ART. VIII.—OUR MUSEUM METEORITES, *et caetera.*—BY REV. D. HONEYMAN, D. C. L., F. R. S. C., F. S. SC., *Hon. Mem. Geologists' Association London, &c.*

Read May 14, 1888.

Of these mysterious and interesting bodies, we have examples: I. Victorian. II. Bolivian.

At the Great London Exhibition 1862, in front of the Department of Victoria, Australia, a great mass of meteoric iron lay. I passed it almost daily during seven months. It became very familiar. It was found at Ballarat. The authorities of the British Museum purchased it.

On a counter in the same department lay another small one with a pair of horse shoes made from a part of it. This was exhibited by Sir Henry Barklay, the Governor. We have two pieces of its crust.

These meteorites come into Daubrée's 1st division, 2nd subdivision of 1866.

Towards the close of the Exhibition, Prof. Sheppard, of New Haven, Conn., U. S. A., came to London with a collection of meteorites. I examined these at Prof. Tennant's, Strand, W. C. The latter purchased one; giving for it an equal weight of silver coin.

At L' Exposition Universelle de Paris, 1867, I became acquainted with M. Daubreé, and his work on meteorites. I also found an account of his experiments and results in " Bulletin de La Société Geologique de France 1866." On my way home I visited the British Museum, where Prof. Maskeleyne showed me a very large meteorite which was falling in pieces, although every effort was made to arrest decomposition. This seems to be an American meteorite.

At the Centennial Exhibition, Philadelphia, 1876, I had another opportunity of seeing other meteorites. In the Canadian Mineral department, in front of my office, was placed the Madoc meteorite. It is thus described in "Geology of Canada 1863." "It was found in 1854 upon the surface of a field and weighed 370 lbs. Its shape is rudely rectangular and flattened on one side. The surface is irregularly pitted, as is generally the case with meteoric masses, and coated with a film of oxide of iron. This iron is malleable and highly crystalline in texture, and when etched by an acid exhibits beautifully the peculiar markings which are known as the Widmanstættian figures. Its analysis shows it to be an alloy of iron with 6.35 per cent of nickel. Small portions of the phosphuret of nickel and iron are disseminated through the iron and in making a section of it rounded masses of magnetic iron pyrites are met with."

In the United States Government building were the Smithsonian collections. Here was a fine display of meteorites. A ring-shaped one was the most remarkable, and not readily to be forgotten. This is called the Tucson meteorite. The greatest diameter is 49 inches. Its weight is 14 cwt.

Our second Museum specimen differs from all these, as far as I can remember. It is from Atacama, Bolivia, South America. The late H. B. Bland, Esq., Hill-fields, Berks, kindly presented it. It is a fine specimen; its size is 3 x 2½ x 1½ inches; its weight 1 lb. 580 grs. It belongs to the 2nd sub-division of Daubrée, 1st division of which the Pallas meteorite is the type.

Mr. Kuntz, of New York, has kindly given me a series of beautifully illustrated and instructive memoirs on meteorites.

In *one*, "On two new meteorites from Carroll County, Kentucky, and Catorze, Mexico," we read: "The mass is largely made up of fine yellow transparent olivine, resembling closely that of the famous Pallas iron. This meteorite belongs to the Siderolites or Syssidiéres of Daubreé."

This is compared with the meteorites of Atacama, such as our Museum specimen.

"Their specific gravity is 4.33.

"Taking the specific gravity of iron as 7.6, and that of olivine as 3.3, these meteorities consist of about three parts of olivine and one part of iron."

Olivine and iron are the obvious constituents of our own specimen.

Analysis of these meteorites:

Olivine sp. gr. 3.3

Si O	36.92
Fe O	17.21
$Mn_2 O_3$	1.89
Mg O	43 90

Schmid-Pogg Ann 87.501

IRON.

Fe	88.01
Ni	10.25
P	0.33
Na	0.21
K	0.15

Buchner Die Meteoriten Giessen, 1859.

Mr. Kuntz, in another memoir, "On the meteorites of Glorietta Mountain, Santa Fe Co., New Mexico," observes: "This iron is of the 'Holosiderites' of Daubreé, and comes under the general group of 'Caillite' of Stanislaus Meunier (type meteorite of Caille, Var). It is related to the iron of Augusta County, Virginia; Whitfield, Georgia, and Washington County, Wisconsin. It is of characteristic octohedral structure, and the Widmanstættian figures are made of *kamacite*, i. e., iron with a little nickel enveloped in *taenite*, i. e, iron rich in nickel and plessite. Olivine was observed at the upper end of fragment No. 1. The meteorite had been broken into seven fragments." A plate of this from an electrotype of the etched surface shows the characteristic Widmanstættian figures in great beauty.

In *another:* "On the Waldron Ridge, Tennessee, Meteorite," he observes: "This iron is of the Caillite group of Meunier. *Schreibersite* is a constituent, also *Troilite,* as well as *graphite,* clearly suggesting that the iron is identical with that of the Greenbrier County mass in the British Museum." This has already been referred to.

In *another:* "On Chatooga County, Georgia, Meteorite," he observes: "This, too, is of the 'Caillite group' of Meunier. Part of it was worked into a horse shoe, nails and other forms, by the local blacksmith."

Yet *another:* "On Taney County Meteorite, Mo:" "This is one of the 'Syssidieres' of Daubreé. Two large crystals of olivine are present."

Before proceeding farther, I would observe that the announcement of Professor Macgregor's lecture, delivered before our Institute at the March meeting, "On Lockyer's Spectroscopic investigation of Meteorites," directed special attention to "Our Museum Meteorites." I had intended to show them as illustrations, but was prevented by indisposition. Subsequently, Mr. Kuntz's Memoirs, in their allusion to the Atacama Meteorites, led me to examine my specimens with new interest. Their frequent allusion to Daubreé reminded me of the Bulletin de la Société Geologique de France and Daubreé's 'Communications.' Referring to this Journal I found, in that of 1866, page 391, one of which this is the title (translated), "Synthetic experiments relative to Meteorites. High-probabilities *(rapprochements),* to which these experiments lead, as well for the formation of these planetary bodies as for that of the terrestrial globe: By Daubreé." As far as I can learn from the report of Prof. Macgregor's lecture, Daubreé's investigations seem to be *very much akin* to those of Mr. Lockyer. I consider, therefore, that I am doing some service in submitting to the Institute a translation of the salient points of Daubreé's paper, with an occasional illustration from our local investigations.

Daubreé observes: "Already, for a long time, we could not doubt that among the matters that fall from the atmosphere on the surface of our globe, they (the Meteorites) are in origin incontestably foreign to the planet which we inhabit. Their fall is recognized by the considerable production of light and of noise which accompanies it, by the trajectory almost horizontal which they describe, and by the excessive speed with which they are animated,—a velocity which has not its analogue on earth, and which we can only compare with that of the planets gravitating.

in their orbits. Whatever may be the region whence these masses proceed, they constitute the only tangible products which reach us of celestial bodies. Anyone can comprehend the interest that their study presents, not only for Astronomy, but also for Geology, who thus sees the horizons of these to be enlarged, and who draws a comparison between these bodies from a distance with our globe of 'useful information' *(d'utiles renseignements)* on the mode of the formation of the latter and of our planetary system, as I shall try to demonstrate.

It seems to me that the time has arrived for confirming by synthetic experiments the numerous notions, that analysis has furnished, on the constitution of meteorites.

Permit me to hope that experimental synthesis will not render less service in this study than in that of the earth's rocks and minerals.

Before entering on this subject I would state very briefly—

That the various Meteorites known arrange themselves into two grand divisions: the irons *(fers)* and the stones *(pierres)*
The Irons:

I. Of the *first* we have established *three* divisions.

1. Iron with a mixture of stony matter (Meteorite of Caille, Var.)

2. Iron containing globules of *peridote* (Fer de Pallas.)

3. Iron associated with the Silicates *peridote* (olivine) and *pyroxene* (augite), (Sierra de Chaco.)

The last establishes a connection between the *two grand divisions* established, between the extremes—in appearance so different.

II. The *stones*, for the most part, do not contain native iron except in small grains, and disseminated in the Silicates principally with a base of magnesia and of protoxide of iron, of which the peridote forms in general a great part. It is this group that we designate here, by reason of its extreme frequence, under the name of the "common type."

The other stony Meteorites which do not contain native iron can be referred to three principal groups:—

1st. In the one, the magnesian silicates predominate. On the one hand, peridot may constitute almost the whole mass (Chassigny); on the other, a silicate less basic may predominate (Bischopville.)

2nd. Another group without peridot, poor in magnesia, containing alumina in notable quantity, is characterized by a granular anorthite and pyroxene, and by its analogy with certain lavas (Jovinas, Jonzac, Stannern.)

3. The last type is characterized in a very remarkable manner by the presence of carbonaceous matter (Alais, Orgueil).

I. Synthetic experiments relative to meteorites.

THE WIDMANSTÆTTIAN FIGURES.

" The most characteristic physical feature of the meteoric iron is the crystaline structure which appears on a surface that has been polished and then treated with an acid," e.g., the Madoc meteorite of Canada and the Glorietta mountain meteorite.

" The regular design which then appears has been named after the *Savant* who first recognized them. Since then the structure has been the subject of profound observation by Haidinger, Reichenbach and Gustave Rose.

The figures are produced not only by crystallization but also by the homogeneity of the mass and by the separation mode of a substance not so easily acted on by acids as iron. The substance so disseminated in the middle of the iron is considered to be the phosphuret of iron and nickel, with the first predominating.

Up to the present we have not been able to imitate this remarkable structure.

In trying to reproduce it I have melted the meteoric iron of Caille, Var., &c.

The chemical analyses have been made by M. Stanislaus Meunier attaché to the Geological Laboratory of the museum of the Ecole des Mines, to whom I have the pleasurse of rendering justice for the care which he has brought to their execution.

PERIDOT OR OLIVINE.

" Stromeyer has marked a singular contrast that the composition of this mineral presents. The terrestrial almost all contain a little nickel but the peridots of the meteoric iron like that of Siberia and Atacama do not contain it, although they are enveloped in one mass of iron, where the nickel enters in the proportion of 6 to 10 per cent.

Note.—I have frequently directed the attention of the Institute to the terrestrial olivines. 1st. In my Polariscopic investigations (Trans., vol. vi., pp. 122–3) I noticed—for the first time—olivine, in a section of our Blomidon basalt (dolerite). I also showed it abounding in pieces of a large basaltic boulder. This was examined macroscopically, and also microscopically in a section similar to that of Blomidon, prepared for me by A. Julien, N. Y. 2nd. Subsequently it has been referred to frequently in my Papers "On Glacial Geology" (Trans.) as occurring in similar boulders on the Bedford Basin and in the Halifax Peninsula, such as on the Citadel Hill and other strategic glacial accumulations, noticed in my Paper "On the Glacial Period on the East Coast of Canada," read before the Victoria Institute, London, April 8th. In some of these boulders the green of the olivine appears very abundant and distinct on the weathered outside, which is generally red in consequence of the decomposition of the abounding *magnetite,* associated with the *augite* (pyroxene) and *labradorite.*

Temperature.

"The operations of which I am going to render an account have been made with a temperature near the melting point of platina." *Vide Comm.*

II. Conclusions relative to the mode of formation of the planetary bodies, whence the meteorites proceed.

It is necessary, first of all, to remark that we do not here seek the cause which brings the meteorites to our globe. It is our object to illustrate their mode of formation as far as the difficulty of the subject permits.

The meteorites reach us on the surface of the earth with a form, in general, that of polyhedrons with the angles blunted. They appear only to be pieces detached from masses of greater or less size, which after entering our atmosphere retreated, when a sort of *ricochet* was possible. *Note.*—The fall of May 14th, 1864, of Argeuil. Tarn et Garonne appears to furnish an example of this sort of trajectory as I have shown. *Compt. rend.* Sceance du May, 1864, vol. lviii., p. 177.

"These wandering masses could themselves be only fragments of planetary bodies, shattered at epochs undetermined and perhaps extremely remote.

Be it as it may with the preceding suppositions, it appears certain that these masses, when circulating in space, do not at all possess an elevated temperature. By their entering into our atmosphere they acquire a sudden incandescence, which, without doubt, makes them break in pieces, but which, in wholly vitrifying their surface, does not at all modify the interior of the pieces. This, then, represents the state of the mass such as it was in space and up to a certain point, and consequently the state of the planetary bodies, of which these fragments are specimens.

To study these specimens in a profound manner, is, then, to prepare certain landmarks *(jalons)*, so full of interest, of the history of these planetary bodies.

III. Conclusions relative to the mode of formation of the terrestrial globe. The terrestrial rocks which are analogous to the meteorites, are eruptive masses of a basic nature, e. g., basalts, which have come from depths *inferior* to the granites.

Importance of the magnesian rocks of the "peridot type" as well, in the terrestrial globe as in our planetary system.

Among the basic silicates, there is one which presents itself with a remarkable constancy in almost all the variety of meteorites from *lefers* to *lepierres* properly so called, i. e., peridot. It is seldom alone (Chassigny); ordinarily it is mixed with silicates, more acid often in parts undiscernible." *Note.*—In more than 150 falls represented in the collections examined we have only four which belong to the "aluminous type" as Jovinas, Jonzac, Stannern and Petersburg, U. S., the others are magnesian meteorites, which almost all include peridot."

On the other hand, the peridot necessarily exists in the depths of our globe. Indeed, the basalts of countries the most distant carry fragments (?) of it, often angular, and, as one would say, derived from a mass profound and pre-existent: *e. g.*, Nova Scotian Basalts already referred to.

"There are other pyroxenic rocks where peridot abounds, *e. g.*, in the dolerites of Montarville and Montreal, Canada. M. Hochstetter has recently recognized it in considerable mass and called it "*Dunite*." NOTE.—We would add the Peridotic rocks in the diamond mines of South Africa.

"Transformation of Serpentine or Lherzolyte, or, in Peridot, theoretic consequences. *Vide Comm.*"

Note.—Subsequent to this, in 1869, I examined what I now call the Archæan series of rocks at Arisaig, N. S. These had *previously* been regarded as igneous rocks of uncertain (Devonian) age. While engaged in the geological survey under the direction of Sir W. E. Logan, I found they were altogether different from what we had supposed them to be. I recognized in them rocks corresponding with the Laurentian rocks as represented in the beautiful series of specimens exhibited by the geological survey in the Canadian Department of the late Paris Exhibition (1867). At Arisaig I found crystalline limestones, Ophites, Ophicalcites, Hornblendic rocks, Diorites, Syenites, &c. Sir W. E. Logan considered that my specimens corresponded with his Quebec series. Dr. T. S. Hunt agreed with me in regarding them as Laurentian. Dana, in his Manual, 2nd edition, applied the term Archæan to this series

In 1878 I adopted this term, and have invariably applied it since then to this typical series and corresponding rocks. Trans. Ins.

Application of what proceeds to the mode of formation of our globe. Origin of peridot as a "scorie universelle," like a *metallurgic*, not volcanic scoria.

Absence in the meteorites of stratified rocks and granite.

The meteorites so analagous to certain rocks of ours differ considerably from the greater part of those which form the earth's crust.

The most important difference consists, in that we do not find in the meteorites anything that resembles the constituent material of stratified rocks—*e. g.*, neither arenaceous rocks nor fossiliferous rocks; that is to say, nothing which recalls the action of an ocean on these bodies, no more than the presence of life.

A grand difference reveals itself even when we compare the meteorites with the terrestrial rocks *not* stratified. We never find in the meteorites either granites or gneiss, or any of the rocks of the same family (the Archæan), which form with these the general bed upon which the stratified rocks repose. We do not even see any of the constituent minerals of the granitic rocks—orthoclose, mica or quartz—no more than the tourmaline and the other silicates which are accidental to those rocks.

So the silicate rocks which form the envelope of our globe are wanting among the meteorites. It is only to the profound regions that we must go to find the analogues of the latter—that is to say, in the basic silicate rocks which do not reach us except by eruptions, which make them come forth from their initial abode.

This contrast shows how just and profound is the division of the Silicate rocks into *acid* and *basic*, which M. Elie de Beaumont has established in his memorable work "On the emanations, volcanic and metalliferous."

At all events the absence in the meteorites of all the series of rocks which form a thickness so important of the terrestrial globe, whatever may be the cause, is a thing altogether remarkable.

This absence can be explained in different ways. It may be that the meteoric fragments which reach us only come from the interior part of the planetary bodies, which may be constituted like our globe. It may be that these planetary bodies themselves fail in Silicate rocks, quartziferous or acid, as well as in the stratified rocks.

In this latter case, which is the more probable, they would have followed evolutions less complete than the planet which we inhabit, and it would be to the co-operation of the ocean that the earth would be indebted for the origin of her *granitic* rocks (Archæan) as she is indebted later for the *stratified* rocks.

One can conclude from the preceding that the oxygen so essential to organic nature would also play an important role in the formation of the planetary bodies.

We add, that without it we cannot at all conceive of an ocean or of those grand functions, superficial and profound, of which water is the cause.

We arrive, so as to touch the foundation of the History of our Globe, and to draw closer the bonds of relationship (already revealed by the similitude of composition) between the parts of our planetary system, of which it is given us to know the nature.

We present this as a very interesting article by a recognized authority on meteorites. It is to be borne in mind, that it is over 20 years since it was written. It is therefore possible that in some respects it may be subject to modification. From Mr. Kuntz's memoirs we observe changes in nomenclature, e. g. In that on the Glorietta mountain meteorites, we have the meteorites of Division 1 and 1st sub-division characterized as the Holosiderites of Daubreé and the "Caillites of Meunier." Our first museum specimen is of this kind. The Atacama meteorites are also characterized as the "Syssidieres of Daubreé." Our second museum specimen is of this class.

Our latest information regarding his operations is derived from Bulletin de la Société Géologique de France, July 1871.

M. de Chancourtois communicates a letter which he had addressed to M. Elie de Beaumont concerning the bombardment. In this he says: "The second *obus* fell on the night of the 12th, at 9 p. m. It penetrated into the room of M. Daubreé, Professor of Mineralogy, traversing the thick stone wall at the side of the window and settling itself, without bursting, on end, like a bottle, right under the table of the Professor, about 2½ metres from the opening of the wall. We have long known that the aërolites are chiefly formed of iron, other metals have been recognized, also sulphur and carbon, &c. Their composition has therefore much analogy with that of the *obus* (small bomb shell). Is it not then striking to see one of these artificial missiles (bolides) coming right to the seat of the eminent mineralogist, who in these times has made a specialty of the study of natural *bolides.*"