PROCEEDINGS OF THE ROCHESTER ACADEMY OF SCIENCE
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DESCRIPTION OF FOUR METEORITES

ANDOVER }
CUERNAVACA } New
ARISPE }
BALD EAGLE, redescribed

BY

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(Read before the Academy November 10, 1902.)

THE ANDOVER METEORITE.

The State of Maine has long had three meteorites to its credit. Nobleboro 1823, Castine 1848, Searsmont 1871. All are stones, and all fell in the southern half of the State. We now give first public record to a fourth, also from south of the middle parallel of the State, and also an aerolite. We owe the first knowledge of this to Mr. Henry V. Poor, of Brookline, Mass., the present owner of the mass. This gentleman obtained the specimen from the original owner, on whose farm, adjacent to his summer residence in Andover, Oxford Co., Maine, it fell. Mr. Poor, with great liberality, placed it at my disposition for examination and description. I further received a letter from Mr. Lincoln Dresser, of Andover, who tells the whole story of its fall. Mr. Dresser says, "The meteor that fell near my house on the morning of Aug. 5th, 1898, was witnessed by me, and I was within 25 feet of it when it came down. It came from the north west at an angle of 75 degrees, and in all probability came from the constellation of Perseus. (!) It was accompanied by a loud noise resembling a buzz saw, and had a following of smoke. It was in intense heat when it struck a stone in the wall, grazing the stone. In its fall it passed down through the branches of an elm tree, cutting many of them off as clearly as if done by a sharp knife. I supposed at the time it was a gaseous ball of fire, and thought it exploded, but after examination I found where it imbedded itself in the earth to the depth of 2½ feet. I secured, by digging, a large piece weighing 7½ lbs., and two or three small ones which were broken by its striking the rock fence. The large piece was irregular in shape and had the appearance of having exploded in the air, as a large piece was lost from one side before it went into the ground.

The crust of this one on three sides had a blackened surface with shallow dents like finger points. The broken part shows a gray rock, looking like silver. The break was fresh, and on exposure to the air you could observe the iron coloring in it. It was of the finest of granite. People in the adjoining towns heard the peculiar buzzing noise, and heard a loud report, probably when it burst."

In June, of the present year, I had the privilege of visiting the spot in Andover where the stone fell. A sharp dent in the granite wall still shows freshly where the stone struck at its first impact. In falling it had passed through thickly set, small branches of an elm tree directly above. Mr. Dresser tells me that it was seeing these branches fall, cut off by the stone, which had changed his first instant's impression that the latter was of a gaseous character.

By the aid of a ladder and a saw I obtained the portion of a branch two inches in diameter, half cut through by the meterorite. I also obtained two small pieces of the stone itself, one from Mr. Dresser, and another from Mr. E. M. Bailey, also a resident of Andover. Through the kind favor of Mr. Poor I am able to here present a cut of the large mass which weighs about 6½ lbs. (Fig. 1, plate VIII.)

In general shape it is an irregular lengthened polygon like a flattened triangle, with the three points largely truncated. The cut presents one side whose largest dimensions are 7¾ inches in length by 4 inches in greatest breadth. The opposite side which was broken off in the fall is of the same length, but 5½ inches in the measure at right angles. All other sides are well coated with a brownish black crust, relieved by occasional patches of lighter brown. The crust is roughened by little, slightly raised pimples, often connected with very short ridges, of the molten matter. On several sides are shallow pittings as large as the impressions of finger-ends. Some of these are separated, others confluent, the latter, as is to be expected, all on the same side of the mass, having their depressed rim in the same direction or aspect. The broken side of the mass shows an interior of a light gray color, and is granular, with a few chondri of much darker color. The whole mass is, in a fresh fracture, brilliant with points of nickeliferous iron sparsely interspersed with bronze-colored troilite. I have given the name of Andover to this meteorite from the proximity of its fall to the town of Andover, Oxford Co., Maine.

THE CUERNAVACA METEORITE.

In Castillo's catalogue of Mexican Meteorites (1889) he mentions, p. 3, "Meteorite of Cuernavaca, State of Morelos. It is a fragment of meteoric iron found, so it is said, on the road from Mexico (city) to Cuernavaca. It is in the National Museum of Mexico."

While in that capitol in April of the present year, and visiting the Museum, I was shown by the keeper of the mineral collections, Professor Manuel Villada, the specimen which lay in a lower compartment of one of their table cases. I promptly availed myself of permission to photograph it, and later on I was able to obtain, through the kind services of Professor Villada, permission from the Director of the Museum to cut the mass in twain and to carry away the smaller half.

The mass, as shown in the accompanying plate, (Fig. 1, plate VII) was entire, never having had further than a minute chisel-clipping, the common way of Mexican prospectors, who test all troven metal masses in their search for silver. The length of the mass was 480 mm. (about 19 inches) while its other diameters were about 130 mm. to 150 mm. (about 5 to 6 inches) varying in different parts of the mass. The form might be described as a square-sided, irregular column, with some protuberances and constrictions; and one of its extremities, much enlarged, projecting several inches forward of the main line of the mass in a sort of sub-cylindrical turban. The surface of the mass, though very uneven, with alternate elevations and depressions short and sharp in contour, is still smooth in texture, and is quite covered with a reddish brown crust which is of unusual thickness and continuity. This surface is impressed over the entire mass with indentations from ½ to 1½ inches long, like chisel-marks. The section of the iron (Fig. 2, plate VII) shows these indented lines to correspond with numerous straight, short seams of troilite, which cross the mass in all parts and at all angles. There are also several small troilite nodules, with one of 30 mm. in diameter. These nodules are surrounded and crossed by a narrow border of schreibersite. Etching brings out well marked Widmanstätten figures of the octohedral type. In these the kamacite blades vary much in both breadth and length, causing a coarser or finer pattern in different parts of the section. The plessite patches are seen to be generally composed of alternate layers of kamacite and tænite. The latter, although in fine films between the kamacite blades, show prominently from their brightness. The characters of the etched surface of this iron show much similiarity to those of the Bella Roca siderite.

The analysis of the iron as made by Professor J. E. Whitfield, of Philadelphia, gives:

Iron, - - -	88,982
Nickel, - -	10,300

The specific gravity is 7,725.

This Cuernavaca mass seems to have lain *perdu* since its finding, never having been described or analyzed. It has been claimed by Brezina and others as belonging to the group of Toluca irons. No one who has seen the mass in either its external or its internal features could make this mistake. Moreover, as Fletcher has shown (Mexican Meteorites, 1890, p. 79) Cuernavaca is far away, to the southeast, from the Toluca or Xiquipuco district. The two irons are as diverse in structure as they are distant in their localities.

THE ARISPE METEORITE.*

This most interesting siderite was found in the northeastern part of the State of Sonora, Mexico, in 1898. After various vicissitudes of rambling with changed owners, it became last year the property of Mr. A. F. Wuensch, a mining engineer of wide reputation in the western country, whose present residence is Denver, Colorado. Mr. Wuensch had encountered it while on a professional tour in Sonora. From this gentleman and a Denver newspaper of August 17 of the present year, I gather the following notice of the mass.

The meteorite was discovered first in 1898 by some Mexican mescalleros in the mountain some fifteen miles northwest of Arispe, Sonora. Finding the mass malleable and composed of a silver white metal, they regarded it as some form of silver ore, and secreted it near the place of its discovery until transportation for it could be secured. Other parties, however, followed up the trail, found the place of concealment and stole the supposed lump of silver. After some time and some strife, personal and in the courts, the mass was acquired by Senor Canizaris at Cucurpe in the Magdalena district. This gentleman had a hole half an inch in diameter and two and one-half inches deep drilled into it, to test its interior for precious metals. When these drillings showed no value in either gold or silver, the mass was laid aside. Its existence was subsequently referred to

*This description of the Arispe meteorite was presented to Academy November 24, 1902.

during a visit of Mr. Wuensch to that vicinity, and this expert promptly recognizing it as a genuine meteorite, he secured it and had it transported to his Denver home. From this owner the meteorite has, at last, come into my hands to be cut, studied and disposed of, he reserving a slice for the mineral collection of the Colorado Scientific Society.

The specimen, as it came to me, had nothing of remarkable interest in its exterior. It is as irregular and shapeless as are nearly all masses of meteoric iron, notably those from Mexico and our southwestern states, where prolonged decomposition has with most of them corroded and broken down the sharper angles. A view from one side shows a parallelogram about 16 inches long by 12 inches at one end and about 9 inches at the other. This surface shows no true pittings, but a few shallow concavities, one of them nearly an inch across, due to the deep decomposition which has ensued, doubtless, since its fall. On the opposite side the form is more trifid, as shown in plate IX, and measures 18 inches in greatest length, 13½ inches in greatest breadth, and 13 inches in thickness. Its surface is covered with evenly distributed shallow pittings, ranging from 1½ to 3 or 4 cm. in diameter. These are sharp in outline, this surface having been less worn or decomposed since the fall than have been the other sides of the mass. On one side is a large depression, nearly 3 inches in depth and in greatest width, semilunar in shape and with nearly vertical walls on two of its sides. This deep pit-like valley has on its bottom and sides, smooth surfaces, without either ridges or pittings, which give strong indication of the fact of the present vacancy having once been filled with matter which has been worn away or decomposed and fallen out, probably a great troilite nodule. This empty cavity is indeed the most striking feature of the outside of the mass.

On a section of the iron (Plate X) troilite nodules are quite abundant, some of them up to 30 mm. in diameter. In several instances within these nodules are small patches and angular fragments of the nickeliferous iron. (Plate XI Fig. 2.) These nodules are surrounded with an envellope of schreibersite. In two or three of the nodules were found masses of chromite from 4 to 5 mm. in diameter, and in one instance on the edge of one of the plates was chromite nodule 12 to 14 mm. in diameter. On some of the surfaces that have been polished or etched there have occured in groups of crystals in arborescent form some 10 x 18 mm. in diameter, what is apparently cohenite, the carbide of iron. Nothing is more striking in the composition of the iron than the numerous large masses of schreibersite scattered through it. Some of these average from 30 to 40 mm. in diameter, while others again occur in blades some 3 mm. in width and 45 mm. in length. The Widmanstätten figures are sharp and clear and of unusual size, picturing vividly the octahedral structure of the iron. The kamacite plates are of unusual width, averaging from 3 to 4 m m. in width, and in one instance extending in an unbroken line for 195 mm. The taenite films are comparatively small, but are noticeable from their difference in color as they lie between the kamacite plates. The iron is also characterised by almost the entire absence of what is called plessite, the "Fülleisen" of the German chemists.

There remains to notice a point in the structure or construction of the iron mass which is of the highest interest, and is, in some respects, quite unique. The section across the meteorite shows it to belong to the limited group of brecciated siderites (see Plate X.), and that its individual pieces, or soldered fragments, are by far the largest which have ever been recorded. It will be noticed that the surface of the section is crossed from one side to the other by a fissure. And from a point somewhat beyond the middle of this fissure a branch fissure leads off at right angles until it reaches the edge of the mass. The two together make a letter Y, dividing the surface into three areas. This fissure in parts of its course shows as a fine line with the sides tightly closed up, and in other parts there is a filling of the fissure with troilite in a broken vein varying in general width from 1 to 3 m m., but expanding at these points to twice that width. That this bifid fissure is a fracture of the original mass and that the troilite has subsequently gathered in it, seems apparent, although that the cracking and the filling shall have been closely allied in time is more than likely, particularly when we keep in view the fact of the low fusion point of the troilite. But the prominent and most novel feature of this siderite section is still to come, and is as follows. We have already mentioned the great length and distinctness of the kamacite plates. They form on the surface lines of orientation showing the structual growth of the area. As, now, we notice the union of any one of these areas with its two neighbors, we make the surprising discovery that these surface lines do not match or correspond in direction across the line of union—the fissure. (See Plate XI Fig 1.) In short, each area is quite distinct from each of the other two. The appearance is as if the whole mass had originally been of continuous structure clear across, that it had afterwards cracked into three pieces, and that these pieces had swung around and reunited with different sides together than those which at first existed. This must needs have been done at a time when the iron was still in a somewhat plastic state, and before the troilite had cooled to its fusion point. Whether such mobility is conceivable in a mass pressed inward from all sides is, perhaps, open to question. Another view is that each of these three divisions is an area of original crystalization.

In speaking of the above structure of Arispe, I should not omit mention of the fact that a somewhat similar changed-about (umgewandelt) phenomenon has been noticed in the iron meteorite Mukerop from southwestern Africa, and described by Prof. Frederick Berwerth in a paper read before the Imperial Academy of Sciences, of Vienna, on the 20th of February, 1902. In this paper, which is, unfortunately, unaccompanied by any cut or photograph, there are four distinct areas mentioned, each defined, as in Arispe, by differently directed figures. These are in two pieces, with sharp lines of demarcation, which, Berwerth says, "appear to be brought out by the changing of the system of lamellae on the plane of contact". Here then, are no fissures, as those in Arispe, which have once separated the mass into parts, but those are held by him to be a twinning of two supposed original crystals. The African and Mexican meteorite thus present two entirely distinct phenomena. Both undoubtedly owe their inner structural framework to the time when they existed as a crystalizing magma in some incandescent celestial body. The opportunities there present for variation in ultimate structure were large, and the outcome will be different in different masses, while all are held firmly in unison with primal laws of composition and of crystalization which have fashioned the phenomena of these earth-wandered fragments which we to-day have under our inspection. They announce no new laws, but they tell us new and unexpected stories.

Prof. J. E. Whitfield, of Philadelphia, has analyzed Arispe and finds :

Iron, - - - - - -	92.268
Nickel, - - - - - -	7.040
Specific Gravity, - - -	7.853

Mr. John M. Davison, of Reynolds Laboratory, of the University of Rochester, writes :

" I find a trace of platinum in the Arispe siderite. From as care-
" ful a separation of schreibersite as time permitted, its percentage is
" 1.84. This is the mean of two closely agreeing determinations made
" on material caught from the sawing of small slices of the meteorite
" with a hack saw. Had it been practical to collect sawings from
" larger sections which seem to have larger patches of schreibersite
" the percentage of that mineral would doubtless have been greater.
" No other meteorite with which we are acquainted shows such a pro-
" portion of this."

" Some black particles, picked from the centre of a troilite nodule,
" prove to be chromite. They are insoluble in nitric acid, and give
" chromium reaction. Cohenite appears to be present, but the material
" at my disposal was too scanty to permit its certain identification."

As some chemical work in reference to the constituents of this most remarkable meteorite has not at the present moment been completed, the results will be published at a later date.

The largest outside surface (end-piece) together with the largest section, both as described in this paper, are taking their places in the Ward-Coonley Collection of Meteorites, now displayed (on deposit) in the main Geological Hall of the American Museum of Natural History in New York. The two pieces together weigh nearly 40 kilogrammes.

THE BALD EAGLE METEORITE.

This interesting siderite has been loaned to me for examination and cutting by Prof. Wm. G. Owens, of the Bucknell University, Lewisburg, Pa. Prof. Owens read a paper upon the specimen before the Chemical Society of the University, and this was, the following year (1892), published in Vol. 43 of the American Journal of Science. From this article of Prof. Owen's I take my facts as to the finding of the mass.

Bald Eagle Mountain, on the east side of which the meteorite was found, is seven miles south of Williamsport, Pa. The mountain comes down to the edge of the Susquehanna river, and on the border of the latter runs the Philadelphia and Erie Railroad. Numerous transverse depressions occur here in the mountain-side, some of which are filled with loose blocks of sandstone, large and small. "It was in one of these depressions, several hundred feet from the railroad track, that on or about Sept. 25, 1891, some Italians, while getting out stones for a stone-crusher, found in a bed of loose stones, about two meters deep, something which resembled a stone in appearance. It was covered with a fungus growth, as were the stones, but when picked up attracted the laborer's attention on account of its weight. He showed it to the Superintendent who tried to break it, and failing attempted to cut it with a cold chisel, when it proved to be soft iron. When several weeks later the owner of the crusher, Mr. George S. Matlock, came to the works it was given to him, and he, realizing its value, presented it to this university. It weighs 3.3 Kilos. (7 lbs. 1 oz.) In shape it resembles in general outline, a human foot. (Fig. 2, plate VIII.) The flat face, corresponding to the sole, measures 16.6 cm. (6½ inches) long, and 8 cm. (3⅛ inches) wide at the broadest place. From the extremity of the heel it projects upward 14 cm. (5½ inches), ending in a point. The surface is covered with a reddish brown iron rust. This easily scales off in many places, and at several points this covering is so thin that the bright metal shines through. It is pitted quite deeply in some places, and very irregular in outline. * * * * Its specific gravity is 7.06. It is quite soft compared with ordinary wrought iron. Chemical analysis gave Fe 91.36; Ni 7.56; Co. 0.70; PO .09; SO .06; Si. trace,= 99.77.

Nothing is known as to the time of its fall, though as it was found covered by several feet of stones which have not been moved sensibly since the Susquehanna valley has been inhabited by white men, it could not have been recent. As far as can be learned, this is the only specimen of the fall which has been found."

It has seemed to be desirable to add to this description by Prof. Owens a view of this most interesting iron. The picture (Fig. 2, plate VIII) is a half-tone taken from a photograph of the mass before cutting. Its resemblance to a human foot is very striking, despite the many rough notches and depressions which cover the surface. But few of these depressions are well defined pittings, seeming rather to be fractuosites, caused by the violent tearing of the iron from a parent mass, and the sharpness of the angles and crests reduced by the attrition to which the whole mass has been subjected. A portion only of the surface, all the upper part of the ankle, has a well smoothed surface, with a fine granulation akin to a skin or crust. On the back, above the heel, are two sharp depressions, one round and ⅜ of an inch in depth and in diameter, the other, half as deep, a paralellogram ¾ of an inch long and ⅓ inch wide. Both of these have vertical walls, and show clearly as cavities which have once been filled with softer matter, probably troilite nodules, which have since been eroded or decomposed away. On the top of the front part of the foot is a deep cavity, due to the folds in the iron, which passes nearly through to the sole. The sole itself is very flat, which has allowed a thin slice, ¼ of an inch thick and weighing 300 grammes, to be cut off, of same width from toe to heel, and like thickness throughout, like the sole of a shoe. The polished section is quickly etched by the use of dilute nitric acid, and the Widmanstätten figures produced are both sharp and peculiar. (Fig. 3, plate VIII.) The iron is typically octahedral. The etched surface is composed mainly of short kamacite blades, with an average thickness of about 1 mm. and from 5 to 10 mm. in length. These depart from the ordinary rule defining the usual angular figures by being largely curved or snake-like in form, giving a pattern like that of floss or tangled yarn. Many of these kamacite blades are club-shaped (rounded on both ends) as in the Augusta Co., Va., iron. The patches of plessite are minute, sometimes showing clearly the alternate layers of tænite and kamacite. The tænite plates lying between the kamacite blades are very narrow, but stand out in prominent relief on the etched surface, and are faintly distinguishable by their bronze yellow color from the tin-white kamacite.

Two fissures, each about 25 mm. in length and averaging from 1 to 2 mm. in width, cross the sole diagonally, and are filled with troilite. No rounded nodules of this mineral were to be seen in in the section made. Several patches of schreibersite, rudely representing cuneiform characters, are scattered throughout the etched surface. These are brighter and with denser surface than the troilite, the latter being granular and less lustrous. But the main peculiarity of this iron is the extremely winding, vermiform assembling of the kamacite plates, to which we have already referred. In this respect the Bald Eagle iron is quite unique.

FIG. 1. External form. One-fourth actual size.

FIG. 2. Section showing Widmanstättan figures. One-half actual size.

CUERNAVACA METEORITE.

HENRY A. WARD.

FIG. 1. ANDOVER AEROLITE.
About three-fifths actual size.

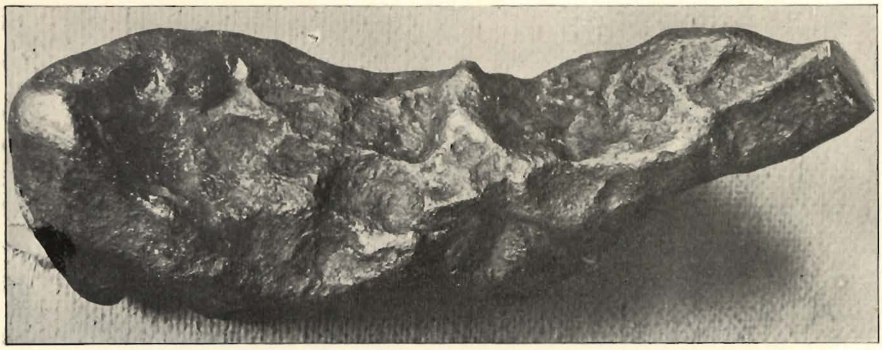

FIG. 2. BALD EAGLE METEORITE.
Showing the foot-like form with pittings. About three-fifths actual size.

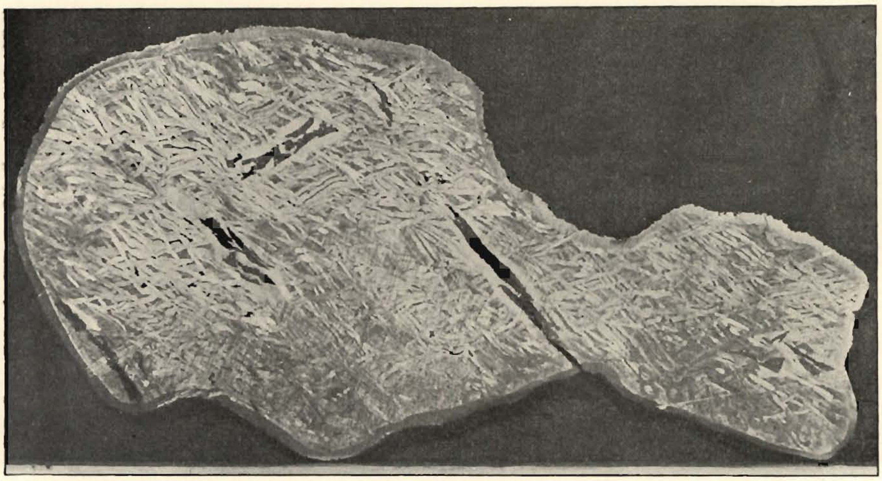

FIG. 3. BALD EAGLE METEORITE.
Section showing Widmanstättan figures. Three-fifths actual size.

ANDOVER AND BALD EAGLE METEORITES.

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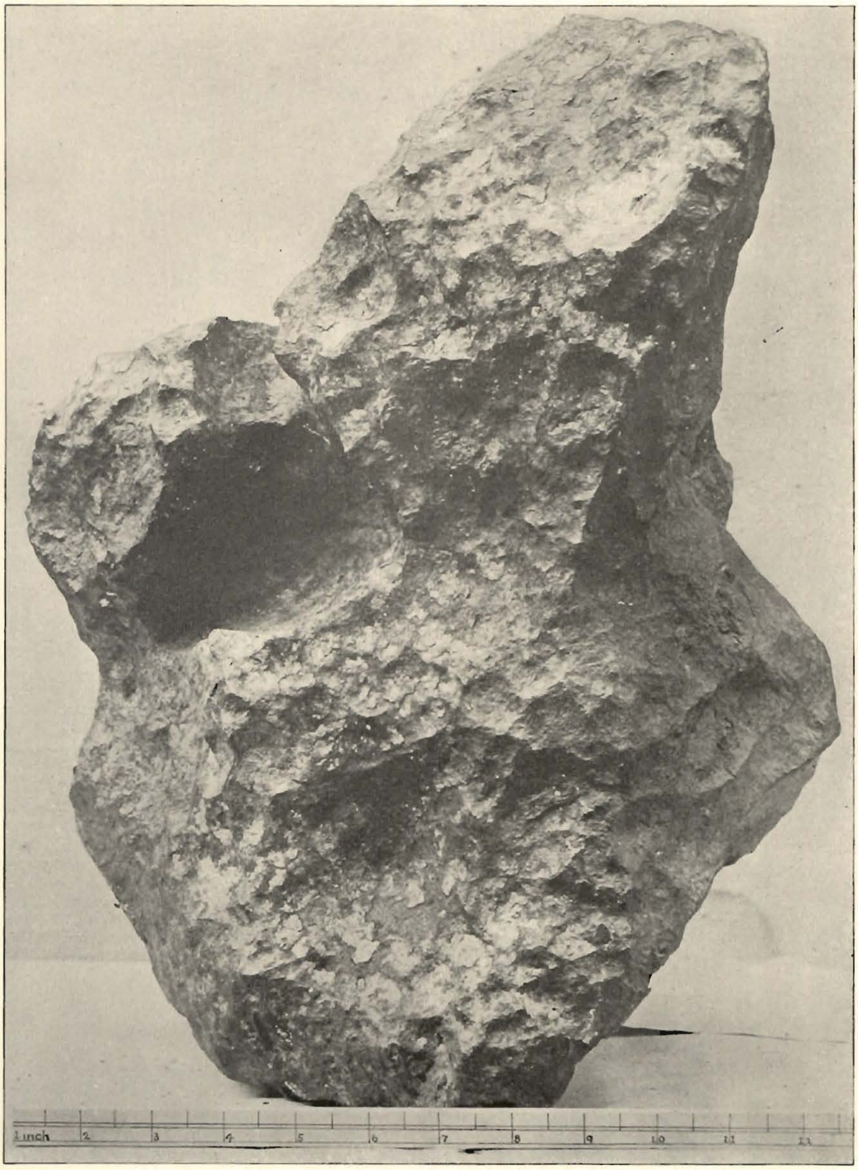

External form with pittings. One-third actual size.

ARISPE METEORITE.

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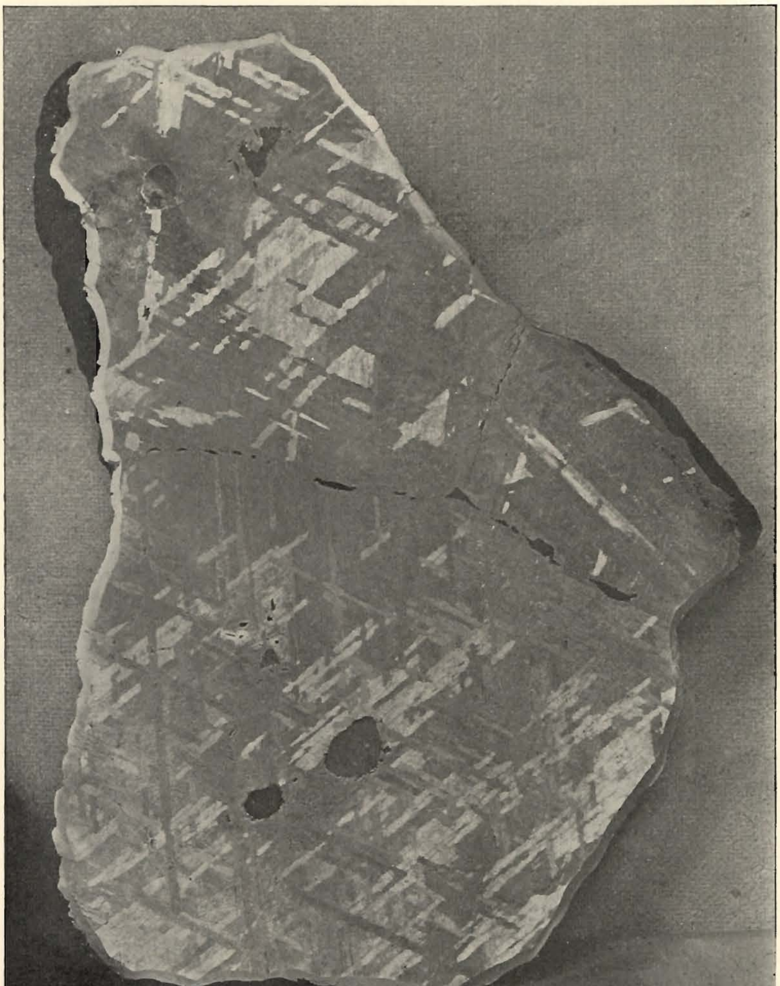

Section showing Widmanstättan figures. One-third actual size.

ARISPE METEORITE.

HENRY A. WARD.

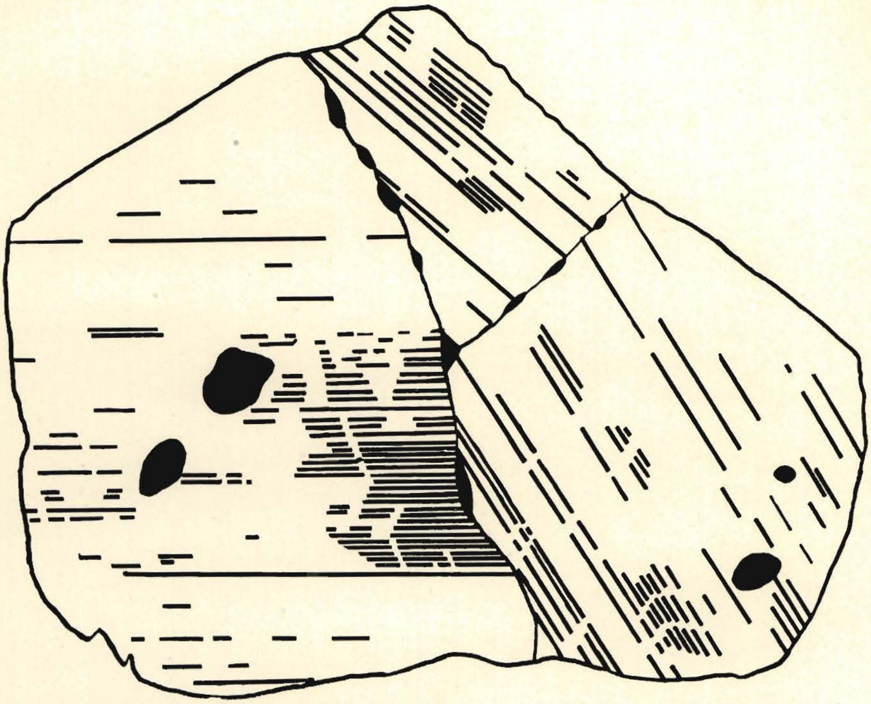

FIG. 1. Diagram of section, showing the tripartite structure. The lines represent plates of kamacite.

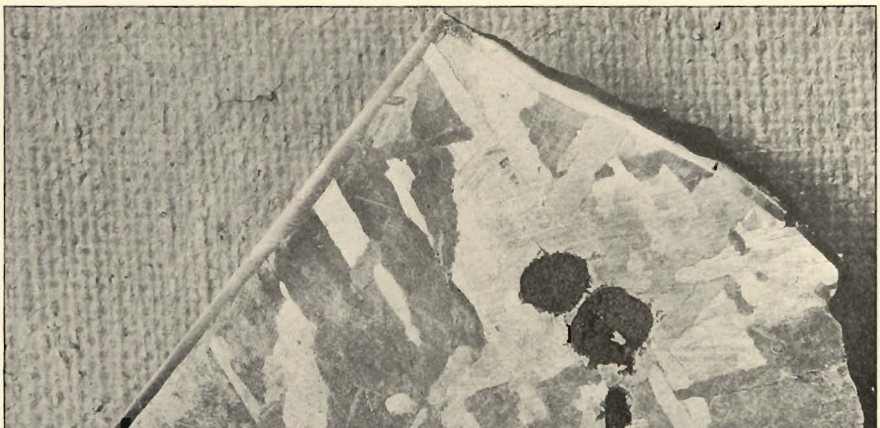

FIG. 2. Section showing the dark troilite nodules surrounded by the lighter schreibersite.

ARISPE METEORITE.

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