

ART. XLIV.—*A New Locality for Meteoric Iron with a Preliminary Notice of the Discovery of Diamonds in the Iron*;* by A. E. FOOTE. With Plates XIV, XV.

Historical sketch of the discovery.—In the latter part of March, 1891, the mining firm of N. B. Booth & Co., of Albuquerque, New Mexico, received a letter from a prospector in Arizona informing them he had found a vein of metallic iron near Cañon Diablo, sending them at the same time a piece with the request for an assay. Sometime in April this piece was examined by a Colorado assayer who reported "76·8 per cent of iron, 1·8 per cent lead, $\frac{1}{2}$ oz. silver, and a trace of gold. From its appearance we should take it to be a furnace product."†

This result was naturally not satisfactory to the mining firm and a mass weighing forty pounds was broken into several fragments with a trip hammer. One of these was sent to the President of the Santa Fe Railroad, and another to Gen. Williamson, the land commissioner of the Atlantic and Pacific Railroad Co., in Chicago. Gen. Williamson consulted me as to the probable value of the so-called mine of "pure metallic iron," stating on the authority of the prospector that the vein had been traced for a distance of about two miles, that it was forty yards wide in places, finally disappearing into a mountain and that a car load could be taken from the surface and shipped with but little trouble.

A glance at the peculiar pitted appearance of the surface and the remarkable crystalline structure of the fractured portion convinced me that the fragment was part of a meteoric mass, and that the stories of the immense quantity were such as usually accompany the discovery of so-called native iron mines, or even meteoric stones. As soon as possible, in June, I made a visit to the locality and found that the quantity had, as usual, been greatly exaggerated.

There were some remarkable mineralogical and geological features which, together with the character of the iron itself, would allow of a good deal of self deception in a man who wanted to sell a mine.

Description of Locality.—Nearly all of the small fragments were found at a point about ten miles southeast from Cañon

* Read before the American Association for the Advancement of Science, August 20th, 1891.

† This assay was of such a remarkable character that I took the trouble to stop at the city where it was made and ask how such extraordinary results were obtained. I was informed that the lead, silver and gold were probably the results of the materials used in making the assay.

Diablo near the base of a nearly circular elevation which is known locally as "Crater Mountain." I believe this is the same as Sunset Knoll figured on the topographical sheets of the U. S. Geological Survey. This is 185 miles (297·72 kilometers), due north from Tucson and about 250 miles (402·34 kilometers) west of Albuquerque.

The elevation, according to the survey, rises 432 feet (131·67 meters) above the plain. Its center is occupied by a cavity nearly three quarters of a mile (1·2 kilometers) in diameter, the sides of which are so steep that animals that have descended into it have been unable to escape and have left their bleached bones at the bottom. The bottom seemed to be from fifty to one hundred feet (15·24 to 30·48 kilometers) below the surrounding plain. The rocks which form the rim of the so-called "crater" are sandstones and limestones and are uplifted on all sides at an almost uniform angle of from thirty-five to forty degrees. A careful search, however, failed to reveal any lava, obsidian or other volcanic products. I am therefore unable to explain the cause of this remarkable geological phenomenon. I also regret that a severe gallop across the plain had put my photographic apparatus out of order so that the plates I made were of no value.

About two miles (3·22 kilometers) from the point at the base of the "crater" in a nearly southeasterly direction, and almost exactly in a line with the longest dimensions of the area over which the fragments were found, two large masses were discovered within about eighty feet (24·38 meters) of each other. The area over which the small masses were scattered was about one-third of a mile (0·53 kilometer) in length and one hundred and twenty feet (36·57 meters) in its widest part. The longer dimension extended northwest and southeast.

Description of the specimens.—The largest mass discovered weighs 201 pounds (91·171 kilos,) and as the photograph shows, Plate XIV, has a somewhat flattened rectangular shape showing extraordinarily deep and large pits, three of which pass entirely through the iron. The most remarkable example of such perforation is the Signet Iron from near Tucson, Arizona, now in the National Museum and figured in Prof. F. W. Clarke's Catalogue.*

One other large mass was found weighing 154 pounds (69·853 kilos.) This is also deeply pitted. A mass weighing approximately 40 pounds (18·144 kilos) was broken in pieces with a trip hammer and it was in cutting one of the fragments of this mass that diamonds were discovered. Plate XV.

* The Signet Iron was discovered about 30 miles (48·28 kilometers) from Tucson. Dr. Geo. H. Horn states that 25 years ago he was told by the Spaniards that plenty of iron could be found on a range of hills extending northwest and southeast half way between Albuquerque and Tucson.

Besides these masses of considerable size a careful search made by myself with the assistance of five men was rewarded by the discovery of 108 smaller masses. Twenty-three others were also discovered making a total of 131 small masses ranging in weight from $\frac{1}{16}$ of an oz. (1.79 grm.) to 6 lbs. 10 oz. (3.006 kilos.)* A brownish white slightly botryoidal coating found on a number of the meteorites, is probably aragonite.

A thorough examination of many miles of the plain proved that the car load of iron existed only in imagination. Accompanying the pieces found at the base of the "crater" were oxidized and sulphuretted fragments which a preliminary examination has shown are undoubtedly of meteoric origin. About 200 pounds (90.718 kilos) of these were secured, from minute fragments up to 3 pounds 14 oz. or (1.757 kilos.) These fragments are mostly quite angular in character, and a very few show a greenish stain, resulting probably from the oxidation of the nickel. This oxidized material is identical in appearance with an incrustation which covers some of the iron masses and partially fills some of the pits.

Composition.—After obtaining the meteorite I was unable to return to Philadelphia for sometime, and, therefore, sent a fragment of the 40 pound mass (18.144 kilos) to Prof. G. A. Koenig for examination. Prof. Koenig was compelled to leave town before this examination was completed. I take the following, therefore, from his letters to me and from an account furnished the daily *Public Ledger* by Dr. E. J. Nolan, Secretary of the Academy of Sciences, of a preliminary notice made by Prof. Koenig, June 23rd, before the Academy of Natural Sciences of Philadelphia. In this account he says:

"In cutting the meteoric iron for study it had been found of an extraordinary hardness, the section taking a day and a half, and a number of chisels having been destroyed in the process. When the mass, which on the exterior was not distinguished from other pieces of meteoric iron, was divided, it was found that the cutting apparatus had fortunately gone through a cavity. In the attempt to polish the surface so as to bring out the characteristic Widmannstätten figures, Dr. Koenig received word that the emery wheel in use had been ruined.

On examination, he then found that the exposed cavities contained diamonds which cut through polished corundum as easily as a knife will cut through gypsum. The diamonds exposed were small, black, and, of course, of but little com-

* Oct. 18th.—During September I received three additional large masses weighing respectively 632, 506 and 145 pounds (or 286.678, 229.516 and 65.771 kilos.) The two latter were each perforated with three holes. A number of smaller masses up to 7 pounds, (3.175 kilos.) were discovered by digging. The three large masses and one of 23 pounds, (10.432 kilos) were covered with grass and earth.—A. E. F.

mercial value, but, mineralogically, they are of the greatest interest, the presence of such in meteorites having been unknown until 1887, when two Russian mineralogists discovered traces of diamond in a meteoric mixture of olivine and bronzite. Granules of amorphous carbon were also found in the cavity, and a small quantity of this treated with acid had revealed a minute white diamond of one-half a millimeter, or about $\frac{1}{56}$ of an inch in diameter. In manipulation, unfortunately, this specimen was lost, but others will doubtless be obtained in the course of investigation. The minerals, troilite and daubréelite, were also found in the cavities. The proportion of nickel in the general mass is three per cent, and the speaker was not as yet able to account for the extraordinary hardness apart from the presence of the diamonds in the cavities."

Prof. Koenig in a letter to me gives the following points as definitely known.

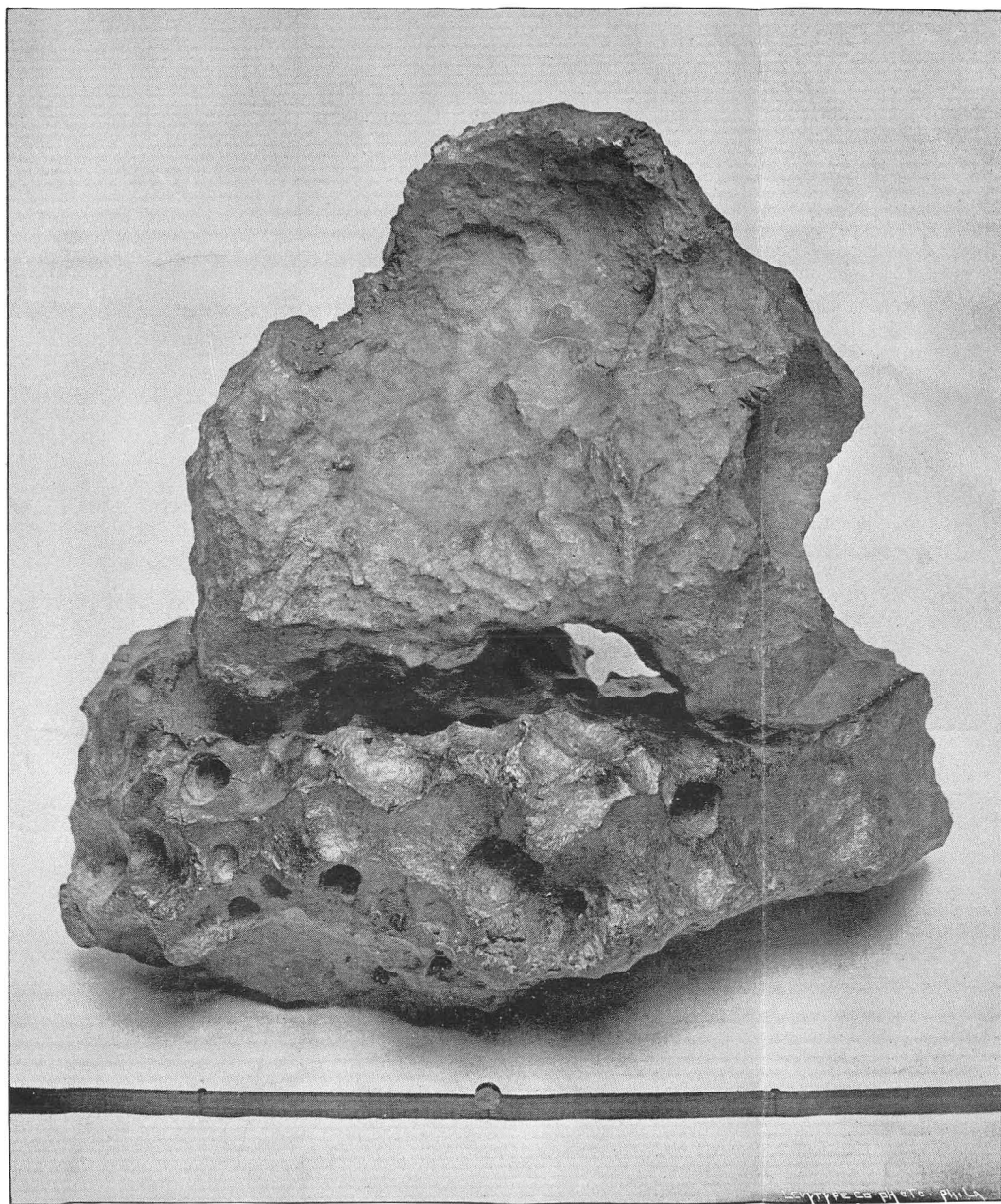
"(1.) *Diamonds*, black and white established by hardness and indifference to chemical agents. (2.) *Carbon* in the form of a pulverulent iron carbide occurring in the same cavity with the diamonds. The precise nature of this carbide, whether containing hydrogen and nitrogen is not ascertained except in so far that after extracting all iron by nitro-hydrochloric acid, the black residue goes into solution with deep brown color upon treating it with potassium or sodium hydrate. From this solution acids do not precipitate anything. (3.) *Sulphur* is not contained in the tough malleable portion of the meteorite but in the pulverulent portion. (4.) *Phosphorus* is contained in the latter, and not in the former. (5.) *Nickel* and *Cobalt* in the proportion of 2:1 are contained in both parts nearly equally. (7.) *Silicon* is only present in the pulverulent portion. (8.) The Widmannstätten figures are not regular. (9.) The iron is associated with a black hydroxide containing Fe, Ni, Co, P, in the ratio of the metallic part and therefore presumably derived by a process of oxidation and hydration of the latter."

Conclusions.—As this meteoric iron contains only 3 per cent of nickel while that from the Santa Catarina Mountains, 30 miles (48.28 kilometers) southeast of Tucson and 215 miles (346 kilometers) from this locality, contains from 8 per cent to 9 per cent, according to the analysis of Brush and Smith, they are quite distinct although somewhat alike in external appearance. They also somewhat resemble the Glorietta meteoric irons from about 300 miles (482.8 kilometers) to the east northeast, in New Mexico. These contain 11.15 per cent of nickel.

The most interesting feature is the discovery for the first time of diamonds in meteoric iron.* This might have been predicted from the fact that all the constituents of meteoric iron have been found in meteoric stones, and *vice versa*, although in different proportions.

The incrustation of what is probably aragonite shown by some of the masses has rarely been noticed (I find two records by J. Lawrence Smith which he states to be unique, and both of these were from regions south of this one). The incrustation is especially interesting as showing that the meteoric irons must have been imbedded a long time, as the formation of aragonite would be exceedingly slow in this dry climate.

The remarkable quantity of oxidized black fragmental material that was found at those points, where the greatest number of small fragments of meteoric iron were found, would seem to indicate that an extraordinarily large mass of probably 500 or 600 pounds (226·796 or 272·156 kilos) had become oxidized while passing through the air and was so weakened in its internal structure that it had burst into pieces not long before reaching the earth.



Meteoric Iron, collected near Cañon Diablo, Arizona, June, 1891.
Larger mass weighing 201 lbs., completely perforated in three places.



Polished Surface of Meteoric Iron from Cañon Diablo, Arizona, showing Widmanstätten figures. A small black diamond is shown protruding near one side of the central black cavity; at D; a circle of scratches made by small loosened diamonds can be seen near this spot.