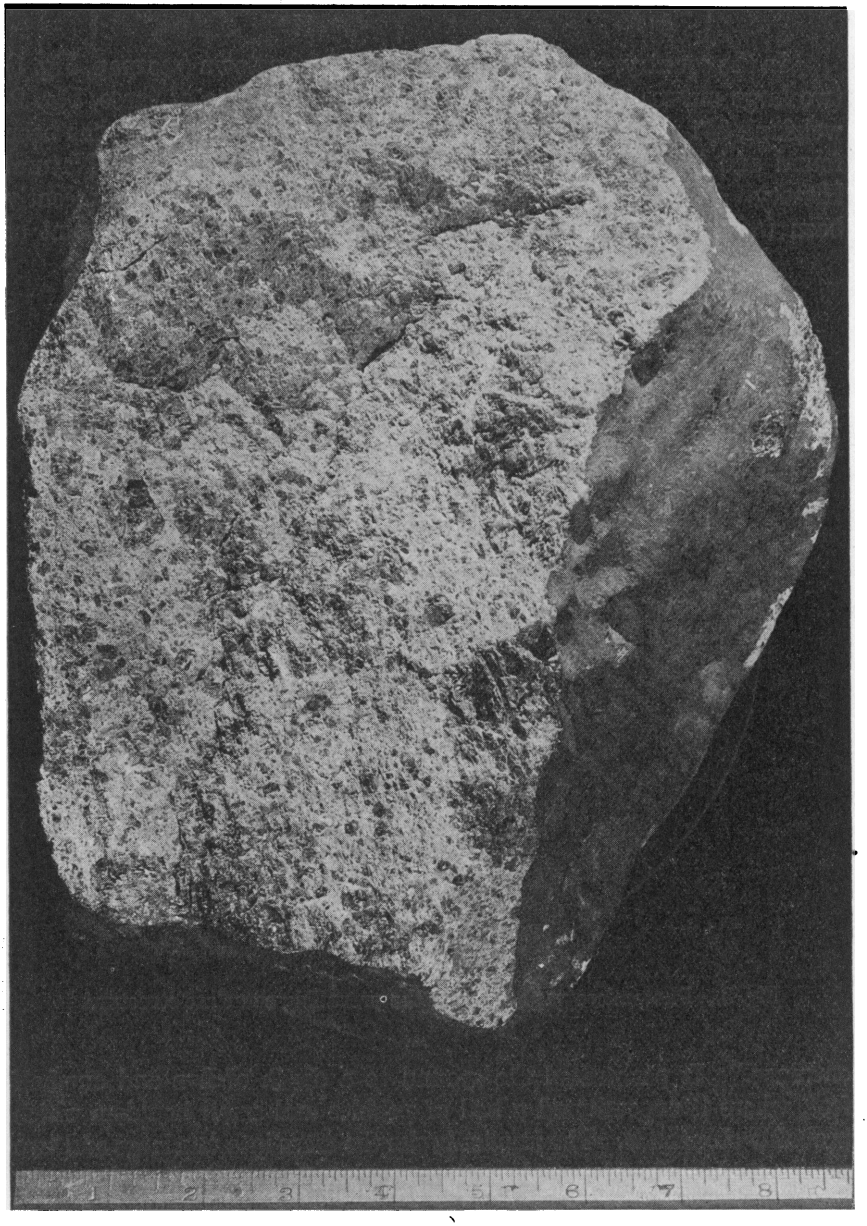

Fig. 2. Photograph of the largest fragment of the Johnstown aërolite. Weight 680 ounces.

Location of fall: S. W. ¼, Sec. 29, T. 5 N., R. 67 W., near Johnstown, Colorado. It now rests in The American Museum of Natural History, New York.

In the country, about two miles north of Johnstown (see map, Fig. 1) two large masses struck and buried themselves. One of these, Fig. 2, weighing 831 ounces (23,558 grams), is the largest mass that has been found and is the one secured by The American Museum of Natural History. It was seen to land in a sugar-beet field which had recently been irrigated, and it "threw up a ridge of dirt about the point of

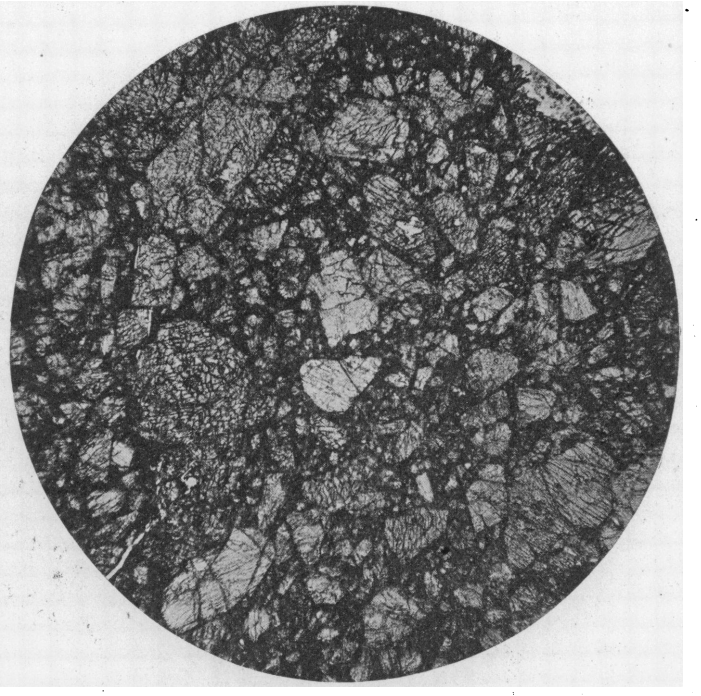

Fig. 3. Photomicrograph showing the prevailing cataclase structure.

entrance." It penetrated the ground to a depth of five and one-half feet, where it encountered a bed of pebbles and small boulders which probably stopped it. The impact broke the mass into one large and two small portions, besides some comminuted material which was not recovered, by reason of water and mud that entered the excavation from an underground source. The other of these two masses fell within three-fourths of a mile of the larger one. It was located through the finding of a crater-like hole, less than a foot in diameter, in the muck of an old river channel. It is reported that probing showed that it was down about

eight feet, but it has not been recovered yet because of the overflow of an irrigation ditch which renders work impracticable. The small size of the crater-like hole in the ground renders it probable that this fragment is of moderate size. It may be doubted, however, whether the probe actually located the mass, which perhaps did not penetrate the earth so far. If it did, it was because the ground where it fell was very soft.

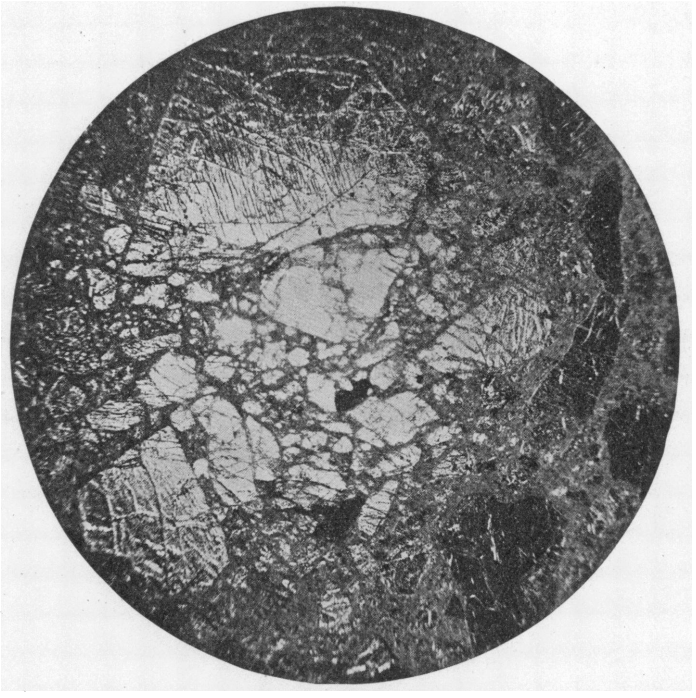

Fig. 4. Photomicrograph showing the prevailing cataclase structure.

Smaller masses of the fall, all weighing less than a kilogram, have been recovered from points southwest of Johnstown. The most distant one was found immediately south of Mead. The area, therefore, over which the fall was spread, is a narrow ellipse about ten miles long and about two miles wide. The direction of the long axis is S.S.W. to N.N.E. The localities of the various falls, as furnished by J. D. Figgins, Director of the Colorado Museum of Natural History, Denver, are given on the accompanying map, Fig. 1. The locations and weights for the various specimens are as follows:

LOCALITIES AND WEIGHTS OF THE JOHNSTOWN AËROLITE SPECIMENS

Localities	*Weights*
S. W. ¼, Sec. 29, T. 5 N., R. 67 W.	23558 gm. Note: Another fell in the southeast quarter of this section, but has not been recovered.
S. E. ¼, Sec. 1, T. 4 N., R. 68 W.	6832 gm.
N. E. ¼, Sec. 23, T. 4 N., R. 68 W.	1729 gm.; 1503 gm.
N. W. ¼, Sec. 30, T. 4 N., R. 67 W.	3175 gm.
N. W. ¼, Sec. 25, T. 4 N., R. 68 W.	794 gm.
N. E. ¼, Sec. 26, T. 4 N., R. 68 W.	652 gm.; 580 gm.; 365 gm.; 202 gm. The first lies to the east of the others.
N. W. ¼, Sec. 2, T. 3 N., R. 68 W.	14 gm.
N. E. ¼, Sec. 3, T. 3 N., R. 68 W.	148 gm.; 123 gm.; 98 gm.
N. W. ¼, Sec. 11, T. 3 N., R. 68 W.	85 gm.; 30 gm.
N. E. ¼, Sec. 10, T. 3 N., R. 68 W.	90 gm.; 71 gm.
N. W. ¼, Sec. 10, T. 3 N., R. 68 W.	92 gm.; 88 gm.; 49 gm.; 25 gm.; 20 gm.; 10 gm.; 8 gm.
N. E. ¼, Sec. 16, T. 3 N., R. 68 W.	5.5 gm.
	Total, 40,346.5 gm.

Chemical analyses on a selected sample yielded Dr. J. E. Whitfield results as below:

Specific Gravity	3.4113

MINERAL COMPOSITION

Chromite	(Cr_2O_3 FeO)	1.48%
Troilite	(FeS)	0.62%
Iron	(Fe)	0.88%
Mineral	(Silicate)	97.02%

The silicate portion yielded:

Silica	(SiO_2)	50.310%
Alumina	(Al_2O_3)	2.352%
Chromite	(Cr_2O_3. FeO)	1.500%
Phosphoric Acid	(P_2O_5)	0.035%
Manganous Oxide	(MnO)	0.400%
Calcium Oxide	(CaO)	2.630%
Magnesium Oxide	(MgO)	26.880%
Ferrous Oxide	(FeO)	14.050%
Troilite	(FeS)	0.548%
Sulphuric Anhydride	(SO_3)	0.868%
Sodium Oxide	(Na_2O)	0.330%
Potassium Oxide	(K_2O)	0.100%
		100.003%

The portion separated by the magnet from the pulverized stone had the following composition:

Troilite	(FeS)	8.34%
Metal	(Fe)	91.66%

This metallic portion gave:

Iron	(Fe)	95.46%
Phosphorus	(P)	0.29%
Nickel	(Ni)	3.97%
Cobalt	(Co)	0.28%

SUPPLEMENTAL NOTES BY GEORGE P. MERRILL AND EARL V. SHANNON OF THE UNITED STATES NATIONAL MUSEUM

The stone left so briefly described by the death of Doctor Hovey is of quite unusual interest and merits a more detailed study. Such it doubtless would have received had he lived. The results of our combined examinations are given below:

To the unaided eye the stone presents a gray, somewhat rough and gritty ground, thickly studded with round and angular particles of greenish-gray pyroxenes of varying sizes up to several centimeters, the largest single individual noted being a rounded mass some 4-5 centimeters across. These present a most striking feature of the stone and at once differentiate it from any other of which the writers have knowledge. No metal or metallic sulphide is visible to the unaided eye, and only occasionally small white spots suggest the presence of a feldspar. In the thin sections, as shown in figures 3-6, the structure is for the most part markedly cataclastic, consisting of the larger, sometimes quite perfectly outlined pyroxenes in a finely fragmental ground. The structure as a whole is strongly suggestive of a holocrystalline porphyritic rock which has undergone compression, the results of which are most strongly manifested in the yielding and crushing of the smaller interstitial particles. In a few instances the stone, as shown in figure 5, still preserves its original holocrystalline character.

Two pyroxenic minerals are seemingly present, or if but one, the mineral presents two dissimilar phases. The one has a moderately high index of refraction and well developed prismatic cleavage, and gives extinction angles on the second pinacoid rarely as high as 15 and 20 degrees. The second with a lower refractive index (1.690-1.695) gives somewhat lower extinction (8-10 degrees) angles on the clinopinacoid and shows on sections cut parallel with the front pinacoid a somewhat platy or fibrous structure produced by twinning, and the emergence of

an optic axis. The feldspathic minerals occur but rarely, being visible occasionally as small white spots on a broken surface of the stone, and show under the microscope the twinning characteristic of anorthite or bytownite. No silicate minerals, other than those mentioned, could be determined. The phosphatic mineral is not sufficiently developed to render safe a determination of its exact nature.

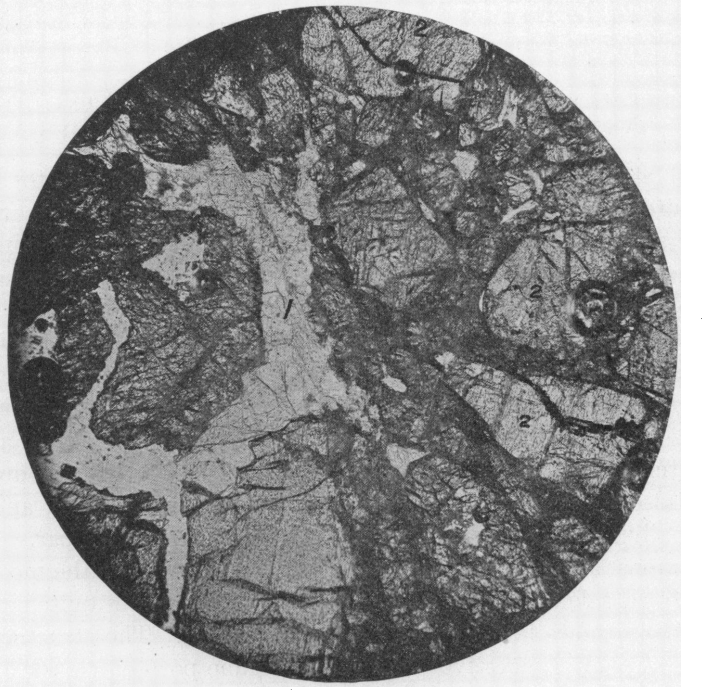

Fig. 5. Photomicrograph showing area of slight crushing, and interstitial character of the feldspar.
(1) Feldspar, (2) pyroxenes.

The size, crystalline development and purity of the chief constituents, together with their easy separation from the matrix, offered unusually favorable opportunity for further detailed study, which Mr. Shannon kindly volunteered to undertake. His results are given below. Especial attention was given to the possible presence of metallic oxides in the silicates and the content of nickel in the metallic portion, as these matters have both been the subject of recent discussion.

The Pyroxene

"It was not found possible, in the study of the powdered meteorite, to establish any distinction in optical properties between the twinned and the untwinned grains of pyroxene. Neither could they be separated from each other by any difference in specific gravity or magnetic properties. In several cases large phenocryst-like pyroxenes were extracted, and nearly every sample thus obtained was found to consist predominantly of the untwinned mineral, but in every instance was invariably contaminated by some 10 per cent. of twinned grains. The sample analyzed, however, did not show more than 1 or 2 per cent. of twinned material. This was made up of fragments from the larger pyroxene masses. It was ground to pass an 80-mesh screen, and the dust which passed 200-mesh was discarded. The sample was then treated to a gravity separation, using methylene iodide, by means of which a little feldspar and fragments of the crust of the stone were removed. It was then examined microscopically and found to consist essentially of the pyroxene and a little troilite. The grains of pyroxene were variable in their content of opaque inclusions. The sample was then several times run through a magnetic separation, by which process were obtained three products, troilite and two phases of pyroxene, varying only in their degree of magnetism. They differed only in that the more magnetic sample contained more opaque inclusions than the other. The least magnetic portion of the pyroxene was analyzed with the following results:

Constituent	Per Cent.	Ratios	
SiO_2	52.16	.870	.908
Al_2O_3	3.91	.038	
Cr_2O_3	.69		
CaO	1.97	.036	.912
FeO	13.39	.186	
MnO	.56		
NiO	none		
MgO	27.60	.690	
	100.28		

"The optical properties of the pyroxene (or pyroxenes) are rather uniform. It is biaxial and negative, with an axial angle of approximately 80°. The dispersion is variable from weak to strong with (ρ) less than (υ). The refractive indices are:

$$\alpha = 1.681, \quad \beta = 1.690, \quad \gamma = 1.696$$

"The principal peculiarity lies in the fact that the mineral is optically negative, whereas all clinoenstatites thus far reported have been optically positive.

"The twinning which characterizes much of the pyroxene gives it the appearance of a plagioclase, and, as in the common twinning of the albite law, the twinning and composition plane is the clinopinacoid *b* (010) and the twinning axis the *b* axis.

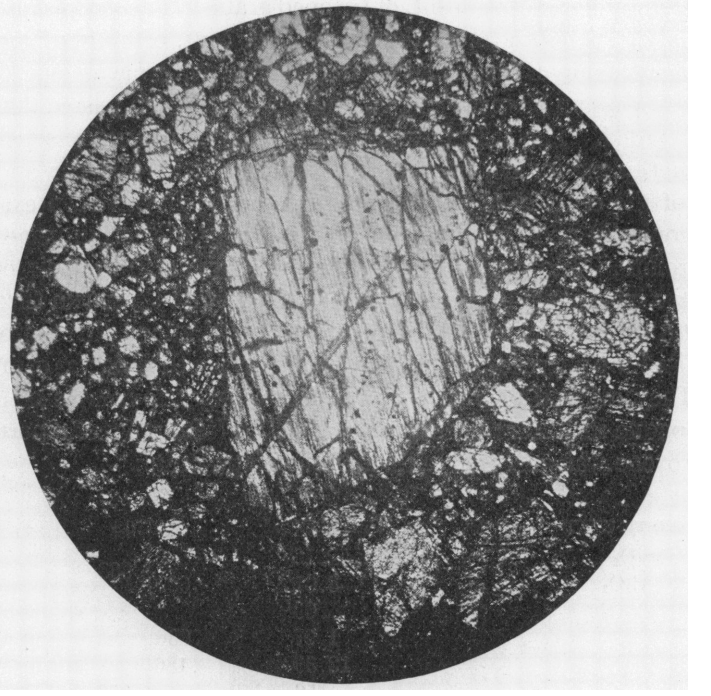

Fig. 6. Photomicrograph showing twinned pyroxene phenocryst in cataclastic ground.

"If the above analysis is recast into constituent pyroxene molecules in the manner adopted by Washington and Merwin, the following results are obtained:

	Per Cent.
Diopside	7.78
Clinoenstatite	65.40
Clinohypersthene	24.55
Alumina	3.91

"If the above analysis be regarded as that of a rock—and the present meteorite contains little else—it is of interest to calculate a "norm" after the method used in the quantitative classification of igneous rocks. This calculation gives the following results:

	Per Cent.
Anorthite	10.56
Enstatite	69.00
Hypersthene	2.90
Olivine (fayalite)	16.73

"This illustrates how the ordinary method of arriving at the relative proportions of metasilicates and orthosilicates in a stone from the silica ratio may fall into serious error, since the present stone contains no olivine.

The Feldspar

"The feldspar is uniform in optical properties and does not seem to vary appreciably in composition. Although occasionally visible under a lens, its amount is very small. From 32 grams of the crushed stone only .11 grams were recovered, and it is not probable that the amount lost in the fine material screened out would have brought the total percentage above 0.70 per cent. of the whole.

"The mineral is friable, easily crushed and white on a broken surface. Under the microscope it is colorless, limpid and free from alteration or important inclusions. Most of the grains show twin lamellæ. Optically it is negative with an axial angle of approximately 80°. The dispersion, $\rho < \upsilon$ is marked and the refractive indices are:

$$\alpha = 1.569, \quad \beta = 1.575, \quad \gamma = 1.579$$

"These properties indicate a medium bytownite, $Ab_{20}An_{80}$, in composition.

"A sample of .1155 grams, purified by the use of heavy solutions, was analyzed with the following results. The material was insufficient to permit soda to be determined.

	Per Cent
Silica (SiO_2)	43.72
Alumina (Al_2O_3)	35.40
Lime (CaO)	16.28
Magnesia (MgO)	.70
Loss on ignition	.70
	96.80

"This composition approximates closely to medium bytownite, as stated above, although, if taken by difference, the soda content is 1.60 per cent. too high, probably due to cumulative error falling upon this minor constituent."

Inasmuch as Doctor Whitfield's analysis indicated a metal unusually low in nickel, Mr. Shannon made a new separation, and gained results as below:

COMPOSITION OF METALLIC PORTION OF THE JOHNSTOWN, COLORADO, METEORIC STONE

Amount of meteorite taken	31.3141 grams.
Metal recovered	.1034 grams.
Proportion of metal indicated	0.33 per cent.

The metal was picked out of the crushed powder with a hand magnet and further ground and the particles flattened to free them as far as possible from brittle silicate particles. They were then dissolved in dilute nitric acid and the insoluble portion (0.0190 grams) filtered out, weighed and deducted from the weight of the sample. The analysis gave the following results:

	PER CENT
Iron	96.78
Nickel	2.80
Cobalt	.35
Sulphur	.66
Phosphorus	trace
Total	100.59

These figures are of interest in connection with the idea advanced that "in meteoric stones generally the poorer they are in nickel-iron, the richer that iron is in nickel."[1]

It will be observed that the stone belongs with the group rich in magnesia and low in alumina and lime known as chladnites and represented among known falls by those of Ibbenbuhren, Manegaum and Shalka, from which, however, it differs in the character of its pyroxenic constituent which is that of a ferrous clinoenstatite or clino bronzite. Unfortunately the National Museum collections comprise a mere fragment of but one of these—Shalka—and satisfactory comparisons are impossible. It is to be noted, however, that in both Ibbenbuhren and Shalka a portion at least of the pyroxene is clinoenstatite. Especial tests

[1]Prior, Min. Mag., XVIII, 1916, p. 44.

were made to ascertain the presence of oldhamite and other rare constituents in the Colorado stone, but none could for a certainty be determined other than those mentioned.

Aside from the somewhat unusual circumstances attendant upon the fall and its mineral nature, the stone is of interest as being the sixth of the class of chladnites (if we include the Cumberland Falls whitleyite), all of which were seen to fall. Its date of fall—July 6—adds no support to the suggestion of Högbom relative to the close approximate date of fall of certain stones of the less common and more distinctive types.[1] It will be of interest to all students of meteorites to note that, while the total weight of the three most closely related stones, Ibbenbuhren, Manegaum and Shalka, is but 5,689 grams, that of Johnstown alone is more than 40,000 grams. As the name Elwell does not appear in the Post Office directory, Johnstown, some two miles to the east, has been selected as the name appropriate to the fall.

[1]Bull. Geol. Inst. University of Upsala, V, 1900–1901.