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THE GREAT METEORITE OF SINALOA, MEXICO.

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For more than a century the meteorites of Mexico have attracted attention and record. In his great work on La Nouvelle Espagne, published in 1811, Humboldt described in a broad and philosophical way the great field of the Toluca Irons and the size of some isolated masses in the States of Zacetecas and Durango. From that day until this, naturalists and travellers in Mexico have examined and described this product of the country, commenting particularly upon their frequence and their size.

Their frequence has been greatly overestimated. The total number credited to the Republic in Castillo's full catalogue, published in 1889, was twenty-seven. At the present day there are known thirty-two distinct localities, omitting the numerous points embraced in the distribution of the masses in two or three wide-spread showers. Leaving out one or two extra-limital localities, the Mexican falls have all been in a belt some 1000 miles in length, reaching from the 30th parallel of north latitude, south to the 17th parallel, and with an average breadth of about 280 miles. This belt of meteoric falls follows largely the central axis of the greal Mexican Plateau, reaching from the United States frontier-line obliquely south and east through the Republic to near the Pacific. In this tapering, truncated triangle, which encloses about 280,000 square miles, there occur thirty well distinguished meteorite falls. Comparison with other parts of the world shows that the relative number of Mexican meteorites is much less than seems to be generally supposed. Turning to the United States we measure a like area, though of a somewhat different form, with its major axis east and west, and enclosing the six continuous states of Kansas, Missouri, Kentucky, Tennessee, North Carolina and South Carolina. This area

comprises 286,000 square miles and contains sixty-six meteorite localities, more than twice the number that we have seen in the Mexican belt. In India, in an area of similar extension, which includes its northwestern provinces, we find forty-eight meteorite localities, or one and one-half times the number in the Mexican belt. It would seem, then, that Mexico must vacate her claim, often asserted, to preëminence in meteoric localities.

Only, perhaps, the wide-spreadness of some falls, notably in the States of Coahuila and Toluca, may be distinctive; although this meets an approaching rivality in the dispersion of some which we consider identical falls of aërolites in Kansas and in Iowa.

It would be interesting to notice here the fact of the high elevation of these three meteorite belts or areas above the general altitude of the country at large. This is especially remarkable in Mexico and in India. Also the fact that the Mexican meteorite list shows 23 irons to 7 stones; the United States as a whole, 102 irons to 54 stones; while India gives 55 stones and only 2 irons. We cannot here digress to even guess at the possible cause of these phenomena.

The prominent character and preëminence of the Mexican meteorites is the vast size of many of them. In this matter of bulk they are unapproachable. Taking but ten of them—Chupaderos, San Gregorio, Casas Grandes, Concepcion, Charcas, Descubridora, Bacubirito, Zacatecas and Apolonia—we find a total weight of 86,744 kilograms (191,076 lbs.) or 95½ tons. This equals an average weight of 9 1-10 tons for each of these Mexican irons. If now we take the largest ten meteorites of the United States, (they are in the order of their weight Red River, Tucson, Long Island, Cañon Diablo, Mt. Joy, St. Genevieve, Sacramento Mts., Estherville, Brenham, and Kenton Co.,) we find their combined weight to be 8,365 lbs., or 8 1-3 hundredweight, as the average individual weight of the ten. In short, the Mexican masses weigh on an average 22½ times as much as our own. What may have caused this so vastly greater mass of Mexican meteorites we will not venture to define. Has the great height above sea level of the Mexican Plateau, with its drier air and drier soil, delayed the decomposition and wasting away of their irons? But Anighito in Greenland, Bemdego in Brazil and Cranbourne in Southern Australia, three giants, all lay close at sea-level, and all three were in exceptionally moist regions.

The Mexican Government has taken an active and enlightened part in the protection of her meteorites. Twelve years ago it expended the sum of $10,000 in bringing five of the largest to the

capital, where they are mounted on huge iron pillars in the entrance court of the School of Mines.

Having during the last fifteen years paid visits to most of these Mexican meteorite localities, seeing most of the large masses before they had been removed from the spot where they fell, and where some of them had lain perhaps for many centuries, the writer acquired great interest in all that pertained to them. While in the capital a few months ago, studying and cutting some of the large pieces in the Museo Nacional, the writer sought almost in vain in scientific circles for substantiation and defining of stories which have long been current relating to an enormous iron meteorite existing in the State of Sinaloa, far in the northwest portion of the Republic.

The first and, so far as we can find, the only positive notice of this meteorite was in 1876. Then Señor Mariano Barcena, a noted Mexican scientist and astronomer, in a 5-page article in the Proceedings of the Philadelphia Academy of Sciences devoted to Mexican meteorites, notices "an enormous meteoric mass lately discovered in the State of Sinaloa." He says, "I can assure the Academy that its length was more than twelve feet." Many years later Castillo in his catalogue of Mexican meteorites refers to this same mass, giving its length at 3.65 metres ; with 2 metres in height and 1.50 metres thick. Three years later, Eastman, of the United States Naval Observatory, taking the above measures as being correct, estimated its weight as 40,800 kilograms or about 42 tons. Brezina, Cohen and Wülfing speak of it as weighing 50 tons, and as being the largest meteorite in the world. But in all this there was no definite description of the mass, and no one who mentioned it claimed to have seen it. We were anxious to ascertain about all this. The Mexican savants were all interested in having this great celestial body investigated. One of them, Señor Jose C. Aguilera, the Director of the Instituto Geologico, a government institution, and the present headquarters of the Geological Survey of the Republic, aided us in obtaining from the Minister of State letters to the Governor of Sinaloa and to the Director of Mines in that State. We had decided to visit Bacubirito, for so the place and the meteorite itself were called, and see what was fact and what was rumor about it. So on the 2nd of April of the present year we started out to resolve the matter. Sinaloa is a hard State to reach from the City of Mexico. One must pass far around to the north through the United States, returning south through Sonora, a journey of over 2,000 miles, or go by the Pacific coast, a shorter but harder route. We took this latter, cross-

ing by train and mule-back to Manzanillo, the sea-port of the State of Colima, and thence by steam up the coast for six hundred miles to Altata on the east coast of the Gulf of California; thence 60 miles by cars to the city of Culiacan, the capital of Sinaloa. Here we met the Governor of the State, and from him obtained letters to authorities further up the country. We also got an outfit of provisions, a carriage with four mules, and an American photographer who accompanied us with his camera. Bacubirito is 95 miles to the north and west of Culiacan. Our drive took three days, over a very rough road, crossing some streams and ravines, and gradually rising to and among the lower foot-hills of the Sierra Madre, the great Cordilleras chain which separates Sinaloa from the States of Chihuahua and Durango. Bacubirito itself, our goal in this search, is a small but very old mining town situated on the Rio Sinaloa in latitude 26 and in west longitude 107. The elevation above sea level is some 2,000 feet. The meteorite is seven miles nearly due south from there, near the hamlet called Palmar de la Sepulveda. Here we found it on a farm called Ranchito, which fills the narrow mountain valley or interval between two spurs of the foothills, running nearly north and south. It lay in a cornfield, close by the eastern edge of this vale, where the level ground began to raise against the hill-side. The valley and the field were of black vegetable soil, some two yards in thickness. In this soil the great meteorite lay imbedded ; its surface but little below the general surface of the field around it, but with one end slightly projecting above the level. The other end was so deeply imbedded in the soil, and so apparently undisturbed or even uncovered, that it was easy to see why the size and measures of the mass had been uncertain. It was a long, monstrous boulder of black iron, which seemed to be still burrowing to hide itself from the upper world. Its surface form was something that of a great ham. We could walk for many feet along and across its surface, surveying these dimensions as far as they were exposed, but knowing nothing of how far the mass penetrated the soil beneath. Our first work was excavation. For this there was no lack of help. We soon got no less than 28 stout, able-bodied, willing Peons who were delighted to work for us at fair wages. We undertook an excavation of about 30 feet on a side, with the great meteorite lying within. In a single day we passed down through nearly 4 feet of the soft, vegetable soil. At the end of that time the meteorite had assumed the appearance shown in photograph No. 1, its upper surface and one side being revealed. On this surface the characteristic "pittings" were well marked, covering the entire surface. They

were very regular in size, about 2 to 3 inches across, with well defined walls, yet quite shallow. The general form of the mass seen from the side was that of one side or ramus of a huge jaw. The surface was very even, with no holes due to the destruction of Troilite nodules. Nor were there any points which showed the devastation of deep rust. The dryness of the soil and the large proportion of nickel in the meteorite's composition had doubtless impeded this. As often happens in such cases, the part which had been most above ground was best preserved, with a light oxydized crust, brown and somewhat bronze-like in appearance.

On one side there was a deep crack, running horizontally through nearly half the length of the mass. At one end this crack was too narrow to insert a knife-blade. Going toward the other end it increased to a fissure wide enough to first admit our hammer handle and finally our arm. This fissure at a distance of some three feet from the smaller end of the mass cut off the lower part from the upper, the latter extending beyond in diminished size for three feet further. Our Mexicans were astonished at the revelation of their own work ; they marvelled alike at the size of the mass as their digging had developed it, and at our credulity in believing that it had ever fallen from space above. View *No. 2* gives a somewhat oblique view after further excavation. *No. 3* gives same view and shows the unequal weathering of the mass, the part most exposed being the least weathered. *No. 4* is another view taken from above and lengthwise of the mass. This shows on the right hand the fissure in the mass.

By the end of the second day we had carried our excavation to an average depth of about six feet on every side. The black vegetable soil was from three to four feet thick. Below it was a porphyry rock, common in this part of the country, much broken up by natural cleavages and a good deal decomposed *in situ*. The vegetable soil passed very gradually into this rock, and seemed to have unquestionably formed above it, as an operation of gradual change. Immediately around the meteorite we had dug much lower, leaving the great iron mass poised on a pillar or pedestal of the undisturbed rock. Finally we performed a feat of moving the great mass. To lift one end would have been a physical impossibility ; all our men with the stoutest tackle in the district could not have done that ; but it needed little mechanical aid to make the mass move itself. We attacked with our long iron bars one side of the supporting pedestal on which it was balanced. It was slow work, for the rock seemed to be here somewhat less decomposed. After long chiseling away one side of the

pedestal, the center of gravity was reached, and with a slow, almost dignified movement the great meteorite sank at one end, and assumed the semi-vertical position which is brought out in the *No. 5* picture. In *No. 6*, the photographer is seen standing midway of the mass. Incidentally there is well shown the depth of our excavation, below the level of the cornfield. We upset the mass in an effort to ascertain, if possible, by the nature of the rock beneath it, the recent or the ancient fall of the mass. Was the soil already there when the meteorite fell, and did the latter by virtue of its weight crush through it to the rock? In the latter case it seemed probable that some of the soil should have been caught and held between the meteorite and its bed. A good deal to our surprise we found that this bed was a clean depression crushed into the rock with absolutely no trace of soil between it and the part where the full weight of the mass had fallen and lain. It would thus *seem* that the meteorite had fallen on the bare surface of this district at a period before the vegetable soil had begun to form here. This would be an interesting and astounding fact, carrying back the fall of our meteor to a remotely distant period, perhaps thousands of years. But there are other conditions which would need careful consideration before accepting such a momentous conclusion.

The wonderful preservation of the mass, with its little oxydation, and the clean, sharp-rimmed pittings which cover its surface, seem to point to a more modern sojourn within the destroying influences of our air and moisture. We leave this for future consideration.

It is an interesting fact that this, perhaps the largest and the heaviest meteorite mass yet discovered on our globe, should have fallen so near the present border of our own country. Interesting too, that Mexico with all its other extra large meteorites should have received this champion mass.

The extreme measures of Bacubirito, for so our meteorite from the first has been called, are :

Length, 13 feet and 1 inch.
Width, 6 feet and 2 inches.
Thickness, 5 feet and 4 inches.

Its form, as shown by the photographs, is extremely irregular, and though measures have been taken around the mass at many different points, its cubic contents can not be calculated with more than an approximation to accuracy.

The five largest meteorites known to Science to-day are :

Bemdego (Brazil), 5⅓ tons.
San Gregorio (Mexico), 11½ tons.

Chupaderos (Mexico), 15⅔ tons.
Anighito (Greenland), 50 tons.
Bacubirito (Mexico), 50 tons.

The former three are weights proven on scales. The latter two are thus far simple estimates. How far estimated weights, based on simple guessing, may differ from proven weights is well illustrated by the case of Chupaderos, one of the meteorites just cited. Fletcher, the noted mineralogist of the British Museum, says of it, "According to one recent estimate its weight is 15 tons, according to another it is 82 tons." Anighito, the great Greenland meteorite, has been guessed at all figures, from 30 to 100 tons. A late unofficial estimate of it, after careful measuring, puts its weight at 46⅓ tons.

Should the Mexican Government, as we some expect, move the great mass, as it has done all the others, to the capital, its exact weight will be finally and definitely known. Whichever mass shall, after accurate calculation, prove to be the heavier, it will ever remain of interest that the two largest meteorites known to our earth shall have fallen on the North American Continent, one far toward its northern end, the other toward its southern.

The inner structure of this meteorite is interesting as showing the octahedral system of crystallization in a very marked degree. We know of no other meteoric iron which shows this equally, unless it be that of Sevier Co., Tennessee, or San Angelo, Texas.

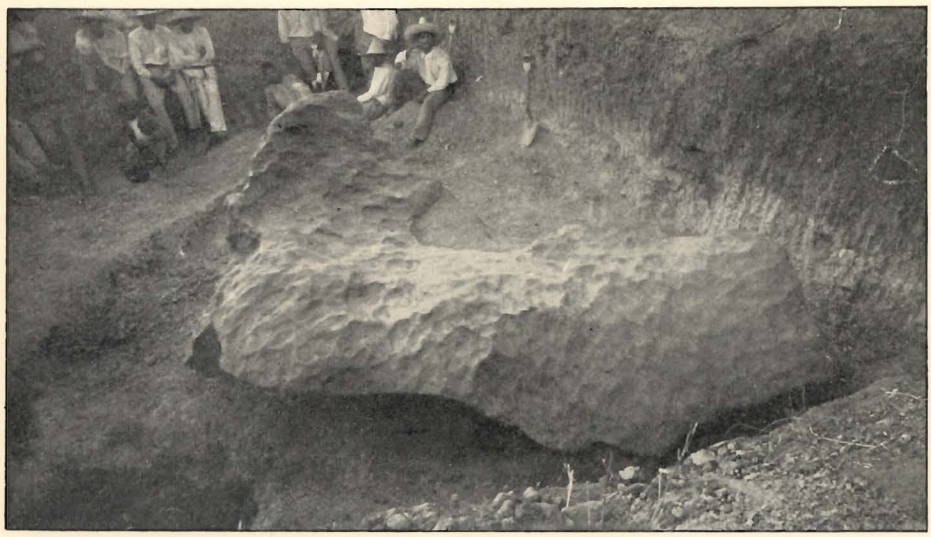
Fractured surfaces show crystallization plates with faces from 3 to 19 mm. in greatest diameter. Many of these faces are covered with fine films of taenite, which in most cases are of the characteristic bronze yellow color. Acid brings out the Widmanstätten figures in a most beautiful manner. From the coarse crystals on a fractured or a weathered face of this iron, we might anticipate that etching would reveal a large, wide pattern in its markings. As a fact, quite the converse is true. The figures, while very sharp and clear, are small in pattern and are composed of narrow blades of kamacite, which are but a fraction of a mm. in diameter. At intervals, these blades appear to be of more than double that thickness; but when examined with a glass it is seen that these apparently broader plates are composed of what might be expressed as bundles of the narrow kamacite bands. The rhombic figures on the etched face will average from 1½ to 5 mm. in diameter, the two angles of same being 60° and 120°, while the triangular markings will generally range from 8 to 15 mm. with angles of 55°; 55° and 70°. Troilites are particularly scarce, but two or three small ones having shown on any of the sections made. The

iron is essentially tough, although not more dense than in the majority of siderites.

The specific gravity of Bacubirito is 7.69. Its analysis has been made by Prof. J. E. Whitfield, of Philadelphia, as follows :

Iron,	88.944%
Nickel,	6.979%
Cobalt,	0.211%
Sulphur,	0.005%
Phosphorus,	0.154%
Silicon,	Trace

We succeeded after a long, protracted effort in detaching from the mass an already partly loosened piece of about 11 lbs. weight. This, polished and etched on one side, showing the beautiful Widmanstätten figures, has taken its place in the Ward-Coonley collection of meteorites now on display (on deposit) in the American Museum of Natural History in New York.



No. 1. ONE SIDE OF METEORITE UNCOVERED.

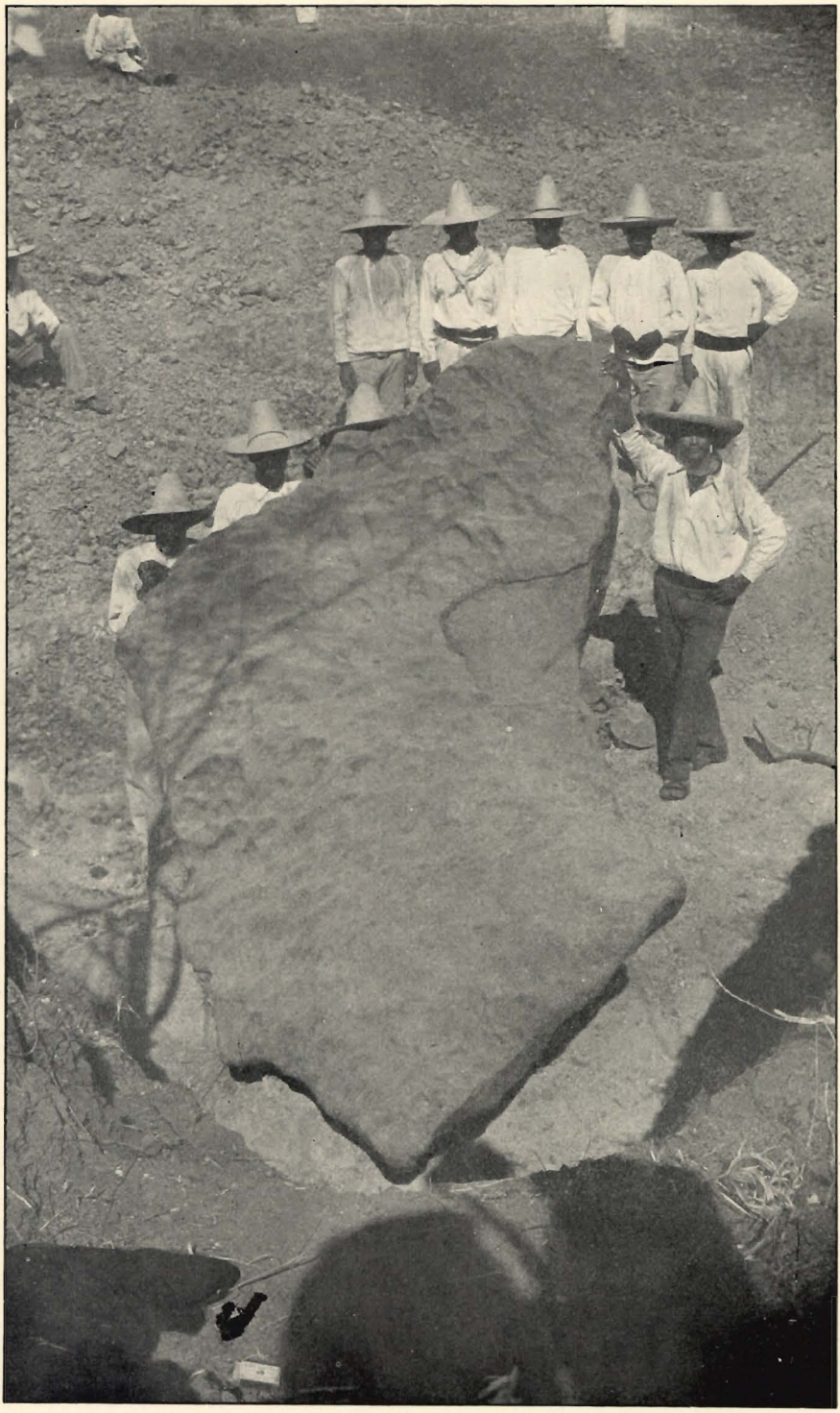
No. 2. AFTER FURTHER EXCAVATION.

HENRY A. WARD.

No. 3. UNEQUAL WEATHERING OF MASS.

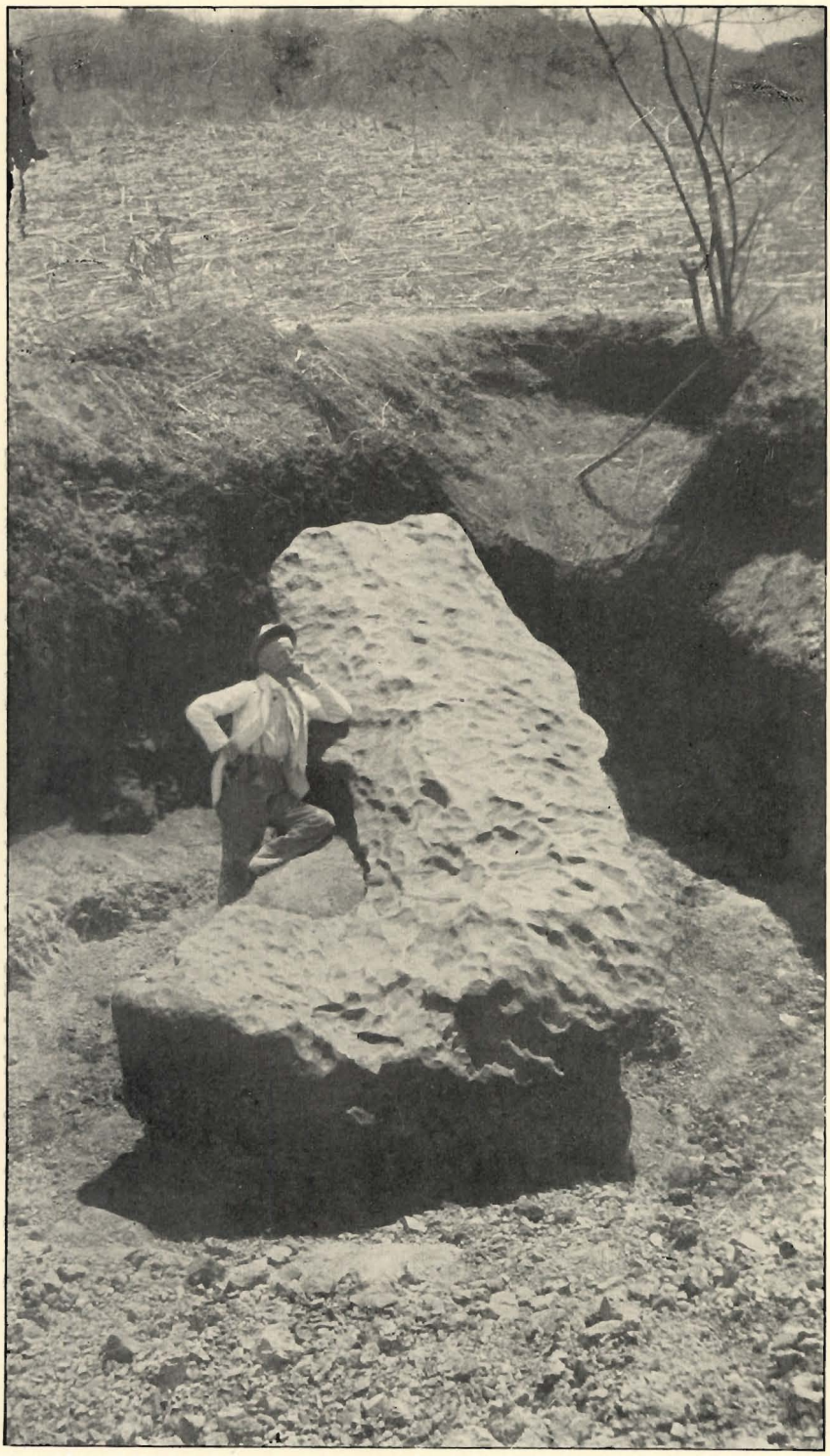
No. 5. METEORITE PARTIALLY UP-ENDED.

HENRY A. WARD.



No. 4. VIEW TAKEN FROM ABOVE AND LENGTHWISE OF THE MASS. SHOWS AT RIGHT HAND THE FISSURE.

HENRY A. WARD



No. 6. THE METEORITE FINALLY UP-ENDED.

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