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METEORITE STUDIES III

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LEIGHTON.

This meteorite fell at 8 P. M., Sunday, January 12, 1907, eight miles south of Leighton, Colbert County, Alabama. The exact place of fall was near the old Bethel church in township 5, range 10, west of the Huntsville meridian. So far as is known to the writer only a single stone of the fall is preserved. To Dr. A. Graves of Leighton and Professor E. A. Smith of the University of Alabama the Museum is indebted for such information as it possesses regarding the fall. According to Dr. Graves the meteor which produced the meteorite passed over the region with a mighty roar which ended in a report something like pistol-firing in rapid succession and from which "particles flew like sparks from a coal of fire." A stone from this meteor struck in the yard of the residence of Mrs. M. D. Allen. Mrs. Allen and her daughter Mattie were standing on their front porch and saw the meteor, heard the explosion, then heard a whizzing in the air and the striking of a stone in the yard. On going to the place they found the stone which is now preserved, sunken to the depth of about 12 inches. This stone weighed one pound and fifteen ounces (877 grams). About one ounce was chipped off from one corner by the parties who found the stone, in order to examine its interior. Accordingly the weight of the stone as received by the Museum was one pound and fourteen ounces (850 grams). The shape and size of the stone may be roughly described as like that of a man's fist. It is shown in Fig. 1, Plate LV. The greatest length is 4 inches (10 cm.), the height 2½ inches (6 cm.). About three-fourths of the surface is covered with crust, the remainder has a rough, irregular, fractured appearance. The lack of crust on part of the uncrusted surface is probably due to the breaking done by the finders, the remainder perhaps represents a fracture of the stone in the air. The large fractured surface is roughly triangular in shape with sides about 3 inches (7.5 cm.) in length. The encrusted surfaces of the stone are all smoothed and rounded. They are either convex or concave. The convex surfaces are of comparatively uniform slope, the concave, irregular and showing depressions resembling pittings, though these are rarely as well-defined as is usual in meteorites. Five of these pits which occur together in one concavity are approximately circular in outline, shallow, and have a diameter of about one centimeter each. On another portion of the stone two similar but smaller pits may be seen and on another portion a larger, crescent-shaped pit. Nothing in the shape or markings of the stone indicates orientation during flight. The general shape of the stone is, as already noted, irregular and the crust remarkably uniform in appearance. In color the crust is dull black with occasionally an inclination to a reddish shade. Seen under the lens it presents a porous, slaggy appearance with no indications of flow. The indications are that the surface fused in place. The pores of the slag are very minute and the crust strongly adherent. Grains of nickel-iron rounded by fusion can be seen here and there and occasionally spots from one to three millimeters in diameter having smoother crust appear. These doubtless indicate portions which for some reason fused somewhat more readily. The color of the interior of the stone is in general brownish-black resembling the black chondrites. A marked feature (shown in Fig. 2, Plate LV.) is that of large spots of a much lighter color scattered over the dark ground. These are best seen on polished sections. The color of these spots is a light gray, and so much lighter than the mass of the meteorite as to be very prominent. The spots vary in size, the largest seen covering nearly one square inch of surface. The outline of the spots is irregular but not strongly so, and tends to be curved rather than straight. There seems to be no indication megascopically of any separation other than that of color, of the substance of these spots from the remainder of the mass. The section in which they are best exhibited and that illustrated in Fig. 2, Plate LV, was made near one end of the meteorite. On a section parallel to this made about one centimeter nearer the interior, the larger spots while retaining their relative position were found to be much smaller, less than half the size of those on the outer section. They do not, therefore, extend uniformly through the meteorite. As solid bodies their shape is probably somewhat lens-like or flat-pyramidal. One spot which was small on the outer section was about twice as large on the inner section. Hence the spots are probably to be found scattered irregularly through the meteorite. The structure of the meteorite on the whole in respect to these spots is the same as that designated by Brezina as breccia-like. This term should be understood however, in the same sense in which Brezina uses it, i. e., as an imitation of brecciated structure, without an actual clastic origin being assumed.* The writer knows of no meteorite in which this structure is so strongly marked as in Leighton. Besides the spotting already referred to, the dark mass of the meteorite is also speckled by numerous chondri of various sizes and shapes but in general more or less circular in outline and ranging from 2 mm. in diameter down. The color of these closely resembles that of the light-colored spots just referred to. There is also a thick sprinkling of metallic grains. These are as a rule small, independent of each other and very irregular in outline. Some of the larger ones are elongated, one seen being 4 mm. long and 7 mm. wide. The distribution of the metallic grains as a whole is comparatively uniform, except that they tend to encircle the chondri. Troilite is to be seen in the form of grains, but is much less abundant than nickel-iron. At one point, however, a large nodule of a somewhat crescentic form occurs which has a length of 11 millimeters and a width of 5 millimeters. This troilite is of bronze-yellow color, brittle, and slightly magnetic.

The texture of the stone is firm and compact so that it breaks with difficulty and takes an excellent polish. The specific gravity obtained by weighing the whole stone was 3.604.

Under the microscope, chondri appear to be much more numerous in the dark-colored than in the light-colored portions of the sections. This difference is doubtless in part due to the greater contrast in which the chondri are thrown by the dark-colored background, but there is also a real relative scarcity of chondri in the light-colored portions. The line of demarcation between the light and dark-colored portions is as sharply distinguished under the microscope as to the naked eye. Leighton in this respect, therefore, forms an exception to other brecciated chondrites, if Cohen's statement in regard to the latter is accepted, for he states that the megascopically sharp-appearing boundaries of the differently colored areas of such meteorites disappear under the microscope.† Yet the difference in appearance of the two portions of Leighton as seen under the microscope is not sufficient to establish the existence of a true brecciated structure in the sense that it is certain that the mass was at one time broken up and recemented or that fragments of different origin are here seen cemented together. The appearance rather suggests that a dark-

* Jahrb. K. K. Geol. Reichsanstalt, Wien, 1885, xxxv, 172.

† Meteoritenkunde, Heft II. p. 63.

colored liquid has been infused into the mass and affected certain portions. This infusion appears to have taken place subsequent to the cooling of the original magma. The siliceous minerals seen under the microscope are chrysolite and bronzite, apparently in about equal proportions. They occur as chondri, as fragments of chondri and of crystals, and as more or less completely formed crystals. The chrysolite chondri tend to be of small size, circular in form and monosomatic. One such chondrus measures .45 mm. in one diameter and .52 mm. in the other. Its border is composed of a series of grains more or less circular in outline and .06 mm. in diameter. A series of parallel alternate rods of chrysolite and glass averaging .03 mm. in width fills the interior. All these and the border extinguish simultaneously. Some of the other chrysolite chondri are characterized by a porphyritic structure. All the chrysolite is highly fissured, as is characteristic of meteoritic chrysolite. The bronzite chondri are as a rule less regular in outline than the chrysolite chondri and vary greatly in size. The largest seen is nearly 3 mm. in diameter, though of irregular boundary. It is made up of minute parallel fibers of bronzite .0075 mm. in width and 2–3 mm. in length. Other chondri show eccentric-radiated, parallel or irregular arrangement of fibers. One conspicuous chondrus is of oval outline, 6 mm. in its longest diameter and is composed of seven fan-shaped rays of bronzite set in an opaque background. The rays radiate from a point near the circumference of the chondrus and widen as they pass toward the opposite periphery. Each ray is divided into two longitudinally and there is a more or less sharply marked border of bronzite. The chondrus as a whole has circular polarization. Another chondrus of somewhat rectangular outline is about half composed of well-crystallized bronzite and the remainder passes into a series of half-glassy fibers. Narrow black veins evidently subsequent in origin to the chondri cut through the sections. The nickel-iron occasionally exhibits a tendency to follow these veins. The nickel-iron and troilite grains are megascopically of amœba-like outlines and evidently formed subsequent to the chondri. The crust when seen in section on the darker portions of the meteorite appears as a black, opaque band about .4 mm. in width. Owing to the dark color of the interior the crust is not easily distinguished from it. It is certain, however, that it does not exhibit the zones usually characterizing the crust of chondritic meteorites. As none of the sections prepared for study showed crust bordering the light-colored portions, no study of this could be made.

A partial analysis of the meteorite was made by Mr. H. W. Nichols with results as follows:

SiO_2	35.69
Al_2O_3	1.03
Cr_2O_3	0.12
NiO	1.04
CoO	0.08
CaO	1.93
Na_2O	0.95
K_2O	0.47
P	0.40
S	2.11
Fe	10.48
Ni	1.59
Co	0.21
	56.10

The remaining 44% is almost wholly Fe O and Mg O in approximately equal proportions, with probably a little water and some minor ingredients. The composition is that usual to the chondritic meteorites.

QUINN CANYON.

This meteorite was found, according to Mr. Walter P. Jenney,* at the above locality in Nevada, in the latter part of August, 1908, by a prospector looking for borax. Mr. Jenney further states that the prospector cut off a few small pieces from the meteorite with a cold chisel and took them to Tonopah, Nevada, for identification. Soon after he sold out his interest in the find and left the country. The purchaser of the prospector's interest placed such information as he had in the hands of Mr. Jenney with a view to rediscovering the meteorite. As a very imperfect description of the locality where the meteorite was situated had been obtained from the original discoverer, it was necessary for him to make two trips to the region before the mass could be relocated. These trips, made by automobile, required 430 miles of travel. The place of find was in the foothills of the Quinn Canyon range of mountains, Nye County, Nevada. These mountains are marked on some maps as the Grant Mountains. The locality is 90 miles east from Tonopah, 18 miles north from the Mt. Diablo base line, and 100 miles west of the Utah boundary. The meteorite was found on the western slope of the range and on the northern slope of a low hill of andesite. The slope was a gentle one and the contour

* Mining & Scientific Press, Jan. 9, 1909, p. 93.

of the surrounding hills was such that the meteorite in falling may have come at a low angle from the west, north, or northeast. The area is treeless but bears a sparse growth of grass and sage brush. It is uninhabited except for a few sheep herders and occasional wandering prospectors. The meteorite was found with its flat side down and its arched side projecting above the ground. It lay with its longest dimensions in an east and west direction and was imbedded in the mantle of soil covering the hill to a depth of 10 or 12 inches. Mr. Jenney states that the contour of the surface of the ground had evidently resulted from extremely slow erosion and there was no indication that the meteorite had ever been buried deeper and exposed by the wearing away of the hillside. Under Mr. Jenney's direction a freight wagon drawn by a team of six horses and provided with a crew of three men, and with derrick and chain pulleys, went to Quinn Canyon and hauled the meteorite to Tonopah, the nearest railroad point. The round trip consumed eight days.

Through the generosity of Messrs. Stanley Field, R. T. Crane, Jr., Cyrus H. McCormick, and George F. Porter of the Board of Trustees of the Museum, the meteorite was acquired by this Museum in April, 1909. It was shipped from Tonopah under the direction of Mr. Jenney and reached the Museum in good condition. It is the largest specimen in the Museum collection and one of the large iron meteorites of the world.

In form the meteorite shows considerable shaping from its passage through the air and hence, as is typical with such meteorites, is a low cone. This form is due doubtless to the excessive action of the heat and erosion of atmospheric resistance about the periphery of the front side of the meteorite. Here the meteorite is worn away most rapidly and thus acquires a slope toward the center. Another effect of the atmospheric resistance is seen in the production of deep channelings, furrowings, pittings, and numerous cylindrical holes on the front side. All these, while very irregularly distributed, have a generally radial arrangement from the center outward. The outline of the meteorite in the direction of its greatest length is essentially oval though somewhat irregular. The contours may be seen by referring to Plates LVI–LVIII. The longest diameter of the oval is 47 inches; the diameter at right angles to this is 35 inches, and the circumference 132 inches. The height of the cone is 20 inches. The weight of the meteorite as determined by two careful weighings is 3,275 lbs. (1,450 kilog.). The front or conical side of the meteorite and the rear or basal side present very different appearances both in contour and relief of the surface. The front side is highly corrugated by deep and irregular channelings, pittings, and furrowings. The rear side is relatively smooth but with broad, shallow pittings. The features of the front side of the meteorite while very irregular may be classed as knobs, furrows, large and small pits and cylindrical holes. Of these the knobs lie between irregularly coursing furrows which leave the metal standing out in prominences, ranging in size from that of a man's fist down. These knobs are especially noticeable toward the apex of the cone, so that this has none of the smoothness which is often observed in meteorites of this form. The furrows are very irregular in their course but in a general way may be said to radiate outward from the center. They are shallow and sinuous, with the ridges between them usually broad and rounded. An average width for the furrows is one-half inch (1 cm.). Interspersed with and interrupting the furrows are shallow, shell-shaped pits from 1 to 3 inches (2.5 to 7.5 cm.) in diameter. These are the small pits referred to. The large pits differ in shape and character from the small pits, since they penetrate deeply into the mass of the meteorite. The largest of these pits is a bowl-like depression about nine inches (23 cm.) in diameter and four inches (10 cm.) deep. On Plate LVII it may be seen near the base of the meteorite. The contour and surface of this pit are irregular but it is much the deepest and largest depression observed. Perhaps the most interesting feature in regard to it is the occurrence, spread over the bottom in two places covering about one square inch each, of a crust of black, magnetic iron oxide. This adheres very firmly to the metal which it covers so that it can only be removed by blows with a hammer and chisel. It is continuous as a broad patch in the two places where it occurs but the two patches, while situated near together, do not join. The thickness of one of these patches is about 2 mm., that of the other is much less at the thickest point and dwindles away to nothing. The surface of the thicker patch is rough and corrugated.

The cylindrical holes referred to occur irregularly over the surface, not being grouped or lineally arranged so far as can be determined. Of these 35 may be counted with orifices varying from one-fourth of an inch (5 mm.) to one and one-fourth inches (3 cm.) in diameter. The majority are about one inch (2.5 cm.) in diameter. They penetrate to various depths the deepest being two inches (5 cm.). Frequently the cavity within is larger and of somewhat different shape from the orifice. As a rule, though, it has an approximately cylindrical shape and is about the size of the orifice. Other shapes noted for the orifices besides circular are oval, semicircular, kidney-shape and pear-shape. The direction of the cavity tends to be at right angles to the surface, but this varies also. Holes similar to these occur in many large iron meteorites, such as Chupaderos and Charcas, and are usually ascribed to a boring action of the air, or to the fusing out of troilite nodules. Their occurrence in the Quinn Canyon meteorite does not seem to throw any additional light on their origin. Their existence must be more or less responsible for the noise which accompanies the fall of a meteorite, for when a current of compressed air is directed against one of them a sharp, ear-piercing sound is produced. What the noise must be from this cause when the whole mass, highly heated, is advancing at an enormous velocity, is almost beyond comprehension.

Aside from these coarse features of relief of the surface, there are others of a more minute character. These may be designated as structure markings and lines of flow. The structure markings show the intimate crystal structure of the iron and are most abundant on the walls and at the bottom of cavities near the apex of the meteorite. They consist of groups of parallel ridges about 1.5 mm. apart, cross-hatched by shorter ridges at right angles. Small square pits about 1 mm. on a side are formed as a result. The long ridges are probably formed by tænite ribbons. Those at right angles are at irregular intervals, and probably mark the crossing of other bands. As a rule the groups of long ridges run in three directions at angles of 60° and often intersect to form triangles. The lines of flow as a rule cap the ridges of the meteorite and for the most part follow the crests but also at times cross them in a series of sinuous, more or less parallel lines. The metal is brighter along the lines of flow and in broad patches adjacent to them. They have the appearance therefore of a thin skin of metal which has fused and started to flow at various points. The thickness of this skin can hardly be more than 0.1 mm. The direction of flow is always away from the center of the meteorite, or in other words from the apex toward the base of the meteorite.

The pittings on the rear side may be divided into two classes as regards size and shape though all are probably similar in origin. The pittings of one class are large and circular or oval in outline. One of the circular pits is 4 inches (10 cm.) in diameter, and the largest oval pit has dimensions of 8 x 8 inches (20 x 13 cm.). Others of the large pittings have less regular shapes but all have sharp edges and do not merge into one another. The pittings of the other class are smaller, dot the surface pretty uniformly and average about one inch (2.5 cm.) in diameter. They show all variations of shape between cavities of circular form and angular depressions between angular elevations. These angular elevations doubtless represent the octahedral structure of the meteorite. The fact that the octahedral structure is thus brought into relief indicates that this pitting is due to a slow process of weathering and solution which the meteorite has undergone since its arrival on the earth. The larger pits are all doubtless produced by a process of weathering and solution, but the cause of their size and shape is not clear to the writer. Pits of the same general nature though much larger and deeper characterize the Willamette meteorite and were referred by Ward,* to a weathering process without any theory as to details. The rear side of the Quinn Canyon meteorite was, as has been stated, immersed in the soil and this gave, probably, moisture which aided solution of the iron. Carbonate of lime in the form of a whitish, closely adhering deposit covered, when the meteorite arrived at the Museum, the portion which had been imbedded, about the sides but not to any extent on the bottom, that is, the flat surface. The larger pits contained a considerable deposit of hydrous iron oxide in the form of scales which could easily be pried off. The side of the meteorite which had not been imbedded showed no weathering.

In connection with his account of the finding of the meteorite, Mr. Jenney described the passage of a large meteor over the region February 1, 1894. This account he repeats and elaborates in a later article† and considers it highly probable that the Quinn Canyon meteorite fell at this time. While there seems nothing impossible in the view, it is also true that there seems no way of positively connecting the two occurrences. The decomposition seen on the imbedded portion of the meteorite might seem to have required a longer time than fourteen years for its production, but no definite means of measuring this is known. The slight depth to which the meteorite was imbedded in the soil shows that it must have reached the earth with a very low velocity, in fact, so low that it is difficult to conceive how so large a mass could have alighted so gently. The assumption of a path nearly tangential to the earth's surface and a direction of motion similar to that of the earth seems the only way of explaining so slight a vertical penetration.

In order to determine the character of the etching figures of the meteorite two small fragments, weighing 9 and 15 grams respectively, have been cut from it since its arrival at the Museum. The surface

* Proc. Rochester Acad. Sci., 1904, 4, 141–146.

† Am. Jour. Sci., 1909, 4, 28, 431–434.

of the iron was quite resistant and hence the cutting was performed with some difficulty. Beneath the surface the iron is relatively soft. The depth to which the hardening extends is small and unmarked by any change of structure that can be observed either on etched or

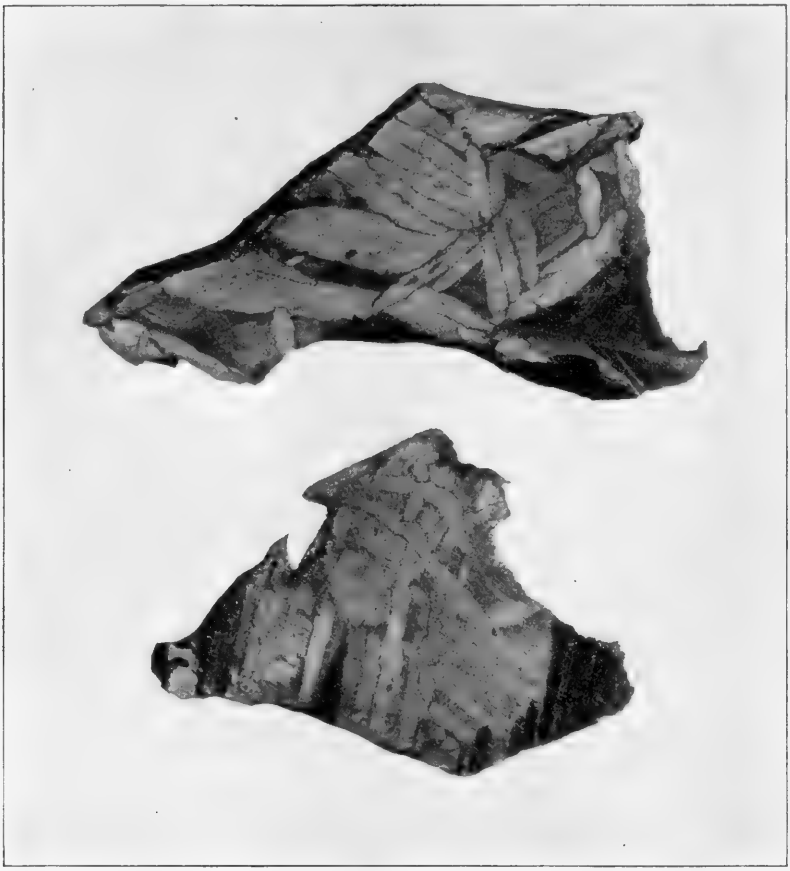

Fig 1. Etching figures of Quinn Canyon meteorite. ×2.

unetched sections. Mr. Jenney describes the meteorite as covered with a "thin, smooth skin of magnetic oxide" which he considered to have protected the mass from corrosion. It is true that the color of the surface of the meteorite is brownish-black as compared with the nickel-white color of the interior, and this surface color probably indicates superficial oxidation. The coating of oxide is, however, exceedingly thin. The interior of the iron is of nickel-white color and polishes well. Etching is easily performed with dilute nitric acid, the figures coming out very quickly. In fact, they are dimly outlined on surfaces which have been simply polished. The figures seen on etching the fragments are shown enlarged in Fig. 1. They are octahedral in character with long, straight, swollen, and little grouped bands. The fields are few in number and subordinate. They vary in size and have the forms of triangles, rhombs, and parallelograms. They are filled with dark-gray plessite, much darker in color than the kamacite. This plessite may be quite uninterrupted or it may contain networks of tænite, seen over the whole field or only in portions of it. The kamacite of one of the fragments etched shows well-marked hatching, the lines running in three directions, two at right angles and one diagonally. The directions of these lines are as a rule different for the different bands, each band having its own system but in one group of bands 8 mm. wide but subdivided by little tongues of tænite into smaller bands about 1 mm. in width, the orientation of the hatching lines is the same throughout.

While one of the fragments exhibits hatched kamacite the other exhibits only spotted kamacite. The spots of the latter are about 1 mm. in diameter, and of uniform size. It is possible that the portion of the meteorite showing spotted kamacite was more highly heated and the hatched kamacite thus metamorphosed to spotted kamacite.

Analysis of the meteorite was made by H. W. Nichols from material obtained by boring with a $\frac{5}{16}$-inch drill to a depth of 2½ inches. About 20 grams of material were thus obtained, varying in structure from continuous shavings an inch or more in length to fine metallic powder. The color of the material was iron-gray. The portions used for analysis were carefully sampled from the whole lot of borings. The analysis gave:

Fe	91.63
Ni	7.33
Co	0.73
Cu	tr.
S	0.00
P	0.20
Si	0.02
	99.91

The composition of the meteorite thus corresponds to that usual to the medium octahedrites. In addition to the components shown above careful search was also made for gold, platinum, or other rare metals. These were looked for in the following manner: A portion of the carefully sampled borings weighing 5½ grams was dissolved in nitric acid. Although no residue was obtained, the solution was evaporated to dryness, ignited so as to convert the iron to sesquioxide, and an assay made by the crucible method. The charge used consisted of 50 grams litharge, 25 grams soda, 25 grams borax glass, 5 grams scouring sand, and 4½ grams argols. The lead button obtained weighed 22 grams. On cupelling this no residue was obtained.

A partial analysis was made of the crust of magnetic oxide described on page 171. Fragments of this were broken off by careful chiselling, and in this way .3396 grams were obtained. The material was evidently somewhat hydrous and more or less coated with carbonate of lime. It was dissolved by hydrochloric acid although acted on very slowly by that solvent. Determinations of ferrous and ferric iron in the solution gave:

		Calc. to 100	Theory for Magnetite
Fe O	20.84	27.62	31
Fe_2O_3	54.60	72.38	69
	75.44	100	100

The remainder which was not determined quantitatively, was chiefly water, lime, CO_2, and silica. The proportions of ferrous and ferric oxide shown by the analysis leave little doubt that the mineral is magnetite and show that the oxidation which the surface of an iron meteorite undergoes in its passage through the air may produce this mineral.

COMPOSITION OF TÆNITE.

The composition of tænite, as is well known, varies between rather wide limits. As these limits do not seem as yet to have been determined by comparison of analyses, the writer has endeavored to collect all existing reliable analyses in order that such determination may be made. The compilation of analyses together with a calculation of the ratio of iron to nickel-cobalt-copper will be found below:

	Fe	Ni		Co	Cu	C	Total	Fe: Ni+Co +Cu
1	86.44	13.02		0.54	....	....	100.00	6.9 : 1
2	85.00	14 00		....	....	....	99.00	6.4 : 1
3	85.00	15.00		....	....	....	100.00	6.0 : 1
4	83.28	....	16 68	....	0.04	....	100.00	5.2 : 1
5	80.30	.....	19.60	....	....	....	99.90	4.1 : 1
6	74.78	24.32		0.33	....	0.50	99.93	3.2 : 1
7	73.10	23.63		2.10	....	1.17	100.00	3.0 : 1

	Fe	Ni		Co	Cu	C	Total	Fe:Ni+Co +Cu
8	73.0	27.00		....	....	....	100.00	2.8 : 1
9	72.12	27.73		0.02	....	0.12	100.00	2.7 : 1
10	71.29	26.73		1.68	....	0.30	100.00	2.6 : 1
11	70.14	29.74		....	....	....	99.88	2.5 : 1
12	69.30	29.73		0.60	....	0.37	100.00	2.4 : 1
13	68.13	30.85		0.69	0.33	....	100.00	2.2 : 1
14	65.54	32.87		1.59	....	....	100.00	2.0 : 1
15	65.39	33.20		1.41	....	....	100.00	2.0 : 1
16	65.26	34.34		0.40	....	....	100.00	2.0 : 1
17	63.55	34.65		1.01	0.30	0.49	100.00	1.9 : 1
18	63.04	35.53		1.43	....	tr.	100.00	1.8 : 1
19	61.89	36.95		0.36	....	0.80	100.00	1.7 : 1
20	61.87	.....	38.13	....	tr.	....	100.00	1.7 : 1
21	57.18	34.00		....	....	0.55	91.73	1.7 : 1
22	50.73	47.80		0.63	0.37	0.47	100.00	1.1 : 1

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22. Beaconsfield. Sjöström: Monatsberichte Berlin Akad., 1897, 1041. Tin to silver-white, lustrous plates. Iron determined by difference.

The analyses, as will be observed, show variations of composition from Fe_7 Ni to Fe Ni. While this variation is a wide one it is evident that it is between certain limits, and that it would be incorrect to ascribe too indefinite a composition to tænite.

TIMES OF FALL OF METEORITES.

The following study has already been published in part by the author.* In the present paper the records are given in full and contributions to the subject by other authors are incorporated.

The times of fall of meteorites may be studied with reference to the year, month, day, and hour. The yearly falls should give evidence as to the frequency of the occurrence and exhibit periods if any occur. The falls by months should show the relation of meteorites to well-established star showers and the portion of the earth's orbit where meteorites are most frequently encountered. The falls by days should exhibit periodicity if any exists and variation in the uniformity of supply. Finally the hours of fall should give the direction of move-

*Am. Jour. Sci., 1910 (4), 29, 211–215.

ment of meteorites. Since new falls occur yearly, data for study of these points are obviously constantly on the increase. It is desirable, however, to make comparisons at intervals in order that any changes may be discerned. At the present time the admirable catalogues of Wülfing * and others, afford excellent means for the collection of such data. From these catalogues, with such additions and corrections as could be made from other sources, the writer has obtained record of 350 well authenticated meteorite falls of which the year and month are known, 327 of which the day is known, and 273 of which the time of day is known. In this number it has been sought not to include finds referred by residents of a locality to meteors which they had seen a year or more before, since the residents of most localities can, on the occasion of a meteorite find, recall a large meteor seen in that locality at some previous time. To connect this, however, without further reason with the meteorite found seems an unreliable method of procedure.

Considering the falls by years it is well known that previous to the nineteenth century little reliable record of meteorite falls is available. Single falls are known for the years 1492, 1668, 1715, 1723, 1751, 1766, 1773, 1785, 1787, 1790, 1794, 1795, and 1796, and two falls each for the years 1753, 1768, and 1798. For the early part of the nineteenth century the record is not very complete since during the that period the possibility of meteorite falls was yet much doubted. However, the record may as well begin with 1800. From that year to the present 331 falls may be accepted as well authenticated as to their month and year. During this period eleven years show no falls whatever. These years are, 1800, 1801, 1809, 1816, 1817, 1832, 1839, 1888, 1906, 1908, and 1909. Of these the years of the present decade will probably have falls to their credit after a time, since the record of falls usually lags several years behind their occurrence. The largest number of falls shown in any year during the period is 11 in 1868. The years 1865, 1877, and 1886 show 7 each. All the other years show from 1 to 6 falls each. The full record by years beginning with 1800 is as follows:

1800......	0	1806......	1	1812......	4	1818......	3
1801......	0	1807......	2	1813......	2	1819......	2
1802......	1	1808......	3	1814......	2	1820......	1
1803......	3	1809......	0	1815......	2	1821 .. .	1
1804......	2	1810......	2	1816......	0	1822.. ..	5
1805......	2	1811......	2	1817......	0	1823.. ...	2

* Die Meteoriten in Sammlungen, Tübingen, 1897.

1824	3	1846	4	1868	11	1890	6
1825	2	1847	2	1869	6	1891	2
1826	2	1848	3	1870	3	1892	3
1827	3	1849	1	1871	3	1893	4
1828	1	1850	2	1872	4	1894	3
1829	3	1851	2	1873	3	1895	3
1830	2	1852	4	1874	5	1896	4
1831	2	1853	3	1875	5	1897	6
1832	0	1854	1	1876	5	1898	3
1833	1	1855	4	1877	7	1899	5
1834	2	1856	3	1878	5	1900	3
1835	3	1857	6	1879	6	1901	3
1836	3	1858	4	1880	3	1902	5
1837	1	1859	5	1881	2	1903	3
1838	5	1860	5	1882	4	1904	1
1839	0	1861	3	1883	3	1905	3
1840	3	1862	2	1884	3	1906	0
1841	3	1863	6	1885	4	1907	1
1842	3	1864	3	1886	7	1908	0
1843	5	1865	7	1887	6	1909	0
1844	3	1866	6	1888	0		
1845	3	1867	2	1889	5		350

This record on the whole seems to indicate a comparatively uniform supply of meteorites, which is the more remarkable when one considers the various chances affecting the observation of their fall. The record seems to afford no evidence of cycles or periodicity which can be traced with certainty. Still the record of years is perhaps not as satisfactory for establishing conclusions in this regard as is that of other periods. As the writer has shown elsewhere* at least 900 meteorites probably reach the earth yearly. Of these only an average number of three is recorded, so that it is evident that a large allowance must be made for unrecorded ones. Yet it is fair to presume that those recorded are typical of the whole, because while opportunities for observation of meteorite falls have probably continually increased in number since 1800, the record by decades shows that the decade from 1860 to 1870 considerably exceeded in number of falls either of the two succeeding ones.

Passing from the falls by years, the falls by months may be examined. Such an examination should have an especial significance in showing the relations which meteorites may have to well-known star showers. Two of the best known of these showers occur in August and November. If meteorites are related to these, these months should show a larger fall than others. If meteorites are not related to these, no special increase for these months should be shown.

*Pop. Sci. Mon., 1904, pp. 351–354.

On compiling the results it is found that the months of May and June exhibit the greatest number of falls. The number for November falls below the average and that for August rises only slightly above. The evidence from this record is therefore that meteorites are not related to the best known star showers. It is fair to presume that the record by months will be somewhat influenced by the times that observers are most abroad. Most of the observations of meteorite falls are made in the northern hemisphere and in this hemisphere observers are more likely to be out of doors and hence more likely to observe the fall of meteorites in the summer than in the winter months. The record shows that as a whole the number of falls recorded *is* less for the winter than the summer months, yet the number of falls cannot be influenced by that alone since the high record for May and June drops to nearly half that number in July. Further the months of August, September and October are equally favorable as regards weather for observations of meteorite falls with those of April, May and June, yet the latter period much excels the former in number of falls. The excess of falls in May and June must, therefore, be due to other causes than favorable conditions of observation and seems to indicate that in the portion of the earth's orbit passed through in these months there is an unusual number of meteorites. The full table for the different months is as follows:

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
25	24	22	32	44	45	23	36	30	24	24	21=350

This record is shown graphically in the accompanying diagram, Fig. 2.

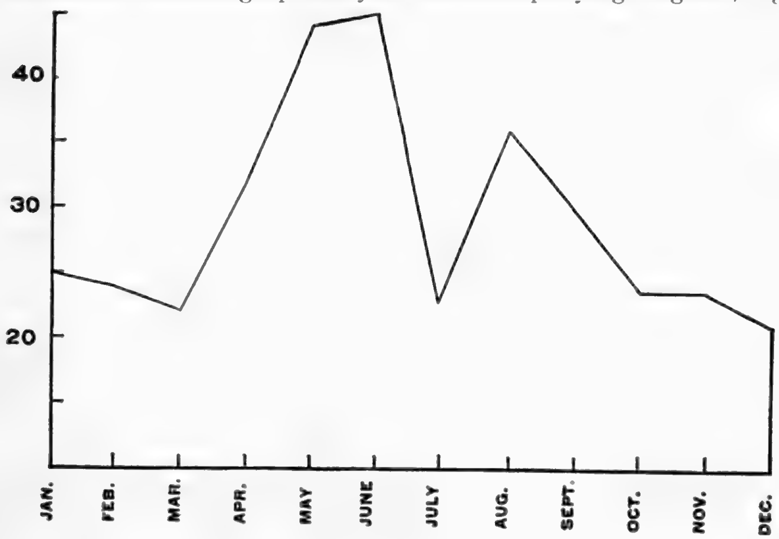


Fig. 2. Curve of meteorite falls by months.

Comparison of the falls of meteorites by months as here given with those of falling stars and fireballs as given by W. H. Pickering * shows a marked difference of distribution. According to Pickering's list the falling stars and fireballs are much more uniformly distributed through the year than are meteorites and the periods of greatest number of meteoric falls are from July to November. In May and June their number is at its minimum. Hence the record seems to show a difference in character between meteors and meteorites and furnishes *per se* a ground for questioning the gradation that has been supposed to exist between meteors and meteorites.

Tabulation of the falls by days of the year seems to show little of significance. The largest number of falls for any one day is 5 on October 13, and this is a month when the total number of falls is not large. Four days show 4 falls each and 158, or nearly half the total number, no falls at all. The days without falls seem to be scattered indiscriminately through the year, without marked grouping or arrangement. The days showing falls aside from those mentioned, have from one to three falls each without any marked grouping that is apparent. Such a record seems also to indicate that to refer a meteorite falling on the day of a star shower to such showers is unsafe practice especially if the observations are not sufficient to assign the two to the same radiant. The meteorite falls are so uniformly distributed throughout the year that the two occurrences might easily be coincident without being otherwise related. The full record of the falls by days is as follows:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	2	..	..	1	1	..	1	3	..	2	..	1
2		1	..	..	1	2	..	1	1	..	..	2
3	2	2	..	1	..	3	..	..	1	2	..	..
4		..	1	1	..	2	2	1	1	..	..	1
5		..	..	1	1	..	..	4	4	2	1	1
6		..	2	2	..	2	..	..	1	1	..	1
7		..	..	2	..	2	..	2	2	1	..	1
8	1	..	..	..	3	..	1	1	..	1	..	..
9		1	..	2	2	2	..	..	2	..	..	1
10		3	..	3	1	..	1	2	1	..	1	1
11		..	..	1	2	1	1	3	..	1	1	..
12	1	2	3	1	1	4	1	1	..	..	2	..
13		2	..	2	2	2	..	1	3	5	..	3
14		..	..	..	3	2	3	2	1	1	..	1
15	1	2	1	2	1	2	1	..	1	..	2	..
16	1	3	1	..	..	2	..	2	1	..	1	..

* Popular Astronomy, 1909, 17, 277.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
17	..	..	1	1	3	1	2	..	..	..	1	..
18	..	3	..	1	..	2	1	1	..	1	..	..
19	2	1	2	1	3	1	..	..	1	..	2	1
20	1	..	1	1	3	2	1	..	..	..	1	..
21	1	..	..	..	1	2	..	..	1	2	..	1
22	..	..	1	..	3	1	1	1	3	1	..	2
23	3	..	..	..	1	..	1	..	1	..	1	..
24	..	..	1	1	2	..	2	..	..	1	1	..
25	2	1	3	..	1	1	1	2	..	..	1	1
26	..	..	..	3	2	1	..	..	1	1	1	..
27	1	..	1	1	2	..	1	..	1	..	3	2
28	1	1	2	..	1	3	..	..	1	..	..	..
29	1	1	..	1	..	1	..	3	..	1	..	..
30	1	..	..	..	1	1	..	1	..	..	4	..
31	2	..	1	..	..	..	..	1	..	1	..	..
	23	23	21	29	41	42	21	32	28	24	23	20 = 327

Of all times of fall of meteorites the most satisfactory for study are probably the hours of fall, since the ratio of number of falls to number of hours is larger than to days, months, or years. As is well known, the hours of fall show the direction of movement of meteorites, since (with a few minor possible obvious exceptions) meteorites falling from noon to midnight, or afternoon falls, as they may be called, must be moving in the same direction as the earth; while those falling between midnight and noon, or forenoon falls, are moving in a direction opposite to that of the earth or else at a speed so slow that they are overtaken by it. While the hour of fall is not known of as many meteorites as is the year and month, yet of 273 sufficiently satisfactory records are available. Of these 273 falls 184 occurred in the time from noon to midnight, and 89 from midnight to noon. The record in full is as follows, the total number being less by seven than that recorded for forenoon and afternoon, since of these seven the hour is not known:

Hours	12	1	2	3	4	5	6	7	8	9	10	11	Total
A. M.	1	2	3	2	6	7	7	18	12	10	9	12	= 89
P. M.	24	13	19	33	21	15	11	8	16	7	9	3	= 176

As in the case of the months and the years, it is quite likely that here also considerable allowance should be made for conditions of observation. It is reasonable to expect that the number of falls recorded in the early morning hours would be less than that for other times, since mankind is generally asleep then. That some such allowance must be made is indicated by the records, for the number of falls from midnight to 6 A. M. is only 21, while from 6 A. M. to noon it is 68;

from noon to 6 P. M. 124, and from 6 P. M. to midnight 60. Hence it seems probable that some of the diminution in the number of falls is due to lack of observers, although Newton* seemed to conclude from studies of the orbits of the morning falls that lack of observers had little to do with their scarcity. Lack of meteorites during morning hours may also be due in part, as Newton suggested, to the fact that such as have retrograde motion are more likely to be burned up by the greater velocity with which they strike the earth's atmosphere. This increase in velocity is not so great as might be supposed since Lowell has shown † that it cannot exceed 2.66 miles per second. Yet Pickering ‡ thinks it is sufficient to destroy all that have retrograde motion, or that the velocity of such as have retrograde motion would be higher than any that has yet been recognized. It is not clear how such an increase would be very apparent if this increase at most is only 2.66 miles per second. On account of the above probabilities Pickering is of the opinion that most if not all of the meteorites which fall in the morning hours are moving at so slow a speed that they are overtaken by the earth. Schiaparelli, who gave the matter much study and to whom we are indebted for extensive researches in the relations between comets and meteors, concluded that many meteorites had hyperbolic velocities and hence must come from the world of fixed stars rather than from comets or the solar system.|| Newton assigned to the stone of Stannern a velocity of 45 miles per second, and concluded that most meteorites are allied to short period comets in their velocities.§ Pickering ¶ regards it doubtful whether any stony meteorites move fast enough to be accredited with cometary velocities.

The hourly falls of the writer's table are shown plotted in Plate LIX. It will be observed that the peak of the falls occurs at 3 P.M. Pickering has shown ** that other things being equal the greatest number of meteorites would be expected when the Earth's quit is highest above the horizon and that this occurs for the northern hemisphere, longitude 90°, at 3 P. M., May 6. This high point agrees with that of the greatest number of meteorites, for they are most numerous in May

* Am. Jour. Sci., 1888, 3, 36, 10.

† Science, N. S., 1909, 30, 339.

‡ Popular Astronomy, 1910, 18, 264.

|| Entwurf einer Astronomischen Theorie der Sternschnuppen. Boguslawski's translation, 1871, p. 228.

§ Am. Jour. Sci., 1888, 3, 36, 11, and 13.

¶ Popular Astronomy, 1910, 18, 276.

** *Op. cit.*, p. 272.

and at 3 P. M. It may also be remarked that the writer has shown that meteorites are most numerous in mountain regions,* so that the high points seem in every respect to be the most successful in acquiring meteorites.

It would be possible from the writer's data to compare falls at different intervals and for different periods in order to determine whether various periods agree in times of fall. Such examination of the records as the writer has made shows that the distribution of the falls is about the same in all the periods. In order to secure independent testimony on this point the writer's results may be compared with those of Haidinger, who in 1867 † gave the hours of 178 meteorite falls. His table was as follows:

	12	1	2	3	4	5	6	7	8	9	10	11		
A. M.	1	3	2	2	4	5	4	13	5	7	5	23	=	74
P. M.	9	11	11	19	18	9	6	10	5	1	0	5	=	104

On examination of these falls by name, however, it appears that some are assigned times of fall which later investigation has shown to be unreliable, as is true of the meteorite of Mincy for example and others listed are not now recognized as meteoritic. For these reasons about 40 falls must be eliminated from Haidinger's list. Omitting these the result is as follows:

	12	1	2	3	4	5	6	7	8	9	10	11		
A. M.	1	1	1	2	3	3	4	10	5	5	5	17	=	57
P. M.	7	9	9	16	15	7	5	7	3	0	0	3	=	81

An excess of afternoon over forenoon falls is seen here as in the writer's list, although the proportion is less, it being nearly 2 : 1 in the writer's list and 1.4 : 1 in Haidinger's list. More significant perhaps is the fact that both lists show an excess of falls at 7 A. M., 11 A. M., and 3 P. M.

On the whole the study of the times of fall of meteorites in the manner here adopted seems to show (1) that they differ considerably from meteors in times of fall, (2) that they are not noticeably related to any of the well known star showers and (3) that the rate of their supply to the earth is remarkably uniform.

LIST OF METEORITES OF THE UNITED STATES OF AMERICA BY STATES.

The following list comprises the meteorites of the United States as at present known, grouped by States. Great care has been taken in

* Pop. Sci. Mon., 1904, p. 352.

† Sitzb. Kais. Akad. der Wiss. Wien. Bd. 55.

the preparation of this list to include only meteorites which may properly be regarded as separate falls, and on the other hand to include all that should be so regarded. It is thought that such a list will be useful for reference and tend toward uniformity of nomenclature. The classification of each meteorite according to Brezina's system, so far as known, is shown by abbreviations, the full forms of which are as follows:

Cc.	Stone, Spherulitic chondrite.
Cca.	Stone, Veined spherulitic chondrite.
Ccb.	Stone, Breccia-like spherulitic chondrite.
Cco.	Stone, Ornans spherulitic chondrite.
Cck.	Stone, Crystalline spherulitic chondrite.
Cg.	Stone, Gray chondrite.
Cga.	Stone, Veined gray chondrite.
Cgb.	Stone, Breccia-like gray chondrite.
Chla.	Stone, Veined chladnite.
Cho.	Stone, Howarditic chondrite.
Ci.	Stone, Intermediate chondrite.
Cia.	Stone, Veined intermediate chondrite.
Cib.	Stone, Breccia-like intermediate chondrite.
Ck.	Stone, Crystalline condrite.
Cka.	Stone, Veined crystalline chondrite.
Ckb.	Stone, Breccia-like crystalline chondrite.
Cs.	Stone, Black chondrite.
Csa.	Stone, Veined black chondrite.
Csb.	Stone, Breccia-like black chondrite.
Cw.	Stone, White chondrite.
Cwa.	Stone, Veined white chondrite.
Cwb.	Stone, Breccia-like white chondrite
D.	Iron, Ataxite.
Db.	Iron, Babb's Mill ataxite.
Dc.	Iron, Cape ataxite.
Dl.	Iron, Linville ataxite.
Dn.	Iron, Nedagolla ataxite.
Dr.	Iron, Rafruti ataxite.
Ds.	Iron, Siratik ataxite.
Dsh.	Iron, Shingle Springs ataxite.
Dt.	Iron, Tucson ataxite.
H.	Iron, Hexahedrite.
Ha.	Iron, Granular hexahedrite.
Hb.	Iron, Breccia-like hexahedrite.
Ho.	Stone, Howardite.
Kc.	Stone, Carbonaceous, spherulitic chondrite.
M.	Iron-stone, Mesosiderite.
Mg.	Iron-stone, Grahamite.
O.	Iron, Octahedrite.
Of.	Iron, Fine octahedrite.

Off. Iron, Finest octahedrite.
Offbp. Iron, Breccia-like finest octahedrite.
Og. Iron, Coarse octahedrite.
Ogg. Iron, Coarsest octahedrite.
Oh. Iron, Hammond octahedrite.
Om. Iron, Medium octahedrite.
P. Iron-stone, Pallasite.
Pi. Iron-stone, Imilac pallasite.
Pk. Iron-stone, Krasnojarsk pallasite.
Pr. Iron-stone, Rokicky pallasite.

LIST OF METEORITES BY STATES

ALABAMA.

Auburn, Lee Co., H. 32° 37′ N. 85° 32′ W., found 1867.
Chulafinnee, Cleburne Co., Om. 33° 35′ N. 85° 42′ W., found 1873.
Danville, Morgan Co., Cga. 34° 24′ N. 87° 5′ W., fell Nov. 27, 1868.
Desotoville, Choctaw Co., H. 32° 13′ N. 88° 10′ W., found 1859.
Felix, Perry Co., Kc. 32° 33′ N. 87° 12′ W., fell May 15, 1900.
Frankfort, Franklin Co., Ho. 34° 30′ N. 87° 52′ W., fell Dec. 5, 1868.
Leighton, Colbert Co., Cgb. 34° 40′ N. 87° 35′ W., fell Jan. 12, 1907.
Limestone Creek, Monroe Co., Dc. 31° 34′ N. 87° 30′ W., found 1834.
Selma, Dallas Co., Cc. 32° 25′ N. 87° W., found 1906.
Summit, Blount Co., Ha. 34° 13′ N. 86° 30′ W., found 1890.
Walker County, H. 33° 50′ N. 87° 15′ W., found 1832.
Stones, 5; irons 6; total, 11. Observed falls, 4.

ARKANSAS.

Joe Wright Mountain, Independence Co., Om. 35° 43′ N. 91° 27′ W., found 1884.
Cabin Creek, Johnson Co., Om., 35° 24′ N. 93° 17′ W., fell March 27, 1886.
Stones, 0; irons 2; total, 2. Observed falls, 1.

ARIZONA.

Canyon Diablo, Coconino Co., Og. 35° 10′ N. 111° 7′ W., found 1891.
Coon Butte, Coconino Co., Cib. 35° 10′ N. 111° 7′ W., found 1906.
Tucson, Pima Co., Dt. 32° 12′ N. 110° 35′ W., found 1851.
Weaver, Maricopa Co., Dt. 33° 58′ N 112° 35′ W., found 1898.
Stones, 1; irons 3; total 4. Observed falls. 0.

CALIFORNIA.

Canyon City, Trinity Co., Og. 40° 35′ N. 123° 5′ W., found 1875.
Ivanpah, San Bernardino Co., Om. 35° 30′ N. 115° 28′ W., found 1880.
Oroville, Butte Co., Om. 39° 18′ N. 122° 38′ W., found 1893.
San Emigdio Range, San Bernardino Co., Cc., found 1887.
Shingle Springs, El Dorado Co., Dsh. 38° 43′ N. 120° 53′ W., found 1869.
Surprise Springs, San Bernardino Co., Om. 34° 12′ N. 115° 54′ W.. found, 1899.
Stones, 1; irons, 5; total, 6. Observed falls, 0.

COLORADO.

Bear Creek, Jefferson Co., Of. 39° 38′ N. 105° 16′ W., found 1866.
Franceville, El Paso Co., Om. 38° 48′ N. 104° 35′ W., found 1890.
Guffey, Park Co., Dr 38° 45′ N. 105° 30′ W., found 1907.
Russel Gulch, Gilpin Co., Of. 39° 47′ N. 105° 31′ W., found 1863.
Ute Pass, Summit Co., Ogg. 39° 48′ N. 106° 10′ W., found 1894.
Stones, 0; irons, 5; total, 5. Observed falls, 0.

CONNECTICUT.

Weston, Fairfield Co., Ccb. 41° 13′ N. 73° 27′ W., fell Dec. 14, 1807.
Stones, 1; Irons, 0; total, 1. Observed falls, 1.

GEORGIA

Canton, Cherokee Co., Ogg. 34° 12′ N. 84° 30′ W., found 1894.
Dalton, Whitfield Co., Om. 34° 59′ N. 84° 54′ W., found 1877.
Forsyth, Monroe Co., Cwa. 33° 3′ N. 83° 56′ W., fell May 8, 1829.
Hollands Store, Chattooga Co., Ha. 34° 22′ N. 85° 26′ W., found 1887.
Locust Grove, Henry Co., Ds. 33° 20′ N. 84° 8′ W., found 1857.
Losttown Creek, Cherokee Co., Om. 34° 10′ N. 84° 32′ W., found 1868.
Lumpkin, Stewart Co., Cck. 31° 54′ N. 84° 57′ W., fell Oct. 6, 1869.
Pickens County, Cck. 34° 30′ N. 84° 28′ W., found 1908.
Putnam County, Of. 33° 16′ N. 83° 25′ W., found 1839.
Thomson, McDuffie Co., Cga. 33° 23′ N. 82° 30′ W., fell Oct. 15. 1888.
Union County, Ogg. 34° 56′ N. 83° 58′ W., found 1853.
Stones, 4; irons, 7; total, 11. Observed falls, 3.

IDAHO.

Hayden Creek, Lemhi Co., Om. 45° 0′ N. 113° 45′ W., found 1895.
Stones, 0; irons, 1; total, 1. Observed falls, 0.

INDIANA.

Harrison County, Cho. 38° 12′ N. 86° 8′ W., fell March 28, 1859.
Kokomo, Howard Co., Dc. 40° 34′ N. 86° 2′ W., found 1862.
Plymouth, Marshall Co., Om. 41° 20′ N. 86° 18′ W., found 1893.
Rochester, Fulton Co., Cc. 41° 5′ N. 86° 13′ W., fell Dec. 21, 1876.
Rushville, Rush Co., Cg. 39° 22′ N. 85° 3′ W., found 1860.
South Bend, St. Joseph Co., Pi. 41° 40′ N. 86° 15′ W., found 1893.
Stones, 3; iron-stones, 1; irons, 2; total, 6. Observed falls, 2.

IOWA.

Estherville, Emmet Co., M. 43° 24′ N. 94° 50′ W., fell May 10, 1879.
Forest City, Winnebago Co., Ccb. 43° 17′ N. 93° 38′ W., fell May 2, 1890.
Homestead, Iowa Co., Cgb. 41° 39′ N. 91° 32′ W., fell Feb. 12, 1875.
Marion, Linn Co., Cwa. 41° 57′ N. 91° 34′ W., fell Feb. 25, 1847.
Stones, 3; iron-stones, 1; irons, 0; total, 4. Observed falls, 4.

KANSAS.

Admire, Lyon Co., Pr. 33° 0′ N. 96° 5′ W., found 1891.
Brenham, Kiowa Co., Pk. 37° 38′ N. 99° 13′ W., found 1885.
Elm Creek, Lyon Co., Cco. 38° 40′ N. 96° 5′ W., found 1906.

Farmington, Washington Co., Csa. 39° 48′ N. 97° 5′ W., fell June 25, 1890.
Jerome, Gove Co., Cck. 38° 47′ N. 100° 14′ W., fell Apr. 10, 1894.
Long Island, Phillips Co., Ck. 39° 56′ N. 99° 34′ W., found 1891.
Modoc, Scott Co., Cga. 38° 30′ N. 100° 55′ W., fell Sept 2, 1905.
Ness County, Cib. 38° 30′ N. 99° 37′ W., found 1897.
Oakley, Logan Co., Ck. 38° 55′ N. 101° 0′ W., found 1895.
Ottawa, Franklin Co., Cho. 38° 37′ N. 95° 18′ W., fell Apr. 9, 1896.
Prairie Dog Creek, Decatur Co., Cck. 39° 42′ N. 100° 24′ W., found 1893.
Saline, Sheridan Co., Cck. 39° 22′ N. 100° 27′ W., fell Nov. 15, 1898.
Scott, Scott Co., 38° 30′ N. 100° 55′ W., found 1905.
Tonganoxie, Leavenworth Co., Om. 39° 8′ N. 95° 7′ W., found 1886.
Waconda, Mitchell Co., Ccb. 39° 20′ N. 98° 10′ W., found 1873.
Stones, 12; iron-stones, 2; irons, 1; total 15. Observed falls, 5.

KENTUCKY.

Bath Furnace, Bath Co., Cia. 38° 2′ N. 83° 37′ W., fell Nov. 15, 1902.
Casey County, Og. 37° 20′ N. 84° 55′ W., found 1877.
Cynthiana, Harrison Co., Cg. 38° 24′ N. 84° 16′ W., fell Jan. 23, 1877.
Eagle Station, Carroll Co., Pr. 38° 37′ N. 85° 0′ W., found 1880.
Frankfort, Franklin Co., Om. 38° 7′ N. 84° 57′ W., found 1866.
Kenton County, Om. 38° 40′ N. 84° 29′ W., found 1889.
La Grange, Oldham Co., Of. 38° 37′ N. 85° 25′ W., found 1860.
Marshall County, Om. 36° 50′ N. 88° 17′ W., found 1860.
Mount Vernon, Christian Co., Pk. 36° 50′ N. 87° 28′ W., found 1868.
Nelson County, Ogg. 37° 48′ N. 85° 27′ W., found 1860.
Salt River, Bullitt Co., Off. 37° 56′ N. 85° 54′ W., found 1850.
Scottsville, Allen Co., H. 36° 45′ N. 86° 10′ W., found 1867.
Smithland, Livingston Co., Db. 37° 18′ N. 88° 17′ W., found 1839.
Williamstown, Grant Co., Om. 38° 35′ N. 84° 30′ W., found 1892.
Stones, 2; iron-stones, 2; irons, 10; total, 14. Observed falls, 2.

MAINE.

Andover, Oxford Co., Cc. 44° 36′ N. 70° 47′ W., fell Aug. 5, 1898.
Castine, Hancock Co., Cwa. 44° 24′ N. 68° 48′ W., fell May 20, 1848.
Nobleborough, Lincoln Co., Ho. 44° 4′ N. 69° 28′ W., fell Aug. 7, 1823.
Searsmont, Waldo Co., Cc. 44° 22′ N. 69° 12′ W., fell May 21, 1871.
Stones, 4; irons, 0; total, 4. Observed falls, 4.

MARYLAND.

Emmitsburg, Frederick Co., Om. 39° 43′ N. 77° 20′ W., found 1854.
Lonaconing, Allegheny Co., Og. 39° 28′ N. 79° 2′ W., found 1888.
Nanjemoy, Charles Co., Cc. 38° 25′ N. 77° 12′ W., fell Feb. 10, 1825.
Stones, 1; irons, 2; total, 3. Observed falls, 1.

MICHIGAN.

Allegan, Allegan Co., Cco. 42° 34′ N. 85° 52′ W., fell July 10, 1899.
Grand Rapids, Kent Co., Of. 42° 59′ N. 85° 42′ W., found 1883.
Reed City, Osceola Co., Oh. 43° 53′ N. 85° 32′ W., found 1895.
Stones, 1; irons, 2; total, 3. Observed falls, 1.

MINNESOTA

Arlington, Sibley Co., Om. 44° 30′ N. 93° 56′ W., found 1894.
Fisher, Polk Co., Cia. 47° 48′ N. 96° 49′ W., fell April 9, 1894.
Stones, 1; irons, 1; total, 2. Observed falls, 1.

MISSOURI.

Billings, Christian Co., Om. 37° 5′ N. 93° 28′ W., found 1903.
Butler, Bates Co., Off. 38° 18′ N. 94° 25′ W., found 1874.
Cape Girardeau, Cape Girardeau Co., Cc. 37° 13′ N. 89° 32′ W., fell Aug. 14, 1846.
Central Missouri, Ogg. Central portion of state, found 1855.
Little Piney, Pulaski Co., Cc. 37° 55′ N. 92° 5′ W., fell Feb. 13, 1839.
Mincy, Taney Co., M. 36° 35′ N. 93° 7′ W., found 1856.
Saint Francois County, Og. 37° 55′ N. 90° 36′ W., found 1863.
Saint Genevieve County, Of. 37° 47′ N. 90° 22′ W., found 1888.
Warrenton, Warren Co., Cco. 38° 44′ N. 91° 12′ W., fell Jan. 3, 1877.
Stones, 3; iron-stones, 1; irons, 5; total, 9. Observed falls, 3.

MONTANA.

Illlinois Gulch, Deer Lodge Co., Dn. 46° 39′ N. 112° 32′ W., fell 1897.
Stones, 0; irons, 1; total, 1. Observed falls, 0.

NEBRASKA.

Ainsworth, Brown Co., Om. 42° 30′ N. 99° 50′ W., found 1907.
Mariaville, Rock Co., Iron, 42° 45′ N. 99° 25′ W., desc. 1897.
Ponca Creek, Boyd Co., Ogg., desc. 1863.
Redwillow County, Iron, desc., 1897.
York, York Co., Iron, 40° 52′ N. 97° 33′ W., found 1878.
Stones, 0; irons, 5; total, 5. Observed falls, 0.

NEVADA.

Quinn Canyon, Nye Co., Om. 38° 30′ N. 115° 20′ W., found 1908.
Stones, 0; irons, 1; total, 1. Observed falls, 0.

NEW JERSEY.

Deal, Monmouth Co., Ci. 40° 14′ N. 74° 1′ W., fell Aug. 14, 1829.
Stones, 1; irons, 0; total, 1. Observed falls, 1.

NEW MEXICO.

Costilla, Taos Co., Om. 36° 50′ N. 105° 13′ W., found 1881.
El Capitan, Lincoln Co., Om. 33° 30′ N. 105° 30′ W., found 1893.
Glorieta Mountain, Santa Fe Co., Om. 35° 22′ N. 105° 50′ W., found 1884.
Luis Lopez, Socorro Co., Om. 34° 0′ N. 107° 0′ W., found 1896.
Oscuro Mountains, Socorro Co., Og. 33° 45′ N. 107° 20′ W., found 1895.
Sacramento Mountains, Otero Co., Om. 32° 32′ N. 105° 20′ W., found 1896.
Stones, 0; irons, 6; total 6. Observed falls, 0.

NEW YORK.

Bethlehem, Albany Co., Cck. 42° 6′ N. 73° 47′ W., fell Aug. 11, 1859.
Burlington, Otsego Co., Om. 42° 40′ N. 75° 8′ W., found 1819.

Cambria, Niagara Co,. Of. 43° 13′ N. 78° 45′ W., found 1818.
Seneca Falls, Seneca Co., Om. 42° 57′ N. 76° 58′ W., found 1850.
Tomhannock Creek, Rensselaer Co., Cgb. 42° 52′ N. 73° 36′ W., found 1863.
Stones, 2; irons, 3; total, 5. Observed falls, 1.

NORTH CAROLINA.

Asheville, Buncombe Co., Om. 35° 36′ N. 82° 31′ W., desc. 1839.
Black Mountain, Buncombe Co., Og. 35° 53′ N. 80° 3′ W., found 1839.
Bridgewater, Burke Co., Of. 35° 45′ N. 81° 53′ W., found 1890.
Castalia, Nash Co., Cgb. 36° 4′ N. 78° 4′ W., fell May 14, 1874.
Colfax, Rutherford Co., Om. 35° 18′ N. 81° 45′ W., found 1880.
Cross Roads, Wilson Co., Cg. 35° 38′ N. 78° 7′ W., fell May 24, 1892.
Deep Springs, Rockingham Co., Db. 36° 20′ N. 79° 35′ W., found 1846.
Duel Hill, Madison Co., Og. 35° 51′ N. 82° 44′ W., found 1873.
Ferguson, Haywood Co., Stone, 35° 36′ N. 83° 0′ W., fell July 18, 1889.
Flows, Cabarrus Co., Cga. 35° 18′ N. 80° 33′ W., fell Oct. 31, 1849.
Forsyth County, Dn. 36° 8′ N. 80° 20′ W., found 1895.
Guilford County, Om. 36° 4′ N. 79° 48′ W., desc. 1822.
Hendersonville, Henderson Co., Cc. 35° 19′ N. 82° 28′ W., found 1901.
Jewel Hill, Madison Co., Of. 35° 49′ N. 82° 45′ W., found 1854.
Lick Creek, Davidson Co., H. 35° 40′ N. 80° 12′ W., found 1879.
Linville, Burke Co., Dl. 35° 48′ N. 81° 55′ W., found 1882.
Murphy, Cherokee Co., H. 35° 6′ N. 84° 2′ W., found 1899.
Persimmon Creek, Cherokee Co., Offbp. 35° 3′ N. 84° 4′ W., found 1893.
Smith's Mountain, Rockingham Co., Of. 36° 32′ N. 79° 58′ W., found 1863.
Stones, 5; irons, 14; total, 19. Observed falls, 4.

NORTH DAKOTA.

Jamestown, Stutsman Co., Of 46° 42′ N. 98° 34′ W., found 1885.
Niagara, Grand Forks Co., Og. 47° 58′ N. 97° 52′ W., found 1879.
Stones, 0; irons, 2; total, 2. Observed falls, 0.

OHIO.

Anderson Township, Hamilton Co., P. 39° 10′ N. 84° 18′ W., desc. 1884.
Cincinnati, Hamilton Co., Ds. 39° 7′ N. 84° 29′ W., desc 1898.
Hopewell Mounds, Ross Co., Om. 39° 10′ N. 83° 20′ W., desc. 1902.
New Concord, Guernsey Co., Cia. 39° 58′ N. 81° 44′ W., fell May 1, 1860.
Pricetown, Highland Co., Cw. 33° 11′ N. 83° 44′ W., fell Feb. 13, 1893.
Wooster, Wayne Co., Om. 40° 48′ N. 81° 58′ W , found 1858.
Stones, 2; ironstones, 1; irons, 3; total, 6. Observed falls, 2.

OREGON.

Port Orford, Curry Co., P. 42° 46′ N. 124° 28′ W., found 1859.
Willamette, Clackamas Co , Om. 45° 22′ N. 122° 35′ W., found 1902.
Stones, 0; ironstones, 1; irons, 1; total, 2. Observed falls, 0.

PENNSYLVANIA.

Bald Eagle, Lycoming Co., Om. 41° 12′ N. 77° 5′ W., found 1891.
Mount Joy, Adams Co., Ogg. 39° 44′ N. 77° 20′ W., found 1887.

Pittsburg, Allegheny Co., Ogg. 40° 27′ N. 79° 57′ W., found 1850.
Shrewsbury, York Co., Om. 39° 45′ N. 76° 35′ W., found 1907.
Stones, 0; irons, 4; total, 4. Observed falls, 0.

SOUTH CAROLINA.

Bishopville, Sumter Co., Chla. 34° 12′ N. 80° 18′ W., fell Mar. 25, 1843.
Chesterville, Chester Co., Dn. 34° 42′ N. 81° 15′ W., found 1847.
Laurens County, Off. 34° 30′ N. 82° 14′ W., found 1857.
Lexington County, Og. 33° 57′ N. 81° 18′ W., found 1880.
Ruff's Mountain, Newberry Co., Om. 34° 15′ N. 81° 21′ W., found 1844.
Stones, 1; irons, 4; total, 5. Observed falls, 1.

SOUTH DAKOTA.

Bath, Brown Co., Ccb. 45° 27′ N. 98° 19′ W., fell Aug. 29, 1892.
Fort Pierre, Stanley Co., Om. 44° 23′ N. 100° 46′ W . found 1856.
Stones, 1; irons, 1; total, 2. Observed falls, 1.

TENNESSEE.

Babb's Mill, Greene Co., Db. 36° 18′ N. 82° 54′ W., found 1842.
Carthage, Smith Co., Om. 36° 20′ N. 85° 56′ W.. found 1844.
Charlotte, Dickson Co., Of. 36° 13′ N. 87° 20′ W., fell Aug. 1, 1835.
Cleveland, Bradley Co., Om. 35° 8′ N. 84° 53′ W., found 1860.
Coopertown, Robertson Co., Om. 36° 25′ N. 87° 0′ W., found 1860.
Cosby Creek, Cocke Co., Og. 35° 48′ N. 83° 15′ W., found 1837.
Crab Orchard, Cumberland Co., Mg. 35° 53′ N. 84° 48′ W., found 1887.
Drake Creek, Sumner Co., Cwa. 36° 18′ N. 86° 34′ W., fell May 9. 1827.
Jackson County, Om. 36° 25′ N. 85° 37′ W., found 1846.
Jonesboro. Washington Co., Of. 36° 16′ N. 82° 30′ W., found 1891.
Morristown, Hamblen Co., Mg. 36° 9′ N. 83° 24′ W., found 1887.
Murfreesboro, Rutherford Co., Om. 35° 50′ N. 86° 20′ W., found 1847.
Petersburg, Lincoln Co., Ho. 35° 20′ N. 86° 38′ W., fell Aug. 5, 1855.
Smithville, Dekalb Co., Og. 35° 55′ N. 85° 46′ W., found 1840.
Tazewell, Claiborne Co., Off. 36° 27′ N. 83° 48′ W., found 1853.
Wallens Ridge, Claiborne Co., Og. 36° 30′ N. 83° 30′ W., found 1887.
Stones, 2; ironstones, 2; irons, 12; total, 16. Observed falls, 3.

TEXAS.

Bluff, Fayette Co., Ckb. 29° 52′ N. 96° 48′ W., found 1878.
Carlton, Hamilton Co., Off. 31° 50′ N. 98° 10′ W., found 1887.
Denton County, Om. 33° 14′ N. 97° 8′ W. found 1856.
Estacado, Crosby Co., Cka. 33° 35′ N. 101° 30′ W., found 1906.
Fort Duncan, Maverick Co., H. 28° 35′ N. 100° 24′ W., found 1852.
Iredell, Bosque Co., H. 31° 53′ N. 97° 52′ W., found 1898.
Kendall County, Hb. 29° 24′ N. 98° 30′ W., found 1887.
MacKinney, Collin Co., Cs. 33° 9′ N. 96° 45′ W., found 1870.
Mart, McLennan Co., Off. 31° 10′ N. 96° 45′ W., found 1898.
Pipe Creek, Bandera Co., Cka. 29° 43′ N. 98° 56′ W., found 1887.
Red River, Om. 32° 7′ N. 95° 10′ W., found 1808.
San Angelo, Tom Green Co., Om. 31° 20′ N. 100° 20′ W., found 1897.

San Pedro Springs, Bexar Co., Cw. 29° 27′ N. 98° 27′ W., found 1887.
Travis County, Cs. 30° 20′ N. 97° 29′ W., found 1890.
Wichita County, Og. 34° 0′ N. 98° 40′ W., found 1836.
Stones, 6; irons, 9; total, 15. Observed falls, 0.

UTAH.

Salt Lake City, Salt Lake Co., Cgb. 40° 58′ N. 111° 25′ W., found 1869.
Stones 1; irons, 0; total, 1. Observed falls, 0.

VIRGINIA.

Botetourt County, D. 37° 30′ N. 79° 50′ W., found 1850.
Cranberry Plains, Giles Co., O. 37° 13′ N. 80° 47′ W., found 1852.
Hopper, Henry Co., Om. 36° 35′ N. 79° 45′ W., found 1889.
Indian Valley, Floyd Co., Ha. 36° 58′ N. 80° 39′ W., found 1887.
Richmond, Henrico Co., Cck. 37° 29′ N. 77° 28′ W., fell June 4, 1828.
Staunton, Augusta Co., Om. 38° 14′ N. 79° 1′ W., found 1858.
Stones, 1; irons, 5; total, 6 Observed falls, 1.

WEST VIRGINIA.

Greenbrier County, Og. 37° 32′ N. 80° 18′ W., found 1880.
Jennie's Creek, Wayne Co., Og. 37° 53′ N. 82° 22′ W., found 1883.
Stones, 0; irons, 2; total, 2. Observed falls, 0.

WISCONSIN.

Algoma, Kewaunee Co., Om. 44° 30′ N. 87° 30′ W., found 1887.
Hammond, St. Croix Co., Oh. 44° 55′ N. 92° 22′ W., found 1884.
Trenton, Washington Co., Om. 43° 20′ N. 88° 12′ W., found 1858.
Vernon County, Cka., 43° 30′ N. 91° 10′ W., fell Mar. 26, 1865.
Stones, 1; irons, 3; total, 4. Observed falls, 1.

WYOMING.

Silver Crown, Laramie Co., Og. 41° 10′ N. 105° 20′ W., found 1887.
Stones, 0; irons, 1; total, 1. Observed falls, 0.

Fig 1. Leighton Meteorite. x ⅔.

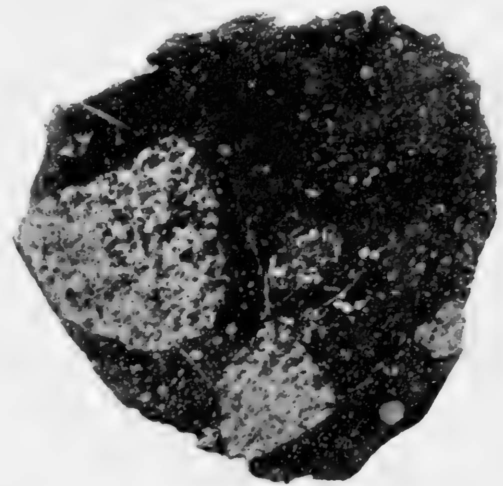
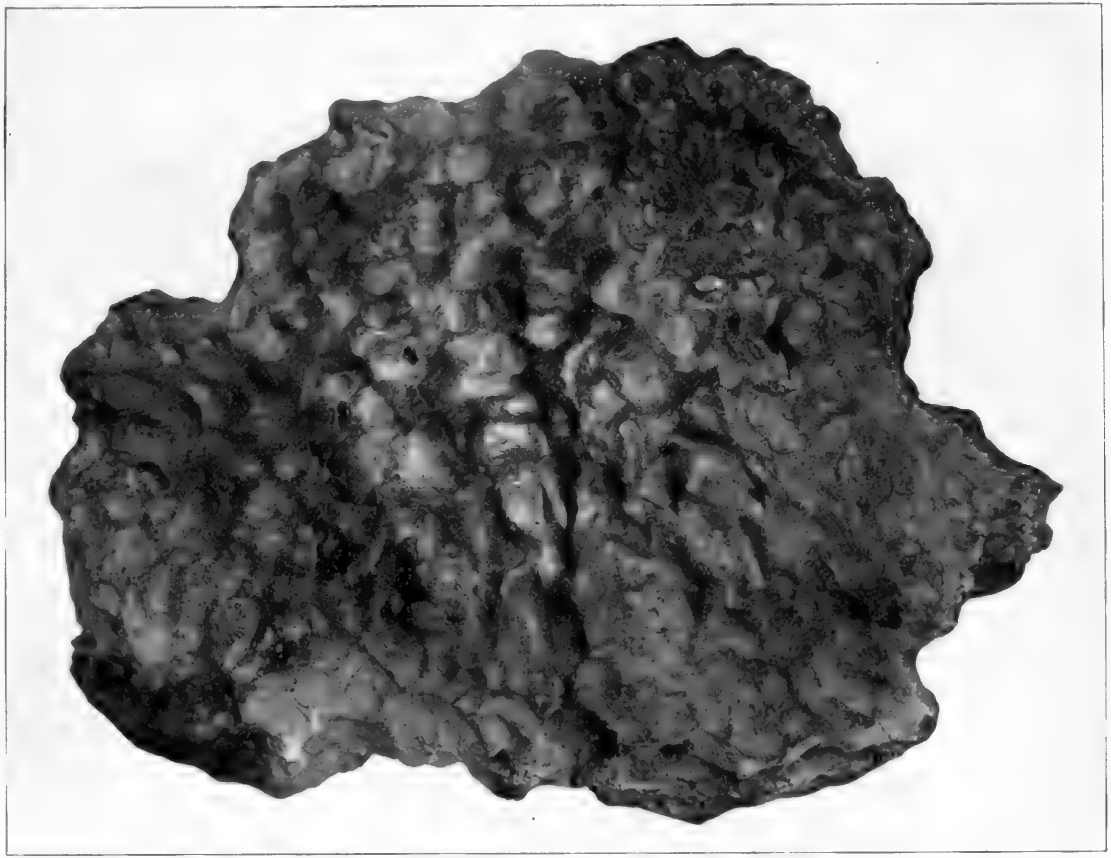
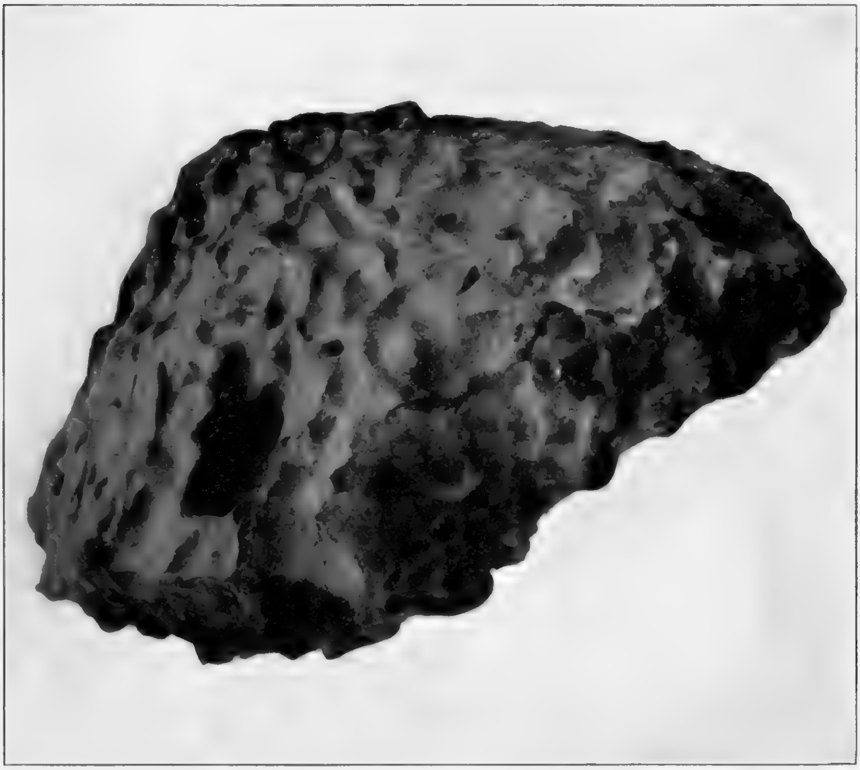


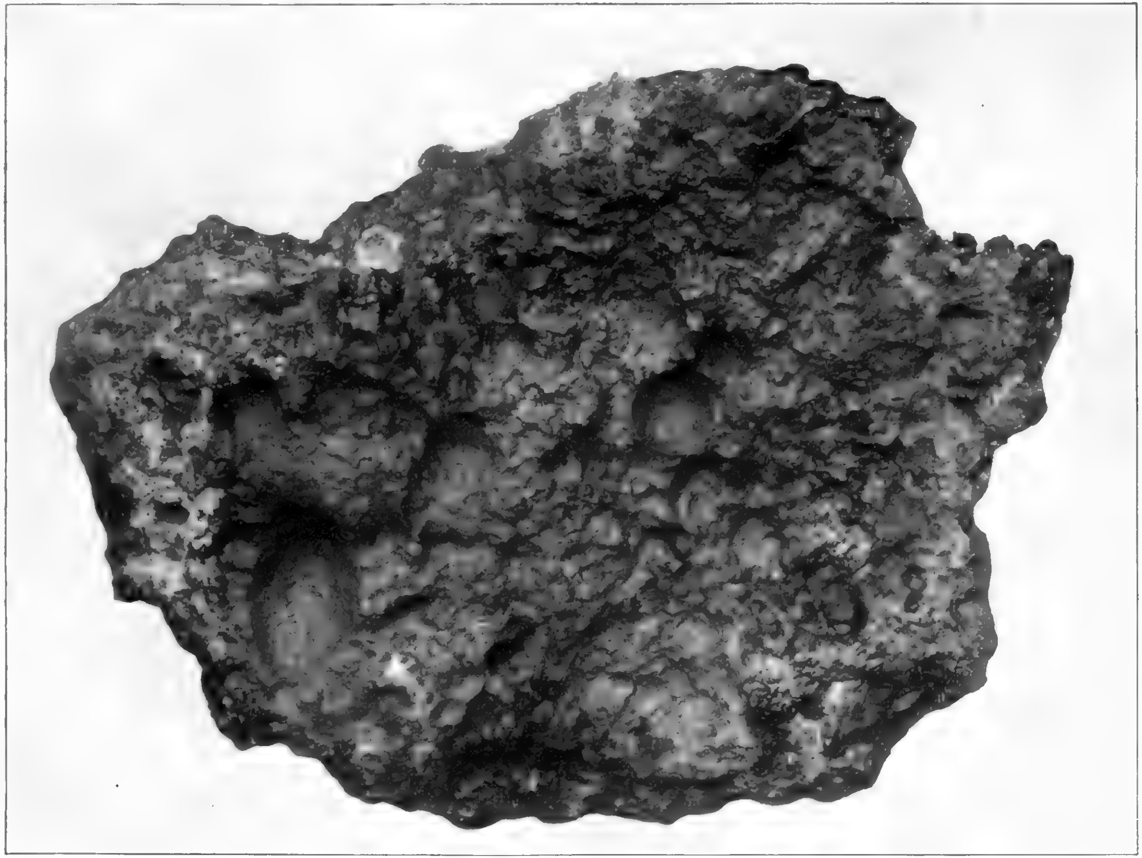
Fig. 2. Section of Leighton Meteorite. x 1.



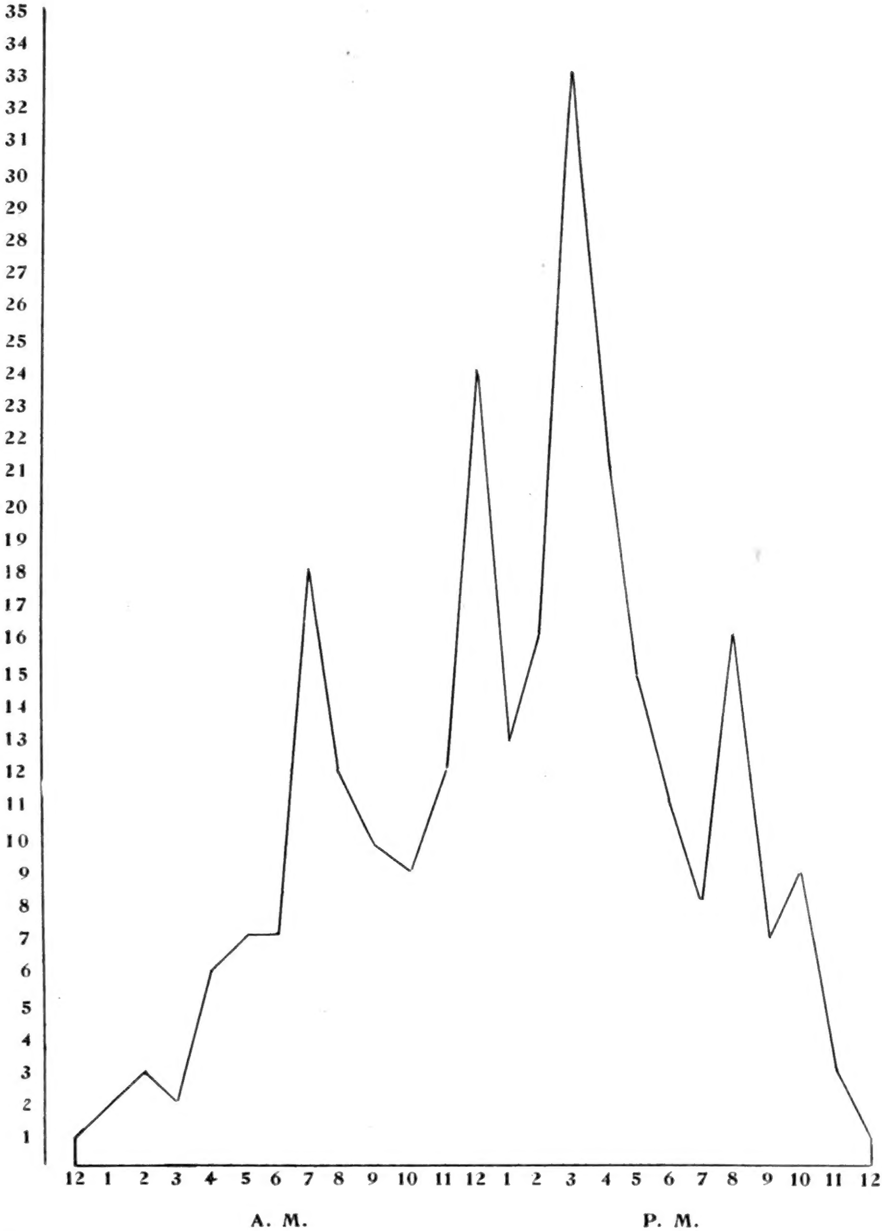
FRONT SIDE OF QUINN CANYON METEORITE. X 1/11.



SIDE VIEW OF QUINN CANYON METEORITE. X 1/7.



REAR SIDE OF QUINN CANYON METEORITE. X 1/11.



CURVE OF METEORITE FALLS BY HOURS.