PROCEEDINGS OF THE ROCHESTER ACADEMY OF SCIENCE
VOL. 4, PP. 149-164.

GREAT METEORITE COLLECTIONS AND THEIR COMPOSITION

BY

HENRY A. WARD.

ROCHESTER, N. Y.
PUBLISHED BY THE SOCIETY,
OCTOBER, 1904.

One of the seven cases of the Ward-Coonley Meteorite Collection.

PROCEEDINGS OF THE ROCHESTER ACADEMY OF SCIENCE
VOL. 4, PP. 149-164. OCTOBER 10, 1904.

GREAT METEORITE COLLECTIONS; SOME WORDS AS TO THEIR COMPOSITION AS AFFECTING THEIR RELATIVE VALUES.

BY HENRY A. WARD.

(Presented before the Academy, October 10, 1904.)

The great attention which is at the present time being given to the study of meteorites, and especially the activity which is being shown in their gathering and in the increasing of meteorite collections, both public and private, is a notable feature in the view over this field of inorganic study. The time seems thus a favorable one for consideration of some of the material features of the subject—both in past time and in the present.

A retrospect through the pages of meteorite lore is instructive and of practical interest in this connection. We find, to our surprise, that meteorites and their fall are among the earliest of recorded facts. The ancient Chinese chronicles are full of these. So also in the archives of Phœnician, Grecian and Roman peoples, where the fall of these celestial bodies is recorded with many attendant circumstances, the whole usually crusted over with mythical and religious lore. There are now extant in the European numismatic collections—according to Brezina, who has made an exhaustive study of the matter—no less than two hundred medals in silver, bronze and iron, which were cast in record of falls of meteorites in these lands. The worship of these Betyls (Beth-El: House of God) was an extensive one, while their superstitious reverence among aboriginal folk has ever been a universal feature of primitive man.

Meunier, one of a trio (Brezina, Cohen, Meunier) of European leaders in meteorite study, cites 32 meteorite falls commencing with 1478 B. C. and continuing down to 6 B. C. Of these, 28 are so exact and circumstantial in their recording that he considers them as reliable historical occurrences, although none of the masses have been preserved. Several of them, notably the "Image which

fell down from Jupiter" at Ephesus (Acts 19 : 35), and the much more definitely determined ones of Aegopotamus and the Ancyle, have been seriously sought after within the present century. The traveller Brown, in 1810, sought the former in Thrace, and all excavators of the Roman ruins have in mind the possible finding of the Ancyle. This iron—so called from its shield shape—is reported by Plutarch to have fallen from heaven in the eighth year of the reign of Numa Pompilius (about 705 or 704 B. C.), taken to Rome and there cared for by one of Numa's Salishan priests. Meunier further enumerates 161 meteorite falls commencing with 106 A. D., and continuing till 1799 A. D. Of these he accepts 142 as being well authenticated. We have thus a total of about 170 falls in 30 centuries preceding the year 1800, or about 19 falls in each century. The number is meager, but we bear in mind the insufficiency of written record in those early ages. Of those which fell since the commencement of our era and preceding 1800, but 35 are positively known to exist in collections to-day. If now we add the 135 meteorites known to have been lost, to the 680 to-day known in collections, we have about 815 individual kinds of these heavenly bodies known and recorded as having been held in human hands. Of the many more hundreds of meteorites which have fallen and been handled in these past centuries of which we know by a process of sure induction, it is beyond our purpose to speak here. Our present theme is

THE STATE OF METEORITE COLLECTIONS TO-DAY, WITH THEIR EARLY ORIGINS.

Doubtless the earlier meteorites were too rare an occurrence, too little understood and too sparsely distributed, that they should have been brought together to any "collection." They were often —perhaps usually—taken to some temple, where they were preserved with reverence, often on a pedestal and under a roof of their own. It would be facetious to note the case of the Ancyle and its 11 *fac-similes*. But when we read that a meteorite was preserved in the Lyceum at Girgenti, we have a curious thought of others which may possibly have been there preserved and displayed with it. If so, that was our initial collection !

It may here be the place to call attention to the fact that the conception of meteorites—that they fell from space—was more universal and unchallenged in earlier centuries than it became in times nearer our own. This because probably all that were recog-

nized were seen to fall. Further, because the phenomena of an extra-terrestrial origin had not any exactness of the definite physical knowledge of those days to clash with. They were Heaven-born (Beth-El) ; they were sacred ; and no questions of gravity or other physical incongruities were allowed to trouble the popular verdict. Still, a short time before the close of the eighteenth century, as more and more of them were found and they were more spoken of, there arose a widespread doubt of their cosmic character. And perhaps it should not surprise us that the more highly educated led among the doubters.

The two oldest meteorites which we to-day possess—Elbogen and Ensisheim—had fallen, one in Bohemia in about 1400, the other in the Rhine valley in 1492. One was an iron, the other a stone ; both of them were duly taken off to the church, where all material marvels (as these sky-stones, mastodon bones, etc.) were wont to be gathered to be joined to the other less material priestly conundrums.

In 1753, when Tabor fell in Bohemia, it met before long with some doubts. Born, in 1772, in his mineral work called "Lithophylactum Bornianum," says of this stone : "e cœlo pluvisse creduliores asseverant." And although in 1794 Chladni—the earliest and profoundest meteorite historian—had described the great Pallas meteorite from Siberia and had given cogent reasons for the cosmic character—as opposed to the terrestrial—of this and many other meteorites which he enumerated, the incredulity still continued. Indeed, Chladni, in his great, parent meteorite work in 1819, speaks of many which had been *thrown away* in his day because the directors of museums were ashamed of their presence ; with the implied belief in their celestial character. Most strange is it that the French savants should have been slowest of all Europe to acknowledge meteorites. While Chladni had made many converts in Austria and Prussia, French savants still held aloof. When in July, 1790, a shower of stones—more than 100 in number—fell near Barbotan in S. Western France, a full account thereof was prepared by a committee of citizens who observed the fall, and this document, signed by the municipal chief, was sent to the authorities at Paris. This report was presented to the Academy of Sciences by Bethelon, the notable chemist and physicist. Its reception by the Academy is shown by notes in their Transactions and by a paper at the same time by Berthelon in a Journal of Science. We quote from it two sentences : "How must we grieve

to-day to see an entire municipality join in giving serious credence to popular tales which can but excite the pity, not only of physicists, but of all reasonable people. What shall we say of this seriously presented report, what reflections come to the philosophical reader in perusing this evidently false attestation of a phenomenon physically impossible." We find recorded no modification of unbelief as to meteorites in France until 1803, when on the 26th of April another great meteorite fall occurred at l'Aigle, in Normandy. Then the Minister of the Interior sent the celebrated physicist, Biot, to the spot to investigate. Biot did his work thoroughly and his report presented on his return to the National Institute at Paris, was overwhelming and conclusive as to the truth of the fall from space of these stones, many of which he had brought back with him. Thenceforth the extra-terrestrial nature of meteorites has not been challenged in France.

In the early part of the last century there are on record nearly a score of meteorite collections. The Vienna Royal Cabinet, which seems to have had its first meteorite in 1747, had, when Schneider took charge of it in 1805, eight specimens. The British Museum had in 1807 four or five specimens. Berlin Museum had in 1810 about twelve specimens. The Paris (Jardin des Plantes) Museum crowned the century with a 9 kilo Ensisheim presented by Faucroy, an Elbogen and a Tabor, and in 1803 was materially increased by numerous specimens of l'Aigle and of several other French meteorites, so that it recorded early in the century nearly a score of meteorites. These were, however, held for a long time in the mineral collection without further classification.

Previous to 1825 we find noted the existence of some 23 or 24 public meteorite collections, notably in the cabinets of the Royal Museums. There were also a considerable number of collections of these bodies held by private collectors. The earliest of these was that of Sir Charles Greville, which in 1810 passed into the possession of the British Museum. That of Chladni, numbering over 50 specimens, which at his death went to the Berlin Museum; and that of Born, which seems to have been distributed through many museums; Heuland, Neville, Sowerby, Klaproth, Bergman, Rammelsberg, Reichenbach, Wöhler, the Marquis de Dace, the Duc de Luynes, and many others. We find record of meteorite exchanges going on between these museums and between private collectors as early as 1817, with the usual activities and rivalries.

Travellers, too, brought them from their distant wanderings. Humboldt, from Mexico ; Bousingault, from the Upper Valley of the Magdalena; Woodbine Parish, from Buenos Ayres, etc., etc.

We cannot undertake to note the increase of collections from then on through the century which has just closed. We have on our list nearly two hundred of these in Europe alone. Twelve of them, in the order of their numerical importance, are : Vienna, 560 ; London, 557 ; Paris, 490 ; Berlin, 470 ; Buda-Pesth, 390 ; Greifswald, 358 ; Stockholm, 245 ; Göttingen, 210 ; Tübingen, 200 ; Museum of Practical Geology (London), 200 ; Dorpat, 175 ; and Strasburg, 135.

Of private meteorite collections in Europe there are but four prominent ones : Dr. Brezina and Prof. Friedrichs of Vienna, Marquis de Mauroy of Wassy, France, and Max J. Neumann of Gratz, Austria. Each of these lies in numbers of kinds between 200 and 250. The struggle to increase their number of specimens is very great ; yet for an evident, if not a commendable reason, these large museums do not share specimens with each other. It would be an easy matter for any two of the larger museums of Europe to increase their collections any day by thirty or more specimens (a normal growth of two or three years) by each giving to the other of its duplicate material in exchange for such kinds as it lacks. It would seem that this action would accord with a true spirit of science.

The issuing of catalogues of the contents of the meteorite collections of Europe is a matter of old standing, commencing with Chladni in 1817, and has increased with the growth of the collections themselves. These catalogues are to-day a prominent feature of every collection, to be repeated every second or third year. Most of these are simply enumerative, giving the names and localities of the specimens with their individual weight and size. But many of the catalogues—particularly from the great museums—are almost treatises on the subject by reason of the attention paid to the classification adopted, the remarks on the character of individual specimens, the correction and extension of geographical dispersion, and the introduction of latest and widest views of the whole subject. The introduction by Brezina to his catalogue (1895) of the Vienna collection, that of Fletcher of the British museum, of Klein of Berlin—and, still more, the whole contents of Meunier's catalogue (1898) of the Paris collection, is a real treatise

and text-book of the science. In short, both in the activity of collecting, the prices paid for individual specimens, and the issuing of catalogues of the specimens, the European meteorite collections have far outrun the rest of the world. Vienna, the birthplace of meteorite study, has continued to be the headquarters of meteorite collecting and distribution.

The *high prices* paid for meteorites, particularly for those of small size and rare—preferably, too, for those of European origin—are most notable, and a constant surprise to the layman. It suffices that the extreme rarity of a meteorite be known to make it command an extraordinary price. We read that after the L'Aigle meteorite shower, just a century ago, Mr. Lambertin, a mineral dealer in Paris, did a large business in selling many hundred specimens throughout Europe at ten francs (two dollars) per ounce. This is not very far from what Pultusk—also a great shower—sells for to-day. But many others sell at prices ranging up from fifty cents to one dollar, two dollars, or even five dollars per gramm, the latter being seven times its weight in gold. This comes from the gradual diminution and dispersion through an entire century.

Instances of the highest-priced would be those meteorites of which the original amount was small—perhaps only one or two pounds—and the greater part went at once into some public or royal collection, whence no influence or persuasion will bring any out. There are probably twenty meteorites of each of which two or three gram pieces might be sold, if they would be given up, for ten dollars per gram—*fourteen times their weight in gold!* This touches the extreme side of the question—the fancy of eager competing collectors. With these there is the effort, amounting to a true struggle, to obtain a fragment of every known kind. It is the apotheosis of the collecting mania—not surpassed by postage stamps or orchids. Such a collector would probably give a hundred dollars for a gram of the Kaaba could he get it and prove its authenticity.

Various causes contribute to a meteorite's value. Among these are some peculiarity in fall or time of fall, some peculiarity of composition or structure, some historical character, its being worshipped, its being pre-historic, etc. Some, too, have marked an epoch in the science or a factor in classification. In most of these cases there has been but a small amount of the meteorite, so that at best very few can have it. It is like a piece of the true Cross.

Certainly, if we could have but three meteorites in our collection,we should wish one to be an Iron ; another a Stone ; the third a Siderolite, mingling iron and stone in its composition. But of the Irons we should want three or four of the most marked kinds, as shown mainly by inner structure and composition. In the same way, with the Stones we should want those of varied mineral composition, varied inner structure, varied outward structure, and phenomena of appearance. These wants would soon increase to a desire to have one kind which best shows each one of the many mineral elements known in meteorites. A collection thus may induce great study—which is the highest, truest aim in any collecting. It would contain many common meteorites; but also there would be need of rare ones like Bishopville, Lograno, Orgueil, Indarch, Veramin, etc. Historical falls, such as Elbogen, Ensisheim, L'Aigle, etc., would claim prominent place in such a collection.

Meteorites are now collected eagerly in all countries of the earth. Exchanges are active. So specimens are growing individually smaller, but the number of kinds in each collection, as well as the number of collections, is rapidly increasing. In the middle of the last century but three or four collections numbered a hundred kinds. Now there are about twenty noted in catalogues, which are over three hundred in number. Four of these are in the United States.

These meteorite collections are fast becoming one of the leading adjuncts to a large museum, and by reason of the activities of collecting, and the distribution, study and comparison of the catalogues, the question is brought up which has long been considered as to libraries, picture galleries, and others, that is : Which is the most valuable collection, and what are the reasons ?

We are disposed to answer this question abstractly by a careful consideration of some of the most prominent

FACTORS OF VALUE OF A COLLECTION OF METEORITES.

1. Number of distinct, well-authenticated kinds—" Falls " and "Finds."

2. Average weights and sizes of the individual specimens of the collection, including also the possession of one or more great masses.

3. The proportion of specimens of interest in the growth of the science. Also type-specimens.

4. The proportion of specimens showing leading points in meteorite classification—either chemical or petrographical.

5. The proportion of specimens of great rarity—usually the mass small at the outset.

6. The completeness of original exterior structure, with crust, pitting, orientation, etc.

7. The proportion of specimens of traditional or of historical value.

8. The proportion of *old* falls in the collection.

9. The extent to which the specimens have been treated by cutting, polishing, etching, etc., to show inner structure.

10. The broad geographical distribution of the specimens.

11. All Siderites or Siderolites ever *seen* to fall.

We will notice briefly some of the merits of each of these factors.

NUMBER OF DISTINCT, WELL-AUTHENTICATED KINDS—"FALLS AND FINDS."

It is here understood that the localities are quite distinct—not repetitions of each other under different names. Nearly all collections contain specimens—outliers of falls and bearing different names—which are really of one and the same fall, and should thus count as one locality. Most falls have some outliers of this kind. Pultusk, Mocs, Toluca, Coahuila, and others have each many of them. These may be used, and often are so, to swell a collection, where their presence attains redundance, without usually adding an element of value.*

In other cases the number of kinds in a collection is increased by the introduction of those practically undetermined and often unmeteoric. Such unauthentic specimens have no standing or rating in a collection. *They should be weeded out*, for their presence is detrimental.

If, then, all the specimens or kinds are genuine, a great number of them is a great factor of value. The more of them that there are, the more is the opportunity, or even the likelihood, that the other conditions of merit in the collection are met.

It might be that in a collection consisting of 200 meteorites out

*Pultusk (Poland, Jan., 1868) was a shower over an area of about four by six miles. The villages or hamlets included have added the following names to encumber nomenclature and render deceptive the numbers in meteorite collections, useful as they may be in some other ways: Pultusk, Psaly, Obryte, Zambski, Sokolowo, Gorstkowo, Sielce Nowry, Sielce Stary, Rozan, Ciolkowo, Rowy, Zastruzny, Rozdialy, Rchwnie, Mrozy, Daborowka, Clrzonny, Ochulenka. All these fell in a period of one minute between Pultusk and Ostrolenka, and are one meteorite—Pultusk.

of a possible 600, the whole 200 should be of the most inferior kind, although in fact this would rarely be true. But if there were 400 kinds, several of the other conditions of excellence would be necessarily met. In actual fact—as meteorite collections are ordinarily made—the presence of a very high number of kinds is a very certain index of other excellence. In a practical way the presence of a great number of kinds in a meteorite collection vastly facilitates comparisons and scientific study of the whole. The earnest efforts of the largest museums—controlled by sober, sensible scientists—to increase to the highest attainable point the number of their localities, is an index of the general appreciation of the value of numbers as a factor of merit. Large numbers show effort, study, and money outlay. The argument is practically a sure one that excellence has resulted. In a word, the factor of number of kinds will always take a high, leading position in rating a meteorite collection.

AVERAGE WEIGHTS AND SIZES OF THE INDIVIDUAL SPECIMENS OF THE COLLECTION.

The ideal of a meteorite collection might be that each specimen should be undivided—the entire bolide as it existed in space. It is unnecessary to tell how, from the inherent conditions of the subject, this in actuality cannot be. By far the greater number of the falls are accompanied by explosions of the mass in the air or by its breaking in reaching the earth. In the largest collections—as in the smaller ones—fully seven-tenths of the specimens are pieces taken from the larger masses, or are masses with smaller pieces taken from them. The exceptions are more commonly cases where several—sometimes many—bolides have fallen in the same meteoric shower. With these latter, the collector must accept them as they fell—large or small. Of pieces broken or cut from larger masses, the collector's desire will be to get a piece so large that it will show well all the features both of outer and of inner structure. A piece with surfaces of several square inches' superficies is none too large for this purpose. And with great masses of one or more feet in diameter, there is ever something additional to be seen. Furthermore, there is something imposing and impressive in the size itself of the Great Thunderbolt. A certain number of these great masses are cherished and placed prominently in the large collections which are fortunate in possessing them. Purely as a matter of scientific interest—setting aside the *entire* bolides—a

fragment of moderate size of either an iron or a stone meteorite will show its character fully. When these fragments are above one or two inches on a side, and one of the sides has an original surface or crust, it matters little from a rigidly scientific point of view whether they are of said size or are twice or thrice as large.

But often, when a very rare meteorite is under consideration, only a very small fragment—perhaps only five or ten grammes, or even less—is obtainable. Such fragments, though insignificant in appearance, have still a very material value, showing at least the color and petrographic character of the meteorite. No collection can despise or omit to give place to such specimens. The Royal Museum of Vienna has recorded in its catalogue twenty-seven meteorites weighing one gramme each, and sixty-four specimens weighing five grammes or under. The British Museum has fifty-two kinds weighing not over five grammes each. It may be given as a negative factor of value of a meteorite collection, that it contains few very small bits. Yet to omit these altogether would take important material from a collection.

It merits notice that the larger the meteorite collection the greater will be the number of these small specimens. Their scientific value is acknowledged, their minuteness is a feature which is unavoidable. Octibbeha is a siderite with a most exceptional quantity (62 per cent.) of nickel in its composition, and furthermore, is prehistoric. Small pieces (one or two grammes) of this may be obtained with much difficulty and expense. But a hundred thousand dollars would not supply a two-ounce piece. We will not omit Octibbeha because it must appear as a minute specimen.

Finally, while *small* specimens—of a very few grammes—are often an index of the especial wealth of a meteorite collection, there may be, and are, many cases where many score of kinds are represented by these fragments, when with time much larger pieces of the same fall would be attainable.

For all these reasons it is correct to consider the *average weight* of the specimens as an important factor in the value of a meteorite collection.

But it often happens that a collection may possess a few pieces of very large size, several hundred pounds in weight. To relieve the estimate of this highly vitiating feature in computing average weight, we would limit the estimate *so as to include only fifty pounds—say, twenty-five kilograms—of any one meteorite kind.*

N. B.—It is, of course, to be remembered that after a collection of meteorites passes the number of three hundred or three hundred and fifty kinds, every added kind will—in almost every case—materially reduce the average weight of the pieces forming the whole collection. Here an excellence in one factor will be the deterioration of another.

THE PROPORTION OF SPECIMENS OF INTEREST IN THE GROWTH OF THE SCIENCE—ALSO TYPE SPECIMENS.

In a collection of material representing any subject, there will be some objects which mark points where new views of the subject had their birth. With meteorites this has been a specimen showing a crust, another showing pittings, another orientation, another chondri, another Widmanstätten figures, another new mineral combinations, another alteration of structure by the addition or the substitution of an element of its composition or by the apparent conditions of its origin.

With the observing of each of these features has come an added growth in the science itself. Hence the value of these growth-registering specimens. The number of these is not large, and they are distributed in many collections. There they exist as *type-specimens* of high interest and value.

THE PROPORTION OF SPECIMENS SHOWING LEADING POINTS IN METEORITE CLASSIFICATION, EITHER CHEMICAL OR PETROGRAPHICAL.

The former factor noted features which were discovered *seriatim* and progressively. The present one results more from close study at a later period of large series of specimens. In this many divisions are formed, each one based upon a specimen of a definite composition or an especial structure, which thus becomes a *type* of its kind. Again, a specimen newly studied comes to modify or to destroy a plan of classification previously adopted. In all this, as in the preceding division, the original specimens have the very highest value as type specimens, to be forever preserved and referred to as controlling types.

Two great collections—Vienna and Paris—possess these in the main, and thus far they are unapproachable by others. Vienna, from Partsch's first essay of classification in 1862 to the present day, has built taxonomical structures; the last of these—that of Brezina, 1904—being composed of 74 groups. Paris classifications were led by Daubree in 1867. Meunier has been more prolific—with

62 groups. A representation, so far as possible, of *each one of these groups* is, for evident reasons, a desirable feature in any collection.

N. B.—It is interesting to notice that all of Brezina's 42 groups of aerolites contain at least one stone *seen to fall*.

The same is also true of Meunier's 28 aerolite types.

THE PROPORTION OF SPECIMENS OF GREAT RARITY—USUALLY THE MASS SMALL AT THE OUTSET.

This is a factor whose merit is evident. Rare specimens of any natural object are ever valued. But there are still several kinds of rarity, one higher than another in value.

1. There are a very limited number of meteorites which are represented by only a single specimen, and that a small one. The chance of this specimen ever being cut into and distributed is very small indeed. These are and will remain *uniques*. There are a few —hardly more than a score—of these ; Paris, London and Vienna have the greater part. In other instances the small original has been divided into but three or four individuals, which have gone into as many different collections, and will stay there undisturbed. In some cases the individual mass was large ; but it has been lost, and there are but small fractions—and these, small pieces—existing in collections. All the above are practically unattainable by other than the favored collection possessing them, and then they confer very especial merit on that collection. As a rule, only the very largest public collections possess specimens of this category of merit.

2. There is another kind of rarity less interesting to consider. This is where there was a large mass at the outset—enough to supply all collections. But it has been the policy of the museum or of the amateur collector into whose hand this mass came, to hoard it, refusing its distribution. In this case the meteorite is artificially rare, and the collection has attained an increased value by the selfish course pursued.

The proportion in any collection of meteorites possessing either of these two classes of rarity gives that collection signal value. The size and weight of such specimens is an important item in the valuation.

THE COMPLETENESS OF ORIGINAL EXTERIOR STRUCTURE, WITH CRUST, PITTING, ORIENTATION, ETC.

While nearly every meteorite—whether iron or stone—shows itself clearly to be a fragment torn originally from a larger mass, it is often of interest to have that mass just as it reached our earth,

bearing all the features which it acquired by the way, however trivial some of these may be. It seems to be more a unit, and that we have everything which it ever taught. This feeling, which is very often an exaggerated one, has some moiety of merit. It is certainly a distinct loss when the surface has been rudely marred or chipped here and there. The presence of a crust over a stone tells by its density the fusibility of the rock and suggests the duration of its passing through our air. The pittings and furrowings also tell of its experience in transit, while these and thread-like flows of metal matter tell of the orientation or line of travel of the mass. It is true that some small broken surface is most essential and desirable as showing its inner structure, unaffected by external treatment. But a piece of an aerolite showing only the inner structure with none of the imposed crust, is clearly incomplete. Often this must be—particularly in small fragments—but the possession of an area of original surface adds great value.

SPECIMENS OF HISTORICAL OR TRADITIONAL VALUE.

A great point of interest in a collection of any class of objects, is that it possesses objects which are connected with events—usually of distant date—which are of historical or traditional value. Instances of this as touching books, paintings, statuary, armors, dress, furniture, etc., are too evident to require any examples. Among meteorites—comparatively few as are the number of kinds —there are still some which have this merit. Elbogen, the Pallas Iron and Ensisheim each are notable in the history of an early province, of travel, and of war, as well as being each the oldest preserved of its class. Barbotan and Tabor tell of early incredulity; L'Aigle, of incredulity dispelled. Medwedewa, Campo del Cielo, Rasgata, and Toluca tell of the early distant voyages of Pallas, Rubin de Celsis, Bosingault and Humboldt. The Cape York meteorites (Anighito, etc.) told us first by Ross and later much more fully by Peary of the use of a heaven-born iron by a tribe of polar people. Red River and Weston first pointedly called American attention to meteorites. San Gregorio (El Morito) and Zacatecas first awoke Mexican attention. Casas Grandes, mummied in a cave of Chihuahua, and Charcas, before an old temple in San Louis Potosi, are instances of early worship of meteorites by aboriginal Mexicans. Iron Creek, on a hill of British America, Anderson and Octibbeha, in prehistoric graves in our Western and Southern states, the Kaaba in Mecca and Kesen in Japan, all these meteorites and a few

others are instances of man's wonder at Nature's display of the apparently supernatural. They give character to the collection in which they are found.

THE PROPORTION OF OLD FALLS IN THE COLLECTION.

These, whether historical or not, whether or not of any especial scientific value, have still the well recognized merit of age. They are, in their sentimental character, like old books. But unlike these, they have nothing in their structure, composition, or other features, to differentiate them from the falls of to-day. There are about 35 of these in collections whose fall antedates the 19th century; two of them include Elbogen and Ensisheim—in the 14th century. We enumerate them in foot-note.*

The list, of course, takes no note of the much greater number of those which have been *found* even in the last 50 years, of which some at least may be older of date of fall than any dates which we have preserved. Indeed, there are five (Octibbeha, Anderson, Till Porter, Casas Grandes and Lujan) which are prehistoric,—the last, in fact, of geologic (Pliocene) age.

These old falls in our collections have not only the sentimental value of age, but by reason of time elapsed having brought their division and distribution, they are of greater intrinsic value. Few old aerolites are in *large pieces* to-day.

THE EXTENT TO WHICH THE SPECIMENS HAVE BEEN TREATED BY CUTTING, POLISHING, ETCHING, ETC., TO SHOW THEIR INNER STRUCTURE, AS ALSO TO PRESERVE THE MASS.

It is evidently a point of prime merit that a meteorite collection should possess sizeable pieces of all available falls. This is a basic, fundamental factor of value. But just as the value of a specimen is increased by a label telling of its name, locality, etc., so any treatment of the specimen which tells more about it than it shows in its natural state, is an enhancing of its value. A small cut surface of a stone meteorite will when polished show the structure of the mass, whether homogenous or heterogenous in composition—whether brecciated, fragmentary, chondritic, granular, compact or crystaline; also whether it has veins, fissures or

* Meteorites fallen or found prior to 1800, and now preserved: Elbogen, 1400 (?); Ensisheim, 1492; La Caille, 1600 (?); Morito, 1619; Tucson, 1650; Vago, 1668; Schellin, 1715; Ploschkowitz, 1723; Ogi (Hizen), 1744; Medwedewa, 1749; Hraschina, 1751; Steinbach, 1751; Luponnas, 1753; Tabor, 1755; Senegal, 1763; Alboreto, 1766; Luce, 1768; Mauerkirchen, 1768; Sena, 1773; Descubridora, 1780; Campo del Cielo, 1783; Bendego, 1784; Toluca, 1784; Adargas, 1784; Eichstädt, 1785; Charkow, 1787; Barbotan, 1790; Zacatecas, 1792; Cape of Good Hope, 1793; Sienna, 1794; Wold Cottage, 1795; Bjelaja-Zerkow, 1796; Pranbanan, 1797; Salles, 1798; Benares, 1798.

inclusions. The irons, too, when cut, polished and etched first reveal all the many teachings of their inner part. The Widmanstätten figures—present in four-fifths of them—tell many genetic stories, besides serving as a certain index of identification of the fall. Gustave Rose, the great chemist, while director of the Royal Prussian collection of meteorites, announced to the Berlin Academy in 1865, "I have caused the whole series of stone and of iron meteorites to be cut and the latter (the irons) to be etched, because only thus can there be obtained an insight to the composition of the first and structure of the latter."

There is an immense amount of work involved in this preparation of a meteorite collection—incidentally, too, in the preparation of its siderites so that they shall not rust when exposed to damp atmosphere.

A collection thus enhanced and conserved has a great added factor of value.

THE BROAD GEOGRAPHICAL DISTRIBUTION OF THE SPECIMENS.

While the rapid revolution of our globe, and its fleet flight through space prevents any constancy of external action upon any single part of it, the possession in a collection of meteorite specimens from wide-spread localities is still a point of great interest. The showing of the absolute lack of regularity of distribution, and of all things relating thereto, is a negative teaching which it is interesting and valuable to have manifest in the collection. The similarity of three irons falling respectively in Arabia, Australia, and in Kansas, or the difference in two others falling in the same county of one of our states, is a matter of the highest interest and value to record. Only a great collection can possess this merit. Wide distribution of the sources of the specimens is thus an important factor of value.

ALL SIDERITES OR SIDEROLITES EVER SEEN TO FALL.

Of the 334 aerolites known to science, all but 41 have been seen to fall. The fall having been seen, thus loses its nature of novelty or peculiarity by its frequency. Their frequence leads us to more readily accept those which are simply *found*, long years or centuries after they fell. Furthermore, their structure and their material gave some apparently plausible ground to the idea, which was formerly frequently advanced, that they are a segregation of material in the air or in space.

With irons such a theory seems less plausible, while their general similarity to terrestrial iron has led their cosmical character to be more often doubted. Thus it is a matter of the greatest satisfaction that a few irons have been seen to fall—their fall well attested. These are 10 in number, the first being Hraschina (Agram), Hungary, in 1751, and the last N'Goureyma in the Sudan, Africa, in 1900. It is interesting to note that these 10 irons belong to no less than 5 out of the 23 groups of known siderites, thus authenticating, as it were, nearly one-quarter of all. These fall-seen siderites have ever been sought for in collections. The same interest attaches itself to the 4 siderolites (Barea, Estherville, Marjalahti, and Veramin) which—out of a total in the group of 29—have been seen to fall.

It is evident from the above that the factors of value in a large meteorite collection are numerous and of very different degrees of value; also, that they so link with and control each other that the value of certain ones depends upon the value possessed by certain others. Thus, for instance, if a collection is small—say of 200 or 250 kinds only—its size will become of less account as a factor of excellence than would be the fact of its having a great proportion of rare specimens, or of those showing leading points of classification. In this case, too, the extent to which specimens have been prepared for study (factor 9) will become of more account than will factor 7—the proportion of specimens of traditional or historical value.

The writer has had in mind in expression of relative values of factors of excellence the consideration of *a collection of the greatest size.* In this case the factor of number of kinds is given the leading place (factor 1) for the reason that it almost surely and of necessity *includes all the other factors.* And thus factor 2—the average weights and sizes of the individual specimens—becomes, as it otherwise surely would not, the second condition of value of the collection.

It is evident that different persons will have different judgments as to the relative points of value in the different factors which have been given, according to their own views, and possibly according to their success of management of their own collection.

Further elucidation of this subject by others would be of great interest and advantage to all who are interested in this restricted, yet at the same time broad, subject.