XIX. *Report of an Examination of the Meteorites of Cranbourne, in Australia; of Rowton, in Shropshire; and of Middlesbrough, in Yorkshire.*

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[PLATE 53.]

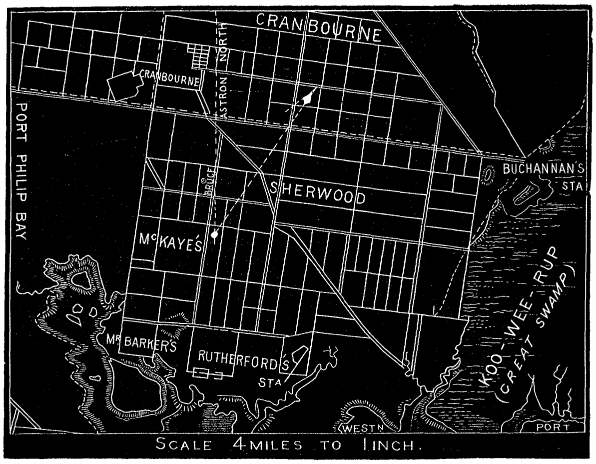
I. THE SIDERITES OF CRANBOURNE, NEAR MELBOURNE, AUSTRALIA.

ALREADY, in 1854, it was known that masses of iron lay near Western Port, south-east of Melbourne. Mr. E. FITZGIBBONS, the Secretary of the Municipality of Melbourne, was the first to direct attention to their meteoric characters, and he succeeded in removing enough of the larger mass to have the pieces forged into a horseshoe.

Two masses of meteoric iron were discovered in Victoria, and they were first reported upon by the late W. HAIDINGER in the 'Sitzungsberichte Akad. Wien'* in 1861. The smaller block became the property of Mr. ABEL, the engineer; the larger one was purchased for a sovereign 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. Its position in the ground is well shown in a photograph taken on the spot by my late friend, Mr. R. DAINTREE, the Agent-General for Queensland, after the tertiary sandstone enclosing it had been removed. It is the same sandstone which crops out at Broughton; with basalt from 12 to 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.

* W. HAIDINGER, 'Sitzungsberichte Akad. Wien,' xliv., 18th April, 6th June, and 17th October, 1861; xlv., 65, 9th January, 1862.

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 shown in the accompanying 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 (see *infra*), is met with, but in place 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 positions of the two masses was S. 34° W. and N. 34° E. (magnetic declination), and they were 3·6 miles (60 miles to a degree at the equator) 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 lies north of the other, is 38° 8′ S. and the longitude 145° 22′ E.; those of the larger being latitude 38° 11′ S. and longitude 145° 20′ E. of Greenwich. The height above sea level of the former was 107 feet, and of the latter 127 feet.



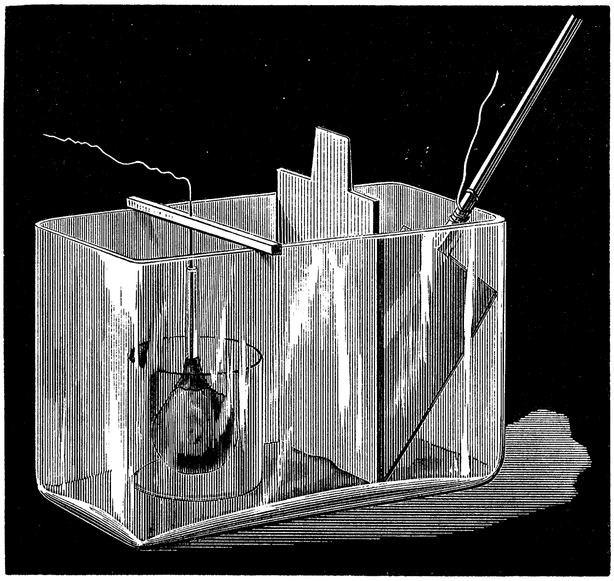
They showed no polarity beyond that due to the action of the earth. The under side of each mass was strongly south magnetic, and on the upper side north magnetic. The longer axis of the Bruce meteorite, the larger mass, is about 5 English feet, and it lay exactly in the magnetic meridian of the place.

Neumayer made a number of determinations of the specific gravity of the nickel-iron of the smaller mass, in the possession of Mr. Abel, ranging from 7·12 to 7·6, 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 it was 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, and between them were very thin plates of another constituent, which less readily underwent 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 solid original condition and present beautiful structure. Of this I shall have more to say later on.

II. *Proportion of nickel and other constituents present in the nickel-iron.*

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 only alloyed with nickel, cobalt, copper, &c., or whether it contained combined carbon. A weighed portion was suspended by



a platinum wire, carefully covered up with glass and caoutchouc, in a solution of recrystallised salt, and connected with a BUNSEN cell, in the apparatus shown in the accompanying woodcut. 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 very slowly and with considerable difficulty by hydrogen chloride, but disappear readily in hydrogen nitrate. But I shall return to the consideration of the characters and composition of the prisms later on. The absence of all combined carbon was fully established. The nickel-iron thus dissolved was found to contain of:

	Per cent.
Prisms	0·932
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 in porcelain tubes in hydrogen, 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.

III. *Edmondsonite, a well defined mineral species, occurring in the Cranbourne meteorite.*

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 was made in the case of some which had been reduced in 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	÷28 = 2·504 : 5
Nickel . . .	29·744	÷29·5 = 1·008 : 2
	99·882	

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 Wiedmannstättian figures, and not schreibersite, as usually stated in writings on the etched figures of meteoric iron. Tänite is the name which Professor GUSTAV ROSE gave to leaves containing 13·2 per cent. of nickel, and which he stated to form the figures on an etched surface. Dr. K. G. ZIMMERMANN, in a letter to one of the editors of the 'Jahrbuch für Mineralogie,' 1861, p. 557, proposed the name "meteorine" for a new metal occurring in the Cranbourne meteorite which he found to contain no copper, nickel, or cobalt. The substance referred to in both cases was 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 progress of 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 (Plate 53, fig. 1). This result accords with the conclusion arrived at by STODART and FARADAY some sixty years ago,* on the oxidation of alloys of iron and nickel. An alloy of iron, or rather of the best Bombay wootz,

* FARADAY'S 'Experimental Researches in Chemistry and Physics,' p. 63. TAYLOR and FRANCIS, 1859.

with 10 per cent. of nickel made by them in 1820, in imitation of the Siberian meteoric iron of Krasnojarsk, in which CHILDREN found as a mean of three analysis 8·96 per cent.* 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."

IV. *Troilite of the Cranbourne siderite.*

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 enclose 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. Plate 53, fig. 2, represents a section of the nodule of graphite, the shaded enclosed part representing the sulphide. Excepting daubréelite, troilite is the only sulphide found in this meteorite and, it need hardly be said, was not in the slightest degree magnetic. 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, as the mean of these determinations:

* BERZELIUS found nickel 10·73 per cent. and cobalt 0·46 per cent. in the Krasnojarsk nickel-iron.

		FeS requires
Iron	=63·613	63·64
Sulphur	=36·333	36·36
Copper	= 0·079	..
Chlorine	= 0·130	..
	100·155	100·00

V. *Square, strongly magnetic, prisms of iron-nickel phosphide.*

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 1 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, of their normal length. It was a difficult matter to obtain the prisms quite free from organic matter (dried varnish, &c.), but the following very pure material was at last obtained:—

	I.	II.	III.	Mean.	$(Fe_4Ni_3)P$.
Nickel . . .	49·715	..	48·955	49·335	48·38
Iron	36·666	39·519	38·540	38·242	38·23
Phosphorus . .	[13·619]	12·586	12·645	12·950	13·39
					100·00

The specific gravity of several specimens of the prisms gave numbers varying from 6·326 to 6·78.

A few years ago Professor DAUBRÉE* pointed out the great resemblance which he had traced between the artificial phosphide of iron, Fe_8P, 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† communicated a 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

* G. A. DAUBRÉE, 'Comptes Rendus,' lxxiv., 1427; and M. SIDOT, 'Comptes Rendus,' lxxiv., 1425.

† 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.

magnetic, have a specific gravity of 6·71 and the composition indicated by the formula Fe_7P. They, of course, contain no trace of nickel; in all other respects, however, they bear the closest resemblance to the above body.

VI. *Schreibersite in the Cranbourne siderite.*

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 consisted of a very brittle, very magnetic, coarse powder, which dissolved easily in strong hydrogen nitrate. Analysis gave the following results:—

	I.	II.		
Iron	56·245	55·990	56·117 ÷ 28 = 2·004	2·993
Nickel. . . .	29·176	..	29·176 ÷ 29·5 = 0·989	
Phosphorus . .	13·505	..	13·505 ÷ 31 = 0·435 × 7 = 3·045	
	98·798			

This is, doubtless, the mineral *Schreibersite* which appears to have the composition indicated by the formula $(Fe_2Ni)_7P$. 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 of a dark brown colour. Analyses of these crystals gave the following results:—

	I.	II.		
Iron	69·251	69·843	69·547 ÷ 28 = 2·484 =	2·972
Nickel* . . .	..	..	14·410 ÷ 29·5 = 0·488 =	
Phosphorus . .	15·420	16·666	16·043 ÷ 31 = 0·517 = 0·517	
	100·000			

which results point to $(Fe_9Ni_2)P_2$ as the true representative of its composition. It

* Both determinations were lost.

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.

VII. *Curious crystals with dark centres, occurring in the Cranbourne siderite.*

Mention should here be made of a curious crystal which on two or 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. On Plate 53, fig. 3, is represented such a prism broken across, showing the dark centre. An analysis of this compound gave the following results :—

Iron	67·480 ÷ 28	2·410
Nickel.	20·318 ÷ 29·5	0·688
Phosphorus	12·317 ÷ 31	0·397
	100·115	

which numbers agree with the formula $(Fe_7Ni_2)_8P$.

VIII. *Graphite.*

Graphite occurs occasionally, but rarely, as nodules; sometimes as nodules, enclosing 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, &c.)	10·412
	100·330

IX. *Gases occluded by the nickel-iron.*

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

X. THE ROWTON SIDERITE.

The metallic mass which I shall next proceed to describe is one of unusual interest in more than one respect: in the first place, before it fell only one iron meteorite was known to have fallen in Great Britain, while eight stony meteorites that have fallen in the British islands are in the national collection; and, secondly, of the more than 300 meteorites which are contained in the collection in the Natural History Museum, more than 100 are unquestionably iron meteorites, and of these the fall of seven only has been witnessed.

The circumstances attending the fall of the Rowton iron are as follows. At about 20 minutes to 4 o'clock on the afternoon of the 20th of April, 1876, a strange rumbling noise was heard in the atmosphere, followed almost instantaneously by a startling explosion resembling a discharge of heavy artillery. There was neither lightning nor thunder, but rain was falling heavily, the sky being obscured with dark clouds for some time both before and after the incident related. About an hour after the explosion Mr. GEORGE BROOKS had occasion to go to a turf field in his occupation adjoining the Wellington and Market Drayton Railway, about a mile north of the Wrekin, when his attention was attracted to a hole cut in the ground. The land where it fell, it should be stated, is part of the property of the Duke of Cleveland, at Rowton, near Wellington, in Shropshire; and Mr. ASHDOWN, the agent of the Duke, exerted himself in the matter, and obtained his Grace's assent to the meteorite being presented to the trustees of the British Museum.

As regards the hole which was found in the field, Mr. BROOKS probed the opening with a stick and discovered a lump of metal of irregular shape, which proved to be a meteorite, weighing $7\frac{3}{4}$ lbs. It had penetrated to a depth of 18 inches, passing through 4 inches of soil and 14 inches of solid clay down to the gravel. The hole is nearly perpendicular, but the stone appears to have fallen in a south-easterly direction. Some men were at work at the time within a short distance, and they, together with many other people in the neighbourhood, heard the noise of explosion. According to other observers, the sound was heard as of something falling during a heavy shower of rain, accompanied by a hissing and then a rumbling noise. It is, moreover, stated that when Mr. BROOKS found the mass "it was quite warm." Mr. WILLS described it as being black on the surface and apparently covered with a scale of metallic oxides; but at the point where it impinged on the earth the oxides had been removed, and the metallic character of the mass had been revealed.

When the meteorite reached the British Museum it was at once seen that it was wholly metallic in structure and was covered with a very thin pellicle of the jet-black magnetic oxide of iron, and only where this had been removed by abrasion with the soil is the bright metallic surface of the nickel-iron revealed. The depth to which the meteorite penetrated the soil is proof of how much momentum still remained to it, partly due, no doubt, to the approximately vertical direction with which it entered the atmosphere, and in some degree to the higher density of an iron mass as compared with one of stone, the rocky meteorites rarely penetrating to so considerable a depth. The meteorite closely resembles the siderite of Nedagolla, in India, as Professor Story-Maskelyne, M.P., F.R.S., has pointed out.

XI. *The nickel-iron of the Rowton siderite.*

Some fragments which had been removed by the lapidary's wheel were submitted to analysis, with the following results :—

	I.	II.
Iron	91·250	91·046
Nickel	8·582	9·077 (Nickel and Cobalt)
Cobalt	0·371	
Copper	trace.	trace.
	100·203	100·123

This nickel-iron has the composition closely approaching that of what may be called a normal nickel-iron—in short, the metals are in the ratio in which they are met with in their oxides when precipitated from an iron solution, containing an excess of nickel oxide, by ammonia, both when a large excess of ammonium chloride is present and when it is absent. As a result of several analytical determinations it was found to be :

Iron	=0·1231	=91·12
Nickel	=0·0120	= 8·88
	0·1351	100·00

XII. *The troilite of the Rowton siderite.*

One of the fragments of nickel-iron devoted to the analytical examination was found to contain a section of a nodule of troilite; this easily dropped out of the iron; where it was in close contact with the alloy it was covered with a very thin layer of graphite. No cleavage planes were noticed on the specimen; it was examined with a magnetic needle and found not to be in the slightest degree magnetic. It was shown on analysis to have the composition:

		The protosulphide requires
Sulphur	= 36·073	36·36
Iron	=[63·927]	63·64
	100·000	100·00

Some fragments of the iron were sawn into very thin plates, and were kept quite cool all the time by a current of methylated spirit; they were carefully dried and weighed, and the gas drawn from them when at a bright red-heat with a SPRENGEL pump. The plates of iron taken measured 1·198 cub. centim., and the gas collected after many hours' heating was 6·38 times the bulk of the metal. This is about double the quantity met with by GRAHAM and MALLET in other meteoric irons which had lain a long time in the ground.

XIII. *The gases occluded by the Rowton nickel-iron.*

After subtracting a little oxygen and the corresponding amount of nitrogen, due probably to the entrance of a little air into the apparatus, the gas was found to have the following percentage composition:—

Carbonic acid	5·155
Hydrogen.	77·778
Carbonic oxide	7·345
Nitrogen	9·722
	100·000

Plate 53 shows a drawing of the mass (fig. 4, actual size) as well as a sketch of the figures developed by etching the surface with bromine (fig. 5); they show larger figures than are usual, with less of the bright extruded ingredient, doubtless a compound rich in phosphorus. The small darker-coloured rounded mass near the bottom of the section is a nodule of troilite.

XIV. THE METEORITE OF MIDDLESBROUGH, YORKSHIRE.

During the past year a very beautiful specimen of a meteorite fell near Middlesbrough, in Yorkshire. It struck the earth at a spot called Pennyman's Siding, on the North-Eastern Railway Company's branch line from Middlesbrough to Guisbrough, about one mile and three-quarters from the former town. Its descent was witnessed by W. ELLINOR and three platelayers, who heard a whizzing or rushing noise in the air followed 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 on the 14th March, 1881, at 3·35 P.M. The wind was from the north-east, and it was a clear and bright but rather cold afternoon. At more distant places, as Northallerton and four miles to the eastward, the sound resembled the boom of a gun; no luminous or cloud-forming phenomena are reported. The character of the hole, according to Professor ALEXANDER HERSCHEL, who at once visited the spot, points to the fall having been vertical or nearly so. The stone was "new milk warm" when found, and weighed 3 lbs. $8\frac{1}{4}$ oz.; the dark surface is entirely fused and crusted, and has scarcely suffered by the fall. The stone forms a low pyramid, slightly scolloped, $6\frac{1}{4}$ inches in length, 5 inches wide, and 3 inches in height. The rounded summit and sloping sides are scored and grooved deeply with a polish like black lead, in waving furrows running to the base, showing that this side came foremost during the fusing action of the atmosphere which the meteorite underwent in its flight. The rear or base is equally fused or branded by heat, but is rough, dull brown in colour, and not scored or furrowed.

The meteorite penetrated the soil to a depth of 11 inches, and the penetration line apparently slopes about 10° from the vertical from the S.S.E.; it passed through 7 or 8 inches of coke-ballast, and thereafter brick-earth or coarse clay to the remaining depth. From experiments made by Professor HERSCHEL on the power of penetration of a cast-iron model of the meteorite, it is calculated that the actual velocity of fall with which the stone struck the ground must have been 412 feet per second. As it would acquire this velocity by falling freely through half-a-mile, it is clear how little of the original planetary speed with which it entered the atmosphere can have remained to affect its fall.

The interior of the stone has a greyish-white appearance, and is evidently for the most part composed of silicates: frequent bright metallic granules are to be seen, and they appear to be entirely or almost entirely granules of nickel-iron. The rocky portion varies from grey to pure white, of which there are patches, and while the greater part appears to be homogeneous in structure, there are many enclosed chondra of large size and of a darker grey than the body of the stone.

In the well-developed markings of the exterior of the stone it bears a close resemblance, as Professor HERSCHEL points out, to the meteorite of KARAKOL (Kirgis Steppe, May 9th, 1840), of which Professor GOEBEL gives a figure in his paper of 1866 in the 'Mélanges physiques et chimiques de l'Académie Impériale de St. Pétersbourg,' vii., 318–324.

The railway company, who at the time this notice was written retained possession of the stone, kindly permitted a few fragments to be removed for examination; and I shall now proceed to describe the results of the chemical analysis of them. It has since been presented to the Yorkshire Philosophical Society, and is now preserved in the museum at York.

XV. *The nickel-iron enclosed in the rocky constituents of the meteorite.*

A quantity was dried and weighed and treated with mercury chloride, and it was found that 9·379 per cent. of constituents were removed. As already stated, when examined under a microscope the metallic particles appeared to consist entirely, or almost entirely, of nickel-iron. The nickel-iron was found to have the following composition :—

Iron	76·990
Nickel	21·320
Cobalt	1·690
	100·000

The remaining constituents, consisting of purely rocky matter, amounting to 90·621 per cent., are thus composed :—

A. Soluble silicate	54·315
B. Insoluble silicate	36·306
	90·621

XVI. *The gelatinisable constituents of the rocky portion of the aerolite.*

The soluble portion and the silicic acid belonging to that portion was found to have the following composition :—

		Oxygen.
Silicic acid	41·100	21·92
Iron protoxide	27·960	6·213
Magnesia	30·940	12·380
	100·000	18·593

These numbers indicate the presence of one olivine of the form $2(\frac{1}{3}Fe, \frac{2}{3}Mg)O, SiO_2$ or one closely resembling that which occurs in the Lancé stone, which fell July 13th, 1872, and was examined by DAUBRÉE. No lime and no alumina were found in the soluble part, though carefully sought for.

XVII. *The insoluble silicates in the rocky portion of the Middlesbrough aerolite.*

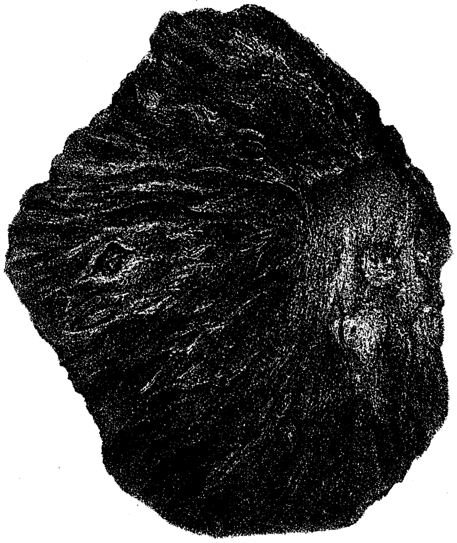
The constituents of the insoluble part were as follow :—

		Oxygen.
Silicic acid	55·389	29·541
Alumina, and a little chromium oxide	4·770	2·223
Iron protoxide	23·580	5·241
Lime	4·373	1·249
Magnesia	11·043	4·417
		10·907
Alkalies	not determined	
	99·155	

If the chief silicate in the above portion be regarded as bronzitė it most closely resembles that met with in the meteorites of Iowa Co., Iowa, east of Marengo, which fell 12th February, 1875 ;* if, on the other hand, as is more probable, it be regarded as a lime-magnesia-iron augite it is closely allied to the augite of the stones of STANNERN and JUVINAS. The aluminous constituent is doubtless labradorite, and is probably present as some of the occasional chondra which are seen in a microscopic section of the meteorite.

In Plate 53 the front furrowed side is shown in figs. 6 and 7 and the back view in fig. 8. They require no further explanation.

* J. L. SMITH, Amer. Jour. Sc. [3], vol. x., 1875, p. 363.



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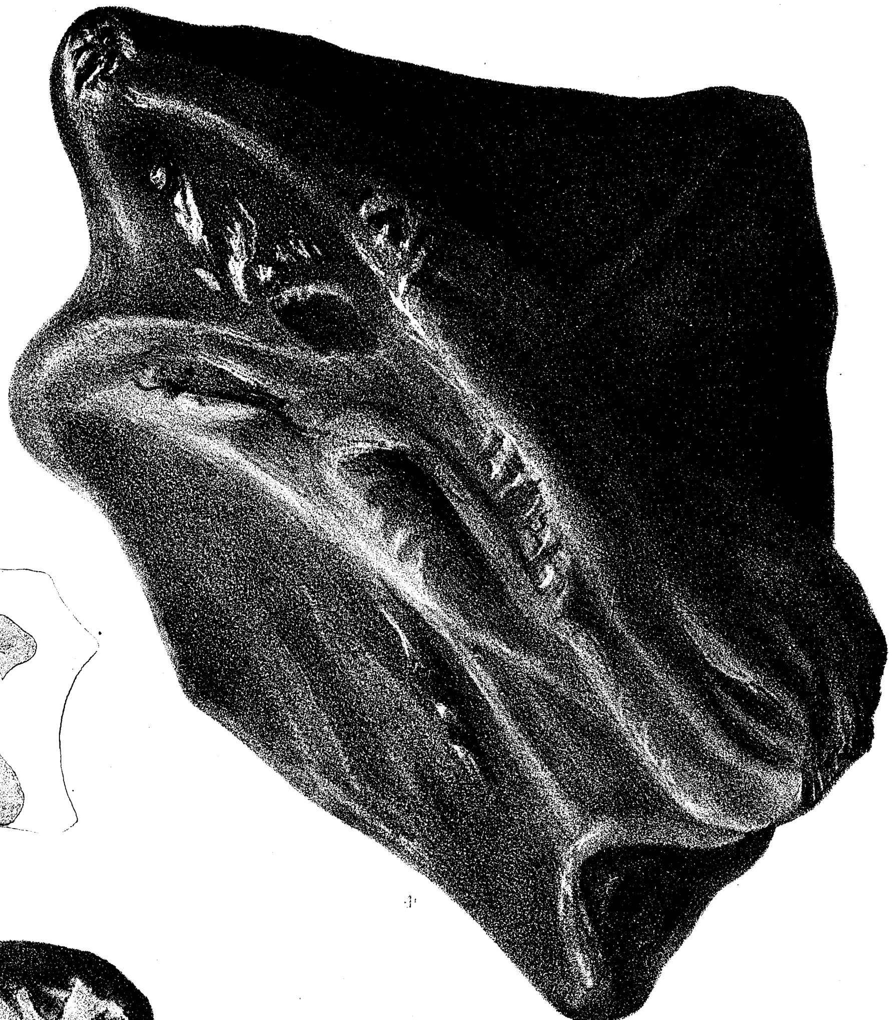

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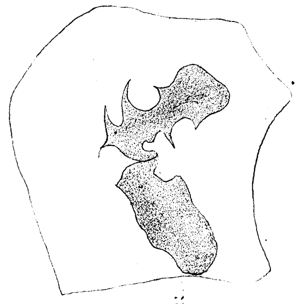

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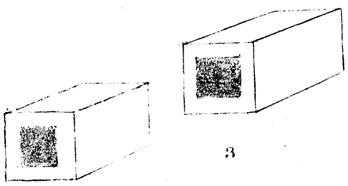

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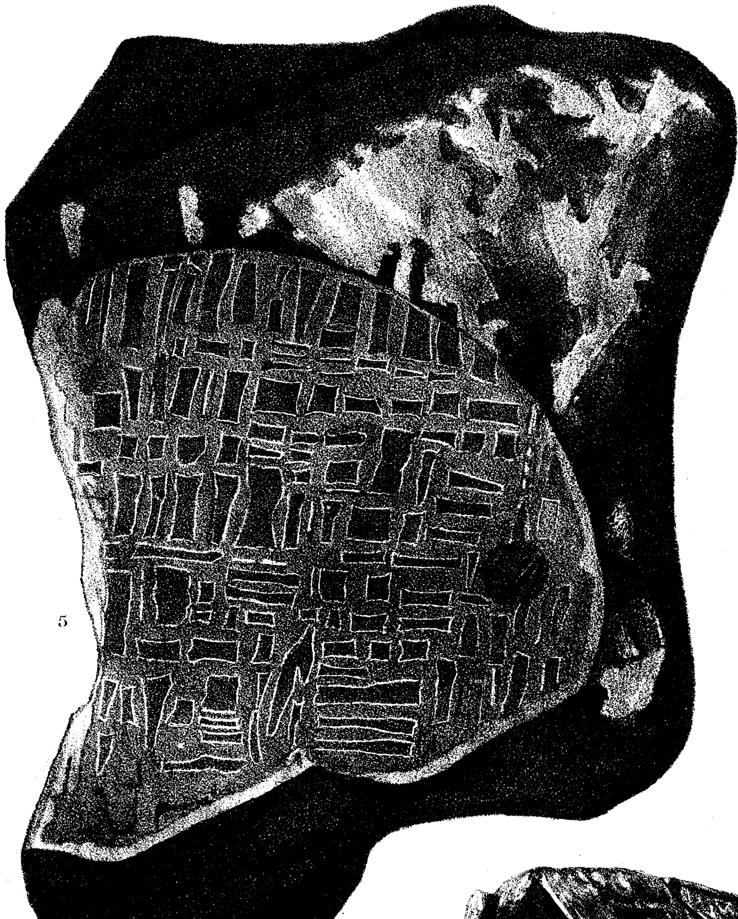

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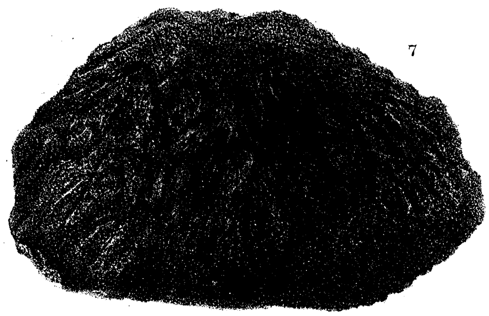

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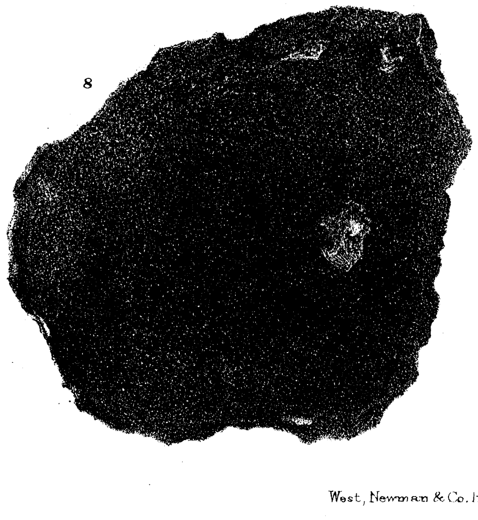

8

1

1.2.3 & 5. K. F. } del. ad nat.
4. C. M. }
6.7 & 8. photograph.

West, Newman & Co. lith.