A NEWLY FOUND METEORITE FROM ADMIRE, LYON COUNTY, KANSAS.

By George P. Merrill,
Head Curator of Geology.

Concerning the fall of the meteorite here described, little if anything is definitely known, the material being plowed up in a very badly oxidized condition, indicating that it had laid for a long time in the soil. A correspondent informs me that some thirty years ago a meteorite was seen to fall in the vicinity, but nothing was found at the time. It is possible that this may be the material, for certainly its condition would indicate that it must have been exposed for many years.

The first piece found was plowed up by Mr. W. Davis, of Admire, Kansas, about ten years ago, the original mass weighing some 12 or 15 pounds. This was all broken up and lost, with the exception of some 432 grams obtained by the United States National Museum.

In addition to these there were obtained three masses weighing, respectively, 2,048, 5,460, and 6,720 grams. There is known to be in existence another oxidized mass weighing upward of 7,000 grams. It is safe to assume that not less than 30,000 grams must at some time have been in existence, though the total weight can never be accurately ascertained.

The distribution of the pieces found, together with their corresponding weights, so far as I have been able to gather them, was as follows:

Township.	Range.	Section.	Weight.
			Grams.
16	12	35	6,725
16	12	36	7,280?
16	12	25	2,048
16	12	14	432
16	17	1	5,460

On casual inspection the masses found have the appearance of ordinary limonite segregations and nothing to suggest their meteoric origin. (See Plate L.) The specimens are deeply fissured. On breaking a mass open it is found to consist of metallic iron and olivine, both in such quantities as to be readily determined by the unaided eye. Cut and polished specimens show it to be a pallasite and to belong to Brezina's Rökicky group, of which the meteorite of Eagle Station, Carroll County, Kentucky, is the only representative thus far found in America. In fact, the Admire meteorite is the third representative of the group thus far known.

A polished surface brings out very plainly the mineral composition, and presents some exceedingly interesting structural peculiarities. (Plates LI and LII.) The silicate mineral is olivine, which occurs in single crystals and aggregates from 1 to 30 millimeters in diameter. These are almost universally fractured, and many of them are in a decidedly sharply angular condition. The proportional amount of iron varies considerably, but as a rule probably constitutes one-third in bulk of the mass and occupies the position of a binding or cementing constituent. Schreibersite is comparatively abundant and easily distinguishable by its luster from the metallic iron. Troilite in sporadic patches is common, and there is also a fairly abundant scattering of chromite granules in sizes up to 1½ millimeters in greatest diameter. All but the last named are readily distinguished by the unaided eye on a polished surface.

A freshly cut surface of the meteorite shortly becomes coated here and there with a greenish exudation which reacts for chlorine and iron, and is undoubtedly lawrencite. This exudes sometimes from the mass of the iron itself, but is more abundant along the line of separation between the iron and schreibersite plates. It is very abundant and undergoes such ready oxidation that polished surfaces are quickly tarnished, and it has become necessary to protect the samples by immersing them in paraffin. Once thoroughly soaked in paraffin, however, they do not seem to undergo further deterioration.

The above completes the list of determinable mineral constituents.

A most striking feature of the meteorite is the brecciated condition of the olivine, as shown in Plates LI and LII. The angular character of the particles is even more pronounced than in the Eagle Station meteorite. The brecciation, however, is scarcely that of a rock which has been subjected merely to ordinary crushing; it is more like that which one could conceive to have been brought about by the sudden plunging of a hot body of low heat-conducting power into an intensely cold medium, or the opposite.

A very important feature is that the native iron, schreibersite, and troilite often penetrate the silicates along these lines of fracture, as shown in Plate LIII, fig. 1. The threads or veinlets of iron and schreibersite vary from a mere line to a width of 1 or 2 millimeters, and indicate beyond question a solidification and perhaps reduction subsequent to the shattering of the crystals. Under the microscope what are plainly portions of the same crystal, but slightly separated and with almost identical optical orientation, are seen with thin veinlets of iron or schreibersite traversing the fracture lines, as shown in Plate LIV. I can not discover that there exists any constant proportional relationship between these two minerals, although the iron is by far the more abundant, and the schreibersite, while sometimes in thin plates, is also present in granular forms.

The metallic minerals often occur associated in a peculiarly suggestive manner. This may be best understood by reference to Plate LV, which is from a photographic enlargement of about five diameters. The broad, white outer band (1) is of nickeliferous iron. Inside this is a dark area (3) interspersed with iron in the form of rounded blebs and dashes. Between the iron and the dark interiors are always thin metallic plates (2), at first thought suggestive of tænite, but which chemical tests have shown to be invariably schreibersite. They do not show in the illustration, though very evident on a polished surface. The gray interior matter is not in all cases homogeneous. When subjected to friction the outer portions—white in the figure—quickly take a highly lustrous, fairly lasting polish. The interiors come up more slowly, are less lustrous, often showing under the glass a surface of minute metallic points interspersed with others without luster—that is, which take no polish, indicating a lack of homogeneity in the material. Often a central portion of the area has seemed to be more compact and more homogeneous than that nearer the margins, though one portion grades into another without sharp lines of separation. (See Plate LI, fig. 2-a.)

On exposure some of these areas quickly tarnish, while others hold their dull polish for a considerable length of time. Those which tarnish most quickly exude a greenish material, which reacts for chlorine, and which, when washed away, leaves the iron beneath of a dull black color and pitted. The conclusion is inevitable that in such cases the material is a spongy mass of metallic iron and iron chloride, presumably lawrencite. Other portions, again, seem to be like spongy mixtures of iron and iron sulphide, and still others nearly pure iron.

Attention should here be called to the spicules of iron (4 on Plate LV) which are seen extending from points of attachment on the white metallic portion inward and in some cases nearly across this gray interior area, which has been described as composed in part of lawrencite. These spicules have all the appearances of incipient stages of crystallization where the process has been arrested before completion. They resemble greatly in their general appearance frost crystals which are to be seen upon the windowpane in cold weather, or acicular crystals forming on the surface of pools of quiet water.

The iron on etching, it should be stated, does not yield the Widmanstattian figures, but there is brought out a prominent line of demarcation between the outer zone of iron and the inner, very brilliant thin plate which, though suggestive of tænite, proves to be schreibersite, as already noted.[1] So far as I have been able to determine, but one nickel-iron alloy exists, that corresponding most nearly to kamacite, as noted below.

The general structure of the meteorite, as revealed by the microscope in thin sections, is shown on Plate LIV. Weathering, as already noted, has produced extensive alteration in the metallic portions of the rock. Naturally, the lawrencite has been the first to yield, and following this, the troilite and native iron, the schreibersite being left standing in relief and quite conspicuous.

The first product of the oxidation of the iron is not limonite, but a highly lustrous—on polished surfaces, blue—material which crushes down readily to a fine brown magnetic powder.[2] On further exposure this goes over into ordinary limonite. Where the oxidation has gone on largely, the silicates are shattered, and veins of the oxidized material traverse them in every direction, producing a network of fine lines which, in the thin sections, show up with a pronounced blue reflection, at first scarcely distinguishable from the native iron itself.

A chemical analysis of the meteorite as a whole has not been attempted, as it was felt such would be of little value, owing to its extremely coarse nature and the varying proportions of metallic and silicate constituents. Carefully separated bits of the olivine, free from inclosures or oxidation products, yielded the following results:

	Per cent.
SiO_2	39.14
MgO	47.63
FeO	13.185
Total	99.955

This olivine, in the thin section, it may be well to note, showed at times a well-defined and quite regular pinacoidal cleavage, which, on basal sections, so closely resembled the prismatic cleavage of enstatite, that the true nature of the mineral was ascertained only by noting the position of the plane of the optic axes.

The analyses given below were made for me by Mr. Wirt Tassin, assistant curator in the Division of Mineralogy. A portion of the mass relatively rich in iron was taken. This was carefully cleansed mechanically from any visible traces of silicates or oxidation products, the cleansed material amounting to 3.3209 grams. Of this 0.07

[1] The investigations on this meteorite and on that of Casas Grandes, studied by Mr. Tassin, lead us to feel that schreibersite occurs more frequently in thin plates, simulating tænite, than is commonly supposed.

[2] This agrees with observations made by J. Lawrence Smith in 1875 on other irons. See Original Researches, pp. 480–486.

gram consisted of small black grains, later identified as chromite, the soluble portions separated from which amounted to 3.2509 grams. From this the following percentages were obtained:

	Per cent.
Fe	93
Ni	6
Co	0.02
S	0.03
P	0.025
Cu	Trace.

This corresponds to:

Nickeliferous iron (Fe, Ni, Co, Cu, etc.)	98.273
Schreibersite $(Fe, Ni)_3P$	1.645
Troilite, FeS	0.082
	100.00

The chromite obtained from various portions as a result of mineralogical separations was purified so far as possible by treatment with acids, and 1.025 grams taken for analysis. This gave results as follows:

	Per cent.
Cr_2O_3	65.49
FeO	33.00
MgO	0.40
SiO_2	0.50

It is a fair assumption that the magnesia and silica here shown belong to included olivine.

A fresh sample, weighing 2.05 grams, yielded 0.028 per cent of chlorine, equivalent to 0.05 per cent of lawrencite. No traces of tin, platinum, or manganese could be detected.

Specific gravity determinations made on masses weighing from 117.5 to 139.35 grams, were found to vary from 3.95 to 4.2. The iron, it should be noted, was quite active, taking quickly a coating of metallic copper when treated to a solution of copper sulphate.

I can but feel that a great deal of importance may be attached to the peculiar structural features shown by this meteorite and the association of the metallic constituents. These latter have been plainly introduced since the first consolidation, and subsequent to the shattering of the olivines. They occupy the position of a binding constituent in a siliceous breccia.

The source of the metallic constituents of meteorites has long been a matter of speculation, though it has been suggested by various authorities that it might result from the reduction of an iron-rich silicate. There is nothing in the present case to suggest any such origin, and it would seem to the writer much more probable that it should come from the lawrencite and troilite. That a portion of it thus resulted, is, it seems to me, extremely probable, from the conditions shown in Plate LV, above noted, in which we have the acicular forms starting from the metallic borders at the right and extending inward into the spongy mass of the interior. The appearance in every way suggests the beginnings of crystallization, which have been interrupted by changed conditions. If I am right in this, the Admire meteorite, as it will be known, is by far one of the most important and interesting of recent finds.

This find adds one more to the long list of meteorites for which Kansas is becoming noted, making eleven thus far reported. Attention has been called to this remarkable condition of affairs by Preston, from whose paper[1] the following table is taken, with the addition of the Admire fall here described:

Tonganoxie, Leavenworth County	kilos	11.5
Brenham, Kiowa County	kilos	900.0
Farmington, Washington County	kilos	84.0
Ottawa, Franklin County	grams	876.0
Waconda, Mitchell County	kilos	26.0
Oakley, Logan County	do	27.9
Ness County	do	10.9
Kansada (Ness County)	do	9.2
Jerome, Gove County	do	31.4
Prairie Dog Creek, Decatur County	do	2.9
Long Island, Phillips County	do	534.6
Admire, Lyon County	do	22.0

In order to bring out more plainly the striking features of the case, I append hereto a map of the region, on which the positions of the various falls are approximately noted. (Plate LVI).

The Kansada stone should probably be considered a part of the Ness County fall. The amount of the Ness County material, as given by Preston, has been very considerably increased, the United States National Museum alone having eleven stones, weighing altogether 2,044 grams.

It is possible, indeed probable, that this condition of affairs is not so remarkable or anomalous as may at first appear, since, as is well known, Kansas is a country but little forested, in which the surface rocks, so far as exposed, are of a calcareous or sandy nature, and in which the drift is, as a whole, small and inconspicuous. Hence, in plowing, any unusual bowlder turned up would naturally excite the interest of the inhabitants. More than this, the prices which dealers have been willing to pay for the materials have naturally excited the interest of the agriculturists, who, having their wits sharpened, are continually on the lookout for new materials. It is safe to say that the same number of falls might have occurred in other States, and, under less favorable conditions, the materials been entirely overlooked.

[1] Am. Jour. Science, IX, June, 1900, pp. 410–412.

EXPLANATION OF PLATES.

PLATE L.

Fig. 1. The 5,460-gram mass, as found.
2. The 6,725-gram mass, as found.

PLATE LI.

The 2,048-gram mass, cut in halves. Size of faces shown, about 10 by 11 cm. The enlarged area shown in Plate LV appears at a spot just above and to the right of the center in fig. 1. In fig. 2, just to the left of center, are shown like areas consisting exteriorly of metallic iron with interiorly the spongy iron and lawrencite. This last shows the interior, more compact, central portion mentioned on page 909.

PLATE LII.

Slice, slightly reduced, from the 6,725-gram mass shown in fig. 2 of Plate L. The dark areas are olivine; the white, the metallic portions.

PLATE LIII.

Photographic enlargement of about three diameters. The dark areas are in all cases olivine; the white (1), nickel-iron; (2), schreibersite; and (3), troilite.

In fig. 1 a large fractured olivine is shown in the lower center, with nickel-iron (1) above, which extends downward into the fracture for a distance of about 1 millimeter, where it stops abruptly, the remainder of the fracture being occupied by schreibersite (2). In fig. 3 the schreibersite (2) is shown both in granular form and as a thin plate lying between the troilite (3) and nickel-iron (1).

PLATE LIV.

Photomicrographs of thin sections enlarged about ten diameters. The colorless areas (1) are olivine; the white lines (2), schreibersite; the dark areas (3), bordered by schreibersite (2), are troilite. The other dark, nearly black areas, not numbered, are secondary iron-oxides.

PLATE LV.

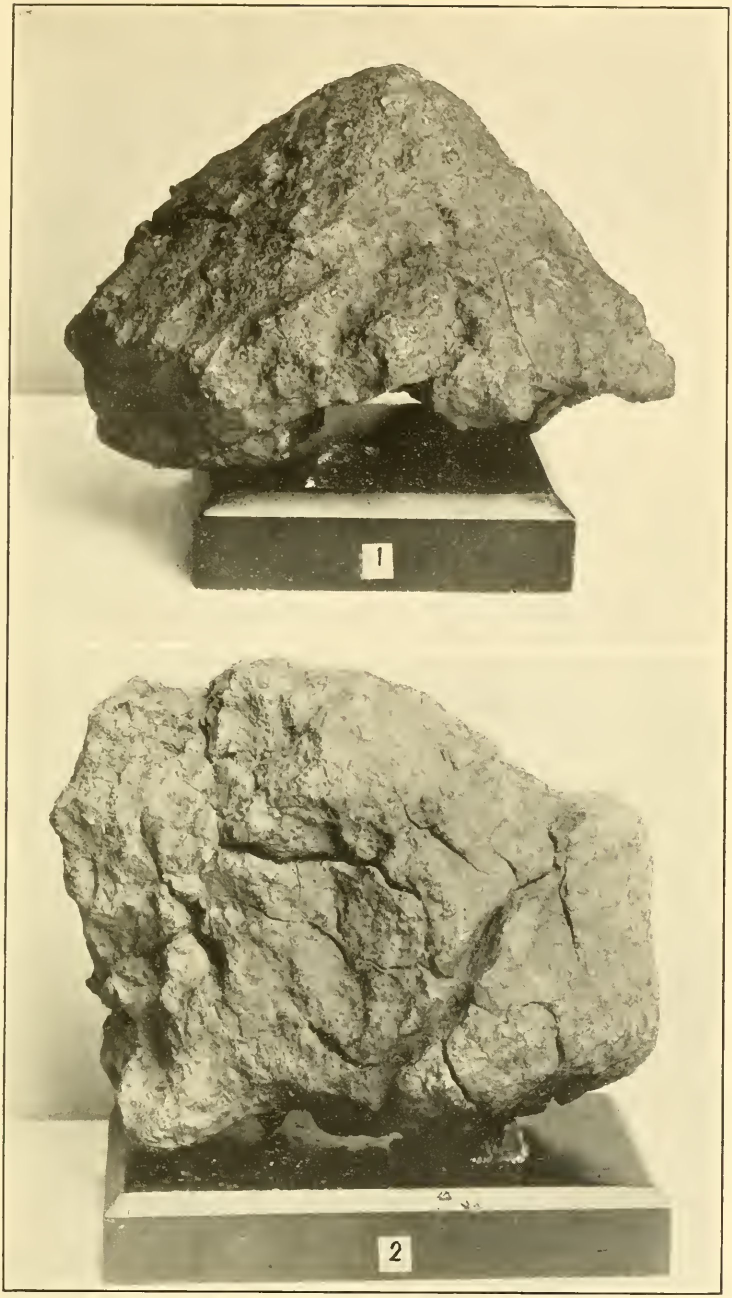
Photographic enlargement of about five diameters. The dark outer areas are olivine; the white (1), nickel-iron. The dark areas (3) within the nickel-iron are spongy aggregates of iron, lawrencite, or troilite. Extending outward from the metallic portions and into the spongy mass are acicular crystals of nickel-iron (4). Between the nickel-iron (1) and the spongy areas is commonly a thin plate of schreibersite (2), which can not, in the illustration, be differentiated from the nickel-iron.

PLATE LVI.

Outline county map of Kansas, showing sources of the various meteorite finds and falls.

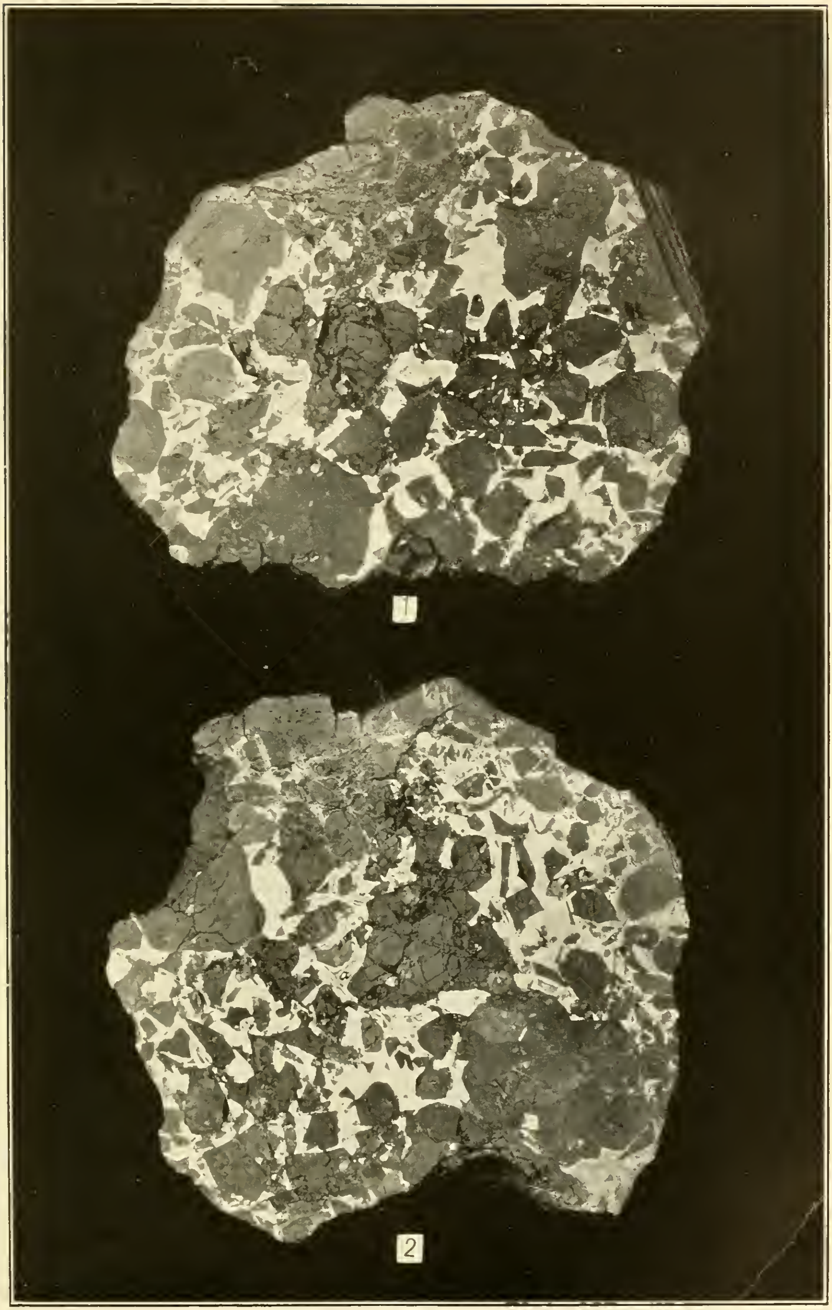
Fig. 1.	Tonganoxie, Leavenworth County (iron)	kilos	11.5
2.	Brenham, Kiowa County (pallasite)	do	900.0
3.	Farmington, Washington County (stone)	do	84.0
4.	Ottawa, Franklin County (stone)	grams	876.0
5.	Waconda, Mitchell County (stone)	kilos	26.0
6.	Oakley, Logan County (stone)	do	27.9
7.	Ness County (stone)	do	10.9
	Kansada, Ness County (stone)	do	9.2
8.	Jerome, Gove County (stone)	do	31.4
9.	Prairie Dog Creek, Decatur County (stone)	do	2.9
10.	Long Island, Phillips County (stone)	do	534.6
11.	Admire, Lyon County (pallasite)	do	22.0

The area of the State is given as 81,318 miles, the average length being 400 miles and the average width 200 miles.



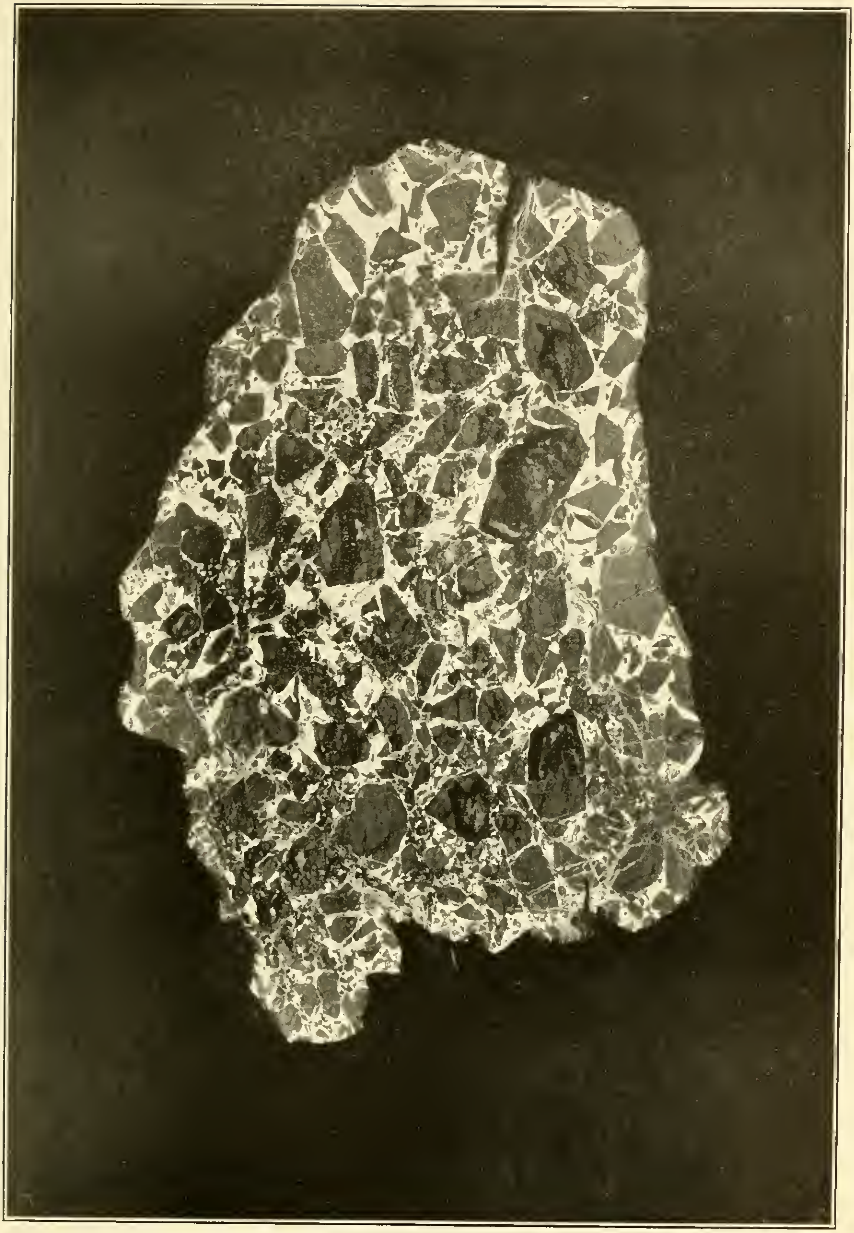
ADMIRE METEORITE.

FOR EXPLANATION OF PLATE SEE PAGE 913.



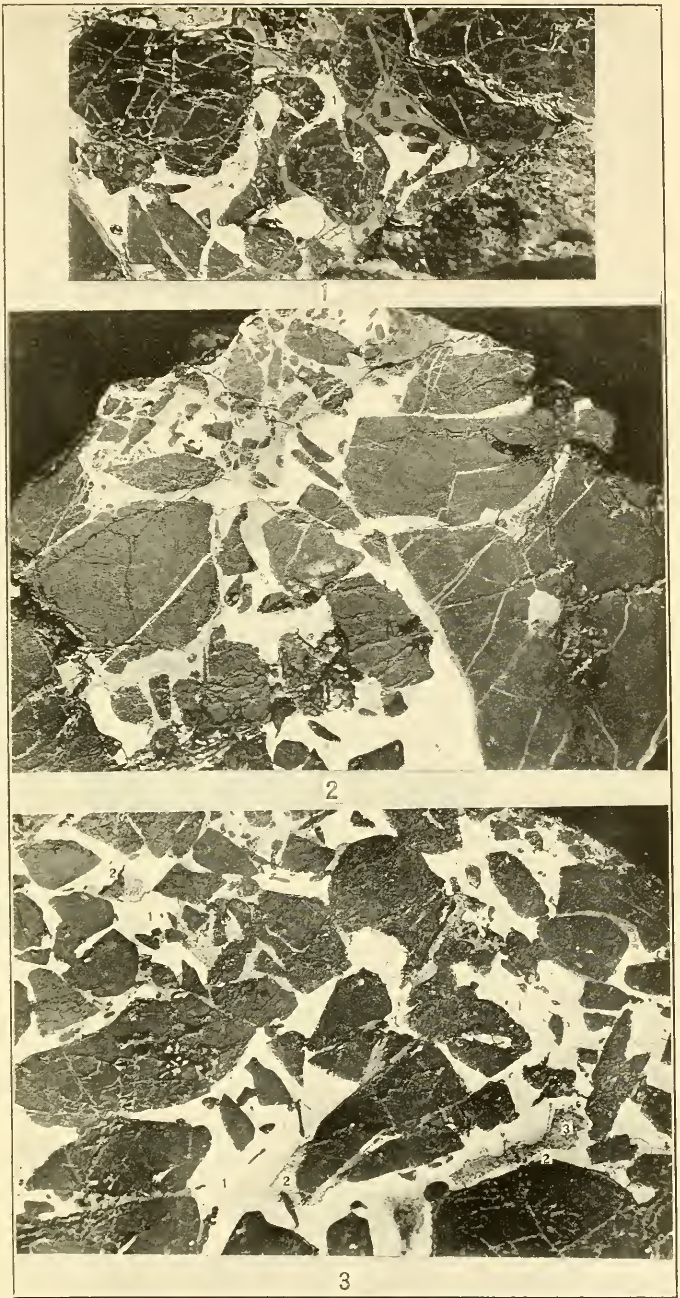
ADMIRE METEORITE.

FOR EXPLANATION OF PLATE SEE PAGE 913.



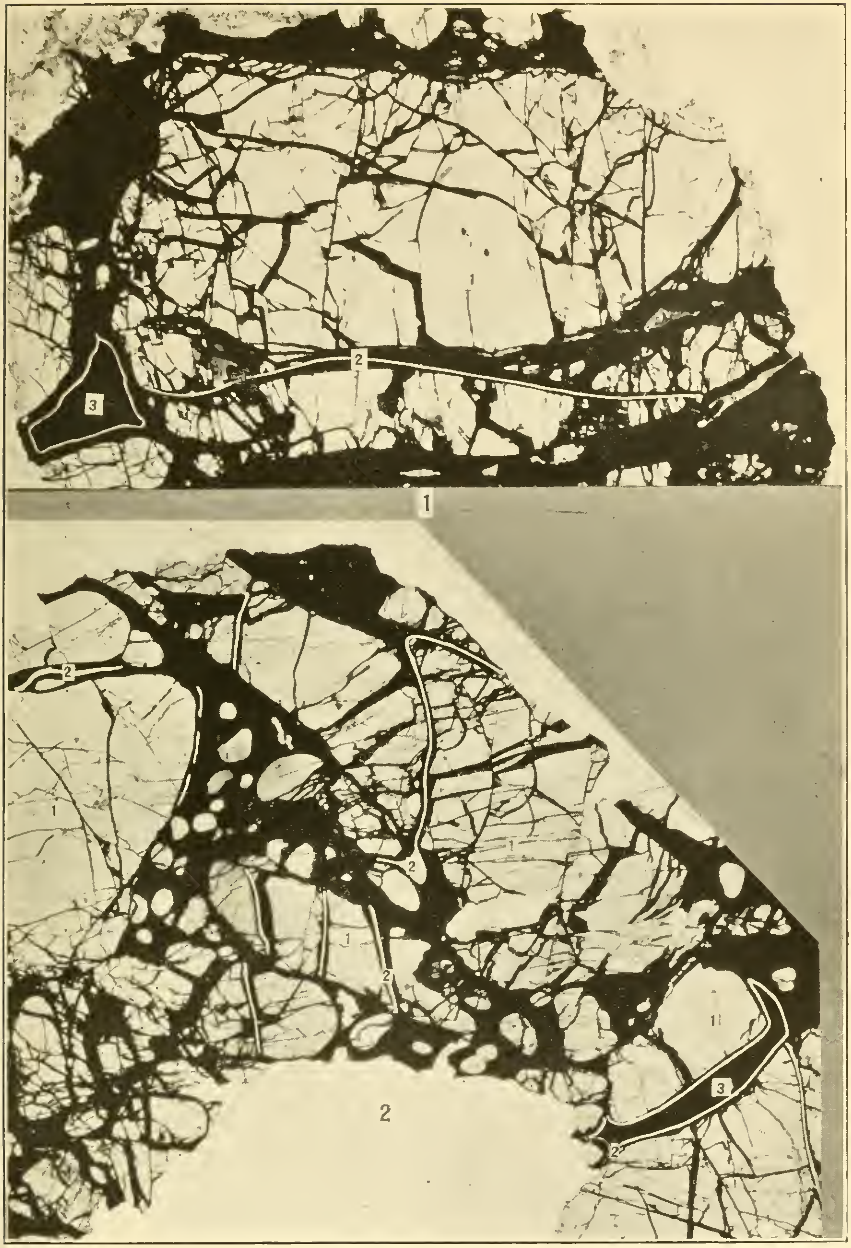
ADMIRE METEORITE.

FOR EXPLANATION OF PLATE SEE PAGE 913.



ADMIRE METEORITE.

FOR EXPLANATION OF PLATE SEE PAGE 913.

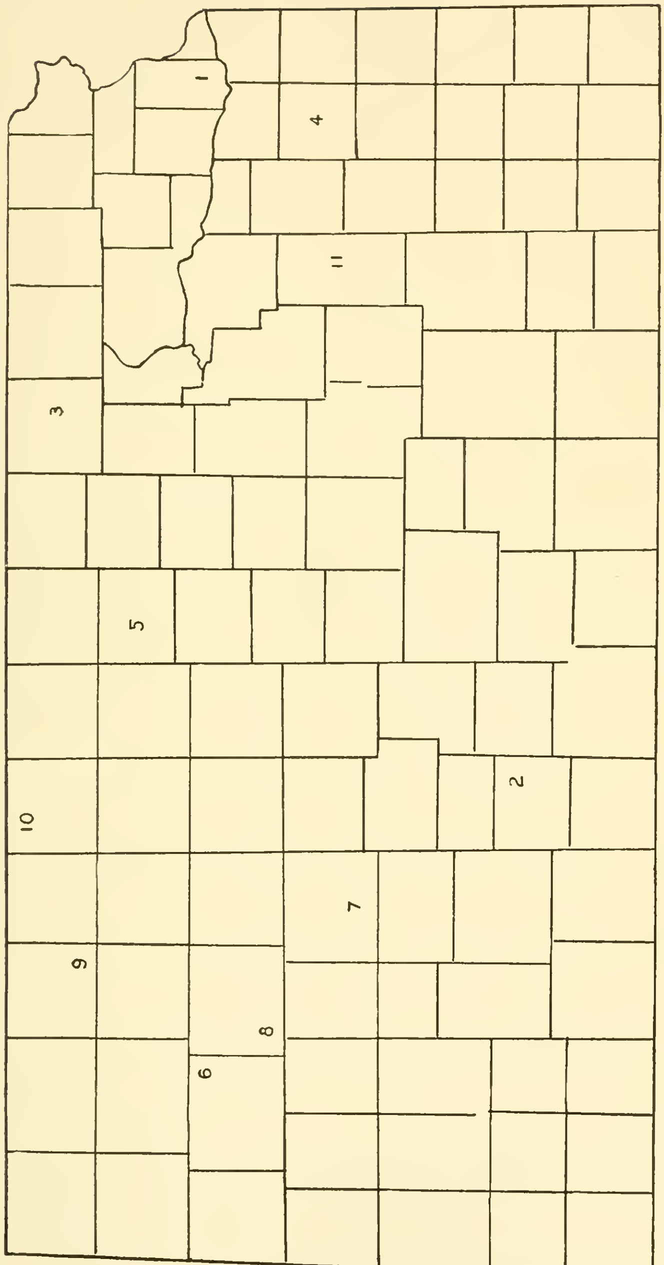


ADMIRE METEORITE.

FOR EXPLANATION OF PLATE SEE PAGE 913.

ADMIRE METEORITE.

FOR EXPLANATION OF PLATE SEE PAGE 913.



OUTLINE MAP OF KANSAS, SHOWING METEORITE FINDS AND FALLS.

FOR EXPLANATION OF PLATE SEE PAGE 913.