WALTER FLIGHT, D.Sc., F.R.S.

History of Meteorites, more especially dealing with the period from 1869 to 1883; comprising a description of all meteoric bodies that fell or were found during that period, and of the phenomena attending their descent, a description of their physical and chemical characters, or of their ingredient minerals, with a digest of the works dealing with meteors of an earlier date. **Illustrated by 7 full-page plates and 6 woodcuts.** Demy 8vo, cloth, pp. xii, 224 (pub 12s 6d *net*) Dulan, 1887

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A CHAPTER

IN

THE HISTORY OF METEORITES.

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IN THE

HISTORY OF METEORITES

BY THE LATE

WALTER FLIGHT, D.Sc. Lond., F.R.S.

WITH SEVEN PLATES AND SIX WOODCUTS.

[*Reprinted from the* Geological Magazine *with some additional Notes by the Author.*]

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UP.

PREFACE.

Of the arduous literary task undertaken by the author, only the first two divisions referred to on pages 1 and 2—namely, digests of the memoirs relating to meteorites published since 1868—are here presented to the student. The remaining divisions, including that which would have dealt with the methods which have been proposed for the chemical analysis of meteorites, and for the discussion of which Dr. Flight was so well qualified, were still unwritten at the time of his death.

The first 144 pages were printed off twelve years ago, after revision by the author himself, at a time when he looked forward to the speedy completion of the work: the proofs of the remainder have been read and arranged for press, and where needful have been compared with the original memoirs.

To facilitate reference to the Articles an Index to the names and synonyms of the meteorites has been added.

The Editors.

In Memoriam.

WALTER FLIGHT, D.Sc. (Lond.), F.R.S., F.G.S.

Walter Flight was the son of William P. Flight, of Winchester, in which city he was born on the 21st of January, 1841. He was sent, after a period of pupilage at home, to Queenwood College, Hampshire, in the days when George Edmondson was Head Master, and Tyndall and Debus were the teachers of science. Here he had the good fortune to attract the notice of Prof. Debus, who encouraged the youthful chemist, and in after years remained his constant friend.

From Queenwood Walter Flight went to the University of Halle, to pursue his scientific studies, and in the laboratory of Prof. Heintz he specially applied himself to the study of chemistry during the winter session of 1863–64.

In 1864 and 1865 he entered the University of Heidelberg, where, in the laboratories of the celebrated Professors Bunsen, Kopp, and Kirchhoff, he devoted himself earnestly to acquire that thorough knowledge of the various branches of theoretical and practical chemistry, and that marked facility for overcoming experimental difficulties, which characterize the practised and careful worker.

From Heidelberg Flight passed to the University of Berlin, where he remained until 1867, studying and working in Prof. Hofmann's laboratory, and for a time filling the office of his Secretary and Chemical Assistant.

Returning to England in 1867, he graduated D.Sc., in the University of London, and in the following year was appointed by the Senate to the office of Assistant-Examiner under Prof. Debus, F.R.S. (his former teacher at Queenwood).

On the 5th September, 1867, Dr. Flight was appointed an Assistant in the Mineralogical Department of the British Museum, where, under the direction of Professor Nevil Story Maskelyne, M.A., F.R.S., the Keeper of Mineralogy, he carried on a series of researches into the chemical composition of the mineral constituents of meteorites and the occluded gases they contained.

Many of the methods by which he carried out these investigations were originated by him in the course of his researches, and displayed in a remarkable degree his skill and ingenuity in chemical manipulation.

Shortly after this date he was appointed Examiner in Chemistry and Physics at the Royal Military Academy, Woolwich, and in 1876 Examiner to the Royal Military Academy, Cheltenham.

For several years Dr. Flight served on the "Luminous Meteors Committee" of the British Association, to which he gave much valuable assistance.

Between the years 1864 and 1883 he was author of numerous original papers; that relating to the Cranbourne, Rowton, and Middlesborough Meteorites appeared in the Philosophical Transactions: his researches were also referred to by Prof. Story Maskelyne in two papers on the mineral constituents of the Busti, Manegaum, and Breitenbach Meteorites, read before the Royal Society between 1870–71.

In January, 1875, he commenced to publish in the Geological Magazine a series of articles, entitled "A Chapter in the History of Meteorites," of which twelve appeared in that year; nine supplemental essays followed in 1882, and a final one in February, 1883. These articles form the substance of the present work, some slight additions only having been made by the author to the first part printed in 1875.

In 1880, Dr. Flight married Miss Kate Fell, daughter of Dr. Fell, of Ambleside.

He was elected a Fellow of the Royal Society on June 7th, 1883.

In 1884 he was seized by illness which prostrated his mental powers and rendered it needful for him to resign his appointment in the British Museum in June, 1885; but notwithstanding all that medical skill or the affection of friends could devise, he succumbed on the 4th of November, 1885, leaving his widow and three young children to deplore his early loss.

Dr. Flight enjoyed the regard and esteem of a very large circle of scientific men, with many of whom he was on terms of intimate friendship. It is to these more especially that this little Book is dedicated as the last Memorial of a life full of promise, but all too early brought to an abrupt conclusion.

LIST OF PAPERS PUBLISHED BY DR. WALTER FLIGHT.

Ueber Darstellung und Zusammensetzung des jodsauren Kalks.—*Zeitschr. Gesammt. Naturwiss.* Halle, 1864.

Ueber die thermoelectrische Spannung verschiedener Mineralien. — *Ann. Chem. Pharm.* Bd. 135, and *Phil. Mag.* vol. 30, 1865.

On the Chemical Composition of a Coin of Bactria (copper-nickel alloy).—*Numismatic Chronicle*, vol. viii. p. 305, 1868; *Pogg. Ann.* Bd. 139, 1870.

[With Prof. N. S. Maskelyne.] Mineralogical Notices: No. 1, On the Formation of Basic Cupric Sulphates. 2, Opal from Waddela Plain, Abyssinia. 3, Francolite from Cornwall. 4, Epidote and Serpentine from Iona. 5, Vivianite. 6, Cronstedtite. 7, Pholerite.—*Journ. Chem. Soc.* vol. ix. 1871.

[With Prof. N. S. Maskelyne.] Mineralogical Notices continued: No. 8, Isopyre. 9, Percylite. 10, Vanadinite. 11, Uranite. 12, Analyses of some pisolitic iron ores from North Wales. 13, Prasine.—*Journ. Chem. Soc.* vol. x. 1872.

[With Prof. N. S. Maskelyne.] Ueber die Destillationsmethode zur Bestimmung Kieselsäure. Read before the *Naturforscherversammlung*, held at Wiesbaden, September, 1873.

[With Prof. N. S. Maskelyne.] Ueber die Farbe der Diamanten. Read before the *Naturforscherversammlung*, held at Wiesbaden, September, 1873.

[With Prof. N. S. Maskelyne.] Mineralogical Notices, continued: No. 14, Caledonite. 15, Lanarkite.—*Journ. Chem. Soc.* vol. xii. 1874.

[With Prof. N. S. Maskelyne.] On the Character of the Diamantiferous Rock of South Africa.—*Quart. Journ. Geol. Soc.* vol. 30, 1874.

[With Prof. N. S. Maskelyne.] On Andrewsite and Chalkosiderite.—*Journ. Chem. Soc.* vol. xiii. 1875.

An Examination of Methods for effecting the Quantitative Separation of Iron Sesquioxide, Alumina and Phosphoric Acid.—*Journ. Chem. Soc.* xiii. 1875.

Examination of two new Amalgams, and a Specimen of Native Gold.—*Phil. Mag.* vol. ix. 1880.

Contributions to our Knowledge of the Composition of Alloys and Metal-work, for the most part Ancient.—*Journ. Chem. Soc.* vol. xli. 1882.

On the Action of Sodium Hydrate and Carbonate on Feldspars and Wollastonite. —*Journ. Chem. Soc.* vol. xli. 1882.

Report of an Examination of the Meteorites of Cranbourne, in Australia; of Rowton in Shropshire; and of Middlesborough, in Yorkshire.—*Proceed. Roy. Soc. Lon.* vol. 33, 1882; *Phil. Trans. Roy. Soc.* vol. 3, 1883.

Two New Mineral Species, Evigtokite and Liskeardite.—*Journ. Chem. Soc.* vol. xliii. 1883.

Examination of the Meteorite which fell on the 16th February, 1883, at Alfianello, in the district of Verolannova, in the province of Brescia, Italy.—*Proc. Roy. Soc.* vol. 35, 1883.

[With Mr. George Murray.] Examination of Mr. A. Stephen Wilson's "Sclerotia" of Phytophthora infestans.—*Journ. of Botany*, 1883.

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HISTORY OF METEORITES.

FROM 1869—1875.

INTRODUCTION.

In submitting the following digest of what has been published on the subject of Meteorites since the beginning of 1869, it should be stated, to explain the selection of this period in particular, that up to that year the then numerous and scattered contributions to this question had been collected and published in the form of a most careful digest by Professor Rammelsberg, in his *Die Chemische Natur der Meteoriten*, 1870; further that Buchner's series of papers in *Poggendorff's Annalen* on *Die Meteoriten in Sammlungen*, had in many ways supplemented the work of Rammelsberg. But while, as to the period previous to 1869, we thus possess in a form most convenient for reference the substance of all the then known contributions to this subject, it appears that since that year there has been no continuation of this laborious work of collecting and examining scattered materials. And yet it cannot be said that such is unnecessary, for in this interval many important contributions have been made to this branch of mineralogical science; meteoric falls of great interest, as, for example, that at Hessle, in Sweden, have taken place; remarkable cosmical masses have been discovered, of which none are more curious than the colossal meteoric irons of Ovifak, in Greenland; and the presence of new meteoric minerals has been determined, such as the calcium sulphide of the Busti aerolite,[1] and the rhombic form of silicic acid in the Breitenbach siderolite. It has therefore become a matter of necessity that the work of Rammelsberg and Buchner should be continued, and this is the justification of the present attempt.

It is proposed to deal with the subject under the following four divisions:—

I. To present seriatim a description of all meteoric bodies that have been known to fall, or that may have been found, since the 1st January, 1869, with an account of all the important phenomena attending their descent, and a description of their physical and chemical characters, or those of their ingredient minerals as far as they have yet been determined. In the examination of the analyses, it will be shown that the hypothetical silicate shepardite, which at the present time is supposed by many mineralogists and geologists[2] to form a constituent of meteorites (although

[1] A preliminary note of this mineral appeared in the *Brit. Assoc. Report*, 1862, "Notices and Abstracts," Appendix ii., 190.

[2] In his address "Ueber die Entwickelung der Geologie in den letzten 50 Jahren," delivered before the German Naturalists' Association at Leipzig in 1872, Von Dechen alluded to shepardite (anderthalbfach kieselsaure Magnesia) as a characteristic meteoric mineral.

it has never been isolated), not only need not be assumed to be present, but that the analytical results of these observers indicate the presence in the aerolite of such silicates only as have on some occasion or other been observed to occur as distinct species in a meteorite.

II. To produce a digest of work published from 1869—1875 on meteorites which had fallen, or had been found, at an earlier date, giving such results as correct earlier analyses.

III. To prepare an exhaustive notice of papers published from 1869—1875 on meteorites:

(1). In their relations to astronomical questions; their probable orbits; the phenomena attending their fall; their distribution on the earth's surface; spectroscopic examination, etc.

(2). In respect to better methods of analysis; new catalogues of collections; and the bibliography of this branch of mineralogy.

IV. To examine cases of doubtful falls, pseudo-aerolites, etc., which have been placed on record during the above interval.

PART I.

1869, January 1st, 12h. 20m. p.m.—Hessle, near Upsala.[1]

This is the first meteoric fall recorded to have taken place in Sweden. The sky was cloudy, and, though apparently unobserved at Hessle, a luminous meteor was noticed by observers at a distance. The noise accompanying the fall resembled heavy peals of thunder, followed by a rattling noise as of waggons at a gallop, and ending at first with a note like an organ tone, and then a hissing sound. The stones were strewn over a line of country lying 30° E. of S. towards 30° W. of N. Some of them fell within a few yards of a number of peasants who were coming out of church; one struck the ice close to a man who was fishing on the Mälar Lårsta-Viken, and after digging a hole three or four inches deep, rebounded; when picked up, it was still warm.

The stones differ greatly in weight, from 2lbs. to 0·17 gramme (about $2\frac{1}{2}$ grains). The smallest have the same structure and thickness of crust as the largest, and are in fact small complete meteorites. Such diminutive stones have not hitherto been noticed, and should be sought for at future aerolitic falls.

The exterior of the stones is black; the interior bright grey, and sufficiently porous to cling to the tongue. Though the structure of

[1] O. Fahnehjelm. Meteorfallet i Fittja socken af Upsala län d. 1 Januari, 1869, *Oefversigt Vet. Akad. Förd.* 1869, No. 1, 59.—A. E. Nordenskjöld. *Kongl. Svenska. Vetensk. Akad. Handl.* viii. No. 9; *Pogg. Ann.* cxxi., 205.—G. Lindström. Kemisk Undersokning af Meteorstenarne från Hessle. *Kongl. Svenska Vetensk. Akad. Förd.*, 1869, No. 8.—K. A. Fredholm. Om Meteorstensfallet vid Hessle. Leipzig: Fritsch.—G. A. Daubrée. *Compt. rend.*, lxviii., 363.

these meteorites is so loose that they break in pieces when thrown with the hand against the floor or frozen ground, it is a remarkable fact that nearly all the specimens which have been collected fell intact, and some of the heavier stones which struck the ice of the Lårsta-Viken failed to penetrate it, although the thickness was only a few inches on New Year's Day. This explains in some degree the statements of eye-witnesses as to their remarkably small downward velocity.

In appearance they resemble very closely the meteorites of Aussun and Clarac, Haute Garonne (1858, December 9th). They have been examined by Nordenskjöld, who so arranges the results of his analyses that he finds them to be composed of: 20 per cent. nickel-iron (chamoisite, Fe_8Ni), with some schreibersite and rather less than one per cent. of chromite; a variable amount of troilite (iron mono-sulphide); a trace of carbon, probably in the form of a hydrocarbon; 10 per cent. of labradorite; 37 per cent. of olivine; and 23 per cent. of 'shepardite.'

Two great difficulties, however, are presented by this explanation of the constitution of the Hessle meteorites. It is not only assumed that a basic silicate, like olivine, and a sesquisilicate, or acid silicate, like 'shepardite,' exist in intimate association in the same rock-mass, but it necessitates the retention as a mineral species of this very 'shepardite' which the researches of Dr. L. Smith on the Bishopville stone have shown to be no other than a pure magnesian enstatite (MgO,SiO_2).

In the following table are given: under I. the oxygen ratios of the mean of the total constituents from three analyses, after the nickel-iron had been removed by mercury chloride in one case, and by the magnet in another; under II. the oxygen ratios of acid and bases of silicate broken up by acid; and under III. the difference between I. and II., or the oxygen ratios of acid and bases of silicate unaffected by acid.

	I. Total.	II. Soluble.		III. Insoluble.	
Silicic acid	26·45	10·78		15·67	
Iron protoxide	2·971	1·858	9·976	1·113	7·352
Magnesia	11·82	7·559		4·261	
Lime	0·748	0·219		0·529	
Alumina	1·431	0·03		1·401	
Soda	0·358	0·31		0·048	

In the soluble part the oxygen ratios do not widely differ from those of an olivine, while the atomic ratio of iron oxide to magnesia, nearly 1 to 4, is that observed in many meteoric olivines; among others those of the aerolites of Chantonnay, Oesel, and Richmond. From the fact that in Nordenskjöld's analysis the soluble portion was collected after the powdered mineral had been digested for a long time with warm concentrated acid, it is certain that some portion of any bronzite or enstatite that might be present would undergo decomposition, and this would explain the slight excess over 1 to 1 in the oxygen ratios of acid and total bases in the insoluble part. This insoluble portion, it will be seen, appears to be chiefly bronzite, and here again the ratio of the two metallic oxides, also about 1 to 4, is that of the bronzite of several meteorites, including among them the three mentioned above; and the Hessle meteorite is a fourth example, in both the olivine and bronzite of which the atomic ratio of iron oxide to magnesia is the same (1 : 4). The alumina has been regarded as a constituent of the bronzite, very few specimens of that mineral, whether terrestrial or meteoric, being quite free from this oxide; it could not be present as anorthite, since the chief amount is in the insoluble portion; nor could it be in the form of any other felspar, as the requisite alkali is not present.

The most remarkable feature of the Hessle shower is the association with the stones already described of other cosmical matter, chiefly composed of carbon. It was remarked by the peasants that some of the stones which fell on the ice near Arnö soon crumbled to a blackish-brown powder, which formed with the snow-water a mixture resembling coffee-grounds. Similar powder was found on the ice at Hafslaviken in masses as large as the hand, which floated like foam on water, and could not be held between the fingers. A small amount, secured for examination, was observed under the microscope to be composed of small spherical granules. It contained metallic particles extractible with the magnet, and, when ignited, burnt away, leaving a reddish-brown ash; heated in a tube, it gave a small amount of a brown liquid distillate. A specimen dried at 110° had the following composition:—

		Equivalent Ratios.
Carbon	51·6	4·3
Hydrogen	3·8	3·8
Oxygen (calculated)	15·7	0·98
Silicic acid	16·7	
Iron protoxide	8·4	
Magnesia	1·5	
Lime	0·8	
Soda, with trace of lithia	1·5	
	100·0	

The combustible constituent accompanying the stony matter in the above mixture appears to have the formula $nC_9H_8O_2$. The Hessle stones form a new member of the small class of carbonaceous meteorites, that is to say, such as contain carbon in the amorphous state, or combined with hydrogen and oxygen, or in both these conditions; it includes at present those which fell at Kaba, Cold Bokkeveldt, Alais, Orgueil, Goalpara, and others.

It was noticed that the stones found in the same district with the carbonaceous state were, as a rule, quite round, and covered on all sides with a black, dull, and often sponge-like, crust. The iron particles on the surface of the smaller stones were usually quite bright and unoxidized, as would be the case if the stone had been heated in a reducing atmosphere. Nordenskjöld believes that the carbon compound frequently, perhaps always, occurs in association with meteorites, and he attributes its preservation at Hessle to the fact of the stones having fallen on snow-covered ground.—The paper is illustrated by a map of the district, indicating the exact points where the larger masses descended.

1869, May 5th, 6.32 p.m.—Krähenberg, near Zweibrücken, Rhenish Bavaria.[1]

A single stone was seen to fall, the sky being clear and bright. The noise of the explosion is described as having been louder than that of a cannon; this was followed by one resembling a roll of musketry, terminating with a sound as of the rushing of steam from a locomotive; the tone of the last sound increased in pitch, and abruptly ended with another loud noise. Although no luminous phenomena were observed at Krähenberg, a meteor was seen at Bingen, Speyer, Neuweiler, in Alsace, and in other parts, which observers agree in describing as emitting an intensely white light; one witness, who saw it in the zenith, states that the light was bluish. The inclination of the path of the meteor to the horizon is computed to have been 32°. From observations, made independently by two witnesses, it appears that this meteor came from the point in the heavens, 82° North Polar Distance and 190° Right Ascension. In the *Atlas of Meteors* (British Association) there is given a radiant point (85° N.P.D. and 189° R.A.) for the epoch of 2nd April to 4th May, which is indicated as one of those that are "well-defined." It appears, then, to be highly probable that the Krähenberg meteorite, while traversing its cosmical path, belonged to the meteor shower, the radiant point of which lies near δ *Virginis*.

Vom Rath states that the stone fell from a small cloud. A little girl was within a few paces of the spot where it struck the earth, on the slope of a hill facing the S.E.; it entered the ground to a depth of from three to four feet, making a perfectly vertical hole. It was soon dug out, and when brought to the village was warm, but not hot.

The stone is of the form of a flattened spheroid, and weighed, when entire, about 33lbs. The crust is about 0·5 mm. thick, and though in most parts black, some portions possess the peculiarly reddish-brown colour noticed on the Pultusk stones. The specific gravity of the stone, free from crust, is 3·497; that of the crust is 3·449; as in the Pultusk meteorite, the crust is lighter than the body of the stone. A remarkable feature of the surface are the numerous furrow-like depressions, some 8 mm. deep, which often anastomose and radiate from the more even crown of the stone towards its periphery; they are confined to the more rounded side of the stone. A newly broken surface is light grey, and exhibits a net-work of fine black lines and veins of nickeliferous iron; in one place a little gangue of metal measured 3 inches in length and 0·3 to 0·5 mm. wide. This meteorite bears a great resemblance, both as regards the crust and internal structure, to those above alluded to, which fell at Pultusk, in Poland, on 30th January, 1868. Spherules are abundant; and other minerals

[1] O. Buchner. *Pogg. Ann.*, cxxxvii, 176.—G. vom Rath. *Pogg. Ann.*, cxxxvii., 328.—C. E. Weiss. *Pogg. Ann.*, cxxxvii., 617.—G. Neumayer. *Sitzber. Wien. Akad.*, lx., 229.—P. Reinsch. Lithographic "*Suite Mikroscopischer Praeparate*" of this Meteorite, issued March, 1872; and *Tageblatt* 45, *Versammlung der Naturforscher in Leipzig*, 1872, 132.

readily distinguishable are: olivine, magnetic pyrites, and chromite; the whole being inclosed in a "sphaerolithic" ground-mass of white and grey grains.

Nickel-iron, containing 15·3 per cent. of nickel, constitutes 3·5 per cent. of the stone, a less quantity than is found in the Pultusk meteorites; magnetic pyrites amounting to 5·52 per cent., a larger proportion than is met with in the Pultusk stones, occurs in grains, some 1 to 2 mm. wide. The dark-coloured spherules, the presence of which is a characteristic of chondritic meteorites, are more distinct and numerous than those of the Pultusk stone: some are 2 mm. wide, and are easily removed from the ground-mass. Yellowish-white grains, some 1 mm. wide, are abundant, and here and there are found grains of chromite, bearing octahedral faces.

Viewed in the microscope, the mass of the stone is made up of numberless small white crystalline granules, which give colour in polarized light; they are stated by Vom Rath to be unacted upon by acid, and to consist essentially of a magnesium silicate, richer in silica than olivine. Among other curious constituents detected by the microscope are: a very small purple-red crystal bearing faces; a number of bright-yellow granules in distinct crystals; some light-yellow long prism-like forms; and a few large granules 0·5 mm. across, of a translucent red mineral, exhibiting conchoidal fracture. So small a portion of the stone could be devoted to chemical examination that none of these substances, nor even the large spherules, could be separately analyzed. The analysis of the stone furnished, after the nickel-iron and magnetic pyrites have been deducted, the per-centage numbers of acid and bases, the oxygen ratios of which are 1 : 1·448, the ratio in the Pultusk stone being 1 : 1·507. The analogy in composition, in respect of each constituent, of two bodies from so widely separated regions of planetary space is very striking. Vom Rath expresses his belief that "the siliceous portion of this meteorite, and indeed of the Pultusk stone, is mainly composed of olivine and another, a magnesium, silicate richer in silicic acid; but whether it be enstatite or shepardite ($2MgO,3SiO_2$), or whether both silicates accompany the olivine, cannot, unfortunately, be determined."

Apart, however, from the doubts that are now entertained respecting the existence of the magnesium sesquisilicate of Rose as a mineral species, the analytical determinations of Vom Rath will not be found, on examination, to support the theory in question. In addition to the composition of the entire stone, which is to be found below (I.), he gives in his paper the amounts of each of the bases dissolved in acid during a sulphur determination (see II.).

	I. Total Silicates.	II. Bases dissolved	Oxygen.		III. Bases undissolved	Oxygen.	
Silicic acid ...	46·37						
Magnesia ...	27·13	11·7	4·68	9·55	15·43	6·17	6·92
Lime	2·15	0·56	0·16		1·59	0·45	
Iron protoxide...	22·56	21·2	4·71		1·36	0·30	
Alumina	0·67	0·14			0·53		
Loss (Soda ?) ...	1·12						
	100·00						

Assuming the bases dissolved to be those of an olivine, they would require 17·90 per cent. of silicic acid to form 51·36 per cent. of an olivine of the form FeO, MgO, SiO_2 (like that occurring in the meteorites of Chateau-Renard and Kakova), while the undissolved bases with 25·95 per cent. of silicic acid form 45·45 per cent. of a nearly pure magnesian enstatite. There now remain only 2·52 per cent. of silica, which, with the alumina, and what may possibly be potash, give oxygen ratios, pointing, with more accuracy than might be expected in so small a residue, to about 4 per cent. of what may be a felspar. This method of regarding the constitution of the meteorites of Krähenberg and Pultusk has the advantage of assuming the existence in these stones of such meteoric minerals only as have been isolated and clearly identified.—In an elaborate paper on the lithology of this meteorite, Weiss states that he detected the presence of three silicates, and by a careful study of a fresh surface of the stone, he finds that the grey silicate, which is probably enstatite, occurs in three distinct forms. This is a point of considerable interest, not only as tending to confirm the above calculations, but from the fact that three varieties of a nearly pure magnesian enstatite likewise occur in the Busti aerolite.

Reinsch has prepared eighteen microscopic slides of this meteorite, and made very effective pen-and-ink sketches of the more important of them. One shows a remarkable eroded spherule of iron; the evenly serrated surface is inclosed in a metallic shell, or rather net, so regular are the intervals at which this covering is broken through. Another exhibits spherules traversed by little dykes or veins of a mineral, which in one case is of a purple colour. Others show a beautiful blue mineral, which he suggests may be haüyne. He directs attention to the presence of magnetic pyrites and nickel-iron in the crust of the meteorite, and contends that, as these minerals would undergo change if exposed in air to a temperature at which the silicates forming the crust fuse, the meteorite must have been covered with a crust before it entered our atmosphere, and he ascribes the fusion to electrical agency, as seen in the perforated rocks (fulgurites?) of the Lesser Ararat, described by Abich.

1869, May 20th, 11.20 p.m.—Moriches, Long Island, Suffolk Co., New York.[1]

An unusually brilliant meteor was seen at New Haven, New York, Philadelphia, Hartford, and many other places. It appears to have moved, nearly horizontally, at an elevation of fifty miles, along a visible path of about 200 miles, and to have exploded over the Atlantic somewhat N. and E. of Boston. The time of flight is estimated at five seconds, which indicates a velocity of forty miles

[1] E. Loomis. *Amer. Jour. Sc.*, 1869, xlviii. 145.

per second. Three minutes after the passage of the meteor, "a terrific sound" was heard at Moriches, which shook the house of the observer to the very foundation. The angular diameter of the meteoric body is estimated to have been 30′, the distance from Moriches at the time of the explosion, thirty-nine or forty miles, the altitude twenty-eight miles, and the actual diameter 1843 feet. It recalls to mind the celebrated meteor of 1783, August 18th, 9·30 p.m., which traversed Europe from N.W. to S.E.[1]

1869, May 22nd, 10.5 p.m. Paris time (9.45 p.m. Vannes time).—Kernouve, 2 kilometres from Cléguérec, Arrondissement de Napoléonville, Morbihan, France.[2]

A meteor was seen moving in the direction from S. to N. It very soon burst, throwing off a number of greenish-white sparks, which almost immediately lost their brilliancy, and in two and a half or three minutes an explosion was heard. At Vannes, the very intense bluish-white light, which lasted for some seconds, resembled that of burning magnesium. The stone penetrated the soil of a meadow to the depth of one metre, and was quite covered by the loose earth thrown up by the shock; when exhumed it was broken up by the peasants. A young girl, distant only a few metres, was the sole witness of the fall; the leaves and ends of the branches of some trees close at hand bore marks of having been scorched. The stone, when perfect, probably weighed about 80 kilogrammes, and was of a conical form; the crust is of two kinds: an outer black enamel rugose and blistered, and an inner simple coat of glaze; in some places grains of iron projected through both crusts. The interior is a dark grey colour, and is very compact and granular. The iron is disseminated in very brilliant grains; here in veins some centimetres long, there in masses several millimetres in diameter. The magnetic pyrites (troilite?) occur but rarely in veins, sometimes in masses 3 centim. long, and 2 millim. broad. Occasionally grains of an enstatite or felspar are seen. In texture this stone bears a great resemblance to the aerolites of Pultusk (1868, January 30th). The density of the meteorite is 3·747; it gelatinizes with acid, giving off hydrogen-sulphide. Pisani states that the iron sulphide is not

[1] May 20th–22nd, appears at the present time to be a period during which meteoric falls may be looked for. During the last six years the following five falls have occurred:

1868, May 22nd,	Slavetic, Croatia.
1869, May 20th,	Moriches, New York.
1869, May 22nd,	Cléguérec, France.
1871, May 21st,	Searsmont, Maine.
1874, May 20th,	Virba, Turkey.

[2] De Limur. *Compt. rend.*, lxviii. 1338.—F. Pisani. *Compt. rend.*, lxviii. 1489.

attracted by the magnet; he has, however, given it in the form of magnetic pyrites in the following total composition of the stone:

Nickel-iron	20·50
Magnetic pyrites (?)	5·45
Dissolved silicate	34·60
Undissolved silicate	40·22
	100·77

The nickel-iron is composed of:

Iron = 92·44 Nickel = 7·56 = 100·00

and the silicates of:

	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	
A. *Soluble* ...	29·04	2·98	22·31	42·95	1·36	1·36	= 100·00
B. *Insoluble* ...	56·94	5·37	9·89	21·93	3·53	2·34	= 100·00

1869, September 19th, 9 p.m —Tjabé, near Pandangan, Bodgo-Négoro, in Residence Rembang, Java.[1]

A meteor, the brilliancy of which is stated to have surpassed that of the moon, was seen about nine in the evening to move in a north-easterly direction over the village of Tjabé. It was observed at Pandangan, the chief place of the district, as well as at Bodgo-Négoro, chief town of the division, lying east of Pandangan. At the same time a meteorite fell at Tjabé, at a distance of about twenty metres from the house of a native named Sokromo. The sound following the appearance of the meteor is described as an explosion, as loud as that of a cannon, followed by a noise resembling that caused by a carriage crossing a bridge; this lasted some time. The villagers sought in vain for the spot where the meteorite fell; at six o'clock next morning, however, it was found at the place already mentioned, at a depth of two feet in soil which had been hardened with a long drought. According to the report drawn up by the President of Rembang, it was remarked by the villagers that the aerolite, when found, was still so hot that it could not be touched with the hand. This statement, however, must be received with caution.

This stone, the only one found, weighed about 20 kilogrammes. It is covered with a dull greyish black crust, 0·5 mm. in thickness; the fresh fracture is dark grey, and exhibits a number of brilliant points: here and there brilliant plates 1 mm. square are met with, as well as a small number of very dark, almost black, grains of spherical form, with a diameter of about 2 mm. The mass of the stone is coarsely granular, and is so very hard that portions are only detached with a hammer with great difficulty.

The specific gravity of the metallic portion is 6·8; the magnet removed 14 per cent. constituents, which consist of two alloys of nickel-iron, containing respectively 6·2 and 12·5 per cent. of nickel; in one portion of the stone was found 6·17 per cent. of troilite. The density of the stone is 3·695.

[1] E. H. von Baumhauer. *Archives Néerlandaises*, vi. No. 4 (1871).—G. A. Daubrée. *Compt. rend.*, 1871, 16th December.

The analyses of the rocky portion yielded the following results :—

	SiO_2.	Al_2O_3.	FeO.	MnO.	MgO.	CaO.	Na_2O.	K_2O.	Chromite.	
A. *Soluble* ...	34·72	0·70	26·14	0·65	35·70	1·61	0·48	Trace	—	=100·00
B. *Insoluble*...	60·83	4·74	12·92	0·60	14·14	3·30	1·53	0·82	1·12	=100·00

The soluble siliceous portion, forming 45·94 per cent. of the non-metallic part of the aerolite, consists of an olivine in which the oxygen ratios of FeO and MgO are as 2 : 5. As in most analyses of meteorites, where the separation of the silicate of the form $2RO,SiO_2$ is attempted to be effected by means of acid, the silica in A, the soluble portion, is insufficient to form an olivine. The silica of B, the insoluble portion, on the other hand, is not only present in ample quantity, to make good what is wanting in A, and to supply the silicates of the form RO,SiO_2, but is in sufficient excess to lead Baumhauer to assume the presence of a bisilicate in the insoluble portion. If, however, the requisite amounts of silica be apportioned to the protoxides of iron, manganese, magnesium, and calcium of A and B, to form the respective silicates, there remain in the insoluble portion the following constituents, the oxygen ratios of which, as will be seen below, do not differ widely from those of an albite or orthoclase :

$$SiO_2 = 5·326 ; \; Al_2O = 1·13 ; \; K_2O = 0·16 ; \; Na_2O = 0·39.$$

Baumhauer traces a resemblance, in point of composition, between the aerolites of Tjabé and Mezö-Madaraz (1852, September 4th), by comparing his results with those published by Atkinson,[1] who analysed the latter stone in Wöhler's laboratory. About the time of the publication of this paper of Baumhauer's (1871), Rammelsberg[2] announced the result (see infra) of his examination of the Mezö-Madaraz stone, which differs very considerably from those arrived at in the earlier analysis ; where, in the insoluble portion of the Mezö-Madaraz stone, Atkinson found no iron protoxide, Rammelsberg finds 13·27 per cent. It will suffice in this place to mention that the later analysis of the Transylvanian aerolite does not indicate the presence of an excess of silica, and yields numbers which point to the presence of an olivine, like that found in the meteorites of Hainholz (1856) and Shergotty (1865, August 25th), and of a bronzite resembling that occurring in the aerolite of Chantonnay (1812, August 5th).

1869, October 6th, 11.40–45 a.m.—Stewart County, Georgia.[3]

When this stone fell, the sky was somewhat hazy, but there was no cloud. An observer at Bladen's Creek heard a roaring rushing sound in a north-westerly direction ; in a moment it appeared to be directly westward ; then a loud explosion, followed by six other

[1] E. Atkinson. *Jour. Prakt. Chem.*, 1856, 357. *Phil. Mag.* xi. 141.
[2] C. Rammelsberg. *Zeit. Deutsch. Geol. Gesellsch.*, 1871, 734.
[3] J. E. Willet and J. L. Smith. *Amer. Jour. Sc.* l. 335, and 339.

reports, occurred. After these explosions a peculiar whizzing sound was heard, produced apparently by some large irregular body moving rapidly away, while a smaller one passed to the south-west with such a noise as is caused by a flying fragment of a shell. This piece, it was found, descended about two miles and a half from the point where the explosion occurred; it weighs about 12½ ounces. Two men, who were looking in the direction of the explosions at the time they took place, state that they saw a quantity of vapour much like a volume of steam escaping from an engine-pipe, which was violently agitated, and increased in bulk after each report, but disappeared soon after the last of them. Some labourers close at hand saw directly after the explosions something like a thin cloud cast its shadow over the field in which they were. The stone, already alluded to, and which was seen to strike the ground by two negroes who happened to be at work about twenty paces distant, appears to have come from the north-west, at an angle of about 30° with the horizon; it passed to a depth of ten inches into the soil. It has an irregular, seven-sided form, the longest side being about 2¾ inches long, and is covered with a black crust. The specific gravity is 3·65. The explosion appears to have been heard over a region about 30 miles N.E. and S.W. and 50 or 60 miles N.W. and S.E.

The fractured surface has a greyish aspect, and exhibits numerous greenish spherules, with white granular interstitial matter, and occasional particles of nickel-iron, troilite, or chromite. The nodules are sometimes more than 3 mm. in diameter, with an imperfect fibrous crystalline structure, the radiation usually commencing from one side of the spherule; they are more or less opaque, and of a dull, bottle-green colour, with a hardness of about 6. Analysis of this selected mineral gave the following results:—

		Oxygen Ratios.	
Silicic acid ...	48·62	... 29·9	29·69
Alumina ...	8·05	... 3·79	
Iron protoxide	11·21	... 2·51	14·31
Magnesia ...	30·18	... 11·80	
	98·06		

The formula of this mineral, with a portion of the silica replaced by alumina, a not unfrequent occurrence in minerals like hornblende, hypersthene, etc., is therefore RO,SiO_2 and it is probably a bronzite. The nickel-iron has the composition:

Iron = 86·92; Nickel = 12·01; Cobalt = 0·75 = 100

and that of the rocky portion is as follows:

	SiO_2.	Al_2O_3.	FeO.	MgO.	CaO.	Na_2O.	
A. *Soluble*	41·08	0·32	18·45	41·06	—	—	=100·91
B. *Insoluble*	56·03	5·89	15·21	21·01	0·10	2·97	=101·21

The author deduces the following for the composition of the stone:

Nickel-iron	7·0
Magnetic pyrites (?)	6·1
Bronzite, olivine, albite or oligoclase, and chromite	86·9
	100·0

1869, November 6th, 7 p.m.—Fawley, near Southampton.[1]

The correspondent observed two meteors within a few minutes of seven o'clock on the evening of that day, which was a Saturday, and on the following Wednesday discovered a 'meteorite' which weighed more than 1 lb. avoirdupois. "It had not penetrated the ground more than half an inch." From the description of what he found, it appears that he picked up a nodule of marcasite, which had probably been left exposed on the surface after heavy rain had washed away the surrounding soil.

1869, December 25th.—Murzuk, Fezzan [Lat. 26° N.; Long. 12 E. of Paris].[2]

The letter of M. Coumbray, communicated to the Geological Society by Mr. R. H. Scott, announced the fall of an aerolite, or bolide, at Murzuk, in the presence of a group of Arabs. The bolide on falling is described as having "exploded with a sound resembling pistol shots and a strong odour." The intelligence was communicated to the Vienna Academy by Haidinger, and to the Berlin Academy by Dove; and Mr. Greg, in the British Association Report, states that it fell on the 26th December, and that it weighed 6000 lbs.

It appears highly probable, however, from a statement laid before the Berlin Academy by G. Rose[3] at a more recent date, that no meteoric fall took place. According to letters received from the Austrian Consul at Tripoli and Hag Ibraim Ben Alua, Shiek of Murzuk, a corporal, who was on guard at the gate of the town on the night of the 25th, heard a series of explosions, like the discharge of nine muskets. Hearing the alarm, the officer collected five men, and, sallying forth, they met a man, who stated that the noise was not the report of guns, but the explosion of a meteor, which burst in the direction of a little village called Namus. The writers of the letters were of opinion that no meteorite had been found.

Meteoric Iron. Found in 1869 or 1870.—Shingle Springs, Eldorado County, California.[4]

This mass, said to be the first discovered in California, was rescued in 1871 from the forge of a smith, who found it in a field near Shingle Springs. It weighed about 85 lbs., and its largest dimensions were 24 and 29 c.m. It is very homogeneous, only two small masses of

[1] A. T. Smith. *The Standard*, November, 1869.

[2] M. Coumbray, *Jour. Geol. Soc.*, xxvi. 415. GEOL. MAG., VII. 236.—R. P. Greg. *Rep. Brit. Assoc.* 1871.—*Bullet. Meteorologico*, ix. 4.—G. Rose. *Monatsber. Berlin Ak.*, November, 1870.—G. Tschermak. *Sitz. Wien. Ak.* June, 1870.

[3] G. Rose. *Monatsber. Berlin Ak.*, 1871, 804.

[4] B. Silliman. *Amer. Jour. Sc.* [3] vi. 18.

pyrites (troilite?) being visible on one of the sides. The crust to a depth of from 4 to 5 c.m. is remarkably hard. The density 7·875 (that of some pieces removed by the planing tool being 8·024) is above the average density of meteoric iron, and this is most probably due to the presence of an unusually large proportion, more than 17 per cent., of nickel, as the subjoined analysis indicates.

Iron	81·480	Carbon	0·071
Nickel	17·173	Silicium	0·032
Cobalt	0·604	Phosphorus	0·308
Aluminium	0 088	Sulphur	0·012
Chromium	0 020	Potassium	0·026
Magnesium	0·010		
Calcium	0·163		99·987

Another remarkable feature of this iron is the obscure characters of its crystalline structure: when etched, the acid discloses a confused granular surface, exhibiting under a lens a reticulated structure with numerous brilliant points and V-shaped lines. The Eldorado iron resembles that of the Cape of Good Hope, analyzed by Uricoechea, in the absence of Widmannstättian figures and in the presence of a large per-centage of nickel.

The meteoric irons which contain most nickel (and cobalt) are:

	Nickel.	Cobalt.	Total.
Grenville, Tenn.	17·10	2·04	19·14 per cent.
Tazewell Co., Tenn. ...	14·62—15·02	0·43—0·50	— „
Cape of Good Hope ...	15·09	2·56	17·65 „

Few analyses have detected more than 10 per cent. of nickel in an iron, and the average amount of this metal in eighty analyses compared by Silliman is not above 7·25 per cent.

This is not the earliest notice of the Eldorado iron. In June, 1872, Shepard[1] published a short note on it in the same journal. He determined the specific gravity to be 7·80, and found only 8·88 per cent. of nickel, as well as 3·5 per cent. "insoluble, consisting of a mixture of Fe_2O_3 and FeO, with minute silvery particles of supposed phosphor-metals." The examination was evidently an imperfect one.

Meteoric Irons found in 1869.—Staunton, Augusta Co., Virginia.[2]

This is the fourth recorded instance of meteorites having been found in the State of Virginia. Three masses of meteoric iron have recently been met with: No. 1, weighing 56 lbs., was turned up by a plough, five miles somewhat E. of N. from Staunton, in lat. 38° 14′ N., and long. 79° 1′ W.; No. 2 weighs 36 lbs., and was met with one mile S.E. of No. 1; and No. 3, which weighs 3½ lbs., was found half a mile still further S.E.

They were covered with a dark brown crust ⅛ to ⅓ in. thick; on

[1] C. U. Shepard. *Amer. Jour. Sc.*, [3] iii. 438.

[2] J. W. Mallet. *Amer. Jour. Sc.*, [3] ii. 10; *Brit. Assoc. Report* (Brighton), 1872, 77; *Proc. Royal. Soc.* xx. 365; *Pogg. Ann.* cxlvii. 134.

exposure to moist air, a liquid, containing iron, nickel, and chlorine, exuded from many parts of the surface. This iron, which exhibits feeble magnetic polarity, and has a specific gravity of 7·83 to 7·85, is compact and highly crystalline, and contains occasional grains of troilite. Traces of Widmannstättian figures can be detected even without acid; but this reagent developes them in great beauty, and with considerable resemblance to those of the Lenarto and certain Mexican specimens. The irons were cut so as to give different projections of the same crystalline structure; in No. 1 the bands of iron and schreibersite intersect at 120° and 60°, in No. 2 they approach 90°, and in No. 3 are at about 60°.

The author states that by prolonged action of acid, white, pliant, and strongly magnetic laminæ of schreibersite are brought to view. He does not appear to have analyzed them, but, to judge from observations made on other irons, it seems highly probable that the plates are not schreibersite, which is very brittle, but an alloy free from phosphorus, and containing about one-third its weight of nickel. The three masses gave on analysis the following results:

	No. 1.	No. 2.	No. 3.
Iron	88·706	88·365	89·007
Nickel	10·163	10·242	9·964
Cobalt	0·396	0·428	0·387
Copper	0·003	0·004	0·003
Tin	0·002	0·002	0·003
Manganese	trace.	—	trace.
Carbon	0 172	0·185	0·122
Phosphorus	0·341	0·362	0·375
Sulphur	0·019	0·008	0·026
Silica	0·067	0·061	0·056
Chlorine	0·003	0·002	0·004
	99·872	99·659	99·947

The chlorine is not of meteoric origin; a solid piece of No. 1, weighing 50 grammes, and quite free from flaws or fissures, contained no chlorine whatever. Some portion of the siliceous residue from the action of the acid probably consists of silicide of iron; when magnified 500 diameters, and examined by polarized light, it is found to consist of an amorphous powder, and rounded transparent grains of 0·0025 to 0·0100 mm. diameter, and with well-marked doubly refracting characters.[1] The three masses are, beyond question, portions of the same fall.

Pieces of this iron have been forged. One, which was hammered cold, could be beaten into any desired shape; a second, which had been exposed to a red heat in vacuo, could only be forged in the cold with much difficulty; while a third piece that had been subjected to a white heat could not be forged at all, and crumbled under the hammer when reheated. Mallet is of opinion that the brittleness arose from the melting out of the phosphide, "leaving the iron

[1] The residue left on treating the Tuczon iron with acid appears to have borne a great resemblance to this substance. Compare with the description given in Buchner's *Meteoriten*, p. 183.

porous." As the amount of phosphorus present was but small, and did not exceed one per cent., it may have rendered some portion of the iron, "cold short."

The gases occluded by this iron were collected by Mallet and analyzed. The material consisted of some turnings and a solid piece of the metal. The cutting apparatus employed to reduce them to the requisite size was heated to a red heat, and quenched in water, to remove all traces of oily matter. Graham extracted from the Lenarto iron 2·85 times its volume of gas; Mallet obtained 3·17 volumes from his specimen. The latter was heated during fourteen and a half hours at a red heat, and then to an incipient white heat. During the first two and a half hours 52 per cent. (I.) of the entire gas was removed; in the next 2 hours 20 minutes, 24 per cent.; (II.), and in the remaining nine and a half hours, 24 per cent. (III.). Below are given for comparison the composition of these three quantities as well as that of the gas occluded in the Lenarto iron and that of manufactured iron:

	Virginia Iron.				Lenarto Iron.	Shoeing Nails.
	I.	II.	III.	Total.		
Hydrogen	22·12	10·52	3·19	35·83	85·68	35·0
Carbonic oxide	15·99	11·12	11·22	38·33	4·46	50·3
Carbonic acid	7·85	1·02	0·88	9·75	—	7·7
Nitrogen	6·06	1·45	8·58	16·09	9·86	7·0
	52·02	24·11	23·87	100·00	100·00	100·0

These results unfortunately do not admit of very exact comparison, as only a portion of the gas extracted from the Lenarto iron was quantitatively examined. Although the relative quantity of hydrogen in the Augusta iron is much less than in the Lenarto iron, it amounts to 1·4 times the volume of the iron, while manufactured iron under ordinary pressure takes up only 0·42 to 0·46 of its volume of this gas. Mallet's results have shown Graham's view, that the predominance of carbonic oxide among the occluded gases is indicative of telluric origin, to be no longer tenable. In connexion with these differences in composition of the gaseous constituents of meteorites, it is interesting to notice that the observations of Secchi and Huggins have shown that carbon plays an important part in certain cosmical regions, although the spectroscopic evidence in the case of this element is as yet less definite than it is in regard to hydrogen.

1869 (and 1871). Trenton, Washington Co., Wisconsin.[1]

An additional fragment of this meteorite, weighing 16½ lbs., was found in 1869; and another, weighing 35 lbs., was dug up in 1871. All the six fragments (143 lbs.) now collected were found in the same field.

[1] J. L. Smith. *Mineralogy and Chemistry*, 348.—J. A. Lapham. *Am. Jour. Sc.*, [3] iii. 69.

1870, January 23rd.—Nidigullam, near Parvatypore, Vizagapatam District, Madras. [Lat. 18° 41′ 20″ N.; Long. 83° 28′ 30″ E.] [1]

A meteoric iron, weighing 407 tolas (about 10 lbs.), fell at Nidigullam, and penetrated the ground to the depth of twenty inches. Those who saw the meteor describe it as very large and beautiful, and as exhibiting increased brilliance when it burst. The explosion was followed by a series of rumbling noises. The meteorite passed over Parvatypore from N. to S.; the people of the village were greatly alarmed, and one man, near whom it fell, was stunned. The villagers "carried it off to their temple, and, much alarmed, were found making púja to it." The author of the notice in the *Proceedings* considers that this aerolite contains no stony matter, and he states that it is marked with striæ lying obliquely to its greatest length, which is 6½ inches. The lamented Dr. Stoliczka, however, was of opinion, from the description of the striation, that it is a stone containing much iron, "like the Mooltan aerolite which fell some short time ago." [2] If it be metallic throughout, as Saxton asserts, it is the third [3] iron recorded to have fallen in India, and one of the very few the descent of which has been witnessed. Among these very few is the iron of Jullunder (Jálandher), Lahore, the history of which has quite recently been studied by H. Blochmann.[4] According to the Iqbálnámah i Jahángírí, a dreadful explosion was heard in a village near Jullunder on the morning of the 10th April, 1621 (old style),[5] and "a lightning-like lustre shot along the heaven and descended to the earth, and disappeared." Muhammad Sa'íd, the Collector of Jullunder, rode to the spot, and ordered the burnt ground where the meteor struck to be dug. The deeper his men dug the hotter and crisper the ground became "till they alighted on a lump of iron, which was so hot that it seemed to have come that very moment out of the oven. His Majesty (Jahángír) sent for Ustád Dáúd, who was well-known in those days for the excellent sword-blades that he made, and ordered him to make the lump into a sword, a dagger, and a knife; but the iron would not stand the hammer, and crumbled to pieces." [6] He mixed the meteoric iron (*ahan i barg*, lightning iron) with common iron, and forged the weapons. This meteorite is calculated to have weighed 5·27 lbs. Troy.

[1] G. H. Saxton. *Proc. Asiat. Soc. Bengal*, 1870, 64.—This fall is stated by Mr. Greg, in the *Report Brit. Assoc.*, 1870, to have taken place December 26th, 1869.

[2] This is probably the meteorite of Lodran which fell 1st October, 1868 (see Part II.).

[3] The second is that found at Prambanan, Soerakarta, Java, in 1865; if we include under the word 'India' not only the British possessions, but the foreign settlements in the Indian Archipelago.

[4] H. Blochmann, *Proc. Asiat. Soc. Bengal*, 1869, 167.

[5] This fall, in Mr. Greg's Catalogue, bears the date April 17th, 1620.

[6] Compare with Mallet's experiments in forging the meteoric iron of Augusta County. (See page 14.)

1870, June 17th, 2 p.m.—Ibbenbühren, Westphalia.[1]

This stone was seen to fall. It is stated that a flash of light was succeeded in about one minute by a noise as of thunder, which attracted the attention of many persons within a radius of some three miles, and three minutes later the stone was seen to fall by a peasant distant some hundred paces. It entered the ground to the depth of 0·7 metre in a well-trodden footpath; a fragment (30 grammes) was afterwards found 300 to 400 paces from the spot. The meteorite, which weighs 2·034 kilog. and is almost perfect, has the form of a flattened spheroid; and the black crust, which is somewhat less than 0·1 mm. thick, bears on its surface a great number of very minute 'ridges of fusion' that are less marked than in the aerolites of Stannern and Pultusk. On the posterior portion of the stone the fused matter has streamed along the surface. The stone, moreover, exhibits curious depressions, resembling the marks which are made by fingers on a plastic mass.

The body of the stone is of a remarkably light colour, and consists of a greyish-white granular mass, through which are very unequally distributed numerous large and small grains of a light yellowish-green mineral. Some attain a size of 3 mm., and all that were examined were so deficient in crystal-faces, and even in cleavage-planes, that an accurate determination of their form could not be made; judging from the cleavage, however, this mineral appears to be rhombic. It has a specific gravity of 3·42 and the following composition:

		Oxygen.	
Silicic acid	54·51	29·07	
Iron protoxide	17·53	3·89	
Manganese protoxide	0·29	0·06	14·82
Magnesia	26·43	10·57	
Lime	1·04	0·30	
Alumina	1·26	0·59	
	101·06		

or that of a bronzite of the form $(\frac{2}{7}FeO\frac{5}{7}MgO)SiO_2$.

The pale grey very friable interstitial matter, freed as thoroughly as possible from the grains of bronzite, was next examined. The specific gravity is 3·40, and the mean composition of two analyses is as follows:

		Oxygen.	
Silicic acid	54·47	29·05	
Iron protoxide	17·15	3·81	
Manganese protoxide	0·28	0·06	14·72
Magnesia	26·12	10·45	
Lime	1·39	0·40	
Alumina	1·06	0·50	
	100·47		

It is seen, then, that the interstitial mineral and the grains have

[1] G. Vom Rath. *Monatsber. Ak. Wiss. Berlin*, 1872, 27; *Pogg. Ann.*, cxlvi. 474.

the same composition, and that the constitution of the Ibbenbühren meteorite is one of the simplest of any meteorite yet investigated. It not only consists essentially of a single silicate, but contains neither chromite, magnetic pyrites, nor sulphur compound of any kind. A trace of metallic iron was met with, and some reddish-yellow grains with a brilliant surface, which have not been examined. Can they be the curious mineral found in the stone of Busti, which appears to be a compound of zirconium (or titanium), calcium, and sulphur? The black crust is strongly magnetic, some of the iron protoxide of the bronzite having been converted during the passage of the stone through the atmosphere into the higher and magnetic oxide.

While this meteorite very nearly resembles that of Manegaum, it approaches still more closely in composition to the bronzite of the Shalka stone. It will be remarked that the meteoric bronzites far exceed terrestrial bronzites as regards their per-centage of iron oxide.

We now know four aerolites consisting of a single silicate:

Chassigny (1815, October 3rd)	Olivine.
Bishopville (1843, March 25th)	Enstatite.
Manegaum (1843, June 29th)...	Bronzite.
Ibbenbühren (1870, June 17th)	

Vom Rath's paper is illustrated with a drawing of the stone.

In a short supplement in *Poggendorff's Annalen* is given a brief description of a microscopic section of this stone, prepared by Buchner, of Giessen. The entire slice is seen to be made up of rounded bronzite grains, without any heterogeneous ground mass uniting them. By rotating the Nicols the most brilliant play of colours is observed, the entire stone presenting crystalline characters. Little clefts filled with fused material cross the field in every direction. Two very small red granules were observed in the bronzite; their composition is not known. Similar bright coloured grains have been met with in meteorites by Wöhler and other observers.

1870, October 27th, 3 a.m.—Forest, Ohio. [Lat. 40° 50′ N.; Long. 84° 40′ W.][1]

The meteor exploded with a report like that of a heavy siege gun, followed by two or three reports in rapid succession. The firmest houses were shaken to the foundations, and thousands of sleepers aroused in an instant. People awake at the time were startled to see the night suddenly lighted into day and again relapse in darkness. The time between the extinction of the light and the sound of the explosion is estimated at from one minute to half a minute. An observer at Patterson, a mile from Forest, states that the meteor came from the direction S. 35° W. The descriptions of its size are of the usual vague kind: one man makes it as large as a beer-keg,

[1] J. L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 139.

another as a load of hay, while a third observed a tail thirty feet long and three feet wide!

The report appears to have been heard for fifty miles around, if not at still greater distances. No fragments of the meteorite have been found.

Found 1870.—Kokomo, Howard Co., Indiana.[1]

A lump of meteoric iron was found in plastic clay under a bed of peat. It is described as a flattened, irregularly-shaped mass, rounded on one side and concave on the other. It is 5 inches long, $3\frac{1}{2}$ inches wide, and $1\frac{7}{10}$ inches thick; and it weighs 4 lbs. $1\frac{1}{2}$ oz. It is granular, like fine steel, and is malleable; and though harder than common iron, can be wrought into any form. No quantitative analysis of this iron has yet been made, but the presence in it of the following elements has been determined: nickel, cobalt, tin, carbon, phosphorus, and perhaps sulphur. By acid the Widmannstättian figures are developed in great perfection.

Found 1870.—Ilimaë, Desert of Atacama, Chili. [Lat. 26° S.; Long. 70° W.][2]

This, the most recent addition to the little group of irons and siderolites which have from time to time been found on the desert and cordilleras of Atacama, in about the latitude of the Tropic of Capricorn, partly in Chili and partly in Bolivia, was acquired for the Vienna Collection in 1870. It is a very interesting specimen of meteoric iron, apparently nearly complete, and weighing about 51 kilog. It bears a rough resemblance to a shield, being convex on one side, somewhat hollow on the other.

Over the entire concave side are shallow hollows from 3 to 4 cm. in breadth, and these in turn are marked with smaller hollows. The whole surface is also covered with three systems of fine parallel lines, forming a network; two of these are at once apparent, the third only after careful inspection: they are Widmannstättian figures developed by the natural oxidation of the surface. The positions of the blunted edges between the shallow cavities are seen to be closely connected with the course of these traversing lines, and the meteorite is, as regards its crystallographic characters, formed alike throughout.

The second side exhibits sharper ridges and a greater number of

[1] E. T. Cox. *Amer. Jour. Sc.*, 1873, v. 155.

[2] G. Tschermak. *Denkschrift Wien. Akad. Math. Naturw. Classe*, xxxi. 187.—E. Ludwig. *Sitz. Wien. Akad.*, lxiii. 323.

the smaller hollows, which are only one-fourth or one-third the size of those on the concave surface, and have much steeper sides. Here also is seen the network of lines, still more distinct, and traversing corresponding directions. Two systems intersect at an angle of about 70°; the third, which is only occasionally visible, forms equal angles with the other two. If these lines be sketched, as has been done by Tschermak in his memoir, it becomes apparent that they correspond with a 110 face (rhombic dodecahedral face) on meteoric iron, which in the Widmannstättian figure is an isosceles triangle, with the angle of the apex equal to 70° 32′. The lines or lamellæ forming the equal sides of the triangle are perpendicular to the 110 face, while the lamellæ of the third system form with the 110 face, angles of 35° 16′ and 144° 44′. It thus becomes clear why it is that the lines inclined to each other at an angle of 70° stand out so distinctly, while the others are less readily detected: the former meet the cut surface perpendicularly, the latter at a comparatively slight inclination.

The original surface is gone, but it was probably pitted, and the iron presents the appearance of having at one period formed a portion of a larger mass. In the different characters of the hollows on the two sides, it bears a general resemblance to the Agram iron, on which von Widmannstätten in 1808 first developed the figures that bear his name.

This aerolite, mineralogically considered, contains: iron; nickel-iron; schreibersite; and troilite.

The iron occurs in three distinct forms: as beam-iron (*Balkeneisen*); as tänite or fillet-iron (*Bandeisen*); and as interstitial iron (*Fülleisen*).[1]

The beam-iron is seen on an etched surface in the form of long stripes, which often extend right across it; they are 1 mm. and sometimes 2 mm. in breadth, and occupy the greater part of the surface, traversing it in three directions. One of these intersects a second at an angle of about 83°, and the third at about 97°. If the cut surface were parallel to a cubic face, only two of these directions would be seen, and they would intersect at an angle of 90°. The face of the section, however, happens to lie somewhat out of the plane of the (100) face, and is nearly parallel to the face of a leucitoid (811), for which face the angles of the trapeze, in Tschermak's drawing, are 82° 59′ and 97° 1′.

If etched, the beam-iron takes a set lustre, which Haidinger termed crystalline damaskining. Each stripe, when viewed in particular directions, exhibits a sheen, in intervening directions appearing dull; the orientation of the lustre, is not the same in all the stripes, a group, irregularly distributed, always shining forth at the same moment. A single stripe of this form of iron, if only slightly etched, exhibits, under the microscope, very fine etched figures of two kinds: fine threads 0·01 mm. broad, which are straight along one side and serrated on the other; they have the same habit and traverse the same directions as the etched lines that were first

[1] Von Reichenbach distinguished four varieties of iron developed by etching: Balkeneisen, or kamacite; Bandeisen, or tänite; Fülleisen, or plessite; and Glanzeisen, or lamprite (*Pogg. Ann.*, cxiv. 99).

observed in the Braunau iron.[1] These threads are the sections of lamellæ which are inclosed in definite crystallographic orientation in the beam-iron. When one of them meets a plate of tänite, the former is as a rule terminated, not unfrequently to be continued in the next stripe of beam-iron; some, however, which meet a fillet of tänite at an angle of about 70°, are seen to pass through the last-mentioned mineral. The other appearance, developed by slightly etching the beam-iron, consists of small oblong areas with fine hatching. Seen in favourable light, all the parallel sunken lines shine out along one slope; and if the plate be rotated through 180°, they light up again along the other; in intervening positions they appear dull. These brighter areas are often in parallel position, though not invariably so; if, however, the angles be measured which they make with the fillets of tänite and with the cubic lamellæ, it is observed that in point of relative position they exactly accord with the etched lines on the Braunau iron. They never penetrate the plates of tänite. When the corroding action of the acid is prolonged, these appearances are destroyed, and are replaced by etched lines and etched cavities.

The etched lines have the same characters as those of the Braunau iron, but they are shorter and more difficult to measure. The section, as stated, is not exactly parallel to the face 811, so that the following determinations of some of the angles which the etched lines make with lines parallel to 100 are only approximate:

Observed.	Calculated for 100	Calculated for 811
27°	26° 34′	25° 7′
63°	63° 26′	64° 7′
86°	82° 53′	85° 40′
109°	104° 2′	110° 47′
119°	119° 45′	117° 49′

while the angles which the etched lines form with lines parallel to 111 are:

Observed.	Calculated for 100	Calculated for 811
23°	30° 58′	23° 51′
45°	45° 0′	45° 24′
53°	52° 7′	48° 58′
69°	71° 34′	70° 30′

These observations place beyond doubt the fact that the deeper lines thus brought out are the usual lines of etching.

The cavities, produced by the action of acid, are very small, about 0·005 mm. across, and have a rounded, sometimes quadratic, outline; the more perfect having the form of rounded cubes. They are most abundantly met with on the fillets alluded to above, those in the same piece of beam-iron being similarly orientated, and it is to them and the parallel serration of the fillets that the crystalline damaskining is due.

In the beam-iron are inclosed schreibersite and troilite, but graphite was not observed. The schreibersite is only met with in this form

[1] J. G. Neumann. *Aus der Naturwiss. Abhandl.* (*W. Haidinger*), iii. Abth. 2, 45.

of iron, and occurs there in rounded particles and elongated forms, which proceed from plates of this mineral, many of which lie parallel to an octahedral face. It occurs very frequently round about the remarkable lamellæ of troilite (see *infra*) that lie parallel to the faces of the cube.

The fillet-iron (*Bandeisen*), or tänite, presents itself on the etched surface in the form of prominent bands or fillets between the stripes of beam-iron, and they are sections of lamellæ lying parallel to those of the beam-iron,—in other words, to the octahedral faces. This form of iron, though in such thin plates, is found by the microscope to be a fine tissue of heterogeneous substances. One of these is nickel-iron, which coats the lamellæ of tänite. A section of this mineral is dull in appearance, but the boundary is brilliant; while outside it, lie brilliant points of not unfrequently regular form. The framework and the points have the yellowish colour of nickel-iron. The duller field, when strongly magnified, is seen to consist of exceedingly fine plates of nickel-iron, which lie in two different directions, for the lines intersect at 90°. The material lying between these plates, which has been removed in greater abundance, is pure iron. The lamellæ of tänite are often penetrated and traversed by fine plates of beam-iron.

The interstitial iron (*Fülleisen*), which, as the name implies, occupies the areas between the minerals already mentioned, is abundantly present in masses sometimes extending to the breadth of 1 cm. It is made up of tänite and beam-iron, and is a representation of the structure of the entire meteorite on a smaller scale, with such modifications as seem to indicate that after the large lamellæ of beam-iron and tänite were already formed, the matter inclosed between them became solid, and, shaping itself in accordance with the same laws in a limited area, produced this variety of meteoric iron. It occurs in two forms that vary but little from each other. In one, fine stripes of beam-iron intersect, while between them is tänite: this is an exact reproduction of the coarser structure of the meteorite. In the other (and this is observed in the larger masses) the square form is provided along its boundary with stripes of beam-iron, the remainder appearing granular through a number of little particles of beam-iron being ranged together with nickel-iron between them.

The occurrence of troilite in lamellæ has been observed for the first time in this iron. They lie parallel to the cubic faces, and, unlike those of tänite, do not traverse any considerable portion of the etched surface. The largest are 3·5 cm. long and 1·5 wide, and have a thickness of from 0·1 to 0·2 mm. They have a sharp outline, homogeneous structure, and are easily recognized as consisting of the brittle bronze-coloured sulphide which decomposes with acid. These lamellæ are covered on either side with a layer of beam-iron, which separates them from the tänite, the interstitial iron, and the lamellæ of beam-iron that are parallel to the octahedron; whenever one of the last-mentioned plates happens to be situated near a lamella of troilite, it will be found that the troilite has broken through it.

The troilite seems to have been formed first. After it had become covered with a layer of beam-iron, the octahedral lamellæ (the tänite and the beam-iron) appear to have been developed; and last of all the interstitial mass, likewise in accordance with the law which governed the formation of the octahedral lamellæ.

The troilite of this iron occurs almost entirely as cubic lamellæ, but rarely in the familiar nodular form. On examining the irons of the Vienna Collection, Tschermak discovered thin plates of troilite, covered, as above, with beam-iron, in the meteorite of Jewell Hill, Madison Co., North Carolina, found in 1856. The lamellæ are just as abundant, have the same orientation as those of the South American iron, and are about one-third the size.

These two irons differ but slightly in composition:

	Ilimaë.	Jewell Hill.
Iron	91·53	91·12
Nickel	7·14	7·82
Cobalt	0·41	0·43
Copper	trace.	trace.
Phosphorus ...	0·44	0·08
	99·52	99·45

The paper is illustrated with four beautifully executed plates: two showing the natural markings of the surface, the other two the figures developed by etching a section.[1]

[1] The following meteoric irons and siderolites from this region, several of which probably belong to one fall, have now been recorded; the greater number are preserved in one or other well-known collection, and have been submitted to examination.

(1). 1827. *Siderolite* (Brit. Mus. Coll.). Atacama, Bolivia.—Reported on by Bollaert (*Journ. Royal Geogr. Soc.*, xxi. 127); and by Reid (*Chambers' Jour.*, March 8, 1851), who places the locality in lat. 23° 30′ S. and 45 to 50 leagues from the coast. According to R. A. Philippi (*Jahr. Min.*, 1855, 1), masses weighing 120 to 150 lbs. were found one league from Imilac, in the centre of the Atacama Desert. Imilac is 35 leagues from the coast, 40 leagues from Cobija, and 35 from Atacama. Rose places the locality in Chili. (In Stieler's Atlas, Atacama Mt. is in Bolivia; the Desert of Atacama, partly in Chili, partly in Bolivia; the Province of Atacama, in Chili; and Atacama Alta in Bolivia.) This will be the meteorite analyzed by Frapolli, and described by Bunsen in 1856, the metallic portion of which contains:

$$Fe = 88{\cdot}01;\ Ni = 10{\cdot}25;\ Co = 0{\cdot}70;\ Mg = 0{\cdot}22;\ Ca = 0{\cdot}13;\ Na = 0{\cdot}21;\ K = 0{\cdot}15;\ P = 0{\cdot}33 \quad = 100{\cdot}00.$$

(2). 1858. *Iron* (Brit. Mus. Coll.). Atacama, Bolivia.

(3). 1862. *Siderolite* (Brit. Mus. Coll.). Sierra de Chaco, Desert of Atacama.—Rose places this in Chili, and the position of Chaco is stated to be lat. 25° 20′ S. and long. 69° 20′ W.; he (*Ber. Berlin Akad.*, 1863, 30) could not develope etched figures on the nickel-iron, which had the composition: Fe = 88·55; Ni = 11·5; the meteorite resembles that found at Hainholz some years earlier.

(4). 1863. *Siderolite* (Brit. Mus. Coll.). Copiapo, Chili.—In the *Amer. Jour. Sc.* (1864) xxxvii. 243, C. A. Joy describes a siderolite from the Janacero Pass, 50 English miles from Copiapo, Province of Atacama, Chili. The spec. gravity of this specimen is 4·35, and it is composed of nickel-iron, troilite, and silicates. J. L. Smith (*Amer. Jour. Sc.*, xxxviii. 386) considers it to be identical with the Sierra di Chaco meteorite described by Rose (see No. 3). Captain Gilliss, of the United States Observatory at Washington, believes 'Janacera' to be a misprint for 'Jarquera,' the name of a river which rises in one of the Atacama passes.

(5). (No date). *Siderolite* (Brit. Mus. Coll.). Atacama, Bolivia.

(6). 1866. *Iron* (Brit. Mus. Coll.). Cordilleras of Atacama, Chili.—M. Daubrée

Found 1870.—Iquique, Peru.[1]

This mass of iron was discovered on a mountain slope on the western border of the pampa of Tamarugul, ten leagues east of the harbour of Iquique. It lay at a depth of from two to four feet below the surface, being imbedded partly in a bed of nitre, of the hardness of stone, partly in the overlying soil. When found, the metal was so hard that two chisels were broken in an attempt to remove a fragment of it. A piece that had been heated became malleable, and was beaten into very thin plate.

The Iquique iron is in the form of a slab, 6 cm. in thickness; on one side it is convex, bent somewhat inwards on the other, with a deep cavity on one part of the surface. The former is covered with ridges, running obliquely across its side, and in most cases parallel to each other. The weight of this block of metal is 21 lbs., and the specific gravity 7·925. When cut, it takes a fine polish, and exhibits strong metallic lustre and a steel-grey colour. Four analyses have

(*Compt. rend.*, lxxvi. 569) describes a large iron, weighing 104 kilog., acquired in 1867 for the Paris Collection. It was found in November, 1866, on the west slope of the high cordillera of the Andes, between the Rio Juncal and the Salt-works of Pedernal, 50 leagues N.E. of Paypote. (The difficulty of transporting heavy masses across such an arid region is very great; according to Dr. Phillippi (*The Times*, August 31st, 1874), it only rains about once in from 20 to 50 years.) This mass bears on the surface the systems of lines which Tschermak observed on the Ilimaë iron, and Damour finds them agree in composition. They are probably all members of the same aerolitic fall.

(7). (No date). *Iron* (Brit. Mus. Coll.). Sierra di Deesa, Chili.—Under this name M Daubrée has given (*Compt. rend.*, lxxvi. 571) a description of a brecciated iron from the cordillera of Deesa, near Santiago, acquired in 1867. It closely resembles the iron found in 1840 at Hemalga, in the Desert of Talcahuayo, in Chili. It contains 2·4 per cent. of silicate, which has been chemically examined by Meunier. (*Sitz. Wien Ak.*, lxi.).

(8). 1866. *Iron* (Brit Mus. Coll.). Juncal, Cordilleras of Atacama, Chili.

(9). 1864. *Siderolite* (Berlin Coll.). Atacama, 50 miles from Copiapo.—It appears probable from the rough description of the locality that this may be the same meteorite as the one mentioned under No. 4, although the dates do not correspond. In that case J. L. Smith's view of the identity in character of the meteorites will have to be extended to Nos. 3, 4, and 9.

(10). 1870. *Iron* (Vienna Coll). Ilimaë, Desert of Atacama, Chili.

(11). (No date). *Siderolite.* Taltal, Desert of Atacama.—J. Domeyko (*Compt. rend.*, lviii. 551) describes some masses of considerable size on the high plateau of the Desert near the copper mine of Taltal, south of Imilac. The spec. gravity of a fragment was 5·64.

(12). 1863. *Siderolite* (Vienna Coll.). Copiapo, Chili.—Described by Haidinger (*Sitz. Wien Akad.*, xlix. 499), as a coarsely granular brecciated meteorite. The nickel-iron, according to Von Hauer, consists of: Fe = 93; Ni = 6·4.

(13). 1859. *Iron*? Toconado, Desert of Atacama.—J. J. von Tschudi, writing under the above date to Haidinger (*Sitz. Wien Akad.*, xlix. 494), mentions a meteoric mass, weighing 80 arobas (20 cwt.), which lies 20 leagues N.E. of Toconado. He states that it agrees in structure and appearance with the Atacama iron lying 50 leagues southward.

[1] G. Rose. Abdruck aus der Festschrift der Gesell. Naturforsch. Freunde zu Berlin, 33. Berlin: Dümmler, 1873.

been made of it, three by A. Raimondi, of Lima, and one by Rammelsberg, that last quoted, with the following results:

	I.	II.	III.	IV.
Iron	81·42	85·61	87·59	81·66
Nickel	18·51	14·37	12·38	15·49
Cobalt	...	...	...	0·19
Insoluble portion	...	...	...	2·66
	99·93	99·98	99·97	100·00

The insoluble constituents of IV. were: iron 2·17; nickel 0·37; phosphorus 0·05; and a residue, that withstood the action of hydrochloric acid, 0·07.

The attention of the reader will be raised by the unusually large per-centage of nickel present in this meteorite, it being as high as, or higher than, that of the aerolite of Shingle Springs (see page 13). We saw that the American iron, and the one from the Cape of Good Hope, found at the end of last century, resembled each other not only in the quantity of nickel in the alloy, but in the fact that neither of them developed figures when etched. The Peruvian iron forms a third example of this class, for it also shows no Widmannstättian figures: by treatment with acid it takes a pale grey colour, and is dull. In lieu, however, eight fine straight parallel stripes, singularly unlike any markings usually observed, are seen to traverse the etched surface, almost directly across the greatest length of the block. Four of these crossing near the middle of the surface appear to be equidistant from each other, like lines on ruled paper; the remaining four lie in pairs, one on the right, the other to the left of the group of four, the whole number, as stated, being in parallel position. The spaces between the members of the first pair and of the second pair respectively exhibit for some distance the same lighter surface that gives prominence to the stripes themselves. These stripes do not appear to be in any way connected with the ridges on the outer surface, and though evidently brighter than the face generally when seen in certain directions, are duller than it when viewed in others. Very similar stripes were noticed on the Cape iron[1] already mentioned; in fact, till Rose made these observations, it was the only iron which was known to exhibit such phenomena. As to their cause, the author has not advanced any explanation beyond attributing them to the position of the small particles composing the stripe. They present some of the characteristics of the plates of beam-iron observed in the Atacama and many other irons.

This iron apparently contains no sulphur, and the sections of little inclosed crystals, such as those met with in the Cape iron, which Baumhauer believed to be of pyrites (FeS_2), but which Rose maintained were of magnetic pyrites, were in vain sought for.

Two plates, copied from photographs of the aerolite, are appended to the paper.

It rarely happens that Widmannstättian figures are developed in

[1] G. Rose. *Aus Abhandl. Berl. Akad. Wiss.*, 1863, 70.—E. H. von Baumhauer. *Archiv. Néerland. des Sciences Exactes et Natur.*, ii. 377.

irons containing more than nine per cent of nickel. With a knowledge of the difficulties attending the complete separation of nickel and cobalt from iron and of the different action of the re-agents, employed to bring these metals into solution, on the phosphides, rich in nickel, which frequently accompany them, it would not be advisable to lay too great stress on the results of earlier analyses of meteoric irons as pointing to any general conclusion when the details of the processes made use of cannot likewise be studied. It is worthy of note, however, that the irons mentioned below, with the per-centage of nickel found in them, give lines occasionally, but no figures:

Oktibbeha Co. = 59·69; Caille = 17·37; Babb's Mill = 17·1, 14·7, and 12·4; Howard Co. (1862) = 12·94; Atacama (1862) = 11·5; Krasnojarsk = 10·73; Tucuman = 10·0; Livingstone Co., Kentucky = 10·0; Zacatecas = 9·89; and Szlanicza = 8·91.

While the following irons exhibit them in great perfection:

Elbogen = 8·5; Lion River = 6·7; Lenartó = 6·55; Madoc = 6·35; Sevier Co. = 6·5 and 5·8; Schwetz = 5·77; Tabarz = 5·69; Cambria = 5·7 and 5·0; Asheville = 5·0; Cohahuila = 3·53; and Ruff's Mountain = 3·12.

Meteoric Irons found August, 1870.—Ovifak (or Uigfak) near Godhavn, Kekertarssuak or Island of Disko, Greenland [Lat. 69° 19′ 30″ N.; Long. 54° 1′ 22″ W.][1]

The interesting story of the discovery of these enormous masses by Prof. Nordenskjöld is already known to the readers of the GEOLOGICAL MAGAZINE through a translation of his original memoir. While exploring in Danish Greenland in 1870, his attention was

[1] A. E. Nordenskjöld. Redogörelse för en Expedition till Grönland år 1870. *K. Vet.-Akad. Förh.*, 1870, 873. (See translation in GEOL. MAG., IX. 289, *et seq.*) —D. Forbes, *Abstract Geol. Soc.*, No. 238, November 8th, 1871. *Chem. News*, November 17th, 1871.—A. E. Nordenskjöld. Remarks on Greenland Meteorites. *Abstract Geol. Soc.*, December 20th, 1871.—T. Nordström. *Ofv. Vet. Akad. Förh.*, 1871, 453. See also GEOL. MAG., VIII. 570, and IX. 88.—A. E. Nordenskjöld. Les Météorites. *Revue Scientifique*, 1872, ii. [2], 128.—G. A. Daubrée. *Compt. rend.*, lxiii. 1268. *Compt. rend.*, lxxiv. 1542. *Compt. rend.*, lxxv. 240. E. Ludwig. *Min. Mitt.*, 1871, i. 109.—E. Hébert. Séance Soc. Géol. de France, February 5th, 1872. *Revue Scientifique*, i. [2], 858.—E'. de Chancourtois and M. Jennatez. Séance Soc. Géol. de France, February 19th, 1872. *Revue Scientifique*, i. [2], 905.—G. A. Daubrée. Séance Soc. Géol. de France, May, 20th, 1872. *Revue Scientifique*, i. [2], 1169. *Amer. Jour. Sc.*, iii. 71 and 388.—F. Wöhler. *Nachricht. K. Gesell. Wiss. zu Göttingen*, 1872, No. 11, 197. *Pogg. Ann.*, cxlvi. 297. *Ann. der Chem.*, clxiii. 247. *Nachricht. K. Gesell. Wiss. zu Göttingen*, 1872, No. 26. *Ann. der Chem.*, clxv. 313.—G. Rose. *Zeit. Deutsch. Geol. Gesell.*, xxiv. 174.—G. von Helmerssen. *Zeit. Deutsch. Geol. Gesell.*, xxv. 347.—C. Rammelsberg. Ueber die Meteoriten (*Samm. wiss. Vorträge*), pages 14 and 18.—C. W. Blomstrand. *Ber. Deutsch. Chem. Gesell.*, iv. 987.—G. Nauckhoff. *Svenska Vet. Akad. Handl.*, 1872, i. No. 6. *Ber. Deutsch. Chem. Gesell.*, vi. 1463. *Mineralogische Mittheilungen*, 1874, 109.—G. Tschermak. *Mineralogische Mittheilungen*, 1874, 165. *Der Naturforscher*, 1874, Nos. 49–52.—For a map of Disko see *Geographical Mag.*, February, 1875.—J. Lawrence Smith, *Compt. rend.*, lxxx. 301.

Fig. 1. 1/6700.

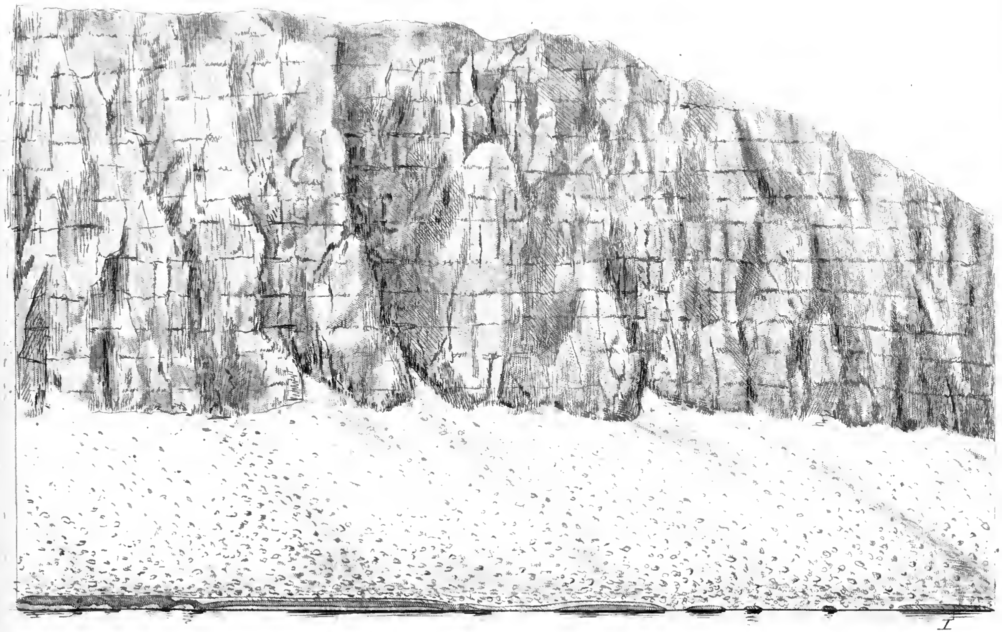


Fig. 3. 1/288 1'''=2'.

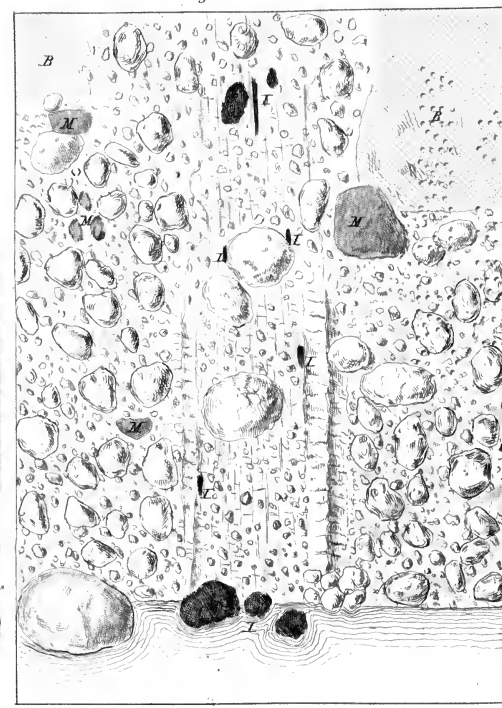


Fig. 2. Mlstk for Længden 1/5000 for H. 1/2500.

K. J. S. del.   C. Thornam sculp.

directed to the possibility of meteorites being met with in Disko Island, by the accidental discovery of a block of meteoric iron in some ballast which had been taken in at the old whaling-station at Fortuna Bay, near Godhavn, and he urged the Greenlanders to search the district for masses of that metal. He proceeded to explore Omenak and other islands north of Disko, and, on his return to Godhavn at the end of August in the same year, not only learned from the Greenlanders that masses such as he was seeking for had been found, but he was shown a specimen of meteoric iron in confirmation of their statement. The masses were discovered, not at Fortuna Bay, but further westward along the shore, at Ovifak, between Laxe-bugt[1] and Disko fjord, a spot than which there is none more difficult to reach along the whole of the coast of Danish Greenland, as it lies open to the south wind, and is rendered inaccessible by even a very moderately rough sea. Nordenskjöld at once chartered two whale-boats, manned by Greenlanders, and set sail for Ovifak, where, the sea being calm, they were able to land, and the stone at which they lay to proved afterwards to be the largest block of meteoric iron that they were to discover.

For the description which Nordenskjöld gives of the condition under which these masses are found, we refer the reader to the Geological Magazine, and proceed to consider the more recently published report of Nauckhoff, the geologist of the expedition of 1871, of the peculiar geological characters of the rocks at Ovifak (Blåfjell, or Blue Cliffs) with which they are associated.

The surface of the south-western and western portion of the island of Disko is composed of basalt, which extends as far as Smith's Sound, and was probably erupted in Miocene times. In only a few points of the island, Godhavn, the islets of Fortuna Bay and Nangiset, the primitive rock is observed. It consists for the most part of slaty gneiss, passing over in some places into mica-schist and often traversed by veins of pegmatite. Granite was nowhere seen.

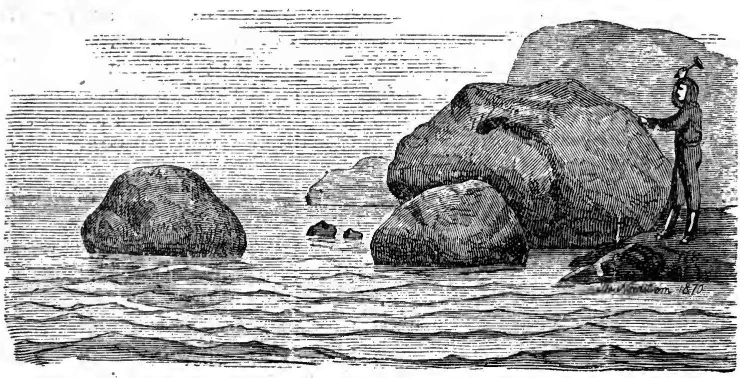
Immediately overlying the gneiss is a basalt breccia of dark blackish-green colour, some two hundred feet in thickness. In places the large angular fragments are cemented together with calcite; as a rule, however, they are so small that the rock at some distance appears homogeneous. Few cavities are observed, and they are usually filled with calcite, rarely with zeolites. Above the breccia lies a bed of basalt-wacké of rust-brown colour, and with amygdaloidal structure, the cavities containing apophyllite, chabasite, levynite, stilbite, desmine, mesotype, analcime, and other zeolites. Over this again rises a bed of basalt of vast thickness, sometimes attaining one thousand feet, and of a dark greyish green hue; it occurs not unfrequently in vertical regular six-sided columns. The texture is generally crypto-crystalline, though exhibiting in places the characters of anamesite and dolerite; the few cavities are filled with chalcedony, rarely with zeolites. At Ovifak the cliffs rise to a

[1] See Geol. Mag., 1872, Vol. IX. Pl. VII. In this map two bays called Laxebugt are given; the one mentioned above is situated to the south of Disko fjord.

height of 2,000 feet above the sea-level. The upper portion consists of compact dark-coloured basalt. Proceeding downwards on the nearly vertical face, we see thick beds of red-wacké and basalt-clay, until already at mid height the face is hidden by vast screes of large and small fragments of basalt. Where the cascades of surface-water have removed the finer portions of the talus, and the face can be inspected at greater depths between the larger blocks of basalt, the basalt-wacké is seen which overlies the breccia.

On the shore below these screes between high and low-water, and within an area of about fifty square metres, twelve large and many small iron masses were found. The six largest weigh respectively 21,000 kilog., 8,000 kilog., 7,000 kilog., 142 kilog., 96 kilog., and 87 kilog.

Thanks to the kindness of Prof. Nordenskjöld, I am enabled to give a representation (see Plate) of the largest mass (about 19 English tons in weight), which is now preserved in the hall of the Royal Academy at Stockholm. This magnificent block is about two metres in length and 1·7 metres wide. The second block, weighing about nine tons, has, as a compliment to Denmark, on whose territory the meteorites were found, been presented to the Museum of Copenhagen. Another of the masses, weighing 195 lbs. 8 oz., has been acquired by the British Museum. The aggregate weight of metal collected by the Expedition amounted to 36,700 kilog. The woodcut, representing the three largest blocks, is from a sketch made by Nordström in 1870.



For the earlier account of the discovery of these masses the reader is referred to Nordenskjöld's memoir,[1] and Nordström's paper. The expedition of that year, 1870, having no means of bringing such vast masses to Europe, a new expedition was equipped by the Swedish Government in the following spring, consisting of the gunboat "Ingegerd," Capt. F. W. von Otter, and the brig "Gladan," under the command of M. von Krusenstern, who brought the meteorites to Denmark in September, 1871.

[1] Geol. Mag. 1872, Vol. IX. pp. 461, 462, and Plate VIII.

Meteoric Iron, found 1870, at Ovifak, Disko, Island, Greenland.

Nauckhoff in his paper draws attention to one remarkable block, about 200lbs. in weight, which lay three feet below high water. On the under-side it was covered with basalt grains, cemented together with hydrated oxide of iron, and consisted of coarsely crystalline iron, containing much carbon, and which readily weathered.

Sixty-five feet N.E. of the spot where the largest block lay, a ridge of dark brown basalt-like rock comes to the surface. Through its superior hardness it had withstood the denudation better than the loose basalt-wacké on either side of it. It is soon lost to sight, but reappears to take a direction towards the spot where the large iron lay. The rock forming this ridge resembles ordinary compact basalt, and is of finely granular texture. Near the margin it becomes crypto-crystalline, and is seen under the microscope to consist of labradorite, greenish-brown augite and black grains of magnetite. It will be found, when we come to speak of the analysis of the rocks accompanying this iron, to accord in composition with the basalt itself. It differs from it, however, in having the presence of two accessory constituents which are disseminated through the parts forming the edge of the ridge, and are: a greenish hydrated ferrous silicate resembling hisingerite, and a yellowish brown iron sulphide. The analyses of the former mineral, it will be seen in the sequel, show that it is not identical with the chlorophæite so often occurring in basalt; the sulphide completely accords in composition with the troilite of meteorites. The columnar structure, so often found in basalt, was not noticed, the cracks occurring near the sides appearing to be all parallel to the margin. The surface of a freshly broken fragment displays peculiar smoothness and lustre. On the east side of this ridge, and in the solid rock, a piece of much-weathered iron was found inclosed by Nauckhoff; while another member of the expedition, Mr. J. Steenstrup, detected metallic iron on the west side of the ridge. An analysis of this iron, apparently of the same kind as that analysed by Lindström, will be referred to later on. While blasting this basalt, a rock was hit upon which was at once seen to differ considerably from the matrix. It consists of a greenish ground mass, inclosing spangles and grains of iron, and occurs in rounded masses that are separated from the basalt by a coarsely crystalline greenish shell, about 20 mm. thick as well as by an outer rusted brown crust. The boundaries of these masses were well defined; in no instance were they detected passing over into the basalt.

The masses of iron lying in the basalt ridge had usually an ellipsoidal form and a rusted crust, which allowed of their being easily detached from the basalt. Nauckhoff succeeded in removing six lumps, the aggregate weight whereof was 150 lbs. This iron is hard and crystalline, exhibits Widmannstättian figures, and is in every respect like that of the large loose blocks. Moreover, like them, it unfortunately possesses the property of exuding a yellow liquid (ferrous chloride), and of weathering away. It was noticed that these inclosed masses had their major axes parallel to the direction of the ridge, and that they were in a way connected with each other by little veins of weathered iron.

Nordenskjöld states that the large free blocks of metal had a tombac to rusty-brown colour, and, when found, exhibited metallic lustre on parts of their surface. Here and there, fragments of basalt, similar to that of the ridge, were found adhering to them. The inner parts contained none of the rock, and his analyses detected the presence of little silicic acid. They were strongly polar, the upper surface attracting the north, the lower side the south pole of a magnetic needle.

The iron of the large masses is crystalline and brittle, so that pieces can readily be removed with a hammer; the metal of the ridge is tougher, and has a rougher fracture. The presence of troilite was rarely detected in the detritus; a few black magnetic grains were met with which, by their octahedral faces, were recognized to be magnetite.

The characters of the polished sections of the different masses differ greatly: in some the surface shows rounded areas of varying brightness and shades of colour, with parts of a brassy yellow (troilite); others are more homogeneous, or appear to be made up of fine prisms of "carburetted nickel-iron." Some, not all, exhibit figures when etched.

Though containing little sulphur, the Greenland irons, since they have been brought to Europe, have shown a marked tendency to crumble to pieces. On the shore at Ovifak, sometimes exposed to the wash of the waves, sometimes left high and dry, but preserved at the constant temperature of the sea, which varies little throughout the year, the masses apparently underwent little change. Already during the passage, however, many fragments crumbled away, and when unpacked at Stockholm two months later, and placed in a room of ordinary temperature, others broke up into a reddish brown powder. A freshly fractured lustrous surface of one of the masses began to rust at one place, expand and crumble away; while the remainder experienced no change, till at length the oxidation extended into the interior and the whole fell to pieces. In a hermetically sealed glass tube the iron is preserved unchanged; but in another tube with a fine crack oxidation continued. In alcohol no change takes place; in air, dried by sulphuric acid, the change is greatly impeded. Attempts to preserve them by coating them with varnish were of slight avail. The cracking is caused by dilatation, and takes place with such force that masses of metal, on which chisel and saw were without effect, are broken and bent out of shape during oxidation.

Nordenskjöld found that a fragment of the largest iron, when heated to redness, gave off more than 100 times its volume of a gas which had a bituminous smell. It was evidently gas not simply occluded by the metal, but was produced by the decomposition of "the organic matter in the meteorite," through the reducing action of those compounds on the oxide of iron associated with them. When such iron is treated with mercury chloride very little gas is evolved; in aqua regia it dissolves, leaving in some cases a carbonaceous residue, in others very little residue of any kind;

by the action of hydrochloric acid a gas is given off which has a penetrating odour resembling that of some hydrocarbon. By treatment with acid a humus-like compound appears to be generated, which is soluble in ammonia, insoluble in acid, and can be oxidized only with difficulty by long boiling with very strong acids.

In Nordenskjöld's paper are given the earliest analyses of these irons:

I. Fragment of one of the large iron masses: this specimen evolved more gas than II. and III. Specific gravity = 5·86—6·36. Analysed by Nordenskjöld. II. Fragment of iron, more compact and less crystalline than I., probably from the basalt ridge. Small grains were observed to be malleable. The specimen from which this was taken subsequently crumbled away. Specific gravity = 7·05—7·06. Analysed by T. Nordström. III. Fragment of iron from the basalt ridge, which exhibited well-marked Widmanstättian figures. In external appearance this iron exactly resembled II. Specific gravity = 6·24. Analysed by G. Lindström.

	I.	II.		III.
Iron	84·49	86·34		93·24
Nickel	2·48	1·64		1·24
Cobalt	0·07	0·35		0·56
Copper	0·27	0·19		0·19
Phosphorus	0·20	0·07		0·03
Sulphur	1·52	0·22		1·21
Chlorine	0·72	1·16		0·16
Alumina	trace	0·24		—
Lime	trace	0·48		—
Magnesia	0·04	0·29		trace
Potash	trace	0·07		0·08
Soda	trace	0·14		0·12
Silicic acid	trace	0·66		} 0·59
Insoluble portion	0·05	4·37		
Carbon, Organic Matter, Oxygen, and Water	10·16	3·71	Carbon...	2·30
			Hydrogen	0·07
	100·00	99·93		99·79

Nordström analysed the carbonaceous residue of the compact iron II., after digestion with double chloride of copper and sodium, and iron chloride, and found, when a quantity of ash is deducted, that it is composed of:

Carbon	63·59	63·64
Hydrogen	3·26	3·55
Oxygen (by difference)	33·15	32·81
	100·00	100·00

These numbers yield no satisfactory atomic ratios, and it is not improbable that the carbon is present in two allotropic modifications, as well as a constituent of a complex organic compound.

In 1872 two interesting papers were published by Wöhler on the results of his examination of this iron, especially that from the ridge. The specimen he chose for examination came from a vein of metal several inches wide and some feet in length, which was inclosed in a rock "that presents a marked difference in composition from the basalt breccia whence it protrudes." He describes this iron as bearing a close resemblance to grey cast iron; it has a bright lustre, is very hard, is quite unalterable in air, and has a specific gravity = 5·82. Nordenskjöld, as we have seen, extracted gas from the metal of the larger masses by heating it. Wöhler finds that the iron of the vein evolves more than one hundred times its volume of a gas that burns with a pale blue flame, and is carbonic oxide, mixed with a little carbonic acid. The "iron," in fact, contains a considerable amount of carbon, as well as a compound of oxygen; and, according to Wöhler, can at no time have been exposed to a high temperature. After it has been heated, the iron becomes brighter, and, though more soluble in acid, it still leaves a carbonaceous residue. A fragment heated in dry hydrogen, with a view to determine the amount of oxygen present, formed a quantity of water, and lost 11·09 per cent. of its weight. "It contained, in other words, 11·09 per cent. of oxygen." It is not stated whether the water corresponded in weight to that amount of oxygen. Hydrochloric acid acts very slowly and imperfectly on this metal, evolving first sulphuretted hydrogen, and then hydrogen possessing the odour of a hydrocarbon, and leaves a black granular magnetic powder, which, though insoluble in cold acid, generates on the application of heat a gas with a strong odour of a hydrocarbon, leaving a residue of amorphous sooty carbon and slightly lustrous graphitic particles. In iron chloride the "iron" dissolves without evolution of gas, about 30 per cent. of a black residue remaining, which, after having been dried at 200° C., lost by ignition in hydrogen 19 per cent. of its weight, water being produced. It is now very readily attacked by acid, evolves sulphuretted hydrogen, and gives a residue of nearly pure carbon in powder or in graphitic scales. Iron chloride and acid appear, therefore, in the main, to remove the free metal only, and to be without action on the compounds with sulphur and oxygen. The ultimate composition of the specimen he analysed is as follows:

Iron	80·64	Sulphur	2·82
Nickel	1·19	Carbon	3·69
Cobalt	0·47	Oxygen	11·09
Phosphorus	0·15		
			100·05

Wöhler was disposed to regard the oxygen, constituting so considerable a portion of an apparently metallic mass, as present in the form of a diferrous oxide, Fe_2O, were it not that, according to this view, there would be no iron provided for combination with the sulphur and carbon. As, however, Nordenskjöld found magnetite in or near other Ovifak irons, Wöhler regards that constituting the veins as an intimate mixture of magnetite, of which there would be 40·20 per cent., with metallic iron, of which there would then be 46·60 per cent., the sulphide, carbide, and phosphide, as well as the alloys with nickel and cobalt, and some carbon in isolated particles. The latter probably undergo no change when the magnetite and carbide, by the action of heat, generate carbonic oxide.

A specimen of the iron from the basalt has also been investigated by Daubrée; he describes it as having a metallic lustre and being nearly black. He found its composition to be:

	I.
Iron in the free state	40·940
Iron in combination	30·150
Carbon in the free state	1·640
Carbon in combination	3·000
Nickel	2·650
Cobalt	0·910
Phosphorus	0·210
Arsenic	0·410
Sulphur	2·700
Silicium	0·075
Nitrogen	0·004
Oxygen	12·100
Water (hygrometric)	0·910
Water in combination	1·950
Chromium, Copper, etc.	1·010
Calcium sulphate, chloride, etc.	1·354
	100·013

In his second paper he gives analyses of two more specimens:

II. Light grey iron, possessing metallic lustre. It is not homogeneous, as it might be assumed to be from its lustre and colour. When crushed in a mortar, it is divided into two parts: the one crumbles to fine powder, the other is flattened into plates, requiring much trituration to break them up. III. Metallic grains mechanically separated from the rocky portion in which they were distributed. These spherules exhibit figures, when etched, and contain silicate distributed in very fine pieces throughout their mass; in one rounded fragment the silicic acid of this silicate amounted to 11·9 per cent. of the total constituents.

	II.	III.
Iron in the free state	80·800	61·990
Iron in combination	1·600	8·110
Carbon in the free state	0·300	1·100
Carbon in combination	2·600	3·600
Silicium	0·291	—
Water	0·700	—
Calcium chloride	0·233	0·146
Iron chloride	0·089	0·114
Calcium sulphate	0·053	0·047
Copper	trace.	trace.

It will be seen that in specimen III. the amount of carbon is the same as in I., and that specimen II. also contains a considerable quantity. Specimen I. is distinguished from II. by a large proportion of combined iron. By treatment with alcohol, calcium chloride was extracted and determined in I.; with cold distilled water, the soluble salts were removed from II. and III. I. contains more lime sulphate and less chloride than II. and III.

These meteoric masses are distinguished by the amount of carbon, free and combined, which they contain; by the presence in them of a large proportion of iron in combination with oxygen, but in what state of oxidation is not clearly ascertained; and by the occurrence of soluble chlorides and sulphates, especially calcium sulphate, throughout their structure. No salt of potassium has been detected in them, nor, which is very remarkable, has sodium chloride been found, although carefully sought for. The intimate distribution of these salts throughout the Ovifak iron is certainly an indication that they must be numbered among the original constituents of these meteorites.

Daubrée noticed that specimen II. showed a marked tendency to absorb water and to rust away; a few days sufficed to make this apparent. The local nature of the oxidation he attributes to the irregular distribution of the deliquescent salts. Among these compounds, instead of iron chloride, to the action of which the decay of meteoric iron has usually been ascribed, calcium chloride appears to play the most prominent part. In support of this view it may be remarked that No. II. iron, the one most liable to change, is that which contains the greatest proportion of this salt, the amount being six times that met with in No. I. iron.

Calcium and magnesium sulphates were noticed by Daubrée to form constituents of the Orgueil Stone, and the latter salt is also present in the aerolites of Kaba and Alais. All these are carbonaceous meteorites. May the calcium sulphate of these irons, as well as that of the above-mentioned aerolite, be a product of the oxidation of a calcium (magnesium) sulphide such as occurs in the meteorite of Busti, which stone also contains, among other constituents, augite and metallic iron?

The greater stability which these masses exhibited so long as they were in polar latitudes is no doubt due to the reduced tension of aqueous vapour; had they fallen in regions further south and been exposed to a milder climate, they would without doubt have long since fallen to powder.

In his second paper Wöhler points out the probability of the No. II. iron which Daubrée examined being of the same kind as that which he himself analysed. He remarks that, although Daubrée found this variety of the metal to show a tendency to oxidize even in a few days, his specimen had remained bright and unchanged after it had been a year in his collection.

Nauckhoff, whose exhaustive examination of the rocks associated with the Ovifak irons we shall immediately turn to consider, analysed the spangles and spherules which can be removed by a magnet from the rock that occurs in rounded masses in the basalt ridge, and of which the composition is given in the table of his analyses under III. Some of these spangles could be pulverized only with difficulty, and were readily flattened out; the spherules, though so hard that a sharp steel file would scarcely touch them, were easily crushed. They had the following composition:

Iron	58·25	Phosphoric acid	trace.
Nickel	2·16	Alumina	1·45
Cobalt	0·30	Nickel and Cobalt oxides	0·44
Copper	0·13	Magnesia	0·33
Hydrogen	0·28	Lime	0·50
Carbon	1·64	Soda	0·09
Sulphur...	0·16	Potash	trace.
Chlorine	0·16	Residue...	6·07
Magnetite	30·42		
Silicic acid	0·26		102·64

In the basalt of the ridge, of which an analysis is given under II. in the same table, a compact, very brittle, yellow, or slightly brown mineral occurs in thin flakes, sometimes in nodules of the size of a pea; it is invariably penetrated and usually surrounded by a mineral resembling hisingerite, to which attention will presently be directed. The mineral has a hardness of 5 to 5·5, and easily fuses before the blowpipe with evolution of sulphurous acid to a magnetic regulus. It has the composition:

			Equivalent Ratios.	
Iron...	52·94	57·91	2·068	2·258
Nickel	5·06	5·53	0·190	
Copper	trace.	trace.	—	
Sulphur	33·41	36·56	2·285	
Silicate	8·59	—	—	
	100·00	100·00		

These numbers give the formula (Fe,Ni) S, or that of the iron (nickel) monosulphide or troilite, which has hitherto only been met with in meteorites.

Intimately associated with the troilite, and evidently a product of its oxidation and further alteration, is the mineral already mentioned, the fresh fracture of which is of a light olive-green colour, which by exposure to the air soon becomes brown, and after some days turns quite black.

Its specific gravity is 2·919, and composition:

		Oxygen.
Silicic acid	31·70	16·90
Iron sesquioxide	51·49	15·44
Iron protoxide...	3·81	0·85
Water	15·56	12·05
	100·56	

These numbers indicate the formula:

$$FeO,SiO_2+3(2Fe_2O_3.3SiO_2)+14H_2O$$

as that of the mineral. Nauckhoff, however, draws attention to the rapidity with which the oxidation of the pulverized mineral takes place: five days after the analysis was made the per-centage of iron protoxide in another portion had fallen to 3·47, and after three weeks to 1·55. The original unchanged mineral was probably a hydrated ferrous silicate.

The following rocks from Disko Island have been examined by Nauckhoff:

I. Section of a six-sided basalt column from B室ededal, east side of Skarfvefjell, and about 10′ E. of Godhavn; showing compact dark greyish-green ground-mass with crypto-crystalline texture; under the microscope crystals of a felspar, augite and magnetite are recognized. Fusible before the blowpipe.—II. Basalt from the east side of the ridge at Ovifak, where the iron and breccia were found. Fusible before the blowpipe.—III. Rock occurring in rounded masses, with green foliated crust, in the basalt ridge, and inclosing spangles and spherules of iron, some 6—7 mm. in diameter; these exhibit Widmannstättian figures. Appears to be a very finely granular mixture of a felspar with a small amount of a green mineral, probably augite, and imperfectly crystallized magnetite, which latter usually surrounds the spangles of iron; olivine is only occasionally met with, in grains the size of a pea. Melts with difficulty before the blowpipe.—IV. Very hard brown-coloured mass inclosing rock in which iron spangles are found; it closely resembles III. The ground-mass consists of a felspar, probably anorthite, the crystals of which are occasionally large, and show marks of twinning, and a great number of reddish octahedra closely resembling spinel. Small particles of a greenish mineral of the appearance of augite are also to be distinguished. Spangles of iron are very rarely found in the felspar; and magnetite is apparently absent. Melts very slowly before the blowpipe.—V. Rounded lump of grey rock from the basalt ridge; it was covered with a dark green vesicular crust, from 15 to 20 mm. thick. Through the ground-mass, which appears to consist of a felspar, were disseminated numerous brilliant greyish scales, besides some very black magnetite or graphite. Augite sparsely distributed; abundance of red spinel in some parts, none in others. Melts with great difficulty before the blowpipe.—VI. The dark greenish-brown crust of V, closely resembling that of the rounded masses III. It consists of a felspar inclosing a brown and a green augite-like mineral, and, in places, clusters of granules of spinel. Melts with great difficulty before the blowpipe.—VII. Light grey foliated rock from Ovifak, the exact circumstances of the occurrence of which are not known. The ground-mass consists of a mixture of a felspar with a grey, finely foliated mineral with graphitic lustre. Red spinel is met with abundantly in both constituent minerals. This variety of rock, like those from the ridge, is covered with a rust-like crust. It breaks easily, and always parallel to the scales. Before the blowpipe it melts with difficulty on the edges.—VIII. Compact, slightly-weathered breccia, filling a fissure two to three inches wide in the basalt ridge, parallel to which it runs. It is a black granular mass, devoid of metallic lustre, and incloses fragments, some with edges sharp and angular, others with the corners rounded, of a rock exactly like that forming the ridge.—IX. Loose, much-weathered breccia, from the top of the ridge, in irregularly-shaped fragments. It can be broken in pieces with the hand, is much rusted, and closely resembles the product of the oxidation of the metal blocks. Like the preceding specimen, it incloses rounded fragments of the rock forming the ridge. The specific gravity is about midway between that of iron and of magnetite.—X. The broken-up basalt, resembling that of the ridge, inclosed in the weathered breccia IX.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Silicic acid......	49·18	48·04	42·72	34·72	36·59	44·94	37·92	1·04	0·81	41·25
Titanic acid ...	0·52	0·39	trace	—	—	—	—		—	0·34
Phosphoric acid	0·13	0·07	trace	—	—	—	—	0·12	0·12	—
Iron sesquioxide	5·52	6·89	1·64	4·88	—	—	—		—	16·18
Alumina.........	13·52	13·13	16·01	31·83	19·18	22·20	32·36	2·31	2·92	13·06
Chromium oxide	—	—	—	—	—	—	0·08		—	—
Magnetite	—	—	—	—	—	—	—	52·51	77·39	—
Iron protoxide..	10·31	11·14	14·27	5·53	14·85	9·45	4·02		—	10·78
Manganese protoxide...	0·28	0·11	trace	—	0·29	—	0·19		—	0·25
Nickel and Cobalt oxides	—	—	—	—	—	—	—	1·17	0·82	—
Magnesia	6·83	5·17	7·93	9·35	7·24	4·98	2·86	0·02	trace	6·41
Lime	11·51	10·87	10·10	10·19	8·73	11·01	11·57	0·30	0·20	7·97
Soda	1·84	2·83	1·65	1·00	0·79	1·86	1·48	0·08	0·11	1·54
Potash	0·06	0·06	0·13	0·27	trace	0·06	trace	trace	trace	0·03
Iron	—	—	4·57	0·09	5·01	1·11	—	28·36	7·73	—
Nickel	—	—	0·44	—	0·25	—	trace	1·22	1·81	—
Cobalt	—	—	trace	—	trace	—	trace	0·30	0·33	trace
Copper	trace		trace		trace	trace	trace	0·08	0·30?	trace
Hydrogen	—	0·25?	0·30?	0·29?	0·31?	0·31?	0·24?	0·38	0·51	0·49
Carbon	—	0·79	0·30	0·53	2·55	3·35	6·90	3·52	2·33	0·86
Sulphur	—	0·98	0·32	—	trace	trace	0·77	0·34	trace	trace
Chlorine.........	trace	trace	0·08	0·12	0·23	0·20	trace	trace	0·14	0·25
Water	0·34	—	—	—	—	—	—		—	—
Residue	—	—	—	—	—	—	—	9·64	3·71	—
	100·04	100·72	100·46	98·80	96·02	99·47	98·39	100·39	99·23	99·41
Specific Gravity	3·016	3·024	3·169	2·942	3·141	2·927	2·761	4·560	6·570	3·358

Tschermak examined two microscopic sections of the Ovifak rocks, and compared them with sections of the meteorites of Jonsac, Juvinas, Petersburg, and Stannern, which consist chiefly of augite and anorthite, with little or no nickel-iron; they form a class which G. Rose termed 'eucritic.' Both sections exhibit a crust, as meteorites possess; it is, however, so altered by oxidation, that it is not possible to determine whether it is the fused crust usually noticed on a meteorite. The crystals of felspar, which, according to Nauckhoff's analyses, must be regarded as anorthite, are fully developed; they penetrate the augite, iron, and magnetite, and must evidently have been formed before them. They are completely transparent, and have but few and large cavities, which are filled, partly with black granules, partly with a brown substance of irregular form; some traversing the length of the crystals are filled with a transparent glassy substance. The augite is of a light greenish-brown hue, traversed here and there by flaws; it fills gaps between the other constituents, as has been often observed in dolerites and diabases, and encloses individual black grains. In the section containing iron the colourless felspar encloses a black or brown substance running the length of the crystals, or dust-like fine black granules, or larger round transparent bodies of a violet colour, which may be the mineral Nauckhoff regards as spinel. Side by side with the felspar, brown grains, less numerous than in the former section, are seen, and these are probably augite. Black particles, moreover, occur, which by reflected light appear to be semi-metallic, and are probably magnetite, as well as others that are likewise black, but devoid of lustre, which seem to be graphite. A few small grains of troilite were also recognized. In the second section, which bore a general resemblance to the first, the felspar crystals were larger, the matrix being made up of finer crystals. In some of the felspar crystals cloudy pale brown patches were observed, which, when viewed with a higher power, were found to be due to numberless minute elongated inclosed granules lying in parallel position, or to others that were shorter and more rounded. These appearances recall those noticed in eucritic meteorites, like that of Jonsac, except for the fact that the inclosed particles are of smaller size. The larger cavities in the felspar are filled in the same manner as in the other rock section from Ovifak. The structure of eucritic meteorites is tufaceous; that of the Ovifak rock very compact. This distinction, however, has often been observed in meteorites. Many chondritic meteorites are tufaceous; while others, having similar chemical composition, like the aerolites of Lodran and Manbhoom, are compact and crystalline. The augite of the Ovifak rocks has not the characteristically filled cavities observed in that of certain eucritic meteorites; but in the augite of some meteorites, as those of Shergotty and Busti, for example, they are equally wanting.

The meteorites of Ovifak in some respects resemble the carbonaceous meteorites, though they differ greatly from them in other characters: especially in the appearance of both metallic and rocky portions. They form a new type in the series of meteoric rocks, and fill the gap that has hitherto separated the carbonaceous from other meteorites.

If some differences are to be traced between the remarkable rocks and irons of Ovifak and known meteorites, others still greater present themselves, when we compare the Greenland masses with terrestrial rocks, even with the basalts and diorites, near which it might be proposed to class them, on account of the occurrence in them of magnetite, and of the crystalline arrangement of their silicates. Iron has not hitherto been found as metal inclosed in basalt, except on very rare occasions (as by Andrews in the basalt of Antrim,[1] and then only in fine particles, and apparently not alloyed with nickel and cobalt), while troilite is a meteoric mineral, and has never been met with in a terrestrial rock.

But if the weight of evidence favours the assumption that these masses are of meteoric origin, there remain the following considerations, to which attention has been drawn by Rammelsberg, supporting the view that they may possibly have been erupted.

Of the rocks composing the globe, the greater portion accessible to us have been modified by the action of water. There is one class of which this cannot be said: the molten masses brought to the surface by volcanos, the various rocks we term "lava." However they may differ as regards constituent minerals, they have amongst them a family resemblance, and it is with them that the meteoric rocks may be compared. The old lavas of Iceland and Java consist of augite and anorthite, as do the meteorites of Juvinas, Jonsac and Stannern. The "bombs" of the prehistoric volcanos of the Eifel are composed of olivine, augite, bronzite and chromite, minerals that are commonly met with in meteorites. Hence arises the question: Are these masses, so similar in their lithological characters to the meteorites, samples perhaps of the inner unchanged nucleus of our planet? Does the original mass of the earth differ only in point of magnitude from the fragments which yield to its attraction?

The mean density of the earth is greater than that of the minerals composing the rocks of the outer crust. The volcanic rocks and the meteorites, which in point of chemical constitution are basic, are alike denser than this crust. The presence of metallic iron, a characteristic feature of meteorites, points to the absence of water and free oxygen as one of the essential conditions for their formation. Terrestrial rocks rarely contain iron, but it is replaced by an oxidized form of iron,—magnetite; only in combination with platinum is it found in the metallic state. May the rocks of the

[1] A. E. Reuss detected the presence of iron in some Bohemian basalts by Andrews' method. (*Kenngott's Uebersicht Result. Min. Forschungen*, 1859, 105.) At a meeting of the American Association for the Advancement of Science, held at Hartford, J. L. Smith (*Revue Scientifique*, 1875, June 5th, No. 49, 1167,) maintained the great importance of the study of basaltic rocks as affording us the only means of becoming acquainted with the mineral constitution of the greater part of the globe. He called attention to the existence of metallic iron and the presence of nickel and cobalt in the basalt of Arizona, and alluded to some researches on which he had been recently occupied which had convinced him that at temperatures which we are able to produce by artificial means the oxides of iron can be dissociated.

interior of our globe contain this, the most important of all the metals, in an uncombined condition?

It has been pointed out by Daubrée that a region like Greenland, where doleritic rocks cover so wide an area, appears in a marked degree to present the conditions necessary and favourable for the upheaval of masses from very considerable depths.

Another phase of the question to which he directs attention should also be mentioned. It appears not improbable that the basalt of Greenland, which contains more than 20 per cent. of iron oxide, may during eruption have undergone reduction such as he imitated in his laboratory some years since. This theory is the more admissible from the fact that in the region under consideration, between Lat. 69° and 72°, numerous large beds of lignite, as well as graphite, occur, especially in the island of Disko, in which Ovifak is situated.

In a paper on the anomalous magnetic characters of iron sesquioxide, prepared from meteoric iron, recently communicated to the French Academy by Dr. Lawrence Smith, he announces that the investigation of this iron, on which he is at present occupied, has convinced him that the Ovifak metallic masses are of terrestrial origin.

The fact, observed by Nordenskjöld and Wöhler, of the evolution of a large amount of gas by Ovifak iron when heated, led these observers to the conclusion that it could never have been exposed to a high temperature. Tschermak, however, points out that this phenomenon has only been observed in experiments conducted at ordinary pressure; and it must not be forgotten, he maintains, that these masses, though surrounded by a heated medium, were at the same time subjected to the superincumbent pressure of a vast layer of fluid basalt. They may, moreover, have originally had a different composition, and the oxygen, which plays so essential a part in the gaseous evolution, may have been taken up subsequently during exposure to the atmosphere.

Daubrée draws attention to a reaction, mentioned by Stammer, and thoroughly investigated by Gruner,[1] that, in the presence of iron oxide, or even of iron under certain circumstances, carbonic oxide breaks up, depositing carbon, partly in combination with iron, partly in intimate mixture with iron oxide; and that this reaction, which has been found to occur at 400°, does not take place at very high temperatures.

Nordenskjöld's paper is illustrated by a plan of the shore at Ovifak, where the irons were found, and by a sketch made on the spot by Nordström of the three largest masses, showing them partly immersed; while in a plate are given representations of seven of the blocks—one showing very distinctly the manner in which the metal is rent during oxidation. Nauckhoff has appended to his paper in the *Mittheilungen* a drawing of the gangue, indicating the position of the smaller pieces of iron and the breccia. Four excellent photographs of the larger masses have been published by the Hofphotograph Jaeger, in Stockholm.

[1] E. L. Gruner. *Compt. rend.*, xxiii. 28; xxiv. 226.

One of the largest blocks, weighing 10,000 lbs., was offered for sale in New York for 12,500 dollars in gold, and smaller specimens at eight dollars per lb.

As is well known, implements of meteoric iron have from time to time been found in the possession of the Esquimaux. Some recent specimens, inserted in bone handles, from Esquimaux kjœkkenmœddings, were described by Steenstrup at the *Congrès international d'Anthropologie et d'Archéologie préhistoriques à Bruxelles* (Session de 1872). Figures of a number of these implements are to be found in the *Matériaux pour l'histoire primitive et naturelle de l'Homme,* 9 Année, 2e Série, Tome IV. 2e Livraison, 1873, 65, the original paper with illustrations appearing in the *Compt. rend. de la* 6e *Session,* 242, and plates 24, 25, and 26. J. Steenstrup examined more than twenty of these implements, and gives drawings of seven of them, four of which are reproduced in the following woodcut.

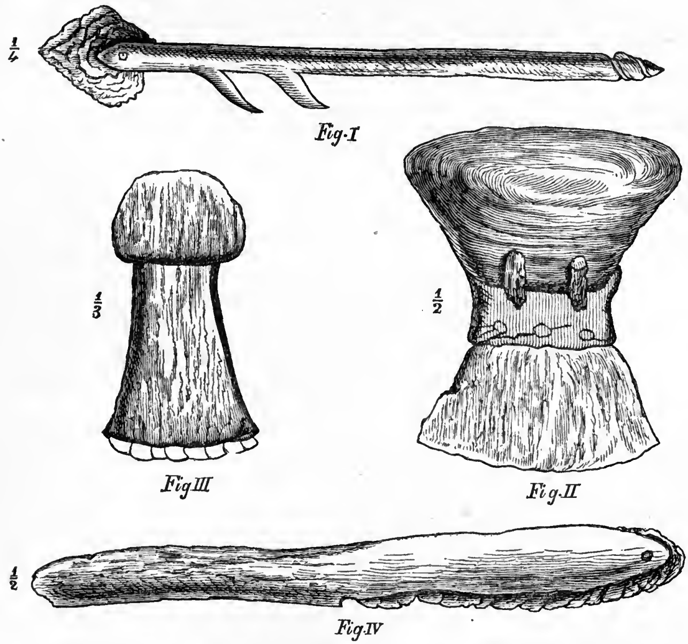


Fig. I. is a barbed weapon with iron point; Fig. II. is an axehead set in bone, with a socket of wood; Fig. 3 is an "Ullo," a tool for cutting leather; and Fig. IV. is a knife with a blade of meteoric iron, formed like the earlier known implements. Prof. F. Johnstrup, Professor of Mineralogy in the University of Copenhagen, determined the presence of about 3 per cent. of nickel in these irons, and found them to distinctly exhibit Widmannstättian figures. He believes that the metal has not been subjected to the action of heat. It is not a little curious that among the Esquimaux tradition has always pointed to the Island of Disko and the neighbourhood of Waigat, those districts, in fact, whence they procured iron, as the area where the earliest settlements took place in Greenland.[1]

Cryoconite found 1870, July 19th—25th, on inland ice, east of Auleitsivik Fjord, Disko Bay, Greenland.—Meteoric metallic particles found in snow, which fell:—1.) 1871, December—Stockholm.—2.) 1872, March 13th—Evoia, Finnland.—3.) 1872, August 8th—Lat. 80° N.; Long. 13° E.—4.) 1872, September 2nd—Lat. 80° N.; Long. 15° E.[2]

Early in December, 1871, there was a heavier fall of snow in the neighbourhood of Stockholm than any that had occurred there within the memory of living persons; and it presented to Nordenskjöld an opportunity of determining whether the snow brought cosmical matter to the earth's surface. A cubic metre of apparently pure snow, collected towards the end of the fall, left on melting a small black residue. From some of this substance, when heated, a liquid product distilled over; a portion when burnt left a red ash; while a magnet extracted particles which, when rubbed in an agate mortar, exhibited metallic characters, and on being treated with acid proved to be iron. Although the possibility must be admitted that this material may have been derived from the chimneys and iron roofs of the city, already covered with a thick layer of snow, the result was sufficiently interesting to make it desirable that a similar experiment should be tried with snow falling remote from towns. For this purpose snow was collected on the 13th March, 1872, by Dr. Karl Nordenskjöld at Evoia, in Finnland, to the north of Helsingfors, and lying in the centre of a large forest. It was taken from off the ice of the Rautajerwi, at a spot which is separated by a dense wood from the houses of that northern station. When melted, this snow yielded a soot-like residue, which under the microscope was found to consist not only of a black carbonaceous substance, but white or yellowish-white granules, and from it the magnet

[1] Dr. I. J. Hayes, the arctic explorer, in a letter to Prof. Shepard (*Am. Jour. Sc.*, 1866, xlii., 249), speaks of a flake of meteoric iron which he obtained at Port Foulke in 1861 from an Esquimaux, who had carefully preserved it and other fragments to make (with an ivory blade) the edge of a knife. The iron, it was stated, had been detached by means of flints, and was obtained from a place called Savisavik (*savik* =knife) 20 miles S. and E. of Cape York, N. Greenland, in Lat. 76°. This does not appear to be the same source of metal as that described in Ross's *Voyage to Baffin's Bay*, 1819, 105, as Sowallick (iron mountain), between Cape Melville and Cape York (Lat. 76° 12′ N., Long. 65° 53′ W.), which is N.W. of the latter Cape.

[2] A. E. Nordenskjöld. Redogörelse för en Expedition till Grönland år 1870, 28. (See also Geol. Mag. IX. 356.) *Compt. rend.*, lxxvii. 463. *Jour. Prakt. Chem.*, x. 356. *Pogg. Ann.*, cli. 154.

removed black grains, that when rubbed in a mortar were seen to be iron. Here again the material was too small in amount to allow of a determination of the presence of nickel and cobalt; in other words, to establish the meteoric origin of the metal. The Arctic Expedition of 1872 presented an opportunity for the collection of snow in a region as far removed as possible from human habitation. On the 8th August, the snow covering the drift-ice at Lat. 80° N. and Long. 13° E., was observed to be thickly covered with small black particles, while in places these penetrated to a depth of some inches the granular mass of ice into which the underlying snow had been converted. Magnetic particles were abundant, and their power to reduce copper sulphate was established. Again, on the 2nd September, at Lat. 80° N. and Long. 15° E., the ice-field was found covered with a bed of freshly fallen snow, 50 mm. thick, then a more compact bed 8 mm. in thickness, and below this a layer 30 mm. thick of snow converted into a crystalline granular mass. The latter was full of black granules, which became grey when dried, and exhibited the magnetic and chemical characters already mentioned; they amounted to 0·1 to 1·0 millegramme in a cubic metre of snow. Analysis of some millegrammes enabled Nordenskjöld to establish the presence of iron, phosphorus, cobalt, and probably nickel. The filtrate from the iron oxide gave a small brown precipitate, which gave a blue head with borax. The portion insoluble in acid consisted of fine angular colourless matter, containing fragments of diatoms. This dust from the polar ice north of Spitzbergen bears a great resemblance to the remarkable substance, cryoconite,[1] which was found in Greenland in 1870, very evenly distributed in not inconsiderable quantity on shore-ice, as well as on ice thirty miles from the coast and at a height of 700 metres above the sea. The dust of both localities has probably a common origin.

The cryoconite is chiefly met with in the holes of the ice, forming a layer of grey powder at the bottom of the water filling the holes. Considerable quantities of this substance are often carried down by the streams which traverse the glacier in all directions. The icehills which feed these streams lie towards the east, on a slowly rising undulating plateau, on the surface of which not the slightest trace of stone or larger rock masses was observed. The actual position of this material, to which Nordenskjöld has given the name of cryoconite (*κρύος* ice, and *κόνις* dust), in open hollows on the surface of the glacier, precluded the possibility of its having been derived from the ground beneath.

The grey powder contained a not inconsiderable amount of organic matter, which, even at the low temperature of the ice, undergoes putrefactive decomposition. A quantity, amounting to from two to three cubic metres, which was lying in the dried-up bed of a glacier stream, emitted a very offensive odour, bearing some resemblance to that of butyric acid.

[1] A. E. Nordenskjöld. An Account of an Expedition to Greenland. Geol. Mag. Vol. IX. p. 355.

When examined with the microscope, the chief constituent of this powder appears to consist of colourless, crystalline, angular, transparent grains, among which are a few yellow and less transparent. Some had distinct cleavage-surfaces, and were possibly a felspar; other crystal fragments, having a green colour, were probably augite; while other black, opaque particles could be removed with a magnet. These foreign constituents, however, are present in so small a quantity that if all the white grains consist of one and the same mineral, it may be regarded as homogeneous. The specific gravity of this mineral is 2·63; the hardness apparently inconsiderable, and the form probably monoclinic. It resists the action of acids: by long digestion with sulphuric acid 7·73 per cent., with hydrochloric acid 16·46 per cent. were dissolved. Lime carbonate was not present. According to Lindström's analysis, it consists of:

Silicic acid	62·65	Potash	2·02
Phosphoric acid	0·11	Soda	4·01
Alumina	14·93	Chlorine	0·06
Iron oxide	0·74	Water (hygroscopic)	0·34
Iron protoxide	4·64	Organic matter and combined water[1]	2·86
Manganese protoxide	0·07		
Lime	5·09		——
Magnesia	3·00		100·12

This composition corresponds with the formula:

$$2RO,SiO_2 + Al_2O_3,3SiO_2 + H_2O.$$

The origin of this cryoconite is highly enigmatical. That it is not a product of the weathering of the gneiss of the coast is shown by its inferior hardness, indicating the absence of quartz, the large proportion of soda, and the fact of mica not being present. That it is not dust derived from the basalt area of Greenland is indicated by the subordinate position iron oxide occupies among the constituents, as well as by the large proportion of silicic acid. We have then to fall back on the assumption that it is either of volcanic or cosmical origin.

That dust can be carried enormous distances has been well established. Darwin[2] refers to instances of dust having fallen on ships when more than a thousand miles from the coast of Africa, and at points sixteen hundred miles distant in a north and south direction. If the Greenland dust were volcanic, it would probably have been wafted from Iceland or Jan Mayen, or some as yet unknown volcanic region in the interior of Greenland. Nordenskjöld found it to bear the closest resemblance under the microscope to the ash of Vesuvius (1822), and a specimen of that which fell at Barbadoes and probably came from St. Vincent. Looked at in the mass, however, it is at once seen that the volcanic ash is of a brownish red; the cryoconite is grey. The magnet when placed in contact with the Vesuvian ash extracted nothing; out of that from Barbadoes

[1] This passed off when the mineral was heated to temperatures ranging from 100° to a red heat.

[2] C. Darwin. *Journal of Researches. . . . . Voyage of H.M.S. Beagle*, new ed. 1870, p. 5.

it drew magnetic particles, which, however, were not metallic, nor did they contain nickel or cobalt.

The cryoconite, nevertheless, whencesoever it comes, contains one constituent of cosmical origin. Nordenskjöld extracted, by means of the magnet, from a large quantity of material, sufficient particles to determine their metallic nature and composition. These grains separate copper from a solution of the sulphate, and exhibit conclusive indications of the presence of cobalt (not only before the blowpipe, but with solution of potassium nitrite), of copper, and of nickel, though in the latter case with a smaller degree of certainty, through the reactions of this metal being of a less delicate character. Moreover, ammonia removes from cryoconite a humus-like substance that, among other characteristics, in its powers of resisting powerful oxidizing reagents, closely resembles the organic compound found in the residue of Ovifak iron after treatment with acid.

Hail, which fell at Stockholm in the autumn of 1873, was found by Nordenskjöld to contain grey metallic particles that reduced copper from its sulphate. Although the roofs of the buildings surrounding the Academy, in the courtyard of which these hailstones fell, are of iron, the grains were rounded, and of light colour, instead of a reddish-brown, and the observation is of sufficient interest to allow of its being placed on record.

It has been shown that small quantities of a cosmical dust, containing iron, cobalt, nickel, phosphorus, and carbonaceous substances, fall with other atmospheric precipitates on the earth's surface. Nordenskjöld, in his paper, alludes to the theory, already advanced, we believe, by Haidinger, that this deposit may play an important part in the economy of nature in supplying phosphorus to soils already exhausted by the growth of crops. His observations, moreover, are of value from the light they throw on the theories of star-showers, auroræ, etc. The small but continuous increase of the mass of our planet which appears to take place may lead students of geology to modify the view at present held, that from the time of the first appearance of vegetable and animal life upon our planet it has undergone no change, in a quantitative sense—in other words, that the geological changes which have occurred have been confined to a difference in the distribution of material, and not to the introduction of new material from without.

When the instances of the fall of soot-like particles, blood-rain, sulphur-showers, etc., which have from time to time been described, are considered, the view pronounced by Chladni, that these phenomena are due to the precipitation of large quantities of cosmical dust, appears of great import. The black carbonaceous substances which fell with the Hessle meteorites, and coated some of them, may be quoted as an illustration. Some meteorites, moreover, are so loose and friable in texture that they are very readily reduced to powder, as the Ornans meteorite (1868, July 11th), while that which fell at Orgeuil (1864, May 14th) breaks up when placed in water. If this stone had not fallen on a day when the atmosphere was dry, portions, if not the whole of it, would probably have reached the earth's surface in the form of powder. These atmospheric deposits may have a very varied composition. The dust which fell in Calabria, in 1817,[1] contained chromium. The red rain that fell at Blankenberg, in Flanders,[2] in 1819, owed its colour to the presence of cobalt chloride.

In 1872 three papers were published in the *Comptes rendus*,[3] on the origin of polar auroræ, which called forth one from Baumhauer,[4] where he refers to a theory as to their origin propounded in his thesis *De ortu lapidum meteoricorum* (Utrecht, 1844). After having shown the connexion which apparently exists between the planets, their satellites, the comets, the shooting-stars, the meteorites ("*qui, pour moi, sont de petites planètes*"), and the zodiacal light, a disk of asteroids or cosmical matter massed together near the sun, he gives expression to the following views respecting the polar auroræ: Not only solid masses, large and small, but clouds of "uncondensed" matter probably enter our atmosphere (probabile etiam est nebulas materiei primigeniæ sine nucleo condensato in atmosphæram venire). If, from our knowledge of the chemical composition of the stones and irons which fall to the earth's surface, we may draw any conclusion respecting the chemical constitution of these clouds of matter, it appears possible that, as many of these stones consist partly, and the irons almost entirely, of iron and nickel, the attenuated cloud-like matter may also contain a considerable proportion of these magnetic metals.

Let such a cloud, the greater part of the constituents of which have magnetic characters, approach our earth, which we have been taught to regard as a great magnet. It will evidently be attracted towards the poles of this magnet, and, penetrating our atmosphere, the particles which have not been oxidized and are in a state of extremely fine division will, by their oxidation, generate light and heat, the result being the phenomenon which we term a polar aurora. Observations have shown that the seat of these phenomena is about, not the geographical, but the magnetic poles. Not a few facts, even at that time, could be advanced in support of the theory, which assumes the occasional presence of metallic particles in the higher regions of our atmosphere. More than once such particles had been discovered in a fall of hail. Eversmann[5] found in the hailstones which fell on the 11th June, 1825, at Sterlitamak, 200 wersts from Orenburg, Siberia, crystals of a compound of iron and sulphur, in which Hermann found 90 per cent. of that metal.[6] In hail which fell in

[1] L. Sementini. *Atti della Reale Acad. delle Scienze*, 1819, i. 285. *Gilbert's Ann.*, lxiv. 327.
[2] Meyer and Van Stoop. *Gilbert's Ann.*, lxiv. 335.

[3] Le Maréchal Vaillant. *Compt. rend.*, lxxiv. 510 and 701.—J. Silbermann. *Compt. rend.*, lxxiv. 553, 638, 959, and 1182.—H. Tarry. *Compt rend.*, lxxiv. 549.

[4] E. H. Von Baumhauer. *Compt. rend.*, lxxiv. 678.

[5] E. Von Eversmann. *Archiv für die gesammte Naturlehre*, iv. 196.—A. Neljubin. *Archiv für die gesammte Naturlehre*, x. 378.—R. Hermann, *Gilbert's Ann.*, lxxvi. 340.

[6] Though von Baumhauer cites this instance, it does not appear that the metallic character of the "crystals" was fully established in this case. Neljubin found them to consist of 70 per cent. iron oxide, and 17·5 per cent. of other metallic oxides. In

the province of Majo in Spain on the 21st June, 1821, Pictet[1] found metallic nuclei which were proved to be iron; and the hail which fell in Padua on the 26th August, 1834, was observed to contain nuclei of an ashy grey colour. The larger ones were shown by Cozari[2] to be attracted by the magnet, and to contain iron and nickel. "It would," wrote Baumhauer, "be very interesting, in verification of this theory of the origin of polar auroræ, to detect in the soil of polar areas the presence of nickel." This theory, which at the time it was promulgated appeared so rash that it met with severe criticism by the great Berzelius,[3] has gained support from recent researches; among others, the discovery by Heis of the simultaneity of boreal and austral auroræ, the relation between the auroræ and the meteor showers, the perturbations of the telegraph lines, which not only accompany, but forecast an auroral display; and the identity of the light, principally that of the green portion of the spectrum, in zodiacal and auroral light, as established by Respighi.[4]

In connexion with this subject, reference should be made to the discovery by Reichenbach some years since of the presence of nickel in soils. From the Lahisberg in Austria, a conical hill some 300 to 400 metres in height, and covered to the summit with beech-trees, he took samples of soil from the thick underwood, and found therein traces of nickel and cobalt. Other specimens from the Haindelberg, Kallenberg, and Dreymarcksteinberg, adjacent hills, yielded the same results, and that from the Marchfeld plain also revealed traces of nickel. These hills consist of beds of sandstone and chalk, and are quite free from metallic veins. It has already been suggested that impoverished soils may have their fertilizing powers renewed by the precipitation of cosmical matter containing phosphorus.

1871. February 4th. 2·20 p.m.—Konisha, Minnesota.[5]

The meteor appeared to come from N. of E. When it reached a point 4° N. of W. of Konisha (Lat. 45° 10′; Long. 94° 10′), and was at an elevation of 38°, it exploded with a detonation like the combined roar of a park of artillery. The concussion was so great that

fact, this substance appears to have been an impure limonite, like that which fell at Iwan, in Hungary, on the 10th August, 1841, and was probably not meteoric.

[1] M. Pictet. *Gilbert's Ann.*, lxxii. 436.

[2] D. L. Cozari. *Ann. Sc. Regn. Lomb.*, 1834, Nov. e Dec. *New Ed. Phil. Jour.*, xxxvii. 83.

[3] *Jahresbericht*, xxvi. 1847, 386.

[4] L. Respighi. *Compt. rend.*, lxxiv. 514.—The green ray is that known as 1241 in Kirchhoff's scale; and near it is another of less brilliancy, 1826 in the same scale. —For a description of a spectroscopic examination of the zodiacal light see a paper by A. W. Wright (*Arch. sc. ph. et. nat.*, October, 1874).

[5] *Amer. Jour. Sc.*, 1871. i. 308.

it shook the houses. From four different points on a base-line of 42 miles observers were not able to mark any divergence from the general direction of N. 86° W. The distance from Konisha must have been considerable at which the explosion of the meteor took place. No meteorites have yet been found.

1871. March 24th. 2 a.m. (local time).—Urbino, Province of Urbino and Pesaro, Italy.[1]

A brilliant meteor was observed by Serpieri at the Observatory of Urbino, which left a persistent streak. It was attended with an explosion.

1871. March 24th. 4·25 a.m. (local time).—Volpeglino, Piedmont, Italy.[2]

This meteor is described in a Turin newspaper by F. Denza. Its apparent course was from α Cygni across α Andromedæ to near ζ Piscium. The nucleus had a diameter of 25′. The colour was of a brilliant white, and it left a very persistent ruddy streak along its whole course. It burst with a violent detonation, which was heard about half a minute after its disappearance.

1871. April 12th. 8·15 p.m. (local time).—Lodi, Moncalieri, Piedmont, Italy.[3]

A very large and brilliant meteor traversed the heavens from 111 + 7 to 105 + 2, and burst with a loud detonation, which was heard in houses with closed doors. The account of this meteor is communicated by F. Denza, of the Observatory of Moncalieri.

1871. May 21st. 8·15 a.m.—Searsmont, Maine.[4]

The explosion attending this fall resembled the report of a heavy gun, followed by a rushing sound like the escape of steam from a

[1] *Brit. Assoc. Report*, 1871. Obs. Luminous Meteors, 37.
[2] *Brit. Assoc. Report*, 1871. Obs. Luminous Meteors, 36.
[3] *Brit. Assoc. Report*, 1871. Obs. Luminous Meteors, 36.
[4] C. U. Shepard. *Amer. Jour. Sc.* [3], ii. 133.—J. L. Smith. *Amer. Jour. Sc.* [3], ii. 200.

boiler. It probably came from the south, as the report was heard at Warren, 12 miles to the S.W., but not at Searsmont, 3 miles to the N.E. About two minutes after the explosion a woman saw the earth thrown up at a spot about 30 rods distant from her. The meteorite entered the hard soil to a depth of two feet, making a vertical hole, and striking some large pebbles which shattered the stone. It weighed altogether 12lbs., the largest fragment being 2lbs. When dug out, 25 minutes after the fall, it was still hot. The form of the complete stone is described as of an oval subconical figure, with a flat base, and resembles the Durala meteorite (1815, February 18th) preserved in the British Museum. The crust of the base is perfectly black, and more perfectly fused than that of the sides; it is moreover of unusual thickness, amounting to about 1–16th of an inch. The colour of the interior is a bluish-white and is very uniform. More than half the stone is made up of rounded grains of the size of mustard-seed, with fine-grained white or greyish-white interstitial matter, which Shepard calls chladnite, but which would perhaps now be more correctly termed enstatite. The larger globules are bluish-grey, with an occasional faint tinge of yellow, are vitreous and translucent, have two imperfect oblique cleavages, and bear a resemblance to boltonite. Minute grains of iron are thickly scattered through the mass, with a few grains of troilite and one little black mass, which was probably graphite. The specific gravity of the stone is 3·626—3·701. Dr. Lawrence Smith traces a great resemblance, as regards the crust, between this stone and that which fell at Mauerkirchen (1768, November 20th); but both observers agree that in other respects, more especially in spherular structure, it is like the meteorite of Aussun (1858, December 9th). It is to be regretted that the constituents of this stone, which can apparently be so readily isolated, have not been subjected to separate analysis.

The total composition of the stone is as follows:—

Olivine	43·04
Bronzite, hornblende, with a little albite (or orthoclase) and chromite	39 27
Nickel-iron	14·63
Magnetic pyrites (?)	3·06
	100·00

The nickel-iron consists of:

Iron = 90·02; Nickel = 9·05; Cobalt = 0·43 = 99·5

and the stony portions, soluble and insoluble in acid (and alkali), amounting respectively to 52·3 per cent. and 47·7 per cent., have the following composition:

	SiO_2	Al_2O_3	FeO	MgO	Alkalies	Fe_7S_8		
A. *Soluble*	40·61	...	19·21	36·34	...	3·06	=	99·22
B. *Insoluble*	56·25	2·01	13·02	24·14	2·10	...	=	97·52

1871, Spring of.—Roda, Province of Huesca, Spain.[1]

The exact date of the fall of this meteorite is not known, but it is stated to have occurred during the spring of 1871, at a spot two kilometres from Roda. Two fragments, in the possession of Pisani, weigh about 200 grammes, and appear to have formed the half of a stone which was of the size of a fist. It is covered with a black crust, which is continuous and brilliant in places where this species of lustrous varnish has run. The interior is ashey-grey, with greenish grains resembling peridot (some of them several millimetres in diameter) scattered throughout the mass. The grey surface is, however, not of a uniform tint, but presents two irregularly shaped areas, one being grey, the other yellowish-grey. The stone is very friable, and is without action on the magnetic needle. Before the blowpipe it is fusible, becoming black and feebly magnetic.

Only a small portion, 14·75 per cent., of the meteorite is broken up by acid, that unacted upon amounting to 85·97 per cent. Below are given, in addition to the composition of the constituents separated by acid, the results of an analysis of the minerals constituting the mass of the stone:

	SiO_2	Al_2O_3	Cr_2O_3	FeO	CaO	MgO	K_2O and Na_2O	S	
A. *Soluble.*	38·85	4·81	...	24·27	8·21	23·86	...	...	=100·00
B. *Insoluble.*	52·93	1·95	0·39	16·29	1·92	26·52	...	...	=100·00
C. *Total.*	51·51	2·30	0·34	17·04	2·31	26·61	0·80	0·40	=101·31

The soluble portion appears to be an iron olivine, mixed probably with a little anorthite; the insoluble portion consists chiefly of bronzite, or, according to Pisani, probably hypersthene, with the specific gravity of which mineral that of the meteorite more closely accords. The sulphur and the chromium are, it is presumed, present as magnetic pyrites and chromite; no nickel whatever was detected.

The yellowish-green grains were very slightly attacked by acid, only 6 per cent. being soluble in that reagent. Their composition proved to be—

Silicic acid	51·10	... ... 27·3	
Alumina...	2·83	... ... 1·3	
Iron protoxide	27·70	... ... 11·1	} 14·9
Magnesia	17·20	... ... 3·8	
	98·83		

These numbers indicate, according to Pisani's view, the presence of a hypersthene rather than a bronzite, a hypersthene richer in iron than that of Farsund, Norway. The ratio of iron oxide to magnesia is the same as that in the bronzites of the Hainholz, Shalka, Borkut and several other meteorites.

On some grains of this mineral a well-marked cleavage was distinguished along one direction; in others a disposition to cleave

[1] F. Pisani. *Compt. rend.*, lxxix. 1507.—G. A. Daubrée. *Compt. rend.*, lxxix. 1509.—*Der Naturforscher*, viii. 92.

along a second direction was remarked; on examining such fragments in the polarizing microscope, however, one of the optic axes was almost always seen, while the other was invisible. The angle of the optic axes, as measured in oil, was approximately determined, making $2H=104°$. The bisectrix is negative; but whether it was the acute or obtuse bisectrix, was not determined.

This meteorite is remarkable for containing no metallic iron, and a very large proportion of bronzite or hypersthene.

Daubrée, during an examination of microscopic sections, noted many characters which favour the assumption that the chief constituent of this meteorite is bronzite rather than hypersthene. Such are: the absence of dichroism, the frequent occurrence of the right angle in the contour of the crystals, and the fineness of the striæ, peculiar to bronzite. When magnified 800 diameters, most of the crystals are found to enclose yellowish-brown rarely translucent matter, with very varied contour, and occasionally with a crystalline form, that of a modified oblique prism, which is that of pyroxene. They are ranged in rectilinear series, which are not always orientated parallel to the axes of the crystal. Here and there, adhering to the crystals, a brown vitreous substance, which is without action on polarized light, is seen; and in it occur cavities of relatively large dimensions, closely resembling those usually found in basaltic rocks. The Roda meteorite, with the single exception that it contains no iron, bears a great likeness to the meteorite of Lodran (1868, October 1st), and establishes a new link between cosmical rocks and those belonging to our planet. If, says Daubrée, we were to refuse to admit the testimony of those persons who affirm that they witnessed the fall of this fragment of rock, the characters of its crust would fully attest its cosmical origin.

1871, November.—Montereau, Seine-et-Marne, France.[1]

"It is stated that a meteorite, weighing 127lbs., lately fell near Montereau. It came from the east, and burst with a loud explosion, emitting a bright blue light. It is an irregular spheroid, and is black (on the outer surface only?). It is to be sent to the Academy of Sciences." No more recent information respecting this meteorite has reached me.

1871, December 10th, 1·30 p.m.—Gœmorœh, etc., near Bandong, Java.[2]

Three strange explosions were heard, and six stones were found. The largest, weighing 8 kilog., fell in a rice-field in the village of

[1] *Nature*, November 30, 1871.—R. P. Greg. *Brit. Assoc. Report*, 1872, 79.
[2] G. A. Daubrée and R. Everwijn. *Compt. rend.*, lxxv. 1676.

Gœmorœh, and penetrated the soil obliquely to the depth of one metre. A second, 2·24 kilog. in weight, and a third, weighing 0·68 kilog., fell in a rice-field about 2200 metres S.W. of Babakan Djattie, and 1500 metres from Tjignelling, or 3700 metres from the spot where the first stone struck the ground. The three remaining stones weighed in all 150 grammes.

The stone second in size, now in the Paris collection, is an irregular block, with rounded edges. It is completely enveloped in a dull black crust, and the natural surface exhibits numerous cavities of different size, which bear a great resemblance to those produced on quartzite by exposing it to the oxy-hydrogen flame. A fresh fracture is grey, and enclosed in the silicate forming the greater portion of the stones are three kinds of granules, which have metallic lustre: the one, of an iron grey, which is at once identified as nickel-iron; the second, of a bronze-yellow, which often possesses a blue or yellow tint, is troilite; and the third, black and insoluble, is chromite. The siliceous portion, when examined under the microscope, was found to be made up of transparent, much-broken grains, which are, throughout, crystalline.

The stone was examined in Java by Dr. Vlaanderen, who found it to have the specific gravity 3·519, and the following composition:

	SiO_2	Al_2O_3	FeO	MnO	MgO	CaO	K_2O	Na_2O	Fe	Ni	Co	S	Chromite.	
A. *Soluble.*	28·669	2·377	28·036	0·199	21·290	0·498	1·479	1·164	8·227	1·712	0·233	3·540	...	= 97·424
B. *Insoluble.*	51·218	6·352	10·796	trace	13·633	1·908	0·452	3·741	...	...	...	...	11·074	= 99·174

The analyst's method of grouping these constituents shows the meteorite to have the following mineralogical composition:

Olivine	47·26
Augite	20·98
Felspar	17·00
Nickel-iron	2·81
Troilite	5·44
Chromite	4·41
	97·90

If we assume that the iron oxide in the insoluble portion of this meteorite, which is stated in Vlaanderen's analytical results to be in the state of peroxide, to be, as is more probable, in the form of protoxide, this portion of the stone appears to consist of a bronzite, in which Fe : Mg is as 1 : 1, and a felspar with the oxygen ratios of $RO : R_2O_3 : SiO_2$ as 1·04 : 2·96 : 11·6 or those of an albite or orthoclase. About 60 per cent. of the minerals in this meteorite may be broken up by acid, the remaining 40 per cent. withstanding its action.

[1] *Annales des Mines*, 1869, xix. 29.

Meteoric Irons found 1870 or 1871.—San Gregorio, etc., Bolson de Mapimi, Mexico.[1]

With the object of fixing with greater precision the geographical position of the meteoric masses that have from time to time been met with on the Mexican Desert, Dr. Lawrence Smith communicated a paper to the *Amer. Jour. Science.* There were already known the Cohahuila meteorite of 1854 (No. 1); the Cohahuila meteorite of 1868 (No. 2); the Chihuahua iron of 1854 (No. 3), still at the *Hacienda de Conception*, weighing about 4000lbs.; and the Tucson iron (No. 4), found in 1854 on the north side of the Rio Grande; it is in the form of a ring, and weighs from two to three thousand pounds. Another mass (No. 5) has since been heard of on the western border of the Mexican Desert, which from the locality has been named the *San Gregorio Meteoric Iron.*[2] It measures 6 feet 6 inches in length, is 5 feet 6 inches high, and 4 feet thick at the base, and is in the form of a sofa. On one part of its surface the date "1821"[3] has been cut with a chisel, and above it stands the inscription: "*Solo dios con su poder este fierro destruirá, porque en el mundo no habra quien lo pueda deshacer.*" (God alone with his might this iron will destroy, for in the world is no one able to break it in pieces.) It lies within the enclosure of a hacienda, having been hauled to the ranch years ago by the Spaniards, who, so the story goes, thought to use it for the manufacture of farm implements. Its weight is estimated to be about five tons. An examination of a fragment showed it to consist of:

Iron = 95·01; Nickel = 4·22; Cobalt = 0·51; Phosphorus = 0·08; Copper = Trace; Total = 99·82.

Still more recently we have news of the discovery, in the central portion of the desert, of a meteorite (No. 6) larger than any previously found in that region. It should be stated here, that in addition to meteorites No. 3 and No. 4, Juan Urgindi mentions other larger ones at Chupaderos, 20 leagues N.W. of No. 4. L. Smith's paper is illustrated with a little map indicating the relative position of these masses. He is of opinion that they are the result of two falls. The Tucson iron (also called the *Signet meteorite* and the *Ainsa meteorite*) he finds to possess characters which distinguish it from the other five. The latter probably fell at an epoch far remote, moving from N.E. to S.W. during their descent. Nos. 1 and 2 fell first, 85 miles apart. The distances between the larger masses are—from No. 2 to No. 6, 135 miles; from No. 6 to No. 5, 165 miles; and from No. 5 to No. 3, about 90 miles.

In a paper on some of the meteoric irons of Mexico, D. J. Correjo

[1] J. L. Smith. *Amer. Jour. Sc.*, 1871, 335. See also H. J. Burkart. *Neues Jahr. Min.*, 1871, 853. J. Urgindi. *Amer. Jour. Sc.*, 1872, iii. 209.

[2] This is probably the meteoric iron of which earlier mention is made by W. H. Hardy in his *Travels in the Interior of Mexico in* 1825–1828, London, 1829, 481.

[3] Burkart gives the date 1828.

(*La Naturaleza, Periodico cientifico de la Sociedad mexicana de Historia Natural*, i. 252) reviews what has been published about the Mexican irons, and gives some additional facts respecting them. A recent number of the journal contains an indignant protest on the part of the Society with reference to the destruction of the large meteorite, called "*The Descubridora*," ordered by the Mexican Society of Geography and Statistics (*Amer. Jour. Sc.*, vii. 75). A detailed description of this meteorite will be found in Part II. (See the Mexican Meteorites.)

1871.—Victoria, Saskatchewan River, British North America, [Lat. 53° 45′ N., Long. 111° 30′ W.].[1]

In 1870 Captain Butler received orders from Lieut.-Governor Archibald, of Manitoba, to proceed on a mission to the Saskatchewan. While returning from the Far West he passed, on the 25th December, 1871, through the village of Victoria, which lies on the North Branch of the river, about midway between Fort Edmonton and Fort Pitt, and was shown, in the farmyard of the mission-house of that Station, a curious block of metal of immense weight. It was rugged, deeply indented, and polished on the edges by wear and friction. Longer than any man could say, it had lain on the summit of a hill out on the southern prairies. It had been a medicine-stone of surpassing virtue among the Indians far and wide, and no tribe, or member of a tribe, would pass in the neighbourhood without visiting this great medicine. It was said to be increasing yearly in weight. Old men remember to have heard old men say that they had, at one time, lifted it easily from the ground; now, no single man can carry it. Not very long before Captain Butler saw this meteorite, it had been removed from the hill on which it had so long rested and been brought to Victoria. When the Indians found that it had been taken away, they were loud in the expression of their regret. The old medicine-men declared that its removal would bring great misfortune, and that war, disease, and dearth of buffalo would afflict the tribes of the Saskatchewan. This was not a prophecy made after the outbreak of small-pox which was devastating the district when Captain Butler was there, for in a magazine published by the Wesleyan Society of Canada, there appears a letter from the missionary, announcing the predictions of the medicine-men a year prior to Captain Butler's visit, and concluding with an expression of thankfulness that their dismal prognostications had not been realized. A few months later, however, brought all the three evils upon the Indians. Never, probably, since the first trader had traversed their land had so many afflictions of war, famine, and plague fallen upon the Crees and the Blackfeet as during the year succeeding the removal of

[1] *The Great Lone Land.* By W. F. Butler. London: Sampson Low. 1872. Page 304.

their Manito-stone from the lone hill-top upon which the skies had cast it.[1]

This iron has not yet been analysed.

1871.—Rockingham Co., N. Carolina.[2]

This meteoric iron, a small specimen of which is in the Vienna collection, is described as exhibiting the ordinary lamellæ and figures. It contains iron chloride in the form of a solid green substance enclosed in the metal itself. This compound was first observed by J. L. Smith in 1852 in the Tazewell iron.

1872, July 23rd, 5·20 p.m. (Tours mean time).—Lancé and Authon, Canton of St.-Amand, Loir-et-Cher, France.[3]

An observer, reports M. De Tastes, stationed between Champigny and Brisay, in the Canton l'Ile-Bouchard, noticed during full sunshine a sudden increase of light, and raising his eyes saw a brilliant meteor, which was of a rosy orange colour, and appeared to be double, traversing the heavens with enormous velocity from S.W. to N.E. Its brilliancy suddenly increased as it separated into two luminous globes and passed out of sight in the direction of Tours. At 5·26 he

[1] The supernatural attributes ascribed by savage or superstitious races to meteorites are not a little curious. The large block of meteoric iron, found near the source of the Brazos River, Texas, Lat. 34° N.; Long. 100° W., was held by the Comanches to possess healing virtues. (B. F. Shumard. *Trans. Ac. Sc. St. Louis*, 1860, i. 622.—O. Buchner. *Die Meteoriten*, 161.) The iron of Charcas, Mexico, was built into the wall of the church, and held in peculiar veneration, especially by women, who paid it worship, believing that in return for offerings made to it they would be shielded from the misfortune of sterility. The soldiers of Bazaine, however, carried off their fetish, and it has been placed in the Paris Collection, sawn asunder, polished, etched, and analysed, without apparently causing any sensible diminution in the average increase of the Mexican population. (S. Meunier. *La Nature*, i. 294.) The meteoric stone which fell at Durama, Wanika-land, East Africa, in 1853, was anointed with oil by the natives, dressed with beads, and set up as a god. (R. P. Greg. *Phil. Mag. Suppl.*, January, 1863.) The meteorites of Khetrie, Rajpootana, India, which fell in 1867, were treated with less respect; being regarded as the missiles of an offended deity, the greater part of them were seized upon by the natives and ground to powder to render them harmless. (R. Waldie. *Proc. Asiat. Soc. Bengal*, 1869, 169.) Compare also with Nidigullam iron (page 16).

[2] G. Tschermak. *Mineralog. Mitt.*, Jahrgang 1872.—J. L. Smith, *Am. Jour. Sc.*, 1874, vii. 395.

[3] *L'Union libérale*, Tours, 26th July, 1872.—*Le Loir*, 4th August, 1872.—M. De Tastes. *Compt. rend.*, lxxv. 273.—G. A. Daubrée. *Compt. rend.*, lxxv. 308 and 465.—G. A. Daubrée and M. Jolly. *Compt. rend.*, lxxv. 505.—P. de Fleury. Note sur les Météores d'origine cosmique a propos de l'Aérolithe du 23 Juillet, 1872. Blois: Imp. P. Dufresne, 1872.—M. Nouel. Notice sur le bolide du 23 Juillet, 1872. Vendôme, 1873.—G. A. Daubrée. *Compt. rend.*, lxxix. 277.—*L'Institut*, August 5th, 1874.—*La Nature*, ii. 159.—R. von Drasche. *Mineralogische Mitt.*, 1875, i. 1.

heard a sharp sound, unattended by an echo. The inhabitants of the Communes Monthodon, Neuville, Châteaurenant, Beaumont-la-Ronce, and Dammarie, north of Tours, were alarmed by a tremendous explosion, which shook the houses, and a small cloud of smoke was seen in the direction of Saint-Amand, still further north. Had this happened at night instead of in an atmosphere illumined by the evening sun, it would certainly have attracted the notice of more than the few observers whose attention happened at that instant to be directed towards the sky. The meteors, though seen distinctly separately by many observers, were close together, and had the appearance of two candle flames proceeding horizontally at a very low elevation.[1] The loud report, which to many persons appeared to be two reports in rapid succession, was followed, as is so often the case in explosions of this kind, with "rolls of musketry," lasting 30 to 40 seconds.

A large meteorite fell in a field at La Haye de Blois, near the boundary of the commune of Lancé and Saint-Amand, and penetrated the soil to a depth of 1·4 metres. The explosion detached the hinder portion of the meteorite, which fell as one block to the ground, but which, when taken out of the hole, broke into three pieces. The anterior portion of the stone was shattered into fragments, which were scattered over a stubbled field of wheat. The owner of some cultivated land near St.-Amand was within 200 metres of the spot where it fell. It weighed altogether 47 kilog. The trajectory of the meteorite appears to have been nearly parallel to the plane of the horizon, and the velocity is calculated to have been 640 metres per second.

A search having been instituted in the neighbourhood for other meteorites that may have fallen at the same time, a second stone, weighing 250 grammes, was found a few days later at a depth of half a metre below the surface, at a point two kilómetres from the village of Pont-Loiselle in the Commune of Authon, and 12 kilometres to the S.W. of the spot where the first stone fell. These two places are on the line of the trajectory of the meteor. Here, as in the case of the fall of other meteorites—for example, those of Orgueil, Tarn-et-Garonne (1864, March 14th)—the smaller stone fell first. A superficial inspection will convince the observer of the common origin and similar constitution of the two stones.

The crust of this meteorite is dull, and shows in different parts the manner in which the air has affected the heated surface during the descent. A freshly-fractured surface of it differs from that of a great number of meteorites in being of a very dark grey or black colour, recalling that of certain basalts; it possesses a spherular structure, the grains not exceeding 1 mm. in diameter. Many are transparent and colourless, while some are of a yellowish-green; when examined in a microscopic section, these are seen to be full of flaws and to act powerfully on polarized light; here and there are

[1] A similar instance of the division of a meteor into two during its passage through the atmosphere (which may be represented thus ——*——*) was observed at the Nicobars, 1874, May 31st, 5·30 p.m. (*Proc. Asiat. Soc. Bengal*, 1874, No. viii. 156.)

particles of the bronze-like yellow hue of iron monosulphide or with metallic lustre; the latter are rarely more than ½ mm. in diameter, and are malleable. The specific gravity is found to be 3·80; but whether this is the density of the silicate freed from nickel-iron, is not stated.

By treatment with water 0·12 per cent. of sodium chloride was extracted from a portion of this meteorite. As this salt is so common a constituent of the earth's crust, it seemed at first sight probable that it owes its presence to infiltration of water holding it in solution. The clay-like soil, however, in which the Lancé meteorite lay during three days was dry, and the vitrified crust covering the stone would preclude an infiltration of salt to its centre, from which part the fragment analysed was taken. Moreover, the absence of calcium salts, which would be expected to be associated with it, was fully established. The sodium chloride[1] of the Lancé meteorite, like the calcium chloride of the Ovifak iron (see page 33), appears beyond question to be of cosmical origin. The probable presence of what must be a trace only of copper was ascertained by spectrum analysis. No carbon was met with.

An analysis of the stone showed it to possess the following composition:

1.	Iron, as nickel-iron...	7·81
2.	Iron and other metals combined with sulphur	9·09
3	Sulphur combined with the above metals	5·19
4.	Silicic acid	17·20
5.	Iron protoxide...	11·33
6.	Manganese protoxide	0·05
7.	Magnesia	13·86
8.	Sodium chloride	0·12
9.	Constituents not acted upon by acid	33·44
10.	Hygrometric water...	1·24
		99·33

The constituents Nos. 4, 5, 6, and 7 make up 42·44 per cent. of the stone, and are those of an olivine in which the oxygen ratio of Fe : Mg is 1 : 2, the same as that of the olivine of Chassigny, Alais, and other meteorites.

By acting upon a portion of the meteorite with hydrogen and chlorine successively at a high temperature it lost 34·98 per cent. in weight. It appears from this that the iron and manganese oxides of the olivine underwent reduction, and the water was removed by the first reagent, while the iron, nickel, and cobalt, either free or combined with sulphur, together with this sulphur, as well as the two metals forming constituents of the olivine, which, it appears, lose their oxygen when treated with hydrogen, were, one and all, removed by the action of chlorine. They amount together to 34·66 per cent. Daubrée concludes from this that the residue consists of

[1] Scheerer found this chloride in the meteorite of Stannern (*Jour. de Phys.*, lxi., 469).—In some hailstones which fell 1871, August 20th, 11 a.m., at Zurich, some of which weighed 12 grains, Kenngott found cubes or fragments of cubes of sodium chloride. He believed that they might have been carried by the wind from North Africa.

the silicate which withstood the action of acid, together with the silicic acid and magnesia of that which gelatinizes in contact with this reagent. It is to be regretted that the composition of the insoluble portion, which constitutes one-third of the stone, and of which we are told that it consists at least of two substances, one colourless (enstatite?), and the other almost black (chromite?), has not been determined. In its general aspect the Lancé meteorite resembles that which fell at Ornans (1868, July 11th).

Since the publication of these papers recording the fall and the examination of the Lancé stone, a letter has been addressed to M. Daubrée by M. Jolly, stating that an observer, who was at Chincé, Commune of Jaulnay, Canton of Saint-Georges, Dép. of la Vienne, heard two loud explosions, which appeared to come from the direction of Chatellerault, and a hissing noise, such as would be caused by the rapid passage of a large body through the air. This point is forty kilometres to the S.W. of that reported on by M. De Tastes. In Aug., 1874, Daubrée announced the discovery of four more meteorites belonging to this fall. They weigh 3 kilog , 0·62 kilog., 0·60 kilog., and 0·30 kilog. The first had fallen near the Sablet, between Authon and Villechauve; the second and third were found about 100 metres apart at points north of Authon and about three kilometres from Prunay; and the fourth had fallen in the Commune of Authon.

The most recent contribution to the history of this meteorite is a paper by von Drasche, who has examined its mineralogical characters. His memoir is illustrated with three drawings of the stone itself, and twelve displaying its microscopic structure. The crust is about 0·5 mm. in thickness, and exhibits on one part a number of fine lines,[1] which appear to be the result of the oscillation of the meteorite about its centre of gravity during its transit through the atmosphere; on the posterior surface the crust has an appearance as if it had been pricked with fine needle-points, a phenomenon which the author attributes to a disengagement of gas from the meteorite while the crust was still soft. (Compare with Wright's experiments on the evolution of gas from the Iowa meteorite.) Von Drasche's description of the grains which make up the rock confirms and extends that given by Daubrée. The microscopic sections exhibit numberless spherules of remarkable structure: some have a perfect circular section, are colourless and translucent, and consist either of a congeries of crystals lying apparently in no order, or a few crystals symmetrically arranged about a point; one is made up of a compact group of polygons, which, when magnified, presents the appearance of the facetted eye of a fly. They probably consist of olivine, and are the white granules observed on the freshly fractured face of many meteorites.

One spherule presents a very unusual appearance: it is colourless and exhibits no change with crossed Nicols; from a point lying excentrically within the circle eight fine bands radiate at angles of

[1] The great stone of Timochin (1807, March 13th) bore on its black crust markings which resemble iron wires.

45° towards the boundary of the spherule, and from each of these again proceed other and shorter bands at about the same angle. With a power of 240 these bands are seen to be hollows filled with a dark-green flocculent substance. The homogeneous ground-mass of the spherule is fractured in many places, the cracks traversing these bands as well. Another spherule, of which also only one was met with, and which was sufficiently large to be recognized with the naked eye, consists of a nucleus surrounded by a ring of material, about one-third the radius of the section in breadth. The central portion is filled with a dark-brown opaque mass; the envelope is traversed by a number of lines or veins which break it up into sectors and is an aggregation of small colourless crystals enclosed in a fine network of a brown fibrous mineral, probably the same substance which occurs in the nucleus. While the above ingredients of the Lancé meteorite consist probably of olivine, another class of spherule, readily distinguished from them, appears to be formed of bronzite. These bodies, which are made up of a finely fibrous mineral, arranged excentrically within the spherule, are of the kind described and figured by G. Rose, which have since been shown by Tschermak to occur in the stone of Gopalpur (which see). Certain of these spherules, as met with in the Lancé stone, are so compactly fibrous that little light can penetrate even a thin section of them; in one where the radiating crystals diverge from a point on the circumference of the spherule, they are seen with a high power to merge towards the margin into a flocculent material.

Other spherules are a tangle of bronzite crystals, some being very thin and of great length. Individual crystals of olivine, some 1 mm. in length, were often met with; but only one large isolated crystal of bronzite was observed. Von Drasche is of opinion that the iron sulphide is present in the form of magnetic pyrites, and that the insoluble portion of the stone will be found to contain a felspathic mineral of the kind occurring in the meteorite of Gopalpur.

1872, August 31st, 5·15 a.m. (Rome mean time).—Orvinio (formerly Canemorto), near Rome. [Lat. 42° 8′ N.; Long. 12° 26′ E.][1]

A meteor was seen at daybreak by many observers in the provinces of Rome, Umbria, Abruzzo, and Terra di Lavoro. At first it appeared like a large star of a red colour. It increased in brilliance

[1] A. Secchi. *Compt. rend.*, lxxv. 655.—G. S. Ferrari. Richerche fisico-astronomiche intorno all' Uranolito caduto nell' agro Romano il 31 di Agosto, 1872. Roma: Tip. Bell. Arti. 1873.—P. Keller. *Pogg. Ann.*, cl. 171. *Mineralog. Mitt.*, 1874, 258.—M. le Chevalier Michel-Etienne de Rossi and G. Bellucci. *Atti dell' Acc. pontif. di nuovi Lincei*, 1873.—*Les Mondes*, 25th December, 1873.—L. Sipöcz. *Mineralog. Mitt.*, 1874, 244.—G. Tschermak. *Sitz. Ak. Wiss. Wien*, lxx. November Heft, 1874.

as it traversed the sky, in a northerly direction, leaving a white train. At a certain point it became brilliantly white, and then vanished, a luminous cloud remaining, which was visible for a quarter of an hour. The meteor appears to have crossed the coast-line at a point near Terracina, to have passed over Piperno in a direction 7° W. of N., and, moving N.N.E. over Cori and Gennazzano, to have exploded over the latter town. After the lapse of two to three minutes, two reports were heard, the first like that of a cannon, the second like a series of from three to six guns fired in rapid succession. The greater part of the stone fell at Orvinio, over which place the second explosion appears to have taken place, and some fragments were carried further northward.

Six fragments of the meteorite, weighing collectively 3·396 kilog., have been found :—No. 1, weighing $4\frac{3}{4}$ grammes, fell with a hissing noise near a peasant at Gerano; No. 2, weighing 92 grammes, fell at La Scarpa, within ten metres of a farmer, who picked it up while hot; No. 3, weighing 622 grammes, was found two or three days after the fall a few centimetres below the surface, in a stubbled field at Pezza del Meleto, between Orvinio and Pozzaglia; No. 4, 1242·5 grammes in weight, was found a week after the fall, close to Orvinio: the grass around it had been somewhat singed; No. 5, weighing 432 grammes, was picked up a week after the fall at Pezza del Meleto; No. 6, weiging 1003 kilog., was found on the 8th May, 200 metres distant from No. 4, at a very trifling depth, while turning up the soil of a field. At the time of the fall a man was passing the spot where fragments numbered 4 and 6 were found. Immediately after the explosion, he heard the sound of a heavy body striking the earth, and he fell on the ground with fear. At the same time, or a little later, a fire broke out in a barn filled with hay in the village of Affile, and the occurrence was, with general consent, ascribed to the meteorite.

In September, 1873, Keller learnt that two more small fragments had fallen near the village of Anticoli Corradi ; one fell near two boys who were tending cattle. The boys became alarmed at the hissing noise, and believing this projectile to be aimed by the Devil, they picked it up, and threw it far away from them. The other stone was observed to fall on the bare rock, and to break in pieces. The fragments were collected, but as they were held to be of no value, they were subsequently lost. In the case of this aerolite, as in that of others, the smaller fragments appear to have fallen before the larger.

The velocity of this fall must have been very slow. The authors do not state whether any of the fragments could be fitted together; their specific gravity ranged between 3·58 and 3·73—in one, richer in metallic constituents, it amounted to 4·598. Two of the fragments bear portions of the crust lying in pits and hollows. It is only $\frac{1}{2}$ mm. thick, has a pitch-black colour, and exhibits in some places a waxy lustre. The mass of the stone is of a lead grey colour, being darker than that of the aerolites of Pultusk and Monte Milone. A polished surface exhibits metallic grains, some 2 mm. in diameter, and a green silicate, probably olivine. The ground-mass appears to be made up of two minerals, one clear and uniform, the other dull and less homogeneous. The stone acts powerfully on the magnet.

In Ferrari's memoir is given a plan of the country near Rome, on which is indicated the track of the meteor and the positions where the stones fell. The line of flight, a singularly devious one, is seen to pass immediately over the summits of M. Leano, M. Sempreviso, M. Lapone, and quite near to that of M. Gennaro, the chief mountains of the district, and suggests the gravitating action of these more elevated masses of the earth's surface on the path of the meteor. A sketch of the latter, the trajectory of which is computed to have been inclined 27° to the plane of the horizon, accompanies the map.

The paper of M. Le Chevalier Michel-Etienne de Rossi gives the analysis and observations of Prof. Bellucci, of Perugia. When heated to 120° the powdered mineral lost 1·875 per cent., and by treatment with water a little potassium and sodium chloride were dissolved. (Compare with Daubrée's examination of the Lancé stone, page 56.) The magnet removed 29·04 per cent. and acid 45·04 per cent. The analysis of a portion of the stone gave the following numbers: silicic acid = 46·72; alumina = 16·84; magnesia = 1·97; iron = 25·59; iron oxide (*fer oxydé*) = 4·82; sulphur = 2·24; nickel with trace of cobalt = 1·37; with traces of calcium, chromium, manganese, arsenic, and phosphorus. Two points are worthy of remark in this analysis: first, the astonishingly large amount of alumina present, far in excess of that found in any other meteorite. In the absence of a second and confirmatory analysis, it may be assumed that insufficient ammonium chloride was employed, and the greater portion of the 16·84 per cent. is magnesia, which precipitated with the alumina. The second point is the occurrence of arsenic, which is of extreme rarity in a meteorite; it is stated to be present in the iron of Braunau and the olivine of the Atacama and Krasnojarsk siderolites.

Tschermak's report of his examination of this stone appeared in the winter of 1874. The structure developed on cutting the stone is unusual and remarkable, consisting of light-coloured fragments (I.), surrounded by a compact dark cementing material (II.). The former are yellowish-grey, enclose spherules and particles of iron and magnetic pyrites; are, in fact, normal chondrite, and resemble the mass of the stone which fell at Seres in Macedonia (1818, June). The latter encloses numerous particles of iron and magnetic pyrites, for the most part uniformly distributed; the portion nearest the enclosed fragments bears very distinct indications of having been at one time fluid, and conveys the impression that this cementing material was at one time in a plastic condition while in motion. Along the boundary of these two very dissimilar portions flaws are seen, in which nickel-iron has crystallized in delicate plate-like forms; and here, moreover, the fragments are darker, harder, and more brittle than those of the centre, which argues the exposure of the cementing material to a very high temperature while in a plastic condition. Both portions have nearly the same density and apparently the same chemical composition and mineral characteristics. The Orvinio stone resembles, in fact, certain brecciated volcanic rocks which consist of a ground mass through which granular fragments of the same rock are distributed, as when older crystalline lavas are interpenetrated by others more compact and of a more recent period. The light-coloured fragments are, as stated, chondritic; the spherules are usually of one kind, lying in a splintery matrix of the same mineral, containing some nickel-iron and magnetic pyrites. Among the transparent constituents, olivine is recognized by its imperfect cleavage; a second mineral, with a distinct cleavage along a prism of nearly quadratic section, is evidently bronzite; while a third, which occurs in fine foliated or fibrous particles, may be either identical with the above or be a felspathic ingredient.

The meteoric rocks possessing chondritic structure are regarded by Tschermak as tufas, which have undergone detrition; and their spherules to be such particles as, by their superior toughness, have, during the trituration of the rock, instead of breaking up into splinters, acquired a rounded form. A black material is observed to coat the fragments of the rock and to fill the finer flaws existing between them, whereby their transparent character is considerably impaired; this has also been noticed in the meteorite of Tadjera (1867, June 9th).

The dark-coloured cementing material contains two ingredients: an opaque semi-vitreous constituent, and particles in every way similar to the dark crust of the fragments from which they may probably have been detached; many of them can still be recognized as olivine and bronzite. The nickel-iron and magnetic pyrites of this portion of the stone are more finely divided than in the fragments, and have often a rounded form. The metal of this portion, as well as in the other, exhibits no Widmannstättian figures; but in both, by treatment with acid, lines are developed like those of the Braunau iron.

The two species of rock: the chondritic fragments (I.) and the darker cementing material (II.): have the following composition:

	I.	II.
Silicic acid	38·01	36·82
Alumina	2·22	2·31
Chromium oxide	trace	trace
Iron protoxide	6·55	9·41
Magnesia	24·11	21·69
Lime	2·33	2·31
Soda	1·46	0·96
Potash	0·31	0·26
Iron	22·34	22·11
Nickel, with trace of cobalt	2·15	3·04
Sulphur	1·94	2·04
	101·42	100·95
Specific gravity	3·675	3·600

These results establish the similarity in composition of the two portions, and, as Tschermak points out, the erroneous character of Belucci's analysis, to which attention has already been directed.

Tschermak's paper is illustrated with a plate, giving a figure of the meteorite he examined; a drawing, actual size, of the section, showing very distinctly the appearances of fusion; and three microscopic sections, magnified 20 diameters, of the two rock varieties composing the greater part of the stone.

1872, November 3rd, 5·30 p.m.—Nairn, Scotland.[1]

A meteor of unusual brilliancy was observed to take a direction from E.S.E. about 20° from the horizon. The sky was so lighted up for two or three seconds that the observer could have seen to pick a pin from the ground. Darkness followed, and again the light burst forth stronger than before, and shortly afterwards a sound was heard as if three or four cannon had been discharged at the distance of a quarter of a mile. The meteor appeared to move from the southern part of Banffshire, towards the centre of Inverness-shire, and to burst somewhere near the source of the river Nairn. It was also observed at Glasgow.—A second very bright meteor was seen about 9·15 (G. M. T.) at Bristol and Portsmouth,[2] passing from the zenith down towards 10° E. of the Pleiades in Taurus. A sound as of an explosion was heard three seconds after its disappearance.

1872, November 13th, 2 a.m.—"Sevenstones" Light-ship, The Scilly Islands.[3]

A letter, addressed by the Secretary of the Corporation of the Trinity House to the President of the Royal Society, states that at the above hour a meteor burst over the "Sevenstones" light-vessel, moored about 9½ miles E. by N. of the Scilly Islands. The watch were struck senseless for a short period, and on recovery they observed "balls of fire falling in the water like splendid fireworks," while the deck was covered with cinders, "which crushed under the sailors' feet as they walked." The writer states that the "cinders" were, there is reason to fear, all washed off the decks by the rain and sea before daylight. Miss Carne, of Penzance, and Mr. Talling, of Lostwithiel, to whom I applied for information, did not succeed in obtaining any further details respecting this remarkable occurrence.

[1] H. D. Penny. *Brit. Assoc. Report*, 1873, Obs. Luminous Meteors, 369.
[2] E. B. Gardiner. *Brit. Assoc. Report*, 1873, Obs. Luminous Meteors, 365.
[3] R. Allen. *Proc. Royal Soc.*, xxi. 122.

1872, November 30th, 2·8 p.m.—Slough, England.[1]

The descent of this 'meteor' was witnessed by Sir J. C. Cowell, who states that it fell one mile east of Slough, and about 150 yards south of the Great Western Railway. He writes that the phenomenon occurred during a short and sharp thunderstorm which passed over North Hants and East Berks. It is a question whether this was not a form of ball-lightning. "The explosion was similar to that of a heavy gun when fired." A sketch accompanying the notice represents the fire-ball striking a ploughed field, between the observer and some trees. It is not stated whether any search was made at the time for a meteorite.

1872, December 12th, 4·53, p.m.—Lexington, Kentucky.[2]

The meteor took a direction S. 45° E., and exploded with a loud noise at an altitude of about 20 miles, the cloud remaining several minutes. The inclination to the horizon was probably not less than 30° or more than 60°. The fragments of the meteorite, which have not yet been found, probably fell 20 or 30 miles N.W. of Lebanon.

A number of meteorites have fallen about this date, and they are separated in a group by an interval of some days from the aerolites of the earlier and later days of December. The members of this group are:—

1858. December 9th.	Aussun and Clarac, Haute Garonne, France.
1870. December 9th.	Tjabé, Bodgo Négoro, Rembang, Java.
1871. December 10th.	Gœmorœh, near Bandong, Java.
1836. December 11th.(?)	Macao, Brazil.
1872. December 12th.	Lexington, Kentucky.
1795. December 13th.	Wold Cottage, Thwing, Yorkshire.
1798. December 13th.(?)	Krakhut, Benares, India.
1803. December 13th.	Mässing, Eggenfeld, Bavaria.
1813. December 13th.	Luotolax, Wiburg, Finland.
1807. December 14th.	Weston, Connecticut.

Found 1872.—Los Angeles, California.[3]

A very brief account is given of a mass of iron weighing 80lbs., which was found at Los Angeles. It is stated that its specific gravity is 7·905, and that, when acted on with dilute nitric acid, the smooth surface exhibits innumerable scales of schreibersite, but that the usual figures are not developed.

[1] Sir J. C. Cowell. *Nature*, 26th December, 1872.
[2] D. Kirkwood. *Amer. Jour. Sc.*, 1873, v. 318.
[3] C. T. Jackson. *Amer Jour. Sc.*, 1872, iv. 495.

Found December, 1872.—Neuntmannsdorf, Saxony.[1]

A block of iron, weighing 25lbs., now preserved in the Dresden Museum, was found in 1872, at Neuntmannsdorf, two feet below the surface of the ground. As I could meet with no announcement of the constitution of this meteorite, I conceived it possible that it might form a new member of the interesting little group of siderolites to which the Breitenbach, Steinbach and Rittersgrün meteorites belong. I learn, however, from Professor Geinitz, that it is a metallic mass, and that it has been analyzed by Lichtenberger with the following results:—

Iron = 94·59; Nickel = 5·31 = 99·90

It contains no cobalt, carbon, manganese, or uranium. The author states that although it is carefully preserved under a glass shade, a liquid (ferrous chloride) exudes from it, and it shows a tendency to scale off, as the Greenland (Disko) irons do. A more complete investigation of this meteorite will shortly be undertaken.

1873, February 3rd, 9·58 p.m.—Liverpool and Chester.[2]

This meteor, which is described as one of the largest class of detonating meteors, illuminated the whole district which it traversed with one or two prolonged flashes of light at least as powerful as that of the full moon. Owing to the clouded state of the sky, which nearly concealed the moon in many places, the descriptions of its apparent path are nowhere sufficiently determinate to indicate with much precision its real course; the meteor, however, appears to have moved at a lower elevation than is usual with shooting-stars over the north of Staffordshire and Cheshire, passing at a height of less than 40 miles over Crewe, and to have vanished at an altitude of less than 30 miles over a point between Liverpool and Chester; a sound like the loud boom of a distant gun or a loud roll of thunder was heard about three or four minutes after the disappearance of the meteor. The observations of its apparent path show considerable discordance, and it seems that its course may have been more directly from E. to W. The light of the meteor was of a bluish hue, leaving a train of brilliant sparks along its track. It appears to have been visible as far south as Bristol. On the same date, and at the same local time, a very brilliant fireball was seen in Australia.

[1] *Amer. Jour. Sc.*, vi. 237.—*Sitzungs-Ber. der Isis zu Dresden*, 1873, 4.
[2] *Brit. Assoc. Rep.*, 1873, Obs. Luminous Meteors, 353 and 364.—*Brit. Assoc. Rep.*, 1873, Obs. Luminous Meteors, 376.—*English Mechanic*, 1873, 171.

1873, June 17th, 8·46 p.m. (Breslau mean time).—Proschwitz, near Reichenberg, Bohemia [Lat. 50° 40′ N.; Long. 14° 31′ E.][1]

A brilliant meteor was seen about half an hour after sunset, and in bright twilight, over the whole of the Eastern area of Germany and in Austria; the train remained visible for a quarter of an hour, which enabled the astronomer of the Breslau Observatory to measure the position of two points along its course. It was observed in Saxony, Thuringia, Brandenburg, Mecklenburg, Pomerania, West Prussia, and in many parts of Austria as far as Hungary; and the report of the explosion was heard in the Hirschberger Thal and along the Riesengebirge range. The explosion appears to have taken place near the Bohemian frontier, at a height of about 4½ geographical miles, nearly over Grosschönau in Saxony and Warnsdorf in Bohemia, the altitude being nearly the same as that at which the cosmical path of the meteorites of Pultusk (1868, January 30th) is believed by Galle to have terminated.[2] According to Niessl, it was seen nearly vertical over the village of Herrnhut in Saxony at the time of its dissolution. The general course of the meteor was from S.S.E. to N.N.W.

Although it does not appear that any fragments of a meteorite are known to have descended in the neighbourhood of Herrnhut, some information was gathered by Prof. Hornstein, of Prague, respecting a very remarkable form of matter which is stated to have fallen at the time of the flight of the meteor. According to an account communicated to the *Reichenberger Zeitung* by the Head Master of the School at Proschwitz, the meteor was seen to explode in the zenith at the time stated, and some of the burning fragments of the meteor fell in that village, one of them on the high road not far from him. It was of about the size of a fist, and continued to burn, emitting a blue light and an odour like that of sulphur, until the flame was extinguished by the villagers stamping it out with their feet. This rough treatment reduced the mass to small pieces, which, mixed with sand and dust, had the appearance of a slag, and were not larger in size than a pea. A stone, a fragment of porphyry, which happened to be selected by one of the bystanders to extinguish the flame, together with some of the above-mentioned fragments, was examined by Websky and Poleck, by whom the substance was pronounced to be pure sulphur.

If this burning mass actually traversed our atmosphere, the occurrence is of peculiar interest, as being one of the very few instances where sulphur in the separate elementary condition has been found as a meteoric substance. Chladni, in his *Feuer-Meteore*,[3] refers to a statement in the *Theatrum Europæum*, vol. iv. p. 399,

[1] G. von Niessl. *Astronom. Nachrichten*, lxxxii. 161. (No. 1955) and lxxxiii. 321. (Nos. 1989–90).—J. G. Galle. *Sitz. Meteorolog. Section der Schles. Gesell. für vaterländische Cultur*, 1873, December 17th.

[2] J. G. Galle. *Naturw. Abh. zu den Schriften der Schles. Gesell.*, 1868, 79.

[3] E. F. F. Chladni. *Ueber Feuer-Meteore.* Vienna, 1819. Page 367.

that in June, 1642 (?), sulphur fell at Magdeburg, and at Lohburg four miles distant; one mass, the size of a fist, striking the roof of the castle. Galle, in his memoir *Ueber den gegenwärtigen Stand der Untersuchungen ueber die gelatinösen sogenannten Sternschnuppen-Substanzen*, published in the year 1869, cites a paper by von Hoff,[1] describing a substance which was found on the 6th September, 1835, between Friemar and Gotha during a star-shower. It smelt like liver of sulphur, and when held in the hand melted to a thick liquid, which evaporated, diffusing a strong odour like that of burning sulphur and phosphorus. Another substance resembling liver of sulphur is stated by Chladni in his paper *Ueber den Ursprung der von Pallas gefundenen und anderer ihr ähnlicher Eisenmassen*, page 26, to have been found at Coblence.[2] Wöhler[3] detected the presence of a little free sulphur in the carbonaceous meteorite of Cold Bokkeveldt (1838, October 13th); and Roscoe[4] found 1·24 per cent. of sulphur in the remarkable carbonaceous aerolite which fell at Alais (1806, March 15th).

Galle's paper contains a detailed examination of the observations of the path of this meteor, made over a wide area. The English reader will find a very complete analysis of these measurements and the conclusions deduced from them in the "Report on Luminous Meteors" in the *Report of the British Association* for 1874. The most remarkable circumstance connected with the real course of this meteor, says Prof. Herschel, is that, according to the calculations of von Niessl and Galle, the rate of the motion of this meteor and the calculated direction of its flight belongs to an orbit which is decidedly hyperbolic. As already stated, it was observed along the unusually long path, one of nearly 300 miles, which it traversed with very considerable meteoric speed. According to the three most truthworthy measurements of its time of flight, made at Breslau, Rybnik and Ratibor, which accord in making it very nearly ten seconds, the velocity appears to have been 28½ miles per second. Other observations reduce the velocity to 18·4 miles per second. The hyperbolic elements of the two orbits found by Galle are given in his paper, side by side, for the purpose of comparison, with the hyperbolic elements of the aerolitic fireball of Pultusk. Both these large fireballs were well seen and recorded at the Observatory in Breslau; and the concurrent testimony of two such well-investigated cases is, as observed by Galle, strongly indicative of a tendency of aerolitic and detonating fireballs to belong to a class of astronomical bodies which differ from comets or annual periodic star-showers by moving in hyperbolas instead of parabolas or long ellipses, so as to have motions of their own beyond the sphere of the sun's attraction, carrying them apparently from star-system to star-system instead of in constant revolutions about a single solar centre. It is pointed out

[1] K. E. A. von Hoff. *Pogg. Ann.*, xxxvi. 315; *Handw. der Chem.*, v. 224.

[2] *Comment. de rebus in Scientia Naturali et Medicina gestis*, xxvi. 179.

[3] F. Wöhler. *Sitzber. Wien. Akad. Wiss.*, 1863, February 24th. *Phil. Mag.*, xxv. 319.

[4] H. E. Roscoe. *Proc. Lit. Phil. Soc. Manchester*, 1863, February 24th. *Phil. Mag.*, xxv. 319.

by Galle that observations of the duration, length of path, and points of first appearance of meteors of the August and November star-showers may show some of the shooting-stars of those well-known streams to possess velocities which cannot belong to other than hyperbolic orbits; in such cases it must be assumed that the excessive velocities are due to some physical cause to which special and most accurate investigation will have to be directed.

Found July, 1873.—Ssyromolotowo, on the Angarà, Wolost Keshma, Gouv. Jenisseisk, Siberia.[1]

Lopatin, the mining engineer, who at the direction of the Academy of Sciences of St. Petersburgh recently visited the locality at Krasnojarsk where the "Pallas" iron was found (see Part II.) reports on the discovery of a block of meteoric iron weighing 12 puds (nearly 4 cwt.) on the sandy plain on the left bank of the Angarà. It is a pear-shaped mass exhibiting a number of pits and hollows which are shown in the two woodcuts, from photographs taken at Krasnojarsk, which illustrate Goebel's paper; a portion of the surface is covered with a very thin blackish-brown layer of magnetite. The metal is very malleable, and so soft that it may be cut with a knife. A polished surface viewed by daylight exhibits in some directions and over certain areas a brilliant bluish hue; when etched the Widmannstättian figures are developed in great beauty. The beam-iron (kamacite), occurring in stripes 1·0 to 1·5 mm. in breadth and extending across the plate, is enclosed on either side by thin shining plates of tänite,[2] and beyond these again lie dark grey patches, from 3·0 to 5·0 mm. in width, of plessite or interstitial iron. The kamacite bands, at first sight apparently finely granular, display on closer inspection a brilliant cross-hatching recalling the *moiré métallique* of tin and the appearances which Tschermak noticed on the Braunau iron (see Part II.), (G. Rose ascribed this phenomenon to the lines of etching taking certain predominating directions in different portions of the mass; von Reichenbach referred it to the embedded tänite prisms; while Volger considered it due to the scattering action on light of fine crystals of rhabdite). In addition to these ingredients there occur, occasionally and irregularly distributed through the mass, small very white and brilliant particles of what is believed to be lamprite (glanzeisen).

The iron has the following composition:

Iron = 92·635; Nickel (cobalt) = 7·104; Magnesium = 0·056; Silicium = 0·042; and Phosphorus = 0·163. Total = 100·000.

as well as traces of carbon and calcium, and of an insoluble crystal-

[1] A. Goebel. *Bull. Ac. Imp. Sc. St. Pétersbourg*, 1874, xix. 544.

[2] This is what has been termed fillet-iron on page 20. Schreibersite, the other name which the author gives this alloy, is reserved for the meteoric phosphide of iron and nickel.

line residue. The magnesium and silicium are probably derived from a silicate the presence of which, in very small amount, can be recognised under the microscope. Many of the so-called 'irons' are not metallic throughout, and enclose a few, sometimes as in the case of the Tucson iron five, per cent. of siliceous ingredients.

Found August, 1873.—Duel Hill, Madison Co., N. Carolina.[1]

A mass of meteoric iron was found in August, 1873, on the land of Mr. Robert Farnesworth, lying on a hill-side, where it had been used probably by the first settlers to support a corner of a rail fence since rotted away. (A similar block, weighing about 40 lb., was discovered about a mile further west, "before the war, perhaps about 1857," but has since been covered over and lost.) The mass above referred to originally weighed some 25 lb.; but specimens have been hammered off it, and it now weighs 21 lb. and measures $9 \times 6\frac{1}{2} \times 3\frac{1}{2}$ inches. It has the usual coating of magnetite, and from various points of the surface bead-like drops of iron chloride exude. When polished and etched, "the usual markings appeared, though rather indistinct," and when the action of acid was prolonged distinct particles of Schreibersite were seen to protrude from the face of the metal. The meteorite has a specific gravity=7·46 and the following composition:—

Iron	94·24
Nickel	5·17
Cobalt	0·37
Copper	*Trace*
Phosphorus	0·14
Residue	0·15
	100·07

1873, August 24th.—Marysville, California.[2]

All the facts that I have yet been able to gather respecting this fall are that an aerolite, weighing 12lbs., crashed through the tree-tops with a bright flash, and was buried to the unusual depth of eight feet in the ground. When dug out it was so hot that it could not be handled. If the mass be metallic, this is one of the very few instances on record where the fall of a meteoric iron has been witnessed.

Found 1873, August 27th.—Eisenberg, Saxe-Altenburg, Germany.[3]

A block of metal, weighing 1·579 kilog., was left exposed on the surface of the ground at the foot of the Schneckenberg, north of Eisenberg, by a heavy thunder shower washing away the surrounding soil. It is a finely granular iron, through which are disseminated

[1] B. S. Burton, *Amer. Journ. Sc.* 1876, xii. 439.
[2] *Nature*, 1st January, 1874. (From *Iron*.)
[3] H. B. Geinitz. *Sitzungs-Ber. der Isis zu Dresden*, 1874, 5.

here and there yellow particles of magnetic pyrites or troilite. Unlike metallic masses of undoubted meteoric origin, it contains neither nickel nor cobalt; when etched with nitric acid it exhibits, in place of figures, minute star-like forms. It has the composition:—

Iron	97·27
Phosphorus	0·21
Carbon	0·44
Silicic acid	1·50
Graphite	0·90
	100·32

The presence of silica was confirmed by submitting the white amorphous, somewhat rounded particles, which remained undissolved, to the action of hydrofluoric acid.

1873, September 23rd, 5·10 a.m.—Khairpur, 12 miles south of Multan, 36 miles E.N.E. of Bhawalpur, Punjab, India. [Lat. 29° 56′ N.; Long. 72° 12′ E.][1]

The morning is described as having been remarkably clear, and the sky unclouded, with a faint glow in the east, the sun still being 45 minutes below the horizon, when a meteor, or rather a cluster of meteors, appeared to the west of an observer at Khairpur. Each of them exceeded in brightness a star of the first magnitude, and the breadth of the train left behind them is estimated to have been from 3° to 5°. The first thought of the eye-witness was that he was gazing at a rocket; this, however, was soon dispelled, as the phenomenon, instead of fading out, rapidly increased in brightness, and continued to move towards him, leaving a train behind. According to the report of the Rev. G. Yeates, "its motion was not very rapid but steady, and by the time it had reached about 10° of the meridian, which it passed south of the zenith, it assumed an exceedingly brilliant appearance, the larger fragments, glowing with intense white light with perhaps a shade of green, taking the lead in a cluster, surrounded and followed by a great number of smaller ones, each drawing a train after it, which, blending together, formed a broad belt of a brilliant fiery red." It lit up the whole country, and produced an effect similar to that of the electric light. It proceeded in this way till it reached a point nearly due east, paling again as it drew near the horizon, and at about 20° above it appeared to go out rather than to fall. The train, which continued very bright for some time, was distinctly traceable three-quarters of an hour afterwards. At first it changed to a dull red; then, as the morning broke, to a line of silvery-grey clouds that divided into several portions, and floated away on the wind. The track of the meteor was unusually long, extending through nearly 180°. It first appeared near the star Algenib, at the time about 15° above the horizon on the west, passed

[1] H. B. Medlicott. *Jour. Asiat. Soc. Bengal*, 1874, pt. ii. no. ii. 33.—*The Pioneer*, Sept. 30th, 1873.—*Brit. Assoc. Report*, 1874, Obs. Luminous Meteors, 300.—G. Yeates. *Astronom. Register*, March, 1874.

close under Orion, the lowest star of which (Rigel) was very near the meridian, and disappeared as already stated. After this had taken place, and while the train still attracted attention, there was perfect silence, which was at length broken by a loud report, followed by a long reverberation, that gradually died away like the roll of distant thunder. This interval is estimated to have been four minutes.

At Bhawalpur the explosion was sufficiently violent to shake the houses and slam the doors. At Bhawalgur, 80 miles from Khairpur, the meteor was seen, but no explosion was heard. It was also observed at Jodhpur and Moradabad, and was probably visible within a radius of 300 miles of Khairpur.

A correspondent of *The Pioneer* of the 30th September records his observations made on the Shujabad road, 13 miles south of Multan. He states that the different fragments into which the meteor broke up were distinctly visible, "more than twenty of them, I should say, moving in parallel courses, two or three of the larger ones taking the lead in the centre, and each of them leaving a tail of red light behind," which blended together, forming one huge band of light. The report, which was very terrific, followed after the lapse of about three minutes and a half, which would make the point where the disruption of the aerolite took place about 42 or 45 miles distant. The train remained very bright for some time, and the clouds into which it was transformed were visible upwards of an hour afterwards, till they faded away in the bright sunlight.

Another correspondent, "Shikaree," states that on the left bank of the Chenab, some 60 miles S.W. of Bhawalpur, the meteor displayed great brilliancy, and that a double detonation followed after an interval of six or seven minutes.

One of the meteorites fell close to a man who had gone out into the jungle for the purpose of nature, and frightened him so much that he hardly knew what occurred, and was under the impression that the stone pursued him for two hours. He showed the spot where it fell, however, and this was the first fragment unearthed and forwarded by the Tuhsildar of Khairpur to Major Minchin, Political Agent for Bhawalpur.

The stones fell partly in the State of Bhawalpur and partly in the Multan district, on either bank of the Sutlej, over an area extending 16 miles in a direction bearing 35° S. of E., with a breadth of about three miles. The largest and perhaps the greater number fell to the eastward of Khairpur, and penetrated the earth to the depth of about 1½ feet. They are preserved in the following collections in India, and weigh respectively:—

	Lbs.	Oz.	Grs.
Lahore Museum	10	12	126
Indian Museum	9	11	219
" "	7	14	236
Geological Museum... ...	1	2	412
" "	0	3	79

Of those stones or fragments that fell on the Multan side seven have been heard of: four at different spots near Gogewala well, E.S.E. of Mahomed Moorut; two at Khurampur, on the right bank of the Sutlej; and one at Araoli, two miles N.W. of Khurampur. Of these one only is in known hands, that from Mylsi Pergunnah, which weighs 6 oz. 70 grs.

The account of the physical characters of the stones is very meagre. They are all very irregular in form, and are more or less broken. While some of the fractures have evidently been accomplished by hand, and others probably took place at the moment of falling, several appear to have occurred during the fall, as the glazed surface has been partially renewed. The stones are of the usual steel-grey colour, and exhibit compact crypto-crystalline texture. One specimen has the specific gravity = 3·66.

1873, December.—Coomassie, Kingdom of Ashantee, Africa.[1]

In a letter from the War Correspondent of *The Standard* it is stated that among the portents of evil which were observed at Coomassie while the British Army halted on the banks of the Prah, an aerolite fell in the market-place of Coomassie. In reply to an application for further details respecting this event, Mr. Henty writes that he obtained his information from one of the clergymen of the Basle Mission. He says: "They mentioned these 'prodigies' as matters of common rumour and belief at Coomassie, but they do not appear to have even made any inquiries whatever as to their truth. Coomassie was deserted when we got there, so there was no opportunity of gaining further information."

1873.—Chulafinee, Cleborne Co., Alabama.[2]

The writer refers to a mass of iron which was found in 1873, and supposed at the time to be a specimen of bog iron-ore. It was taken to a blacksmith, who managed to remove a piece weighing 3¼ lbs., which was wrought into horseshoe nails and a point for a plough. It remained where it was found till last year, when it was sent to Menlo Park. It weighs 32½ lbs., and its form, as well as the character of an etched surface, are shown in woodcuts accompanying the paper. An analysis shows it to contain iron and nickel, with a little copper, phosphorus, and carbon: it is being made in duplicate, and will be published later on. The Wiedmannstättian figures are well developed.

1874, April 10th, 7·57 p.m. (Prague mean time). Bohemia.[3]

A detonating meteor; conforms in radiant-point with that of 1876, April 9th.

[1] G. A. Henty. *March to Coomassie.* London: Tinsley Bros. 1874, page 320.
[2] W. E. Hidden, *Amer. Journ. Sc.* 1880, xix. 370.
[3] G. von Niessl, *Sitzungsber. Akad. Wiss. Wien,* lxxv. April 19th, 1877.

1874, May 14th, 2·30 p.m.—Castalia, Nash Co., N. Carolina. [Lat. 36° 11′; Long. 77° 50′.][1]

A short notice in *Silliman's Journal* states that the descent of these meteorites, numbering a dozen or more, was accompanied with a series of explosions and rumbling noises which lasted about four minutes, and were "not unlike the discharge of firearms in a battle a few miles off." Although the fall took place by day, a luminous body was observed. The area over which the fragments fell was ten miles long and three wide. Three stones, weighing 5·5, 1·0, and 0·8 kilog., have been found. The dull-coloured crust does not entirely cover the stones, the fused matter forming it being scattered over some small parts of the surface in the form of pear-shaped beads; in one or two crevices the fused material has penetrated 5 mm. below the surface, and here it is more brilliant than on the exterior.

The colour of the interior is in many parts of a dark grey, owing to the presence of a large amount of nickel-iron; in the lighter portions are seen some white spots of a mineral which is doubtless enstatite. The specific gravity of the stone is 2·601, and its proximate composition:

Nickel-iron	15·21
Soluble silicate	44·92
Insoluble silicate	39·87
	100·00

The metallic part consists of:

Iron = 92·12; Nickel = 6·20; Cobalt = 0·41; Total = 98·73.

and the siliceous portion of:

	SiO_2	Al_2O_3	FeO	MgO	Na_2O	S		
A. *Soluble*	38·01	0·46	17·51	41·27	—	1·01	=	98·26
B. *Insoluble*	52·61	4·80	13·21	27·31	1·38	—	=	99·31

The soluble silicate is an olivine, in which the ratio of Mg to Fe is about 5 : 2, and is almost identical in composition with the olivine of the Nashville meteorite (1827, May 9th); the insoluble part is a bronzite. In addition to these minerals, the presence in the Castalia stones of small amounts of iron sulphide and anorthite was recognised.

1874, May 19th, 0·50 a.m.—Holyhead, Wales.[2]

A very brilliant meteor, oval in form and with the major diameter equal to the apparent diameter of the moon, was seen off Holyhead. It appeared stationary for the first two or three seconds, and then moved slowly northwards, spreading a soft green light on objects along its course. It 'formed' near Antares and before it disappeared in Ursa Major six sparks of the same apparent size as Jupiter were thrown off from the hinder portion. The disappearance of the meteor is stated to have been followed by a crackling sound.

[1] J. L. Smith. *Amer. Jour. Sc.*, 1875, x. 147. *Compt. rend.*, 1875, lxxx. 1453.
[2] W. W. Kiddle. *Brit. Assoc. Report*, 1874, Obs Luminous Meteors, 307.

1874, May 20th.—Virba, near Vidin, Turkey.[1]

This meteorite fell with a loud noise, and entered the ground to the depth of one metre; it weighed 3·60 kilog. A fragment presented to the Paris Collection by His Excellency Safvet Pacha is covered with the usual dull black crust: a fractured surface shows the meteorite to have a light-grey colour and a very finely grained texture, with grains of metal distributed through the mass; in certain parts spherular structure is apparent. In a microscopic section it was found that the transparent and almost entirely colourless stony particles act on polarized light. The metallic portion is nickel-iron, the presence of an iron sulphide is recognized by the action of acid, and numerous small black grains of chromite are distributed throughout the stone. A part of the siliceous constituents gelatinize with acid, indicating the presence of olivine; and a residue, which resists the action and constitutes less than one-half of the weight of the stone, is believed to be enstatite.

The Virba stone belongs to the large class of which the meteorite of Luc, Sarthe, France (1768, September 13th), may be taken as a type; and is most closely allied to the aerolites of Bachmut, Island of Oesel, St. Denis-Westrem, Buschof, Dolgaja Wolja, and those of other localities mentioned in Daubrée's paper.

1874, July 8th, 10 p.m.—Louisville, Kentucky. [Lat. 38° 20′ N.; Long. 85° 25′ W.][2]

A meteor, described as a brilliant pear-shaped body, one-third the apparent diameter of the moon, moved over Louisville from N.N.W. to S.S.E., leaving a stream of light in its rear. When about 20° above the horizon it burst into three or four parts, flashing forth red and blue lights, and instantly disappeared, without detonation. At Franklin, 150 miles S.W. of Louisville, this meteor was observed to take a course from N. to S.W. It had a light bluish colour and cast off sparks as it proceeded. About three minutes after it burst a noise was heard as of distant thunder. No fragments resulting from the explosion have been found.

1874, August 1st, 11 p.m.—Hexham, Northumberland.[3]

In *The English Mechanic* is a letter from a person signing himself "Ralph Lowdon," of Gateshead, stating that at the above time and place "a massive ball of intense light," accompanied by other pear-shaped balls of fire, was seen to drop towards the earth. The aerolite, which is alleged to have fallen in an orchard on

[1] A. Daubrée. *Compt. rend.*, lxxix. 276.
[2] J. L. Smith. *Amer. Jour. Sc.* 1875, x. 203.
[3] *The English Mechanic*, August 21st, 1874.

the bank of the North Tyne, at no great distance from Hexham, is stated to have been found the following day at 9 A.M. at a depth of 14 inches in the soil, still quite warm, and to have weighed 301½lbs. Letters directed to the above are returned by the Post-office authorities, while an obliging reply which I received from the Rev. H. C. Barker, of Hexham, states that the editor of *The English Mechanic* must have been misinformed. The rev. gentleman writes: "To make assurance doubly sure, I have made inquiry in several quarters, and cannot find even the slightest foundation for the statement."

1874, November 26, 10·30 a.m.—Kerilis, Commune de Maël-Pestivien, Canton de Callac (Côtes-du-Nord).[1]

A great noise, lasting two minutes, and resembling a peal of thunder, was heard at this date at Maël-Pestivien, and for ten kilomètres around. At the same instant a workman near the village of Kerilis saw the earth struck, at a spot 12 mètres distant, by what he believed to be thunder. He visited the spot the next day, and found a meteorite at a depth of 0·78 mètre. The stone weighed 5·000 kilogrammes, and is covered with a remarkably thick black crust: a number of fragments were detached from the stone till its weight was reduced to 4·200 kilogrammes; it then passed into the hands of a clergyman, who bought it and presented it to the Natural History Museum of Paris.

A freshly broken surface of the stone shows a mottled and striated surface, with metallic grains of nickel iron; the surface is of a deep grey colour with ochre-coloured spots, due doubtless to traces of iron chloride. The individual grains vary in size; some, the largest, are chalk-white, the most numerous are of an ashy-grey; here and there rounded grains (the chondra of Gustav Rose) are apparent, as well as yellow or bronzy grains of pyrrhotine. The grains of nickel iron are very small. The density of the meteorite is 3·51. By the action of hydrogen chloride 60 per cent. of the stone dissolves: this consists of olivine, nickel iron, and pyrrhotine; the residue under the microscope is found to consist of a great number of crystalline grains, much acted upon by polarised light, and some of which show the forms of the prism; others show the cleavage which indicates enstatite. Besides these are black grains of chromite with an octahedral contour.

This stone most closely resembles those of Limerick (Adare) which fell 1813, September 10th, and Ohaba, Siebenbourg, 1867, October 10th, and belongs to the group of Sporadosideres and the sub-group Oligosideres.

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[1] A. Daubrée, *Compt. rend.* 1880, xci. 28.

Found 1874.—Waconda, Mitchel Co., Kansas.[1] [Lat. 39° 20′, Long. 98° 10′.]

This meteorite was found in 1874, lying above ground upon the slope of a ravine about two miles from the village of Waconda. Fragments amounting to about one-half of the stone were removed at the time; the remainder, weighing about 58 lb., is partially covered with a black crust. The freshness of the original fracture, at the time when the stone was submitted to examination, points to the fall being one of recent date.

It closely resembles the stone of Searsmont (21st May, 1871) in colour, but is less chondritic, and only exhibits this characteristic of certain meteorites in a very imperfect manner. Crystals of what appear to be augite are observed imbedded in an amorphous whitish ground-mass; nickel-iron is present thickly scattered throughout the stone in minute rounded lustrous grains; while troilite is now and then met with in grains of considerable size or aggregations of imperfect crystals. A fragment partially covered with crust was found to have a specific gravity = 3·81; that of another fragment without crust was = 3·58.

Mechanical separation of the ingredients was attempted, and 5·66 per cent. of nickel-iron and 1·34 per cent. of troilite were isolated. Of the remaining siliceous portion rather more than one-half gelatinized with acid, and was, presumably, olivine; the remainder, according to Prof. Shepard, consists of "augite, some felspathic species, and chladnite," by which last mineral enstatite presumably is meant. There exists a rumour that a second meteorite has been met with twelve miles distant from the above.

Dr. Lawrence Smith found the density of this stone to vary from 3·4 to 3·6 and its composition to be:—

Stony matter = 90·81; Nickel-iron = 5·34; and Troilite = 3·85.

The nickel-iron contained:—

Iron = 86·18; Nickel = 12·02; Cobalt = 0·91; Copper = 0·04.

and the stony part consisted of:—

Soluble part = 59·00; Insoluble part = 41·00.

which are made up of—

	Soluble.	Insoluble.
Silicic acid	34·52	54·02
Iron protoxide	30·01	18·10
Alumina...	0·43	2·30
Magnesia	32·50	23·45
Manganese	0·61	0·36
Soda, with trace of potash and lithia ...	0·89	1·58
Lime		*Trace.*

The analysis clearly shows that the stony part of this meteorite consists of the usual mixture of olivine and pyroxene; the hydrosiderite predominating in the former and bronzite in the latter.

Two minerals were detached in small quantities and analyzed

[1] C. U. Shepard, *Amer. Journ. Sc.* 1876, xi. 473. See also J. L. Smith, *Amer. Journ. Sc.* 1877, March, xiii.

separately. The first was a dark-coloured mineral readily seen in small parcels or veins; it was almost entirely decomposed by hydrogen chloride; its composition was :—

Silicic acid	41·10
Iron protoxide	27·20
Alumina	0·80
Magnesia	28·31
Manganese	0·32
Soda	1·35

It clearly belongs to the olivine type. The other mineral was found only in one part of the specimen which reached Dr. L. Smith; it formed a white crystalline mass, and weighed about 20 millegrammes. It resembled enstatite, but was completely decomposed by hydrochloric acid, and as far as he could judge consisted only of silicic acid and magnesia. It appears to occupy the same place among the unisilicates as enstatite does among the bisilicates, but requires further examination.

1875, February 12th, 10·30 p.m. (Chicago time).—Iowa Co., State of Iowa.[1]

A very large and brilliant fireball passed over Iowa City at the above date, in a direction slightly N. of W.; the apparent size of the meteor was about half that of the full moon, and it was accompanied by a broad train of light of a slightly green hue. Three separate explosions of the fireball were noticed while it was still in view, and about two or three minutes after it disappeared, three reports, resembling the discharge of the blast of a quarry, were heard.

The phenomenon attracted general attention throughout several counties in the central part of the State of Iowa, and although the visible path of the meteor does not appear to have exceeded 50 to 60 miles, the occurrence attracted attention and was heard over an area measuring about 125 miles from E. to W., and half that distance from N. to S. An observer at Brooklyn was aroused from his bed by the report, and another, who was riding in a sleigh near West Liberty, 40 miles E. of the spot where the stones fell, states that objects were rendered about as visible as if it were day; the explosions being loud, and followed by a rumbling sound that lasted some 60 or 90 seconds. According to the *Grinnell Herald*, the interval, as observed at that town, between the light of the meteor being seen and the report being heard was three minutes. The *Des Moines*

[1] A. W. Wright. *Amer. Jour. Sc.* ix. 459, and x. 44.—G. Hinrichs. Preliminary Note on the Iowa Co. Meteorites, n. d.—N. R. Leonard, *Amer. Jour. Sc.* x.—Cuttings from American newspapers, kindly sent to me by Prof. Herschel. J. W. Mallet, *Amer. Journ. Sc.* 1875, x. 206; N. R. Leonard, *ib.* x. 357; A. W. Wright, *Amer. Journ. Sc.* 1876, xi. 253; *An Account of the Detonating Meteor of February* 12, 1875, by C. W. Irish, Iowa City, 1875, *Daily Press* Job Printing Office, Dubuque Street; M. Delafontaine, *Bibliothèque Universelle*, October, 1875, 188; G. A. Daubrée, *L'Institut*, 1875 (Nos. 105-122), 138; C. W. Gümbel, *Sitzungsber. Ak. Wiss. München*, 1875, v. 313.

Register states that between Red Rock and Newton some of the meteorites passed so near the earth's surface that they clipped off branches from the trees.

Prof. N. R. Leonard, of the Iowa State University, states that the meteorites weighed altogether about 250 lbs., whereof 141 lbs. came into his possession; Prof. Hinrichs makes the total weight about 300 lbs. The largest mass, which was broken in falling, weighed $43\frac{1}{2}$ lbs.; the chief fragments, found together, being 20 lbs. and 16 lbs. in weight.

According to a description, of a very sensational character, which is given in the *Dubuque Times*, one of the meteorites was found in a field about three miles S. of the village of West Liberty, having penetrated, so it is stated, to a depth of fifteen feet into the ground.

The *Davenport Gazette* states that another stone fell at Homestead, near Iowa City (Lat. 41° 46′ N.; Long. 92° 0′ W.) in a field covered with ice and snow, and rebounded in a N.E. direction for a distance of more than thirty feet up a slight declivity, where it came to rest in the sand which was fused and adhering to it. It weighed originally about 7 lbs. 6 oz., but had been reduced by eager curiosity, hunters to 3 lbs. 8 oz.; the fractured surface of this meteorite had a dark and less distinct coating than that belonging to the larger blocks from which it had been detached by the explosion.

The stones are covered with the usual black crust, and there is evidence on some of the pieces of the meteorites of the fused material of the outer portion having run partially over the freshly fractured surfaces. Some fragments show distinct evidence of a sort of lamination or imperfect stratification, the parts where the surfaces cleaved being smoothed down, as if by pressure or friction. About 100 were found, varying in size from 9500 to 50 grammes: Hinrichs obtained 60·5 kilog. in all, which have been distributed among mineralogical collections, 25 kilog. having been sent to Paris. A preliminary chemical examination of this meteorite has already been made by L. Smith and by Hinrichs. Smith finds the specific gravity to be 3·57 and the composition:

Nickel-iron = 12·54; troilite = 5·82; silicates = 81·64 = 100·00

The nickel-iron consists of:

Iron = 89·04; nickel = 10·35; cobalt = 0·54 = 99·93

with traces of copper, phosphorus and sulphur. The silicate contains iron protoxide, alumina, magnesia, soda with traces of lithia and potash; and has, according to L. Smith, very similar compositions to the meteorite of New Concord, Guernsey Co., Ohio (1860, 1st May). Daubrée remarks on its chondritic structure, and considers it to belong to a large class of meteorites, notably represented by the stones which fell at Vouillé (1831, May 31st) and Aumale, Algeria (1865, August 25th). Hinrichs, in his "Preliminary Note," classes them with the *Oligo-sporado Sideres* of Daubrée, with the dark chondrites of Rose. He finds the nickel-iron, amounting to 7·0 per cent., to consist of:

Iron = 88·0; nickel = 12·0; manganese = trace = 100·0 while the entire meteorite has the following composition:

Nickel-iron	=	7·00
Troilite	=	1·68
Soluble silicate	=	49·40
Insoluble silicate	=	41·92
		100·00

the last two constituents being:

	SiO_2	MgO_3	FeO	MgO	CaO	Na_2O	Li_2O		
Hyalosiderite	37·0	trace	28·7	33·1	1·2	trace	trace	=	100·0
Hypersthene.........	53·9	—	19·6	21·6	4·9	—	—	=	100·0

The ratio of FeO to MgO is much the same in both soluble and insoluble portions, as the following oxygen ratios indicate:

	Soluble Portion.			*Insoluble Portion.*	
Silicic acid...		19·76	......		28·74
Iron protoxide	6·38			4·35	
Magnesia ...	13·28	19·93	......	8·64	14·38
Lime	0·32			1·39	

This meteorite, being of the stony kind, and having so recently fallen, it occurred to Wright to examine the gases contained in the particles of iron distributed throughout its mass with a view to learning whether they present the same characters as the gases occluded by the iron forming larger and independent masses.

He extracted from this picked iron at a moderately elevated temperature several times its volume of gas, consisting of 35 per cent. of carbonic acid, 14 per cent. of carbonic oxide, the remaining 49 per cent. being chiefly hydrogen. These results were obtained from metallic portions removed with the magnet; the pulverised rocky residue, however, retained a considerable amount of iron in too finely divided particles to enable them to lift the stony fragments adhering to them; accordingly a piece of the solid meteorite, about four cubic centimetres in amount, was reduced to powder and placed in the tube attached to the pump. The warmth of the hand sufficed to disengage some little gas, which, when tested, was found to contain carbonic acid and hydrogen. The pump was then set in action, and heat applied to the tube in the following manner. I. The temperature of boiling water continued for several hours. II. The moderate heat (200°—250°) of a small Bunsen flame applied for a short time. III. A stronger heat, kept below visible redness, applied for nearly an hour. IV. Low red heat maintained about half an hour. V. Full red heat. The total amount of gas evolved was about two and a half times the volume of the material operated upon, and twenty times that of the iron. Below are given the relative proportions of the gases obtained at different temperatures:

	I. At 100°	II. At 250°	III. Below red heat.	IV. At low red heat.	V. At full red heat.
Carbonic acid	95·46	92·32	42·27	35·82	5·56
Carbonic oxide ...	0·00 ?	1·82	5·11	0·49	0·00
Hydrogen...	4·54	5·86	48·06	58·51	87·53
Nitrogen (calculated)	0·00	0·00	4 56	5·18	6·91
	100·00	100·00	100·00	100·00	100·00

As regards the gas they occlude, iron and stony meteorites show a marked distinction. While the gases of the Lenarto iron contained 85·68 per cent. of hydrogen, those obtained from cosmical masses of the stony kind, if the Iowa meteorite may be regarded as a type, are characterised by the presence of carbonic acid, which constitutes nine-tenths of the gas evolved at the temperature of boiling water, and about one-half of that given off at a low red heat.

The spectrum of the gas of the Iowa meteorite, when the pressure of the pump was high, gave very brilliant carbon bands, the hydrogen lines being weak and comparatively inconspicuous, although at a very low pressure they became relatively stronger. The brightest carbon bands were the three in the green and blue, the red one being much feebler. These are precisely the ones most conspicuous in the spectra of some of the comets, and this fact is a remarkable confirmation of the received theory as to the meteoric character of those bodies.

This, moreover, is a very significant fact in showing that it is quite unnecessary to assume the existence of volatile hydrocarbons to explain cometary spectra, as some writers have done; and that the presence of the two oxides of carbon in such quantity is quite sufficient to account for all that has been observed when we consider the circumstance that the tension of the gases of the cometary appendage must be extremely small. Were a large comet to approach near enough to the sun to have its nucleus intensely heated, it is highly probable that, over and above the bands already observed, the hydrogen lines would be found in its spectrum.

Wright expresses regret that such a comet as Donati's should have departed into space just early enough to escape observation with the spectroscope. While the most probable cause of the emission of light under these conditions is electricity, another may be found in the property of gaseous bodies of emitting light of the same character as that which they absorb. It is not altogether improbable, Wright suggests, that the solar radiations absorbed by the gaseous matter, although for the most part converted into heat, would also in part be emitted again as light, and that in the case of volumes of gas filling many cubic inches, the intensity might be sufficient to give a distinct spectrum of broad bands or lines, even though, on the scale of any possible experiment, no trace of such an action can be detected. These researches have led the author to accept the following conclusions:

1. The stony meteorites are distinguished from those which are metallic by occluding the oxides of carbon, chiefly carbonic acid, as their characteristic gases, in place of hydrogen.

2. The proportion of carbonic acid evolved is much greater at low than at high temperatures, and is sufficient to mask the hydrogen in the spectrum.

3. The amount of gas contained in a large meteorite, or a cluster of such bodies, serving as a cometary nucleus, is sufficient to form the train, as ordinarily observed.

4. The spectrum of these gases closely resembles that of several of the comets.

The emission of gaseous constituents by the action of solar heat may explain the loss of tail and the diminution of brilliancy observed in the case of several comets in their successive revolutions, and their final disappearance from sight will follow as an inevitable consequence, the number of revolutions necessary to discharge the gases depending chiefly on their size and the nearness of their approach to the sun at their perihelia. When a meteorite enters our atmosphere, the gases which are evolved from it by the heat which is liberated, must greatly contribute to increase the intensity of that heat, while the sudden expansion which these gases experience must constitute the leading cause of the violent disruption of these masses.

The conclusions arrived at by Wright, on examining the gases occluded by the iron of these meteorites, have been referred to. He considered that the stony meteorites were distinguished from the iron ones by having the oxides of carbon, chiefly the dioxide, as their characteristic gases instead of hydrogen. This theory has been called in question by Mallet, who refers to his examination of the gases of the iron of Augusta Co., Virginia, where the ratio of the oxides of carbon to hydrogen is 4 : 3, and to his having pointed out in 1872 that hydrogen could no longer be regarded as *the* characteristic gaseous ingredient of meteoric iron. In his paper of that date he stated that although it might be assumed that carbonic oxide would be the original form in which the gaseous carbon-compounds existed in the iron, and that it broke up at the temperature of the experiment into carbon retained by the iron and into carbonic acid, yet in view of the steady decrease of the quantity of the latter gas which was evolved as the experiment proceeded, it seems more likely that a larger amount of carbon originally existed in the higher state of oxidation. Mallet considers that, when all the circumstances of the experiment are considered in each case, Wright's conclusion cannot be sustained.

In a paper dated some months later, Wright replies to Mallet's criticism. He states that he only meant this expression of opinion to be tentative, but that the results of further work completely justify the conclusion at which he had arrived. He has re-examined the gases of the iron of this meteorite, and examined those of the iron of some other stony meteorites, such as Ohio, Pultusk, Parnallee, and Weston, and finds that not only do the stony meteorites give off a much larger volume of gas at low temperatures, but the composition of the gas in all the cases studied is quite different from that evolved from meteoric iron. In no case among the results obtained with the alloy is the amount of carbonic acid greater than 20 per cent. at 500°, nor than 15 per cent. of the whole quantity evolved, while in every case but one the volume of carbonic oxide is considerably larger. In the chondritic meteorites, on the other hand, the per-centage of the latter gas is conspicuously small, while the carbonic acid constitutes more than half the total gas evolved below a red heat, except in the case of the meteorite under consideration which fell at Iowa, and here the per-centage is not much less, especially if we reject the numbers representing the amount obtained by a second and long-continued application of a red heat. At a temperature of about 350° it constitutes from 80 to 90 per cent. of the gaseous products, and at 100° it forms more than 95 per cent. of the gas evolved. The hydrogen, on the other hand, progressively increases in quantity with the rise of temperature, and is the most important constituent of the first portions removed at a red heat. The form in which the carbonic acid is occluded is a problem which he cannot at present solve. That it is actually absorbed appears to be certain. That it has been taken up from the atmosphere has been proposed. He finds, however, that the iron of the Iowa meteorite contains no more carbonic acid now than it did at the time of its fall.

Leonard gives a detailed account of the appearance presented by the meteor, which is stated to have been seen throughout a region 400 miles from S.W. to N.E., and 250 miles in breadth. The stones vary in weight from a few ounces to 74 lbs., and the aggregate weight is 500 lbs.; the area over which they were scattered appears to be seven miles in length, and four miles at its greatest breadth. A plan of the townships included in this area is given in Leonard's paper, and it shows where the chief stones fell. By reason of the frozen condition of the ground at the time of the fall, and the low angle of descent, it appears probable that almost all the fragments which fell have been secured. The velocity of the meteor has not been satisfactorily determined; it appears probable that during the last 60 or 70 miles of its course it travelled at the rate of from six to seven miles per second.

An interesting pamphlet by Mr. Irish, C.E., deals with the appearance presented by the meteor. He has incorporated in his paper a number of letters received from observers stationed over a wide area, describing their impressions as to its altitude, velocity and appearance; and he has given a drawing of the meteor, and prepared a map of the district, showing the projection of its path through the air. I learn by a recent letter from Mr. Irish that two blocks, one weighing 72 lbs., the other 48 lbs., which evidently formed one and the same mass which was disrupted during the descent, have since been found; and the aggregate weight of the stones now collected cannot be less than 700 lbs. I am also indebted to Mr. Irish for six excellent photographs of the Iowa stones, sixty-seven in number, which form the collections of Prof. Hinrichs, Mr. J. P. Irish, and himself. They were taken by Mr. Thomas James, of Iowa city, and are in the very best style of photographic art.

Prof. Gümbel, of Munich, has recently published an interesting paper on the characters of this meteorite. He finds the crust to possess a deep bottle-green or brownish-red colour, and to possess in polarized light all the characters of an amorphous glass-like mass. When a fragment is heated, it turns of a dark-brown colour, like that noticed by him in the eruptive rocks of the Fichtelgebirg, and he regards this change as a safe indication of the presence of olivine.

The composition of the stone is found to be :—

Meteoric iron	12·32
Troilite	5·25
Silicate, decomposed by acid	48·11
Silicate, not acted upon by acid	34·32
	100·00

The silicate decomposed by acid is an olivine, having the formula 2 ($\frac{2}{3}$ MgO, $\frac{1}{3}$ FeO), SiO_2; and the insoluble silicate, which has been regarded by Dr. Lawrence Smith as pyroxene, gave the oxygen ratios—silicic acid = 29·68; bases = 10·29. It appears not improbable that in this case the silicate was not completely decomposed during analysis.

The paper is illustrated with an interesting plate of a microscopic section, showing olivine, augite, meteoric iron, chromite, troilite, particles of a reddish hue which resemble garnet but which doubly refract light and exhibit optical characters which will not allow of their being identified with nosean, and chondra showing fibrous, radiate, and granular structure, as well as others which evidently consist of olivine, and some which are opaque and finely granular. The meteoric iron has a hackly angular structure, and has the appearance which it would present if reduced to the metallic state in the position which it at present occupies.

END OF PART I.

PART II.

In this Part it is proposed to present a digest, similar to that given in Part I., of the memoirs and notices published during the years 1869—1875 in reference to meteorites, which either have been seen to fall or have been found at a date earlier than the beginning of 1869, including a description of their history, or of any investigations of the physical and chemical characters of these meteorites, together with such results as tend to correct earlier analyses.

The Pre-Homeric Meteoric Irons.[1]

Von Haidinger, in April, 1870, in a letter addressed to Fr. von Hauer, directed attention to a communication which he had received from Sir John Herschel, supplementing a short notice on the above subject,[2] which was sent to von Haidinger six years previously by Prof. Miller, of Cambridge.

[1] W. von Haidinger. *Mitt. Anthrop. Gesell. Wien*, i. no. 3, 63.

[2] W. von Haidinger. *Sitzungsber. Acad. Wiss. Wien*, l., Pt. II. 288.—In this paper, *Ein vorhomerischer Fall von zwei Meteoreisenmassen bei Troja*, Miller called attention to *Iliad*, xv. 19-32:

19. Ἄκμονας ἧκα δύω . . . .
31. . . . . . . μύδρους δ' ἐνὶ Τροίῃ
32. Κάββαλον· ὄφρα πέλοιτο καὶ ἐσσομένοισι πυθέσθαι.

Miller remarking that these lines were enclosed in brackets, and given as doubtful, applied to Babington, who wrote: *Iliad*, xv. 30. Memorat Eustathius post hunc versum nonnullos adscripsisse hos versos:

Πρὶν ὅτε δὴ σ' ἀπέλυσα ποδῶν· μύδρους δ' ἐνὶ Τροίῃ
Κάββαλον· ὄφρα πέλοιτο καὶ ἐσσομένοισι πυθέσθαι·

Adding as a commentary: Καὶ δέικνυνταί, φασιν, ὑπὸ τῶν περιηγητῶν οἱ τοιοῦτοι μύδροι. [" lumps of this kind they say are pointed out by the Periegetae "]. Eustathius was Archbishop of Thessalonica, and died in 1198. Moreover, he says that the Periegetae called them "anvils from above (fallen from heaven)." Von Haidinger points to the incomplete character of the passage without lines 31 and 32:—

Dann dir erst löst' ich die Füsse, die Klumpen aber nach Troja
Warf ich hinab, noch spätern Geschlechtern die That zu verkünden.

He also alludes to the fact that *two* iron masses fell at Braunau, Bohemia, and *two* at Cranbourne, near Melbourne, Australia.—It is not a little curious, in its bearing on this question, to find that the Egyptian word for iron, *baa-en-pe*, of which two forms are given below, also signifies 'stone, or metal of heaven':

(19th Dynasty.) Lepsius' *Denkm.* iii, 194, l. 10.

The Harris Papyrus. Pl. xl. b, l. 11.

Herschel points out that the Trojan irons do not constitute the only instance in the writings of Homer where that metal is mentioned in a manner to provoke the assumption that all the iron used at that time by the Greeks was of meteoric origin. The mass of iron which Achilles offered as a prize at the funeral games of Patroclus, and which had been carried off as treasure from the palace of Eetion, is described as *σόλον αὐτοχόωνον* (crude, self-fused); while to show the scarcity of iron in those times, it is stated that this block of metal, though of such a size that a strong man could hurl it some distance, would prove a sufficient supply of iron for five years to the winner, and render unnecessary a journey to the city for the purchase of that metal. Again, among the prizes for the archers we find, in addition to ten two-edged axes and ten hatchets of bronze, *ἰόεντα σίδηρον* as material for arrow-heads. This is not "crude, self-molten" (meteoric?) iron, but forged metal, converted probably on the surface by cementation into steel. It is far from improbable that in early times, before the art of forging iron was known, many metallic masses of meteoric origin lay strewn over the then known surface of our planet, which, as their adaptation to the useful arts became known, were collected and turned to use, as was the case with gold. Von Haidinger further called attention to the statement in Sir John Herschel's letter that the latter had noticed these references to the early use of iron before he perused the former's first report published in 1864. Herschel remarks, moreover, that in south-east Africa considerable masses of nickel-iron have been met with,[1] which were collected and worked into implements by the aborigines, when they learned their value by intercourse with Europeans. Further instances where iron is mentioned are to be found in *Iliad*, iv. 485, and *Odyssey*, i. 184.[2] We know of other cases where meteoric iron has been worked into implements; among which may be mentioned the iron of Arva, Szlanicza, Hungary, and that composing the blades of the Esquimaux knives discovered in 1819 by General Sir Edward Sabine,[3] which are in the British Museum Collection of Meteorites. (See also page 40.)

Reference to a Meteorite in the Time of Buddha.

In the pages of ancient history the fall of stones from heaven has not unfrequently been placed on record. The reader who may desire to know where these notices are to be met with is referred to

[1] O. Buchner. Die Feuermeteore. Giessen: 1859. Page 128.

[2] For the early history of iron see F. X. M. Zippe. Gold, Kupfer, Eisen. *Almanach Akad. Wiss. Wien*, 1856, Anhang. 135.—F. X. M. Zippe. *Geschichte der Metalle.* Vienna, 1857.—E. Buchholz. Die Homerischen Realien. Leipzig: 1871. (chapter on Mineralogy), 289–349.—On Some Evidences as to the Very Early Use of Iron. By St. J. V. Day. Two communications of the *Phil. Soc. Glasgow.* Ednburgh: 1871 and 1873. On the High Antiquity of Iron and Steel. By the same author. Communicated to the *Phil. Soc. Glasgow.* London: 1875.

[3] E. Sabine. *Quart. Jour. Sc.*, vii. 79.

the article "Meteorolite" in the last edition of the *Encyclopædia Britannica*. Our present purpose is merely to direct attention to an allusion to a meteorite in Mr. Beal's interesting volume entitled "The Romantic Legend of Sâkya Buddha,"[1] which has recently appeared; it takes us back to the sixth century B.C., to a more recent date than that of the shower of stones, stated by Livy to have fallen on the Alban Mount, but previous to the descent of the great stone near Ægospotamos, described by Pliny, and mentioned in *The Parian Chronicle*. Although in the present instance the fall of a stone is merely foretold, every allusion to occurrences of this kind in early writings is of interest.

Mr. Beal's work is a translation of the Chinese version of the "Abhinishkramana Sûtra," which was written in that language by a Buddhist priest from North India, who resided in China during the Tsui dynasty (the end of the sixth century A.D.). The story of "The offering of Food by Two Merchants" (chap. xxxii.) tells how "the world-honoured one" sat in the Ktchirnika grove forty-nine days, and that he took no food. Two merchants of North India, who were carrying valuable goods to Middle India, came that way, and as they passed the Guardian Spirit of the grove assumed a bodily form, and stood in front of the oxen, which were afraid to go on. The merchants being filled with terror, the Guardian Deva again assumed a bodily form, and told them not to fear, and to offer food to the Buddha. Then Buddha having accepted their offering, "delivered their caravan from its difficulties, and presented them (in consequence of their request for some memorial of him) with a hair and fragments of his nails, telling them that hereafter a stone should fall from heaven near the place where they lived, and that they should erect a pagoda and worship the relics as though they were Buddha himself."

1325.—Birki, near Arzerrum (Erzroum), Anatolia, Turkey.[2]

My attention has been directed by Mr. William Simpson to an account of a meteorite, probably a block of meteoric iron, which is given in the translation from the Arabic of "The Travels of Ibn Batūta." It appears that a Mahommedan, who had started on his travels from Tanjiers, came in the year 1325 to Birki, near Erzroum, and had audience with the king. "The king one day said to me, Have you ever seen a stone that came down from heaven? I answered, No. He continued, Such a stone has fallen in the environs of our city. He then called some men, and ordered them

[1] The Romantic Legend of Sâkya Buddha: from the Chinese-Sanscrit. By S. Beal. 1875. London: Trübner. Page 239.

[2] The Travels of Ibn Batūta. Translated from the abridged Arabic Manuscript Copies preserved in the University of Cambridge. By the Rev. S. Lee. Printed for the Oriental Translation Committee. 1829. London: J. Murray. Page 72.

to bring the stone, which they did. It was a black, solid, exceedingly hard, and shining substance. If weighed, it would probably exceed a talent (according to some 112, to others 120 lbs. weight). He then ordered some stone-cutters to come in, when four came forward. He commanded them to strike upon it. They all struck together upon it accordingly with an iron hammer four successive strokes, which however made not the least impression upon it. I was much astonished at this. The king then ordered the stone to be taken to its place."

1628, April 9th, about 6 p.m.—Chalows and Barking, near Wantage, Berkshire.[1]

Mr. Webb directs attention to a letter, preserved in Wallington's *Historical Notices*, i. 13, which was written in 1628 "by Mr. John Hoskins, dwelling at Wantage, to his son-in-law, Mr. Dawson, a gunsmith, dwelling in the Minories without Aldgate," relating to the fall of meteorites. Describing the explosion, Hoskins says: "It began as followeth:—First, as it were, one piece of ordnance went off alone. Then, after that, a little distance, two more; and then they went as thick as ever I heard a volley of shot in all my life; and after that, as if it were the sound of a drum. . . . . Yet this was not all; but, as it is reported, there fell divers stones, but two is certain in our knowledge. The one fell at Chalows, half a mile off (from Wantage), and the other at Barking, five miles off. Your mother was at the place where one of them fell knee deep, till it came to the very rock, and when it came at the hard rock it broke, and being weighed, all the pieces together, they weighed six-and-twenty pound. The other that was taken up at the other place (Barking) weighed half a tod, 14 pound."

1640, May 24th (N.S.) about Noon.—Antony, near Plymouth.[2]

Among the tracts and broadsheets incorporated in the valuable catalogue of the writings of Cornishmen, *Bibliotheca Cornubiensis*, is one by the Rev. Arthur Bache bearing the title, "The Voyce of the Lord in the Temple; or a most strange and wonderfull Relation of God's great Power, Providence, and Mercy, in sending very strange sounds, fires, and a Fiery Ball into the Church of Anthony, neere Plimmouth, in Cornwall, on Whit Sunday last, 1640. To the scorching and astonishment of fourteen severall persons who were

[1] T. W. Webb. *Nature*, July 14th, 1870.

[2] G. C. Boase and W. P. Courtney. *Bibliotheca Cornubiensis.* London: Longmans, 1874.

smitten, and likewise to the great Terrour of all the other people then present, being about 200," etc. This little pamphlet is chiefly devoted to harrowing descriptions of "divers hurts" received by the congregation. One man, in recording his experiences, stated that he heard "as it were the hissing of a great shot." It is not improbable that this phenomenon was caused by lightning.

Found 1751.—Steinbach, Saxony.

For a short description of the probable composition of this siderolite see the *Breitenbach meteorite.*

1776.—Krasnojarsk, Siberia. (The Pallas Iron.)[1]

This celebrated siderolite has recently been sawn into two nearly equal parts, and the occasion presented a fitting opportunity for an exhaustive examination of its constituent minerals, more especially of the olivine forming the chief ingredient. It was accordingly undertaken by von Kokscharow, at the desire of the Imperial Academy of Sciences, and his memoir is mainly devoted to a description of the crystallographic characters of the silicate enclosed in the nickel-iron.

He finds that the interior presents no new leading features. The olivine, which has a greater number of crystal-faces than Pallas observed on it, occurs not only in spherular or drop-like masses bearing numerous faces, but in tolerably well-developed crystals, which, though rounded here and there, exhibit sharp edges, and a considerable number of forms, some of which have not been observed on terrestrial olivine. The individual crystal has generally a rounded surface, on which the planes lie; and although these are separated from each other by curved areas, their mutual inclination enables the observer to identify them. They are in most instances smooth and lustrous, and allow of the most accurate goniometrical measurement being performed. The best developed faces are: $c = \text{o P}$; $d = \overline{\text{P}}\ \infty$; and $o = \frac{1}{2}\text{P}$. Biot[2] showed half a century since that these rounded masses of olivine exhibit crystalline structure, and possess two optic axes. The first minute investigation of them was conducted by G. Rose.[3]

Rose observed eleven crystal-forms on the Pallas olivine; von

[1] N. von Kokscharow. *Bull. l'Acad. Imp. Sc. St.-Pétersbourg*, 1870, xx., No. 3. *Mémoires l'Acad. Imp. Sc. St.-Pétersbourg*, xv., No. 6. *Jahrb. Mineralogie*, 1870, 778.—E. H. von Baumhauer. *Archives Néerlandaises*, 1871, vi.—G. von Helmersen. *Zeitsch. Deutsch. Geol. Gesell.* xxv., 347.—A Goebel. *Bull. Ac. Imp. Sc. St.-Pétersbourg*, 1874, xx. 100.

[2] J. B. Biot. *Bull. de la Soc. Philomatique*, 1820, 89.

[3] G. Rose. *Pogg. Ann.*, 1825, iv., 186.

Kokscharow has added eight more, making nineteen altogether, which are as follow:

Rhombic Pyramids.

	Weiss.	Naumann.
q	(a : 6 b : 6 c)	$\frac{1}{6}P$
o	(a : 2 b : 2 c)	$\frac{1}{2}P$
e	(a : b : c)	P
a	(a : $\frac{n}{m}$ b : $\frac{1}{m}$ c)	$m\bar{P}n$
f	(a : $\frac{1}{2}$ b : c)	$2\breve{P}2$
l	(a : $\frac{1}{3}$ b : c)	$3\breve{P}3$

Rhombic Prisms.

n	(∞ a : b : c)	∞P
s	(∞ a : $\frac{1}{2}$ b : c)	$\infty\breve{P}2$
r	(∞ a : $\frac{1}{3}$ b : c)	$\infty\breve{P}3$

Macrodomes.

β	(a : ∞ b : 6 c)	$\frac{1}{6}\bar{P}\infty$
v	(a : ∞ b : 2 c)	$\frac{1}{2}\bar{P}\infty$
γ	(a : ∞ b : $\frac{1}{m}$ c)	$m\bar{P}\infty$
d	(a : ∞ b : c)	$\bar{P}\infty$

Brachydomes.

w	(a : 2 b : ∞ c)	$\frac{1}{2}\breve{P}\infty$
h	(a : b : ∞ c)	$\breve{P}\infty$
k	(a : $\frac{1}{2}$ b : ∞ c)	$2\breve{P}\infty$
i	(a : $\frac{1}{4}$ b : ∞ c)	$4\breve{P}\infty$

Pinacoids.

a	(∞ a : b : ∞ c)	$\infty\breve{P}\infty$
c	(a : ∞ b : ∞ c)	oP

The forms *e, f, l, n, s, r, d, k, i, c,* and *a,* are those described by Rose; the remainder were not only previously unknown on Pallas olivine, but, with the exception of *h* and *w*, have not been met with on chrysolite from any locality. The brachydome *w* has recently been noticed by vom Rath[1] on the olivine of the Laachersee sanidine. Although the crystal-faces of the Pallas olivine are somewhat numerous, $\bar{P}2$, noticed by Descloizeaux,[2] and $\infty\breve{P}4$, as well as the macropinacoid $b = \infty\bar{P}\infty$ of other observers, have not been noticed. In two of the plates accompanying the memoir the author gives eight projections of the more important combinations of the above forms, while in a third plate they are all graphically represented according to Neumann and Quenstedt's method.

On comparing his measurements of the faces of the Pallas olivine with the numbers obtained by Mohs, von Haidinger, Scacchi,[3] and himself, when examining crystals of olivine from other sources, the author finds almost complete accordance between them, and deduces the following numbers for the axes of the olivine crystal:

$$a = 1·25928$$
$$b = 2·14706$$
$$c = 1·00000$$

He then proceeds to establish their correctness by comparing in detail the calculated values with those obtained by measuring the meteoric olivine, and that from Egypt and Vesuvius, as well as specimens of the mineral from other localities, investigated by Mohs and von Haidinger.

Rose[4] was the first to observe under the microscope the remarkable

[1] G. vom Rath. *Pogg. Ann.*, 1868, cxxxv., 580.
[2] A. Descloizeaux. *Manuel de Minéralogie*, i., 30.
[3] A. Scacchi. *Pogg. Ann., Ergänzungsband* iii., 184.
[4] G. Rose. *Beschreibung und Eintheilung der Meteoriten*, Berlin, 1864, 75.

structure of this olivine. On examining a section, $2\frac{1}{2}$ mm. in thickness, he noticed, even with very low powers, that it was traversed by a number of straight black lines lying parallel to each other; so sharp and regular were they, that they resembled lines described on paper with a drawing pen. When magnified 200 to 300 diameters, they appeared to be tubes, sometimes empty, sometimes filled more or less with a black or light grey substance, or both substances. In one crystal with two small faces *k*, and between them the face *a*, it was noticed that the faces *a* and the tubes reflect light at the same instant, and that they lie at right angles to the axis of the zone *ka*.

Von Kokscharow found these canals in every granule of the Pallas olivine which he examined; one crystal, 6 mm. in diameter, through which a section was cut, exhibited 17 of them under a pocket lens, and many more in the microscope; they were all parallel to the edge *sr*, that is to say, parallel to the vertical crystallographic axis. A mean of nine measurements of the angle which these canals form with the edge *ea* (which were made with a very good goniometer, designed by von Auerbach and constructed by Hartnack) was found to be 38° 28′, the calculated angle being 38° 27′ 12″. The plane of the optic axes lies at right angles to the canals, and therefore to the crystallographic vertical axis; in short, this plane in Pallas olivine, as in the terrestrial specimens, is parallel to the basal pinacoid $c = oP$.

The canals were studied in seven sections of crystals, and drawings of them are given in a plate. By altering the focus of the microscope, canals lying at various depths are brought into view; when a certain thickness of the olivine has been traversed, the doubly-refractive power of the intervening layer of the mineral causes the canals to appear double. Another effect of this property of the crystal is that the magnifying power of the microscope is also apparently somewhat increased. The partial overlapping of the two images of a canal gives it the appearance of a tube filled throughout the entire length with black material; others, again, viewed through greater thicknesses of the mineral, appear as two distinct tubes. Examination with a Nicol or a tourmaline plate at once convinces the observer that these effects are due to double refraction.

The enclosed black and grey matter is found sometimes at one end only of a tube, sometimes in the middle, or again at different points in its length, in which case it presents the appearance of a thermometer, the mercurial column of which has been broken. Other sections are described which were prepared so that the tubes were cut obliquely, or at right angles. The results of an examination of these sections in polarized light supports the assumption that these appearances are caused by hollows traversing the olivine, and not by transparent crystals enclosed in it.[1]

[1] It should be mentioned that Rose (*Beschr. und Einth. Met.*, 76) found these canals in great perfection and abundance in the olivine of the meteorite found at Brahin, Minsk, Russia (1810), a siderolite bearing the closest resemblance to the Pallas iron. The mineral occurring in the siderolites of Rittersgrün and Steinbach, which Rose termed olivine, and some of the angles of which he found to accord with those of the olivine of the Pallas and Brahin siderolites, is probably not olivine, but bronzite.

This olivine was investigated chemically by Howard, Klaproth, Stromeyer, Walmstedt, and Berzelius. It has recently been examined by H.I.H. the Grand-Duke Nikolai Maximilianovitsch von Leuchtenberg; the mean numbers resulting from his analyses are given under I. Von Baumhauer, to whose paper we shall immediately turn our consideration, also publishes a new analysis of this silicate (II.), and gives in juxtaposition the theoretical numbers (III.) corresponding to an olivine with the formula:

$$2\ FeO,\ SiO_2 + 7\ (2\ MgO,\ SiO_2).$$

	I.	II.	III.
Silicic acid	40·24	40·87	40·70
Magnesia	47·41	46·93	47·17
Iron protoxide	11·80	12·11	12·13
Nickel protoxide	...	trace	...
Manganese protoxide	0·29	trace	...
Alumina	0·06	...	...
Tin oxide	0·08	...	...
	99·88	99·91	100·00

Rumler found arsenic in this silicate, and Howard half a per cent. of oxide of nickel. The Duke of Leuchtenberg discovered none of this oxide in the specimens which he examined. It is not improbable that Howard may have fallen into error through the presence of organic matter in the ammonia, employed in his analysis, having rendered the precipitation of the iron oxide incomplete.

Von Kokscharow finds the specific gravity of some very pure crystals of the olivine to be 3·3372; of some brown fractured granules, 3·3415; the mean being 3·3393.

Many terrestrial olivines contain nickel protoxide. Rammelsberg found 2·35 per cent. in the variety of this mineral occurring in the basalt of Petschau, in Bohemia; Genth determined its presence in that from Thjorsalava, of Hekla; and Sartorius von Waltershausen in the olivine of the Fiumara di Mascali, near Etna. It has also been detected in the olivine of Langeac, Haute-Loire; it forms a constituent of that mineral as met with in the lherzolite of the Pyrenees, in the lava of the Isle of Bourbon, in the basalt of Sneefels-Jockul, Iceland, in the melaphyre of Oberstein, and in the dunite of Mt. Dun, New Zealand. A knowledge of these facts induced von Baumhauer to examine with great care the Pallas olivine for nickel.

That portion of a meteorite which, after the nickel-iron has been removed with a magnet, dissolves in acid, is usually regarded as olivine, $2\ RO,\ SiO_2$. Small quantities of alumina, lime, manganese, and nickel protoxide, and occasionally of alkalies, are, it is true, also found in the solution; but with the exception of the nickel oxide, the occurrence of which is ascribed to the incomplete removal of the nickel-iron by the magnet, the presence of these ingredients is attributed to the incipient decomposition, even in the cold, of the other silicates of the meteorite.[1] Mercury chloride, a reagent the use of which

[1] It has been found that the enstatite of the Busti meteorite (which see) is slowly decomposed by hydrochloric acid.

was proposed by Rammelsberg, enables us to separate by solution the nickel-iron from all the silicates. The sublimate, however, does not dissolve any portion of the nickel-iron which by oxidation may have been converted into hydrated oxide of iron and oxide of nickel. To remove them von Baumhauer heats the powder, which has previously been treated with the chloride, in a current of hydrogen, and, after reducing the oxides to the state of metal, subjects the powder once or twice more to the action of the sublimate in an atmosphere of hydrogen. By careful selection and treatment in the above manner, he proceeded to operate on some apparently pure olivine from the Pallas meteorite; it was of a clear yellow colour, and, when heated for half an hour in hydrogen, lost no weight. It was then broken up with acid, and analysed by the usual method; the iron oxide retaining any nickel oxide that may be present was twice dissolved in acid and thrown down with ammonia. The three filtrates, containing all the magnesia, were treated with ammonium sulphide, which produced a black precipitate, so small in quantity that it could not be weighed. Before the blowpipe it displayed the characteristic reactions of a compound of nickel.

Von Baumhauer expresses a doubt whether the nickel may not have been a constituent of a trace of the metallic alloy which, in spite of all precautions, had adhered to the silicate. It is, moreover, a question whether the repeated precipitation of the iron oxide with ammonia, even in the presence of a large excess of ammonium chloride, would effect the removal of a very small proportion of nickel oxide in so complete a manner as Field's method with lead oxide.[1]

In May, 1873, von Helmersen addressed a letter to G. Rose, stating that several members of the Academy of Sciences of St. Petersburg, Schmidt, Schrenck, von Kokscharow, himself and others, had advised the Academy to institute an inquiry into the nature of the ground of the locality where the Pallas siderolite was found, they being of opinion that such an investigation might throw light on its history, just as an examination of the rocks of Disko had proved of great value in facilitating the study of the Ovifak meteorites. Lopatin, a mining engineer stationed in Eastern Siberia, was directed to proceed to Krasnojarsk for that purpose, and the result of his explorations has appeared in a very elaborate memoir recently published by Goebel. In this paper the author discusses in the fullest details the arguments advanced, especially by Chancourtois,[2] to show that the Pallas iron is not of meteoric origin. It had been stated by Mettich that a very rich iron ore abounds on the hill, close to the spot where the Pallas siderolite was discovered, an ore described as magnetic, and as containing about 70 per cent. of metal. It will be remembered (see page 33) that Daubrée found only 71 per cent. of iron in the Ovifak masses, 41 per cent. thereof being in the metallic state.

[1] F. Field. *Chem. News*, i. 4.
[2] É. de Chancourtois. *Bull. Soc. Géol. France*, xxix. 177 and 210.

Lopatin's account of the features of the locality leave little doubt respecting his having hit upon the spot described by Pallas and Mettich. He finds the ridge to consist of a coarsely granular granite, closely resembling the Rappa-kiwi of Finnland; the magnetite contained no metallic iron.

With a view of securing further fragments of this siderolite, a reward was offered by Lopatin to those few persons who frequent this region for squirrel-hunting; none, however, were found. But large fragments of a meteoric fall are, as Goebel points out, usually scattered over a wide area of country, and it is in the highest degree improbable that two large masses would be found in proximity to each other: the fall of siderolites in Bohemia and Saxony (Breitenbach, Rittersgrün, and Steinbach), probably in the latter part of the twelfth century, affords a case in point. It appears, moreover, that even only a short time after their descent meteorites are by no means easy to discover. In 1833 von Reichenbach[1] prosecuted a thorough search of the district near Blansko, Brünn, Moravia, eleven days after a shower of what appeared to have been as many as 400 stones had taken place; 120 men were employed, and time equivalent to 600 working days was devoted to the search, but only eight small stones, weighing in all 20 loth (about 12 oz.) were found.

The Mexican Meteorites.[2]

In continuation of his earlier papers on the meteorites of the Mexican Republic, which appeared in 1856, 1857, and 1858, the late Dr. Burkart has brought the history of these remarkable masses down to the date 1874. He first directs attention to the masses found near Santa Rosa, a small town in the N. part of the State of Cohahuila, in lat. 27° 55′ N. and long. 2° 16′ W. of Mexico, and near the boundary of the Bolson of Mapimi.

According to the report of Major E. W. Hamilton, published by Shepard, the spot where he discovered a number of masses of meteoric iron is called Bonanza, 30 to 40 miles north, and much further west of Sta. Rosa. Here Hamilton found scattered over an area, one to two miles in diameter, thirteen blocks of iron, twelve of which had never been shifted; the other, weighing 75 lbs., was about to be sent to Sta. Rosa. The largest, a more or less rounded block, is three feet wide and two to two and a half feet high; others were estimated to weigh from two to three thousand pounds.

Meteoric masses found in the neighbourhood of Sta. Rosa are

[1] C. von Reichenbach. *Pogg. Ann.*, cxxiv. 213.

[2] C. Rammelsberg. *Zeitsch. Deutsch. Geol. Gesell.*, 1869, xxi., 83.—J. L. Smith. *Amer. Jour. Sc.*, 1869, xlvii., 383; *Amer. Jour. Sc.*, 1871, i. 335.—S. Meunier. Thèse presentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la composition et la structure des Météorites*, 42 *et seq.*—H. J. Burkart. *Jahrb. Mineralogie*, 1870, 673; 1871, 851; and 1874, 22.

mentioned by J. L. Smith, and a fragment of one of them was exhibited at the meeting of the American Association for the Advancement of Science held at Chicago in 1868. It appears that Dr. Butcher obtained from the son of Dr. Long, who had resided many years in Sta. Rosa, an interesting account of a very brilliant meteor which in the fall of the year 1837 passed over the town in a N.W. direction; shortly after its disappearance over the mountains a rumbling sound was heard, followed by a tremendous explosion. The next day Mr. Long endeavoured to find traces of the meteorite, but after two days' severe and rough riding the search was abandoned. Shortly afterwards an Indian brought into Sta. Rosa a piece of what he believed to be silver, weighing ten to twelve pounds, stating that it had been found ninety miles N.W. of the town; this proved to be meteoric iron. Dr. Butcher, after this long lapse of time, determined to renew the search, and, hiring eight Mexicans and two Indians as guides, succeeded in finding the irons about ninety miles from Sta. Rosa. They consist of six masses, weighing 290, 430, 438, 550, 580, and 654 lbs., which have been sent to the museums of the United States, and two other blocks, weighing 353 and 450 lbs., which have since been hit upon.

This interesting group of meteoric irons consists of compact metal containing no silicate; it is not difficult to cut with the saw, has the specific gravity 7·692, and the composition:

Iron = 92·95; Nickel = 6·62; Cobalt = 0·48; Phosphorus = 0·02;
Copper = trace. Total = 100·07.

Although these irons differ as regards the amount of nickel they contain from the meteoric iron of Santa Rosa described in 1855,[1] J. L. Smith believes that the disparity arises from an error in the earlier analysis, and that it will be found that the Santa Rosa iron belongs to the above group.

The question which next arises is,—Are the two finds, described by Hamilton and Butcher, one and the same? Burkart, after carefully weighing the evidence of both accounts, allowed that there is much to favour the assumption, and suggested that Shepard and J. L. Smith would do good service to science by referring the subject to the consideration of the two observers.

J. Guillemin Tarayre[2] in his *Notes archéologiques et éthnographiques,* while describing the *Casas grandes de Chihuahua* or *Malintzin,* mentions the discovery by Müller, the Director of the Mint at Chihuahua, of a meteorite in the great temple north of Galeana (lat. 30° 22′ N.; long. 110° W. of Paris). While excavating these labyrinthine ruins a lenticular piece of iron, 50 cm. in diameter, was discovered carefully enveloped in cloth similar to that in which the dead of the surrounding graves were wrapped.[3]

[1] O. Buchner. *Die Meteoriten.* Leipzig, 1863. Page 192.

[2] *Archives de la Commission scientifique du Mexique.* Paris, 1869. iii. 348.

[3] In the *Annual Report* (1873) *of the Board of Regents of the Smithsonian Institution* (Washington, 1874, p. 419), is published a letter from Mr. W. M. Pierson, U.S. Vice-Consul at El Paso del Norte, describing the discovery of a large meteorite in the ruins of Montezuma Casas Grandes, on the Gila River, in Arizona.

Among new meteoric stones found in Mexico must be mentioned the chondritic meteorite described by Wöhler; it is stated that it fell in 1855 or 1856 at the Hacienda Avilez, not far from the mining town of Cuencamè, twenty leagues N.E. of Durango in lat. 24° 47′ N. and long. 4° 8′ W. of Mexico.

The large meteoric iron, computed to weigh 19,000 kilog., which lay in the neighbourhood of Durango in Humboldt's time, and of which he brought fragments to Europe that were analyzed by Vauquelin and Klaproth, appears since then to have been lost. Burkart, however, considered some statements made by Guillemin Tarayre in the *Archives de la Commission scientifique du Mexique* to indicate that within the last few years it had again been found near the Cerro Mercado. According to more recent accounts, the locality of this colossal mass is known, but is kept secret, as the owner intends to endeavour to transport it to Mexico.

Burkart briefly notices: the meteoric iron from San Francisco del Mezquital, in the State of Durango, weighing seven kilog., which was described by Daubrée; a piece of meteoric iron[1] "from Mexico," the locality not being more definitely given, which J. L. Smith found to exhibit very distinct figures when etched, and to be composed thus:

Iron = 91·103; Nickel = 7·557; Cobalt = 0·763; Phosphorus = 0·020; with traces of Copper and Sulphur. Total = 99·443.

a meteoric iron at Los Zapotes, four leagues from Cuquio, which is reported to have been brought from Zacatecas; and the meteoric iron of Yanhuitlan (lat. 17° 35′ N.; long. 1° 45′ W. of Mexico), which was in the possession of the Emperor Maximilian, and possibly comes from the same locality as the Misteca Alta iron preserved in some collections. The last two masses contain:

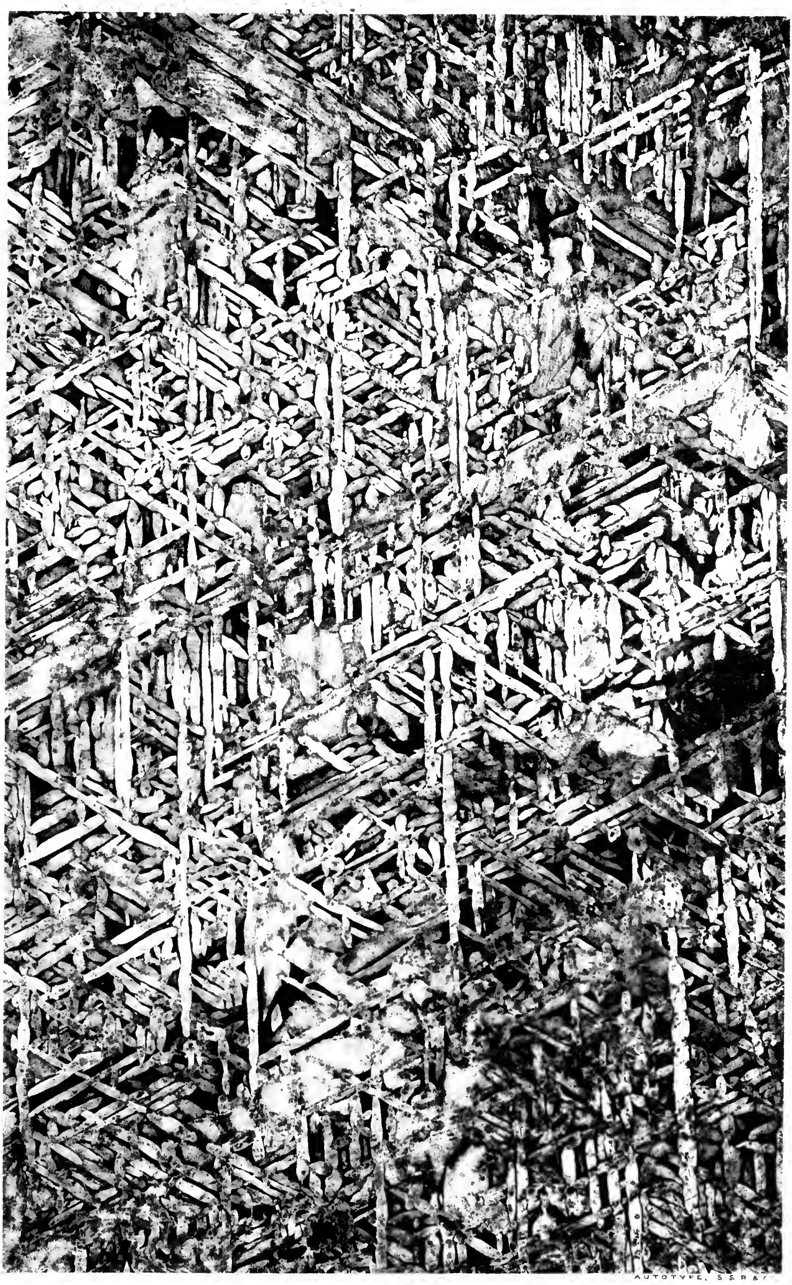
	Yanhuitlan.	Misteca Alta. I.	Misteca Alta. II.
Nickel	6·21	4·39	9·919
Cobalt	0·27	0·18	0·075
Insoluble residue	trace	0·20	—

The first two analyses are by Rammelsberg, the last by Bergemann.[2]

It was found in a large room of the ruins, in the centre of what appeared to be a tomb of adobe-brick, and was carefully wrappped in coarse linen similar to the cere-cloth in which the Egyptians enveloped their mummies. "Twenty-six yoke of oxen were mustered, and as many or more strong log-chains, and with this force and tackle the monster meteorite was hauled to the modern town of Casas Grandes. When struck it emitted a loud and hollow sound much resembling that of a church bell. It is stated to measure 2 feet 6 inches square, and is supposed to weigh over 5000 lbs. The date of this occurrence is not mentioned, and although the form and dimensions of the mass given in this report differ considerably from those of the metallic block above mentioned, it appears not improbable that Tarayre and Pierson describe the discovery of the same block of metal. A specimen of this iron was sent to Washington with the Vice-Consul's report.

[1] This was probably a fragment of the Charcas meteoric iron which General Bazaine sent to Paris.

[2] Burkart gives the following list of localities of meteorites found in the Mexican Republic:—*Meteoric Stones.* 1). Hacienda de Bocas, N. of San Louis Potosi, fell 1804, November 24th. 2). Cerro Cosina, near Dolores Hidalgo, District of San Miguel in the State Guanajuato, fell 1844, January —, 11 A.M. 3). Hacienda Avilez, near Cuencamè in the State Durango, fell 1855 or 1856.—*Meteoric Irons* (each locality lies to the north of those following it in the list). 1). The Casas



METEORIC IRON, FROM TOLUCA, MEXICO.
Polished Surface etched with Bromine.
[*Actual Size.*]

The last paper written by the late Dr. Burkart gives the history of the meteoric iron from Descubridora, Poblazon, near Catorze, State San Louis Potosi, to which we have already alluded (see page 53). It was found between 1780 and 1783; in 1856 it was conveyed to the Amalgamation Works near Catorze to be used in the *morteros* or stamping mills; and in 1871 was removed to Mexico, where it came into the possession of the Geographical and Statistical Society. In 1872 this learned body came to a determination that the meteorite, which weighs 575 kilog., should be broken up for examination, which drew from the Mexican Natural History Society an indignant protest. Those who take an interest in the correspondence which passed between the two Societies will find below references to the journals in which it appeared.[1] A portion of this iron is one of the most recent additions to the University Collection at Göttingen.

The iron, of which the author gives three drawings, is in the form of a prism with rounded ends, and has a length of 90 cm. It has a steel-grey colour, takes a high polish, and is remarkably malleable: nails, knife-blades, wire, and a watch spring have been made of it. When etched it developes good figures, of which a sketch is given in Burkart's paper; they resemble those of the iron of Xiquipilco; the angle 109° corresponding to an octahedron is frequently noticed. Rounded masses of troilite occur here and there; the hardness is = 8; the specific gravity = 7·38. It has been analyzed by Patricio Murphy with the following results:

Iron = 89·51; Nickel = 8·05; Cobalt = 1·94; Sulphur = 0·45; Chromium and Phosphorus — Traces. Total = 99·95.

A very careful investigation has been made of the physical properties of the wire forged from this iron; it possesses an unusually high elasticity, the modulus being = 7436·17 kilog.; the resistance of the iron to rupture by compression = 38 kilog., to rupture by extension = 40 kilog. In each case the sectional area of the metal operated on was 1 mm. square. The coefficient of the linear expansion of the iron when heated between 0° and 100° C. = 0·00002336783.

Meunier has investigated two of the Mexican irons, those from Charcas and the Toluca Valley. A perfectly clear surface of the

grandes de Malintzin, between Galeana and Corralites, District Bravos, State of Chihuahua. 2). Bonanza, State of Cohahuila. 3). Sierra Blanca, near Huajuquillo (or Jimenez), State of Chihuahua. 4). San Gregorio, State of Chihuahua. 5). Hacienda Concepcion, on the Rio Florido, State of Chihuahua. 6). Hacienda Venagas, probably in the State of Chihuahua. 7). Plain near el Mercado mountain, N. of Durango, State of Durango. 8). Durango (block used as an anvil; this mass has recently been removed to Mexico). 9). San Francisco del Mezquital, State of Durango. 10). Descubridora, at Poblazon, near Catorze, State of San Louis Potosi. 11). Charcas, State of San Louis Potosi. 12). Zacatecas. 13). A Hacienda south (?) of Zacatecas. 14). Xiquipilco, Hocotitlan, Istlahuaca, etc., in the Toluca or Lerma Valley, State of Mexico. 15). Chalco, Valley of Mexico. 16). Misteca Alta, State of Oaxaca. 17). Yanhuitlan, State of Oaxaca. 18). (?) Rincon de Caparosa, near Chilpancingo, on the road to Acapulco.

[1] *Boletin de la Sociedad de Geografia y Estadistica de la Republica mexicana.* Seg. Ep. Mexico, 1872. Tomo IV. Pages 5 and 317.—*La Naturaleza Periodico cientifico de la Sociedad mexicana de Historia natural.* Mexico, 1873. Tome II. Pages 277 and 286.

Charcas iron appears to be naturally passive. A drop of copper sulphate, if allowed to evaporate at ordinary temperatures on its surface, yields unchanged blue crystals of the salt. The alloy is of the kind to which von Reichenbach gave the name of kamacite, consisting of:

Iron = 92·0; Nickel = 7·5; Total = 99·5.

which corresponds with the formula Fe_{14} Ni.

The compounds of iron with sulphur which occur in meteorites appear to be sometimes magnetic pyrites, sometimes troilite (iron monosulphide). Meunier finds the sulphides of these two irons to have the composition given below. Side by side with the numbers resulting from his analyses are placed the theoretical percentages of the two sulphides alluded to:—

	Toluca.		Charcas.		Troilite (FeS).		Pyrrhotite (Fe_7S_8).
Iron.........	59·01	...	56·29		63·64		60·5
Nickel......	0·14	...	3·10		...		...
Copper......	trace	...	...		...		...
Sulphur ...	40·03	...	39·21		36·36		39·5
	99·18		98·60		100·00		100·00
Sp. gr.......	4·799	...	4·780	...	4·784[1]	...	4·583[2]

From these results Meunier concludes that the meteoric sulphide has the formula of pyrrhotite—in short that it is not a monosulphide. It will be seen, however, in the foregoing table, that though the analytical numbers point to this conclusion, the specific gravity of the sulphides accords more closely with that of troilite. Analyses of the sulphide in the meteoric irons of Knoxville, Seeläsgen, Sevier Co., and Ovifak (see page 35) show that sulphide in each case to have the composition Fe S. The author states that both sulphides are feebly attracted by the magnet. Though magnetic pyrites in fine powder is attracted, troilite (Fe S), neither in coarse fragments nor in powder, shows, according to my experience, the least tendency to adhere to the magnet.

The crust of the Toluca iron has the following composition:—

Iron sesquioxide = 68·93; Iron protoxide = 28·12; Nickel protoxide = 2·00; Cobalt protoxide = trace. Total = 99·05.

which numbers correspond to the formula $Fe_2 O_3$, (Fe Ni) O.

By treating the Charcas iron with mercury chloride a very small quantity of silicate (?) was obtained, which was not further examined. The particles resembled those obtained from the Caille iron in their action on polarized light. It will be remembered that in the Toluca iron G. Rose found a few grains of what he held to be quartz.

Meunier gives the results of an analysis of the meteoric iron found at Xiquipilco in 1784:—

Nickel iron...	96·301
Troilite	1·482
Schreibersite	1·232
Graphite	1·176—100·191

[1] Mean of three determinations of the specific gravity of the meteoric sulphide.
[2] Mean of five determinations of the specific gravity of pyrrhotite.

The development of figures on polished surfaces of meteoric iron by exposing them to heat and the action of acids, fused alkalies, or saline solutions, has been studied by Meunier. When the Charcas iron is heated, there are simultaneously developed on different parts of the surface the varied colours exhibited successively on a plate of steel by raising it to different temperatures. On examining the altered iron, the author was enabled to detect the presence of a small amount of the alloy termed plessite. The figures are in their general characters identical with those developed by acid. When a polished plate of the Charcas iron is plunged into a hot solution of copper sulphate, the figures are developed with greater distinctness than when acid is used, the lamellæ of tänite appearing red on a white ground. By employing mercury chloride and varying the degree of concentration and temperature of the solution, a metallic surface may be made to present as many as three different phases of crystalline development. With a hot concentrated solution of this salt the Charcas iron exhibits the most beautiful figures. Gold and platinum chloride have also been used by the author, and the former salt is recommended in cases where it is desired to arrive at an immediate knowledge of the crystalline structure of an iron.

To etch a fine section of Toluca iron, recently acquired by the British Museum, water saturated with bromine was used. The edge of the slab was surrounded with modelling wax; the bromine water was then poured on, and in a few seconds removed with blotting paper. The surface was next flooded with distilled water, which was removed as before. Absolute alcohol was then poured over the etched surface, and this again was quickly taken away with bibulous paper. The iron was then preserved face downwards for some days in a dry box filled with burnt lime. The accompanying plate gives a representation of a part of the surface of this beautiful slab of metal. The figures will be considered when we come to describe those of the Braunau iron and the crystals which occur in the Cranbourne meteorite.[1]

1790, July 24th.—Barbotan and Roquefort, Landes, France.[2]

A correspondent communicates to *Nature* a reference to a description of this celebrated fall of meteorites, which is to be found in Gruithuisen's *Naturgeschichte des gestirnten Himmels,* 407. As it does not appear to have been known to Buchner, it may be placed on record here.

[1] Kick (*Pol. Notizbl.* xxix. 105; *Pol. Journ.* ccxii. 40) employs for the etching of artificial iron and steel a mixture of one part of hydrochloric acid and one part of water, to which a little antimony chloride has been added. Surfaces etched with this liquid are less liable to rust. Kick states that some irons and steels are quite passive, but that this property may be destroyed by raising them to a red heat.

[2] *Nature.* February 1st, 1872.

1803, April 26th.—L'Aigle, Orne, France.[1]

While at the end of the last century reports from time to time obtained circulation, to the effect that stones had been seen to fall from the sky, and while these reports were generally discredited as fabulous, a desire had arisen among the curious to collect and preserve them, and even to submit to careful study these strange mineral masses, to which an atmospheric origin was attributed. It was at this time that Howard and De Bournon made a careful examination of the stones reputed to have fallen from the sky, which were contained in the mineral collection of Greville; and, after observing them to possess certain characters in common, as well as others which distinguished them from terrestrial matter, they were led, in the *Philosophical Transactions* of 1802, to give their support to the views, then regarded as purely fantastic, which Chladni had propounded in 1794 in his remarkable memoir *Ueber den Ursprung der von Pallas und anderer ihr ähnlicher Eisenmassen.* The new view had in fact found little favour among scientific men, especially in France, and De Bournon and the French *savant* Patrin were engaged in a controversy on the subject at the beginning of 1803, when the celebrated fall at L'Aigle, of from two to three thousand stones, took place. The first news which reached Paris was received with a smile of incredulity; the illustrious Biot, however, was deputed by the *Ministre de l'Intérieur* to proceed to L'Aigle and institute a full inquiry, which lasted many days; and his exhaustive report, which appeared in the *Mémoires de la classe des Sciences math. et phys. de l'Institut national de France,* finally set the question at rest, and established the fact that the stones were of cosmical origin as Chladni had supposed.

These meteorites were analysed by Thénard, who found in them silica, iron oxide, magnesia, nickel, and sulphur, amounting in all to 108 per cent.; and afterwards by Fourcroy and Vauquelin, who detected the presence of the same ingredients and lime in addition, the total amounting to 104 per cent. The excess of course was due to the fact of the metal present as such in the meteorite being accounted oxide in their calculations.

In consideration of the historical importance of this fall, it occurred to von Baumhauer to submit the L'Aigle meteorite to analysis by the new and elegant methods which he devised and employed with so much success on other meteorites. His results are given below. The specific gravity of the stone is 3·607, and the total composition is as follows:—

Nickel-iron	8·0
Iron sulphide	1·8
Chromite	0·6
Olivine	45·3
Silicate unacted upon by acid	44·3
Lime sulphate	trace
	100·00

[1] E. H. von Baumhauer. *Archives Néerlandaises,* 1872, vii. 154.

After the removal of the nickel-iron, the treatment with acid and sodium carbonate brought about a separation of the silicates, which had the following composition:—

	SiO_2	FeO	MnO	Al_2O_3	CaO	MgO	K_2O	Na_2O		
A. *Soluble*	35·16	30·39	trace	0·18	6·16	26·51	0·85	0·75	=	100·00
B. *Insoluble* ...	57·16	12·56	trace	5·19	4·08	17·91	2·02	1·07	=	99·99

The oxygen ratios of acid and bases in the soluble part 18·63 : 19·53 show the silicate which gelatinised with acid to be an olivine, remarkable, it will be observed, for the amount of lime it contains. Von Baumhauer gives the formula $\left(\begin{smallmatrix} Fe\frac{1}{3} \\ Mg\frac{5}{9}\ Ca\frac{1}{9} \end{smallmatrix}\right)^2 SiO_4$ as an expression of its composition. In the insoluble part the oxygen ratio of acid and bases is 30·28 : 14·15, and here the presence of more than five per cent. of alumina points to the probable occurrence of a felspar in this portion of the stone. If we assume that the iron oxide, magnesia, and lime[1] are present as a bronzite, the oxygen ratios of the alumina, alkalies, and residual silica, differ very little from 3 : 1 : 9, or those of oligoclase, soda-lime felspar, in some varieties of which a considerable proportion of the soda is replaced by potash.

1805, June —.—Constantinople.[2]

Chladni relates the story, given in an Armenian work "Eghang Buzankian," how stones fell with great violence on the shambles in Constantinople. The descent, which took place in daytime, caused great alarm; and as the occurrence was at first attributed to the evil designs of the Greeks, janizaries were posted for three days and nights about the city. The sulphureous odour, however, which prevailed at the time of the fall, as well as the black and apparently burnt crust of the exhumed fragments, pointed, on further consideration, to a meteor as their source, and all doubt respecting their origin was at an end. Chladni adds, "The Turks, it seems, were more open to conviction respecting the truth of the occurrence than many a physicist would have been, since he would not have believed it even if he had seen it with his own eyes." Evidently he had not forgotten how in the hard fight at the beginning of the century (see page 96) he had to encounter opposition where he looked for support.

What became of these meteorites is not known. In 1832 a fragment of what was alleged to be one of the Constantinople stones was acquired by the Vienna Museum. It bore a description to that effect on the authority of von Schreibers; Partsch subsequently added a note to it declaring the statement to be incorrect, and the stone in question to be one of the Stannern meteorites. Still more recently he appended to the above description a note asserting that

[1] The bronzite of Harzburg, analysed by Streng, contains lime.
[2] G. Tschermak. *Mineralogische Mittheilungen*, 1872, heft ii. 85.—See also E. F. F. Chladni. Ueber Feuer-Meteore. Vienna: 1819. Page 278.

the stone was genuine, and that it had been obtained many years before, between 1818 and 1820, from a son of the then Austrian internuncio at Constantinople.

As regards mineralogical constitution it certainly bears the closest resemblance to the stones of Stannern; it belongs to the small group of eukritic meteorites consisting of anorthite, pyroxene, magnetite and chromite; the minute structure also is identical with that of the Stannern stone, and the chemical composition, arrived at by Ludwig as the result of two analyses, is given below side by side with that of the stone which it so completely resembles.

	Constantinople.		Stannern.
Silicic acid	48·59	...	48·30
Alumina	12·63	...	12·65
Iron protoxide	20·99	...	19·32
Manganese protoxide	trace	...	0·81
Magnesia	6·16	...	6·87
Lime	10·39	...	11·27
Soda	0·46	...	0·62
Potash	0·16	...	0·23
Chromite	0·44	...	0·54
Troilite	trace	...	trace
	99·82	...	100·61

The accordance could not be more complete in analyses of two specimens of the same meteorite. Although this fact makes the identity of the two stones highly probable, it must not be forgotten that the meteorite of Juvinas has the same composition as the Stannern stone. Hitherto two meteorites have not been met with possessing identically the same composition, structure and fine texture; and Tschermak is of opinion that it will be safer to assume for the present that no fragments of the stone of Constantinople have been preserved than that that fall yielded stones absolutely similar in all respects to the meteorites of Stannern.

1807, December 14th.—Weston, Connecticut.[1]

The report drawn up by Silliman and Kingsley on the fall of these large meteorites has been reproduced from the *Memoirs of the Connecticut Academy of Arts and Sciences.* All the important details of this paper are to be found in Buchner's *Die Meteoriten*, 22.

1808, May 22nd.—Stannern, Iglau, Moravia.[2]

While considering the question of the possible identity of the stones of Constantinople (page 97) with the above meteorites, Tschermak records a few observations which he has recently made respecting

[1] *Amer. Jour. Sc.*, 1869, xlvii. 1.
[2] G. Tschermak. *Mineralogische Mittheilungen*, 1872, heft ii. 83.

the mineralogical characters of the thirty-six specimens of the above abundant aerolitic shower, preserved in the Vienna Collection.

This meteorite consists of rocky fragments of three kinds cemented by granular matter. The larger portions are chiefly composed of lamellæ of anorthite and elongated fragments of augite; the greater part of the anorthite occurs in very broad twin-lamellæ; the augite, which is of a brown colour, has very rarely well-defined boundaries; in some sections the augite form is recognisable, while a cleavage parallel to the terminal face 001 is not uncommon. The dark coloured, often black, parallel streaks observed in the augite of the meteorites of Juvinas and Jonzac are here less numerous.

The third ingredient is a sparsely disseminated colourless mineral evidently crystalline, and, from the fact of its refracting light simply, a mineral belonging to the isometric system; Tschermak believes it to be the colourless cubic silicate occurring in the meteorite of Sherghotty. Magnetic pyrites, nickel-iron (the presence of which in this meteorite had not been previously observed), and chromite also occur in very small granules among the other minerals. The cementing material, which is made up of particles of anorthite, augite, and another black substance, has a looser structure than the fragments, and is probably the once solid crystalline rock reduced to a fine state of division.

Found 1808.—Red River, Texas.[1]

As Graham[2] has shown that the Lenartó meteoric iron contains 2·85 times its volume of occluded hydrogen, carbonic oxide and nitrogen, and Mallet (see page 15) has found 3·17 times its volume of hydrogen, carbonic oxide, carbonic acid and nitrogen occluded in the meteoric iron of Augusta Co., Virginia, it occurred to Wright that it might be possible to detect in the gas of these irons the unknown gaseous elements assumed to be present in the solar corona and chromosphere. The investigation was undertaken with the hope that the spectroscope would reveal them, if present, although their small amount or peculiar characters might render their detection by ordinary chemical methods difficult or impossible.

A vacuum tube of the form ordinarily employed in spectroscopic work was attached to a branch of the exhaust tube of a Sprengel pump, and a preliminary examination was made of the lines exhibited by this tube after simple withdrawal of the air. As Plücker and Hittorf[3] have already shown, lines of hydrogen and bands due to carbon make their appearance as soon as the limit of exhaustion has been attained; the author noticed the red hydrogen line when the

[1] A. W. Wright. *Amer. Jour. Sc.*, 1875, ix. 294.
[2] T. Graham. *Proc. Royal Soc.*, xv. 502.
[3] J. Plücker and W. Hittorf. *Phil. Transactions*, clv. 1.

tension fell to 4 or 5 mm., and other hydrogen lines when a higher degree of rarefaction was attained. Mercury lines, varying in brightness with the temperature of the room, are also to be seen. His investigations were directed to an examination of the gases of the great Texas meteorite, preserved in the Mineral Collection of Yale College, and the meteoric irons of Tazewell Co. and Arva, Hungary (which see). The iron was in very small particles—chips produced by the borer, and the exhaustion was proceeded with without the application of heat. He noticed that the iron gave off a portion of its gas at ordinary temperatures; and when the tension was reduced to 4 mm., $H\alpha$ and $H\beta$ were bright and distinct, and $H\gamma$ visible, while the carbon bands were also distinctly seen. When a gentle heat was applied, the tube, which had hitherto presented the appearance of an ordinary hydrogen tube, underwent a change; the light in the broad portion became a straight, hazy stream, of a dull greenish-white colour, similar to that observed in a tube containing either of the oxides of carbon. When the tube containing the metal was raised to low redness, only a small quantity of gas was given off. Wright did not measure the amount of gas removed by the pump, but has calculated this quantity from an observation of the degree to which 1 cc. of the gas lowered the guage of the instrument. He finds in this way the mixed gases extracted to have occupied 4·75 times the volume of the metal. While this exceeds the quantity which Graham and Mallet noticed in their investigations, the author believes that the whole amount was by no means exhausted, and ascribes the excess to the fact of the metal which he used having been in a fine state of division.

Found 1810.—Brahin, Minsk, Russia.[1]

Two large meteoric masses were found at Brahin in the early part of this century; the dates of their discovery are variously given as 1810 and 1820, and they were first described in 1822. They bear the closest analogy to "the Pallas iron" in structure, and with it belong to the small class of siderolites. The Brahin iron was very imperfectly examined by Laugier in 1823, who confined his analysis to that of the iron. Since that time it has not been investigated except in one respect by Rose, who a few years ago noticed that the olivine was traversed by canals, as the Krasnojarsk olivine is (see page 87, *note*). Rammelsberg, who has recently examined this siderolite, finds the metallic portion to consist of:

Iron = 88·96; Nickel and Cobalt = 11·04. Total = 100.

During half a century which has elapsed since Laugier's time, new and refined methods of analysis have been devised, and Rammelsberg now finds a per-centage of nickel and cobalt more than four times as great as that given by the original observer. The per-centage

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 440.

is close to that found by Berzelius in the metallic portion of the Krasnojarsk siderolite (11·19 per cent.); so that they have a composition closely according with the formula Ni Fe_8.

The olivine, now analysed for the first time, has the composition:

Silicic acid	37·58
Iron (manganese) protoxide	18·85
Magnesia	43·32
	99·75

These numbers, contrary to expectation, do not agree with those resulting from the analysis of the Pallas olivine; above we have Fe and Mg in the ratio 1:4; in the Pallas olivine about 1:8. It is not a little remarkable, however, that the Brahin olivine has the same composition as that of the Atacama siderolite analysed by Schmid, the iron whereof has been shown by Bunsen to contain nickel=10·25, and cobalt = 0·70 (see page 23, *note*).

1812, August 5th.—Chantonnay, Dép. de la Vendée, France.[1]

This stone, which is included in the class of chondritic meteorites, was originally examined by Berzelius. Von Reichenbach some few years since, after inspection of the stone, arrived at the conclusion that the meteorite which reached the hands of the great Swedish chemist was not that of Chantonnay, but a specimen of another fall. To clear this point of doubt Rammelsberg determined to examine some fragments obtained from Shepard, and answering in all physical respects to the description given in Partsch's Catalogue; and he obtained results which agree in every way with the original numbers given in Berzelius' paper. Rammelsberg finds the Chantonnay stone to consist of:

Nickel-iron	7·89
Iron sulphide	6·16
Olivine	42·13
Bronzite	40·64
Chromite	0·97
	97·79

The nickel-iron contains:

Iron = 85·3; Nickel = 14·7. Total = 100.

and the portions separated with acid and alkaline carbonates consist of:

	SiO_2	Al_2O_3	FeO	MnO	MgO	CaO	K_2O and Na_2O	
A. *Soluble*	37·33	—	23·74	—	38·93	—	—	= 100·00
B. *Insoluble*......	53·27	6·22	11·50	0·66	22·08	3·47	2·80	= 100·00

The olivine of the soluble portion has the formula $\left\{ \begin{matrix} Fe_2\ SiO_4 \\ 3Mg_2\ SiO_4 \end{matrix} \right\}$, while

[1] C. Rammelsberg. *Zeit. Deut. Geol. Gesell.*, 1870, xxii. 889.—G. Tschermak. *Sitzber. Ak. Wiss. Wien*, 1874, lxx. 459.

for the constitution of the bronzite of the insoluble portion, where $Fe : Mg(Ca) = 1 : 4$, Rammelsberg gives the expression $\left\{ \begin{matrix} 15\ \overset{..}{R}\ SiO_3 \\ Al_2\ O_3 \end{matrix} \right\}$.

If the oxygen ratios of the ingredients found by Berzelius be examined,[1] it will be found that the oxygen of the silica in the insoluble portion is in excess, while in the soluble portion it is insufficient to satisfy that of the bases, a result probably arising from an imperfect removal of the gelatinised silicic acid with alkaline carbonate. On subtracting from the former amount that which is wanting in the latter, there remains in the insoluble part, over and above that required by the oxides of iron, manganese, nickel, and magnesium to form bronzite, the quantity written below side by side with the oxygen of the remaining bases:

$$\text{Silicic acid} = 5{\cdot}62\,;\ \text{alumina} = 2{\cdot}81\,;\ \left.\begin{matrix} \text{lime} = 0{\cdot}88 \\ \text{soda} = 0{\cdot}26 \\ \text{potash} = 0{\cdot}08 \end{matrix}\right\} = 1{\cdot}12$$

These numbers agree even more closely than might have been expected with the oxygen ratios of labradorite.

In the winter of 1874 Tschermak published a paper on the structure of the meteorites of Orvinio (see page 60) and Chantonnay, which appear to have many characters in common. Sections of the latter stone, three drawings of which are given in his paper, show it to be made up of chondritic fragments, covered with a dark-coloured crust, and cemented together with a black and in places semi-vitreous material. The fragments are not very abundantly provided with spherules, although large ones are here and there met with. It differs from the chondrite of the Orvinio meteorite in containing less iron; a section shows olivine, bronzite, a finely fibrous translucent mineral, as well as nickel-iron and magnetic pyrites; the presence of chromite was not recognized. Fine black veins of a mineral traverse the fragments here and there, and are connected with the cementing material. Similar veins are noticed in the meteorites of Lissa, Kakowa, Chateau Renard, Alessandria, and Pultusk; and in the Lissa and Kakowa stones they present the appearance as if the meteorite had originally come in contact with a molten material which had been injected into the clefts on its surface. Reichenbach was of opinion that the black veins were directly and intimately connected with the fused surface; his view, however, is open to question, from the fact that the interior of a meteorite has usually a low temperature when it reaches the earth's surface. Moreover, in the case of the Chantonnay stone, clefts are to be met with into which the black matter of the crust has penetrated to a depth of 6 mm. only, although the cleft remains partly open. The black semi-vitreous magma consists of an entirely opaque mass, enclosing flakes of the silicate, which forms the fragments, as well as occasional spherules.

Although Rammelsberg, in his paper, does not minutely describe the physical characters of the material he operated on, and did not

[1] J. J. Berzelius. *Pogg. Ann.*, xxxiii. 28.

separately examine the fragments and the cementing material, as Tschermak has done in his examination of the Orvinio meteorite, to find that the two constituents have much the same composition, Tschermak points out that the two meteorites have a very similar constitution, differing mainly in the proportion of iron. The characters observed in these two meteorites point to the conclusion that they did not originally possess their present constitution, but that to the disintegration of a solid rock-mass and its subsequent cementation with a semi-vitreous magma their present appearance is due. Although they resemble somewhat the eruptive breccias, they differ from them in that the meteoric cementing material is less homogeneous, and encloses fine flakes of the rock itself. The Chantonnay stone possesses the fine texture observed in some metamorphosed breccias. The two stones convey to us evidence of changes which must have occurred on the solid surface of some planet that was subsequently reduced to fragments.

1813, September 10th.—Adare, etc., Co. Limerick, Ireland.[1]

This meteorite, originally investigated by J. Apjohn,[2] has been examined by R. Apjohn, who finds that it contains a trace of vanadium. The date which he assigns to the fall of this stone, 1810, appears to be that of another Irish meteorite, which fell at Mooresfort, Tipperary in that year.

The mineralogical composition of the stone is stated to be:

Nickel-iron	19·07
Chromite	1·75
Magnetic pyrites	6·54
Soluble silicate	35·44
Insoluble silicate	37·07
	99·87

The nickel-iron has the composition:

Iron = 85·120; Nickel = 14·275; Cobalt = 0·602; Phosphorus = Trace; = 99·997

and the result of the treatment with acid:

	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	Na_2O	K_2O	P_2O_5	
A. *Soluble*	42·91	2·35	16·93	6·26	5·34	24·32	0·29	0·02	——	= 98·42
B. *Insoluble* ...	59·48	3·24	7·94	8·84	4·62	13·17	1·86	0·30	trace	= 99·45

The oxygen ratios of the constituents of both soluble and insoluble portions are:

	SiO_2	Total bases.		SiO_2	Total bases.
Soluble	22·88 ...	17·58	*Insoluble*	31·72 ...	12·38

The silica, it will be seen, is in excess of that required to form olivine in the former portion, and bronzite or augite, or a mixture of those minerals, in the latter. The presence of alumina in each part points to the presence of a felspar which, as a consequence of the

[1] R. Apjohn. *Jour. Chem. Soc.* [2], xii. 104.
[2] J. Apjohn. *Trans. Irish Acad.*, xviii. 17.

very small amount of alkalies found in the soluble part, we must assume to be present as anorthite. The lime being in excess of that required to form with the alumina this variety of felspar, we are compelled to assume that a portion of the lime is present as an ingredient of the olivine. The large portion of manganese oxide found by Apjohn in each portion is noteworthy, it being in considerable excess of that hitherto found in any meteoric silicate: one variety of terrestrial olivine, fayalite, contains as much as five per cent. of manganese oxide. As regards the insoluble portion the oxygen ratios of the alumina and the total alkalies is very nearly that of labradorite. After deducting from the oxygen of the silica of this portion that of the acid required to form this felspar, there still remains a large excess beyond what is requisite for the bases to form bronzite and augite. While it is not impossible, although scarcely probable, that the insoluble part contains free silica in the form of asmanite, the fact of an excess occurring in each case leads to the assumption that through the unusually large amount of material employed for analysis (10 grammes) the removal of the gelatinised silica in the first case and the decomposition of the silicate in the second were incomplete.

The chromium oxide present as chromite is not given in any of the special analyses. The iron sulphide is probably present as troilite (iron monosulphide), since, according to the earlier analysis, the greater part of the sulphur is in the part which is not attracted by the magnet. There the ratio is given as Fe = 3·92, S = 2·04; the per-centages of troilite, making the sulphur the basis for the calculation, would be Fe = 3·57, S = 2·04; and for magnetic pyrites Fe = 3·12, S = 2·04.

In an obliging letter received from the author he informs me that the amount of vanadium present was too small to allow of a quantitative estimation being made. He believes it to be about one-half of that which is met with in the trap-rocks of Ireland and Italy, which were recently examined by him. He is inclined to the belief that the vanadium is present as an oxide associated with the chromite, "for we know vanadium occurs in terrestrial chrome iron in comparatively large quantities."[1]

Found 1814.—Lenartó, near Bartfeld, Saros, Hungary.[2]

Boussingault, who some time since found nitrogen in this iron, has recently examined it with the view of determining whether it contains carbon in a state of combination with the metal. His analysis,

[1] A. A. Hayes, in a paper read before a meeting of the Amer. Acad. Sc., held at Boston in January, 1875, states that he has detected vanadium in many rocks usually associated with compounds containing phosphorus and manganese. A tabulated list of the rocks is to be given in a later paper. He also found vanadium in the water of a well at Brookline, near Boston.

[2] J. Boussingault. *Compt. rend.* lxxiv. 1287. *Ann. Chim. et Phys.* xxviii. 124. *Chemical News*, No. 688, 59.—M. Salet, *Revue Scientifique*, 1872, March 9th. *The Academy*, iii. 113.

given below, did not detect the presence of that element in any form.

Iron = 91·50 ; Nickel = 8·58 ; Insol. Residue = 0·30 ; Copper = trace. Total = 100·38.

It was in this meteoric iron, it will be remembered, that Graham made the interesting discovery of the presence of hydrogen condensed (occluded) in the substance of the metal. The gas obtained from this iron has been examined spectroscopically by Salet, who communicated his results to the *Société chimique de Paris* on the 1st March, 1872. His researches on the polar aurorae had led him to seek for the yellowish-green ray ($\lambda = 557$), but he found only those due to the presence of hydrogen and an oxide of carbon. It must be assumed then that the carbon present in the iron, and which must be very small in quantity, exists there not as carbide of iron, but as occluded carbonic oxide.

Found 1818.—Cambria, near Lockport, Niagara Co., State of New York.[1]

This iron has been examined by Rammelsberg, who dissolved the metal in bromine; he found it to have the following composition:

Iron = 88·76 ; Nickel = 10·65 ; Cobalt = 0·08 ; Copper = 0·04 ; Iron Sulphide = 0·47. Total = 100·00.

The per-centage of nickel (and cobalt) is nearly double that given in the earlier analysis of Silliman and Hunt.

Found 1826.—Groslée, Dép. de l' Isère, France.[2]

De Beaumont has recently described a 'tubercule' of native iron which was found, as far back as 1826, in the white Jurassic chalk of the stone quarries of Groslée, on the banks of the Rhone, between Cordon and Quirieu. It was submitted to Moissenet for examination, and he failed to determine in it the presence of either nickel or cobalt.

Found 1828.—La Caille, near Grasse, Alpes-Maritimes (formerly Dép. du Var), France.[3]

Meunier has submitted the Caille iron to an exhaustive examination. He finds, when etched, that it presents much the same appearances

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 440.
[2] E'. de Beaumont. *Compt. rend.* 1871, lxxii. 187.—L. Moissenet. *Compt. rend.* 1871, lxxiii. 761.
[3] S. Meunier. Thèse presentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la composition et la structure des Météorites*, 29, *et seq. La Nature*, i. 292.—J. Boussingault. *Compt. rend.* lxxiv. 1287. *Ann. Chim. et Phys.* xxviii. 124.

as he noticed in the Charcas iron (see page 95); it consists of kamacite (*chamasite*; E. S. Dana's "Second Appendix to Dana's *System of Mineralogy*," 11) and tänite in much the same proportions. The tänite has a specific gravity of 7·380 (von Reichenbach in another meteoric iron found the number 7·428) and the composition:—

Iron = 85·0; Nickel (cobalt) = 14·0. Total = 99·0.
Iron = 85·0; Nickel (cobalt) = 15·0. Total = 100·0.

numbers which indicate the formula Fe_6Ni.

The kamacite has the specific gravity 7·652, and consists of:

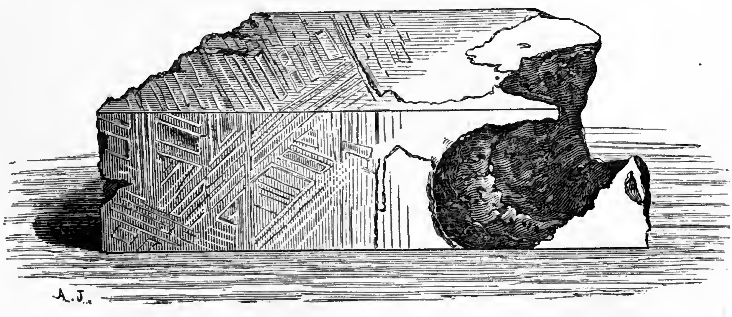
Iron = 91·9; Nickel = 7·0. Total = 98·9.

which is an alloy of the formula $Fe_{14}Ni$. The entire iron appears to contain about 80 per cent. of the latter alloy, and Meunier's numbers correspond very closely with those obtained by Rivot, who analysed the metal in the bulk.

The graphite of this iron, found in the residue after treating the metal with hydrochloric acid, has a density of 1·715, and the composition:

Carbon = 97·3; Iron = 2·4; Nickel = trace. Total = 99·7.

The troilite of the Caille iron, after treatment with acid, left a small amount of siliceous residue, which was precisely similar in its physical characters to that found in the Charcas meteorite (see page 94). By the action of heat and oxidizing agents figures were developed which likewise bore the closest resemblance to those developed on the Charcas iron. The accompanying woodcut gives a representation of a block of this iron (actual size) which is in the Paris Collection. It shows the Widmannstättian figures, developed by etching with hydrochloric acid, and the reniform hollows which have been filled with troilite.



In an examination of this iron, undertaken with the view of determining the presence of combined carbon, Boussingault found it to be composed of:—

	I.	II.
Iron	89·53	89·73
Nickel	9·76	9·90
Carbon combined	0·12	0·12
Insoluble portion	0·59	0·25
Sulphur	trace	trace
	100·00	100·00

1828, June 4th.—Richmond, Chesterfield Co., Virginia.[1]

This meteorite, the chemical characters of which were studied by Shepard, the physical by G. Rose, has recently been found by Rammelsberg to have the following composition:

Nickel-iron	8·22
Iron Sulphide	4·37
Olivine	45·73
Undecomposed silicate	41·68
	100·00

The silicates having been separated by treatment with acid and sodium carbonate were found on analysis to have the composition given below:

	SiO_2	Al_2O_3	FeO	MgO	CaO	
A. *Soluble.*	39·40	—	18·21	41·69	0·80	= 100·00
B. *Insoluble.*	53·74	5·32	13·17	22·23	5·54	= 100·00

In the soluble portion the ratio of Fe to Mg is 1 : 4, which shows it to be an olivine identical in composition with that variety of this mineral which has been met with in the siderolites of Brahin and Atacama. The insoluble portion, according to Rammelsberg, is either a bronzite containing lime, or a mixture of that mineral with diopside.

Shepard had found this meteorite to be composed of 6 per cent. of nickel-iron, with some magnetic pyrites, and 90 per cent. of olivine, the residue being howardite and lime phosphate.

1835, July 31st, or August 1st.—Charlotte, Dickson Co., Tennessee.[2]

The iron, which is found disseminated in small particles throughout the mass of many meteoric stones, represents in miniature the huge blocks of meteoric iron that from time to time have been met with on many parts of the earth's surface, the record of the fall of which is unknown, their descent having probably taken place at an epoch long anterior to that of their discovery. While the stones enclosing iron have not unfrequently been seen to fall, the descent of purely metallic masses has been rarely witnessed. At present we know of only the following few authentic cases: Agram (1751); Braunau (1847); Victoria West, S. Africa (1862); and Nidigullam, Madras (1870). To these few instances is to be added the one heading this notice, of which a brief account was published by Troost, of Nashville, in 1845.[3] The Tennessee iron fell from a cloudless sky, near several persons who were working in the fields. A horse which was harnessed to a plough close by took fright, and ran round the field, dragging the plough with it.

The iron has remained in the Troost Collection up to the present

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 440.
[2] J. L. Smith. *Compt. rend.*, 1875, lxxxi. 84.
[3] G. Troost. *Amer. Jour. Sc.*, xlix. 336.

time, when it passed into the hands of Dr. Lawrence Smith. It is a reniform mass, and has a bright surface like that of soft cast-iron. When etched it exhibits Widmannstättian figures in great perfection, and the author states that in this respect he is acquainted with only three or four irons which rival it. An illustration accompanying his paper, closely resembling the one given by Troost, is a representation of the outer surface, magnified; this is elaborately reticulated, edges of thin laminæ of metal, inclined at angles of 60°, traversing the surface, the edges being separated from each other by an apparently semi-fused slag-like material. The specific gravity of the iron is 7·717, and its composition:

Iron = 91·15; Nickel = 8·01; Cobalt = 0·72; Copper = 0·06. Total = 99·94.

Sulphur is not present, and of phosphorus only a trace was recognized; and the author states that he has never before met with so small a proportion of this element in a meteoric iron. The gas, extracted from this iron by A. W. Wright, who has recently examined the occluded gases of the irons of Texas, Arva, and Tazewell Co., as well as that of the meteorite of West Liberty, Iowa (which see), has nearly twice the volume of the metal operated upon, although this is probably a portion only of that actually present. It is composed of:

Hydrogen = 71·04; Carbonic oxide = 15·03; Carbonic acid = 13·03. Total = 100·00.

A question of no slight interest in regard to the changes which meteoric irons undergo during their passage through the atmosphere is whether their surface becomes fused. From his study of the Tennessee meteorite, Dr. Smith has decided it in the negative. The fact of the delicate reticulated surface having been preserved is a proof that the heat, instead of having been raised to a high temperature on the surface, has quickly been conducted away into the mass of the metal. Had fusion of the superficial layer taken place, the meteorite would have been coated with molten oxide.

The author finds in this fact a confirmation of his theory that the Ovifak masses are not of meteoric origin.

1838, July 22nd.—Montlivault, Dép. Loir-et-Cher, France.[1]

Daubrée gives a brief description of this meteorite, which has recently been acquired for the Paris Collection. It has been preserved almost entire, and is roughly shaped like a three-sided pyramid. It is finely granular, has a white colour, and weighs 510 grammes. The ground-mass of the stone, consisting apparently of an intimate mixture of olivine with an augitic mineral, encloses small grains of nickel-iron and magnetic pyrites. The meteorite belongs to the group, now a large one, of meteorites to which the name luceite has been given.

[1] G. A. Daubrée. *Compt. rend.* 1873, lxxvi. 314. *Der Naturforscher*, 1873, 26th April.

1840.—Szlanicza, Arva, Hungary.[1]

For his investigation by means of the spectroscope of the gases occluded by meteoric iron, Wright examined those from the Red River, Texas, and Tazewell Co., Tennessee (which see).

The amount of carbon present in the former iron was found on chemical examination to be very small; in the latter none was detected. A series of experiments were therefore made with the above iron, which according to Löwe[2] contains a larger amount of carbon. While it was an easy task to remove fragments of the above-mentioned irons, great difficulties were experienced in the present case, the metal having nearly the hardness of steel. When the tube containing fragments of this iron was exhausted, and before heat was applied to it, the spectroscope indicated the presence in the "vacuum-tube" of both hydrogen and carbon gases; the lines of the former element were very brilliant, and the first, second, and third bands of the latter, counting from the red end, were visible. The application of a heat hardly sufficient to pain the hand caused an entire change in the appearance of the vacuum-tube; the broad part took a greenish hue, while in the spectroscope the carbon bands shone quite brightly. When the heat was raised to a temperature considerably short of redness, the only change noticed in the spectrum was a greater intensity of the carbon bands; the gas collected at this stage of the operation was found on analysis to consist of hydrogen, carbonic oxide, and carbonic acid, the latter amounting to three or four per cent.

In some experiments on artificial soft iron the author obtained a spectrum in every way similar to that of the meteoric metals; the hydrogen lines, however, did not appear so early, nor were they so bright as in the latter instances.

The iron of this meteorite, which by its great hardness was separated in the state of fine powder, yielded, when heated at different temperatures up to low redness, 44 times its volume of gas. While it seems not improbable that some portion of what has been regarded as occluded gas may have been air, the yield is so unusually large that it suggests the question, May not the more perfect removal of the gas from the iron be due to the fine state of division of the metal operated upon? In the case of the Texas and Tazewell Co. irons, where the yield of gas exceeded that obtained from the Lenartó and Augusta Co. irons, the metal was in very small pieces, which would favour a more rapid and complete evolution of the gas; in the last-mentioned instances they were *en bloc*. That iron may under certain conditions, as when deposited by electrolysis, take up nearly two hundred and fifty times its volume, has been shown by the recent researches of Cailletet.[3] An observation recently made has a bearing on this question. While analysing a specimen of silver amalgam, I endeavoured to remove the mercury from a weighed fragment of the mineral by heating the specimen in a hard glass tube, during more than

[1] A. W. Wright. *Amer. Jour. Sc.*, 1875, ix. 294.
[2] A. Löwe. *Amer. Jour. Sc.*, [2], viii. 439.
[3] L. Cailletet. *L'Institut*, Nouv. Sér. iii. 44.

five minutes in the flame of the table blowpipe. The silver immediately fused and remained during that time in a molten state. When cold, the globule of metal was flattened into a plate, and having cut it into strips, and subjected it to a second heating, I succeeded in removing a considerable part of a per cent. of mercury from it.

Wright's researches on the gases of meteoric irons have shown a varying character in the oxygen and nitrogen lines when in the presence of hydrogen, and the near coincidence of two of them with prominent lines in the corona, with the possible coincidence of a third line, which appears to indicate that the characteristic lines in the coronal spectrum are due, not so much to the presence of otherwise unknown elements, as to hydrogen, and the atmospheric gases oxygen and nitrogen.

The observations were made with a spectroscope of six prisms with a repeating prism, giving a dispersion of twelve in all.

Found 1840.—Hemalga, Desert of Tarapaca, Chili.[1]

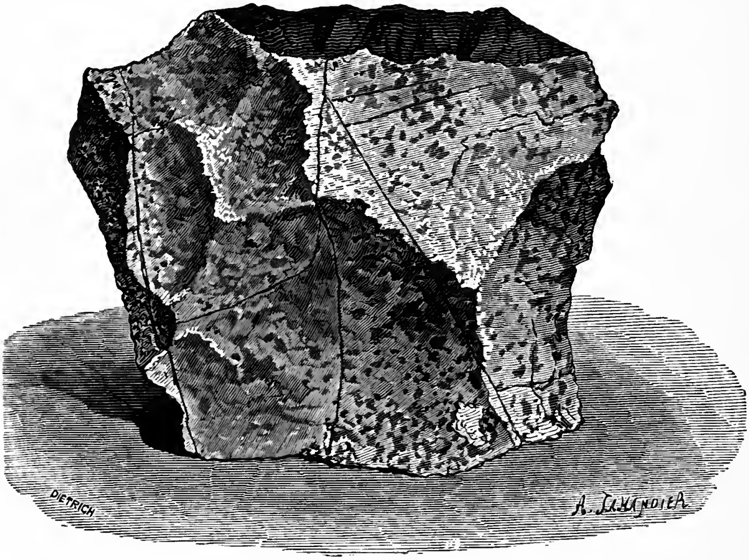
Greg,[2] and Heddle as well, found cavities in certain portions of this iron, some of the size of a pea, which are filled with metallic lead; this is the only instance where that element has been met with in a meteorite. Dr. Lawrence Smith has recently examined several specimens cut from the original mass, and is of opinion that the lead is altogether foreign to the iron, being doubtless derived from material with which the block was treated by the original discoverers for the purpose of extracting some noble metal from it. The lead, he finds, occurs only in cavities near the surface of the mass, which have channels of more or less size leading to the surface. In pieces of the iron detached from the interior of the block and free from fissures no lead could be discovered.

1842, June 4th.—Aumières, Dép. de la Lozère, France.[3]

In an interesting series of papers on the study of rocks, especially as regards the analogies in point of structure and mineral composition which are to be traced between the terrestrial rocks and those met with in meteorites, Meunier has adopted the following classification for the latter series: 1. Normal; 2. Brecciated; 3. Metamorphic; 4. Eruptive; 5. Rocks traversed with veins (*filonniennes concrétionnées*); and 6. Volcanic.[4] The iron of Deesa (which see) he regards as an example of an eruptive meteorite, the stone of Chantonnay represents the class with veins entirely rocky. The veins of cosmical rocks show as many varieties as terrestrial rocks. The upheaval of

[1] J. L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 331.
[2] R. P. Greg. *Phil. Mag.* [4], x. 12.—*Amer. Jour. Sc.*, xxiii. 118.
[3] S. Meunier. Les Pierres qui tombent du Ciel. *La Nature*, 1873, i. 403.
[4] This classification is, it is to be presumed, merely tentative.

rocks on our globe presupposes the existence of faults, that is to say, of vents which establish a communication between the earth's interior and the atmosphere. Faults are recognized by the throws which the rocks constituting their two sides have undergone; these rocks, although preserving their continuity, are shifted vertically in masses that may be very considerable. The more the surface of these faults shows traces of violent friction, the more they become polished, channelled, or striated. In the same way meteorites in a number of cases exhibit true faults, with throws and polished surfaces. In the meteorite of Aumières, of which a representation is given below, one fault is seen to cut another again to which it gives a downthrow of several centimètres.[1]



The stone of Aumières consists of a grey rock, like that forming the meteorite of Aumale (1865, August 25th), which possesses the remarkable property of turning black when heated. By the friction of such surfaces and the consequent development of heat the adjacent surfaces undergo a true metamorphism, and the grey face as a consequence becomes black. The faults in such cases have the form of black lines which have very much the appearance they would present if traced with a pen. On comparing different fragments it becomes evident that where the throw and as a consequence the

[1] The second fault is described in Meunier's paper as being above on the left-hand side of the figure in a position nearly horizontal, and continued below on the right parallel to the first direction, being thrown down more than five cm. by the great oblique fault. It seems, however, that his description is taken from the block and not the engraving, which by his kind permission I have reproduced; and that the two faults respectively referred to are: one of those on the top towards the right, the other that which appears to connect the two great perpendicular veins.

mechanical effect have been considerable, the black lines have a more marked character. The thickness indicates the degree of dynamic energy to which the stone has been subjected, and the grey rock of Aumale and Aumières is in fact an extremely sensitive thermometer of a kind that may render great service in the study of the conditions to which meteorites may have been exposed.

1843, June 29th.—Manegaum, near Eidulabad, Khandeish, India.[1]

The conspicuous ingredient in this stone is a pale yellow-green, or primrose-coloured mineral, with a tint similar to that of a very pale peridot or chrysolite, occurring in crystalline grains, and cemented together with a white opaque silicate. Under the microscope the green granules are seen to be tolerably symmetrical crystals, varying in size from a small pin's head to microscopic dust; they were found on analysis to be a highly ferriferous enstatite or bronzite. They crystallise in the prismatic system, and yield the following results on measurement, which accord closely with the numbers obtained by von Lang when examining the enstatite of the Breitenbach siderolite:

				Breitenbach enstatite.
100, 110	=	About 46°	......	45° 52′
100, 101	=	49° 4′	......	48° 49′
110, $\bar{1}$10	=	About 88°	......	88° 16′
110, 101	=	58° 39	......	58° 24′

The specific gravity of the mineral is 3·198, the hardness 5–6, and the chemical composition:

				Oxygen.	
Silicic acid	......	55·699	......		29·706
Magnesia	......	22·799	......	9·119	14·059
Iron protoxide.. ...		20·541	......	4·564	
Lime	......	1·316	......	0·376	
		100·355			

These numbers agree very closely with those required by the formula ($\frac{2}{3}$ Mg $\frac{1}{3}$ Fe) SiO_3, and show the mineral to be twice as rich in iron as the bronzite of the Breitenbach siderolite, where that silicate occurs in association with abundance of nickel-iron. A portion of the meteorite was analysed in its entirety with the following results:

				Oxygen.	
Silicic acid	......	53·629	......		28·602
Magnesia	......	23·320	......	9·328	14·305
Iron protoxide......		20·476	......	4·550	
Lime	......	1·495	......	0·427	
Chromite	......	1·029			
		99·949			

[1] N. Story-Maskelyne. *Philosophical Transactions*, 1870, clx. 189. *Proc. Royal Soc.*, xviii. 146. For an earlier notice see *Phil. Mag.*, 1863, xxv. 39, and *Journ. Asiat. Soc. Bengal*, xiii. 880. (The date formerly assigned to the fall of this meteorite, viz. the 16th July, has been shown by General Cunningham to be erroneous.) See also C. Rammelsberg. Die Chemische Natur der Meteoriten. *Abhandlungen Ak. Wiss. Berlin*, 1870, 120.

These per-centages differ in so small a degree from those yielded by the analysis of the picked crystals, that we arrive at the conclusion that both ingredients have the same composition, and find in the Manegaum stone an instance of a meteoric rock consisting of a single silicate. The Ibbenbühren meteorite (1870, June 17th) has since been shown by Vom Rath (see page 18) to be similarly constituted. A very minute amount of meteoric iron, far too small for isolation and analysis, occurs in the Manegaum stone.[1]

Found 1846.—Tula, Netschaevo, Russia.[2]

This remarkable mass of iron, which encloses a number of angular fragments of rocky material and resembles a true breccia, was stated by Auerbach to contain but little nickel. Rammelsberg now finds as the result of two analyses, conducted according to different methods, that the per-centage of this metal (and cobalt) is 10·24 and 9·84, or about four times the amount detected by the earlier observer.

1847, February 25th.—Hartford, Linn Co., Iowa.[3]

This meteorite was originally examined by Shepard (*Report on American Meteorites*, 1848, page 37), who states that it consists of 83 per cent. of a silicate to which he gives the name of 'howardite' (an iron-magnesium silicate with the oxygen ratio of $RO : SiO_2 = 1 : 3·3$), about 10 per cent. of nickel-iron and 5 per cent. of magnetic pyrites. Shepard moreover asserts in his paper that this extremely acid silicate fuses easily before the blowpipe, and gelatinises with warm dilute acid. Not a little astonished that a silicate of this form should possess such properties, Rammelsberg undertook an examination of this meteorite, which he finds to possess the following composition:

Nickel-iron	10·54
Troilite	6·37
Soluble silicate	41·85
Insoluble silicate ...	41·24
	100·00

The nickel-iron alloy consists of

Iron = 89·75; nickel = 10·25; Total = 100·00.

and the composition of the two portions of silicate separated by the action of acid and sodium carbonate was as follows:

	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	
A. *Soluble* ...	38·80	—	21·31	39·89	—	—	—	= 100·00
B. *Insoluble* ..	55·08	4·86	13·58	22·70	2·85	0·93	trace	= 100·00

[1] This meteorite is stated to have been comparatively plastic at the time of its fall and to have subsequently become harder and more compact.
[2] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 444.
[3] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 457.

The oxygen per-centages of A clearly indicate the presence of an olivine in which the ratio of Mg : Fe is 3 : 1, or the same as that of the variety of this silicate which occurs in the Hainholz siderolite. The insoluble portion, about equal in amount to the above, appears to consist of a bronzite (or bronzite mixed with a little augite), in which Mg : Fe : Ca is as 12 : 4 : 1; the ratio of iron to magnesium in the two minerals forming the chief ingredients of this meteorite is therefore the same. It is not improbable that the alumina, lime, and soda of the insoluble portion may be present in the form of oligoclase. Rammelsberg's results differ altogether from those given by Shepard, and indicate the presence in this stone of those minerals only which are frequently met with in meteorites. Howardite' has not been identified as a mineral species in any rock, terrestrial or meteoric.

1847, July 14th.—Braunau, (Hauptmannsdorf and Ziegelschlag) Bohemia.[1]

In a memoir on the crystalline characters of iron, and especially those of meteoric iron, Tschermak describes the structure of the specimens of Braunau iron preserved in the Vienna Collection. One piece exhibits the cleavage planes of the cube, as well as other smaller faces on the edges and corners of the cube; the angles which these faces form with those of the cube are 70° and 48°, corresponding evidently with those enclosed between the faces of the triakis-octahedron (221) and the cubic faces, viz. 70° 31′ and 48° 11′. Faces were noticed in the following positions:

$$221,\ 212,\ 122,\ 2\bar{2}1,\ 2\bar{1}2,\ 22\bar{1}$$

other six directions, although present, could not be traced on the specimen which the author examined. Occasionally solid angles or corners are protruded from the cleavage planes with faces at right angles to each other and corresponding, as regards their position to the cube, with the directions (221). Little step-like markings, such as are seen on artificial iron, and fine lines, evidently sections of thin plates, are likewise observed in positions that correspond with one or other face of the triakis-octahedron (221). Tschermak shows that the development of these faces is due to twinning, not by contact, but by interpenetration, the normal on 111 being the axis of twinning. Such twinning is met with on crystals of fluor-spar.

By etching the Braunau iron two varieties of figures are developed: with a moderate use of the corroding reagent an orientated sheen is developed, the fine texture exhibiting what von Haidinger termed crystalline damaskining (see page 20). As the author has shown in the case of the Ilimaë iron this appearance is due to slight depressions of the surface; they are, in fact, little cubical hollows, the sides of

[1] G. Tschermak. *Sitzber. Ak. Wiss. Wien*, 1874, Nov.-Heft, lxx.

which are parallel to the cleavage faces. A second curious feature brought to notice by etching are little furrows which make their appearance on those parts of the cleavage-face where the fine lines were previously seen, lines which owe their origin to the plates parallel to (221). The twin-lamellæ therefore are more readily acted upon than the mass of the metal.

On dissolving this iron in dilute nitric acid a residue remains which consists of fine yellow metallic needles and excessively thin yellow plates; occasionally particles are met with exhibiting every stage of transition from one to the other of these forms. The plates are not unfrequently broken through, or imperfectly developed, in the manner with which we are familiar in crystals of some varieties of specular iron from volcanic localities. The needles, as Rose has already shown, lie parallel to the edges of the cleavage-cube. Tschermak believes both plates and needles to have the same composition, to be in fact schreibersite. By reason of the small amount of material available for examination he was unable to determine the crystalline form of this mineral, but he is of opinion that it will be found to be either tetragonal or rhombic.

1850, November 30th.—Shalka, Bancoorah, Bengal.[1]

The mineral characters of this meteorite were first described by von Haidinger and G. Rose, and the chemical investigation undertaken by C. von Hauer, who found the silicates, when analysed in the mass, to give numbers the oxygen ratios of which were: RO to SiO_2 as 1 : 2·435. While von Haidinger regarded the chief constituent of the meteorite to be a silicate to which he gave the name of 'piddingtonite,' G. Rose considered it to be composed of olivine and another mineral 'shepardite,' which has now been found to be as hypothetical a species as 'piddingtonite.' Rammelsberg during a recent examination of the meteorite determined it to consist of:

Bronzite	86·15
Olivine	10·92
Chromite	2·39
	99·46

the separation with acid and sodium carbonate yielding the following numbers:

	SiO_2	FeO	MgO	CaO	Na_2O	Chromite.		
A. *Soluble* ...	35·17	35·80	29·03	—	—	—	=	100·00
B. *Insoluble* ...	55·55	16·53	27·73	0·09	0·92	0·33	=	101·15

Rammelsberg therefore finds this meteorite to have a much more simple composition than the earlier investigations, and to consist mainly of a bronzite and a few per cent. of olivine, in each of which the Fe is to Mg as 1 : 3.

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 314.—N. Story-Maskelyne. *Philosophical Transactions*, 1871, clxi. 359.

According to the results given in Maskelyne's paper, the constitution of this meteorite, or of the portion of it examined in the British Museum Laboratory, appears to be yet more simple. A small amount of the débris of the stone was found to possess the following composition:

		Oxygen.
Silicic acid	45·370	24·197
Iron protoxide	19·060	4·236
Magnesia	15·636	6·254
Lime	2·214	0·632
Chromite	17·717	—
	99·997	

A mottled grey-coloured mineral, forming the chief constituent of the meteorite, was twice submitted to analysis with the following results:

	I.	*Oxygen.*	II.	*Oxygen.*
Silicic acid	52·831	28·176	52·725	28·120
Iron protoxide	21·863	4·859	22·992	5·109
Magnesia	24·266	9·706	24·085	9·630
Lime	0·502	0·143	—	—
Chromite	0·643	—	—	—
	100·105		99·802	

These numbers correspond with the formula $(\frac{2}{3}\,Mg\,\frac{1}{3}\,Fe)\,SiO_3$, which is identical with the bronzite of the Manegaum meteorite (page 112).

These results, it will be seen, do not indicate the presence of an olivine. To check them, two weighed portions of the mineral were subjected to the action of hydrochloric acid and sulphuric acid respectively, with subsequent treatment with sodium carbonate in each case, whereby the following constituents were removed:

	I.	*Oxygen.*	II.	*Oxygen.*
Silicic acid	1·507	0·804	3·900	2·080
Iron protoxide	0·974	0·216	1·799	0·399
Magnesia	1·058	0·423	1·877	0·750
	3·539		7·576	

The slight excess of iron oxide found in each case is doubtless due to the presence of a little unseparated nickel-iron. These results confirm the above analysis and fail to indicate the presence of olivine in this meteorite.

Found 1850.—Ruff's Mountain, Lexington Co., S. Carolina.[1]

In an examination of this large block of meteoric iron Shepard detected the presence of only 3·12 per cent. of nickel. By employing two more refined methods of analysis, Rammelsberg now finds:

	I.	II.	*Mean.*
Nickel	7·60	9·65	8·62

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 444.

which is still within the limit that I find to obtain in those instances where an iron exhibits Widmannstättian figures. (Compare with the list on page 26.)

1852, September 4th.—Mezö-Madaraz, Transylvania.[1]

Allusion has already been made to Rammelsberg's recent investigation of this meteorite (see page 10). His previous researches on the constitution of the meteorites of Kleinwenden, Pultusk, Richmond, and Linn Co., Iowa,[2] had proved them to consist of a mixture of olivine and bronzite, and in his review of the additions made during the last few years to our knowledge of these cosmical masses,[3] he had demonstrated that of the fifty chondritic meteorites which had up to that time been submitted to analysis, the greater part yielded a like result. Certain among the meteorites, however, did not appear to come under this rule; among them is the one mentioned above which had been analysed by Atkinson,[4] who found no iron protoxide in the insoluble portion, and determined the part broken up by the acid to be a trisilicate. The author was induced to analyse the stone afresh, and he has arrived at the following results:

Nickel-iron	9·79
Troilite	6·24
Chromite	0·80
Soluble silicate	42·83
Insoluble silicate	40·34
	100·00

The nickel-iron, which has the composition indicated by the formula Fe_5Ni, yielded the following numbers:

Iron = 83·25; Nickel (cobalt) = 16·75. Total = 100·00

and the silicates those given below:

	SiO_2	Al_2O_3	FeO	MnO	NiO	MgO	CaO	Na_2O	
A. *Soluble*	36·61	2·19	22·82	0·42	0·14	35·49	0·60	1·02	= 99·29
B. *Insoluble*	52·02	6·08	13·27	—	—	21·85	3·74	3·28	= 100·24
C. *Total*	44·24	4·10	18·25	0·22	0·07	28·98	2·02	2·12	= 100·00

The soluble part is an olivine of the same composition, $3\ Mg_2\ SiO_4 + Fe_2\ SiO_4$, as that met with in the meteorites of Hainholz, Borkut, St. Mesmin, Muddoor, Sherghotty, etc.; the insoluble portion appears to be a bronzite, in which the bases Ca : Fe : Mg=1 : 3 : 9, accord with those of the variety of this mineral which occurs in the Chantonnay stone. The Mezö-Madaraz meteorite therefore belongs to the large class of chondritic masses above mentioned.

[1] C. Rammelsberg. *Zeitschrift Deutsch. Geol. Gesell. Berlin*, 1871, xxiii. 734.
[2] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 440.
[3] C. Rammelsberg. Die Chemische Natur der Meteoriten. *Abhandl. Ak. Wiss. Berlin*, 1870, 75.
[4] E. Atkinson. *Jour. Prakt. Chem.*, 1856, lxviii. 357; *Phil. Mag.*, xi. 141.

1852, December 2nd.—Busti, between Goruckpùr and Fyzabad, India. [Lat. 26° 45′ N.; Long. 82° 42′ E.][1]

With a view to obtain more satisfactory means of dealing with the aggregates of mixed and minute minerals, which constitute meteoric rock, the author of this paper sought the aid of the microscope, having in the first place sections of small fragments cut from the meteorites so as to be transparent. By studying such sections we learn that a meteorite has passed through changes, and that it has had a history of which some of the facts are written in legible characters on the meteorite itself; and we find also that it is not difficult roughly to classify meteorites according to the varieties of their structure. Constantly recurring minerals may be recognized; but as to what they are the method affords no means of determining. Even the employment of polarized light, so invaluable where a crystal of which the crystallographic orientation is at all known is examined with it, fails, except in rare cases, to indicate with certainty even the system to which such minute crystals belong. It was found that the only satisfactory way of dealing with the problem was by employing the microscope, chiefly as a means of selecting and assorting out of the bruised débris of a part of a meteorite the various minerals that compose it, and then investigating each separately by means of the goniometer and by analysis—finally recurring to the microscopic sections to identify and recognize the minerals so investigated. In the memoir, mentioned below, the author publishes the results of the former part of this inquiry. It is obvious that the amount of each mineral which can be so obtained is necessarily small, as only very small amounts of the meteorite could be spared for the purpose. On this account the greatest caution was required in performing the analysis of such minerals, and the desirableness of determining the silica with more precision than usually is the case in operations on such minute quantities of a silicate suggested a process which, after several experiments had been conducted with a view to perfecting it, assumed a definite form. The method, which essentially consists in the separation of the silicic acid from the bases by distillation with hydrofluoric acid, by which means the operator is enabled to proceed to the estimation of the whole of the constituents of any silicate in one and the same portion, will be described in detail later on with other new methods of analysis. (See Part III.)

The first meteorite investigated on the principles here laid down was the remarkable stone which fell at Busti, in India, at the above date. The fall, which took place from a cloudless sky at 10·10 a.m., was attended with an explosion, louder than a clap of thunder and lasting three to four minutes, and must have occurred about the time the stone passed the longitude of Goruckpùr. The meteorite, which

[1] N. Story-Maskelyne. *Proc. Royal Society*, xviii. 146. *Philosophical Transactions*, clx. 189. (See also Abstract in *Nature*, i. 382.)—A preliminary notice of this meteorite appeared in the *Brit. Assoc. Report*, 1862, "Notices and Abstracts." Appendix ii. 190.

THE METEORITE WHICH FELL AT BUSTI, BETWEEN GORUCKPÙR AND FYZABAD, INDIA, 2ND DECEMBER, 1852

(Actual Size.)

weighs about 3 lbs., consists for the most part of the mineral enstatite; at one end, however, are embedded a number of chestnut-brown spherules, in which again were detected minute octahedra having the lustre and colour of gold. These two minerals seem scarcely to have been affected by the heat which fused the silicates surrounding and encrusting them.

The brown spherules are calcium (magnesium) monosulphide, and they have been named by the author 'oldhamite'; their outer surface is generally coated with calcium sulphate. This mineral cleaves with equal facility in three directions which give normal angles averaging 89° 57′; they are no doubt 90°. Its system, therefore, is cubic; in polarized light it is seen to be devoid of double refraction.[1] The specific gravity is 2·58 and the hardness 3·5—4·0. With boiling water it yields calcium polysulphides, and readily dissolves in acid with evolution of hydrogen sulphide. The composition of these spherules was found to be:

		I.	II.
Oldhamite	Calcium monosulphide	89·369	90·244
	Magnesium monosulphide	3·246	3·264
Gypsum		3·951	4·189
Calcium carbonate		3·434	—
Troilite		—	2·303
		100·000	100·000

The presence of such a sulphide in a meteorite shows that the conditions under which the ingredients of the rock took their present form are unlike those met with in our globe; water and oxygen must have alike been absent. The existence of iron in a state of minute division, as often found in meteorites, leads to a similar conclusion. But if the conditions necessary for the formation of pure calcium sulphide be borne in mind, the evidence imported into this inquiry by the Busti aerolite seems further to point to the presence of a reducing agent during the formation of its constituent minerals; whilst the crystalline structure of the oldhamite and of the mineral next described must certainly have been the result of fusion at an enormously high temperature. The detection of hydrogen in meteoric iron by Graham, and more recently by other observers, tends to confirm the probability of the presence of such a reducing agent.

"Osbornite" is the name given by the author to the golden-yellow microscopic octahedra embedded in the oldhamite. These minute crystals gave the following angles:

			Regular octahedron.
111, $11\bar{1}$	=	70° 27′ and 70° 37′	70° 31′
111, $1\bar{1}\bar{1}$	=	109° 31′	109° 28′
111, $1\bar{1}1$	=	69° 58′	

This mineral withstands the action of the most powerful acids, is unchanged by fused potassium carbonate, and possibly when heated

[1] I observed a fragment of this mineral to exhibit phosphorescence. When slightly warmed and illuminated by burning magnesium wire it emitted orange coloured light.

with the chlorate; ignited in dry chlorine it glowed for a few seconds, lost its metallic lustre, and left a residue which soon began to deliquesce. The amount, about 0·002 gramme, was too small for anything but a qualitative examination, which showed it to consist of calcium, sulphur, and an element, which gives the reactions of titanium[1] or zirconium, probably the former, in some singularly stable state of combination. By heating zirconium to an intense heat with lime and aluminium under conditions which probably did not exclude the presence of sulphur, Mallet[2] obtained a golden-yellow incrustation, cubic in form, unattacked by the strongest acids, and possibly analogous in its nature to osbornite.[3]

The next mineral described is an augite of a pale violet-grey colour, intimately mixed with another silicate presently to be considered; it belongs to the oblique system, the measurements yielding the following approximate values:

			Diopside.
001, 100	=	About 75° 30′	73° 59′
001, 110	=	,, 81°	79° 29′
110, $\bar{1}$00	=	45° 54′ to 47° 26′	46° 27′
110, $\bar{1}$10	=	85° 8′ to 86° 20′	87° 5′
100, 111 ?	=	53° 25′ to 54° 15′	53° 50′
001, $\bar{1}$10	=	100° 8′	100° 57′

The plane containing the optic axes is perpendicular to the edge [100,001], and the optical character in the centre of the field is negative. When looked through in any direction parallel to the zone circle [001,010], the crystals show a remarkable dichroism; the plane 100 presents a somewhat facile cleavage, and is also conspicuous for a remarkable metallic lustre, recalling that seen on some kinds of diallage, but of a fine golden hue. The author is of opinion that osbornite may permeate the augite in minute interlaminated layers of sufficient thinness to be transparent.

Two analyses of this mineral gave the following numbers:

	I.	II.	($\frac{5}{8}$ Mg $\frac{3}{8}$ Ca) SiO_3
Silicic acid	55·389	55·594	56·604
Magnesia	23·621	23·036	23·585
Lime	20·020	19·942	19·811
Iron oxide	0·780	0·309	—
Soda	0·554	[0·554]	—
Lithia	trace	[trace]	—
	100·364	99·435	100·000

The iron oxide contains some of the titanoid metal met with in osbornite. In terrestrial varieties of augite the calcium is usually in excess of the magnesium. The mineral was somewhat soluble in acid, the action, however, was found to be simply that of a solvent.

[1] See researches on the presence of titanium vapour in the solar prominences and chromosphere, by C. A. Young. *Amer. Jour. Sc.*, 1871, ii. 335.

[2] J. W. Mallet. *Amer. Jour. Sc.*, 1856, xxviii. 346.

[3] By fusing fragments of the Montréjeau and Aumale meteorites in carbon crucibles Daubrée obtained a compound of titanium "recognisable by its characteristic colour and its power to resist the action of acids." This I take to be Ti_5CN_4, the beautiful copper-coloured substance discovered by Wöhler.

While the augite is present in greatest quantity in the area containing the calcium sulphide, it is met with in other parts of the stone; and associated with it everywhere, and forming the mass of the stone, is another silicate, which proved to be an enstatite like that of the meteorite of Bishopville (1843, March 25th).

It presents the appearance of a number of more or less fissured crystals, with different degrees of transparency, and with a more or less symmetrical polygonal outline, embedded in a magma of fine-grained silicate. Three varieties of this mineral are described: I). a dark-grey glistening crystalline substance, tabular in form, very opaque, and presenting cleavages indistinctly marking the faces of a prism for which the mean of several measurements gave an angle of $\left\{\begin{smallmatrix}88° 35'\\91° 25'\end{smallmatrix}\right\}$; II). a colourless transparent variety, which is rare; and III). a grey semi-transparent splintery mineral in very composite fragments. The following additional measurements were made of this mineral:

				Breitenbach enstatite.
100, 110	=	About 46°	... ...	45° 52′
110, $\bar{1}$10	=	87° 10′ to 88° 0′	... ...	88° 15′
100, 101	=	41° 34′	... ...	41° 12′
010, 011 (?)	=	About 40°	... ...	40° 21′

The planes 100 and 110 are cleavages. The chemical examination of these three varieties yielded the following per-centage numbers:

	I.	II.	III.			MgO,SiO_2
Silicic acid ...	57·597	58·437	57·037	57·961	57·754	60·000
Magnesia ...	40·640	38·942	40·574	39·026	38·397	40·000
Lime	—	1·677	2·294	1·524	2·376	—
Iron oxide ...	1·438	1·177	0·867	0·154	0·423	—
Potash	0·394	0·332	—	0·569	0·569	—
Soda...	0·906	0·357	—	0·680	0·657	—
Lithia	—	—	—	—	0·016	—
	100·975	100·922	100·772	99·914	100·192	100·000

Each variety was acted upon to some extent by acid; the action, however, was found to be simply that of a solvent.

The meteorite also contains a little nickel-iron and schreibersite, having the composition:

Nickel-iron	Iron	94·949
	Nickel	3·849
Schreibersite	Iron	0·884
	Nickel	0·234
	Phosphorus	0·084
		100·000

a very small quantity of troilite, and a small but appreciable amount of chromite, a crystal of which gave the solid angle of a regular octahedron.

The memoir is illustrated with two plates: the one showing very carefully drawn microscopic sections of the augite and enstatite, the other views of the stone and a section of the nodule containing the oldhamite spherules. The accompanying plate is an endeavour to reproduce, by the chromolithographic process, a very elaborate water-colour sketch of this interesting stone prepared by my friend Mr. Edward Fielding. On the upper portion of the section towards the right hand is seen the area where the spherules of the calcium sulphide and some large crystals of the augite are situated; below is a pepita of nickel-iron, the occasional white patches indicating large crystals of enstatite.

Found 1853.—Tazewell, Claiborne Co., Tennessee.[1]

This meteorite was one of those selected by the author for his investigation with the spectroscope of the gases occluded by meteoric iron (see also the meteorites of Red River, Texas, and Arva, Hungary). It is noted for the large amount of nickel, 14·62 per cent., which it contains; it had been examined by Dr. L. Smith,[2] who found no carbon in it. As in the case of the Texas meteorite, this iron appears to evolve gas at ordinary temperatures; the red and green hydrogen lines were brilliant, while the bands of carbon were not noticed. When heat was applied, the spectrum showed the hydrogen lines very brilliantly, and the four chief carbon bands were strongly marked. As the tension of the gas decreased, the hydrogen lines became relatively brighter and the carbon narrower; when the guage stood at 1 mm. these bands were still prominent, while some narrow bands apparently belonging to nitrogen were observed. They differed however somewhat, as regards their relative intensities, from those observed with nitrogen alone. One of the lines appeared to coincide with the chief coronal line 1474 K, although less sharp than it appears in the solar spectrum. An oxygen line, likewise observed, has the position 1462 K very nearly, and closely agrees in point of refrangibility with a bright coronal line noticed by Denza and Lorenzoni during the eclipse of the 22nd Dec., 1870. A second oxygen line, less bright but sharp and distinct, has the position 1359 ± 1 K. The author directs attention to the complete change which the spectrum of an air-tube undergoes by the introduction of hydrogen. According to the method by which Wright calculates the amount of gas present in an iron (see the meteorite of the Red River, Texas, page 99), this metal occludes 4·69 times its volume of mixed gases. Although the greater part of the gas had been removed, the author is of opinion that the whole amount was by no means extracted. The fact of the volume of gas in this instance being in excess of that obtained by Graham and Mallet probably arises from the Tazewell iron having been in a finely divided state, and Wright's recent researches on the iron enclosed in the meteorite of Iowa (1875, February 12th) support this assumption.

[1] A. W. Wright. *Amer. Jour. Sc.*, 1875, ix. 294.
[2] J. L. Smith. *Amer. Jour. Sc.*, [2], xix. 153.

1853, February 10th.—Girgenti, Sicily.[1]

It is unfortunately probable that the history of this fall has been lost to science. Vom Rath has recently endeavoured, but without avail, to gather information from Gemmellaro, of Palermo, respecting what now appears to have been a shower of stones rather than the fall of a single meteorite, as hitherto supposed. Gemmellaro was unable in 1869 to discover any persons who witnessed the fall; as, however, it appears that two years after the occurrence Greg[2] was informed that an account had been printed in a Sicilian scientific journal, more particulars of the fall may yet be obtained.

The two fragments examined by Vom Rath were partly covered with a black crust forming an undulating surface, with occasional little prominences that revealed the presence of nickel-iron. The structure of the rock is chondritic, of a light greyish white, and finely granular, appearing to the eye almost uniform in texture. A fractured surface exhibits a great number of exceedingly fine black lines which seem to have their origin in the crust, although, from their diminutive size (they are generally only to be recognized with a lens), it is, says the author, difficult to believe that they are filled with fused matter. (Compare Meunier's observations on the black lines in the Aumières meteorite, page 111.) They form a tangled mesh-work enclosing the spherules and rounded crystalline grains of olivine; and they are most abundant round the granules of magnetic pyrites, which they occasionally traverse. The nickel-iron is less abundant than in the Pultusk meteorites, and besides forming rounded or hackly grains, occurs, as in the Krähenberg aerolite, in fine veins. The magnetic pyrites (troilite?), which is more abundant than the preceding mineral, takes different hues, and both it and the granules of chromite are grouped together in small circles, which give the rock a more distinctly chondritic character. Spherules of sufficient size to project from a fractured surface and capable of being detached are rare; some, however, have a fibrous structure and a pale green colour. Under the microscope the mass of the rock is found to be an aggregate of white crystalline grains; in it one small yellowish-green crystalline plate having the appearance of mica was noticed. The specific gravity of the stone is 3·549, a number intermediate between those yielded by the Pultusk and Krähenberg meteorites. The Girgenti stone contains 8·3 per cent. of nickel-iron having the composition:

Iron = 87 3; Nickel = 12·7; Total = 100·0.

Here again the proportion of this constituent is intermediate between that found in the meteorites just mentioned; and in composition nearly the same as the nickel-iron of Krähenberg.

The non-magnetic portion, amounting to 91·7 per cent., which, by reason of the small amount of material available for analysis,

[1] G. vom Rath. *Pogg. Ann.*, 1869, cxxxviii. 541.—S. Meunier. *Compt. rend.*, 1873, lxxvi. 109.

[2] R. P. Greg. *Phil. Mag.* xxiv. 534.

was not subjected to the separating treatment of acid, was found to consist of:

SiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O?	Fe	S	Chromite
43·41	1·57	17·96	trace	26·84	1·85	1·50	3·43	2·24	1·20 = 100·00

If the chromite and the iron sulphide, which as it occurs in the portion of the stone unacted upon by the magnet is probably troilite, be deducted, the silicates have the following composition:

			Oxygen.
Silicic acid	46·61	......	24·19
Alumina	1·68	......	0·78
Iron protoxide	19·22	......	4·33
Magnesia	28·89	......	11·55
Lime	1·99	......	0·57
Soda (?)	1·61	......	0·66
	100·00		

The oxygen ratio of the total bases to that of the silicic acid is 1 : 1·352. As this is obviously a mixture of silicates, it seems not improbable, both from the structure of the stone and the analytical determinations, that it consists, as in the Krähenberg rock (see page 5), of an olivine of the form FeO, MgO, SiO_2 (like that also occurring in the meteorites of Château-Renard and Kakova), and a nearly pure magnesian enstatite, as the following scheme indicates:

	FeO, MgO, SiO_2.			MgO (CaO), SiO_2.	
	Oxygen.			*Oxygen.*	
Silicic acid	8·66		...	15·53	
Iron oxide	4·33	8·66	...	—	
Magnesia	4·33		...	7·22	7·79
Lime	—		...	0·57	

For the reason already mentioned the presence of cobalt and of the alkalies could not be directly determined.

Found 1854.—Tucson, Pima Co., Arizona.[1]

This remarkable mass of iron, of which an account is given in Bartlett's "Personal Narrative,"[2] has been chosen by von Haidinger to illustrate some remarks on the rotation of meteorites. It measures 4 ft. 1 in. by 3 ft. 3 in., weighs about 1400 lbs., and is in the form of a ring. When first found, it was set up as an anvil.

Von Haidinger points out that the greatest extension of the iron is in the plane of the ring, and that the rotation must have taken place in this plane. The question arises: What would be the effect which the resistance of the air would exercise on a plate of iron of unequal thickness? In the centre of the compression, and therefore of the expansion, the air, he finds, would be compressed together in a con-

[1] W. von Haidinger. *Sitzber. Akad. Wiss. Wien*, 1870, lxi. 499.

[2] J. R. Bartlett. Personal Narrative of Explorations and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua. 1854. New York: Appleton & Co. Page 297.

dition resembling that of a solid body. What then will be the effect on a large mass of rock, the uneven surface of which is subjected to the unequal action of a temperature of fusion? The stone will be bored into, as the Gross-Divina stone has been to a considerable depth; a similar phenomenon has been remarked in other meteorites. While this will be the effect on brittle stony material, in the present case the resistance of the air, operating on a plate three to four feet in diameter of viscous metal, will be more rapid and energetic. The plate will in process of time be penetrated at one point, and by the gradual expansion of the orifice it will at last develope into a ring, and arrive in this form on the earth's surface.

The meteoric iron which was seen to fall at Agram, Croatia (1751, May 26th), has the form of a plate, and bears evidence of having been subjected to the same eroding influence, though in a less degree. Had it been continued to the depth of another inch this iron would have been perforated, as in the case of the Tucson ring.

The above is a representation, one-twentieth the actual size, of this curious mass, which is preserved in the Smithsonian Institution, at Washington. The figure is reproduced from von Haidinger's memoir.

1855, June 7th.—St. Denis-Westrem, near Ghent, Flandre orientale, Belgium.[1]

The earlier descriptions of this meteorite are by Duprez[2] and Haidinger.[3] Meunier states that the rocky portion of this meteorite

[1] S. Meunier. *Bull. Acad. Sc. Belgique*, 1870 [2], xxix. 210. (See also F. Duprez, *Bull. Acad. Sc. Belgique*, 1870 [2], xxix. 161.)—Acad. royale de Belgique. Centième Anniversaire de Fondation (1772–1872). Tome II. *Rapport séculaire* (*Sciences minérales*), *par G. Dewalque*, 23.

[2] F. Duprez. *Bull. Acad. Sc. Belgique*, 1855 [2], x. 12.

[3] W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, 1860, xlii. 9.

accords in all its characters with that of the stones which fell at Lucé, Sarthe, France (1768, September 13th), Mauerkirchen and others, as well as with that of the meteorite of Sauguis St. Étienne, Basses-Pyrénées (1868, September 7th). The latter rock, to which he has given the name of "lucéïte," is described as white and finely granular, rough to the touch and eminently crystalline, and having the specific gravity of 3·43. He reproduces from another of his memoirs the results of his examination of the last-mentioned stone, and to this we shall presently direct attention. No analysis of the Belgian meteorite appears to have been made. The paper is chiefly devoted to theoretical considerations respecting the stratigraphical arrangement of the star-masses whence the meteorites are supposed to be derived. Meteorites, he maintains, are the product of the breaking-up of larger celestial bodies at the completion of their development, and the moon, he considers, is now approaching this stage of her existence.

1856, November 12th.—Trenzano, near Brescia, Lombardy.[1]

Jervis gives a complete list of the collections in which fragments of this meteorite are preserved.

Found 1856.—Hainholz, near Paderborn, Minden, Westphalia.[2]

This member of the small class of siderolites, originally described by Wöhler, von Reichenbach, and von Haidinger, has recently been submitted to a careful chemical examination by Rammelsberg. It was remarked by von Reichenbach that the olivine of this meteorite formed unusually large crystalline masses, the faces of which, however, were destroyed by weathering; one crystal was $1\frac{3}{4}$ in. long and $1\frac{1}{2}$ in. in breadth.

Two specimens of this meteorite were found by Rammelsberg to have the composition:

Nickel-iron	14·48	12·70
Chromite...	0·58	10·52
Olivine	56·45	62·78
Bronzite	28·49	24·00
	100·00	100·00

The metallic portion consists of:

Iron = 93·84; Nickel = 6·16 Total = 100·00

[1] G. Jervis. I Tesori Sotterranei dell' Italia. Parte Prima. Torino: Loescher, 1873. Page 277.

[2] C. Rammelsberg. *Monatsber. Akad. Wiss. Berlin*, lxx. 314.—C. Rammelsberg. Die chemische Natur der Meteoriten. *Abhandl. Akad. Wiss. Berlin*, 1870, 94. See also *Ber. Deutsch. Chem. Gesell. Berlin*, 1870, iii. 523.

and the two silicates have the following composition:

	SiO_2	Al_2O_3	FeO	MgO	CaO	
A. *Soluble* ...	35·77 ...	— ...	22·91 ...	41·32 ...	—	=100·00
B. *Insoluble* ...	53·05 ...	3·19 ...	15·63 ...	25·40 ...	2·73	=100·00

The soluble part, which constitutes more than one-half of the stone, is an olivine in which the ratio Fe to Mg is 1 : 3, the same proportion as that met with in the Linn Co., Sherghotty and other meteorites. In the insoluble portion we have a bronzite in which the ratio of these two metals is the same as that of the olivine accompanying it, and as that in the enstatite of the Shalka aerolite. In the latter meteorite the bronzite is not associated with nickel-iron. The constitution of these two ingredients of the Hainholz siderolite may be represented by the formulæ:

$$\left\{\begin{matrix} Fe_2\,SiO_4 \\ 3\ Mg_2\,SiO_4 \end{matrix}\right\} \qquad \left\{ 8 \left\{\begin{matrix} Fe\,SiO_3 \\ 3\ Mg\,SiO_3 \end{matrix}\right\} \begin{matrix} \\ Al_2O_3 \end{matrix} \right\}$$

Found 1856 (?).—Jewell Hill, Madison Co., N. Carolina.[1]

This iron has been found by Tschermak to enclose thin plates of troilite like those he recently noticed in the meteoric iron of Ilimaë, Desert of Atacama, Chili. (See page 19.) The lamellæ are just as abundant and have the same orientation as those of the Chilian iron, and are about one-third the size. According to the analyses of Tschermak and Dr. Lawrence Smith, these metallic masses have nearly the same composition. In a volume of his papers collected and published in 1873, the latter author[2] states that the Jewell Hill iron reached his hands in 1854.

1857, February 28th.—Parnallee, Madura District, Madras, India. [Lat. 9° 14′ N.; Long. 78° 21′ E.][3]

Several notices of this remarkable fall, the larger aerolite of which is preserved in the British Museum, have appeared: three by von Haidinger, and three by 1). Cassels, by 2). Pfeiffer, who submitted the rock to analysis, and 3). by Maskelyne, who studied its minute structure under the microscope. Meunier publishes the results of a lithological study of this stone, which he finds to have a very complex structure, and to present in its leading features great similarity with the meteorites of Cabarras Co. (1849, October 31st), Mezö-Madaraz (1852, September 4th), and Bremervörde (1855, May 13th). Its structure has been described as pisolitic: Meunier, on the contrary, likens it to a coarsely granular grit. The grains

[1] G. Tschermak. *Denkschrift Wien. Akad. Math. Naturw. Classe*, xxxi. 187.
[2] J. L. Smith. Mineralogy and Chemistry, 317.
[3] S. Meunier. *Compt. rend.*, 1871, lxxiii. 346.

composing it are often angular, sometimes more or less rounded, and in each instance have the characters of fragments which have been detached from larger masses: the rock, in short, is a breccia. During a careful examination of the four specimens preserved in the Paris Collection, Meunier noted the presence of twelve distinct species of grains: 1). troilite, sometimes in fragments of large size; 2). nickel-iron, in rounded or markedly angular fragments; 3). greyish green translucent peridot, presenting the appearance of having been rolled; 4). chromite, enclosed in a whitish rocky matrix; 5). a grey laminated mineral, with pearly lustre, which is probably hypersthene or amphibole. The remaining seven species, which may more appropriately be designated rocks proper, are divided by the author into two groups, according as he has, or has not, been able up to the present to identify them as individual lithological types constituting distinct meteorites. In the latter group he enumerates 6). a grey scoriaceous rock, free from metallic particles; 7). a dark grey rock, enclosing them; and 8). a bright grey slightly ochreous rock, probably the altered product of another species. Meunier is of opinion that any one of these three species may at some future period be found to constitute an individual meteorite. The remaining four species are: 9). a white granular rock, enclosing nickel-iron and troilite; this variety, which occurs in about thirty of the meteorites in the Paris Collection, he has termed lucéïte; 10). a rock of the whiteness of plaster and enclosing small black grains; this is the 'chladnite' of the Bishopville meteorite, now shown to be magnesian enstatite, MgO, SiO_2; 11). a rock, perfectly black and very tough, containing grains of nickel-iron and troilite; such a material, met with in the stone of Tadjéra (1867, June 9th) and the meteoric irons of Deesa and Hemalga, has received the name of tadjérite; and 12). a greenish grey friable granular highly crystalline rock, containing no metal but small grains of chromite; from its resemblance to the meteoric rock of Chassigny (1815, October 3rd), and in fact by reason of its highly olivinous character, it has received the name of chassignite.

The presence, says the author, in the 'polygenic conglomerate' of Parnallee of fragments belonging to seven types at least of distinct meteoric rocks, demonstrates the co-existence of these types in the star-mass whence this Indian meteorite came.

1858, December 24th.—Murcia, Spain.[1]

This meteorite, which was shown at the International Exhibition of Paris in 1867, is in the form of a right parallelepiped with

[1] S. Meunier. Thèse présentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la composition et la Structure des Météorites*, 9, *et seq.* (See also G. A. Daubrée and S. Meunier. *Compt. rend.*, 1868, lxvi. 639.)

square base, the dimensions whereof are 39 centim., 40 centim., and 27 centim. It weighs 114 kilog., considerably surpassing in size the average of rock masses of meteoric origin.

This meteorite is remarkable for its hardness. The crust, which is nearly perfect, has evidently turned since the fall of the stone from black to brown. On the fractured surface grains of nickel-iron are seen, few of which retain their lustre, as well as an iron sulphide of a bronze hue which is abundantly disseminated through the mass. Besides these are remarked, and this is a distinguishing feature of this rock, very small extremely brilliant crystalline particles, sometimes in minute veins, which appear to be metal, but really have vitreous lustre. They fuse before the blowpipe to a grey enamel, and give the reactions of silica and alumina. They are probably a felspar or an analogous mineral species. Though by their brilliancy and transparency they resemble quartz, the feeble action which they exert on polarized light suffices to distinguish them. In a microscopic section the presence of a large amount of a black opaque ingredient was recognized; grains of a sulphide with a sub-metallic lustre, duller along the margin, are very abundant; while others much smaller and very black were identified with chromite. The stony matter enclosing these substances is made up of two ingredients of different aspect: the one, of a reddish-yellow colour and very transparent, presents the flawed characters usually observed in the siliceous portion of meteoric rocks; the other is of a darker hue and less homogeneous.

The material chosen for analysis, taken from the blackest, and consequently less altered portion of the meteorite, had the following composition:

Nickel-iron	14·990
Troilite	20·520
Chromite	0·920
Soluble silicate	38·688
Insoluble silicate	24·640
	99·758

The nickel-iron consists of:

Iron = 90·93; Nickel = 9·07; Total = 100·00.

The troilite, constituting one-fifth of the stone, is present in larger quantity than in any meteorite previously investigated. The siliceous portions are composed as follow:

	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	Chromite	
A. *Soluble*	38·725	—	12·932	47·206	0·233	0·904	—	—	=100·000
B. *Insoluble*	55·719	1·996	0·880	37·806	—	—	trace	3·599	=100·000

The soluble portion consists chiefly of an olivine having the same composition as that occurring in the meteorites of Tadjéra and Pultusk, while the insoluble part appears to be mostly pure magnesian enstatite, with perhaps a small amount of the aluminous mineral already alluded to.

This stone fell at Molina and is preserved in the Madrid Museum.

Found 1858.—Trenton, Washington Co., Wisconsin. [Lat. 43° 22′ N.; Long. 88° 8′ W.][1]

In the autumn of 1858 a farmer while working on his farm in Section 33, Washington Co., struck his plough against some hard object about 10 inches below the surface; it proved to be a mass of meteoric iron weighing 62 lbs. It appears that four pieces, two of which weighed 16 lbs. and $7\frac{3}{4}$ lbs., were found, in the years immediately following, within a circuit of two or three rods of the spot where the largest was discovered. Dr. L. Smith gives the weights of the masses: 62 lbs., 16 lbs., 10 lbs., and 8 lbs., and the composition of the metal as written below (I.), side by side, with the results of an analysis by Bode (II.), which is incorporated in Brenndecke's report on these meteorites presented by him to the Society of Natural History of Wisconsin:

	I.	II.
Iron	91·03	89·22
Nickel	7·20	10·79
Cobalt	0·53	trace
Phosphorus	0·14	0·69
Copper	trace	—
Insoluble residue	0·45	—
	99·35	100·70
Specific gravity	7·82	7·327

Bode states that the Widmannstättian figures are developed with great distinctness. Dr. Smith arrived at the same result, and finds that the spaces between these figures, which have convex ends and sides, are darker in hue than they are, and exhibit striations, the lines being at right angles to the bounding surfaces; these forms he terms 'Laphamite markings.' When the space where they occur is nearly square the lines extend from each of the four sides; in other cases they are parallel to the longer sides. He considers that these figures indicate "the axes of minute columnar crystals, which tend to assume a position at right angles to the surface of cooling." The author does not describe what phases these figures assume when the iron is cut in various directions.

1859, May —.—Beuste, Basses-Pyrénées.[2]

This meteorite has recently been acquired for the Paris Collection. Two fragments, weighing respectively 1·40 and 0·42 kilog., were found about 700 metres apart, the former having penetrated the soil to a depth of about 50 centim. The black crust has a thickness of

[1] J. L. Smith. *Amer. Jour. Sc.*, 1869, xlvii. 271. Mineralogy and Chemistry, 349.—F. Brenndecke. *Annual Rep. Smithsonian Inst. for* 1869, 1871, 417.—J. A. Lapham. *Amer. Jour. Sc.*, 1872, iii. 69. (See also Part I. page 15.)
[2] G. A. Daubrée. *Compt. rend.*, 1873, lxxvi. 314.

0·4 to 0·5 mm., and the specific gravity of the stone is 3·53. It belongs to the class of which the Chantonnay meteorite (1812, August 5th) is a representative, and consists, it may be presumed, as it has not yet been analyzed, chiefly of olivine, bronzite, and labradorite. The stone has a grey colour and a compact structure. The fractured surface is traversed in all directions by black veins which anastomose.

1860, May 1st.—New Concord, near Zanesville, Guernsey Co. and Muskingum Co., Ohio.[1]

A note on the fall of these meteorites, copied from the *Zanesville Courier*, apparently contains no new information beyond what has already been recorded in Buchner's *Die Meteoriten*, 104.

Found 1861.—Rittersgrün, near Schwarzenberg, Saxony.

For a short description of the probable composition of this siderolite see the *Breitenbach Meteorite*.

Found 1861.—Breitenbach, Bohemia.[2]

This remarkable siderolite was found in Bohemia, at a spot not very far distant from the Saxon frontier or indeed from Rittersgrün, in Saxony, where a mass closely resembling it was almost contemporaneously found. So far back as 1751 at Steinbach, a village about midway between Breitenbach and Rittersgrün, a meteorite in all respects similar was discovered; the three masses are so similar to one another and so dissimilar to any others preserved in collections that there can be little doubt that they belong to the same fall. In 1825 Stromeyer examined a siderolite in which he found 61·8 per cent. of silica; this also appears to have been a member of this shower of meteorites, believed by Breithaupt to have been the "Eisenregen" which occurred at Whitsuntide, 1164, in Saxony, when a mass of iron fell near the town of Meissen.

A polished surface of either of these masses exhibits irregularly formed patches of nickel-iron, the interspaces being partly filled

[1] *Amer. Jour. Sc.*, 1871, i. 309.

[2] N. Story-Maskelyne. *Proc. Royal Soc.* 1869, xix. 266.—V. von Lang. *Sitzber. Ak. Wiss. Wien*, 1869, lix. 848. *Pogg. Ann.* cxxxix. 315.—N. Story-Maskelyne. *Phil. Trans.* 1871, clxi. 359.—G. vom Rath. *Zeit. Deut. Geol. Gesell. Berlin*, 1873, xxv. 106. *Pogg. Ann.* Erganz.-Bd. vi. 337. *Jahrb. Mineralogie*, 1874, i. 79.

with small patches of iron sulphide, the greater portion of the surface being occupied by a greenish and greyish-brown crystalline magma. After the removal of the two first-mentioned ingredients with mercury chloride, the magma is found to consist of (1) highly crystalline, bright green or greenish-yellow grains; (2) rusty-brown, sometimes nearly black, sometimes also nearly colourless grains of a mineral presenting crystalline features, but on which definite planes are rare; and (3) crystalline grains of chromite.

The first of these ingredients is bronzite, the crystallographic characters of which are described in the paper of von Lang, who gives the results of measurements made on nine crystals; these results are mineralogically important as affording for the first time complete data for the crystallography of a rhombic mineral having the formula of enstatite. The elements of the crystal are:

$$a : b : c = 0{\cdot}87568 : 0{\cdot}84960 : 1$$

which give the following among the important angles by calculation:

$$110,010 = 44^\circ\ 8'$$
$$101,100 = 41^\circ\ 11'$$
$$011,010 = 40^\circ\ 16'$$

Von Lang observed the following faces:

100, 010, 001, 011, 054, 302, 101, 102, 103, 104, 410, 520, 210, 530, 110, 120, 250, 130, 111, 121, 112, 122, 212, 133, 232, 124, 144, 324, 344, 524.[1]

The most important zonal relations of these faces are shown in the spherical projection appended to his paper.

The hardness of this mineral is 6 and the specific gravity 3·238, a number differing but slightly from those determined by Stromeyer and estimated by Rumler in the case of the silicates of the Steinbach siderolite. The composition of the bronzite, as determined by analyses made by the new method of distillation already alluded to (page 118) and by fusion with alkaline carbonates, was found to be:

	I.	II.	*Mean.*	*Oxygen.*
Silicic acid	56·101 ...	56·002 ...	56·051 ...	29·89
Magnesia...	30·215 ...	31·479 ...	30·847 ...	12·34
Iron protoxide...	13·583 ...	13·295 ...	13·439 ...	2·97
	99·899	100·776	100·337	

These numbers correspond very closely with the formula $(Mg_{\frac{4}{5}} Fe_{\frac{1}{5}}) SiO_3$. This bronzite, which occurs in association with nickel-iron, contains only half the amount of iron met with in the bronzite of the Manegaum meteorite (page 112), which stone contains next to no nickel-iron. Rammelsberg[2] has recently pointed out the fact

[1] About the time that Von Lang published these results Vom Rath measured some crystals of terrestrial bronzite, found in a sanidine bomb from the Laachersee, and arrived at results which accord very exactly with those of Von Lang. (*Pogg. Ann.*, cxxxviii. 529.)

[2] C. Rammelsberg. *Pogg. Ann.*, cxl. 311. Rammelsberg draws attention to the remarkable accordance between the angles of bronzite and olivine, which would explain the fact of G. Rose having regarded the silicate in the siderolites of Rittersgrün and Steinbach as olivine. (See note to page 87.)

that in Stromeyer's paper, already alluded to, the specific gravity of the silicate is given = 3·27; and he shows that, although the mineral analysed by Stromeyer contained undecomposed silicate, or more probably asmanite, the ratio of Fe to Mg is the same as in the above analyses.

By treating with hydrochloric acid the dark-coloured grains constituting the second ingredient of the meteorite and forming about one-third of the mass of the mixed silicates the iron staining them is removed, and they are left in a state of colourless purity. This mineral, to which Maskelyne has given the name asmanite,[1] is silicic acid, possessing the specific gravity of quartz after fusion, and crystallising in forms belonging to the orthorhombic system. The grains of asmanite are very minute and much rounded, and, although entirely crystalline, they very rarely present faces offering any chance for a result with the goniometer; from several thousand little grains comprised in some two grammes of material Maskelyne obtained a very few crystals with sufficiently distinct crystallographic features to be available for measurement. He found the parametral ratios of asmanite to be:

$$a : b : c = 1{\cdot}7437 : 1 : 3{\cdot}3120$$

The angles, as calculated from these data and as found on seven different crystals, are as follow:

		A.	B.	C.	D.	E.	F.	G.
100,403 =	21° 33′	...	...	21° 31′				
101 =	27 46	27° 40′	27° 48′	27 46	27° 49′	27° 25′	27° 55′	27° 44′
102 =	46 29	46 18	...	46 31	...	46 2		
103 =	57 40	...	...	57 34	...	...	57 25	57 35
001 =	90 0	90 0	...	90 0				
001,$\bar{1}$03 =	32 20	32 22	...	32 19				
203 =	51 42	51 32						
$\bar{1}$02 =	43 31	43 34						
$\bar{1}$01 =	62 14	62 17	...	62 14				
100,010 =	90 0							
110 =	60 10	...	60 13	60 10	...	...	60 10	
$\bar{1}$10 =	119 50							
110,1$\bar{1}$0 =	120 20	...	120 23	...	...	...	120 10	
001,011 =	73 12							
010 =	90 0	...	...	90 0				
101,110 =	63 53	...	...	63 54				
$\bar{1}$10 =	116 7	...	...	116 7				
001,116 =	32 28	...	...	32 56				
112 =	62 21	...	...	62 21				
223 =	68 33	...	...	68 36				
110 =	90 0	...	...	90 0				
548,001 =	63 52	...	...	64 0				
100 =	58 28	...	...	58 30				
101 =	52 18	...	...	51 48				

The cleavage-plane 001 has a vitreous lustre, that on the planes of the forms 100 and 101, as also of the rounded surface in the zone with them, is usually resinous, recalling the lustre of opal. The

[1] Ásman is the Sanscrit term, corresponding to the Greek ἄκμων, for the thunderbolt of Indra.

faces of the octaid forms are almost invariably rounded. The optical characters confirm the measurements in showing asmanite to be rhombic, the optic axes being very distinct and widely separated; their apparent angle, as measured in air, is 107° to 107° 30′.

The hardness of this mineral is 5·5, and the specific gravity 2·245; according to Vom Rath 2·247. Of the following analyses, I. and II. are the original analyses given in Maskelyne's paper, III. are the results of a recent analytical examination by Vom Rath:

	I.	II.	III.
Silicic acid	97·430 ...	[99·210] ...	96·3
Iron oxide	1·124 ...	0·790 (Iron oxide, Lime, Magnesia)	... 1.6
Lime	0·578 ...		... trace
Magnesia	1·509 ...		... 1·1
	100·641	100·000	99·00

It is not a little curious to find that in his Catalogue of the Vienna Collection Partsch[1] describes a specimen of the Steinbach meteorite as "native iron, jagged and hackly, *with quartz in grains*, and a yellow fluorspar." The detection by G. Rose of quartz in the oxidised crust of the Toluca iron is the only earlier instance recorded of the occurrence of free silica in a meteorite. The solvent action of an aqueous solution of sodium carbonate on asmanite and quartz in powder appears to be uniform.

As regards the relation in which the three forms of crystallised silicic acid stand to each other in respect to the mode of their formation, Vom Rath remarks that while crystals of quartz have in most cases unquestionably separated from aqueous solution, and tridymite, as a characteristic mineral of the druses of volcanic rocks, appears to require the co-operation of vapour for its formation, we have probably in asmanite silicic acid crystallised from a molten mass which has become solid. Crystallised silica has not yet been produced by fusion; when it is, it will probably have the characters of asmanite.

The nickel-iron of this siderolite exhibits figures when etched, and consists of:

	I.	II.	*Mean.*	*Equivalent Ratios.*
Iron...	89·975 ...	90·878 ...	90·426 ...	3·229
Nickel	9·642 ...	8·927 ...	9·284 ...	0·314
Cobalt	0·383 ...	0·195 ...	0·290 ...	0·010
Copper	trace ...	trace		
	100·000	100·000	100·000	

The above ratios differ but slightly from Fe : (Ni, Co) = 10 : 1. Rube's examination of the Rittersgrün iron yielded very similar per-centage numbers. The chromite of this siderolite gives angles corresponding to a regular octahedron.

[1] P. Partsch. Die Meteoriten im k. k. Hof-Mineralien-Kabinette zu Wien. 1843. Page 95.

Found 1861.—Cranbourne, near Melbourne, Australia. [Lat. 38° 11′ S.; Long. 145° 20′ E.][1]

This enormous block of meteoric iron, which is a familiar object to those frequenting the British Museum, is, with the exception of the recently found Ovifak irons, preserved at Stockholm and Copenhagen, the largest meteorite contained in any collection. The minerals composing it have for some time past formed the subject of an investigation, and the results which I have obtained will shortly be published. It will suffice here to state that the Australian, like the Greenland irons, oxidises on exposure to moist air and scales off. These masses differ in this that the Ovifak iron yields a rusty-brown coarse powder, apparently without structure; while in the débris of the Australian iron, on the other hand, distinct crystals of nickel-iron are to be met with. Though partially converted into oxide and readily broken when handled, they attain after treatment with an excess of hydrogen at a red heat their pristine stability. A number of crystals of nickel-iron, apparently tetrahedra, large and very perfect, as well as plates of what may possibly be beam-iron and which lie, though not immediately, upon them, were reduced by this method. Between these two forms lie excessively thin plates of an alloy of iron, much richer in nickel, and to the diminished action of an etching fluid on this more stable alloy I ascribe the development of such thin lines as are seen in the section of the Toluca iron (see Plate, page 95). The descriptions and analyses of these and other minerals will appear in the memoir which is in course of preparation. I have now to refer the reader to Von Haidinger's earlier notices[2] of the discovery of this block, based for the most part on a report supplied by Neumayer, at that time Director of the Flagstaff Observatory at Melbourne. Two masses of meteoric iron were discovered, and near the larger meteorite Neumayer found a brown ochrey mineral which he regarded as a portion of its oxidised crust. It had but feeble action on the magnet and did not fuse before the blowpipe, but turned black and became magnetic. The hardness is rather less than that of felspar, and the specific gravity = 3·744; the composition, according to a recently published analysis by Haushofer, is:

Insoluble silicate	4·1
Silicic acid	2·3
Alumina	1·5
Iron oxide	71·1
Nickel oxide	3·1
Lime	1·8
Phosphoric acid	1·4
Water	13·7
	99·0

[1] K. Haushofer. *Jour. Prakt. Chem.*, 1869, cvii. 330.—M. Berthelot. *Ann. chim. et phys.* 1873, xxx. 419.

[2] W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, 1861, xliii. 583; xliv. 378 and 465; and 1862, xlv. 63.

The author suggests that more or less rounded masses of nickeliferous göthite or limonite having a similar origin may probably be met with in the older sedimentary rocks.

In continuation of his valuable researches on the native and artificial varieties of carbon,[1] Berthelot examined a specimen of the graphite-like carbon, which I found among the fragments of metal detached from this iron. His object was to ascertain which variety of carbon it resembled, whether it should be classed with the graphite of pig-iron, native plumbago, the amorphous carbon obtained by treating carbides of iron or manganese with acid, the so-called artificial graphite of the gas-retorts which he had previously shown to be no true graphite, anthracite, or, lastly, the carbonaceous substance found in the remarkable meteorite which fell at Orgueil (1864, May 14th).[2]

The carbon of the Cranbourne meteorite was warmed with nitric acid to remove the iron sulphide, and then digested with fuming nitric acid and chlorate of potash. After two treatments with these powerful oxidising agents, Berthelot obtained a greenish graphitic oxide, identical in every respect with the oxide obtained from the graphite of cast iron, and differing as entirely from the oxidised product which plumbago yields under like conditions. As this meteoric carbon resembles in all respects the variety of this element which has been dissolved in molten iron and separated from the solidified mass after very rapid cooling, Berthelot suggests that its formation and association with the meteoric form of iron sulphide[3] may be ascribed to the action of sulphide of carbon on incandescent iron, since the carbon of the last-mentioned sulphide by decomposition is also liberated in the graphitic form. The carbon of this meteoric iron owes its present form to exposure to a very high temperature; it cannot have been produced by the action of iron on carbonic oxide or from carbon once combined with the metal and liberated at ordinary temperatures by the solution of the iron in some reagent; and is still further removed from the other variety of meteoric carbon occurring in the stone of Orgueil. The carbon of the Ovifak iron (see page 31) has likewise been examined by Berthelot, who finds it to differ so completely in its behaviour with oxidising reagents from the carbon of the Australian iron that he does not hesitate to pronounce the conditions under which these two forms of the element were produced to have been essentially distinct.

[1] M. Berthelot. *Ann. de Chim. et de Physique*, xix. 405.

[2] Wöhler and Cloez have found that certain of the carbonaceous meteorites contain compounds of carbon, hydrogen, and oxygen, resembling the last residues of organic substances of terrestrial origin. By applying his method of hydrogenation to the carbonaceous matter of the Orgueil meteorite, he succeeded in forming a notable quantity of a hydrocarbon of the series ($C_{2n}\ H_{2n+2}$) comparable with the oils of petroleum. This new analogy between the carbonaceous matter of meteorites and substances of organic origin occurring in the crust of our planet is of great interest. (*Compt. rend.*, lxvii. 849.)

[3] Troilite in large nodules is abundantly present in this meteoric iron.

Fell 1862.—Victoria West, Cape Colony, S. Africa.[1]

This mass is of interest as belonging to the very small class of meteoric irons the fall of which was witnessed. It is stated to be shaped like a pear, the one end being smooth and rounded, the other and smaller end being jagged in a manner which indicates the probability of its having been detached from a larger meteorite.

In 1870 the mass, which weighed 6½ lbs., was sawn in two by order of the authorities of the South African Museum at Cape Town, and the one half further divided for distribution.

Tschermak has already shown that the meteorites of Ilimaë (see page 19) and Jewell Hill (see pages 23 and 127) enclose lamellæ of troilite, which are situated parallel to the faces of the cube; he now finds that this iron furnishes a third example of this structure. The section of the iron is not only traversed by fissures, which were evidently once filled with troilite and in many cases still enclose traces of that mineral, but perfect plates of the sulphide are likewise observed. As in the former instances, the troilite lamellæ lie parallel to the faces of the cube, and are enclosed in a shell of beam-iron (kamacite). The etched figures are very distinct, and nodules of granular troilite are also met with.

Dr. L. Smith also directs attention to these fissures, and finds the figures developed by etching to be of that class where the lines are delicate and straight, inclined at a considerable angle to each other, a form common in irons rich in schreibersite. The latter mineral is diffused through the iron in masses with straight boundaries, $\frac{5}{8}$ in. to $\frac{3}{4}$ in. long, and $\frac{1}{8}$ in. in breadth, also in much narrower and longer forms, as well as in others which are triangular and arrow-shaped.

In a drawing accompanying his paper we have an interesting illustration of the specimen which he examined. In the centre of the section a cavity is seen, 1½ in. in the longest and 1 in. in the shortest diameter, the interior of which is also coated with a layer of schreibersite $\frac{1}{20}$th in. thick; the rest of this cavity is stated to be filled with pyrites. In his later paper, however, the nodule is said to consist of the monosulphide, troilite. In the absence of the knowledge of any test, whether with chemical reagents or with the magnet, having been applied, it appears not improbable that some of the elongated enclosed masses described above as schreibersite may be the lamellæ of sulphide which Tschermak observed.

The specific gravity of this iron is 7·692, and the composition:

Iron = 88·83; Nickel = 10·14; Cobalt = 0·53; Phosphorus = 0·28; Copper, trace. Total = 99·78.

[1] G. Tschermak. *Mineralogische Mittheilungen*, 1871, 109.—J. L. Smith. *Amer. Jour. Sc.*, 1873, v. 107, and 1874, vii. 394. *Compt. rend.*, 1873, lxxvi. 294. —See also G. R. Gregory. *Geol. Mag.* 1868, v. 531.

Found 1862.—Howard Co., Indiana.[1]

This mass of meteoric iron, which weighs 4 kilog. and has an irregular elongated oval form, was found in a bed of stiff clay about two feet below the surface. It is one of the class of irons which are only slightly affected by atmospheric agency, freshly cut surfaces retaining their brightness perfectly. The specific gravity of the iron is 7·821 and the composition:

Iron = 87·02; Nickel = 12·29; Cobalt = 0·65; Phosphorus = 0·02; Copper, trace. Total = 99·98.

An etched surface does not give the slightest indication of Widmanstättian figures; their occurrence in short appears to be an exception rather than the rule in the case of irons containing more than 9 or 10 per cent. of nickel (see page 26).

Dr. L. Smith expresses his belief that we shall not arrive at a satisfactory explanation of the formation of these figures until our knowledge of the effect of the presence of a minute quantity of foreign substances in iron is better understood. He alludes to the power iron, containing one per cent. or even a less amount of phosphorus, acquires of withstanding the action of acid, as evidenced in vessels used for parting gold and silver. During the crystallization of iron, as of other substances, "there is a tendency to eliminate foreign constituents to the exterior portion of the crystals": after a blast-furnace, for example, has been chilled and the metal has slowly passed from a plastic to a solid condition, the iron will be found in large crystals containing a very much smaller amount of carbon than is usually the case. If meteoric iron then be rapidly brought to the solid state, we can conceive of such a diffusion of the phosphorus as would give no marked indications in any part of the mass; by slow cooling, however, we might expect a more or less complete elimination of the phosphorus in certain parts representing the spaces between the crystals of the mass. "The portions of the iron forming the limits of the crystals become more richly charged with phosphorus," the homogeneous character of the "iron" is destroyed, and this would render its different parts variously susceptible to the action of an etching fluid.

The irons of Victoria West, South Africa (see page 137), and Tazewell (page 122), which enclose nodules of troilite and schreibersite, contain, the former only a trace of sulphur and 0·28 per cent. of phosphorus, the latter 0·016 per cent. of phosphorus; and in the mass of the Arva iron, which is filled with layers of schreibersite, there remains only 0·019 per cent. of phosphorus. The geologist and the mineralogist have noticed such a segregation in a vast number of instances.

[1] J. L. Smith. *Compt. rend.*, 1873, lxxvii. 1193.—*Amer. Jour. Sc.*, 1874, vii. 391.

1863, March 16th.—Pulsora, N.E. of Rutlam, Indore, Central India.[1]

The village of Pulsora, where the fall of these meteorites took place during the afternoon of the above day, is six miles N.E. of Rutlam. One, the largest, struck the roof of a house, a second fell near a well, and the third in a nulla; they lay within 200 yards of each other. The stones came in a direction from W. to E., and the noise attending their fall was heard three miles distant.

In his descriptive catalogue of the meteorites in the Vienna Collection, which is dated 1st October, 1872, Tschermak describes the stone as chondritic, and as consisting of olivine and bronzite with nickel-iron. It occupies a place between those marked *C w* (white rock without spherules) and *C g* (grey rock with light-coloured spherules). The letters *C i b*, affixed to it in the catalogue, denote that it has a brecciated structure, like the meteorites of Dacca and St. Mesmin.

1863, June 11th.—Tarrangollé, S.E. of Gondokoro, Africa.[2] **[Lat. 4° 31′ N.; Long. 32° 50′ E.]**

In Sir Samuel Baker's work it is stated that on the above day (7·20 A.M.) a curious phenomenon was noticed. "The sky was perfectly clear, but we were startled by a noise like the sudden explosion of a mine or the roar of heavy cannon almost immediately repeated. It appeared to have originated among the mountains (the Madi Mountains?), about sixteen miles due south of my camp. I could only account for this occurrence by the supposition that an immense mass of the granite rock might have detached itself from a high mountain, and, in falling into the valley, it might have bounded from a projection on the mountain's side, and thus have caused a double report." It seems not improbable, as has been suggested, that the explosion may have been caused by the disruption of an aerolite.[3]

[1863.]—South-Eastern Missouri.[4]

Shepard describes a small mass of meteoric iron originally weighing about 12 oz. which was found by Prof. Shumard in 1863 in the collection of the old Western Academy of Sciences of St. Louis;

[1] W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, 1869, lix. 228.—G. Tschermak. *Mineralogische Mittheilungen*, 1872, 165.

[2] The Albert N'yanza, Great Basin of the Nile and Explorations of the Nile Sources. By S. W. Baker. London: Macmillan. 1866. Vol. i. 359.

[3] *Les Mondes*, 1870, xxii. 585.

[4] C. U. Shepard. *Amer. Jour. Sc.*, 1869, xlvii. 233. In the catalogue of the Vienna Collection this iron bears the date 1864.

the only locality given on the label is "*S. E. Missouri.*" Shepard finds it to resemble most closely the irons of Arva and Cocke Co. The specific gravity is 7·015—7·112. The metal encloses so large a quantity of schreibersite that after prolonged treatment with acid that mineral projects in thick laminæ from the surface, as mica does from coarse-grained weathered granite. The intermediate areas are not traversed with the delicate lines of the same substance (?) as in the case of other irons. The meteorite has the following composition:

Iron = 92·096; Nickel = 2·604; Schreibersite = 5·000. Total = 99·700.

with traces of cobalt, chromium, phosphorus, magnesium, carbon and silicium.

Found 1864.—Wairarapa Valley, Province of Wellington, New Zealand.

I have to thank Dr. Hector, F.R.S., Director of the Geological Survey of New Zealand, for a short account of the only meteorite which has yet been found in that colony, and which is preserved in the Colonial Museum at Wellington. It is in the form of an irregular six-sided pyramid, 7 inches high and 6 inches across the base; the edges are rounded, and the sides slightly convex and indented with shallow pits. The capacity of the stone is 49 cubic inches, the weight 480 oz., and the specific gravity 3·254; the hardness 5–6. It is strongly magnetic, but exhibits no decided polarity. The surface is of a light rusty brown colour, and is stained with exudations of iron chloride and sulphate. A freshly fractured surface is dark grey, mottled with bright metal-like particles of what may be iron monosulphide. By treatment with copper sulphate, the presence of iron in the form of metal was determined; with hydrochloric acid sulphuretted hydrogen was evolved, sulphur set free, and a large quantity of gelatinous silicic acid separated. The insoluble portion consisting of silica and insoluble silicates constituted 56·0 per cent. of the stone. In the soluble portion the predominating ingredients were iron, amounting to 24·01 per cent. and magnesia along with nickel, manganese and soda; alumina and chromium are not present. These reactions so far indicate in the New Zealand meteorite the presence of olivine and an insoluble silicate, in addition to nickel-iron and what may be troilite or magnetic pyrites. A short notice of this stone is to be found in the Appendix A to the Jurors' Report of the New Zealand Exhibition of 1865, p. 410. Von Haidinger alludes to the circumstances attending the fall of a meteorite of this date (*Sitzber. Ak. Wiss. Wien,* lii. 151).

1865, May 23rd.—Gopalpur, Bagerhaut, Jessore, India.[1]

In his paper communicated to the Vienna Academy Tschermak gives the history of the fall of this stone,[2] from which it appears that its descent was unattended by the detonation which usually accompanies the descent of a meteorite. The stone, of which three views are given in Tschermak's paper, has a greyish brown colour; when laid on its largest flat surface it has approximately a trapezoidal boundary, the upper side being curved and exhibiting pits and striped markings. The front surface (*die Brustseite*) is covered with a thin feebly lustrous crust which is finely striped and channelled; the channels have a radiate arrangement and converge to a point near which is a small deep pit, while not far removed from it is another deeper-lying hollow; all the pit-like depressions are elongated, the extension being the more marked the shallower they become and the further they lie from the point of radiation. It will be evident from this that during the transit of the meteorite through the atmosphere this point was in front. (See the Tucson iron, page 124.) The heat generated by the compression of the air melts the surface of the stone, and the attrition of particles of air with the more porous portion of the front surface forms the depressions radiating from the foremost point; the fused drops as fast as formed are driven off by the opposing air and give rise to the fine radiated texture of the crust. The hinder surface has very different characters: it consists of two almost flat faces meeting nearly at right angles and forming sharp edges with the front surface. Along this edge the very distinctive crust of the front surface slightly overlaps the hinder portion, terminating in a well-defined and sometimes fringed border. Here the crust is verrucose, most of the granules consisting of fused matter, many enclosing unaltered grains of the meteorite; few follow the radiated arrangement observed in the former case.

As regards the structure of the stone of Gopalpur it closely resembles, in the diminutive size of its chondra, the meteorites of Pegu and Utrecht. They are of three kinds: 1). The most striking have a brownish-grey hue and fibrous fracture, their optical principal sections being parallel and perpendicular to the direction of the fibres; these appear to be bronzite; 2). The next have a radiate structure, and are built up of larger bar-like transparent crystals, which in one spherule were observed to radiate from two centres; these are not improbably a felspar; and 3). The last kind of chondra consist of a granular fissured mineral which appears to be olivine.

The spherules have the same composition as their matrix, bronzite, olivine, nickel-iron and magnetic pyrites forming the predominating constituents in each case. While the chondra, met with in terrestrial rocks, in perlite, obsidian, pitchstone, in many diorites, are radiate-fibrous, those occurring in meteorites are but rarely so, and in these

[1] G. Tschermak. *Sitzber. Akad. Wiss. Wien*, 1872, lxv. 135. *Mineralogische Mittheilungen*, 1872, 95.—A. Exner. *Mineralogische Mittheilungen*, 1872, 41.

[2] *Proc. Asiat. Soc. Bengal*, 1865, 94.

cases the arrangement of the fibres within the spherule is excentric. Moreover, while the meteoric chondra, as already stated, consist of the same ingredients as the matrix, and often differ from it only in being more coarsely granular, the chondra of terrestrial rocks are shown by the microscope to be differently constituted from the matrix. Tschermak is of opinion that in the case of the meteorites solid masses have been reduced to powder by mutual attrition, the tougher particles withstanding the action becoming rounded, and that dust and spherules have undergone subsequent segregation.

The stone of Gopalpur consists, according to Exner's analysis, of:

Nickel-iron	20·35
Magnetic pyrites	4·44
Olivine	28 86
Bronzite	35·60
Felspar	10·75
Chromite	trace
	100·00

The nickel-iron has the following composition:

Iron = 90·37; Nickel = 9·11; Cobalt = 0·52. Total 100·00.

and the portions separated by acid:

	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	
A. *Soluble*......	38·31	0·54	25·72	—	0·72	34·71	—	—	= 100·00
B. *Insoluble*...	57·95	5·19	10·03	0·57	3·04	21·42	9·45	1·35	= 100·00

This, it will be seen, is one of the few meteorites containing a variety of felspar, which in this instance amounts to more than 10 per cent. Tschermak was unable to determine by an examination of microscopic sections whether it was oligoclase.

1865, August 25th.—Sherghotty, near Gya, Berar, India.[1]

The earliest notice of this stone appears in the *Proceedings of the Asiatic Society of Bengal.*[2] It fell near Sherghotty at 9 A.M. on the day mentioned; the weather was calm and the sky overcast, when a loud report was heard and the stone penetrated the soil to the depth of about two feet. When exhumed it was found to be broken into two pieces.

According to Lumpe's analysis, given below, this meteorite consists almost exclusively of silicates, only a trace of metallic iron

[1] E. Lumpe. *Mineralogische Mittheilungen*, 1871, 55.—G. Tschermak, *Mineralogische Mittheilungen*, 1871, 56; and 1872, 87; *Sitzber. Ak. Wiss. Wien*, 1872, lxv. 122; *Jahrbuch für Mineralogie*, 1872, 733.—See also F. Crook. On the Chemical Constitution of the Ensisheim, Mauerkirchen, Sherghotty, and Muddoor Stones. (Inaug.-Dissert.) 1868. Göttingen: E. A. Huth.

[2] *Proc. Asiat. Soc. Bengal*, 1865, 183.

and a very small amount of sulphur having been met with. It contains:

Silicic acid	50·21
Alumina	5·90
Iron protoxide	21·85
Magnesia	10·00
Lime	10·41
Soda	1·28
Potash	0·57
	100·22

These results show that the Sherghotty stone belongs to the class including the meteorites of Stannern, Juvinas, and Jonzac. The stone examined by Crook in Wöhler's laboratory contained more than nine per cent. of nickel-iron and very little lime, from which it is apparent that what Crook held to be the meteorite of Sherghotty is a specimen of another fall.

More recently this meteorite has been submitted to a very complete investigation by Tschermak. He finds a fractured surface to be distinctly granular; the grains are of nearly equal magnitude, and among them the eye readily distinguishes two minerals: one of a light brown colour and with very distinct cleavage, the other transparent and with a strong vitreous lustre. Further microscopic and chemical examination revealed the presence of three more ingredients: a yellow silicate rarely met with and forming grains, 0·1 mm. across, which exhibit doubly refractive power and appear to crystallise in the rhombic system; they are probably bronzite. Magnetite and magnetic pyrites were likewise present.

An augitic mineral, the one above alluded to, forms the chief mass of the stone; it has a greyish-brown colour, and exhibits double refraction with slight pleochroism. The cleavage and optical characters suggest its classification with diopside. The analytical results given below, however, show that it cannot be regarded as a member of the augite group:

Silicic acid	52·34
Alumina	0·25
Iron protoxide	23·19
Magnesia	14·29
Lime	10·49
	100·56

These numbers accord with the formula:

$$CaO, 2\,MgO, 2\,FeO, 5\,SiO_2.$$

A mixture of hypersthene and hedenbergite, the former greatly preponderating, possesses such a composition. Tschermak finds, however, that the silicate cannot be thus constituted, and he considers this augitic constituent of the Sherghotty meteorite to be a chemical compound which has not yet been discovered in our terrestrial rocks.

The second constituent of this stone occurs more rarely in transparent colourless granules with vitreous lustre and conchoidal fracture; they proved to be distorted octahedra. "Maskelynite," as

Tschermak has named this mineral, does not doubly refract light, and agrees in point of composition with no known cubic mineral, approaching nearest to a labradorite from Labrador examined some time since by Tschermak. This silicate has the specific gravity 2·65 and the following composition:

Silicic acid	56·3
Alumina	25·7
Lime	11·6
Soda	5·1
Potash	1·3
	100·0

In comparing maskelynite with labradorite, or suggesting a possible dimorphism of labradorite, the one form triclinic, the other cubic, the fact must not be lost sight of that labradorite already represents a mixture of two silicates, anorthite and albite, which substances, it will have to be assumed, are dimorphous and occur as a mixture in the cubic form. The action of acid on maskelynite pointed to its composite nature, to the possibility of its consisting of an aluminous silicate containing soda which is less readily acted upon than another aluminous silicate containing lime.

Tschermak represents the Sherghotty meteorite as made up of:

	Pyroxene.	Maskelynite.	Magnetite.	Total Composition (Calculated).	Total Composition (Observed).
Silicic acid ..	38·21	12·68	——	50·89	50·21
Alumina	0·18	5·79	——	5·97	5·90
Iron protoxide	16·93	——	——	16·93	17·59
Magnesia	10·43	——	——	10·43	10·00
Lime	7·65	2·60	——	10·25	10·41
Soda	——	1·14	——	1·14	1·28
Potash	——	0·29	——	0·29	0·57
Magnetite ...	——	——	4·50	4·50	4·57
	73·40	22·50	4·50	100·40	100·53
Specific gravity ...	3·466	2·65	5·0	3·285	3·277

While the Sherghotty stone by its peculiar constitution defies in a way proper classification, it finds a place among the small group of eukritic meteorites, and resembles most closely that of Petersburg (1855, August 5th).

Fell 1865.—Wisconsin.[1]

At the meeting of the American Association for the Advancement of Science, held at Detroit in 1875, Dr. L. Smith communicated a notice of an undescribed meteorite which fell in Wisconsin during 1865. The details of this paper have not yet reached me.

[1] *Amer. Jour. Sc.*, 1875, x. 314.

1866, June 9th.—Knyahinya, near Nagy-Berezna, Unghvár, Hungary.[1]

Shortly after this remarkable shower of meteorites had taken place two very full reports on the occurrence were drawn up by von Haidinger. It is computed that over a very limited area more than a thousand stones, weighing in all from 8 to 10 cwt., must have fallen. The largest found is now preserved in the Vienna Collection; it weighs 293·3 kilog. (5 cwt. 3 qrs. 3 lbs.), and measures 2 ft. 4 in. long and 18 in. broad, and penetrated the ground to a depth of 11 ft. For drawings of this enormous block, the largest mass of meteoric stone preserved in any collection, and coloured representations of the meteor which was observed at the time of its descent, the reader is referred to von Haidinger's two memoirs.

Kenngott has published the results of a microscopic investigation of thin sections of a fragment of this meteorite, illustrated with eight drawings indicating peculiarities of structure. To the naked eye the section appears to be finely granular and of a grey tint, and even with a very moderate power is seen to present spherular structure, recalling, if relative size be left out of consideration, that of the globular diorite of Corsica. The opaque ingredients are nickel-iron, troilite, and a black substance; in addition to these are two crystalline mineral species, the one colourless and transparent and somewhat fissured, the other grey and translucent and presenting an appearance of lamellar structure: both appear in angular and rounded granules, and both are bi-refractive; they are differently affected by hydrochloric acid, and from other differences in their crystalline characters it may be inferred that the grey silicate is enstatite, the colourless silicate is olivine. It is hardly possible to give the reader in a small compass an idea of Kenngott's detailed description of the various granules; the grey mineral he observed to constitute several of the round or rounded granules, and in most of the specimens there was clear evidence that the two silicates had crystallized simultaneously; in one instance an alternation of the two minerals in one and the same granule, as it occurs in globular diorite, is remarked, the interior consisting of the grey mineral, finely striated and surrounded with black opaque substance, around which again is a granular aggregation of the transparent fissured silicate, locally interspersed with particles of the black opaque substance and of nickel-iron.

Fragments heated before the blowpipe become covered with a black enamel, while the grey powder of the meteorite, when moistened with distilled water, reacts distinctly, sometimes intensely, on turmeric paper. The specific gravity of this stone is 3·515.

[1] A. Kenngott. *Sitzber. Ak. Wiss. Wien*, 1869, lix. 873. *Phil. Mag.*, 1869, xxxvii. 424.—J. V. Schiaparelli. Entwurf einer astronomischen Theorie der Sternschnuppen. 1871. Stettin: Nahmer. Page 267.—E. H. von Baumhauer. *Archives Néerlandaises*, 1872, vii. 146.—See also W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, liv. 200 and 513.—G. Rose. *Monatsber. Ak. Wiss. Berlin*, lxvii. 203.

It was not till after a lapse of six years from the date of this abundant aerolitic fall that a specimen was submitted to careful chemical analysis. Von Baumhauer, by whom it was undertaken, finds the Knyahinya meteorite to have the following composition:—

Nickel-iron	5·0
Troilite	2·2
Chromite...	0 8
Olivine	39·9
Insoluble silicate	52·1
	100·0

The nickel-iron contains:

Iron = 79·94; Nickel = 20·06. Total = 100·00

The silicates, separated by the action of acid and sodium carbonate, consist of:

	SiO_2	Al_2O_3	FeO[1]	MgO	CaO	K_2O	Na_2O	
A. *Soluble*......	37·16	0·27	26·54	30·18	2·43	2·14	1·28	= 100·00
B. *Insoluble*...	56·35	5·93	11·22	19·58	3·97	1·11	1·84	= 100·00

The soluble portion is olivine, having the composition $(Mg\frac{2}{3}\ Fe\frac{1}{3})_2\ SiO_4$; it is identical with that which, according to Damour's analysis, constitutes the meteorite of Chassigny (1815, October 3rd), and occurs as one of the ingredients of so many meteorites. In the insoluble portion the ratio of the oxygen of the silicic acid to that of the total bases is 2 : 1. Von Baumhauer points to a resemblance between these ingredients and those forming the insoluble portion of the meteorites of Chantonnay, Seres, and Blansko, analysed by Berzelius, as well as that of the Utrecht stone, which he himself examined. He considered it (the insoluble part) to be in that case a mixture of albite and augite; Rammelsberg, on the other hand, held that it consisted either of labradorite and hornblende, or oligoclase and augite; a considerable proportion may be bronzite.

On the last page of Boguslawski's translation of Schiaparelli's *Note e Riflessioni sulla teoria astronomica delle Stelle cadenti* is an interesting mathematical demonstration that the meteorites of Knyahinya and Pultusk (1868, January 30th) cannot have come from the same part of space.

[1] With traces of manganese protoxide.

1866, December 6th, 10.30 a.m.—Elgueras, District of Cangas de Onis, Province Oviedo, Asturias, Spain.[1]

In Meunier's interesting paper a drawing is given of this curious stone, which he selects as one exhibiting peculiarities of brecciated structure and the relation of meteoric rocks to each other as regards stratification. The stone contains abundance of fragments of a white ingredient enclosed in a darker material; the white portions he finds to be identical with the rock forming the meteorite of Montréjeau (1858, December 9th), while the duller substance, cementing them together, is the same as that constituting the stone which fell at Adare, in Ireland (1813, September 10th). He terms these two rock varieties: montrésite and limerickite. Meunier gives November 30th as the date of the fall of this meteorite.

Found 1866.—Frankfort, Franklin Co., Kentucky. [Lat. 38° 14′ N.; Long. 80° 40′ W.][2]

This block of meteoric iron, which was found on a hill 8 miles S.W. of Frankfort, was conveyed to a blacksmith's forge in that town, in order to test its quality as iron. It weighs 24 lbs., has a somewhat globular form and a highly crystalline structure. The specific gravity of this iron is 7·692 and the composition:

Iron = 90·58; Nickel = 8·53; Cobalt = 0·36; Phosphorus = 0·05; Copper, trace. Total = 99·52.

Found 1866.—Sierra de Deesa, near Santiago, Chili.[3]

Meunier has studied the two fragments of this iron preserved in the Paris Collection, and finds it to possess characters of which a superficial view of the exterior gives no indication. It appears to resemble an ordinary meteoric iron, but when sawn through it is found to enclose siliceous fragments, black in colour, markedly angular, and varying in size from a few millimetres to two centimetres; in these in some cases lie embedded grains of nickel-iron and spherular particles of troilite. Troilite, as well as occasionally little pieces of schreibersite, are also observed in the metallic portion. According to Domeyko this iron consists of:

[1] J. R. Luanco. *Ann. Soc. Españ. Hist. Nat.*, iii. p. 64.—F. Römer. *Jahrbuch für Mineralogie*, 1873, 257.—S. Meunier. Les Pierres qui tombent du Ciel. *La Nature*, 1873, i. 403.

[2] J. L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 331.

[3] S. Meunier. *Cosmos*, 1869, vii. (v. ?), 188, 552, 579 and 612. *Sitzber. Ak. Wiss. Wien*, 1870, lxi. 26. *La Nature*, 1873, i. 405.—W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, 1870, lxi. 29.—See also G. A. Daubrée. *Compt. rend.*, 1868, lxvi. 571.

Nickel-iron	95·92
Schreibersite...	1·42
Silicate	2·40
	99·74

Meunier found in one specimen 1·7 per cent. of silicate. The siliceous portion is distributed sparsely and so irregularly throughout the mass that it is impossible to judge with any accuracy of the composition of the meteorite *en bloc*.

A portion of the siliceous ingredient from which a great part of the metal had been detached had the composition:

Nickel-iron	12·62
Troilite (?)	5·01
Chromite, schreibersite and graphite...	traces
Soluble silicate	40·82
Insoluble silicate	41·55
	100·00

Domeyko found the nickel-iron and schreibersite to consist of:

Iron = 90·88; Nickel = 9·12 = 100·00
Iron = 65·00; Nickel = 26·30; Phosphorus = 8·70 = 100·00

The density of the iron = 7·51; it does not show Widmannstättian figures when etched, although small plates enclosed in the alloy develope a pattern. The numbers yielded by the analysis of the phosphide correspond approximately with the formula $Fe_8\ Ni_3\ P_2$.

Meunier adopted a novel means for analysing the nickel-iron: he reduced it to fine particles with a hard file, and fused them with caustic potash in a silver crucible; in this way the sulphur and phosphorus of the troilite and schreibersite are rendered soluble and removed with water. To ensure a perfectly pure condition of the metal it is treated with fuming nitric acid, and is then dried and heated cautiously in a current of air; when the requisite temperature is reached the particles change colour; those acquiring a blue tint are kamacite, Fe_{14} Ni, and those a yellow are tänite, Fe_6 Ni. In the case of the Deesa iron nearly all the particles turned blue, a yellow grain being observed here and there. Meunier finds the composition of the nickel-iron, iron sulphide and schreibersite to be:

I. Iron = 91·4; Nickel = 7·2 = 98·6.
II. Iron and Nickel = 58; Sulphur (calculated) = 42 = 100.
III. Iron = 60·00; Nickel = 26·75; Phosphorus = 10·29 = 97·04.

I. agrees with Domeyko's analysis as regards the iron; II., a very imperfect analysis, accords rather with the formula of pyrrhotite than troilite; and III. differs considerably from the numbers corresponding with the accepted formula of schreibersite.

The composition of the portions separated with acid is:

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	
A. *Soluble* ...	44·13	trace	—	13·52	42·35	—	trace	= 100·00
B. *Insoluble* ...	49·98	5·46	0·98	16·79	23·31	3·48	trace	= 100·00

In the soluble part the oxygen ratios are approximately those of olivine, in the insoluble part those of pyroxene. While the presence of olivine could not be detected in the mass by any crystalline features, in the insoluble part three minerals were recognised. The most apparent has a blackish-brown colour, lamellated structure and a specific gravity 3·35. The composition was found to be:

Silicic acid	51·61
Alumina	7·36
Iron protoxide	24·54
Magnesia	16·05
Lime	3·68
	103·24

The second is white and granular, and possesses the following constitution:

Silicic acid	55·76
Magnesia	41·85
Lime	3·89
	101·50

and closely accords in composition with one of the three (III.) varieties of enstatite met with in the Busti meteorite (see page 121). A third mineral, to which Meunier has given the name of victorite, resembles hypersthene, occurs in colourless and transparent crystals in a geode of 5 mm. diameter; they form six-sided prisms terminated with four-sided pyramids. Through some fragments very small opaque black grains are disseminated, with here and there the cavities and rounded enclosures first observed by Sorby. The prisms are grouped in a remarkable way. This mineral, which is present in so small a quantity that none of it could be sacrificed for analysis, has been declared by Des Cloiseaux from the following measurements to be enstatite:

g'n	=	134° 3′ to 134° 20′.
g^1 h^1	=	90° 40′.
g^1m over h^1	=	46°.
m h^1	=	137° 20.
mm^1 over h^1	=	93° 0′ to 93° 40′.
h^1m (left)	=	136° 25′; and 135° 40′ (?).
g^1 m	=	134° 0′; and 134° 40′.
mm^1 over g^1	=	88° 40′.

Meunier finds this meteorite to be identical, as regards composition, with that which fell at Tadjera, near Sétif, Algiers (1867, June 9th), in which also he recognised the presence of this variety of enstatite. (See page 151.)

1867, Jan. 19th.—Saonlod, 3 Miles N. of Khettree, Shekawattie, Rajputana, India. [Lat. 28° 9′ 45″ N.; Long. 75° 51′ 20″ E.][1]

A shower of stones, numbering about forty, fell near the village of Saonlod on the above day, at 9 A.M. The morning was bright and clear, and no clouds were to be seen, when a loud report, resem-

[1] D. Waldie. *Jour. Asiat. Soc. Bengal*, 1869, xxxviii. 252.—*Records Geol. Survey India*, 1870, ii. 101; 1870, iii. 10.

bling that of a cannon, was heard over an area many miles in length and breadth, and was succeeded by two louder reports and followed in turn by "a regular roll, resembling musketry heard at a short distance." The terrified inhabitants of the village where the stones fell, seeing in them the instruments of vengeance of an offended deity, set about gathering all they could find, and, having pounded them to powder, scattered them to the winds. A gentleman connected with the Topographical Survey, who happened at the time to be a few miles distant from Saonlod, states that he sent all the sowars attached to his camp to scour the country, with the intention of procuring as many of the stones as possible. He adds: "I was very nearly too late, as, between them all, they only managed to get the piece I sent, ... and that under promise of a large reward." According to the description, given by the more respectable class of natives, some of the meteorites were of the size of a 24-pounder shot, and had a blackish appearance on the outside; they fell with such velocity that they sank two or three feet into the ground in a sandy soil.

The crust of the stone is nearly black, cellular on the surface and corrugated somewhat longitudinally, and is about one-third of a millimetre in thickness. The interior has a light bluish-grey colour in some parts, and a much darker grey in others; the two portions lie side by side like two strata in some places, while in others a nodule of the one is seen to be enclosed in the other. The freshly fractured surface is studded with metallic particles of nickel-iron, and exhibits translucent granules of a greenish yellow, which are probably olivine. Siliceous spherules, as well as cavities once occupied by them, are also observed, and when the mineral is finely powdered and examined under water with a lens, the lighter portion of the stone exhibits a considerable quantity of nearly white crystalline particles, mixed with small angular fragments of black, brownish, greenish yellow, and opaque minerals, as well as rounded particles of nickel-iron; the dark-grey portion has very much the same appearance.

The meteorite is not very hard; the specific gravity of some small pieces of the light-coloured portion was 3·743, of the dark-coloured variety 3·612, while analysis showed it to consist of:

Nickel-iron	18·55
Troilite and schreibersite	5·22
Soluble silicate	35·18
Insoluble silicate	42·36
	101·31

The metallic portion contains:

Iron = 91·54; Nickel = 6·79; Cobalt = 1·15; Chromium = 0·52. Total = 100·00.

The sulphide and phosphide are assumed by the author to consist of:

Iron = 51·54; Sulphur = 33·71; and Iron = 12·46; Phosphorus = 2·29. Total = 100·00.

He regards the iron sulphide "as Fe_7S_8, troilite," a view which is hardly tenable in face of the fact that Dr. L. Smith and Rammelsberg, who have analysed the nodules of the mineral, which occur in the meteorites of Knoxville, Seeläsgen and Cocke Co., Tennessee, have shown it to be a monosulphide. Again, no schreibersite has yet been met with which does not contain a very considerable percentage of nickel, the whole of which metal the author takes to be present in the metallic ingredient.

The siliceous portions separated by treatment with acid and sodium carbonate have the following composition:

	SiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	X[1]	
A. *Soluble* ...	30·50	1·17	—	21·35	39·11	1·93	0·26	5·68	= 100·00
B. *Insoluble* ...	57·67	3·22	0·95	8·62	23·70	4·00	1·84[2]	—	= 100·00

While the soluble portion appears to be chiefly olivine, that which resisted the action of acid may be taken to be bronzite, together with some percentage of a felspathic ingredient, possibly labradorite.

The Khettree meteorite, in point of composition, resembles that which fell at Klein-Wenden, near Nordhausen, Prussia (1843, September 16th).

1867, June 9th.—Tadjera (Amer Guebala), near Guidjell, Sétif, Province of Constantine, Algiers.[3]

A meteor was seen to traverse the sky over this district, and two stones, weighing 5·76 and 1·70 kilog., fell near Sétif at about 10.30 P.M. The siliceous portion of the stone has a black colour which distinguishes it from most meteorites, and it is further remarkable for the absence of the usual fused crust. It has a specific gravity of 3·595 and the following composition:

Nickel-iron	8·32
Troilite...	8·04
Chromite	0·20
Soluble silicate	54·64
Insoluble silicate	28·80
	100·00

The nickel-iron consists of:

Iron = 91·6; Nickel = 8·4. Total = 100·0.

and the siliceous portions separated with acid and sodium carbonate:

	SiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	
A. *Soluble* ...	45·24	0·81	—	11·17	42·78	—	trace	= 100·00
B. *Insoluble* ...	50·21	4·15	0·41	27·99	8·03	9·21	trace	= 100·00

In the soluble portion the silicic acid is in excess of that required to form olivine, in the insoluble part of that required to form bronzite; in the latter case a portion of the acid is probably present as a constituent of a felspar.

[1] Constituents removed with sodium carbonate, but undetermined.
[2] With trace of potash.
[3] S. Meunier. Thèse présentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la Composition et la Structure des Météorites*, 13. *Compt. rend.*, 1871, lxxii. 339. *Cosmos*, March 28th, 1866, 7.—See also Angeraud. *Compt. rend.*, 1867, lxv. 240.—G. A. Daubrée. *Compt. rend.*, 1868, lxvi. 513. *Cosmos*, March 21st, 1868, 25.

1868, February 29th.—Villanova di Casale Monferrato, Province of Alessandria, and Motta dei Conti, Province of Novara, Italy.[1]

The village of Villanova lies on the left bank of the Po, 5 kilometres N.E. of Casale Monferrato and 2 kilometres from the village of Motta dei Conti. Between 10·30 and 10·45 A.M. (local mean time) on the 29th February, the sky being calm but cloudy with cirri, cirro-cumuli and cumuli, a loud detonation was heard which was noticed in many villages and towns of this part of Piedmont. In Casale the noise resembled the discharge of artillery or the explosion of a mine; while an observer stationed near the confluence of the Sesia and the Po states that he heard a crackling noise like the discharge of musketry afar off. Near Casteggio, in the district of Voghera, Alessandria, a mass was observed to traverse the heavens with great rapidity, leaving a black track resembling smoke; and two explosions were heard followed by a prolonged noise. A medical man who was near Santo Stefano d'Aveto, in the district of Chiavari, Genoa, saw a globe of fire of considerable size cross the sky from N.W. to S.E. at the same time.

One meteorite fell about 600 metres S.E. of Villanova; it crashed through the branches of a tree and entered the ground a few paces distant from a terrified peasant, who, believing it to be a bomb, fell on his face. The villagers were filled with alarm at the occurrence, and some oxen yoked to a plough near Roggia Marcova stood still with fear. The stone penetrated the clayey soil to a depth of 0·4 metre, and on the following day was exhumed by a boy, while the courageous owner of the field sheltered himself securely hard by and watched the operation.[2]

The Villanova meteorite has somewhat the form of a cube and measures 0·08 metre along the side; it weighs 1·92 kilog. and has a specific gravity = 3·29. It is covered with a thin hard brown crust; the interior has a mottled grey colour and a fractured appearance, and is very friable. The matrix is stated to enclose grains of an ochrey-yellow hue, others much larger and of a brown colour (chromite), as well as lustrous metallic particles, the remainder consisting of various stony ingredients, some consisting of microscopic crystals.

[1] A. Goiran, A Bertolio, A. Zannetti, and L Musso. Sopra gli Aeròliti caduti il giorno 29 febbraio 1868 nel territorio di Villanova e Motta dei Conti, Piemonte, circondario di Casale. Con Introduzione del padre Denza. 1868, Torino. See also *Bull. meteor. dell' Osserv. del R. Coll. Carlo Alberti in Montcalieri*, March to June, 1868. - F. Denza. *Compt. rend.*, 1868, lxvii. 322.—G. Jervis. I Tesori Sotterranei dell' Italia. Parte Prima. 1873, Torino: Loescher. Page 153.

[2] The trajectory of this stone could be approximately determined since three points in a vertical plane were determined: 1) the point where it grazed the top of a tree, 2) the broken end of the bough of a walnut tree severed by the meteorite, and 3) the point where it entered the ground. Other peasants, who were employed lopping trees near the high road which leads from Casale to Vercelli, at a point about 1200 metres from Villanova, observed a rain of black grains; one man was struck on the hat with a piece of considerable size.

According to Bertolio this meteorite consists of:

Iron	20·700
Nickel oxide	5·371
Manganese and copper	traces
Sulphur	0·503
Phosphoric acid	0·597
Chlorine	0·105
Silicic acid	39·661
Alumina	0·415
Chromium sesquioxide	0·036
Iron protoxide	12·234
Magnesia	14·776
Lime	0·878
Potash and soda	4·151
	99·427

I have arranged according to the method adopted in foregoing analyses, the results which Bertolio obtained by treating a portion of the meteorite with acid and have further assumed that the nickel which he quotes in the form of oxide is however present as a constituent of the alloy. The metallic minerals broken up by acid chiefly consist of nickel-iron with perhaps a little troilite and schreibersite, and contain:

Iron = 84·659; Nickel = 11·791; Sulphur = 2·058; Phosphorus = 1·063; Chlorine = 0·429; Copper, trace = 100·000

And their siliceous portions separated by acid have the following composition:

	SiO_2	Al_2O_3	Cr_2O_3	FeO	NiO	MgO	CaO	K_2O	Na_2O	
A. *Soluble* ..	35·287	—	—	21·643	(?)	38·423	—	4·647		=100·000
B. *Insoluble*	69·806	1·053	0·091	12·133	4·293	3·923	2·228	0·246	6·227	=100·000

The oxygen ratio of the silicic acid and of the total bases in A, if the alkalies be regarded as soda, is 18·82 : 21·38, and in B, where the alumina and nickel oxide are included, 37·23 : 7·968; A thus appears to consist of an olivine in which the oxygen ratio of MgO and FeO is approximately 3 : 1. It is not improbable that a portion of the acid which gelatinised was not removed in the carbonate from B; and that the latter moreover was imperfectly decomposed during the subsequent fusion.

A second stone, weighing 6·311 kilog., fell in a cornfield near the farm Roletta at a spot 2350 metres distant from the first. In form it somewhat resembles a truncated pyramid, and measures 0·223 metre in its greatest length and 0·14 metre in its greatest breadth; it is also covered with a thin crust, evidently the result of fusion. It is preserved in the Natural History Museum of the University of Turin. The authors of the paper above alluded to consider the two Villanova stones to be distinct meteorites, and not fragments resulting from the explosion of a single mass during its passage through our atmosphere; their opinion is shared by Denza.

At the same time a meteorite fell at Motta dei Conti, the village already referred to. It struck the pavement in front of a tavern with great violence, driving the slab 0·5 cm. into the ground; the shattered fragments of the meteorite, which rebounded over the roof of a small dwelling 7 metres high, are estimated to have weighed from 300 to 500 grammes. According to the list of the specimens, quoted by Jervis as preserved in collections, their total weight does not exceed 30 grammes. Bertolio, who submitted a small portion of the Motta dei Conti stone to examination, declares it to differ both in physical characters and chemical composition from the Villanova meteorites; the disparity, however, is not difficult to account for. He finds this stone to be more magnetic and dense (specific gravity = 3·76) than the others, and to contain no lime and scarcely a trace of alumina. A fragment of a meteorite, containing nearly one quarter of its weight of nickel-iron, would, during the rough treatment to which this stone was subjected, lose much of the interstitial rocky matter and acquire a greater density in consequence, while the proportion of the two oxides in the Villanova is in any case so small that the indications they may give in a qualitative examination of so small a quantity of material could hardly warrant our drawing a conclusion as to whether or no it had a common origin with, or similar constitution to, the Villanova stones. All the remaining ingredients of the latter are likewise found in the Motta dei Conti meteorite. It is stated that a fourth stone fell further north in the water of the Roggia Marcova, in the parish of Caresana.

Daubrée points out that the above meteorites do not essentially differ from others which have previously fallen in Piedmont, namely, at Cereseto (1840, July 17th), and at Giuliana Vecchia (1860, February 2nd); and finds them very similar in character to the meteorites which fell at Oviedo, Spain (1856, August 5th), and in the Commune des Ormes, Yonne, France (1857, October 1st).

1868, March 20th.—Daniel's Kuil, N.N.E. of Griqua Town, Griqua Territory, South Africa.[1]

This meteorite fell at Daniel's Kuil, near a Griqua, who picked it up while warm and gave it to Captain Nicolas Waterboer, the Griqua Chief, from whom Gregory obtained it. It was broken into two parts when it reached his hands, and has since unfortunately been divided into several more; it weighed 2lb. 5oz. The crust has a dull black colour; immediately below it for a thickness of about $\frac{1}{8}$th of an inch the stone has a browner colour than the interior, the result of oxidation. The rock has a dark grey colour and a fine granular texture, and encloses a very considerable amount of nickel-iron in a finely divided condition, as well as particles of

[1] A. H. Church. *Jour. Chem. Soc.*, 1869 [2], vii. 22. *Jour. Prakt. Chem.*, 1869, cvi. 379. See also J. R. Gregory, Geol. Mag. Vol. V. p. 531

troilite and schreibersite. The rounded grains so commonly present in meteoric rock are not seen.

This meteorite has been examined by Church, who finds it to possess the specific gravity 3·657 to 3·678, and the following composition:

Nickel-iron	29·72
Troilite	6·02
Schreibersite	1·59
Silica and Silicates	61·53
Carbon, Oxygen, other constituents, and loss	1·14
	100·00

The nickel-iron contains:

Iron = 94·72; Nickel = 5·18. Total = 100·00.

The per-centage of troilite is based on a sulphur determination made in a separate portion; the schreibersite "was approximately estimated by calculating its amount as being ten times that of the unoxidised phosphorus in the stone"—a novel method which can hardly be considered a satisfactory one. The rocky portion of the stone, constituting nearly two-thirds of the mass, does not appear to have been submitted to detailed analysis, although we are told that the silicates consist chiefly of olivine and labradorite, "the former species constituting by far the larger portion of the powder unaffected by dilute acids." Olivine, as is well known, is the meteoric silicate *par excellence* which is broken up by such reagents, being easily acted upon even by dilute hydrochloric acid. Church does not state whether he succeeded in detecting the presence of alumina in this meteorite, although he numbers labradorite among its constituent minerals; while the occurrence of silica, as such, in a meteorite is so very rare, having as yet been isolated and submitted to analysis in one instance only (see p. 133), that an investigation of this question is desirable. The author further states that in a second portion of the same sample he found the silicates to amount to 61·10 per cent., in another fragment to 48·99 per cent.; while in yet another portion the nickel-iron, judging from the per-centage of nickel it contained, constituted 39·20 per cent. of the stone.

Found April, 1868.—Losttown (2½ miles W. of), Cherokee Co., Georgia.[1]

According to Shepard's first notice, this block of iron has the form of a human foot and weighs 6lbs. 10oz. "Widmannstättian figures are visible directly in one portion of the surface;" those presented by treatment with acid are stated to be very beautiful and to most nearly resemble the figures of the Seneca Lake iron. The nickel, which in the first notice is stated to be abundantly present, although

[1] C. U. Shepard. *Amer. Jour. Sc.*, 1869, xlvii. 234.—See also *Amer. Jour. Sc.*, 1868, xlvi. 257.

the development of the figures would not lead one to expect the percentage to be large, proved on analysis to be considerably below the average, as the following composition shows:

Iron = 95·759; Nickel = 3·660; Insoluble portion = 0·580. Total = 99·999.

The insoluble part is stated to consist of schreibersite and rhabdite; traces of cobalt, chromium, magnesium, and tin (?) were detected. The specific gravity of the iron is 7·52.

1868, July 11th.—Ornans, Doubs, France.[1]

This meteorite is described as differing in appearance from any of the stones which have fallen in Europe during recent times. It has a dull grey colour, and is so friable that it can be crumbled between the fingers. It is very porous; a fragment immersed in water absorbed about $\frac{1}{10}$th of its weight of water in two hours. Particles of iron can only be detected here and there with a lens, and the stone is feebly magnetic. The specific gravity of the rock is 3·599, and it consists of:

Nickel-iron	1·85
Magnetic pyrites	6·81
Chromite	0·40
Olivine	75·10
Insoluble silicate	15·26
	99·42

The portions of silicate separated by the treatment with acid were:

	SiO_2	Al_2O_3	FeO	NiO	MgO	CaO	K_2O and Na_2O	
A. *Soluble*	33·37	3·93	30·76	3·83	26·37	1·74	—	= 100·00
B. *Insoluble*	40·43	8·98	10·55	—	30·15	6·29	3·60	= 100·00

Pisani, it will be seen, is of opinion that a portion of the nickel is present in the form of oxide in the silicate which gelatinises with acid. He determined the amount of iron present as metal by measuring the volume of hydrogen which it evolved during its solution in acid. In calculating the results of his analysis he considers the sulphur to be combined with a portion of this iron in the form of magnetic pyrites, and the remainder of that metal to be alloyed with some of the nickel, the excess of the nickel above that required to form the normal alloy being present as oxide. As, however, it has not been shown to be a component of the silicate, and recent researches (see page 88) have failed to prove that it forms a constituent of meteoric olivine, it may be present as alloy. If we exclude the oxygen of this nickel oxide, the ratio of the oxygen of the silicic acid to that of the total bases of that portion is 13·35 : 13·43, from which it appears that the chief

[1] F. Pisani. *Compt. rend.*, 1868, lxvii. 663.—G. Tschermak. *Sitzber. Ak. Wiss. Wien*, 1870, lxii. 855.

constituent of the Ornans meteorite is an olivine having the formula 2 ($\frac{2}{5}$ Mg $\frac{3}{5}$ Fe) SiO_4.

Tschermak finds that the dull grey colour of this stone is due, at least in part, to the presence of carbonaceous matter. (Compare with the Goalpara meteorite, page 162.)

1868, September 7th.—Sauguis-St.-Étienne, Canton de Tardets, Arrondissement Mauléon, Basses-Pyrénées.[1]

At 2·30 A.M. a meteor emitting a pale green light traversed the sky over Mauléon, and broke up leaving a faint whitish cloud which lasted for some time. Its disappearance was succeeded by a noise as of thunder, followed by three or four loud detonations, which were heard over an area 80 kilometres wide. The inhabitants of Sauguis-St.-Étienne heard, in addition to these noises, a sound like that produced by quenching hot iron in water, and a dull thud caused by the meteorite striking the ground. It fell about 30 metres from the church in the bed of a small stream, and was so completely shattered that the largest fragments did not measure more than 5 cm. in length; their total weight is about 2 kilog. The fall was witnessed by two men, who, returning home late, had continued in conversation at the door of one of their dwellings. Frightened by the hissing noise, they fell on the ground, and saw the stone strike the earth about 20 metres from them.

The Sauguis meteorite consists chiefly of rocky matter, the metallic grains being small and sparsely distributed; troilite is noticed in nodules, some of which are 10 mm. across. The crust is dull black and possesses the unusual thickness of 1 mm.; the fine black veins observed to traverse certain meteoric rocks are abundantly present in this stone. A microscopic section was found to act strongly on polarised light, and to have the appearance of a breccia of very small transparent and colourless particles.

Daubrée finds the rock composing this meteorite to be identical in all respects with that forming the stones which fell at Villanova di Casale Monferrato in Piedmont (1868, February 29th) [see page 152]; even a practised eye examining specimens of these two falls would fail to distinguish one from the other.

According to Meunier this stone has a specific gravity = 3·369,[2] and consists of:

Nickel-iron	8·050
Troilite	3·044
Soluble silicate	65·909
Insoluble silicate	23·571
	100·574

[1] G. A. Daubrée. *Compt. rend.* 1868, lxvii. 873.—S. Meunier. Thèse presentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la Composition et la Structure des Météorites*, 16.

[2] In his paper on the Belgian meteorite, a specific gravity = 3·43 is given.

The nickel-iron contains:

Iron = 93·88; Nickel 6·12. Total = 100·00.

and the portions of the silicate separated by treatment with acid and sodium carbonate:

	SiO_2	Al_2O_3 & Fe_2O_3	Cr_2O_3	FeO	MgO	CaO	K_2O	Na_2O	
A. *Soluble*......	45·66	—	—	3·05	50·68	—	0·61	trace	= 100·00
B. *Insoluble*...	61·96	2·56	0·05	8·49	24·62	2·12	0·20	—	= 100·00

In both portions the silicic acid is considerably in excess of that required to form a silicate of the form of olivine in A, and of a bronzite in B. The amount of iron protoxide in the portion which gelatinised with acid is unusually small.

Meunier refers to this meteorite in his description of the stone which fell at St. Denis-Westrem, near Ghent (1855, June 7th). (See p. 125.)

1868, October 1st.—Lodran, Mooltan, India.[1]

This meteorite fell at 2 P.M. on the above day at a spot about 12 miles E. of Lodran, the descent being accompanied with a loud explosion, which appeared to come from the west. The chondritic structure noticed in many meteorites was not observed in this stone, but enclosed within its black crust was found a magma of siliceous particles of so coarse-grained a character that the individual granules occasionally measured 2 mm. in diameter. The constituent minerals were carefully isolated before analysis, which showed the stone to consist of:

Nickel-iron	32·5
Magnetic pyrites	7·4
Olivine	28·9
Bronzite, with some chromite and anorthite .	31·2
	100·0

The alloy, an important ingredient, which developes figures resembling those of the Senegal iron, forms a mesh-work enclosing the silicates, the crystals of olivine not unfrequently leaving a complete impression of their faces in it; it has the following composition:

Iron = 85·44; Nickel = 12·79; Magnesia = 0·25; Residue = 0·81. Total = 99·29.

Associated with the substance just mentioned and occasionally entangled in the silicates were fragments of magnetic pyrites: they possess no crystalline structure and dissolve in acid with deposition of sulphur. The olivine is of a bluish grey to Prussian blue colour, and occurs in unusually well-developed crystals, which have been

[1] G. Tschermak. *Sitzber. Ak. Wiss. Wien*, 1870, lxi. 465. *Pogg. Ann.*, cxl. 321. —*Records of the Geological Survey of India*, vol. ii. part 1, page 20.

found by von Lang to agree in all respects with the olivine from basalt; the following measurements were made:

				Calculated.
100, 110	=	65° 2′	......	65° 2′
110, $\bar{1}$10	=	49° 49′	......	49 57
100, 210	=	46° 30′ about	......	47 2
100, 310	=	35° 30′ ,,	......	35 36
100, 210	=	41° 0′ ,,	......	40 27

The fissures of many of the crystals are filled with a black mineral of a dendritic form; this is assumed to be chromite and is believed to be a secondary formation. This silicate has the specific gravity 3·307 and the following composition:

Silicic acid	40·14
Chromium oxide	0·60
Iron protoxide	13·55
Magnesia	46·01
	100·30

These numbers differ only to a slight extent from those of an olivine in which the two compounds $Mg_2 SiO_4$ and $Fe_2 SiO_4$ are in the ratio of 82 : 18.

The bronzite occurs in grains and imperfect crystals, on any of which faces of more than one zone are rarely recognisable. On one crystal von Lang determined the following angles:

				Calculated.
100, 320	=	34° 50′ about	......	34° 30′
100, 110	=	45° 56′	......	45° 52′
100, 230	=	57° 15′	......	57° 6′
100, 130	=	71° 56′ about	......	72° 5′

while a second gave the following numbers:

				Calculated.
110, 010	=	44° 6′ about	......	44° 8′
010, $\bar{1}$10	=	44° 0′ about	......	44° 8′

The calculated angles are based on observations made on the bronzite of the Breitenbach siderolite (see page 132). The plane of the optic axes is parallel to the zone [110, 010] and the mean line perpendicular to 010 has a negative optical character. The specific gravity of this mineral is 3·313 and the composition:

Silicic acid	55·35
Alumina	0·60
Iron protoxide	12·13
Magnesia	32·85
Lime	0·58
	101·51

which corresponds, in point of constitution, with a bronzite in which the isomorphous compounds $Mg SiO_3$ and $Fe SiO_3$ are present in the ratio 78 : 22.

When a microscopic section of this mineral is examined it is found to enclose three substances: 1) colourless chondra of a doubly refracting mineral, which the crossed Nicols show to be twinned, and which is probably a felspar; 2) small round black particles, usually lying in groups, and believed to be chromite; and 3) fine hair-like bodies, disposed parallel to the cleavage-planes; their nature could not be determined. The plate accompanying Tschermak's paper furnishes drawings of all these substances.

In addition to the octahedral faces (111), von Lang observed on the chromite crystals, faces of the rhombic dodecahedron (110) and the leucitoid (311), and made the following measurements:

				Calculated.
111, $\bar{1}11$	=	70° 31′	... ...	70° 32′
011, 131	=	31 25	... ...	31 29
131, 113	=	50 25	... ...	50 29

It should be stated that in the *Records of the Geological Society of India*, Oldham gives the 17th of October as the date of this fall.

1868, November 27th.—Danville, Alabama. [Lat. 34° 30′ N.; Long. 87° 0′ W.][1]

During the (American) war, writes Dr. Lawrence Smith, artillery had often been heard in the valley of the Tennessee, and various speculations were indulged in as to the meaning of a loud report, like that of a cannon, which occurred at about 5 P.M. on the day above mentioned, and appeared to come from a direction northward of Danville. On the following day a man brought to that town a piece of rock which, he said, fell near him and in the presence of some labourers who were picking cotton at a place 3 miles W. of Danville. It entered the soil to a depth of 1½ to 2 feet, and when exhumed was found to weigh about 4½ lbs. Several stones fell in the neighbourhood; one near some negroes at work in a cotton-field, two others whizzed right and left past two men who were ploughing a field about 1¾ miles N.W. of Danville.

The meteorite which reached Dr. Smith's hands, the first of those mentioned, has the usual black crust, which is rough and dull, and appears in some parts to have been whipped round, as it were, and rolled over the border on to the unfused surface as the stone traversed the atmosphere.

A fresh surface has a dark grey colour, and is less chondritic than is the case with many meteorites, and there are veins or patches of a slate-coloured mineral running across it. Iron sulphide and nickel-iron are diffused through the rock, the latter more especially in the slate-coloured areas; and there are occasional white patches of what is probably enstatite.

The meteorite has a specific gravity of 3·398, and contains 3·092 per cent. of nickel-iron consisting of:

Iron = 89·513; Nickel = 9·050; Cobalt = 0·521; Phosphorus = 0·019; Sulphur = 0·105; Copper, trace. Total = 99·208.

and the iron sulphide contains:

Iron = 61·11; Sulphur = 39·56. Total = 100·67.

[1] J. L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 90.

If the excess over 100 be deducted from the iron, the chief constituent, these numbers correspond very closely with the percentages of magnetic pyrites (pyrrhotite), not of iron protosulphide, as stated in this paper; troilite, the presence or absence of which was not established, is of course the protosulphide. The rocky portion of the Danville meteorite consists of:

Soluble silicate	60·88
Insoluble silicate	39·12
	100·00

and has the following composition:

	SiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	K_2O	Na_2O	S	P	
A. *Soluble*..	45·90	1·73	trace	23·64	trace	26·52	2·31	0·64	0·51	1·01	trace	=102·26
B. *Insoluble*	50·08	4·11	—	19·85	—	20·14	3·90	—	—	—	—	= 98·08

In the soluble portion the excess over 100 is due to some of the iron regarded as oxide being present in combination with sulphur; this portion is chiefly olivine, that insoluble in acid is bronzite with a little augite or felspar.

The author finds this meteorite to be similar in every respect to the stone which fell in Harrison Co., Indiana (1859, March 28th), which in many catalogues is incorrectly referred to Harrison Co., Kentucky (1859, March 26th).

1868, December 5th.—Frankfort, Franklin Co., Alabama.[1]

The fall of this meteorite, which occurred at 3 P.M. on the above day, was attended by three loud reports, immediately succeeded by a series of sounds like that of a great fire blazing and crackling. The descent took place four miles S. of Frankfort, and was witnessed by Mr. J. W. Hooper, who saw the stone strike some willow saplings about 70 or 80 yards from him; on going to the spot, he found it nearly buried in the ground and still warm. The noise of the explosion was heard 20 or 25 miles E. and W. and 15 or 20 N. of Frankfort. Mr. Hooper made notes of the occurrence, and sent the stone for analytical examination. "He refused with scorn money offers, which must have been tempting to a person of limited income, preferring the advancement of science to dollars and cents."

The meteorite, which is almost entirely covered with a very lustrous black crust, so thin in some parts that fragments of olivine can be distinguished through it, weighs 615 grammes, and has a specific gravity of 3·31. A fractured surface presents a pseudo-porphyritic structure, having a grey ground on which black, green, white and dark grey spots are seen: the black fragments are very lustrous and slightly magnetic (chromite); and the yellowish-green mineral, passing into yellow and shading into dark grey, appears to be olivine; while the greyer variety cannot, according to Brush, be distinguished

[1] G. J. Brush. *Amer. Jour. Sc.*, 1869, xlviii. 240.

from the "piddingtonite" of the Shalka stone, now shown to be no true mineral species (see page 115). Some brilliant points possessing metallic lustre were found to be troilite; and one or two delicate black veins were also observed.

The nickel-iron constitutes only a few hundredths of one per cent., the chromite 0·62 per cent., and the troilite 0·63 per cent. of the mass; and of the latter about 26 per cent. is soluble in acid. An analysis of a portion of the stone gave the following results:

		Oxygen.	
Silicic acid	51·33	26·37	
Alumina	8·05	3·75	
Chromium oxide	0·42		
Iron protoxide	13·70	3·04	12·28
Magnesia	17·59	7·04	
Lime	7·03	2·06	
Potash	0·22	0·03	
Soda	0·45	0·11	
Sulphur	0·23		
	99·02		

As the greater portion of the lime and but little of the magnesia and iron protoxide were found in the portion soluble in acid, it appears probable that this meteorite will be found after the more detailed investigation, which Brush contemplates undertaking, to consist to a great extent of anorthite, olivine and bronzite. He is of opinion that by sacrificing more material it will be possible to mechanically separate the constituent minerals under a lens. In general physical characters it closely resembles the meteorite of Petersburg, Lincoln Co., Tennessee (1855, August 5th).[1]

1868, December 22nd.—Moteeka Nugla, Ghoordha, Bhurtpúr, India.

A specimen of this stone weighing 14 oz. is preserved in the British Museum Collection.

Found 1868.—Goalpara, Assam, India. [Lat. 26° 10′ N.; Long. 90° 40′ E.][2]

This meteorite, the date of the fall of which is not known, was first described by von Haidinger, who directed attention to the peculiarities of its form and surface as indicating with great clearness the orientation of the stone in respect to the path of flight through the atmosphere; he remarked among its mineralogical characters differences from those observed in all other meteorites, and described it as an olivinous rock, of coarse grain, and of a very

[1] J. L. Smith. *Amer. Jour. Sc.* 1861, xxi. 264.

[2] W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, 1869, lix. 224 and 665.—N. Teclu. *Sitzber. Ak. Wiss. Wien*, 1870, lxii. 852.—G. Tschermak. *Sitzber. Ak. Wiss. Wien*, 1870, lxii. 855. *Jahrbuch für Mineralogie*, 1871, 412.

dark grey hue. Von Haidinger's preliminary notice is illustrated with two beautiful plates showing the remarkable form of the stone.

Tschermak, who has made a very complete investigation of this meteorite, describes the exterior as having a deep greyish-brown colour; the fused crust is extremely thin and hard, and is readily removed in flakes. The interior has a porphyritic structure; the deep grey matrix enclosing light-coloured yellow grains, which have a nearly uniform breadth of 1 mm. These included particles are found on closer inspection to be of two kinds; the one exhibiting a very distinct cleavage, the other none. The first mineral is rhombic, has cleavage-planes forming an angle of 92°, is unacted upon by acid, and is identified with enstatite. The second species is also infusible, gelatinises with acid, and is found to be olivine.

The very finely granular matrix, when viewed under a high power, is seen to consist partly of small transparent particles which appear to be olivine, partly of opaque material in which reflected light reveals the presence of three substances: a sponge-like mass, the thin cell-walls of which are minute crystals, some cubic in form, and readily identified by their lustre with nickel-iron; a smoke-brown pulverulent lustreless substance, of which more will be said below; and diminutive yellow metallic granules, which are probably magnetic pyrites. The relative position which these ingredients occupy in the mass of the rock is clearly shown in the beautiful microscopic drawings accompanying Tschermak's paper.

When a fragment of the meteorite is treated with acid the nickel-iron, magnetic pyrites, and olivine decompose, and at the outset a little sulphuretted hydrogen is disengaged; soon an odour is remarked like that attending the solution in acid of iron containing combined carbon. After prolonged action the residue is still grey; on diluting the solution with water, however, this grey matter rises to the surface, or if it should happen to adhere to the silica can, through its lower specific gravity, be separated by elutriation. When heated on platinum foil the grey substance disappears; it possesses in every respect the properties of soot. This carbonaceous matter is the dark-coloured lustreless ingredient of the matrix already mentioned.

The Goalpara stone has a specific gravity = 3·444 and consists of:

Nickel-iron	8·49
Hydrocarbon	0·85
Olivine	61·72
Enstatite...	30·01
Magnetic pyrites	trace
	101·07

If the total amount of silica, determined by analysis, be apportioned to the bases in the soluble and insoluble portion, it is found, in the first instance, that the olivine contains in 100 parts:

Silicic acid	37·81
Iron protoxide	18·99
Magnesia	43·20
	100·00

These numbers show the mineral to be made up of the silicates Mg_2SiO_4 and Fe_2SiO_4 in the ratio of 3 : 1. The insoluble portion has the following composition:

Silicic acid	56·72
Iron protoxide	5·33
Magnesia	35·95
Lime	2·00
	100·00

The enstatite is remarkable for the small per-centage of iron oxide present; it may be a mixture of a pure magnesian enstatite with a little of the ferriferous variety, bronzite, and is possibly associated with a small amount of augite.

This meteorite, it is seen, consists for the most part of olivine and enstatite, an association of minerals previously noticed by Tschermak in the stone which fell at Lodran (see page 158). The presence of carbonaceous matter forming 0·85 per cent. of the stone, and consisting of 0·72 carbon and 0·13 hydrogen, constitutes by far the most striking feature of this meteorite. While the carbonaceous meteorites which fell at Kaba, Alais, etc., have a very loose texture, the Goalpara stone exhibits great toughness.

A list of meteorites containing carbon has been given on page 4; to that must be added the names of those which fell at Renazzo (1824, January 15th), Mezö-Madaraz (1852, Sept. 4th), Ornans (1868, July 11th), and Zsadány (1875, March 31st).

[1868].—Auburn, Macon Co., Alabama.[1]

In October, 1868, Prof. Darby, of the East Alabama College, drew up a report on a mass of meteoric iron which had been ploughed up "many years since," in the Daniel plantation near Auburn. It was a nearly round mass, weighing about 8 lbs.; it is traversed with such deep cracks and open veins that it would not be difficult to break it in pieces; on one side a "globule" of troilite, half an inch in diameter, was noticed. When etched the iron exhibits a meshwork of exceedingly thin lines, the areas within the lines being lustrous when viewed in a certain direction; the former appearance is ascribed to thin plates of schreibersite, the latter to sections of needles of rhabdite.

The metal has a specific gravity of 7·05, and the composition:

Iron = 94·580; Nickel = 3·015; Phosphorus = 0·129; Insoluble portion = 0·523
Total = 98·247.

Besides the above ingredients the presence of undetermined quantities of chromium, calcium, magnesium, and silicium (?) was recognised. Shepard states that "neither cobalt, tin, nor copper was detected in this iron." Commenting on this statement and the ob-

[1] C. U. Shepard. *Amer. Jour. Sc.*, 1869, xlvii. 230.—L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 331.

servations of other investigators, where the fact of the presence of cobalt in meteoric iron has not been actually recorded, Dr. L. Smith says:[1] "I cannot but suggest the importance of making a most critical examination of these irons before pronouncing this fact; for in every analysis that I have made of meteoric irons (over one hundred different specimens) with this in view, cobalt has been invariably found, along with a minute quantity of copper."

[N.D.]—Collina di Brianza, near Villa, Milan.[2]

It is stated by Chladni[3] that this mass of metal was found about 40 to 50 years earlier (which would be about 1769-79) while digging the foundations of a house, and that it was placed in the Convent of S. Alessandro. Guidotti, Klaproth, and Gehlen, to whom fragments were sent for analysis, found neither nickel, chromium, phosphorus, nor carbon in it, and considered it to be very pure iron; so malleable was it, in fact, that Chladni had a tuning-fork forged from it. Specimens of this mass, which weighed originally from 200 to 300 lbs., are to be met with in most collections; its cosmical origin, however, has been regarded as doubtful, especially since Stromeyer reported that he had discovered the presence of carbon in the metal. A fragment with the above label was submitted by Haushofer to a fresh examination with the aid of more delicate analytical methods, and he inferred that the mass is unquestionably meteoric. When etched the fragment gave very distinct Widmannstättian figures. One part of the metal he found to contain 95·2 per cent. of iron, while the composition of another part was:

Iron = 91·1; Nickel = 7·7; Cobalt = 0·2; Phosphorus = 0·3; Carbon, trace.
Total = 99·3.

He states the specific gravity of the iron to be 7·596, a number very slightly in excess of that given by Chladni. A later analysis by Wöhler[4] of an undoubted fragment of the original specimen confirms, however, the older results, and makes it clear that Haushofer had examined a specimen provided with a wrong label.

[1] J. L. Smith. Mineralogy and Chemistry, 352.
[2] K. Haushofer. *Jour. Prakt. Chem.*, 1869, cvii. 328.
[3] E. F. F. Chladni. Ueber Feuer-Meteore. Vienna: 1819. Page 349.
[4] *Göttinger Nach.*, 1870, 31–32.

END OF PART II.

PART III.

DIGEST OF MEMOIRS AND NOTICES

PUBLISHED SUBSEQUENTLY TO 1875.

[Before 1744.] Hizen, Japan.[1]

Dr. Divers has drawn attention to two Japanese meteorites, the property of a gentleman, Mr. Naotaro Nabeshima, formerly Daimiyo of Ogi or Koshiro, in the province of Hizen, Japan. They are heirlooms in his family, and used to be in the care of the priests of one of the family temples in Ogi, called Fukuchi- in Gomado. After the revolution the temple was closed. In the family archives there is a record of these stones having been entrusted some years after their fall to a priest named Jishobo, which is dated December 10th, 1744, and his receipt for them is also preserved; they must therefore have fallen about 150 years ago. They were formerly among the offerings annually made in the temple in Ogi to Shokujo (Tanabatatsume) on her festival, the 7th day of the 7th month; they were connected with her worship by the belief that they had fallen from the shores of the Silver River, Heavenly River, or Milky Way, after they had been used by her as weights with which to steady her loom.

The meteorites are somewhat similar in appearance, being angular masses, evidently fragments, irregular quadratic pyramids in shape. The smaller shows a number of small pits or depressions. Faintly marked thin ridges and streaks are to be seen on both stones, radiating with some regularity from about the centre of the base over the basal edges towards the apex; the edges and faces are all rounded, and have the usual very thin, nearly black, coating. The interior is light grey in colour, earthy, porous, somewhat soft, and interspersed with particles of nickel-iron and a few of troilite. The larger stone weighs 5·6 kilog., the smaller 4·6 kilog. The density of the stone was found to be 3·62.

[1] E. Divers, *Asiatic Soc. of Japan*, Tokiyo, Feb. 9, 1882: *Chemical News*, 1882, xlv. 216.

The analysis made by Mr. Shimidzu, one of the students of the Kobu dai Gakko, led to the following results :—

Iron	15·35	Iron monoxide, as silicate	8·64
Nickel, etc.	1·75	Lime	1·94
Manganese	0·18	Alumina	1·89
Tin, etc....	0·15	Soda	0·97
Iron monosulphide ...	5·91	Potash	0·16
Iron chromite	0·61	Manganese monoxide ...	0·51
Phosphoric acid	0·34	Nickel oxide	0·30
Silicic acid	36·75		
Magnesia	23·36		99·01

Or, arranged mineralogically :—

Nickel-iron	17·43
Troilite...	5·91
Olivine (silicic acid = 13·10)	32·89
Insoluble silicates (silicic acid = 24·30)	43·16
Chromite	0·61
	100·00

If, in accordance with the suggestion of Baron Nordenskjōld,[1] the quantities of oxygen are neglected, it is found that the proportion between the elements in this, and the Orvinio stone (August 31st, 1872), and in the meteorite of Tajima, Japan (February 18th, 1880), are practically identical, thus establishing the interesting fact that meteorites which fell in Japan one hundred and fifty years ago have the same composition as some of those which have fallen recently, both in Japan and on the other side of the globe.

	Hizen.		Orvinio.[2] I.	Orvinio.[2] II.	Tajima.
Iron	39·70	} 44·7	} 43·29	} 42·55	43·65
Manganese	0·86				—
Tin	0·22				—
Sulphur	3·27				1·10
Phosphorus	0·22				0·30
Chromium...	0·43				2·25
Silicium	26·06		26·09	26·65	24·47
Magnesium	21·30		21·28	20·18	19·56
Nickel and Cobalt ...	3·02		3·16	4·71	3·86
Calcium	2·11		2·46	2·56	2·80
Aluminium	1·53		1·75	1·91	1·37
Sodium	1·09		1·59	1·10	0·38
Potassium...	0·19		0·38	0·34	0·26
	100·00		100·00	100·00	100·00

1766, July. Albareto, Modena, Italy.[3]

This meteorite, which is now said to have fallen at Albarello, has been analyzed with the following results :—

Iron	4·332	Magnesia	22·773
Nickel	0·730	Lime	2·073
Cobalt	0·105	Potash	0·440
Sulphur	2·364	Soda	1·637
Silicic acid	35·913	Loss	0·840
Iron oxide	24·313		
Alumina	4·479		99·999

[1] Jahrbuch für Mineralogie, 1879, 77.
[2] The cementing substance is I., and the granular matter is II.
[3] P. Maissen, *Gazzetta chimica*, x. 20.

with traces of manganese and chromium. The silicate soluble in hydrochloric acid appeared to be analogous to olivine, and the insoluble silicate to bronzite.

Found 1833.[1] The Siderolite of Rittersgrün.

The examination by Dr. Clemens Winkler of the siderolite of Rittersgrün, Saxony, shows it to accord closely in composition with the siderolite of Breitenbach in Bohemia, examined some years since (1871) in the Laboratory of the Mineral Department of the British Museum; and to strengthen the view expressed at the time that these bodies, as well as the meteorite of Steinbach in Erzgebirge were probably members of the same fall, possibly of the "Eisenregen" reported on by Sartorius (died 1609) as having fallen "im Meissnischen" at Whitsuntide, 1164.

The Rittersgrün meteorite was found in 1833, not 1861 (p. 131), by a workman employed in clearing the forest, and offered for sale as old iron to a smith, but without success; but in 1861 it came to the notice of the lamented Professor Breithaupt, and was secured for the mineral collection of the Bergakademie, of Freiberg. Its mean diameter is 0·43 metre, and its weight 86·5 kilogrammes. It has recently been sawn through in Vienna, a troublesome and costly labour extending over two months. An excellent chromolithograph of the surface thus exposed was prepared by Professor Weisbach, in 1876, and published with a few notes.[2]

The meshwork of nickel-iron of the siderolite incloses the following minerals: troilite, asmanite, bronzite, and chromite; the metallic portion constitutes about 51·06 per cent., and the non-metallic ingredients about 48·94 per cent. of the stone. The nickel-iron contains:—

Fe	Ni	Co	Ca	P	S	Si	C	Asmanite.	
89·990	9·740	0·230	0·035	0·150	0·011	0·066	Trace	0·056	= 100·278

which constituents may be arranged as follows:—

Nickel-iron Fe_9Ni	98·995
Iron-nickel phosphide $(FeNi)_4P$	0·293
Iron phosphide Fe_2P	0·539
Iron silicide Fe_2Si	0·330
Iron sulphide FeS	0·030
Iron carbide	trace
Copper	0·035
Asmanite	0·056
	100·278

The iron sulphide, regarded as troilite, is not acted upon by the magnet, when in the form of pieces, and but feebly so when in the form of powder. The ratios of iron to sulphur in troilite or iron

[1] C. Winkler, *Verhandl. der K. Leop. Carol. deut. Akad. der Naturforscher*, xl. Nr. 8, 333. Halle, 1878.

[2] Der Eisenmeteorit von Rittersgrün im Sachsischen Erzgebirge. By A. W. 1876. Freiberg Kön. Bergakad.

mono-sulphide, and in magnetic pyrites, differ in so small a degree that the analytical results do not always put the question at rest. It is moreover a question whether the meteoric sulphide, associated as it is with nickel-iron, does not actually contain some of the metal as an ingredient. The numbers obtained in these analyses are as follow:—

	Calculated	Found		
		I.	II.	III.
Iron	63·63	65·87	63·58	63·00
Nickel	—	1·40	—	1·02
Sulphur ...	36·37	34·27	36·42	35·27
Silicic acid ...	—	—	—	0·67
	100·00	101·54	100·00	99·96

The asmanite appears to have the density of 2·274–2·278, and the following composition:—

SiO^2	Fe_2O_3	CaO and MgO.	Loss on Ignition.		
95·77[1]	3·16	trace	1·07	=	100·00
97·84	1·65	,,	1·01	=	100·50

As regards the crystalline form of this mineral, Weisbach considers that the recent researches of Schuster and of Von Lasaulx have placed almost beyond any doubt the identity of tridymite and asmanite. It occurred to Winkler that the relative solubility of tridymite and asmanite in potash solution should be determined, and in as nearly parallel experiments as it was possible to devise, it was found that of tridymite from Siebenbürgen 49·63 parts, and of asmanite from Rittersgrün 43·88 parts per cent. were dissolved.

The bronzite, the most prominent of the non-metallic minerals, was obtained in a pure form with comparative ease. It is but slightly affected by the blowpipe, and is not acted upon by acids with the exception of hydrogen fluoride. Its specific gravity is 3·310. It possesses the following composition:—

	I.		II.		III.
Silicic acid	57·27	...	56·56	...	56·56
Alumina	2·28	...	2·05	...	2·04
Iron protoxide ...	10·99	...	10·74	...	10·09
Manganese protoxide	0·41	...	0·42	...	0·55
Magnesia	24·78	...	25·13	...	25·59
Lime	1·77	...	2·52	...	1·66
Soda	not determined	...	1·43	...	1·43
Chromite	0·94	...	0·98	...	0·98
	98·44		99·83		98·90

No trace of olivine was met with in this material.

Heated *in vacuo* the substance of the meteorite lost 0·23 per cent. of its weight, and the gas evolved took fire, but was so small in quantity that it could not be further examined. The meteorite possesses the "crust of fusion" in a fully developed form; it is of about the same thickness as a sheet of paper, and close under it are found the mixture of the minerals troilite, asmanite, and bronzite, of an unaltered light brown colour, although they turn deep black when

[1] By difference.

raised to a temperature slightly above that at which lead melts. The author's pages conclude with some considerations on the probable temperatures of meteorites in their passage through our atmosphere.

1840.—De Kalb Co., Caryfort, Tennessee.[1]

Brezina points out that in Tschermak's Catalogue[2] this iron is described as compact, and in Rose's *Beschreibung und Eintheilung* it is shown to resemble that from Babb's Mill. A fine section, acquired from Professor L. Smith, shows it to be rightly placed near the irons of Arva and Sarepta. Almost every band of kamacite, 1·5 to 3 millimètres across, carries a bar of porous schreibersite; band-iron and interstitial iron are sparsely present, and of a dull grey colour. Two inclosed pieces of troilite, from 3 to 4 mm. diameter, are surrounded by schreibersite from 1·5 to 2 mm. thick, and around this is an irregular shell of beam-iron.

1841, September 6th.—St. Christophe-la-Chartreuse, Commune de Roche-Servières, Vendée, France.[3]

The fall of this stone, which was accompanied by a double detonation resembling thunder and a luminous appearance, took place in the vineyards of St. Christophe at the above date. It created quite a panic in the surrounding country; on the first day none of the peasants would approach it; one could only look with fear in the direction where it lay, it was said; but on the following day a young man, who was escorted to the spot, found it out and brought it away with him.

The stone weighs 5·500 kilogrammes, and is in the hands of a proprietor who was neither disposed to communicate any information respecting it, nor to allow any fragments to be removed. M. Daubrée has therefore to content himself with registering its existence, which up to the present time has not been placed on record.

[Before 1845]—Barratta Plain, Deniliquin, Australia.[4]

It was stated in an issue of *The Australasian* of the date given below that Mr. H. C. Russell, the Astronomer-Royal, while visiting Deniliquin, succeeded in acquiring for the Sydney Museum the greater part of a meteorite which fell "some years ago" at Barratta Station, 35 miles "below Deniliquin." The stone originally weighed

[1] A. Brezina, *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct.-Heft.

[2] *Mineralog. Mitth.* for 1872, 165.

[3] G. A. Daubrée, *Compt. rend.*, 1880, xci. 30.

[4] *The Australasian*, April 22nd, 1871.—*Nature*, iv. (1871), 212.—See also *The Journal of Science*, January, 1874, 123.—The Deniliquin or Barratta Meteorite. By Archibald Liversidge. 1873. Sydney: T. Richards, Government Printer.—*Transactions of the Royal Society of N. South Wales*, 1872, p. 98.

300lbs., but it had been broken up and fragments had been distributed as curiosities. An announcement appeared in 1874 to the effect that Mr. Liversidge, of the University of Sydney, had made a preliminary examination of its composition.

From a paper since issued by Liversidge it appears that the pieces of stone originally weighed about 2 cwt. The large mass now weighs 145 lbs., and must at first have amounted to from 150 to 157 lbs. Of the two pieces found near the large mass, one weighing about 4 lbs. has been lost, the other weighed 60 to 70 lbs., and was taken to the Editor of the *Pastoral Times* newspaper at Deniliquin, and it also has been lost.

Barratta Station is situated on a vast plain, on which no signs of rocks can be seen; the largest stone to be found weighed 2 oz. A stockman named Jones stated in 1871 that he remembered the fall, which took place about dusk one evening in May, about ten or twelve years before, when a large body, like a bush on fire, making a loud hissing or roaring noise, came from the S.E. and passed overhead. Some fencers, who were camped four miles N.W. of the Barratta homestead, saw "a thunder and lightning stone" fall on the ground near their camp. It frightened them because they saw it coming directly towards them, but it fell about a quarter of a mile distant. It was found some days afterwards half-buried in the ground, which it had ploughed up for a considerable distance. It was cracked in several places. It is believed to have been, when found, 30 inches in diameter and about 12 inches thick. This would make it one of the largest stones the fall of which has been put on record.

Subsequently, Mr. F. Gwynne, of the next station to Barratta, informed Mr. Russell that he had found the stone when riding over the plain about the year 1845; so far as he could judge it might then have been there for years.

A preliminary chemical examination of the stone by Liversidge shows it to consist of 92 per cent. of silicates of magnesium, iron, and aluminium, and about 8 per cent. of magnetic minerals. The proportion of nickel-iron is small in the extreme, amounting to from 0·063 to 0·086 per cent., and cobalt is stated to be entirely absent. On the outside it has a blackish fused crust, and the outer layers appear to possess a strongly laminated structure to the depth of from three-quarters of an inch to one inch. Below this the stone is much more compact, and granular, inclosing numerous spheroidal bodies. Under the microscope small grains of a green mineral resembling olivine are to be seen, also particles of a yellow mineral which passes into brown. The specific gravity of the outer layer is 3·382. The inner part of the stone has a distinctly chondritic structure; some of the chondra are comparatively large, from one-sixteenth to one-eighth of an inch across, and a few are a little larger. The specific gravity of this portion of the stone is 3·503. Mr. Russell, who took the density of the large block, makes it 3·387. The grey granules were submitted to a superficial examination and showed the reactions of bronzite.

I have to thank Prof. Liversidge for sending me several microscopic sections of this very important meteorite.

Found about 1850.—Pittsburg, Alleghany Co., Pennsylvania.[1]

This large mass of meteoric iron, weighing 132 kilog., was turned up by a plough at Pittsburg. It was briefly described at the time by Silliman, and has now been analyzed by Dr. Genth. The specific gravity appears to be 7·741; and the chemical composition of a somewhat oxidized specimen was found to be

Iron	92·809
Nickel	4·665
Cobalt	0·395
Copper	0·034
Manganese	0·141
Sulphur	0·037
Phosphorus	0·251
	98·332

The phosphorus corresponds with about 1·8 per cent. of schreibersite. The iron, when etched, exhibits Widmannstättian figures, and the presence of minute crystals of a phosphide could be recognized on the surface of the section.

[1851-68].—The Meteoric Irons of the Mexican Desert.[2]

Dr. Lawrence Smith takes stock afresh of our knowledge of the masses of meteoric iron of that region of Mexico called the *Bolson de Mapimi*, or the Mexican Desert, situated in Cohahuila and Chihuahua, two of the northern provinces of the Mexican Republic. In 1854 he described three masses, two of which (one weighing 630 kilogrammes, and the other 125 kilog.) were subsequently conveyed to the United States; in 1868 eight other masses, the largest of which weighed 325 kilog., were conveyed to the United States; and later still, in 1871, Dr. Smith published a description of a still larger block, estimated to weigh 3500 kilog., now lying in the western boundary of the Desert near El Para. There is, moreover, some account of a mass yet vaster to be seen in the very centre of the desolate region. In this district alone not less than 15,000 kilogrammes in weight of meteoritic masses have been discovered.

While examining sections of two of the above-mentioned masses, Dr. Smith noticed a number of nodular concretions imbedded in the metal, having at first sight the appearance of "very finely crystallized troilite"; closer inspection, however, reveals the fact that most of these nodules have more or less of a black mineral associated with them. This substance was ascertained to be—not graphite, as might at first sight have been supposed,—but a compound of chromium and sulphur, a mineral new both to terrestrial and celestial mineralogy.

Daubréelite, as Dr. Smith has named it, is a black lustrous

[1] F. A. Genth, *Amer. Journ. Sc.* 1876, vol. xii. p. 72. *Report of Geological Survey of Pennsylvania*, 1875.

[2] J. L. Smith, *Amer. Journ. Sc.* 1876, xii. 107.

mineral, highly crystalline, usually occurring on the surface of the nodules of troilite, but sometimes traversing them; in one nodule a vein of the mineral, 2 millims. wide and 12 millims. in length, crosses the very centre of a nodule. It exhibits a distinct cleavage, is very fragile, and is feebly magnetic: the powdered mineral is perfectly black, and is but slightly acted upon by strong acids, with the exception of nitric acid, in which it completely dissolves; this reaction serves to distinguish and separate it from chromite. 100 milligrammes, not perfectly pure, were examined and found to contain 36·48 per cent. of sulphur, the remainder being chromium, with nearly 10 per cent. of iron, and a little carbonaceous matter. (Chromium monosulphide contains chromium = 62·38, and sulphur = 37·62; iron monosulphide (troilite) contains iron = 63·64, and sulphur = 36·36.) The discovery of this new body is of great interest in extending the knowledge, already arrived at by aid of the spectroscope, of the distribution of chromium in cosmical bodies.

Later Dr. L. Smith[1] published a further paper on the new mineral daubréelite. When pure, it possesses the following composition:—

	Calculated.	Found.
Sulphur	44·29	43·26
Chromium...	36·33	36·38
Iron	19·38	20·36
	100·00	100·00

It is a sulphide corresponding in atomic constituents to the well-known oxide, chromite (FeO,CrO_3), daubréelite being FeS,CrS_3, sulphur replacing the oxygen. The calculation of the composition is based upon the sulphur found in the analyses. The finer powder obtained by cutting sections of the irons is treated with a magnet to remove the nickel-iron; that remaining consists of troilite and daubréelite. This is then digested with strong hydrochloric acid several times; all the troilite dissolves readily, and the residue consists of the new sulphide. "It consists of shining black fragments, more or less scaly in structure, not altogether unlike fine particles of molybdenite." The fracture is uneven, except in one direction, where there appears to be a cleavage. It is brittle and easily pulverized, the fine particles retaining their brilliancy. It is not magnetic, and but slightly altered before the blow-pipe. It is not acted upon in the slightest degree by hydrochloric acid, either cold or hot, but dissolves slowly and completely in nitric acid when warmed with it. The specific gravity is 5·01.

Other meteoric irons, such as those from Toluca, and Cocke Co., contain this mineral.

In the "Butcher irons" from Coahuila Dr. L. Smith[2] has since met with a nodule of chromite in the interior of compact iron from one of these masses. His attention was attracted to an inclosed nodule, the lustre of which was less vitreous than that of daubréelite: it was virtually a black granular mass. When heated

[1] *Amer. Journ. Sc.* 1878, xvi. p. 270.
[2] *Amer. Journ. Sc.* 1881, [3], xxi. p. 461.

with strong nitric acid in the water-bath, not the slightest impression was made upon it, thus showing that it is not daubréelite. Heating it in fused sodium carbonate in no way affected its non-solubility in acids; 150 milligrammes of the finely pulverized mineral were fused with ten times that weight of sodium bisulphate, and were attacked but not dissolved. Subsequent treatment with sodium carbonate and nitre broke it up, and the results of the analysis were:

Chromium oxide	62·71
Iron protoxide	33·83
	96·54

While chromite has been known to be associated with meteorites, this is the first instance of its having been found imbedded in this manner in the interior of meteoric iron.

Some of the particles of chromite when placed in very intense light were found to be feebly translucent and to have a dark reddish-purple colour. This observation, it appears, had already been made by M. Stanislaus Meunier, of Paris.

1853.—Tazewell, Claiborne Co., Tennessee.[1]

Brezina points out that in the Catalogue prepared by Tschermak[2] this iron (*vide supra* p. 122) is indicated as *Of*, showing fine-ruled Widmannstättian figures. It differs, however, very much from other irons of this group, as Lion River, Jewell Hill, Charlotte, etc., while it closely resembles the Butler iron. While, however, in the latter case the chief walls of the skeleton inclose very large chambers, here they are very small, so that the skeleton-character is far less marked. The characteristic of the two irons of Butler and Tazewell rests mainly on the very unusual smallness of the octahedral lamellæ, whereby the beam-iron, or its representative, almost vanishes, the irons consisting almost entirely of interstitial and band-iron (and of troilite inclosed in both, and schreibersite plates in Tazewell). Whether the almost infinitely thin nucleus of the lamellæ is identical with the ordinary beam-iron can only be decided by further investigation. The appearance of traces of granular structure renders it very probable.

Found 1854.—Cranbourne, near Melbourne, Victoria, S. Australia.[3]

Two masses of meteoric iron were discovered in Victoria in 1854 (p. 135), and they were first reported upon by the late W. Haidinger in the *Sitzungsberichte Akad. Wiss.*[4] in 1861. The smaller block became

[1] A. Brezina. *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct.-Heft.
[2] *Mineralog. Mitth.* for 1872, 165.
[3] Walter Flight. *Philosophical Transactions*, 1882.
[4] W. Haidinger. *Sitzungsberichte Akad. Wiss.* xliv. 18th April, 6th June, and 17th October, 1861; xlv. 65, 9th January, 1862.

the property of Mr. Abel, the engineer; the larger one was purchased by Mr. A. Bruce, now of Chislehurst. It appears that Mr. Bruce had seen a piece of iron, which had the appearance of being meteoric iron, in the fireplace of a squatter there, and he asked the man if any more of that kind was to be met with in that neighbourhood. He was conducted to a spot in the adjoining parish of Sherwood, where an irregular spur of iron projected from the surface, and he there and then purchased it with the intention of presenting it to the British Museum. Later on, when they proceeded to dig round it and uncover its sides, they were astonished at its large size. Various sums of money were offered Mr. Bruce for the splendid block, but his one answer to all such offers was, "No; I have bought it for a sovereign; and I am going to give it to the British Museum." As has been stated, a point only of the iron was above the surface. A photograph was taken on the spot by my late friend, Mr. R. Daintree, the Agent-General for Queensland, after the tertiary sandstone inclosing it had been removed. It is the same sandstone which crops out at Broughton, with basalt from 12–15 feet below, as on the coast at Western Port. Bruce states that the lower bed is Silurian, and that the block of iron penetrated a foot or more into it.

Early in 1861 the spot was visited by Dr. Neumayer and Mr. Abel. One mass was found to weigh several hundredweight; the other from three to four tons. Their relative position is illustrated in the memoir by a small sketch-map of the district. They were found to be beyond all question native, or rather meteoric, iron covered with a crust of the usual characters, in which the customary hollows were not wanting. This statement is, however, somewhat misleading. No crust corresponding to that of magnetite, such as is presented by the Rowton siderite (page 195), is met with; but, in place of it, a layer of considerable thickness of hydrated oxides and magnetite, indicating a long period during which the blocks had lain in the earth. The relative position of the two masses was S. 34° W. and N. 34° E. (magnetic declination), and they were 3·6 miles apart. Both lay close to the surface, and were only so deeply imbedded that a point protruded from the soil. The latitude of the smaller block, which lay north of the other, was 38° 8′ and long. 145° 22′ E.; that of the larger being 38° 11′ and long. 145° 20′ E. of Greenwich. The height above sea-level of the former was 107 feet, and of the latter 127 feet.

They showed no polarity beyond that due to the action of the earth. The under side of each mass was strongly south magnetic, and the upper side north magnetic. The longer axis of the Bruce meteorite, the larger mass, is about 5 English feet, and it lay exactly in the magnetic meridian of the place.

Neumayer made a number of determinations of the specific gravity of the nickel-iron of the smaller mass, in the possession of Mr. Abel; it ranged from 7·12 to 7·6, that of the crust being 3·66. This block was sent to the International Exhibition in London in 1862. The larger was brought down to Melbourne and placed in the University

Grounds there, near the shore, and unfortunately exposed to the action of the sea-water. Efforts were made to delay the shipment of the Bruce meteorite to England, but eventually the smaller block was bought by the Trustees of the British Museum for £300, and presented to the Colonial Museum; the Bruce meteorite was then sent to this country. When it reached the British Museum, some holes were drilled into its under surface, and it was fixed on a turntable in the first room of the Mineral Gallery. It was found to decay to a considerable extent; fragments oxidised and crumbled off, and drops of iron chloride exuded here and there. This, however, was stopped to a very great extent by injecting it with clear shellac varnish, and keeping it in a glass case provided with trays containing caustic lime. By this means the destruction has been reduced to a minimum. It was noticed that the part of the meteorite which was so rapidly decaying presented a very marked crystalline character: that the tetrahedral structure broke up into plates, between which were very thin plates of another constituent, less readily subject to change. The action of moisture on these series of plates was like that of the exciting liquid of a galvanic cell, and caused the oxidation to proceed very rapidly. Many of the fragments which came off at this time were selected and reduced again to the firm original condition: they present beautiful structure.

It was at once noticed that the meteorite consisted entirely of metallic minerals, that it contained no rocky matter whatever. One of the first experiments which suggested itself was to determine whether the iron was alloyed with nickel, cobalt, copper, etc., and whether it contained combined carbon. A weighed portion was suspended by a platinum wire, carefully covered up in caoutchouc, in a solution of recrystallized salt, and connected with a Bunsen cell. The positive cell was kept slightly acid from time to time as it grew alkaline. Nickel-iron weighing 5·9989 grms. was dissolved in this way, and the greater part of the insoluble ingredients was found to consist of very minute bright apparently square prisms, which pervade all the nickel-iron, and apparently constitute nearly 1 per cent. of its mass. These prisms are acted upon slowly and with considerable difficulty by hydrogen chloride, but dissolve readily in hydrogen nitrate.

The absence of all combined carbon was fully established. The nickel-iron thus dissolved was found to consist of:—

Prisms	0·932 per cent.
Nickel	7·651 ,,
Cobalt	0·501 ,,
Copper	0·0156 ,,
Silicium	0·172 ,,

Some of the largest nickel-iron crystals, and cleavages of them, were examined for other constituents than iron with the following results:—I. was a tetrahedron of iron with cleavages parallel to the faces of the tetrahedron; II. was similar to I. but thinner; III. were several examples of cleavage plates, firm not pliant, thicker than the paper-like plates which will be described later on; IV.

were thinner plates, but not pliant ones; V. were thick cleavage plates; and VI. some borings. The following ingredients were met with:

	I.	II.	III.	IV.	V.	VI.
Insoluble part	1·405	0·072	0·103, 0·106, 0·724	none	none	0·137
Nickel	—	{7·837, 7·712; 7·529, 7·504}	9·764, 6·476	—	—	—
Nickel and Cobalt ...	8·057	—	—	9·801	9·046	—
Cobalt	—	0·601	0·756	—	—	—
Phosphorus ...	—	0·187	0·018	0·059	—	—
Sulphur ...	—	—	— 0·023	—	—	—

The rusted fragments of the meteorite, which were very carefully picked over, yielded many very good crystals of nickel-iron. These were reduced by hydrogen in porcelain tubes, a large quantity of hydrogen chloride was extracted from them, and dozens of perfectly complete tetrahedra of nickel-iron, as well as many cleavage pieces with sharp edges, were safely preserved.

In one of the early notes on the Bruce meteorite published by W. Haidinger, in 1862, he wrote, "Vielleicht finden sich in der That innerhalb der Meteoreisenmassen . . . selbst manche Sättigungspunkte, welche wirklich verschiedene Mineralspecies darstellen." Such an instance presents itself in the thin paper-like pliant plates which lie on the faces of the tetrahedra of nickel-iron and between the large plates of the crystals of nickel-iron; they are in the form of equilateral triangles or are lozenge-shaped, have the thickness of stout writing paper, and, unlike the plates of nickel-iron, are quite pliant. They are strongly magnetic, are of a pure white colour, and have evidently been extruded from the nickel-iron at the time of formation. They are soluble in hydrogen chloride and nitrate. As the examination of them had been made in the case of some which had been reduced by hydrogen, a further portion picked direct from the fragments which had come off the meteorite was taken; both kinds were found to be equally pliant. The fresh plates taken direct from the meteorite contained 0·688 per cent. of phosphorus. Analysis of the plates showed them to consist of:—

Iron	70·138
Nickel	29·744
	99·882

and their composition may thus be represented by the formula $Fe_5 Ni_2$.

This is evidently an alloy of very well defined composition, which has been extruded from the nickel-iron under special conditions when the latter was saturated with it and ready to expel it. It is the constituent of nickel-iron which forms the fine lines constituting the Widmannstättian figure, and not schreibersite, as usually stated in writings on the etched figures of meteoric iron. Tänite is the name which Reichenbach gave to leaves containing 13·2 per cent. of nickel, and which he stated to form the figures on an etched surface. Mr. A. T. Abel proposed the name "meteorine" for a new metal occurring in the Cranbourne meteorite which he found to contain no copper, nickel, or cobalt.[1] The substance referred to in both cases is evidently the little plates above described. As the composition of this mineral has now for the first time been definitely made out, I propose to call it Edmondsonite, in memory of the late George Edmondson, the Head Master of Queenwood College, Hampshire, a great lover of science, a man with whom I had the honour to be long and intimately connected.

A curious accident should here be described which established the fact that the alloy is a definite chemical compound. A number of pieces of nickel-iron from this meteorite, which had become rusty, were heated in a porcelain tube in a current of hydrogen. During the experiment, which was conducted out of doors, it came on to rain, and some drops touched the hot tube and cracked it. Air slowly entered the crack and oxidised the iron, till it acquired a bright blue colour; while the little plate of edmondsonite remained colourless. This result accords with the conclusion arrived at by Stodart and Faraday some sixty years ago,[2] on the oxidation of alloys of iron and nickel. An alloy of iron, or rather of the best Bombay wootz, with 10 per cent. of nickel, made by them in 1820, in imitation of the Siberian meteoric iron, in which Children found as a mean of three analyses 8·96 per cent.[3] of nickel, was compared, as regards its powers of undergoing oxidation, with pure iron. And the authors say: "The colour, when polished, had a yellow tinge. A piece of the alloy has been exposed to moist air for a considerable time together with a piece of pure iron; they are both a little rusty, not, however, to the same extent, that with the nickel being but slightly acted upon comparatively to the action on the pure iron; it thus appears that nickel, when combined with iron, has some effect in preventing oxidation, though certainly not to the extent that has at times been attributed to it. It is a curious fact that the same quantity of the nickel alloyed with steel instead of preventing its rusting, appeared to accelerate it very rapidly."

The Bruce meteorite contains many nodules of troilite lying here and there amongst the plates and crystals of nickel-iron, always in rounded masses, only very occasionally an ill-defined cleavage plane being met with. They vary in size from half an inch to more than two inches in length, are usually covered with a thin layer of graphite, sometimes with some daubréelite surrounding them; and one nodule, consisting of graphite, was found to inclose troilite, which had aggregated inside the graphite in a curious way, so that the section of the nodule suggested the outline of a holly-leaf. A sketch appended to the original memoir represents a section of the nodule of graphite, the shaded inclosed part representing the sulphide. Troilite is the only sulphide found in this meteorite, and, it need hardly be said, was not in the slightest degree mag-

[1] *Jahrb. für Mineralogie*, 1861, p. 557.

[2] Faraday's Experimental Researches in Chemistry and Physics. Taylor and Francis, 1859, p. 63.

[3] Berzelius found nickel 10·73 per cent., and copper 0·46 per cent. in the Krasnojarsk nickel-iron from Siberia.

netic. A specimen of pounded and dried mineral was digested with a quantity of carbon disulphide, which had been twice distilled, for a day and a half, and sulphur amounting to 0·0207 per cent. was dissolved. A portion chosen for analysis was found to possess the following composition :—

	I.	II.	III.	IV.
Insoluble part ...	0·215	2·297	—	—
Iron...	—	62·150	63·613	—
Sulphur	36·543	—	36·207	36·250
Nickel	—	0·446	—	—
Copper	—	0·079	—	—
Chlorine	—	0·130	—	—

or,

		Fe S requires
Iron	= 63·613	63·64
Sulphur ...	= 36·333	36·36
Copper	= 0·079	—
Chlorine ...	= 0·130	—
	100·155	100·00

The next mineral, the composition of which we have to consider, is that forming the prisms which, as we have already seen, are scattered throughout the mass of the nickel-iron, and form nearly one per cent. of its mass. They resist the action of hydrogen chloride and are only dissolved after long treatment with very strong acid ; they dissolve, on the other hand, easily in hydrogen nitrate.

They exhibit strong magnetic characters. They seem to be identical with the mineral to which Gustav Rose gave the name of rhabdite. They appear to form square prisms, and the terminal faces of the prism could rarely be met with.

The prisms were exceedingly brittle, and were rarely, if ever, found unbroken. It was a difficult matter to obtain the prisms quite free from organic matter (dried varnish, etc.), but the following very pure material was at last obtained :—

	I.	II.	III.	Mean.	$Fe_4Ni_3P_2$.
Iron	49·715	—	48·955	49·335	48·38
Nickel	36·666	39·519	38·540	38·242	38·23
Phosphorus	(13·619)	12·586	12·645	12·950	13·39
					100·000

The specific gravity of several specimens of the prisms gave numbers varying from 6·326 to 6·78.

A few years ago Professor Daubrée[1] pointed out the great resemblance which he had traced between the artificial phosphide of iron, Fe_4P, which M. Sidot had succeeded in preparing, and the rhabdite of meteoric iron. I have to offer my hearty thanks to Professor Daubrée for permitting me to inspect some of M. Sidot's crystals, which bore the closest resemblance to the above crystals. More recently, in the spring of last year, M. E. Mallard[2] communicated a

[1] G. A. Daubrée, *Comptes rendus*, lxxiv., 1427 ; and M. Sidot, *Comptes rendus*, lxxiv., 1425.

[2] M. E. Mallard, " Sur la production d'un phosphure de fer cristallisé et du feldspath anorthite, dans les incendies des houillères de Commentry," *Comptes rendus*, 1881, xcii. 933.

note to the Comptes Rendus, on phosphide of iron found among the products of the spontaneous fires in the coal-mines at Commentry. The crystals are square prisms, terminated by a pyramid, are strongly magnetic, have a specific gravity of 6·71 and the composition indicated by the formula Fe_7P_2. They, of course, contain no trace of nickel; in all other respects, however, they bear the closest resemblance to the above body.

When the crude nickel-iron of the meteorite was treated with hydrogen chloride till action ceased, coarse insoluble particles, mixed with a black powder, and the needles remained; they could both be removed by decantation and repeated washings. It was then subjected to a thorough cleansing with hydrogen chloride, with dilute nitric acid, with water, with a mixture of ether, alcohol, benzol, and chloroform, and finally, when dried, with the magnet. In this way the coarse powder was obtained in a pure state; it was very brittle, very magnetic, and dissolved easily in strong hydrogen nitrate. Analyses gave the following results:—

	I.	II.	Mean.
Iron	56·245	55·990	56·117
Nickel	29·176	—	29·176
Phosphorus	13·505	—	13·505
			98·798

This is, doubtless, the mineral schreibersite which appears to have the composition indicated by the formula $Fe_2\,Ni\,P$, or perhaps the formula $R_7\,P_2$, the atomic proportion of the iron and nickel being as two to one. The material, as already stated, consisted of a coarse powder, of faceless irregular fragments of a very brittle constituent of the meteorite.

Search was accordingly made for crystals, and occasionally, but very rarely, larger bodies which might when broken up have formed this powder were hit upon. One was met with, a large brass-coloured oblique crystal which readily cleaved across the base; it was but slightly acted upon by hydrogen chloride or nitrate, both of which, however, on long-continued boiling, dissolve it slowly; in *aqua regia*, on the other hand, it quickly disappears. When heated, a fragment of one of these crystals quickly became dark brown. Analyses of these crystals gave the following results:—

	I.	II.		
Iron	69·251	69·843	$69{\cdot}547 \div 28 = 2{\cdot}484$	2·972
Nickel[1]... ...	—	—	$14{\cdot}410 \div 29{\cdot}5 = 0{\cdot}488$	
Phosphorus ...	15·420	16·666	$16{\cdot}043 \div 31 = 0{\cdot}517$	
			100·000	

which results point to $Fe_9\,Ni_2\,P_4$ or perhaps $Fe_5\,Ni\,P_2$ as the true representative of its composition. It does not accord very well with the analysis of the powder, and the relation of one body to the other must be left till fresh material comes to hand.

Mention should here be made of a curious crystal which on two or

[1] Both determinations were lost.

three occasions was met with while searching through the *débris* of the meteorite. It consisted apparently of a square prism, which, while the sides were quite bright and metallic, had a square centre of a dull almost black colour; it very readily broke across the prism.

In the paper there is represented such a prism broken across, showing the dark centre. An analysis of this compound gave the following results:—

Iron	67·480
Nickel	20·318
Phosphorus	12·317
	100·115

which numbers agree with the formula R_4P, the atomic proportion of the iron and nickel being as seven to two.

Graphite occurs occasionally, but rarely, as nodules; sometimes as nodules inclosing troilite, like the one already referred to; sometimes in large sheet-like masses, in one case about four inches in length and two inches wide. A specimen was carefully dried and pounded and burnt in a current of oxygen and gave numbers which show it to have the composition:—

Carbon	89·661
Hydrogen	0·257
Residue (iron, etc.)	10·412
	100·330

The nickel-iron was further examined for occluded gases. A portion of the nickel-iron borings removed from the under surface was selected, and was heated in a porcelain tube connected with a Sprengel pump. Gas amounting in bulk to 3·59 times the volume of the iron was extracted, and was found on analysis to have the following composition:—

Carbonic acid	0·12
Carbonic oxide	31·88
Hydrogen	45·79
Marsh gas	4·55
Nitrogen	17·66
	100·00

The paper is illustrated by a plate and several woodcuts.

Found 1858–59.—Staunton, Augusta Co., Virginia.[1]

In 1871 Mallet described three masses of meteoric iron which had been found near Staunton (page 13); another has now been brought to light, and examined. It was found by a negro in 1858 or 1859, who brought it to Staunton, and endeavoured to sell it. He failed to do so, and threw it away behind a blacksmith's shop, where it lay several years until it was used with other loose material to build a stone fence. By reason of its irregular shape and great weight it soon fell out of the fence, and was next used by a dentist as an anvil, on

[1] J. W. Mallet. *Amer. Journ. Science*, 1878, xv. 337.

which to hammer metal plates, and for such base purposes as the cracking of nuts; then it was again built into a wall round the curbing of a cistern. In 1877 it was removed to Rochester, N.Y., and a fragment of it came into Mallet's possession. It weighs 152 pounds, is 45·7 cm. in length, and 29·2 cm. in breadth, and in shape somewhat resembles that of a shoulder of mutton. A sketch of the mass is given in Mallet's paper. The specific gravity of the iron is 7·688, and the metal, when etched, exhibits the Widmannstättian figures "clearly and beautifully." The composition of the iron was found to be:—

Iron	91·439
Nickel	7·559
Cobalt	0·608
Copper	0·021
Tin	trace
Phosphorus	0·068
Sulphur	0·018
Chlorine	trace
Carbon	0·142
Silicium (reckoned as silicic acid)	0·108
	99·963

There can be no doubt that the four specimens found in the same neighbourhood represent different portions of the same meteoric fall.

1861, June 28th (June 16th, O.S.), 7 a.m.—Grosnaja (Grosnja), Banks of the Terek, Caucasus, Russia.[1]

Sixteen years ago Abich, who was at the time in Tiflis, sent to Gustav Rose, in Berlin, a short description of a large fall of meteorites at Grosnaja on the morning of the above day. The greater number appear to have fallen into the river Terek; one fell in the great square in the interior of the (? Staniza) barrack, and entered the ground to the depth of 1¾ feet; it pursued an oblique course through the air, and was distinctly warm when dug out. The meteorite had the form of a huge hailstone, and was covered with a black crust.

Abich, who had taken up his residence in Vienna, placed the stone in the hands of Professors Tschermak and Ludwig for examination, and the results of their investigations, together with a detailed report of the circumstances attending its descent, have been incorporated in the paper by Professor Tschermak, referred to in the note.

It is stated in the report drawn up by General-Major Kundukof, military commandant of the Tschetschensk district, that on the night of the 15th-16th June (O.S.), a barely dark one, there was neither thunder, wind, nor rain. On Friday, the 16th, the morning was clear and bright; light rain-clouds, which however brought no rain, hung on the western horizon over the station Mekenskoi, the inhabitants of which were startled at about seven o'clock by a deafening sound, which continued a long space of time. A non-commissioned

[1] G. Tschermak, *Mineralogische und petrographische Mittheilungen*, 1878, 153.

officer of the Mosdok regiment, who was walking from the Navursky to the Mekenskoi barracks (? Staniza), noticed that the sound appeared to come from the west, where the rain-clouds were, and describes it as resembling that produced when many cannon are fired simultaneously, followed by a deafening noise like that caused by battalion-firing. He observed the flight of one of the stones, which descended at a low angle, and it was accompanied by lateral bands of a bluish colour (welcher von Nebenstreifen von blaülicher Farbe begleitet war). The stone fell in the court-yard of a house about two paces distant from a summer-house, and thirty paces from the bank of the Terek. A soldier's wife, standing on the threshold of the house, drew back in the greatest alarm as the meteorite struck the ground two paces from her with all the violence of a bomb-shell, scattering the earth over the wall of the house. A soldier soon probed the hole with a ramrod, and found at a depth of rather more than a foot fragments of the stone weighing in all ten pounds. Many heard a second sound, as though the meteorite burst twice in its descent through the atmosphere, and the noise attending the fall was observed by persons eight versts distant on the other side of the Terek. A woman who was occupied in washing clothes, at a spot about 1050 feet distant from the point where the meteorite struck the ground, heard fragments, which had been detached by the explosion, fall into the river Terek. The water fizzed just as it does when brought in contact with a large quantity of heated iron.

The meteorite has a longish rounded form, and has lost the greater portion of its crust; in fact, the crust, together with a thin layer of the inclosed silicate, is very easily removed, and probably dropped off at the time of the fall. Its actual thickness is much greater than in the case of the stones which fell at Knyahinya, and about equal to that of the Pultusk aërolites.

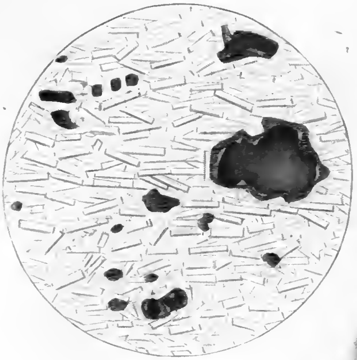
Professor Tschermak goes on to describe the Vandal treatment to which the stone was subjected before it reached his house for investigation. A cast of it had been taken for the Academy of Sciences of St. Petersburg, and it had subsequently been sawn in two. It appears, in the first place, to have been rubbed down with fat, not oil even, and, after the mould was taken, to have been soaked with potash lye to remove the unctuous layer; the carbonate of potash, which penetrated the porous stone with scarcely any crust to protect it, next began to effloresce, and the new danger to which it was exposed had to be compassed by drenching it with water. It was now ready to pass from the clumsy hands of the modeller to experience the yet more tender mercies of the lapidary, who, not to be outdone by his fellow-workman, it is to be conjectured, proceeded to close all the fissures and lines upon its surface with a black varnish. Long treatment with alcohol and protracted drying in a steam bath were the next operations which were made with a view to cleanse it.

A system of cracks and fissures, arranged like the branches of a tree, traverses the whole stone, and gives the impression that they are the result of the blow which the meteorite received on its fall. The mass of the stone is brittle, the colour blackish grey with bright points. There are many inclosed mineral particles, some almost invisible, others 1 cm. across, the greater part having a diameter of less than 2 mm. The matrix is black and opaque even when viewed in a microscopic section, and many of the inclosed particles are opaque or only translucent in points. Most of them, however, are transparent, and the majority have a circular or rounded outline. A plate is appended to Tschermak's paper showing figures of the inclosed minerals. Five distinct ingredients could be distinguished. The first is a clear greenish mineral, with incomplete cleavage along two directions perpendicular to each other, and was identified as olivine. A second in round tough spherules, brownish in hue and not numerous, with a finely foliated or finely fibrous structure, was found to be bronzite. Inclosed particles are sometimes made up of these two minerals, sometimes, but not very frequently, of them together with a third silicate in long greenish prisms which have the appearance and angles of augite. The meteorite also contains some magnetic pyrites (troilite?), a very little nickel-iron and perhaps a little carbon, to which the dark hue of the matrix is due.

Tschermak directs attention to two peculiarities observed in several chondritic meteorites, and noticeable in this one. The first is the occurrence of a crust over the surface of the bronzite spherules, possessing fibrous structure. This crust is thin, and is distinguished from the inclosed material by its paler colour; it has the same fibrous structure, doubly refractive power, and, in fact, is optically orientated like the inclosed silicate. It appears to be produced by some agent acting from without, perhaps heat in conjunction with a reducing gas. The agent has not caused fusion, but a slight modification of the texture of the surface. The second point which he has observed is the distribution in zones of the magnetic pyrites in many of the granular inclosed masses. When a microscopic section is examined by reflected light, it is found that many are apparently surrounded by a crust of the metallic sulphide, in others it occupies the centre of the mass, in all cases apparently filling up interstices. It seems as if the sulphide had impregnated the rocky mass; and the absence of all magnetic pyrites in the very compact inclosed particles, and the tough fibrous bronzite chondra, confirms this view. This impregnation Tschermak believes took place after the inclosed mineral particles attained their present form, and the only explanation which can be suggested is that this must have happened while the whole tufaceous mass was strongly heated. According to this theory, the inclosed granules coming in contact with fused magnetic pyrites must have drawn it into the fine fissures and interstices, in some instances into the cavities of the granules themselves.

This argues the existence of two definite stages in the formation of these and similar chondritic structures. First, the production of the olivinous tuff by the splitting and attrition of the rock when the tougher particles are rolled and rubbed together till they have a roundish or spherular form; and secondly, a subsequent application

Fig 1.

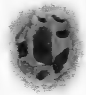


150/1

Fig 2.

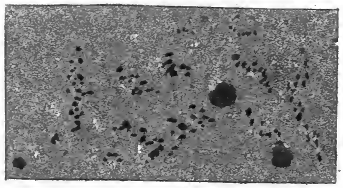
27/1

Fig 3.



2/1

Fig 4.



1/1

Fig 5.

1/23

C. Thornam del. & sculp.

of heat to the tuff, accompanied not unfrequently by the reducing action of gases and vapours.

The Grosnaja meteorite appears to consist of—

Silicic acid	33·78
Alumina	3·44
Iron protoxide	28·86
Lime	3·22
Magnesia	23·55
Potash	0·30
Soda	0·63
Carbon	0·68
Hydrogen	0·17
Magnetic pyrites	5·37
	100·00

Olivine appears to be the prevailing silicate in the meteorite; in addition to bronzite there appears to be a little augite and felspar, although their presence could not be recognized. There is moreover, a small amount of a carbonaceous ingredient, to which, as well as to the magnetic pyrites, the blackish grey colour of the matrix is probably due.

A plate showing six sections of this meteorite accompanies Tschermak's paper.

Found 1870.—Ovifak, Disko, Greenland.[1]

M. Daubrée gives the name *Lawrencite* to the iron protochloride, the presence of which he has detected in the curious meteoric irons of Ovifak. It was earlier recognized in the Tennessee meteoric iron by Dr. Lawrence Smith.

The Academy of Sciences of Paris appointed a commission to report on a paper by Dr. Lawrence Smith on the supposed native iron of Greenland, and their report has recently been presented by M. Daubrée. It is pointed out that the bodies which come from beyond our atmosphere, and which are called meteorites, present, as regards their mineralogical constitution, a most striking resemblance to certain terrestrial rocks. The important fact that masses derived from most widely separated regions of space should present such resemblances was pointed out by Nordenskjöld in 1870, when he discovered large masses of native iron at Ovifak, on the island of Disko, Greenland (p. 26). The first thought which suggested itself to him was that they were of meteoric origin. In order to explain the fact that these masses were fused into the basalt, he assumed that they had fallen into it while it was still liquid. Many adopted this view, and, among others, Nauckhoff and Tschermak. Steenstrup, on the other hand, after visiting the locality twice, came to the conclusion that they were masses of native iron, and that they had the same terrestrial origin as the basalt itself. Not far from Ovifak, in the Waigatstrasse, Steenstrup found evidence which supported this theory: in the basalt of Igdlokungoak he hit upon a mass of metalliferous mag-

[1] G. A. Daubrée, *Compt. rend.* 1877, Jan. 8th, lxxxiv. 66; *Ibid.* lxxxvii. 911.

netic pyrites weighing about 28,000 kilog., and again, in the basalt of Assuk, small grains of native iron. The graphite associated with this iron pointed to the probability that carbonaceous substances had reduced this metal; moreover, the rock enclosing the native iron contained the silicate of ferric hydrate which has received the name hisingerite. With these opposing views so plainly set forth, Dr. L. Smith has gone over the whole question, and comes to the same conclusion as Steenstrup, that the masses of metal are of terrestrial origin. He finds that in the dolerite of Assuk, as well as that of Ovifak, which it closely resembles, metallic iron is found enclosed in labradorite; anorthite is likewise found in certain parts of the mass of the rock, and oligoclase also.

Iron has been obtained from seven localities in Greenland: from Sowallick, Fiskernäs, Niakornak, Jakobshavn, Fortune Bay, Ovifak, and Assuk. The iron of Sowallick and Niakornak is found by Dr. L. Smith to contain combined carbon, just as the Ovifak iron does; in fact, he states that all specimens of iron obtained from Greenland are similar in this respect, and differ from meteoric iron, which contains no combined carbon; moreover, these masses all contain cobalt in considerable quantity in relation to nickel. Dr. Smith next refers to the constant geological character of the area where the iron has been found, the iron being found only in the basalt region, which extends from 69° to 76°, and then disappears under a huge glacier. We shall probably never know how far this volcanic area stretches towards the north; that, however, which has been seen has a length equal to the distance of Gibraltar from Brest. We know that the terrestrial rocks which present the closest resemblance to the meteoric rocks belong to the lowest depths of the earth. Some are eruptive rocks of a basic character, consisting of anorthite and augite, like certain lavas from Iceland; others are olivinous rocks, like lherzolite, to which the meteorites containing magnesia—those, in fact, of the ordinary type—belong. The gangue of olivinous rocks accompanying the platinum of the Urals, and the presence of nickel in the ferriferous platinum, have confirmed these relations, which are of interest alike for the geologist and the astronomer. It was expected that among the aluminous and magnesian rocks some might be found in which iron should begin to make its appearance, and this gap has now been filled. In the Greenland beds layers of lignite are found associated with the basalt, and this may have furnished the material which has reduced the iron to the metallic state.

Found 1872.—Nenntmannsdorf, near Pirna, Saxony.[1]

This mass of meteoric iron was found in 1872 (p. 64), and a superficial examination of it by Lichtenberger was made in the following year ("Sitzungsber. der Isis," Dresden, 1873, p. 4). It is a rounded block of malleable iron, weighing 25 pounds, and is covered with a

[1] F. E. Geinitz, *Jahrbuch für Mineralogie*, 1876, p. 608.

blackish-brown crust of oxide. Like the meteoric irons of Ovifak, and many others, it contains chlorine, and in damp warm air rapidly oxidises and exfoliates. The metal has the grey colour of iron, does not exhibit the Widmannstättian figures, and has a specific gravity of 6·21. Geinitz finds the composition of this iron to be—

Iron	93·04
Nickel	6·16
Phosphorus	0·22
	99·42

In the iron are many rounded, sometimes elongated, hollows filled with a yellowish-brown mineral having the specific gravity 3·98. This on analysis was found to consist of—

Iron	63·82
Sulphur...	37·36
	101·18

which showed it to be troilite (iron monosulphide), and to accord in composition with the sulphide found in the meteoric iron of See-läsgen. One cavity was filled with what appeared to be the same mineral in a crystalline form. This is the first occasion where troilite has been met with otherwise than massive.

[Before 1875.] Butler, Bates Co., Missouri.[1]

This iron has already been described by Broadhead[2] and Smith,[3] the latter finding it remarkable for the very large and regular Widmannstättian figures which it displays. A specimen, weighing 1 kilog. 334 grammes, acquired by the Vienna Collection from Dr. L. Smith, was found to have three etched surfaces nearly perpendicular to each other. It was noticed that the greater part of the iron had an even dull appearance, but in this lustreless iron grey part lay numerous, in part individual, in part grouped together, lamellæ, of which four differently directed systems appear on the sections. The lamellæ together form a skeleton—an octahedral skeleton: as is illustrated by Tschermak in fig. 5 accompanying his memoir,[4] the crystal-structure of iron sometimes indicates a hexahedral skeleton.

The ground-mass, though lustreless and structureless, shows a peculiar play of light, to which later reference will be made; its hardness is remarkably low, a little below 4, being distinctly scratched by fluor. The thin central part of the lamellæ in several respects (hardness, etc.) shows the greatest resemblance to the ground-mass; only in a few broader places a feebly indicated kernel-like structure shows itself, and recalls the beam-iron of other meteoric irons. The lamellæ are covered with band-iron (tänite) which is

[1] A. Brezina. *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct. Heft.
[2] Broadhead. *Amer. Journ. Sc.* [3], x. 401.
[3] Smith. *Amer. Journ. Sc.* [3], xiii. 211.
[4] Tschermak. *Sitzber. Akad. Wiss.* lxx. 1874, 458.

recognized by its high lustre and pale isabel-yellow colour; they are very small, the nucleus and the two covers being in most cases not more than $\frac{1}{60}$ of a millimètre, and the length usually 15 to 20 mm. (some are 30 mm.). Where lamellæ differently directed come together, one system is usually developed quite uninjured; sometimes, though rarely, nucleus lies on nucleus and cover on cover, a proof of the simultaneous origin of the system.

From the main structure formed by the four systems of lamellæ, there project into the ground-mass not only numerous small plates which are parallel to each other, but here and there one which has an irregular orientation: and to this arrangement is due the peculiar play of light of that part of the iron. Troilite occurs in rounded or lenticular masses, about 2 cm. in diameter; but none is found in the lamellæ systems.

The largest of the sections does not differ much (about 13°) from the position of a leucitobedral face; three distinctly marked lamellæ systems cross it and make angles with each other of 70°, 61° and 49°: a fourth less distinctly marked system, making a very small angle with the section, divides the angle of 61° into 44° and 17°, the larger angle being on the side nearest to the angle of 49°. Hence the adjacent angles of the series of lines are:—

70°, 17°, 44°, 49°.

For the face (533) the corresponding values would have been:—

65°·4, 0°, 65°·4, 49·°2.

The drawings of these sections are to be published later on.

1875, March 31st, between 3 and 4 p.m.—Zsadány, Temesvàr, Hungary.[1]

No luminous meteor appears to have been observed at the time these stones fell; the day was bright and sunny, and the sky cloudless. A sound as of platoon firing was heard, and a small shower of black stones descended, some within the area of the village of Zsadány in the court-yards of the inhabitants, others in the open fields. They did not fall together, but at slight intervals, which appear to have been at least one-third of a minute. Some were picked up immediately they reached the ground, and were found to be *cold.* [During a conversation with Prof. Szabó in the summer of 1882, I learned that this was not the case.] It may be mentioned here that the stones which fell at Dhurmsala in India[2] (1860, July 14th) are stated to have been so cold that they could not be held in the hand.

[1] *Egyetértés és Magyar Ujság*, 23rd April, and June 16th, 1875.

[2] W. von Haidinger, *Sitzungsber. Akad. Wiss. Wien*, xlii. 305, xliv. 285. [It was a subject of frequent remark in conversation by Professor Brayley that the only foundation for this statement was a part of the native evidence collected on the occurrence of this stonefall, that the meteorite came "from the abode of snow"—a phrase which, in the native dialect, signifies a "northern direction," by a simple but direct allusion to the snow-topped summits of the Himalayas.—Professor Alexander Herschel.]

Sixteen stones in all have been found, the largest, having the size of a goose's egg and weighing about 152 grammes, is preserved in the National Museum at Pesth; the remainder have an average size of a walnut, and their aggregate weight is nearly 400 grammes. Memák has sent a preliminary report describing the seven largest stones, illustrated with photographs of the four most interesting masses, to the Hungarian Academy of Sciences. The investigation of this aerolite has been undertaken by Wartha and Krenner;[1] the former will subject it to analysis, the latter examine its mineralogical characters.

I learn from an obliging letter, received from Prof. Szabó, that these meteorites have a coarse-grained texture, and are somewhat friable, and that they contain nickel-iron and scales of graphite.

Dr. Cohen, of Heidelberg, received some fragments of the stone from Dr. Babesin, and he has recently published a paper on the results of the physical and chemical examination of them.[2]

The crust of the stone has a brownish black colour, and is $\frac{1}{5}$ to $\frac{1}{4}$ mm. in thickness; it presents the appearance of having been subjected to a less intense heat than that usually developed during the fall of a meteorite. The finely-grained light grey matrix encloses granules of magnetic pyrites (troilite?), granules and plates of nickel-iron, and numerous dark grey crystalline spherules, averaging $\frac{1}{2}$ mm. in diameter; one little sphere had a breadth of $3\frac{1}{2}$ mm. They have an excentric-radiate or contorted-radiate structure. A freshly broken surface of the stone is studded with these chondra, and they are easily removed from the matrix. As regards their mineralogical aspects, the spherules are found to be of two kinds. One consists of small prisms of a rhombic mineral, which has all the appearance of a variety of enstatite; others are found to possess all the properties of olivine. These two minerals also constitute the greater portion of the matrix. The enstatitic mineral occasionally contains opaque granules and colourless microlites, the olivine pores or cavities, some of which, the author states, appear to contain fluid. Metallic particles are rarely, if ever, found in the spherules themselves. An accessory mineral, transparent, pure, and with well-defined edges, is also to be found in the meteorite. It differs from the enstatite in exhibiting no cleavage fissures, from the olivine in the smoothness of its polished exterior, and from both of them in exhibiting distinct pleochroism; the one tone is colourless, the other pale red with a faint tinge of brown. It appears to be rhombic, and shows a close resemblance to a variety of hypersthene found by Cohen in a gabbro from South Africa. The Zsadány stone resembles those which fell on different occasions at Lancé, Gopalpur, and Pultusk.

By treatment with acid a considerable quantity of the silicate was decomposed. The analysis of the portions thus separated gave the following numbers:—

[1] *Természettudományi Közlöny*, 1875, p. 200.
[2] E. Cohen, *Verhandl. Naturhis. Med. Vereins zu Heidelberg*, 1878, II. Heft. 2.

	Soluble Portion.	Insoluble Portion.
Silicic acid	44·56	56·71
Alumina...	trace	2·32
Iron oxide	17·54	13·21
Lime	trace	1·77
Magnesia...	37·90	25·99
	100·00	100·00

The stone, therefore, appears to consist, to the extent of three-fourths, of a bronzite, the remaining fourth being an olivine, in which the equivalents of MgO : FeO are as 3·89 : 1, a ratio approximately that which is often met with in meteoric olivine.

Prof. V. Wartha was desired to analyse the stone, but he was delayed by several causes which he mentions;[1] and eventually Dr. W. Pillitz undertook the examination. Wartha received 30 grammes of the meteorite, a quantity which he considers very small, and he was led to make a preliminary trial on another meteorite, that of Knyahinya, of which he received some fragments from Prof. Szabó. While the latter is very hard, finely-grained, and firmly held together, the stone of Zsadány is very friable and has a rough surface. The numerous iron particles enclosed in the rock so rapidly oxidize that they are covered with rust in a few hours, so that it was not possible to prepare a microscopic section of it. There were plainly visible with a lens, in addition to the iron particles, bronze-coloured troilite, small white crystals, and a black non-metallic body, the same as that found by Kenngott in the Knyahinya stone. These were found to be fine, lustrous, octahedral crystals, and to be picotite, originally found in the rock, from the neighbourhood of L. Lherz, called lherzolite by Delamétherie; it is a spinel. A fragment of the stone heated in a tube connected with a Sprengel pump gave no lines in the spectroscope, except a weak indication of hydrogen. The iron sulphide appears to be present not as pyrites but as troilite, and the same observation was made with regard to the Knyahinya meteorite, contrary to the finding of Piribauer, who held it to contain pyrites.

Pillitz[2] publishes full details of the methods which he employed for the analysis which led to the following results:—Silicates = 78·53 per cent; metals 22·26 per cent.

Or in 100 parts of the

Silicate.		Metallic Portion.	
Silicic acid	47·346	Iron	67·219
Chromium oxide	1·276	Nickel	10·177
Alumina	3·027	Cobalt	trace.
Iron protoxide	15·054	Manganese	6·047
Magnesia	22·343	Copper and tin	2·323
Lime	4·683	Sulphur	9·734
Potash	5·850	Phosphorus	1·658
Soda	0·421	Carbon	0·774
		Chromite	2·065
	100·000		99·997

[1] V. Wartha, *Zeitschrift für anal. Chemie*, xvii., 1878, 431; *Jour. Chem. Soc.* xxxvi., 1879, 210.

[2] W. Pillitz, *Zeitschrift für anal. Chemie*, xviii., 1879, 58.

1875, April 14th, 0·30 a.m.—Haddon, Grenville Co., Victoria, Australia.[1]

A very brilliant meteor appeared from a bank of cloud about 20° above the N.W. horizon; it became elongated and pear-shaped as it traversed the heavens from W. to E., attaining an altitude of 50° on passing the zenith, where the nucleus appeared to break up and roll on in misshapen spheres of various sizes. On reaching a point within 20° of the N.E. horizon, the light became more intense and then the meteor disappeared. Eight or ten seconds later, reverberations as of thunder were distinctly heard. An eye-witness stationed at Haddon thought he saw matter fall near him, and the next day, found a lump of melted matter, light in weight and of a nearly black colour, a portion being "a yellowish-brown substance like cinders from iron-smelting," as well as two fragments that were black, like coke, and a smaller fragment of a yellow hue. This great meteor, of which an engraving is given in *The Illustrated Australian News*, was, it appears, observed in several parts of the country; but no other accounts of it indicating either the extent or position of its real course have yet been received.

1875, August 16th (about noon).—Feid-Chair, Cercle de la Calle, Constantine, Algiers.[2]

This meteorite fell about midday at a spot named Feid-Chair, about 30 kilomètres from La Calle, the descent being attended with the usual luminous appearance. It weighs about 380 grammes; all search to discover other stones has proved of no avail. The stone has a black crust and a grey interior, in which particles of nickel-iron and troilite are imbedded. Spherules are recognized, but the matrix likewise exhibits a brecciated structure; grains of a dull black hue are also distributed through the mass. The siliceous portion acts on polarized light. The enclosed crystals are too small to allow of their form being recognized. This portion of the stone is acted upon by acid, and appears to consist of a mixture of olivine and enstatite. The Feid-Chair meteorite closely resembles the stones which fell at La Baffe, Dép. des Vosges (1822, September 13th), Heredia, Costa Rica (1857, April 1st), Canellas, near Barcelona (1861, May 14th), and Khetree, Rajpootana, India (1867, January 19th). This is the third occasion within the space of twelve years that meteorites have been seen to fall in Algiers and have been preserved.

1875, September 14th, 4 p.m.—Supino, circ. Frosinone, Rome.

The asserted fall of an aërolite on this date, as an authentic stone-fall, in the "Monthly Notices of the Royal Astronomical Society"

[1] *The Illustrated Australian News*, May 17th, 1875, page 68.
[2] G. A. Daubrée, *Compt. rend.* 1877, lxxxiv. 70.

(vol. xxxvii. pp. 205–6), is entirely refuted by a letter from Padre Secchi, in the latter volume of the "Monthly Notices" (p. 365), in which the real circumstances of the supposed meteor and stonefall are related and described. A flash of lightning which occurred in the public square of Supino struck a neighbouring house with sufficient violence to dislodge a stone from the roof, without doing any more material damage to the house. The supposed "meteorite," which fell in the courtyard of the house, is identified by the Padre Secchi with the ordinary volcanic stones of the district, which is in the neighbourhood of an extinct volcano, and it probably lay (as it is customary to protect them against the force of the wind) upon the tiles of the roof until it was projected from its place by the lightning-stroke.

1875, December 27th, 9 p.m.—Kansas.

I have to thank Mr. Irish, C.E., of Iowa City, for two cuttings from newspapers (the *Kansas Chief* of December 30th, and the *Kansas Evening Post* of December 29th) recording the fall of a detonating meteor of the above date. It traversed the heavens in a direction from N.W. to S.E., leaving a lurid streak in its wake. The whole heavens were lighted up, and "made all out of doors almost as light as full moonlight." The meteor was of the usual whitish-red colour, and when it exploded the fiery fragments were scattered in all directions. "Perhaps two minutes later, and after all appearance of the meteor had disappeared, the sound of the explosion came like the discharge of a heavy cannon; or rather one loud explosion, immediately followed by a lighter one like an echo. The explosion jarred houses and rattled windows. The size of the meteor and the terrible force of the explosion may be imagined from the fact that the distance was so great that it required about two minutes for the sound to reach the earth, and that the concussion was plainly felt and heard at that distance. The phenomenon was witnessed over a large extent of country." An observer, writing from Fort Leavenworth, states that it appeared to have its origin in the constellation Cassiopeia, and its course was due east. Mr. Irish states that he has made every effort to secure possession of the meteorites which must have fallen, but has been unsuccessful. The time of flight is estimated to have been from 12 to 15 seconds.

1875, December 27th, 9·20 p.m.—State of Missouri, U.S.A.[1]

I am indebted to Mr. Irish, C.E., of Iowa City, for an interesting description of this detonating meteor, as well as for a map, on which he has traced its course. The point where it was first seen in the zenith is at Thayer, in Nebraska, near the borders of Kansas, and about 120 miles W. of the Missouri River. It was seen by him at

[1] See also G. C. Broadhead, *Trans. Acad. Science of St. Louis*, III. No. 3, 349.

Iowa City first as a small meteor, which rapidly became brighter, and was hidden from view when at an altitude of about 40° by a building; at this moment it gave out a very brilliant quivering flash of light, which illuminated the whole heavens. It appears from Mr. Irish's map to have been seen over a wide area, from Stillwater in Minnesota on the north, to Buffalo in Missouri on the south, and as far west as the shores of Lake Michigan. Near the termination of the flight sounds were heard: over Archer, in Nebraska, a rushing roaring sound, as of a mighty wind, was noticed; at St. Joseph, in Missouri, the first distinct explosion was remarked, and between that town and Livingstone Co. frequent and very heavy detonations occurred. In the last-mentioned district, and at places as far as 60 miles distant, numerous red fragments were seen to fall. He says, "I have had several persons looking for the meteorites where the fall must have taken place; but the whole district is covered with dense forest, and is mountainous and broken, and the ground was very soft from the long-continued rains preceding the fall, so that no fragments have been found. All the observers of the final explosion agree that the great bulk of the material was thrown upward and backward upon the course of the meteor, as the arrow-pointed dots in my sketch indicate. The luminous appearance continued in sight for 15 minutes."

1876, January 5th, 10·30 p.m.—Iowa and Missouri.

This meteor, according to Mr. Irish's letter and accompanying map, was witnessed over an area extending from Cass, in Iowa, to Grundy, in Missouri. It appeared to descend almost perpendicularly, and was a very brilliant meteor, and a very noisy one also. A series of reports, twenty-two in number, were heard during its transit from Cass to Grundy. The rumbling thunder of its artillery, together with its flashes of brilliant light, brought people from their beds with an apprehension that the great Civil War had broken out afresh. Its time of flight over the area indicated was not more than five seconds, and the light it emitted is said to have equalled that of noonday. None of the meteorites which must have fallen have been found, for the reasons already referred to when speaking of the detonating meteor of December 27th.

1876, January 31st, 5·30 p m.—Louisville, Kentucky.[1]

Dr. Lawrence Smith, of Louisville, observed a magnificent meteor traversing the heavens on the afternoon of the above day. He first saw it at an altitude of about 60° above the horizon, and it disappeared from view behind some houses at an elevation of about 20°. Its direction appears to have been from N.W. to S.E., and the angular magnitude about one-sixth that of the disk of the moon. It was

[1] J. L. Smith, *Amer. Journ. Sc.* 1876, [3], xi. 458.

seen over an area 120 miles in diameter. A number of observers witnessed an explosion which took place when the meteor was about 10° above the horizon; all the fragments disappeared instantly, except the largest, which also became invisible before it reached the horizon. One or two of the eye-witnesses think they noticed a whizzing noise, and at the time of bursting heard the explosion. No fragments of a meteorite have yet been met with; but it is the opinion of Dr. Smith that they fell about the range of the Cumberland Mountains in Kentucky, or in the north-east of Tennessee.

1876, April 7th (evening).—Eperjes, Hungary.[1]

A fireball passed over Eperjes 8° [? E. or W.] from the meridian, and detonated at an altitude of 38° above the horizon. It exploded with a very loud noise, and broke into numerous fiery fragments.

1876, April 20th, 3·40 p.m.—Rowton, near Wellington, seven miles north of the Wrekin, Shropshire.[2]

It is not a little curious that twice in five years the British Islands have been visited with meteoric falls; in each case a single specimen has been found and, the one a small block of iron, the other a small mass of rock, they constitute the prettiest little cabinet specimens of the two chief typical classes of meteorites. The former fell at Rowton, in April, 1876; the other near Middlesborough, in Yorkshire, on March 14th, 1881, and will be described later on (p. 218). The Rowton iron weighs $7\frac{3}{4}$ lbs. A strange rumbling noise was heard in the air, followed almost instantaneously by a startling explosion resembling a discharge of heavy artillery. Rain was falling heavily at the time. About one hour after the explosion was heard a man had occasion to go into a turf field, in his occupation and adjoining the Wellington and Market Drayton Railway, when his attention was attracted to a hole cut in the ground. He probed it with a stick and at a depth of eighteen inches, four inches being of soil and fourteen of solid clay, he found the mass of iron. The hole was nearly perpendicular, but the meteorite appeared to have fallen in a S.E. direction. The mass was quite warm, it appears, when found.

The meteorite passed into the hands of Mr. Ashdown, the agent of the Duke of Cleveland, who presented it to the Trustees of the British Museum. The national collection contains 351 distinct meteorites, and of these 118 are iron masses, the fall of only seven of which has been witnessed; nine stony meteorites have fallen in the British Islands and the Rowton iron is only the second iron meteorite known as having been found in Great Britain. Mr.

[1] Egyetértés és Magyar Ujsag. Budapest, April 13, 1876.

[2] *Wolverhampton Chronicle*, and *Birmingham Daily Post*; *Nature*, April 7th, 1876, and *Nature*, July 27th, 1876. Walter Flight, Paper read before the Royal Society, February 9th, 1882.

METEORIC IRON,

WHICH FELL AT ROWTON, NEAR WELLINGTON, SHROPSHIRE.

ON THE 20TH APRIL, 1876, 3:40. P.M.

Maskelyne pointed out the resemblance to be traced between this iron and that of Nedagolla in India, both in its depth of penetration into the soil as well as the direction of the little mass in space.

The iron of this meteorite is compact and bright, and the greater part of the surface is covered with a thin film of magnetite: the point where it struck the ground is worn bright (see plate). The composition of this iron was found to be:—

	I.	II.
Iron	91·250	91·046
Nickel	8·582	9·077
Cobalt	0·371	
Copper	trace	trace
	100·203	100·123

The fragment of iron chosen for analysis contained half a nodule of troilite, which was easily removed, and on analysis was found to have the composition:—

		Theory.
Iron	63·927	63·64
Sulphur	36·073	36·36
	100·000	100·00

The occluded gases removed at a red heat with a Sprengel pump consisted of:—

Carbonic acid	5·155
Hydrogen	77·778
Carbonic oxide	7·345
Nitrogen	9·722
	100·000

The gases extracted were 6·38 times the bulk of the iron taken for experiment; an unusually large quantity, due doubtless to the iron being examined so soon after its fall.

1876, June 25th, 9—10 a.m.—Kansas City, Missouri.[1]

A small meteorite fell between nine and ten in the morning of the above day, on the tin roof of the house, No. 556, Main Street, Kansas City. It struck the roof with sufficient force to cut a hole in the metal; but it did not pass through, bounding back a few feet and coming to rest on the roof. Two observers who were at a window close by heard the sharp concussion when it struck the roof, and one of them immediately picked up the meteorite as it lay near her on the roof, but let it fall again, finding it too hot to retain in the hand. It is described as of a plano-convex form, one inch and three quarters along its greatest length and about one third of an inch thick. "The convex surface possesses the usual crusted appearance, while the inside or plane surface differs from ordinary meteorites in possessing the appearance of sulphuret of iron, sub-

[1] J. D. Parker, *Amer. Journ. Sc.* 1876, vol. xii. p. 316.

jected to some degree of heat, instead of nickeliferous iron. One might easily infer that the meteorite was shaled off from a large bolide that passed over the city at that time." It is much to be desired that this meteorite will pass into the hands of a scientific expert for examination and description.

1876, June 28th, 11·50 a.m.—Ställdalen, near Kopparberg, Örebrolän, Dalecarlia, Sweden.[1]

A meteor traversed a part of Central Sweden in a W.N.W. direction, and was plainly visible in the very bright sunshine. It was observed at Stockholm and Södermanland; at 13 English miles S.W. of Linköping it was seen first in a N.W. direction, and at a considerable altitude, and it descended almost to the horizon in the west. A loud whistling noise was heard in the air from E. to W., followed by two sharp reports, and others less loud resembling thunder. The fall of the meteorites was witnessed by eight or ten persons, and three or four fragments have been secured by Dr. Lindström. The largest, about the size of two fists, weighs 4½ skalpund [1 lb. av.=1·068 ltt. or skalpund]. Ställdalen is a station on the Swedish Central Railway, on the northernmost part of Örebrolän. Some of the meteorites fell in water and have been lost.

It was subsequently ascertained that the total number of stones found is eleven, and they weigh collectively 34 kilog. Lindström finds the total composition of a portion of one of these stones to be—

Silicic acid	35·71
Phosphoric acid	0·30
Alumina	2·11
Chromium oxide	0·40
Iron protoxide	10·29
Manganese protoxide	0·25
Nickel protoxide	0·20
Lime	1·61
Magnesia	23·16
Soda	0·62
Potash	0·15
Iron	21·10
Nickel	1·61
Cobalt	0·17
Phosphorus	0·01
Sulphur	2·27
Chlorine	0·04
	100·00

[1] A. E. Nordenskjöld, Föredrag i Mineralogi vid Akademiens årshögtid den 3 April, 1877. ('Aftonbladets Aktiebolags Tryckeri,' Stockholm, 1877.) [See also *Nature*, July 19th, 1877.]—G. Lindström, 'Öfversigt af Kongl. Vetenskaps Akad. Förhandl.,' No. 4, 1877, p. 35.

Of these ingredients, 4·51 per cent. constitute magnetic pyrites, and 14·65 per cent. nickel-iron, the composition of which appears to be—

Iron	90·78
Nickel	8·29
Cobalt	0·88
Phosphorus	0·05
	100·00

The portions (I.) gelatinisable with, and (II.) unacted upon by, acid have the following composition:—

	I.	II.
Silicic acid	36·76	57·37
Phosphoric acid	0·83	0·07
Alumina	0·13	5·07
Iron protoxide	20·35	8·03
Nickel oxide	0·60	—
Manganese oxide	—	0·63
Lime	0·64	3·41
Magnesia	40·47	23·54
Soda	0·18	1·38
Potash	0·16	0·23
Chlorine	0·13	—
	100·25	99·73

In the soluble portion the oxygen ratio of acids to bases is 20·08 : 21·16, and in the insoluble part 30·64 : 15·08. In addition to olivine and bronzite, this meteorite appears to contain an insoluble felspar and a little apatite.

1876, December 21st, 8·40 p.m.—Rochester, Fulton Co., Indiana. [Lat. 41° 8′, Long. 86° 12′.][1]

This remarkable meteor passed over the States of Kansas, Missouri, Illinois, Indiana, and Ohio, a distance from E. to W. of about 800 miles. It burst into numerous fragments during its passage, producing "a flock of brilliant balls chasing each other across the sky, the number being variously estimated from twenty to one hundred." Over all the regions of Central Illinois a series of terrific explosions was heard. Over the northern part of Indiana the passage of the body was followed by loud explosions. A piece of the meteorite, a few ounces in weight, fell near Rochester, Ia. A portion, now in the possession of Prof. Shepard, was discovered on the following day lying in the snow. Two places were noticed where it had previously struck, whence it had bounded to its resting-place. It is stated by Prof. Shepard to closely resemble the meteorite of Pegu, India (27th December, 1857), and to consist of dark ash-grey spherules (boltonite), imbedded in a nearly white pulverulent

[1] H. A. Newton, *Amer. Journ. Sc.* 1877, xiii. 166; J. L. Smith, *Amer. Journ. Sc.* 1877, xiii. 243, and xiv. 219; C. U. Shepard, *Amer. Journ. Sc.* 1877, xiii. 207; Prof. Kirkwood, *Amer. Journ. Sc.* 1877, xiv. 75; *Western Review of Science and Industry*, 1877, i. No. 1, Kansas City, Mo. 39.

matrix, "chladnite," olivine in distinct grains, nickel-iron, and a little troilite. The specific gravity of a fragment partially covered with crust was 3·65.

According to Prof. Kirkwood its elevation at Bloomington, where it was well noticed, was fifteen degrees, and it is calculated that the length of the observed track was from 1000 to 1100 miles, one of the longest on record. Its height is supposed to have been thirty-eight miles above the place where the small fragment fell from it. Its velocity in reference to the earth's surface appears to have been from eight to twelve miles per second. The pyrotechnical display is said to have been transcendently beautiful.

The entire fragment did not weigh 400 grammes, and it is reasonable to suppose that the stone itself was dissipated into very minute fragments and dust, as appears to have been the case in the Hessle fall and in other similar instances. The stone, according to Dr. L. Smith, is markedly pisolitic (highly chondritic), very friable, of a grey colour, is easily crushed between the fingers partly into a light powder, or fine dust, and partly to small globules, some of which are perfectly spherical. In many respects it appears to bear a close resemblance to the Ornans meteorite. Dr. L. Smith found it to resemble most closely the Aussun stone. The coating is dull black and quite rough, and the specific gravity is 3·55. The stone contained 3·31 per cent. of troilite, and on treatment with hydrochloric acid was found to consist of:—

A. Soluble silicates	47·80
B. Insoluble silicates	52·20
	100·00

which contained respectively :—

	A.	B.
Silicic acid	34·55	57·81
Iron protoxide...	27·75	11·04
Alumina...	trace	0·23
Chromium oxide	——	0·10
Lime	trace	5·31
Magnesia...	36·38	24·97
Soda...	0·46	0·84
	99·14	100·30

Some of the globules, when picked out and analyzed, were found to possess the same composition as that of the complete rock itself, which showed them to be merely concretions of the matrix. The nickel-iron contained :—

Iron = 94·49 ; Nickel = 4·12 ; and Cobalt = 0·51 : total 99·12.

The mineral constituents of the Rochester meteorite are :—

Bronzite and pyroxene minerals...	46·00
Olivine...	41·00
Nickel-iron	10·00
Troilite	3·00
Chrome iron	0·15

1877, January 3rd (Sunrise).—Warrenton, State of Missouri. [Lat. 38° 50′; Long. 91° 10′.][1]

A sound like that of a cannon ball passing through the air was heard by four observers near Warrenton. On looking up they saw an object falling, which struck a tree, breaking off the limbs and then coming to the ground with a crash. The observers were fifty or sixty mètres distant from the spot. The snow was melted where the meteorite fell. From the fragments found, it appears to have had a conical form, and to have been about eighteen inches in length. The pieces, although warm, were easily handled. It is estimated that the stone weighed about one hundred pounds, but only about from ten to fifteen pounds weight have been preserved.

In one specimen the fibres of some of the branches are found adhering to the rough crust of the stone, and though delicate show not the slightest sign of having been heated. No luminous phenomena attended the fall, which appears to have been slow; "it was no doubt a meteorite well spent in its rapid motion through the atmosphere." Its direction, as far as could be ascertained, was from N.W. to S.E.

The stone differs in a marked degree from that of Rochester, although it also is pisolitic and fell only a few days previously. In chemical composition it closely resembles the Ornans meteorite, which fell 11th July, 1868, and the results of Dr. Smith's analysis closely accord with those found by Pisani[2] on analyzing that stone.

The crust in this case is unusually thick, being in some places from two and a half to three and a half millimètres in thickness. The interior has a very dark uniform ash colour, is soft, and is easily crushed. The density of the stone is 3·47; the troilite forms 3·51 per cent. of the stone and the nickel-iron 2·01 per cent.

By treatment with acid it was found that there were present:—

A. Soluble silicates	80·40 per cent.
B. Insoluble silicates	19·60
	100·00

which contained respectively:—

	A.		B.
Silicic acid	33·02	..	56·90
Iron protoxide	37·57	..	10·20
Alumina	0·12	..	0·20
Chromium oxide	——	..	0·33
Lime	trace	..	7·62
Magnesia	28·41	..	22·41
Soda	0·07	..	1·00
Nickel oxide	1·54	..	
Cobalt oxide	0·31		
	101·04	..	97·66

The chromium appears to be in the form of chromite, amounting

[1] J. L. Smith, *Amer. Jour. Sc.* 1877. xiii. 243; and xiv. 222.
[2] *Compt. rend.* 1868, lxvii. 663.

to 0·5 of that mineral; and the nickel oxide to be a constituent of the soluble silicates. The nickel-iron, which is present in very small quantity, contained

Iron = 88·51; Nickel = 10·21; and Cobalt = 0·60: total 99·32.

The mineral constitution of this meteorite was calculated to be as follows:—

Olivine minerals	76·00
Bronzite and pyroxenic minerals	18·00
Nickel-iron	2·00
Troilite	3·50
Chrome-iron	0·50

The proportion of olivine present in this stone is unusually high.

1877, January 23rd, 4 p.m.—Cynthiana, Harrison Co., Kentucky.[1]

At the date given above a brilliant meteor was seen traversing Monroe County, Indiana, in a S.E. direction, about thirty-five degrees above the horizon; it was also seen by several persons in Decatur County of the same State, lat. 39° 27′, long. 85° 28′, where it disappeared just as it seemed to touch the earth, not more than a quarter of a mile distant. It really fell about sixty miles away. Apparently it was not seen in the State of Ohio, but in the State of Kentucky it was observed over a considerable territory. The phenomenon culminated in the usual noises heard in the heavens. Fortunately one observer, an intelligent farmer, heard a solid body strike the ground; he walked immediately to the spot and dug the stone out from a depth of thirteen inches.

The stone weighs six kilogrammes; it is wedge-shaped, with one portion of it very extensively and regularly pitted, while the rest is comparatively smooth. The crust is dull black and is as perfect as when the stone fell. There was a fresh broken spot of two or three square centimètres which was evidently made prior to the fall, for a few small specks of the melted matter adhered to the surface. In texture the meteorite belongs to the harder brecciated variety; and when broken presents a mottled surface, identical with that of the Parnallee stone, which it resembles in every other particular. The specific gravity of the two meteorites is identical, viz. 3·41.

The Cynthiana stone, when treated with hydrochloric acid, gave:—

A. Soluble silicate	56·50
B. Insoluble silicate	43·50

which were found to have the following composition:—

	A.	B.
Silicic acid	33·65	57·60
Iron protoxide	30·83	11·42
Alumina	0·11	0·43
Chromium oxide	——	0·38
Lime	trace	5·70
Magnesia	34·61	23·97
Soda	——	1·24
	99·20	100·74

[1] J. L. Smith, *Amer. Jour. Sc.* 1877, xiii. 243; and xiv. 225.

The troilite amounted to 5·50 per cent. and the nickel-iron to 5·93 per cent., which had the composition :—

Iron = 90·64; Nickel = 8·35; and Cobalt = 0·73: total 99·72.

The mineral constituents are easily distinguished by the eye, and consist of:—

Olivine minerals	50·00
Bronzite and pyroxenic minerals	30·00
Nickel-iron	6·00
Troilite	5·50
Chrome-iron...	0·52

In recording the three interesting falls at Rochester, Warrenton and Cynthiana, Dr. L. Smith draws attention to the remarkable fact that during a period of eighteen years there have been twelve falls of meteorites in the United States, of which specimens have been collected. Eight of these falls, with over one thousand kilogrammes of matter, have occurred over the prairie regions of the West, not far from his home; and the extreme limit of these falls is within a region not exceeding one-eighth of the surface of that part of the United States which is east of the Rocky Mountains. The population of this area is not much above the average of that country. The four other falls in the United States during the same period were attended with the descent of less than two kilogrammes.

1877, March 16th, 8 p.m.—Uitenhage, Cape of Good Hope, South Africa.[1]

A magnificent fireball, such as few would ever see in a lifetime, made its appearance in the East, "coming out of the eastern horizon" at Uitenhage, "and travelling slowly across the firmament in an oblique direction to the westward, when it burst, sending forth streams of fire, as if from a hundred rockets, and then was heard a low rumbling noise as of thunder in the distance. The meteor appeared to be nearly if not quite as large as the full moon, but not round, more of an oblong shape, and while travelling through the air it very much resembled a large turpentine ball. It gave forth a bright bluish light, which lit up the whole sky, and you could distinguish everything around you for miles as plainly as in the day-time." Native Hottentots and Kaffirs, the account adds, were so terrified that they sought refuge in the nearest houses, and the apparition of the fireball was regarded by them as a warning of approaching famine, drought, or some other calamity. None of them had ever seen a meteor of anything like the size or half so brilliant as the present one. The oxen in the wagons stopped on the road and could not for some time be got to start again, others turned round, snapped off the disselbooms of the waggons, and bolted for some distance into the bush. The consternation was general in the country round Uitenhage. The illumination lasted nearly a minute, and the light was such that it dazzled the eyes of all who saw it. The events recorded took place on a beautiful starlight evening.

[1] *The Times*, London, May 21, 1877.

1877, May 17th, 7 a.m.—Hungen, between Steinheim and Borsdorf Provinz, Oberhessen.[1]

An eye-witness of the fall of one of these meteorites states that, as he was passing through a wood, on his way from Steinheim to Borsdorf, he heard a noise as of thunder, although the sky was cloudless, followed by a humming, hissing, whistling sound, such as would be caused by a number of stones rapidly rushing among the trees. One stone struck a pine tree close by him, severed a branch about the thickness of the finger, and fell at his feet. It was some time before he could convince himself that the object before him was not alive, but when he at last ventured to raise it from the ground he found it was cold.

Buchner visited the locality five months later and found a second stone, weighing 26 grammes. The first must have weighed more than 86 grammes, and a portion of it weighing 73·26 grammes has been deposited in the mineralogical collection of the University of Giessen. It has an irregularly triangular and flattened form, and less than one quarter of the stone has apparently been removed. It should be stated here that Buchner learned from several who were able to bear witness to the occurrence, that the sound attending the descent of the meteorites proceeded in a direction from N.W. to S.E. The freshly fallen leaves of mid-October rendered hopeless further search for the other stones which must have fallen.

The crust of the meteorite is dull black and thin, and exhibits here and there granules of nickel-iron. The fractured surface displays a grey, occasionally brownish, matrix, which is traversed by a very thin but very conspicuous brilliant black band of material; it runs obliquely to the flattened side of this stone, and is also found in the smaller mass, picked up five months later, which evidently never formed part of a larger meteorite. On another part of the fractured surface of the larger stone, a second black line, parallel to the first, but less brilliant, is to be seen. Abundant particles of nickel-iron and troilite are met with; and the crust appears to consist, to the extent of one-half, of the metallic alloy. Examination under the microscope shows the groundmass to be colourless and transparent, and to be fissured in every direction. It appears to consist of olivine. Some olivine spherules are quite conspicuous, surrounded either by the black material or nickel-iron; other chondra have a banded or radiate structure, like those observed by Tschermak in the aërolites of Sherghotty or Gopalpur, and appear to be bronzite; and lastly there are spherules of a homogeneous grey translucent substance, devoid of or rarely traversed by fissures. Buchner states that the meteorite of Hungen, while a member of the most common class of meteorites, can easily be distinguished from those which fell at Agen, Girgenti, New Concord, Knyahinya, Krähenberg, Pultusk, and many others which he mentions.

The smaller stone was presented to the Vienna Collection, and

[1] O. Buchner and G. Tschermak, *Mineralogische Mittheilungen*, 1877, 313.

forms the subject of a few notes by Tschermak in an appendix to Buchner's paper. He describes its characters, which nearly approach those of the Pultusk stones. The black crust has the unusual thickness of 1·5 mm., and incloses particles of nickel-iron, granules of magnetic pyrites (troilite ?), and even lustreless chondra, which may consist of chromite or picotite. The transparent minerals constituting the chief mass of the stone are of three kinds: 1. *Olivine*, recognized by its rectangular cleavage and few included minerals, and by its contributing but little to the chondritic character of the stone; 2. *Bronzite*, in granules and aggregated crystals, showing a prismatic cleavage, the latter being either barred or radiate, or contorted and forming the greater number of the chondra; and 3. *Diallage*, for such Tschermak believes to be a brown mineral, forming angular fragments, which are found not to be rhombic, and to resemble an augite. Chromite occurs in granules, and in larger crystals than are met with in other meteorites.

This interesting stone has not yet been analyzed.

1877, October 13th, about 2 p.m.—Soko-Banja, N.E. of Alexinatz, Servia.[1] [Long. 20° 53′ E. of Greenwich; Lat. 43° 38′ N.]

Döll's paper, which appears in the "Transactions of the Austrian Geological Society," contains two descriptions of the fall of meteorites at Soko-Banja, drawn from two different sources. The first, taken from the Servian weekly literary journal "Javor," published at Neusatz, is written by an eye-witness of the occurrence, who states that the 13th October was fine, and the sky clear, and that about two in the afternoon a noise as of thunder was heard resembling batteries of cannon firing briskly. The sound was followed by a violent concussion of the air, and then a number of aërolites were strewn over the adjacent region. One weighing 10 okas (22½ Austrian pounds), fell in front of a house in Soko-Banja, and was driven deep into the earth; a second, which struck the ground at Scherbanowaz, near the Rtanj Berg, weighed 30 okas (67½ Austrian pounds), and is the largest mass which was collected. The peasants at Reanj state that one which fell in that locality was of the size of a sack of flour, and that by striking the rocky surface it was dashed to fragments. From the second and later report, provided by Ritter von Stefanowitsch, of an inquiry instituted by some scientific men from Belgrade, it appears that two explosions like salvoes of artillery were heard, accompanied by a brilliant display of light such as attends the bursting of shells. A dense black smoke was observed at a considerable altitude, which broke up into three columns, and gradually changed to a white smoke. The noise lasted for some time, and then the sound resembled the firing of musketry. The air appeared to be shaken. Soon after the explosion commenced a number of meteorites fell to the ground over an area of a mile and

[1] E. Döll, *Verhandl. der K.K. Geolog. Reichsanstalt*, 1877, No. 16, 283. S. M. Losanitch, *Berichte der deutschen chemischen Gesellschaft*, 1878, xi. 96.

a half in length and half a mile in breadth. The following masses have been collected:

1. One, weighing 23 okas, fell in the village of Scherbanowaz, and penetrated the soil to the depth of four feet. This is the one mentioned in "Javor."

2. One, weighing 15 okas, fell near the vineyard at Soko-Banja, and reached the depth of three feet. This appears not to be the mass referred to in "Javor."

3. Two stones found at Blandija.

4. A fragment, weighing 2 okas, was found at Prevalač.

5. A meteorite of small size fell at Gradič (Prevalač and Gradič are hamlets, west of and close to Soko-Banja).

6. A number of pieces of various sizes fell at Dugopolje, and several very small stones are reported to have fallen on the Djeviza Planina.

One fragment, 2 okas in weight, fell on a pear tree, and then descended to the ground; a man who was under the tree took it in his hands, and received the impression that the mass was still warm.

The meteorites were sent to the Natural History Museum at Belgrade. Döll's paper contains two little maps indicating the area over which the stones were strewn. He describes a small specimen which came into his possession: the matrix is bluish grey and compact, inclosing spherules which vary in size from that of a millet-seed to that of hare-shot, and which project from the fractured surface. But little nickel-iron or magnetic pyrites (troilite?) could be seen. He noticed patches of a brown colour, which he considers characteristic of this meteorite.

Losanitch, in his communication to the Berlin Chemical Society, which appeared subsequently, states that an interval of 25 seconds elapsed between the appearance of the meteor and the first explosion, which was followed by *two* others. The explosion occurred at an altitude of 7000 mètres. The path of the meteor made an angle of 220° 50′ with the magnetic meridian, and was thus directed from N.E. to S.W.; it was inclined at a large angle to the horizon. The track of the meteor has been calculated by Kleritj, and the details are to be found in "Glasnik," the journal of a Servian learned society. He makes the entire weight of the stones, whole and in fragments, to reach 80 kilog.

All the meteorites are coated with a black rough vitreous crust 0·5 mm. in thickness, exhibiting numerous depressions. The interior consists of spherules of various sizes, some brown, some yellow, cemented together by an ash-grey material, and presents the appearance of a trachytic lava. In polished sections, prepared for microscopic examination, nickel-iron in granules, hackly fragments and filiform particles, is to be recognized. The specific gravity of the meteorite is 3·502. The meteorite consists of:—

	I.	II.
Nickel-iron...	3·8	3·7
Silicates	96·2	96·3
	100·0	100·0

and a little iron sulphide. A fragment of the nickel-iron, which was separated from all adhering silicate, possessed the composition:—

Iron...	78·13
Nickel	21·70
Copper	0·17
	100·00

This is a high per-centage of nickel; the ratio of the metals is—Fe : Ni as 4 : 1. The iron sulphide was found to be the monosulphide, and to contain 63·84 per cent. of iron; theory requires iron=63·64 per cent. Analyses of the complete meteoric rock, containing the metallic alloy and iron sulphide, but freed from all trace of crust, were made—(1) by treating it with hydrochloric acid and caustic potash, which removed constituents amounting in three cases to 60·50 per cent., 61·44 per cent., and 61·79 per cent.; and (2) by determining the ingredients of the portions (I.) acted upon by, and (II.) withstanding these reagents. They are as follow:—

	I.	II.
Silicic acid	32·24	56·66
Iron protoxide	28·41	23·55
Manganese oxide	0·20	0·003
Magnesia	30·53	20·84
Soda	0·43	—
Potash...	0·09	—
Iron	0·70	—
Nickel...	0·17	—
Iron monosulphide = 6·78 { Fe	=4·31	—
S	=2·47	—
Chromite	—	0·11
Phosphorus...	—	trace
	99·55	101·63

Neither alumina nor lime appears to be present in this meteorite, and augitic and felspathic constituents are consequently absent. The oxygen present in the two silicates amounts to—

	I.		II.
(Silicic acid)	17·19	... ...	30·20
(Iron protoxide) 6·31 } (Magnesia)... ... 12·21 }	=18·52	... { 5·23 9·33 }	= 14·56

The soluble portion, therefore, is an olivine, having approximately the composition represented by the formula 2($\frac{2}{3}$ MgO, $\frac{1}{3}$ FeO), SiO_2; and the insoluble part a bronzite of the form ($\frac{2}{3}$ MgO, $\frac{1}{3}$ FeO), SiO_2; the ratio of iron oxide to magnesia being the same in both silicates.

1877, Nov. 9.—Cronstadt, Orange River Free State, S. Africa.

All that I have yet been able to gather respecting this occurrence is, that a shower of stones fell near Cronstadt on Nov. 9, 1877, in a wooded district, so that few of them could be collected. One of them, weighing 346 grammes, is preserved in the British Museum.

1877, December 26th, 8 a.m.—Between Höhr and Ballendar, near Coblentz.

A correspondent of the "Coblenzer Zeitung," dating from "Höhr, 27th December," writes that on the preceding day two meteorites fell near the road leading to the former frontier, in the direction of Ballendar, and that the fall was attended by a very characteristic explosion. The editor of the above journal has been unable to gather any further particulars of the occurrence beyond the fact that the stones fell in a wood, and could not be discovered.

1877.—Casey County, Georgia.[1]

A fragment of this iron in the Vienna Collection is stated by the writer to exhibit broad and very regular Widmanstättian figures. The beam-iron averages 2 mm. across; it is almost exclusively developed, and presents unusually sharp lines of etching. Band-iron and interstitial iron are only present in traces, and schreibersite and troilite are not recognizable.

Found 1877—9.—Whitfield County, Georgia.[2]

A fragment in the shape of a wedge was found to exhibit Widmanstättian figures of average size, which in certain places by the massive development of schreibersite were broken through: the band-iron is of average breadth, the interstitial iron distinguished by its unusual dark colour. In many places the magnetite fills partings which penetrate from the natural surface to a depth of 2 to 3 centimètres into the iron.

The original specimen,[3] weighing 13 lbs., was found in 1877 on a farm about 20 miles N.E. of Dalton, near the Tennessee and North Carolina State lines; it is now in the State Museum at Atlanta.

In 1879 a second specimen[4] of meteoric iron, weighing 117 lbs., was found about 14 miles N.E. of Dalton: it is now in the possession of C. U. Shepard, junr., of Charleston, North Carolina. "Some time during the year 1860 an unusual atmospheric phenomenon occurred in the region. A bright light shot across the heavens, followed by a loud report, creating great alarm among the people, many of whom supposed the end of the world had arrived. A large mass of iron was found half a mile from this one, about the year 1862: it was sent to Cleveland, Tennessee, where it appears to have been lost sight of."

1 A. Brezina, *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct. part.
2 A. Brezina. *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct. part.
3 *Amer. Jour. Sc.* 1881, [3], 21, p. 286.
4 *Amer. Jour. Sc.* 1883, [3], 26, p. 336.

1878, July 15th, 2·45 p.m.—Tieschitz, in Moldavia.[1]

A stone fell at this date, with the usual accompanying noise, within 100 paces of some people whose attention was directed by a child four years of age to a small dark cloud, from which a peculiar and increasing sound proceeded. This cloud was suddenly seen to become incandescent, but in no very high degree, and the noise became still more intense when a body was seen to fall from the cloud. The stone was warm when found. The noise was heard about the neighbourhood two miles around. The stone was secured and sent on the 29th to the Museum of the Technical High School, of Brünn. The meteor appears to have passed over Daubrawic and Sloup, and the path to have been directed from azimuth 108° altitude 40°, or from an apparent radiant point in R.A. 68°, N. declination 40°.

One stone only was found, and all search for other specimens of the fall was in vain. The stone weighs 27·4 kilogrammes, and has the form of an irregular pyramid with an almost square base.

The entire surface is covered with a black crust, which in some parts is of about the same thickness as that of the Pultusk stones; on the large convex side, which is called the "breast-side," it is much thinner, and exhibits a radiated character. On the back it is thicker and rougher, and without a trace of the radiated structure. The "breast-side" is free from all great depressions, while the others show them, due probably in part to the original form of the stone, partly to the action of currents of air on the melting surface. The freshly broken surface of the stone is dull ash-grey in hue, darker than the Pultusk stones, the texture finer and more sharply marked than in the case of most of the chondrites. We see many small dull grey or dark-coloured chondra, and splinters and fragments of the same kind, many larger dull grey chondra, also white small chondra and white fragments, the latter far fewer than the former. Between them an ash-grey earthy matrix, and very few yellow metallic lustrous particles. Most of the dark chondra are less than 1 mm. in diameter, those which have a diameter of 1 mm. are fewer, and there are occasional chondra which exceed 1 mm. in size; the largest one had a diameter of 5 mm.

The microscopic examination of sections of this meteorite displayed many curious features, and appears to confirm the views already expressed by Professor Tschermak regarding the origin of the chondritic structure.

Some chondra presented an appearance which has not hitherto been observed. They have round depressions, which point to a plasticity of the chondra during contact, as if the spherules which form the splintered fragments had acquired their form during the act of rubbing. Others again have projections of a rounded form, or an almost pointed end. These chondra are the result of volcanic eruptions or explosion.

Olivine.—Both in the matrix, and in many chondra, well-developed crystals of olivine were met with. They have the same crystalline

[1] *Denkschrifte der math. Naturwissenschaften-Classe, Akad. der Wissenschaften,* Wien. xxxix. November 21, 1878.

form as the olivine in basalt. Many of the chondra consist of individual crystals. Many crystals have cavities inclosing black angular grains, or a black impregnation of the crust, or black slightly translucent spherules or inclosures of "glass"; some exhibit a most distinct surface of the inclosed material.

Bronzite.—Barred and fibrous individuals of a brown colour are regarded as bronzite. Some of the barred chondra shown in the plate accompanying the paper of Makowsky and Tschermak are very perfectly developed and very curious. Some have a darker border, others a lighter rim. In these chondra also the inclosed material already referred to is met with.

Enstatite.—Many of the chondra of this mineral are distinguished by their marked foliated structure, and specimens of such are shown in the plate. Enclosed "glass" is also found in them. Many spherules, and fragments of spherules, of a crystallized mixture of bronzite and olivine or of enstatite and olivine, were noticed, none however of a crystallized mixture of bronzite and enstatite, and it appears therefore as if this meteoric tuff originated from two sorts of stony mixtures.

Augite.—A few small chondra with a compact pale-coloured crust have a texture and colour which differs from all the foregoing. The entire spherule is shown by polarized light to be one individual; the crust is almost colourless, the interior has a brownish-green hue. Their reaction with light points to their being augite.

Magnetic Pyrites and Nickel-iron.—Magnetic pyrites occurs as grains inclosed in the other chondra and splinters of chondra, as well as free in the matrix. The nickel-iron is for the most part in the form of irregular particles with a hackly surface in the matrix. In some of the spherules both magnetic pyrites and nickel-iron have a distinct concentric arrangement.

The stone of Tieschitz belongs to that division of the chondritic meteorites which Tschermak some years since classified as remarkable for "many brown finely fibrous chondra." The specific gravity of the stone is 3·59. It contains about 85·0 per cent. of non-metallic minerals. No trace of any mineral resembling a felspar could be detected. The percentage composition of the stone was as follows:—

	Olivine	Bronzite and Enstatite	Augite	Magnetic Pyrites	Nickel-iron	Total — Calculated	Total — Analysis
SiO_2	13·99	18·84	7·90	—	—	40·73	40·23
Al_2O_3 . ..	—	—	2·09	—	—	2·09	1·93
FeO	13·86	5·47	0·73	—	—	20·06	19·80
MgO	10·94	9·53	0·61	—	—	21·08	20·55
CaO	—	—	1·42	—	—	1·42	1·54
Na_2O.....	—	—	1·26	—	—	1·26	1·53
Fe	—	—	—	2·46	7·97	10·43	10·26
Ni ...	—	—	—	—	1·31	1·31	1·31
S	—	—	—	1·62	—	1·62	1·65
	38·79	33·84	14·01	4·08	9·28	100·00	98·80

or,	Olivine ...	38·79
	Bronzite and enstatite ...	33·84
	Augite ...	14·01
	Magnetic pyrites ...	4·08
	Nickel-iron ...	9·28
		100·00

1879, May 10, 5 p.m.—Estherville, Emmet Co., Iowa.[1]

This curious meteorite fell near Estherville in lat. 43° 30′ N., long. 94° 50′ W., within that region of the United States which has been remarkable for falls of meteorites, three having fallen at Rochester in Indiana, Cynthiana in Kentucky, and Warrenton in Missouri, within the space of a month. The phenomena attending this fall were of the usual character, but on a grander scale. It occurred about five o'clock in the afternoon of May 10, 1879, with the sun shining brightly. In some places the meteorite was plainly visible in its passage through the air, and looked like a ball of fire with a long train of vapour or cloud of fire behind it; and one observer saw it one hundred miles from where it fell. Its course was from N.W. to S.E. The sounds produced in its course are described as being "terrible" and "indescribable," at first louder than the loudest artillery, followed by a rumbling noise, as of a train of cars crossing a bridge. Two persons were within two or three hundred yards of the spots where the two larger masses struck the earth. There were distinctly two explosions: the first took place at a considerable height in the atmosphere, and several fragments were projected to different points over an area of four square miles, the largest going farthest to the east. Another explosion occurred just before reaching the ground, and this accounts for the small fragments found near the largest mass. This latter fell within 200 feet of a dwelling-house, at a spot where there was a hole, six feet deep, filled with water. The clay at the bottom of the hole was excavated to a depth of eight feet before the meteorite was reached. The second largest mass penetrated blue clay to a depth of five feet, at a spot about two miles distant from the first. The third of the larger masses was found on the 23rd February, 1880, at a place four miles distant from the first, in a dried-up slough. On digging a hole the stone was met with at a depth of five feet. The fragments thus far obtained weigh respectively 437, 170, 92½, 28, 10½, 4 and 2 pounds. The height of the meteor is calculated to have been 40 miles, and its velocity from 2 to 4 miles per second. The masses are rough and knotted, like mulberry calculi, with rounded protuberances projecting from the surface on every side. The black coating is not uniform, being most marked between the projections. These projections have sometimes a bright metallic surface, showing them to consist of nodules of iron; and they also contain lumps of an olive-green mineral, having a distinct and easy cleavage. The greater part of the stony material is of a grey colour with the green mineral irregu-

[1] J. L. Smith. *Amer. Jour. Sc.* June, 1880, xix. 459.

larly disseminated through it. The masses vary very much in density in their different parts; the average cannot be less than 4·5. When a mass is broken one is immediately struck with the large *nodules* of metal among the grey and green stony substance; some of these will weigh 100 grammes or more. In this respect this meteorite is unique; it differs entirely from the siderolites of Krasnojarsk, Atacama, etc., or the known meteoric stones rich in iron, for in none of them has the iron this nodular character. The large nodules of iron appear to have shrunk away from the matrix; an elongated fissure of from 2 to 3 millimètres sometimes intervenes, separating the matrix and nodules to the extent of one-half the circumference of the latter. The only mineral which could be picked out separately has a slightly green colour; it occurs in masses, from one half-inch to one inch in size, has an easy cleavage in one direction, and was found to be olivine. The same mineral occurs in minute rounded condition in other parts of the material; and minute, almost colourless, crystalline particles in the cavities are supposed to be olivine. Troilite exists in small quantity. A quantity of the silicates was picked out, separated as far as possible from iron, and treated with hydrochloric acid. The ratio of soluble to insoluble silicates varies very much in different parts of the meteorite, varying from 16 to 60 per cent. for the soluble part. The insoluble consisted of:—

		Oxygen.
Silicic acid	54·12	29·12
Iron protoxide	21·05	4·67
Chromium oxide	trace	—
Magnesia	24·50	9·80
Soda with traces of K and Li	·09	0·023
Alumina	·03	0·013
	99·29	

This is evidently the bronzite commonly found in meteorites.

The green mineral is the soluble part of the meteorite; its cleavage in one direction is very perfect; its specific gravity is 3·35; it has a hardness of almost 7, and is readily and completely decomposed by hydrochloric acid. On analysis it was found to have the composition:—

		Oxygen.
Silicic acid	41·50	22·13
Iron protoxide	14·21	3·12
Magnesia	44·64	17·86
	100·35	

The mineral, therefore, is olivine. Dr. L. Smith, who has examined this meteorite, describes a third silicate which is opalescent and of a light greenish-yellow colour, and cleaves readily. It was a difficult matter to obtain enough of the silicate for analysis, but an examination of 100 milligrammes gave the following numbers:

		Oxygen.
Silicic acid	49·60	26·12
Iron protoxide	15·78	3·50
Magnesia	33·01	13·21
	98·39	

This is equivalent to one atom of bronzite and one atom of olivine, which, he says, is "a form of silicate that we might expect to find in meteorites." The nickel-iron, as has already been stated, is abundant, sometimes in large nodules of from 50 to 100 grammes. It displays the Widmanstättian figures beautifully, and possesses the following composition:

Iron	92·001
Nickel...	7·100
Cobalt	0·690
Copper	Minute quantity
Phosphorus	0·112
	99·903

A careful examination for felspar and schreibersite was made, but with a negative result.

1879, July 1.—Province Entre-Rios, of the La Plata State, between Nagaya (S.E. of Santa Fé, north of the River La Plata) and Concepcion on the River Uruguay.[1]

Websky reports the arrival of a stone which fell at the place mentioned above, and had been sent as a present to the Berlin Academy. Further particulars are expected to arrive shortly.[2] It fell in the evening and developed a light as bright as day. The piece sent to Europe constitutes one-half of the original aërolite. A crack, started when the stone was broken, has since led to the stone falling into two pieces, weighing 1239 grammes and 974 grammes. The meteorite belongs to the very rare class of carbonaceous stones; it is dark grey in structure, has little lustre and is soft; it contains no visible meteoric iron, but an abundance of light grey rounded bodies; among which are occasionally some with a dull metallic lustre and of a greenish yellow colour, and others of a dark grey compact substance and of earthy character.

The meteoric nature of the stone is placed beyond doubt by the crust still adhering to the smaller fragment. When the two pieces are held together, it is easy to recognize which side of the stone was in front during its passage through the atmosphere. The entire stone appears to have had the form of a spheroid 150 mm. in the smallest and 180 mm. in the longest diameter.

Found 1879, July 19.—Lick Creek, Davison Co.[3]

In this paper is given an engraving, actual size, and a short account of a small metallic mass, weighing rather more than two pounds, and found at the above date in Davison county. When found it was covered with a thick scaly crust of oxide. It weighs

[1] H. Websky. *Sitzungsber. K. Akad. Wiss. Berlin*, 1882, xviii. and xix. 395.
[2] A. Brezina. *Die Meteoritensammlung in Wien*, 1885, p. 185.
[3] *Illustrated Scientific News*, New York, March 15, 1880, iii. No. 6, pp. 62 and 66. *Amer. Journ. Sc.* xx. 1880, 324.

1·24 kilogrammes or $43\frac{3}{4}$ ounces avoirdupois. It is one of the rare class that do not show the Widmanstättian figures. It contains iron, nickel, cobalt, and phosphorus. A complete analysis of the meteorite is being prepared. It is the property of Mr. W. E. Hidden, of the New York Academy of Sciences. Mr. Hidden has in his cabinet three other undescribed meteorites from the Southern States, one of which weighs 1·45 kilogrammes, or 51 oz. avoirdupois.

1879, November 4.—Kalumbi, Wayee (Wai, Jaluca), Sattara, Presidency of Bombay, India.[1]

Brezina records the presentation to the Vienna Collection of a piece of a meteorite weighing 165 grammes by Mr. M. Wood, of the Bombay Branch of the Royal Asiatic Society. The fall occurred at the above place and date, and the stone has the form of a four-sided wedge, with a nearly square base. Its weight is $10\frac{1}{4}$ lbs. and 197 grains, and its density is 3·45. According to an incomplete analysis, 58·75 per cent. was insoluble in hydrogen chloride (consisting of silicates, and the silicic acid of the decomposed portion), and in addition, there was iron oxide, or rather iron protoxide with alumina 27·62, nickel 1·55, lime 0·83, and magnesia 11·88 per cent. The meteorite resembles Forsyth, has a light yellowish ground-mass; the chondra are firmly inclosed in the ground-mass, and for the most part white and felspathic. This stone is to be classed with the white chondrites.

1880, February 18, early in the Morning.—Kuritawaki-mura, (Toke-uchi-mura), Yosa-no-gori, Tango, Japan.[2]

An eye-witness of the fall of this stone states that in the early morning he was washing his face, when he saw a ball of fire cross the sky from north-east to south-west. He was much astonished when a small stone fell before him from the sky. He caught it up and found it was very hot, and gave forth a smell like that of gunpowder. The stone is about $1\frac{1}{2}$ inches long and three-quarters of an inch wide, and weighs about 100 grains Troy. It is completely covered with a hard black glaze. It appears to be a stone and not a meteoric iron.

The same correspondent mentions a meteoric stone of large size, preserved at Toji, which is said to have fallen from the heavens in ancient times; and reports another at Chionin. He also says: "I learn that a stone of several pounds weight fell at Tamba a few years ago."

The same number of the *Japan Gazette* contains a short reference to another aërolite. The mineral stone which fell some time ago at the front of a gate of Iwata, of Takeda-mura, Yabe-gori, Tajima, with a brilliant light and report, is about $1\frac{1}{2}$ *sun* thick and 9 *sun* in

[1] A. Brezina, *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct. part.

[2] *The Japan Gazette*, April 19, 1880.

circumference, and weighs about 200 *momme*. This stone has been sent to the Bureau of Agriculture of the Home Department, and will be investigated by Prof. Kinch.

1880 (early in).—Colorado Basin, Ivanpah, Southern California.[1]

This block of iron was found in the Colorado Basin, within eight miles of Ivanpah, which is about 200 miles north-east of San Bernardino in Southern California, by a Mr. Goddard, who while crossing a *wash* had his attention arrested by a singular-looking boulder. The block is oval in shape, having a side somewhat flattened; its surface is covered with depressions and dents, as if it had been pelted all over with pebbles while soft or plastic. These concavities are from 1 to 4 inches across, and, in addition, there are three round holes an inch deep, as if made by the little finger. The mass is supposed to weigh 120 lbs., and it is 14 inches long, 9 inches broad, and 7 inches deep. The examination of a fragment shows it to be highly crystalline, requiring no etching to reveal the Widmanstättian figures; the cleavage appears to be octahedral. The schreibersite is very thin, and, according to Shepard, of two kinds: one in flat leaves, the other in wavy semi-cylinders or irregular prisms; the latter, he says, may be the rhabdite of Reichenbach. The density of the iron is 7·65, and its composition:—

Iron	94·98
Nickel	4·52
Phosphorus	0·07
Graphite	0·10
	99·67

Specimens of Supposed Meteoric Dust which fell in the South of Europe and Algiers, between the end of March and beginning of May, 1880.[2]

In Sicily showers of supposed meteoric dust are often observed, sometimes with, sometimes without rain. During such a shower the air becomes murky and of a reddish-yellow colour, and the barometer falls rapidly. A heavy rain leaves a characteristic yellowish-red residue. Dust fell on the night of March 29, 1880, at Catania, containing, in addition to the ordinary constituents (siliceous, calcareous, and argillaceous minerals, and small organisms), particles of metallic iron. It had a reddish-yellow colour, became black and gave off an empyreumatic odour when heated, and afterwards recovered its original colour. The specific gravity was 2·92. The blowpipe showed the presence of nickel, and phosphoric acid was found to the amount of 0·1456 per cent. (P_2O_5). Under the

[1] C. U. Shepard, *Amer. Journ. Sc.* 1880, xix. 381.
[2] O. Silvestri, *R. Acc. dei Lincei*, iv. ser. 3, 1880. *Jahrbuch für Min.* 1881, i. 200. A. Daubrée, *Comptes rendus*, May 10, 1880, xc. 1098.

microscope small particles of dust were observed, some opaque, others surrounded with a red border, others steel-grey with a metallic lustre. These particles were easily separated by a magnet from the non-metallic more or less transparent particles. The former had a diameter of 0·01 to 0·08 mm. Some were regularly spherical. The dust therefore contains *nickel-iron*, whence it is probably of cosmic origin. Silvestri insists especially on the fact that it did not contain any constituents which might lead to the conclusion that it came from Etna. M. Daubrée examined the dust which fell from April 21st to 25th, 1880, in the Dép. des Basses-Alpes, Isère, and l'Ain. It effervesced with acid, as did the dust of Catania, contained hydrated iron peroxide, spangles of mica, and felspar. It was considered to be dust of terrestrial origin, not volcanic, nor Saharan. About this time, I received from my friend, Dr. Reginald Thompson, of Chelsea, a specimen of reddish powder which had fallen in Algiers in May, 1880. His correspondent, Mr. A. L. Smith, writing under date "Algiers, May, 1880," says: "We have had torrents of rain coming after falls of a red powder in great quantities, of which I send you a little; they say it is meteoric. The sky was yellow: the air quite still. I never saw anything like it." The sand answered in all respects to that examined by Silvestri and Daubrée; it certainly contained particles which were readily removed by the magnet. They were however without action on copper sulphate or mercury bichloride, and the dust did not contain nickel-iron.

1880, April or May (first half of).—Karand, 12 miles east of Teheran, Persia.[1]

"The fall of a meteorite which was actually seen to descend, and which is not an event of every-day occurrence, deserves, on account of its mineralogical interest, some notice. It is not possible here to ascertain with certainty the constituent minerals; it is therefore possible at present only to give a short sketch of the stone; later on, when we have the material to work with and the help of an authority in this branch, we may return to the subject. In the first half of the month of May, 1880, we were called before the Shah, who handed to us a metallic shining mineral, weighing about 400 grammes, which, from the outer crust still adhering to it, we at once recognized as a meteorite. We saw that the Shah took the shining metal in it for silver, for he asked the value of it. But when we spoke of the iron, and its probably containing nickel, and that the mineral had more scientific than intrinsic worth, it was permitted to us to take the stone away, and to break off a piece for closer examination.

The Shah made himself acquainted with the origin and cause of meteorites, and informed us that the stone in question weighed

[1] Mining engineer Ferd. Dietzsch, in Teheran; in a paper intituled 'Geologisches Berg- und Hüttenmännisches aus Persien,' in *Berg- und Hüttenmännische Zeitung*, March 18, 1881.

45 kilogrammes, and fell in the neighbourhood of the village of Karand, twelve miles east of Teheran, with an explosive noise like thunder.

Half of the stone was covered with a thin, blackish, fused crust, while the fresh lustrous fractured surface showed it to have formed a portion of a much larger stone. A fragment weighing 3·66 grammes was found to possess a density of 4·36. The fractured surface showed a grey, passing into green ground-structure, with, in places, single pieces of an oil-green mineral, with a lustre of glass, probably olivine. In the mass lay, closely strewn together, small and large granules of white iron; also little plates of this metal lay inclosed in it, and violet-blue tinted grains, similar in their play of colour to copper pyrites.

The pulverized mineral is pretty light, and almost entirely soluble in hydrochloric acid. The fractured surface was covered in a few days with a thin oxidized crust, although some portions of it are as fresh after five months as at first."

In his note on this meteorite Brezina[1] states that the fall took place at Veramin in the month of April, not May. He received a fragment from Baron Gödel-Lannoy, Secretary of the Legation at Teheran; the portion which Dietzsch received appears to have been lost. Brezina's piece weighs about 16 grammes, the meteorite itself weighs 20 to 25 kilogrammes, and is preserved by the Shah in a garden. This stone, it appears, belongs to the rare group of mesosiderites, of which very few members have been seen to fall. The remaining members of this group, Hainholz (1856), Janacera Pass (1860), Newton Co. (1860), Sierra de Chaco (1862) and Sierra de Deesa (1865), have no crusts. The Persian stone has a fused crust of a lustreless, granular, dull grey colour, with, in places, rusted spots; the crust closely resembles that of Daniel's Kuil (1868), it is exceedingly thin, from 0·05 to 0·08 mm. On the freshly-fractured surface the Persian stone bears the greatest resemblance to that of Newton Co.; numerous crystals of olivine, some 2 mm. in diameter, in one case a mass 7 mm. across, are inclosed in a highly crystalline ground-mass, which appears to consist for the most part of olivine.

1880, Found in May.—Lexington County, South Carolina.[2]

A mass of iron, weighing 10½ lbs., was found at this locality, in May, and sent to the Shepards, father and son, for examination. It has the form of a cylinder with two flattened edges; the surface is nearly free from yellow hydrated peroxide of iron, being mostly enveloped with a black and brittle coating, which, though containing some troilite, is yet almost entirely formed of magnetite. Amygdaloidal masses of troilite, of the size of filberts, are met with. Magnetite and graphitoid are found coating the troilite. The Lex-

[1] A. Brezina, *Sitzber. K. Akad. Wiss.*, 1881, lxxxiv. July part.
[2] C. U. Shepard, *Amer. Jour. Sc.* 1881, xxi. 117.

ington iron closely resembles the Bohumilitz iron found in 1829, and preserved at Prague, especially in the two etched surfaces: they, in fact, are the only two which strikingly show the *moiré métallique* lustre; the crystalline bars in the Lexington iron are nearly twice as large as those in the Bohemian specimen. The included spaces are filled with extremely minute lines of tänite, crossing each other at all angles from 90° to 150°. Its density is 7; that of homogeneous fragments being 7·405, and that of the troilite 4·77. Analysis showed it to consist of:

Iron	92·416
Nickel	6·077
Cobalt	0·927
Insoluble matters	0·264
Tin	a trace
Phosphorus	a trace
	99·684

Supposed Organic Remains in Meteorites, 1880–1882.

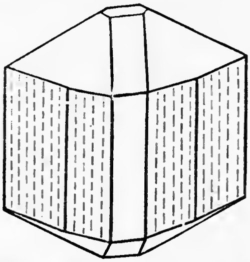
At the end of the year 1880, Dr. O. Hahn, of Reutlingen, a lawyer by calling, published a big work entitled *Die Meteoriten* (*Chondrite*) *und ihre Organismen mit* 32 *Tafeln photographischer Abbildungen* (1880, Tübingen: H. Laupp), by which he claimed to have shown the presence of sponges, corals, and crinoids in meteoric rocks. A statement of his views was read before a meeting of the Geological Society the same summer. Afterwards Dr. D. F. Weinland published a paper in support of these views, *Ueber die in Meteoriten entdeckten Thierreste*. Illustrated with two woodcuts. (1882, Esslingen: G. Fröhner). The question was thoroughly gone into in a scientific way by Prof. Carl Vogt, of Geneva, and the conclusions at which he arrived are contained in a paper entitled *Les prétendus Organismes des Météorites*, published 1882, Genève: H. Georg. It is shown that Dr. Hahn had no foundation for his conclusions; that all the pretended organic structures are purely inorganic; and that in no single case do they present the microscopic structure of the organisms for which they have been mistaken. See also Dr. Lawrence Smith on the subject in the *Amer. Jour. Sc.* 1882, February, 156.

Meteoric Deposits on Arctic Snow, off the Taimur Coast, 1880.[1]

Immediately after the "Vega" lay-to, Baron Nordenskjöld went down on the ice, in order to see whether here too some such metalliferous dust, as he had before found north of Spitzbergen (p. 41), was not to be found on the surface of the ice. Nothing of the kind, however, was to be seen. On the other hand, Lieutenant Nordquist observed small yellow specks in the snow, which he collected and

[1] A. E. Nordenskjöld, The Voyage of the "Vega," vol. i. pp. 327-331, Macmillan, 1881.

handed over for investigation to Dr. Kjellman. Nordenskjöld supposed that the specks consisted of diatom ooze. After examining them Dr. Kjellman, however, declared that they did not consist of any organic substance, but of crystallized grains of sand. Nordenskjöld too examined them more closely, but unfortunately not until the morning after they had left the field, and then found that the supposed ooze consisted of pale yellow crystals (not fragments of crystals), without mixture of foreign matter. "The quantity of crystals, which were obtained from about three litres of snow, skimmed from the surface of the snow on an area of at most 10 square mètres, amounted to nearly 0·2 gram. The crystals were found only near the surface of the snow, not in the deep layers. They were up to 1 mm. in diameter, had the appearance shown in the accompanying woodcut, and appeared to belong to the rhombic system, as they had one perfect cleavage, and formed striated prisms terminated at either end by truncated pyramids. Unfortunately actual measurements of them could not be made, because after being kept for some time in the air they weathered to a white non-crystalline powder. They lay, without being sensibly dissolved, for a whole night in the water formed by the melting of the snow. On being heated too, they fell asunder into a tasteless white powder. The white powder that was formed by the weathering of the crystals was analyzed after our return,—21 months after the discovery of the crystals—and was found to contain only carbonate of lime.



Form of the Crystals found on the Ice off the Taimur Coast. Magnified thirty to forty times.

The original composition and origin of this substance appears to me exceedingly enigmatical. It was not common carbonate of lime, for the crystals were not rhombohedral, nor did they show the cleavage of calcite. Nor can there be a question of its being aragonite, because this mineral might indeed fall asunder "of itself," but in that case the newly-formed powder ought to be crystalline.

Were the crystals originally a new hydrated carbonate of lime, formed by crystallizing out of the sea-water in intense cold, and did they lose their water of crystallization at a temperature of 10° or 20° above the freezing-point? In such a case they ought not to have been found on the surface of the *snow*, but lower down on the surface of the *ice*. Or did they fall down from the inter-planetary spaces to the surface of the earth? And before crumbling down had they a composition differing from terrestrial substances in the same way as various chemical compounds found in recent times in meteoric stones? The occurrence of the crystals in the uppermost layer of snow and their falling asunder in the air, tell in favour of this view. Unfortunately there is now no possibility of settling these questions, but at all events this discovery is a further incitement to those who travel in the High North to collect with extreme care, from snow-fields lying far from the ordinary routes of communication, all foreign substances, though apparently of trifling importance."

Baron Nordenskjöld then refers to the metallic particles found by him on the snow during previous years (see GEOL. MAG. Dec. II. 1875, Vol. II. pp. 157–162), and says in conclusion :—

It may appear to many that it is below the dignity of science to concern one's self with so trifling an affair as the fall of a small quantity of dust. But this is by no means the case. For it is estimated that the quantity of the dust that was found on the ice north of Spitzbergen amounted to from 0·1 to 1 milligram per square mètre, and probably the whole fall of dust for the year far exceeded the latter figure. But a milligram on every square mètre of the surface of the earth amounts for the whole globe to five hundred million kilograms (say half a million tons)! Such a mass collected year by year during the geological ages, of a duration probably incomprehensible by us, forms too important a factor to be neglected when the fundamental facts of the geological history of our planet are enumerated. A continuation of these investigations will perhaps show, that our globe has increased gradually from a small beginning to the dimensions it now possesses; that a considerable quantity of the constituents of our sedimentary strata, especially of those that have been deposited in the open sea far from land, are of cosmic origin; and will throw an unexpected light on the origin of the fire-hearths of the volcanoes, and afford a simple explanation of the remarkable resemblance which unmistakably exists between plutonic rocks and meteoric stones.[1]

1881, March 14, 3·35 p.m.—Pennyman's Siding, Middlesborough, Yorkshire.[2]

During the past year a very beautiful specimen of a meteorite fell near Middlesborough, at a spot called Pennyman's Siding on the North-Eastern Railway Company's branch-line from Middlesborough to Guisborough, about one mile and three-quarters from the former town. Its descent was witnessed by W. Ellinor and three plate-layers, who heard a whizzing or rushing noise in the air, followed

[1] Namely, by showing that the principal material of the plutonic and volcanic rocks is of cosmic origin, and that the phenomena of heat, which occur in these layers, depend on chemical changes to which the cosmic sediment, after being covered by thick terrestrial formations, is subjected.

[2] A. S. Herschel, *Newcastle Daily Chronicle*, March 30, 1881, Newcastle-on-Tyne. Walter Flight, *Proc. R. S.* 1882, p. 346.

in a second or two by a sudden blow of a body striking the ground not far from them; the spot was found to be 48 yards from where they stood. The fall took place at 3·35 P.M. on the 14th March, 1881. No luminous or cloud-forming phenomena are reported. According to Prof. Alexander Herschel, who at once visited the spot, the fall appears to have been nearly vertical. The stone was "new-milk warm" when found, and weighed 3 lb. 8¼ oz.; the crust is very perfect and of an unusual thickness, and has scarcely suffered by the fall. The stone forms a low pyramid, slightly scolloped or conchoidal-looking, 6¼ inches in length, 5 inches wide, and 3 inches in height. The rounded summit and sloping sides are scored and deeply grooved, with a polish like black lead in waving furrows running to the base, showing that this side came foremost during the whole of the fusing action of the atmosphere which the meteorite underwent in its flight. The base is equally fused by heat, but is rough, dull brown in colour, and not scored or furrowed. The stone penetrated the soil to a depth of eleven inches. From experiments made by Professor Herschel, he calculates that it struck the ground with a velocity of 412 feet per second. As it would acquire this velocity by falling freely through half a mile, it is evident that little of the original planetary speed with which it entered the atmosphere can have remained over.

The stone contains 9·379 per cent. of nickel-iron, the composition of which was found to be—

Iron	76·99
Nickel	21·32
Cobalt	1·69
	100·00

The percentage of nickel is high. The remaining constituents consist of rocky matter, amounting to 90·621 per cent., and are soluble silicate 54·315 per cent. and insoluble silicate 36·306 per cent. The soluble silicate appears to be an olivine of the form $2(\frac{1}{3}\text{ Fe}, \frac{2}{3}\text{ Mg})\text{ O}, \text{SiO}_2$, or one closely resembling that which occurs in the Lancé stone, which fell July 13th, 1872, and was examined by Daubrée. The insoluble part is chiefly bronzite, and most closely resembles that which is to be found in the meteorites of Iowa co., Iowa, east of Marengo, which fell 12th February, 1875, and were examined by Dr. L. Smith. The aluminium constituent is doubtless labradorite and is probably the material of some of the occasional chondra which are seen in a microscopic section.

1882, January 31, 2—3 p.m.—Skaufs, Canton Graubündten, Switzerland.[1]

A meteor of rare size and unusual brilliancy was seen in the bright sunshine at several places in the east of Switzerland. A rushing noise was heard at Zurich, at Einsiedeln, and at St. Gallen, and a snow-white lump was seen moving in the air overhead. It

[1] "M." in *Der Naturforscher*, 1882, xv. 87.

threw out a thin yellow band in a north-westerly direction, which appeared to close together again, and break up in a ball-like structure; then it turned red, white, and green, and suddenly vanished. It is said to have fallen to earth at Skaufs with loud detonation.

1882, February 3rd, 3·45 p.m.—Mocs, near Klausenburg, Kolos, Siebenbürgen.[1]

To eye-witnesses at Klausenburg an intensely brilliant meteor was visible at this hour in a north-easterly direction; the sky was cloudless: at once a rolling noise, and intense detonations were heard. At the spot where the light was observed, a white cirrus-like cloud extended in the form of a white stripe from west to east. The next day it became known that meteorites had fallen at Mocs, five (German) miles eastward of Klausenburg. Dr. Herbich at once went there, and was fortunate enough to receive one weighing 35 kilogrammes, which, after striking an oak tree and lopping off several branches, had penetrated the soil to a depth of 68 centimètres in the frozen ground. Later on a block weighing 70 kilogrammes was found, and a number of other masses. They were spread over an area three miles in length.

Brezina traces the closest resemblance between them and the numerous meteorites which fell 30th November, 1822, at Futtehpur (Rouspùr and Bithùr); they are white friable chondrites. Like them they are traversed by a whole system of black veins, consisting for the most part of nickel-iron and troilite.

Later on Koch concluded that about 2000 stones had fallen, the total weight being 245 kilogrammes. A great number were sent to the National Museum at Klausenburg. The density of the stone appears to be 3·67.

The meteor was seen as far as Verespatak, and traces of the cloud were visible for 15 to 18 minutes. The sun was shining brightly at the time, and the light was strengthened by the reflection of the snow; still the light of the meteor was dazzling. One stone was picked up quite warm. As is usual, the smaller masses reached the earth first, the heavier being carried further to the south-east. A map accompanying Koch's paper shows the way in which the stones were distributed over the area.

Those meteorites which fell on the snow, and were quite uninjured, have a perfect crust which has the lustre of varnish; the average thickness of this crust is $\frac{1}{3}$ to $\frac{2}{3}$ mm. The large stone has the usual depressions and hollows on its surface. The fresh surface is ash-grey, in places traversed by brown or black cracks and veins, and sparsely scattered small metallic granules. In conclusion Koch makes a few tentative remarks suggested by his examination of a microscopic section.

[1] F. Herbich, and A. Brezina. *Verhand. der K. K. Geolog. Reichsanstalt*, 1882, 77. (*Der Naturforscher*, 1882, 174.) G. Tschermak, *Anz. Ak. Wiss. Wien*, 1882, 52. A. Koch, *Sitzber. Ak. Wiss.* lxxxv. *März-Heft*, 1882. G. Tschermak, *Anz. Akad. Wiss. Wien*, 1882, 83. A. Brezina, *Anz. Ak. Wiss. Wien*, 1882, 104. A. Brezina, *Sitzber. Akad. Wiss.* lxxxv. *Mai-Heft*, 1882.

Tschermak found on inspecting a great number of the stones that they exhibited a tendency to split up into prisms. The crust is more lustrous than in most meteorites; and long fused threads are occasionally met with. In addition to black veins, there are to be seen, though rarely, broader areas filled with a black magma, as in the stone of Orvinio. White chondra of olivine and enstatite, and brown chondra of enstatite are seen, as well as diopside, a felspar of the plagioclase series, and a black as yet undetermined mineral. Fragments of iron showing very distinct cleavage are also of frequent occurrence.

Brezina still more recently examined the crust and the black veins, and finds that the broad black areas are only met with where the surface exhibits an unusually porous and shrivelled character, properties which fully accord with those of the black chondrites (with the exception of the meteorite of Tadjera, which has no crust whatever), and this appears to support the view that they are in each case due to the same cause.

This remarkably abundant fall took place over an area extending from 46° 48′ to 46° 53′ N. and 24° 2′ to 23° 54′ E. of Greenwich.

1882, March 9th, 11 p.m.—Between Webster and Oswego, Warsaw Co., Indiana, U.S.A.[1]

Some men who were riding home through a very heavy snow-storm suddenly became aware of a large meteor moving near them with inconceivable rapidity and a rushing roaring noise. It had a bright cherry red colour, "just the colour," as one of the party observed, "of melted iron." The light was so brilliant that it blinded them, and, notwithstanding the storm, lighted the entire neighbourhood as clearly as the brightest day at noon. When nearly overhead it exploded with a tremendous report. The entire party were prostrated, horses and men, and some of them did not recover their sight until some twenty-four hours later. The report was distinctly heard at Warsaw, eleven miles distant as the crow flies, and attracted a good deal of attention. The glass of the windows was broken in a number of houses in the neighbourhood.

1883, February 16th.—Alfianello, Verolanova, Brescia, Italy.[2]

I gather from a short preliminary notice, which has been sent by M. Denza to Professor Daubrée, and has been published in a recent number of the "Comptes Rendus," a few particulars respecting the fall of this stone, and its general appearance.

The fall took place, with a loud detonation, at 2·55 P.M. on the day above mentioned; it was heard in the neighbouring provinces of Cremona, Verona, Mantua, Piacenza, and Parma. In Alfianello it is described as "épouvantable."

It descended from N.N.E. to S.S.W., at a distance of about 150

[1] *Warsaw Republican*, March 25th, 1882. Reprinted in the *Evening Times* of Glasgow, April 15th, 1882.

[2] Walter Flight. *Proc. Roy. Soc.* 1883, Nov. 226.

metres from a peasant, who fell fainting to the ground; telegraphic wires were set in motion, and the windows were shaken. It struck the ground about 300 metres south-west of Alfianello, in a field on an estate called Frosera, penetrating the soil, in the same direction as it passed through the air, from east to west, to a depth of about 1 metre, the path through the soil being about 1·50 metre. When taken out of the ground it was still a little warm. It fell complete, but was at once broken to pieces by the farmer of the estate.

The stone was oval in form, and somewhat flattened in the centre, the lower part being larger and convex, like a kettle, the upper part being truncated. The surface is covered with the usual black crust, and strewn with little cavities, now met with as individuals, now in groups, and in the eye of some people bearing a resemblance to the impression of a hand or the foot of a she-goat. The stone weighed about 200 kilos.

In structure this meteorite belongs to the group oligosidères of Daubrée, and resembles *Aumalite*, being almost identical with the meteorite of New Concord, Ohio.

The substance was finely granular, of ash-grey colour; a polished surface appears to be finely grained and breccia-form, with the elements offering different gradations of colour. Metallic grains are disseminated, and little nests are noticed, of iron with one of the compounds, of a yellowish-white or bronze. In one place where the metallic grains are numerous they appear to bear to the stony portion the ratio 68 : 1000. The density of the stone is 3·47 to 3·50.

The meteorite was dried at 120°, and treated with solution of mercury chloride, and thus there were dissolved the troilite and nickel-iron. The troilite constituted 6·919 per cent. of the meteorite, and the nickel-iron forms 2·108 of the stone, with the composition—

Nickel	71·205
Iron	28·795
	100·000

Here, again, as I have shown in earlier analyses, the percentage of nickel present in nickel-iron increases as the percentage of nickel-iron becomes less.

By long treatment with hydrogen chloride the silicates acted upon by that reagent and the silicates which resist the action were separated, and the stone appeared to possess the composition—

Troilite	6·919
Nickel-iron	2·108
Soluble silicate	50·857
Insoluble silicate	40·116
	100·000

The soluble silicate, which amounts to 50·857 per cent., and constitutes one-half the weight of the stone, consists of—

Silicic acid	35·12	18·72	
Iron protoxide	51·43	11·43	16·37
Alumina	1·518	0·707	
Lime	4·644	1·327	
Magnesia	7·269	2·904	
	99·981		

This olivine, which gives a green colour to a fragment of the rock that is at once recognized, is of unusual composition, containing as it does more than 50 per cent. of iron oxide. It agrees most closely with that which occurs in the meteorite of Ensisheim, the first recorded fall which has been preserved in any collection; it fell 17th November, 1492. The latest analysis of that stone is by Frank Crook, of Baltimore, made in Göttingen in 1868, and he found in the soluble portion of that stone 52·90 per cent. of iron oxide.

The insoluble portion, which forms 40·116 per cent. of the stone, has the composition—

Silicic acid	56·121	29·93	
Iron protoxide	13·397	2·97	11·95
Chromium oxide	8·281	—	
Lime	6·712	1·917	
Magnesia	17·663	7·065	
	102·174		

The bronzite, or rather augite, also agrees very well with that which forms the insoluble portion of the meteorite of Ensisheim. What was supposed to be alumina was further examined, and was found to be almost entirely chromium oxide, doubtless present in combination with some iron protoxide, alumina, and magnesia as chromite. And it appears not improbable that this part of the meteorite contains some tridymite, a few per cent., in fact.

End of Part III.

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THE END.

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