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DESCRIPTIONS OF THE VICTORIAN METEORITES, WITH NOTES ON OBSIDIANITES.

By R. Henry Walcott, F.G.S., Curator of the Geological and Ethnological Collections.

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INTRODUCTION.

The total number of recorded authentic meteorites found in Australia is sixty, distributed and classed as follows*:—

State.	Siderites.		Siderolites.		Aerolites.		Unclassed.		Total.	
	No. Falls.	No. Specs. per Fall.	No. Falls.	No. Specs. per Fall.	No. Falls.	No. Specs. per Fall.	No. Falls.	No. Specs. per Fall.	Falls.	Specs
New South Wales†	8	1, 1, 1, 1, 1, 1, 1, 1	3	1, 1, 1	8	1, 1, 1, 1, 1, 1, 4, 6	..	..	19	27
Victoria ..	2	1, 5	2	1, 1	..	..	..	..	4	8
Queensland ..	3	1, 1, 2	..	..	2	1, 1	..	..	5	6
South Australia	4	1, 1, 1, 1	..	..	1	1	..	..	5	5
Western Australia	7	1, 1, 1, 1, 1, 1, 3	..	..	..	..	1	2	8	11
Tasmania ..	3	1, 1, 1	..	..	..	..	..	..	3	3
Total ..	27	34	5	5	11	19	1	2	44	60

Three of these meteorites, so far as the records show, were observed to fall, and all in New South Wales. Victoria has contributed the three largest specimens, but no undoubted aerolites have yet been found in this State, or, at least, definitely determined and recorded as such. Of the eight Victorian meteorites, until now, only the Cranbourne No. 1, Beaconsfield and Bendoc have been chemically and mineralogically examined. The Cranbourne No. 2 and Langwarrin had been very imperfectly investigated; the Cranbourne No. 3 could not be traced; the Yarroweyah is described here for the first time, and the Kulnine yet remains to be examined. The term "first record," as used in reference to the specimens dealt with in this paper, applies to the first printed mention of the occurrence in any publication, and does not necessarily mean that the meteorite was either identified authentically or scientifically described at the given date. The histories of the two large Cranbourne meteorites are so interwoven that it has been impossible to deal with them separately under their respective headings, and they have, consequently, been dealt with collectively in a separate chapter. It may appear, perhaps, that this matter has been made of more importance than it warrants, but the keen interest taken in the disposal of the specimens when their nature was fully recognised in 1860, which led to a controversy extending over several years, is sufficient reason why all the facts, gathered with considerable trouble, should be made known. The geographical positions given must be taken as approximate, but even an approximate estimate is better than a

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[*] With the exception of the Victorian figures the information has been taken from Anderson's Bibliography of Australian Meteorites (1).

[†] There are in the National Museum, Melbourne, two fragments of the Barratta (New South Wales) fall, but whether they represent distinct specimens or portions of recorded specimens is not known.

place name, which may be subject to alteration, and sometimes difficult to locate, even by a resident of the country of origin. Reported discoveries of supposed meteorites have been included in the paper, so that the investigations made concerning them may be available, and save trouble to workers in the future. Although not generally incorporated with meteorites, obsidianites or australites are given a place, for they must now be regarded, at least provisionally, as aerolites, in view of the accumulated evidence concerning them, which is difficult to reconcile with a terrestrial origin.

In addition to those mentioned hereafter, who have so kindly rendered assistance, I am very greatly indebted to Mr. P. G. W. Bayly, analyst to the Geological Survey, Department of Mines, Victoria, and also to his assistant, Mr. Alan G. Hall, for the interest evinced and care taken in carrying out the analytical work in connexion with the investigations on the Cranbourne No. 2, Langwarrin and Yarroweyah meteorites, work which has added so much to the value of the paper. To Dr. C. Anderson, mineralogist of the Australian Museum, Sydney, my sincere thanks are due for the ever-ready response to my requests for information, to Dr. G. T. Prior, Keeper of Minerals in the British Museum, for some facts relating to the Victorian specimens in the collection of that Museum, and to Lady Chas. MacMahon for the loan of the photograph of the Cranbourne No. 1., reproduced in plate I.

History of the Cranbourne Meteorites.

The facts given here concerning the history of the Cranbourne meteorites, taken from published records, have been, where possible, verified by reference to original correspondence, which has also supplied some further particulars.

As to the earliest time the Cranbourne meteorites were first observed by Europeans there is no record. Neither is it known by whom they were discovered.

Geo. Neumayer (42, p. 25), when Director of the old Flagstaff Observatory, Melbourne, visited the meteorites with A. T. Abel (variously called Prof. J. Abel, A. F. Abel, F. A. Abel, Engineer Abel), assayer, then of Ballarat, formerly of Hamburg, and others in February, 1861. Neumayer says that the larger meteorite was originally buried in the ground, a small piece only, 4 inches long, protruding above it, and it was by this means that the specimen was discovered. He was told by some old colonists that they remembered the time when the natives used to dance around the meteorite, beating their stone tomahawks against it, and apparently much pleased with the metallic sound thus produced. The story goes, he continues, that a settler once passing that way was going to tether his horse to what he took to be the stump of a tree; surprised at the peculiar metallic feeling it had to the touch, he examined it, and was soon made aware of the true nature, meaning thereby, presumably, in so far as it was metallic iron. The piece alluded to as projecting above the ground had been cut off before Neumayer's visit, and he was informed that a horse-shoe had been manufactured from it.

The first record of the larger meteorite dates from 1854, in which year " a specimen of iron from Western Port and a horse-shoe made from it " were exhibited in the Melbourne Exhibition by James A. Scott, 32 Little Collins-street W., farrier (38). This is evidently the horse-shoe mentioned by Neumayer. He, from what could be gathered as to the time the meteorite was first seen, or recognised as a mass of metallic iron by Europeans, placed it in the years 1853 or 1854. No mention seems to have been made as to the probable date of discovery of the smaller meteorite. It was likely enough, however, shortly after the discovery of the larger one.

The first authentic report on the occurrences was made by E. G. Fitzgibbon (19), then town clerk of Melbourne, who first heard of it at the beginning of 1860, when acting as a delegate of the City Council at a conference respecting the desirability of constructing a railway from Melbourne to the reputed coal-fields of Cape Paterson.

Alex. Cameron, a member of the conference, resident at Cranbourne, a district through which the railway, if constructed, would pass, brought up and exhibited in Melbourne pieces of the meteoric masses, in the belief that they represented the outcrops of iron deposits extending for a distance of some 5 miles, the working of which in connexion with the Cape Paterson coal would be one of the commercial inducements to construct the railway.

In a private note to the author, dated 9th January, 1900, Fitzgibbon says that the pieces exhibited by Cameron comprised the horse-shoe previously referred to, and a small lump about the size of a man's fist.

To satisfy himself as to the correctness of Cameron's statements, Fitzgibbon visited the locality, probably shortly before reading his note, on the 4th June, 1860 (19), and found that, whilst the rock of the district was seemingly ferruginous, the surface deposits of apparently pure iron were only two, viz.:—

" 1st.—A mass [referred to hereafter as Cranbourne No. 1] lying on the land of a Mr. McKay [Mackay, McKaye], on section 39, parish of Sherwood*, distant about

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* On Neumayer's plan of the locality the position of the Cranbourne No. 1 is shown on a section, which, on comparison with the plan of the parish of Sherwood, is seen to be section No. 40, adjoining section No. 39 on the east side. As far as could be ascertained, section No. 40 belonged to Jas. Bruce, he having applied for and obtained a Crown grant in 1858, while McKay, from whom, as stated later, Bruce bought the meteorite, owned section No. 39. The latitude and longitude of the portion of the meteorite is given as 38° 11′ S. and 145° 20′ E. respectively by Haidinger (33, p. 72), who, probably took them from Neumayer's observations. In order to try and definitely settle the section upon which the specimen was actually found, Mr. G. Ditchburn, of the Department of Lands and Survey, very kindly undertook to fix the position of the northern boundary corner of the two sections. His results showed that the position given by Haidinger would place the meteorite considerably to the N.E. of either section. The observations, therefore, must be discarded as inaccurate, and the statement of Fitzgibbon, that the specimen was discovered on section 39 be accepted as correct. Flight (22) has reproduced Neumayer's plan in illustration of his paper.

$3\frac{1}{2}$ miles in a southerly direction from the township of Cranbourne. It presents a tabular face, nearly level with the surface of the land, and somewhat of a triangular shape, the edges measuring respectively about 31, 33 and 38 inches. A trench excavated around it has revealed its sides to an average depth of about 30 inches, the bulk of the mass becoming greater as the depth increases, inducing a belief that the weight of the portion visible amounts to about 4 tons.* The upper surface is studded with apparently oxidized blisters, which are easily detached in scales, and which, in some instances, contain a non-magnetic metallic substance approaching to the character of black lead. The sides are thickly oxidized, the coat being in some places nearly half an inch in thickness, and mixed with the contiguous earth, with which it is found in close adhesion.

2nd.—A mass [referred to hereafter as Cranbourne No. 2] similarly bedded, in land belonging to a Mr. [Jas.] Laneham, section 39, parish of Cranbourne, distant about 2 miles eastward from the township, and about 4 miles north-eastward from the mass† just described, similar to it in general characteristics, but apparently not more than half its bulk."

Fitzgibbon also obtained and exhibited with other specimens at the meeting of the Royal Society of Victoria, at which he read his note, a portion of a third and very much smaller mass (referred to hereafter as Cranbourne No. 3), of a similar description. In his private letter, Fitzgibbon says, in respect to this piece, that it was given to him by McKay, on whose land the Cranbourne No. 1 was discovered, and that it weighed about 7 pounds, and represented approximately the half of an oblong flattish piece which had been picked up half-a-mile or so away from Cranbourne No. 1. Not being gold, as, from its weight, the labourer who found it imagined, it was placed on the kitchen hob as an andiron, got broken whilst being so used, and the other half was lost. McKay also offered Fitzgibbon the Cranbourne No. 1, if he chose to be at the cost of removing it; but he declined the offer, on the ground that his object was to draw attention to the meteorite, and have it cared

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* Neumayer (42, p. 25) gives the weight, from actual weighing, as 8,200 lbs., which is the weight, less that of the pieces previously removed. The British Museum Catalogue, 1908 (7, p. 7) gives it as 3,500,000 grams (7,716 lbs.) Loss by scaling during the interval between the two weighings would probably account for the difference in the given weights.

† Haidinger (33, p. 72) gives the position of the smaller mass (Cranbourne No. 2) as latitude 38° 8′ S., longitude 145° 22′ E., and, according to Neumayer (42, p. 26) its actual distance from the larger meteorite (Cranbourne No. 1) was 3·6 miles.

for by the Government as a matter of scientific interest. Subsequently, it was purchased from McKay for the sum of £1 by Jas. Bruce, owner of the adjacent property, after whom it has sometimes been called the Bruce Meteorite.

Laneham, on whose land the Cranbourne No. 2 lay, offered that meteorite to Fitzgibbon for the sum of £5, but this offer was likewise declined, for the reason already given for refusing the Cranbourne No. 1. The Cranbourne No. 2 was bought by A. T. Abel from Laneham, during his visit to Cranbourne, in February, 1861, when he was accompanied by Neumayer (42, p. 26.) According to Haidinger (31, p. 379), the purchase was effected through Karl Rupprecht, proprietor of the Sabloniere Hotel, Queen-street, Melbourne, who also formed one of the party. Neumayer says that Laneham looked upon the specimen as rather a nuisance, and was glad to dispose of it. It had been turned over on its broad side, rendering the whole mass visible. The dimensions* are given as 3 ft. 1 in. by 2 ft. 8 in. by 1 ft. 9 in., and its weight was determined to be approximately 30 cwt. Laneham informed Neumayer that, just as in the case of the Cranbourne No. 1, only a small piece of the specimen projected above the surface of the ground when it was first discovered. The approximate bearing of the Cranbourne No. 1 from the centre of No. 2 was given as S. 34° W., and the distance 3·6 miles. It is stated in the Melbourne *Herald* of the 4th March, 1861, that No. 2 was brought to Melbourne by Karl Rupprecht immediately after its purchase. Prof. (afterwards Sir Fredk.) McCoy, Director of the National Museum, Melbourne, stated in a letter to R. Brough Smyth, then Victorian Secretary for Mines, dated 16th May, 1862, that the meteorite had been purchased and brought to Melbourne for about £50. The amount of purchase money is not to be ascertained, but probably it would be small, the bulk of the £50 going to transport expenses. The specimen was exhibited at Rupprecht's hotel, then at the exhibition opened in Melbourne on 1st October, 1861 (39, pp. 248, 285), and later at the International Exhibition, London, 1862 (37), after it had been offered to and refused by the National Museum, Melbourne, on account of the high price ; several hundred pounds and a large portion of the specimen for private sale being demanded.

The British Museum purchased it for £300, in accordance with an arrangement, given later.

Fitzgibbon had spoken to Sir Henry Barkly, at that time Governor of Victoria, and President of the Royal Society of Victoria, of the occurrences, and Sir Henry had expressed a wish that the Society's attention should be drawn to them. The outcome of this suggestion was Fitzgibbon's note, and the exhibition of specimens,

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* See note on measurements in description of this meteorite, p. 22.

mentioned previously, with the purpose of deciding whether the deposits were native iron, and bore affinity to the local formation, or whether they were of meteoric origin. It is evident, from the foregoing, that although at least one of the meteorites was definitely known as early as the year 1854, their meteoric nature was not fully recognised until about the middle of 1860.

The publication of Fitzgibbon's note is said to have excited great interest in Europe, and the Emperor of Austria wrote for further particulars to Sir Henry Barkly. Fitzgibbon thereupon again inspected the meteorites at Cranbourne, to verify his notes, and, the results being given to Sir Henry Barkly, he replied to the Emperor, through Dr. Ferd. (afterwards Baron von) Mueller, who forwarded a fragment not much larger than a crown piece, detached from the small fist-sized piece which Fitzgibbon had given to Sir Henry Barkly. Fitzgibbon also gave to Sir Henry Barkly the andiron portion of the Cranbourne No. 3 and the horse-shoe. The fist-sized piece and horse-shoe were apparently the specimens brought up from Cranbourne by Cameron as exhibits. Fitzgibbon states in his letter that there was yet another portion, weighing probably some half-hundredweight, which had been lying for a long time at the local smithy, and from which the horse-shoe before mentioned and a smaller one, which Fitzgibbon had since lost, were cut. The residue of this block, he says, he last saw in the possession of George Foord, then assayer of the Melbourne Mint. Fitzgibbon did not think that the block came off either the Cranbourne No. 1 or the Cranbourne No. 2.

He was wrong in this, for both Neumayer (42, p. 25), and Foord (24), in his note to Brough Smyth, mention that the part of the Cranbourne No. 1, which originally projected above the ground, had been cut off, and from it a horse-shoe had been made. Foord says that the smith who made the shoe cut off the block, which was about the size of a child's head, from the main mass.

Bruce, the owner of the Cranbourne No. 1, finding the block in the smith's possession, obtained re-possession of it, and forwarded it to Melbourne. Subsequently he presented it to Foord, who had it cut in two, so as to obtain a section. The larger surface was etched, and the piece exhibited at the Melbourne Exhibition of 1861 (39, p. 249), and afterwards at the exhibition held in London in 1862 (37). It passed thence into the possession of A. T. Abel. The other section of Foord's block was probably retained by him, for the writer saw what he believes to have been it among Foord's effects at the time of his death, in 1898. What has since become of the specimen is not known. Foord gives the weight of the block, before cutting, at 35 lbs. 9 ozs. 121 grs. adv., and its specific gravity as 7.5215. It is of interest to note here that Mr. Benjamin Barnes, of Queen's-road, South Melbourne, then manager for Enoch Chambers' engineering works, who cut Foord's specimen, informed the writer that, a week or two before Foord's visit, Captain (afterwards Sir Charles) MacMahon, superintendent of police, called at the works with a little nugget of iron, about half-a-pound in weight, which was worked into a rod for him. He told Barnes that it was native wrought iron, and that he knew where there was a large deposit of it, and had broken the small piece from a mass which projected above the ground. He would not, however, divulge the locality where it occurred ; but there can be little doubt that it came from Cranbourne, and was, in all probability, a fragment of the Cranbourne No. 1.

In January, 1862, correspondence passed between Professor McCoy and James Bruce, who had purchased the Cranbourne No. 1, for the nominal sum mentioned before from McKay, on whose property it had been found, on the understanding that the specimen was to be presented to the British Museum. McCoy asked Bruce to give the meteorite to the National Museum, undertaking, on behalf of that institution, to bear the expense of excavation and transport. Bruce replied that he could not do this, but that he would allow McCoy to retain half, provided the National Museum paid the expenses of the removal of the specimen from Cranbourne, and that the authorities of the British Museum be communicated with, and offered the other half, on the condition that they would be at the expense of dividing it.

This arrangement seems to have been accepted by McCoy, but, in the meantime, Bruce, owing to McCoy's delay in replying to his letter, had concluded that his conditions were not acceptable, and on the 31st of January handed the meteorite over to Dr. Mueller for presentation to the British Museum, according to his original intention. Bruce explained the position in a letter to the Melbourne *Argus* of the 5th December, 1862. About this stage Sir Henry Barkly made an alternative suggestion to Mueller, to the effect that if the British Museum purchased the Cranbourne No. 2, and sent it to the National Museum, there would be no necessity to cut the Cranbourne No. 1. Mueller was apparently agreeable to this variation of Bruce's suggestion. The matter was then referred to the authorities of the British Museum (46) to decide as to which was the more advisable plan to adopt; for the British Museum to purchase the Cranbourne No. 2 from Abel, and present it to the National Museum, in return for the Cranbourne No. 1 intact, or to have the latter divided. They were unanimously and strongly in favour of the former plan.

Notwithstanding this, a considerable amount of local controversy ensued, in which it was sought by some to retain the Cranbourne No. 1 in the colony.

A commission (53, p. 424) was appointed, about July, 1862, by the Honorable (afterwards Sir) John O'Shanassy—at that time

Chief Secretary of the colony—with the Honorable G. S. Evans as chairman, with instructions to investigate the claims of the discoverer, and owner of the land, and to report whether any steps could be taken to secure the meteorites for the National collection. As might have been expected, this Commission found it could do nothing. The report of the Commission cannot be found in the Parliamentary papers of that period. In the Royal Society, Fitzgibbon (46) brought forward a motion at the November meeting, in 1862, urging the expediency of not only retaining the Cranbourne No. 1, but also of recovering the Cranbourne No. 2, then in London. An amendment, however, was carried, appointing a committee of the Society to take what measures were deemed best for securing possession of the Bruce Meteorite (the Cranbourne No. 1).

Eventually, Sir Henry Barkly's suggestion was carried out, and the Cranbourne No. 2, which had been purchased from Abel by the trustees of the British Museum for the sum of £300, was presented to the National Museum, Melbourne, in return for the Cranbourne No. 1 intact. The latter meteorite reached the British Museum in 1865, but there is nothing to show in what year the Cranbourne No. 2 was returned to Melbourne. On arrival at the British Museum, some holes were drilled in the under surface of No. 1, and it was fixed on a turn-table in the Mineral Gallery, where it is now exhibited. The work of removal of this meteorite, the largest then known, from Cranbourne to Melbourne was supervised by A. A. C. Selwyn, then Director of the Geological Survey of Victoria, and his assistant geological surveyor, R. Daintree (afterwards Agent-General for Queensland), who took photographs of the specimens. Neumayer (42, p. 53) accompanied the party, at Selwyn's request, and he gives the date of removal as the 21st February, 1862. Barnes verbally informed the writer that the contract for the removal was let for £100 to Enoch Chambers, whose business, as previously stated, he was then managing. Both he and Chambers went to Cranbourne, taking with them a waggon and the necessary tools, and the transit of the specimen occupied about three days.

In a letter dated 16th May, 1862, to Brough Smyth, McCoy, in giving an account of the transactions in connexion with the disposal of the meteorites, states that Sir Henry Barkly himself defrayed the expenses of moving the specimen. On arrival in Melbourne, the meteorite was set up in front of the National Museum. Flight (22, 23) says that unfortunately it had been placed in the University grounds, near the shore, and exposed to the action of sea-water. This mistake probably arose from the fact that there is a small artificial fresh-water lake in the University grounds, immediately in front of the building which was, until 1899, occupied by the National Museum collections.

RECORD OF FRAGMENTS TAKEN FROM THE CRANBOURNE METEORITES, INCLUDING THE "YARRA YARRA" FRAGMENTS.

The following makes no claim to be an accurate record of the fragments of the Cranbourne meteorites and their present locations. The preparation of such a record is impossible, not only because the actual number of fragments is unknown, but also on account of changes in the ownership of some specimens and the division of others. The present locations of the principal masses are given under the description of each meteorite.

Cranbourne No. 1—

(*a*) Horse-shoe and lump exhibited at the Melbourne Exhibition, 1854 (38); same horse-shoe and (?) same lump said to be about the size of a fist, exhibited by Cameron at conference on construction of railway line. Both passed into the possession of Fitzgibbon, and given by him to Sir Henry Barkly. A small portion, about the size of a crown piece, was sent to the Emperor of Austria by Mueller. In November, 1861, Sir Henry Barkly presented to the K. K. Hofmuseums, Vienna (33, p. 66), a piece weighing 37 ozs. 164 grs., which is probably the fist-sized piece. This was sliced by the K. K. Hofmuseums, and one face was etched and figured by Haidinger (33). Brezina (5, p. 302) gives the combined weight of the two pieces in the Hofmuseums as 1,100 grams, and the weight of the larger piece of the two as 938 grams.

(*b*) A smaller horse-shoe in the possession of Fitzgibbon, and lost by him.

(*c*) A lump from which the horse-shoes were cut, recovered by Bruce from the blacksmith at Cranbourne, and given by him to Geo. Foord. Weight of this specimen given as 35 lbs. 9 ozs. 121 grs. Foord had it cut in two. The larger piece was etched and exhibited in the Melbourne Exhibition of 1861 (39, p. 249), and afterwards at the London Exhibition, 1862 (37). It then passed to A. T. Abel, and probably from him to Jas. Gregory, mineral dealer, of London, who, if this was the case, had it cut up. Two pieces are mentioned in Gregory's catalogue, 1889 (27), one of which has a weight of 457 grams, is etched, and was in his private collection. The other piece weighed 443 grams. Foord's smaller piece was almost certainly in his possession at the time of his death, in Melbourne, in 1898, but its whereabouts since is not known.

(*d*) Two small specimens, weighing 2·16 grams, and for the most part oxidized, mentioned in the Catalogue of Specimens in the National Museum, Melbourne (47 p. 71). These are still on the collection of that Museum.

(*e*) Two small pieces in the National Museum, Melbourne, chiselled off the mass. Combined weight, 13·13 grams.

(*f*) Piece of crust taken from the base of the meteorite on the day it was lifted, and given by Selwyn to Foord Weight, 1 lb. 7¾ ozs. Now in the National Museum, Melbourne.

Cranbourne No. 2—

(*a*) Piece cut off from the mass, leaving a face measuring about 5 inches by 3½ inches. Weighing originally 1 lb. 8¾ ozs., but partly used up for present investigations National Museum, Melbourne.

(*b*) Pieces chiselled off two other places on the meteorite, leaving rough faces. One of these faces, having a crescent shape, is about 8 inches long, and occurs on one of the lower edges. The other face, about 5 inches in length, is on one of the angular corners. With the exception of fragments which were, according to the Melbourne *Herald* of the 8th March, 1861, in Neumayer's possession, some of which it may be inferred he sent to the K. K. Hofmuseums (32, p. 465), none of the pieces can be traced. The pieces, ten in number, sent to the Hofmuseums, weighed 14 grams.

Cranbourne No. 3—

(*a*) One-half lost.

(*b*) Other half, said to weigh about 7 lbs., given by McKay to Fitzgibbon in 1860, and afterwards by the latter to Sir Henry Barkly, identity then lost.

Uncertain—

(*a*) An oxidized piece, weighing 145 grams, in Foot's collection of Meteorites, Philadelphia, in 1912 (25, p. 54).

(*b*) In the Harvard College collection of meteorites (36, p. 74) there are two pieces of crust weighing respectively 283 and 186 grams; one piece of crust with schreibersite weighing 34·5 grams; and a mass of iron with ragged exterior and one polished face, showing very broad, perfect Widmanstätten figures, weighing 27·5 grams.

(*c*) A piece weighing about half a pound in possession of Capt. MacMahon in 1860 or 1861, worked into a rod.

(*d*) An irregular fragment, much decomposed, with plates of taenite, weighing 34·2 grams; and a thin slab of 15 grams, with etched surface, in the Field Museum, Chicago (18, p. 93).

(*e*) A small piece, 1 gram in weight, in Dr. A. Brezina's collection (6, p. 244).

(*f*) Pieces having a total weight of 2,638 grams, in the Ward-Coonly collection (58, pp. 9, 75). The largest piece weighs 2,615 grams. Ward purchased the bulk of Gregory's collection in 1901, but it does not appear whether he secured with it any of the Cranbourne fragments.

(*g*) Three pieces in the British Museum (7, p. 71), found in Abel's collection, with the label "Yarra Yarra River.—Date 1858," obtained from Jas. Gregory, who purchased them when Abel's collection was sold in London. Their weight is 214 grams. These fragments are said to have been probably detached from one of the Cranbourne meteorites. It is curious that Abel, who must have known the localities so well, should have put such a label on the specimens if they were really parts of one of the Cranbourne meteorites.

(*h*) Six pieces, said to be from the Yarra Yarra River, evidently also from Abel's collection, in Gregory's collection, London, in 1889 (27). Three of the pieces, weighing respectively 10, 17 and 25 grams, were offered for sale, and three others, one of which shows Widmanstätten figures, were in his private collection. They weighed 85, 34 and 23 grams. The last three are now (February, 1913) in the possession of Gregory's son (Victor H. Gregory), in London.

(*j*) The K. K. Hofmuseums, Vienna (5, pp. 344, 368), have in their list of meteorites in the collection specimens from the Yarra Yarra ("Yara Yara"), said to have been found in 1853 (= 1858 of British Museum, Fletcher). These may possibly be the specimens offered for sale in Gregory's catalogue.

(*k*) A fragment with prominent octahedral structure, of 4·5 grams weight, with Yarra Yarra River as locality, is given in the catalogue of the Field Museum specimens (18, p. 93).

CRANBOURNE No. 1 METEORITE. PLATE I.

(Cranbourne Meteorite, Bruce Meteorite, Bruce's Fragment, Western Port Iron, Larger Cranbourne Mass, etc.).

Class.—Siderite—Broad Octahedrite.

Weight.—7,716 lbs. (3,500 kilos), original weight not known.

Locality.—About 3½ miles southerly from Cranbourne, (Lat. 30° 11′ S., Long. 145° 20′ E.) Section 39, parish of Sherwood, county of Mornington.

Date of Discovery.—1854, or earlier.

Date of First Record.—1854.

Collection.—British Museum. (Natural History.) London.

References.—1 (p. 57), 2, 3, 4, 5 (pp. 273, 285, 302, 344), 6 (pp. 227, 244), 7 (pp. 7, 11, 71), 8, 9, 10, 11 (pp. 1049–1050), 14, 16, 17, (?) 18, 19, 20 (p. 152), 21, 22, 23, 24, (?) 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, (?) 36, 37, 38, 39 (pp. 129, 249), 42, 43, 44, 46, 47, 48, 49, 50, 51 (pp. 75, 76), 53, 54, 55, 56, 57 (pp. 259, 260, 261, 267, 268, 271, 272), (?) 58 (pp. 9, 75, plate III., Fig. 3), 59.

The history of this meteorite has already been fully dealt with.

The following notes on its chemical and mineralogical composition, unless stated otherwise, have been taken from Flight's report (22, reprinted 23). The specimen was found to consist entirely of metallic minerals, containing no rocky matter whatever.

It decayed to a considerable extent ; fragments oxidized and crumbled off, and drops of iron chloride exuded here and there. The part of the meteorite so rapidly decaying presented a very marked crystalline character ; and the tetrahedral structure broke up into plates, between which were very thin plates of another constituent (taenite), less 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.

Neumayer (42, p. 25) took the specific gravity of four specimens of the iron, and one of the crust. The former gave 7·12, 7·51, 7·51, 7·60 respectively, and the latter 3·66. Flight states that these pieces were taken from the Cranbourne No. 2, but reference to the original paper shows that this was not so.

Foord (24, p. 426) gives the specific gravity of the block in his possession as 7·5215.

Nickel-irons.—A portion of the iron connected with a Bunsen cell was treated in a solution of salt in a sealed vessel, for the purpose of determining whether the iron contained any combined carbon. The absence of the latter was said to be fully established.

The greater part of the insoluble ingredients consisted of rhabdite in the form of very minute, bright, apparently square prisms, which pervade all the nickel-iron, and seem to constitute nearly 1 per cent. of its mass. The nickel-iron was found to contain—

Prisms (rhabdite)	0·932
Nickel	7·651
Cobalt	0·501
Copper	0·0156
Silicon	0·172

This analysis was evidently worked out to 100 by Cohen (11, p. 1050), after deducting the rhabdite, for comparison with a general analysis of the Beaconsfield. The following are his figures:—

Iron (diff.)	[91·74]
Nickel	7·74
Cobalt	0·50
Copper	0·02

Some of the nickel-iron plates were analyzed by Flight for constituents other than iron, but, as the results do not appear to be of any special interest or significance, they are not quoted.

Under the name of edmondsonite, Flight describes taenite as occurring in thin, paper-like pliant plates of a pure white colour lying on the faces of the tetrahedra of nickel-iron, and between the large plates of the crystals of nickel-iron.

They contained 0·688 per cent. of phosphorus.

Analysis of taenite:—

Iron	70·138
Nickel	29·744

Flight states that the name "meteorin" was proposed by Zimmerman [correctly Abel; Zimmerman (60, p. 557) only communicated the information] for what was evidently the same substance in the Cranbourne No. 2 meteorite. But as Flight had made out its composition for the first time, he proposed to call it edmondsonite, in memory of the late George Edmondson, the head master of Queenwood College, Hampshire.

In a section of this meteorite from the K. K. Hofmuseums, Vienna, used for comparison with a section of the Beaconsfield, free from cohenite, Cohen (11, p. 1049) mentions that in both sections the kamacite plates are stout, and of irregular wavy outlines, and show "file marks" plentifully. In both, also, the taenite only stands out slightly on the etched face, and plessite, rich in "combs," is present in very small quantity.

TROILITE.—This mineral occurs in many nodules 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 sizes from half-an-inch to more than 2 inches in length, are usually covered with a thin layer of graphite, sometimes with daubréelite surrounding them.

Analyses :—

	I.	II.	III.	IV.	Mean.
Insoluble	0·215	2·297	—	—	—
Iron	—	62·150	63·613	—	63·613
Nickel	—	0·446	—	—	0·446
Copper	—	0·079	—	—	0·079
Sulphur	36·543	—	36·207	36·250	36·333
Chlorine	—	0·130	—	—	0·130

Daubréelite.—Flight mentions daubréelite in connexion with troilite, which, as we have just seen, is stated to be sometimes covered with graphite and surrounded by daubréelite. Smith (49) also notes the presence of daubréelite in the Cranbourne No. 1, associated with troilite, but the quantity was less than in the other two meteorites examined at the time.

Schreibersite.—After treatment of the nickel-iron with hydrochloric acid until action ceased, Flight obtained schreibersite as coarse insoluble particles. They were very brittle, very magnetic, and dissolved readily in strong nitric acid.

Analyses :—

	I.	II.	Mean.
Iron	56·245	55·990	56·117
Nickel	29·176	—	29·176
Phosphorus	13·505	—	13·505

Rhabdite.—This mineral was mentioned as occurring in apparently square prisms in the insoluble residue of the nickel-iron, and as forming nearly 1 per cent. of the latter. The prisms are strongly magnetic, exceedingly brittle, and rarely, if ever, of their normal length.

Analyses :—

	I.	II.	III.	Mean.
Iron	49·715	—	48·955	49·335
Nickel	36·666	39·519	38·540	38·242
Phosphorus	[13·619]	12·586	12·645	12·950

Specific gravity, 6·326—6·78.

These analyses are given as corrected by Cohen (9) and Dana (16, p. 31), according to whom Flight, in his paper, had transposed the nickel and iron.

Undetermined Iron-nickel Phosphides.—Search was made for crystals from which the schreibersite powder may have been derived, and occasionally, but rarely, larger bodies were found, which, when broken up, might have formed this powder. A large brass-coloured oblique crystal was met with, which readily cleaved across the base. It was only slightly acted upon by hydrochloric or nitric acid, but on long-continued boiling both acids dissolved it slowly. In aqua regia it dissolved rapidly. When a fragment was heated it quickly became of a dark-brown colour.

Analyses :—

	I.	II.	Mean.
Iron	69·251	69·843	69·547
Nickel	(Both analyses lost)		[14·410]
Phosphorus	15·420	16·666	16·043

Another crystal found in the *debris* of the meteorite consisted apparently of a square prism, which, while the sides were bright and metallic, had a square centre of a dull almost black colour. It very readily broke across the prism. A figure is given by Flight of the broken prism.

An analysis yielded the result :—

Iron	67·480
Nickel	20·318
Phosphorus	12·317

LAWRENCITE.—Mention has been made of drops of iron chloride exuding from parts of the meteorite, and that fragments of nickel-iron yielded hydrochloric acid when subjected to the action of hydrogen; but Flight does not appear to have investigated this mineral constituent, which has been such an active agent in the disintegration of the meteorite. It is interesting to note in connexion with the presence of chloride of iron that Foord (24, p. 425) thought it was probably not an original constituent of the meteorite, but the result of the saltness of the soil into which the meteorite had fallen ; or to the latter having originally fallen into the sea or a salt lagoon, from which alterations of levels had since raised it. The kind of action which sea-water constitutents are thus supposed to have exerted upon it is, he says, exactly the same as what is taking place with cast-iron pipes, gas pipes for example, which happen to be buried in soil more or less of a salt character. After such influence they sweat out chloride of iron on exposure just in the same way.

GRAPHITE.—Besides forming an envelope to the troilite nodules, graphite occurs occasionally as nodules ; sometimes as nodules enclosing troilite, like the one already referred to ; and sometimes in large sheet-like masses, in one case about 4 inches in length, and 2 inches wide. A specimen was carefully dried and powdered and burnt in a current of oxygen, with the following result :—

Carbon	89·661
Hydrogen	0·257
Residue (iron, &c.)	10·412

HYDROCARBON AND SULPHUR.—J. Lawrence Smith (48, pp. 394–395; 50, pp. 421–423), found a substance of uncertain composition in a graphite nodule from this meteorite, which he had previously observed in the iron from Sevier County, Tennessee, and to which he had given the name celestialite.* It was first called attention to by Professor Wöhler, when examining the Kaba meteorite, and

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* Compt. Rond. 1875, LXXXI., pp. 1055-1056.

it was afterwards investigated by Professor Roscoe* in the Alais meteorite. Roscoe regarded it as a mixture of sulphur and a hydrocarbon, and Smith thought it might be either sulphur containing a minute quantity of a hydrocarbon, or a sulph-hydrocarbon. In the Cranbourne meteorite, besides graphite and troilite, the substance was associated, according to Smith, with an undefined cobalt mineral. The substance was extracted by treating some of the powdered nodule with petroleum ether, and allowing the solution to evaporate. This procedure yielded acicular crystals, giving off a peculiar odour, and consisting of preponderating sulphur, with carbon and hydrogen.

Olivine.—Foord (24, p. 425) says that in one of Daintree's photographs there is seen a white spot, representing a white friable substance, filling a cavity. This photograph is reproduced here (Plate I.), and the spot referred to occurs about half-way up the specimen, towards its right side. The substance proved to be carbonate of magnesia, probably resulting, Foord thought, from the decomposition of olivine, or some other magnesian mineral. Some of it is in the mineral collection of the National Museum, Melbourne. It has a clay-like appearance, and is stained light-green, with nickel. Besides this, and as affording proof of the substance being an original part of the meteorite, it is reticulated by fine veins of nickel-iron, more or less decomposed into ferric oxide.

Gases occluded by Nickel-iron.—Flight examined the nickel-iron for occluded gases. A portion of the borings removed from the under surface was selected, and 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

CRANBOURNE No. 2 METEORITE. PLATE II.

Abel's Iron, Abel's Fragment, Western Port Iron, Dandenong Meteoric Iron, Smaller Cranbourne Mass, etc.

Class.—Siderite—Broad Octahedrite.

Weight.—About 30 cwt.

Locality.—About 2 miles east of Cranbourne, Section 39, Parish of Cranbourne [Lat. 38° 8′ S., Long. 145° 22′ E.], County of Mornington.

Date of Discovery.—Probably about 1854.

Date of First Record.—1860.

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* Proc. Lit. Phil. Soc. Manchester, 1863, III., p. 57.

Collection.—National Museum, Melbourne.

References..—1 (p. 58), 2, 14, 19, 22 (pp. 885–886), 23 (pp. 59–60), 29, 30, 31, 32, 33, 39 (pp. 129, 248, 285), 42 (pp. 24–26), 46, 54, 55, 57 (pp. 259, 261, 268, 271, 272), 60.

Until now this meteorite had not been systematically examined. Zimmerman, in his letter (60, p. 557), says that Abel made some tests which indicated the presence of a new iron, and suggested for it the name " meteorin." This iron, as already mentioned, is taenite and was more fully investigated by Flight in his examination of the Cranbourne No. 1, and called by him edmondsonite. Zimmerman also states that the meteorite was coated with a thick crust of hydrous oxide of iron and chloride of iron, and gives the specific gravity of the unaltered iron as 7·50.

Haidinger (32, p. 469), evidently from information obtained from a private report of Neumayer, speaks of the specimen as having no real crust, but rather a heavy coating of oxide of iron. He mentions besides the presence of hygroscopic masses, considered to contain chloride of iron. These points are of some interest, and will be referred to again later. Neumayer obtained schreibersite from the meteorite. The writer (57), in addition to schreibersite, records graphite and troilite, all of which were determined by a superficial examination of the polished face of the specimen. Daubréelite was also mentioned as a possible constituent, but the investigation since undertaken, the results of which are given here, failed to affirm the presence of this mineral.

Karl Ritter von Hauer (32, p. 470) analyzed samples from the K. K. Hofmuseums, sent to him by Haidinger (presumably some of the pieces received from Neumayer), and gives the nickel and iron contents, but it is not certain from which of the two large Cranbourne meteorites the samples came.

Seen as it now rests on one side in the Museum, the meteorite has, roughly, a rectangular outline.

It has three well-defined sides, the two larger of which are approximately at right angles to one another, while the remainder of its surface forms a fairly regular, unbroken, convex curve. The largest of the three sides is almost flat, and the other two slightly concave. These features, together with the angular intersections, strongly convey the impression that the three sides have been produced by fracturing. The sides differ also in superficial structure from the curved convex face, about a fifth of which still retains the characteristic furrows and thumb-marks of an original meteoric surface. Besides this, on the curved face, but not within the particular area just referred to, there are a number of cavities, varying in diameter up to 2 inches, and lined with ferric oxide, showing imperfectly a concentric arrangement. These cavities undoubtedly have been formed by the decomposition and removal of troilite nodules. Here and there traces can be seen of the exudation of chloride of iron, for the greater part on the sides and end, and not at all within the original surface area, although no scaling has been noticed since it has been under observation in the Museum by those now living, some 25 years or more.

The dimensions taken by Neumayer, viz., 37 inches by 32 inches by 21 inches, previously mentioned, evidently represent the maximum diameters in three directions, the two smaller measurements being taken from edge to edge. Neumayer refers to the direction of the greatest diameter as from N.E. to N.W., but on the sketch in the plate accompanying the report it is given as from " N. O. to S.W."

Haidinger (32, p. 466) gives some further measurements with outline sketches of the specimen indicating the directions in which the measurements were made.

The material used for the present examination was part of the piece mentioned previously as having been cut off to afford a face for showing the internal structure of the specimen. The surface yielded by the part examined measured about 9 cm. by 6 cm.

General Analysis—

Iron	92·34
Nickel	6·38
Cobalt	0·75
Copper	0·02
Phosphorus	0·19
Sulphur	0·18
	99·86

NICKEL-IRONS.—The section examined consists almost entirely of kamacite. The plates are for the most part very thick and short and frequently of nearly equal length and breadth, so that the disintegrated material is of a coarse granular character. They are also generally of irregular or wavy outline, and often rounded at the ends. In these respects they resemble the kamacite plates of the Cranbourne No. 1, and some of the Beaconsfield described by Cohen (11). In places of the section of the Cranbourne No. 2 the plates and their arrangement are more regular, and they have a uniform width of about 2 mm.

The plessite occurs in small quantity, sparsely scattered, and the taenite in very thin plates between the kamacite.

The taenite obtained from the disintegrated material is tarnished pale yellow, and is decidedly scarce, having apparently been largely removed by decomposition, which has acted most intensely along the junction of the plates of taenite and kamacite. Cohen (11, p. 1039) observed in the case of the Beaconsfield that the iron chloride seemed to be more active in its effect upon taenite than dilute hydrochloric acid, and this might account for the scarcity of taenite in the *detritus*, whilst treatment of the fresh iron with dilute hydrochloric acid leaves a fair amount of taenite lamellae behind after solution of the bulk of the nickel-iron.

Sometimes taenite lamellae can be traced continuously for considerable distances, following a sinuous course between the kamacite plates, and occasionally terminating by branching into the latter. It is always extremely thin, and in places quite invisible. On many flakes of taenite the surfaces are thickly studded with angular metallic particles of what is probably schreibersite, and also fine prismatic crystals which are apparently rhabdite.

Analyses of Taenite :—

	I.	II.	III.	IV.
Iron	65·58	46·33	57·70	58·59
Nickel	24·10	34·98	35·72	25·60
Cobalt	0·74	1·00	0·80	0·73
Copper	0·17	0·05	0·32	0·24
Phosphorus	1·23	4·27	2·87	0·94
Residue	—	0·91	0·14	2·50
	91·82	87·54	97·55	88·60
Amount used	0·0892	0·0550	0·0698	0·100

Bayly makes the following note on these analyses :—

"The material used in analysis No. I. was obtained partly by chemical means (by dissolving the nickel-iron in dilute hydrochloric acid), and partly by mechanically picking out the flakes of taenite from the disintegrating mass. In the other analyses the whole of the taenite was separated by acid treatment. In the case of analysis No. IV., special care was exercised to remove the flakes as quickly as possible from the acid solution. The high phosphorus contents of the first analysis confirmed the belief that the crystals on the taenite lamellæ were phosphor-nickel-iron minerals, and in analysis No. IV., dilute hydrochloric acid (1–5) was used as a solvent in order to try and effect a separation by partial solution. As a result a much larger residue was obtained than in the analyses where this precaution had not been taken, with a corresponding decrease in the phosphorus percentage. An experiment on a further small portion of taenite seemed to indicate that the use of cold dilute nitric acid (1–5) will give a much quicker and equally good separation. Copper-ammonium chloride was not used as a solvent on account of it loading the solution with copper, and also, because the phosphor-nickel-iron did not appear to be entirely insoluble in it. In all the taenite analyses it will be observed that the summation is very low—in one instance over 11 per cent. This discrepancy is difficult to explain. The analyses were made by the methods described elsewhere, which had proved entirely satisfactory in the other analyses of the series. The separations appeared to be complete, and each determination was made with the utmost precaution. In the case of No. III., the analysis was made in duplicate, with the following result:—

Iron	57·65	57·74
Nickel	35·57	35·87
Cobalt	0·86	0·73
Copper	0·32	0·32
Phosphorus	2·87	2·87
Residue	0·14	0·14
	97·31	97·67

There is no reason to question the accuracy of any of the results obtained for the elements recorded."

It is interesting to note that Fletcher* found a similar difficulty in obtaining a summation with the taenite of a meteorite from Youndegin, Western Australia. He found a deficiency of 6·5 per cent., which he presumed to be due to combined oxygen. The present analyses are all included, to show the consistency of their low summation. It has been suggested that nitrides may be the cause of the deficiency. The marked variation in the phosphorus determinations, ranging from 0·94 to 4·27 per cent., indicates a very irregular dispersal of the phosphor-nickel-iron in the taenite. While giving an idea of the total amount of phosphides in each sample, the figures do not permit a safe calculation to be made, as the relative proportions of the phosphides present, presumably rhabdite and schreibersite, are unknown. Taenite being a substance of extreme variability of composition, the analyses strongly support the view that the variation is due to an absence of homogeneity in the taenite plates, and that they consist of a mixture of a rich nickel alloy and kamacite (see 20 and 51). The action of the acid treatment used in separating the taenite from the mass has evidently had the effect of dissolving out to a greater or less extent the kamacite from the mixture.

A nickel-iron, sometimes of a jagged form, and apparently somewhat less soluble than the bulk in cold dilute hydrochloric acid is evidently similar to that occurring in the Beaconsfield. Cohen (11, p. 1042) thinks it may be a mixture of kamacite and fine taenite plates, and, therefore, part of the plessite.

Analyses of residual iron :—

	Cranbourne No. 2.	Beaconsfield.
Iron	92·77	92·09
Nickel	6·77	6·93
Cobalt	0·61	0·56
Copper	trace	—
Phosphorus	0·12	0·06
	100·27	99·64
Amount used	1·50	0·641

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* Min. Mag., 1899, Vol. XII, p. 174.

It seems to be quite as dense as the other iron until treated with hydrochloric acid, when porosity is produced, and the specimens acquire the appearance of being traversed by a series of very fine cracks. The structure must, consequently, be due to the removal of some easily-soluble constituent, probably troilite. The composition of the iron does not differ materially from that of the mass. The analysis of the Beaconsfield material is given here for comparison. If, as Cohen suggests, the iron consists of a mixture of taenite and kamacite plates, the residual portion should, on account of its greater insolubility, be composed for the most part of taenite. The Beaconsfield analysis shows the nickel contents to be slightly under 7 per cent., while the taenite of that meteorite yielded the very high result of about 48 per cent. It is, therefore, fairly obvious that the solvent action of dilute hydrochloric acid would have the effect of increasing the nickel contents by dissolving out the kamacite. The residual product would vary in its percentage of nickel according to the amount of solvent action, from something considerably higher than that of kamacite up to that of almost pure taenite. On the contrary, Cohen's figures show a lower amount of nickel than the bulk.

A white nickel-iron, looking like taenite, forms a fine clearly-defined and uniform margin to part of the branching schreibersite surrounding a troilite nodule, and also to another nodule in which schreibersite is absent.

At a certain incidence of light it contrasts strongly with the granular silvery-white schreibersite on the one side, and the grey nickel-iron forming the mass of the meteorite on the other.

Troilite.—On the polished face of the meteorite, measuring about 12 cm. by 9 cm., there are sections of five nodules. Three of them are of regular oval form. The largest occurs on the edge of the face, and only about half of it has been cut through. It measures about 30 mm. in length, by about 20 mm. in breadth. These three nodules consist of troilite surrounded more or less completely, first, by a regular shell of graphite, and then by schreibersite. The remaining two nodules are of a more irregular shape, and more circular than oval. In one the troilite is mixed with the graphite, and in the other graphite replaces troilite as a nucleus, the latter mineral forming an irregular and broken envelope. The troilite also seems to occur as an impregnation of the graphite nodules. The face of the piece cut from the meteorite shows only one nodule, of very perfect oval form, 8 mm. by 5 mm., in which very small fragmentary pieces of troilite occur in the schreibersite outside the graphite envelope.

Decomposition evidently progresses largely by means of iron chloride, along the outside of the schreibersite envelope, and converts the nickel-iron into the sesquioxide of iron. By this action the nodules are freed, and leave the cavities on certain parts of the surface of the meteorite, as mentioned previously.

Analysis :—

Iron	61·46
Nickel	0·52
Cobalt	0·19
Copper	0·04
Phosphorus	0·21
Sulphur	34·00
Residue	0·87
	97·29

Amount used .. 0·1944

The troilite used in the analysis was part of a nodule picked out of the nickel-iron detritus. The quantity was small, and no check analysis could be made. The low summation may be accounted for to some extent by the omission of carbon and moisture. Carbon was detected but not determined, and the presence of water may reasonably be assumed from the fact that it was found in the troilite of the Langwarrin meteorite, of which a larger amount was available, and permitted a more complete investigation. The determination of sulphur (34·00 per cent.) is the only one of the analysis which is doubtful, the quantity of material used for it being very small.

Schreibersite.—The phosphor-nickel-iron described under this name, as will be seen from the analysis, differs seriously in composition from that usually ascribed to schreibersite, but the absence of sufficient data does not permit any reliable conclusions to be drawn on the subject. The mineral occurs, as already mentioned, as the external envelope of all but one of the troilite nodules. This exceptional instance was one of the two nodules in which a thin margin of nickel-iron resembling taenite was noted. The schreibersite does not usually form a uniform envelope like the graphite, but is most irregular, and sometimes sends out proportionately long branches into the nickel-iron. Apart from its association with the troilite nodules, and its occurrence within the nickel-iron, schreibersite can sometimes also be observed on the etched section, scattered here and there along the junction lines of the nickel-iron, where opened up by decomposition. A few small plates up to ½ mm. in thickness were obtained, which had evidently occupied such a position. Metallic particles occurring on the taenite lamellae have already been referred to as probably schreibersite.

Analysis :—

Iron	70·05
Nickel	22·35
Cobalt	0·40
Copper	0·10
Phosphorus	6·93
Residue	0·20
	100·03

Amount used ..	0·7182
Specific gravity	7·09

The material used for the above analysis was obtained as a residue, together with rhabdite, and probably a little cohenite, after dissolving the nickel-iron in dilute hydrochloric acid. The rhabdite was removed by mechanical means along with the finer part of the schreibersite, but nothing could be done in this way to separate any cohenite present, which, however, as the analysis shows, must only have been there in insignificant quantity. The powder thus prepared was examined microscopically, and, as far as could be judged, appeared to be practically free from admixture with other substances. Assuming, nevertheless, that the powder was not pure, the only possible reason for the amount of phosphorus being so low in comparison with the schreibersite of Cranbourne No. 1 and the Beaconsfield would be the presence of some particles of nickel-iron. But, even if this were the case, the amount could not have been nearly sufficient to reduce the percentage of phosphorus to about half that given for the meteorites just mentioned, without it being detected in the examination. Besides this, the amount of nickel would have been considerably lower than the determination shows. As a further proof that such an error was unlikely, a partial analysis made by Bayly on another portion of the mineral gave the following result, which confirmed the previous work :—

Nickel	22·32
Phosphorus	8·46

RHABDITE.—As in the case of the Cranbourne No. 1, and Beaconsfield meteorites, rhabdite occurs in very fine prismatic needles.

It does not appear to be more intimately associated with one constituent than another, but seems to permeate all the nickel-iron; and some pieces of the iron, after being partly dissolved in hydrochloric acid, could be seen bristling with needles of it. The occurrence of fine prismatic crystals associated with (?) schreibersite on the lamellae of taenite has been mentioned under nickel-iron.

COHENITE.—Owing to the fact that cohenite* was identified in the Beaconsfield meteorite by Cohen, and that it might easily be mistaken for schreibersite, a careful search was made for it. The colour and the comparatively large size of the crystals in which cohenite is said to occur usually, should have enabled it to have been fairly easily distinguished in the nickel-iron, but only in one instance, apart from determined schreibersite, was there anything noticed resembling cohenite. Unfortunately, the substance was lost during examination, and the question of its identity remained unsolved.

Bayly undertook an investigation of the residues, consisting principally of schreibersite and rhabdite, left behind after solution of the nickel-iron in dilute hydrochloric acid, to ascertain whether they contained any cohenite. The residues were first freed from all non-magnetic material—mostly graphite—and then subjected to lengthy digestion with copper-ammonium-chloride, with the object of producing, if cohenite were present, the solid anthracite-like particles which result from the decomposition of cohenite, and which are said by Cohen (12, p. 307) to be sufficient evidence of its presence. There were, undoubtedly, a number of coaly-looking particles to be seen after treatment, and these deflagrated on heating to redness in a platinum dish, and appeared, as far as could be determined, to bear the physical characters ascribed by Cohen to the decomposition product of cohenite. It seems, therefore, extremely probable that a small amount of cohenite was included in the nickel-iron residues.

LAWRENCITE.—In marked contrast to the other meteorites from the same neighbourhood, the Cranbourne No. 2 appears to have exuded comparatively little chloride of iron, and, as previously stated, practically no scaling has been observed since the specimen has been under observation.

The presence of this iron salt was noticed when the meteorite was examined in situ. It is seen to be most plentiful on what have been called the fracture surfaces. The preservation of a part of the original surface, on which no indication whatever of the action of chloride of iron could be detected, shows that that constituent is not evenly distributed through the specimen, consequently, its absence or comparative scarcity in one meteorite, and an abundance in others, would not necessarily bear any special significance.

It is evident from this that any attempt to estimate the amount of lawrencite present would be misleading, for the results would vary indefinitely, according to the part of the meteorite from which the samples for the test were taken. From a piece of a nodule consisting of graphite, troilite, schreibersite, &c. drops of iron chloride exuded, after standing all night. It was mentioned at another place that some of the troilite nodules had evidently

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* Cohenite was first described by Prof. C. Weinschenk, from a meteorite discovered at Magura, Arva, Hungary (Ann. K.K. Hofmus., Wein, 1889, IV., pp. 94–97).

been freed from the mass of the meteorite by the decomposing action of the chloride. This would seem to indicate that that corrosive constituent is either chiefly associated with the nodules, or that it is freer to move and exert more influence along the contact of the latter with the nickel-iron than elsewhere.

GRAPHITE.—This mineral has already been mentioned in association with the troilite. It usually forms a regular envelope to the latter, and is, itself, surrounded by schreibersite. In one instance, it was mixed with the troilite, and in another it formed the nucleus. Some of the graphite nodules appear to be largely impregnated with troilite, and associated with another sulphide referred to under the next heading.

UNDETERMINED SULPHIDE, HYDROCARBON AND SULPHUR.—On breaking up the piece of nodule, referred to under lawrencite which came out of the partly disintegrated material, a small patch of bright, black mineral was exposed within the graphite, and just on its boundary with the troilite. The graphite in this instance formed the nucleus of the nodule. The patch was without regular form, and showed a strong cleavage to which the lustrous face observed was due. The mineral was non-magnetic, fragile, and easily scratched, yielding apparently a shining streak. The last-mentioned character was not established positively, for the face being so small it is quite possible that the graphite was really responsible for the streak. A fragment of the nodule, after treatment with dilute hydrochloric acid to remove the troilite, broke up into a black powder, which, on examination under the microscope, was seen to consist for the most part of dull-black, carbonaceous-looking grains of irregular form. Besides these, there were some small cleavage flakes of the mineral in question, several of which were of regular outline, giving the impression that they had been produced by two other cleavage planes in conjunction with the one already referred to. The physical characters of the mineral and its mode of occurrence resembled so closely those given for daubréelite, that the identity of the two minerals seemed almost certain, and tests were accordingly made for chromium. Particles in the borax bead were not wholly absorbed after prolonged heating. The bead at first became dark, but cleared subsequently to a yellow colour, and was almost colourless when cold.

Particles were not affected by dilute hydrochloric acid, although some slight action appeared to take place on treatment with hot, strong acid. They readily decomposed on being treated with strong nitric acid, with the separation of sulphur. The solution was coloured pale yellow. According to J. Lawrence Smith, who described daubréelite, the smallest particles of that mineral imparted a strong green colour to the borax bead. In addition to this, he mentions that complete solution was effected in hot nitric acid without liberation of free sulphur, and that the liquid was coloured an intense green. It was, therefore, evident that the mineral under examination, although apparently so similar, was not daubréelite. Some of the carbonaceous-looking grains obtained by treatment of a piece of the nodule with hydrochloric acid behaved in a like manner, decomposing in hot nitric acid with the separation of sulphur and leaving a residue of graphite. They, however, gave a faint bluish-green colour to the borax bead when cold. In order to make sure that all the troilite was removed, a part of the granular material was powdered and again treated with hydrochloric acid. The tests were then repeated with similar results. Heated in the closed tube the powder gave a sublimate of sulphur, and in the open tube sulphurous fumes were rapidly evolved. The concentrated nitric acid solution was slightly coloured like the borax bead. These facts seem to point to the grains being the same mineral as the flakes, but containing in addition a little cobalt, probably as an accessory. It is also likely that the substance is identical with the unknown cobalt compound mentioned by Smith (48, 50), as occurring in association with sulphur and a hydrocarbon in the Cranbourne No. 1. Should such be the case the cobalt must be very variable and non-essential. Later tests on a larger quantity of what is undoubtedly the same substance from the Langwarrin meteorite, showed that its composition was essentially a sulphide of nickel and iron with some cobalt. The probability of the mineral in question containing sulphur and a hydrocarbon made it advisable to follow Smith's procedure to ascertain if his results could be repeated. For this purpose an investigation was undertaken in conjunction with Bayly. The quantity of substance available however, from the Cranbourne No. 2 was insufficient, and most of the work had to be done on the material obtained from the Langwarrin. The results of the investigation are set out fully in the description of the latter meteorite. It will suffice to say here that the results were practically the same as Smith's, which indicated the presence of two substances, namely, an uncertain hydrocarbon and free sulphur.

Silicious Residue.—Certain residual grains were obtained after complete solution of the metallic constituents in hydrochloric and nitric acids, but, as the material used was mostly derived from the outside oxidized part of the meteorite, which quite probably contained foreign inclusions, picked up from the contiguous ground into which the meteorite had fallen, much doubt must be attached to their presence. Their occurrence is of interest, however, as they included grains resembling some of those noted by Cohen in his examination of the Beaconsfield meteorite. Of these, Cohen says the majority were dull white, and could be compared to a silicate, in this case probably olivine, decomposed by hydrochloric acid. Besides these, there were colourless, transparent angular particles of quartz.

The white grains of the Cranbourne No. 2 also suggested an origin such as that advanced by Cohen.

Small splinters of quartz were observed in the residue of the nodule in which the hydrocarbon and sulphur occurred, and which were apparently similar to the particles seen by Cohen (11, p. 1048) in a section of stilpnosiderite formed by the decomposition of a troilite nodule in the Beaconsfield meteorite.

CRANBOURNE NO. 3 METEORITE.

Class.—Siderite—Broad Octahedrite.

Weight.—About 15 lbs.

Locality.—About half-a-mile from the Cranbourne No. 1 meteorite, (?) section 39, parish of Sherwood, county of Mornington.

Date of Discovery.—Between 1854 and 1860.

Date first Recorded.—1860.

Collection.—Not known.

Reference.—19, p. viii.

All that is known of this piece of meteoric iron has already been mentioned under the history of the Cranbourne meteorites, and the information given there contains no details as to its structure or composition. That it was of a similar nature to the other Cranbourne meteorites may with safety be taken for granted, for it has evidently passed as portion of one of them. There is but little doubt, also, that its origin was intimately associated with theirs, if, indeed, it is not a fragment of the Cranbourne No. 1, thrown off in the descent of that meteorite. The record of its independent occurrence is evidently generally unknown. Since it left the possession of Sir Henry Barkly it has probably been cut up, and, likely enough, the pieces have been assumed to be artificial derivatives from the Cranbourne No. 1.

BEACONSFIELD METEORITE.

Class.—Siderite—Broad Octahedrite.

Weight.—165 lbs.

Locality.—About 2 miles east of Beaconsfield railway station, (Lat. 38° 31′ S., Long. 145° 30′ E.), Parish of Pakenham, County of Mornington.

Date of Discovery.—About 1876.

Date of First Record.—1897.

Collection.—Krantz, mineral dealer, Bonn, Germany. Specimen not preserved intact.

References.—1 (p. 55), 6 (p. 227), 11, 12, 13, 15, 18 (p. 86), 20, 51 (pp. 74, 76), 57 (pp. 258, 261, 267, 268, 270, 272), 58 (pp. 4, 71, plate I., fig. 9).

Professor E. Cohen (11) who described this meteorite, says that it was found in a cutting about 3 km. east of the Beaconsfield railway station, in the Parish of Berwick, during the construction of the Gippsland railway. The position given would be well within the Parish of Pakenham and not that of Berwick. The line referred to is that from Oakleigh to Sale, authorized by Parliament in 1873. The first section of it, which includes Beaconsfield, about midway between the terminal stations Oakleigh and Bunyip, was opened for public traffic in October, 1877, so that it may reasonably be inferred that 1876 was the probable year of discovery.

The meteorite is stated to have lain for many years unnoticed until it attracted the attention of a blacksmith, named Feltus, who believed it to be a part of a mineral vein. He sent a piece to Mr. R. A. F. Murray, then Government Geologist, who at once recognised its true nature. In 1896 it was acquired from Feltus by Dr. Karl Vogelsang, who sent pieces of the iron and oxidized crust to Cohen. The meteorite afterwards passed into the possession of Dr. Krantz, mineral dealer, of Bonn, Germany, by whom, apparently, it was wholly or partly cut up. The weight given by Cohen as 75 kg. (165 lbs.) was taken after some loss by crumbling. The measurements are given as 40 cm. long, 30 cm. wide, and 15 cm. high. It exuded iron chloride and showed rapid decomposition into hydrous ferric oxide, in places forming nodules composed of concentric shells derived from the oxidation of troilite, a peculiarity attributed by Cohen to an original although invisible structure in that mineral. After storing in a room for five weeks at an equal temperature the exudation of iron chloride ceased. All the analyses of the Beaconsfield meteorite were made by Mr. O. Sjöström.

General Analysis :—

Iron	92·56
Nickel	7·34
Cobalt	0·48
Copper	0·02
Carbon	0·05
Phosphorus	0·26
Chlorine	0·01
Sulphur	0·04
	100·76

From this analysis the proportion of the mineral constituents in the piece examined is given as :—

Nickel-iron	98·07
Phosphor-nickel-iron	1·75
Troilite	0·11
Lawrencite	0·02
Carbon	0·05

The cohenite which occurs in the specimen could not be calculated, as the carbon probably only originates partly from it.

NICKEL-IRONS.—As just seen the nickel-iron was estimated to form 98·07 per cent. of the mass of the meteorite. Kamacite appeared to predominate in the sections examined, and the plates varied in length, but were generally short when they showed wavy or irregular boundaries, and were rounded at the ends. The longer ones were more regular in habit.

In some sections taenite only appeared plainly here and there, although the quantity present was not inconsiderable, as found by examination of the rusted iron. In others it was scarcely to be seen on the etched surface. Plessite occurred also in small quantity in the same section. Lamellæ of kamacite + taenite picked out of the disintegrated material had a thickness up to 2 mm.

The highest specific gravity obtained for the taenite was 7.1754, which Cohen considered low for an alloy so rich in nickel, and which is, in fact, much lower than that noted for other meteorites.

Analyses of taenite:—

	I.	II.
Iron (diff.)	[49·38]	[50·92]
Nickel	46·39	47·98
Cobalt	0·61	0·63
Carbon	0·45	0·47
Phosphorus	0·10	—
Residue	3·07	—
	100·00	100·00

Amount used 0·2783

No. II., after deducting the phosphor-nickel (3·73 per cent.).

After treatment with very dilute hydrochloric acid there remained behind an insoluble nickel-iron, finely porous, and almost spongy in appearance and of a greenish-yellow colour, which was, however, completely soluble in aqua regia.

Analyses of residual iron:—

	I.	II.
Iron ..	92·09	92·62
Nickel	6·93	6·81
Cobalt	0·56	0·57
Phosphorus	0·06	—
	99·64	100·00

Amount used 0·641

No. II., after deduction of rhabdite (0.40 per cent.).

Cohen says the iron, from its physical characters, does not appear to be kamacite, but that it may be a mixture of kamacite and fine taenite plates.*

TROILITE.—The patches of troilite in the Beaconsfield meteorite are mostly of a round or regularly oval form, and are from between 1 and 2 cm. in size. They are surrounded by graphite, and, as just stated above, also schreibersite. The graphite always forms the inner layer and occasionally encroaches upon the troilite.

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* See note on this nickel-iron under Cranbourne No. 2 Meteorite, pp. 24, 25.

Analyses :—

	I.	II.
Iron	57·49	58·07
Nickel	4·30	4·34
Cobalt	1·50	1·52
Sulphur	35·71	36·07
Phosphorus	Trace	—
Chlorine	Trace	—
Graphite	0·33	—
	99·33	100·00

Amount used .. 0·3327

No. II. is calculated to 100 after deducting graphite.

After selecting and treating the troilite by hydrofluoric acid to remove the film of oxide of iron, the specific gravity was calculated as 4.7379.

The nodules of compact, blackish, ferric oxide derived from the decomposition of troilite are referred to stilpnosiderite, the features of which appear to be the presence of phosphoric acid and silica, the latter occurring in form of quartz splinters (11, p. 1048). As in the case of the nickel-iron, chloride of iron undoubtedly helps to bring about and augment the decomposition of troilite. An analysis of the substance gave—

Ferric oxide	82·77
Nickel oxide } Cobalt oxide }	1·68
Phosphoric pentoxide	0·48
Sulphuric anhydride	0·58
Chlorine	0·33
Loss on heating	13·41
Residue	1·52
	100·77

SCHREIBERSITE.—This mineral occurs, as in the case of the Cranbourne No. 2 and as noted later in the Langwarrin also, as an irregular envelope surrounding troilite patches or nodules, neither penetrating nor mixing with them. This mode of occurrence is not mentioned by Flight in his description of the Cranbourne No. 1. Cohen also observed the mineral in irregular stout crystals, with rounded edges and strongly-grooved surfaces, measuring up to 4 mm. in length ; and, in a few instances, in plate-shaped pieces partly with even and partly with grooved surfaces. In consequence of their great brittleness they all broke up very easily. He gives the colour as being between tin and silver-white, and the specific gravity as from 7·1697–7·1754.

Analysis :—

Iron	66·92
Nickel	18·16
Cobalt	0·62
Phosphorus	14·88
	100·58

Amount used .. 0·4023

RHABDITE.—This occurred in the form of exceedingly fine needles and was very plentiful in some parts of the sections.

Analysis :—

Iron (diff.)	[41·54]
Nickel	42·61
Cobalt	[0·80]
Phosphorus	15·05
	100·00

Amount used .. 0·0986

In the above analysis the whole of the iron and part of the cobalt met with an accident, but the latter was estimated at 0·80 per cent.

COHENITE.—The crystals of this mineral are of irregular form and attain a length of 7 mm. by a thickness of 2 mm. The physical properties are very similar to those of schreibersite, so that they are not easily distinguishable. They are both less brittle and their cleavage is not so marked as in other meteorites examined by Cohen. Cohenite was not observed in all sections, and when it was present the nickel-iron plates were thinner.

Analyses :—

	I.	II.	III.	IV.
Iron ..	—	88·66	91·62	90·94
Nickel	—	3·81	2·24	2·22
Cobalt	—	0·30	0·30	0·30
Carbon	5·51	—	6·59	6·54
Phosphorus	—	1·45	—	—
Residue	16.32	—	—	—

In Nos. I. and II. some schreibersite is present. In No. III. the schreibersite is deducted; and in No. IV. the figures are worked out to 100.

The specific gravity of the cohenite (7·2014), like the other physical characters just referred to, also differs from that of the other meteorites in being lower. It still remained low after allowing for a 13·06 per cent. mixture of schreibersite. Cohen thinks that this may be due to a certain porosity of the interior of the crystals, similar to that observed on the surface.

Under the heading of "Carbonaceous Substance" Cohen describes, and gives an analysis of, a substance varying in size from small dust-like particles up to pieces of 3 mm. which, in its physical and chemical properties, closely resembles anthracite. He found later (12, p. 306) that this substance was derived by decomposition from the cohenite, from which he obtained it as small, dense, highly lustrous pieces. As previously stated under cohenite, in Cranbourne No. 2, Cohen regards its identification as sufficient evidence of the presence of cohenite.

LAWRENCITE.—A determination was made on some pieces of the meteorite resulting from disentegration, weighing together 457 grams, to ascertain, if possible, the amount of lawrencite present. They were first leached with water and afterwards with sulphuric acid, and gave respectively ·515 and ·274 per cent. of chlorine, or together 1·412 per cent. of ferrous chloride. As the pieces were only partly oxidized, the determination is probably lower than the actual amount present, on account of the density of the iron preventing a thorough leaching taking place. Cohen noticed that the exudation appeared mostly, if not altogether, along the taenite plates. From this he concluded that between the taenite lamellæ and the kamacite in the unaltered nickel-iron there is not such an intimate contact as between the particles of kamacite. Owing to its expansion in oxidizing, the lawrencite forces the lamellæ apart and, at the same time, strongly attacks the nickel-iron, so bringing about disintegration and decomposition.

GRAPHITE.—Graphite, besides occurring as an envelope round the troilite, sometimes forms nodules without troilite. Cohen could not obtain sufficient material for an analysis, but he estimated the specific gravity at from 2·250—2·292.

SILICIOUS RESIDUE.—The residues consisted mostly of dull white grains which could be compared to a silicate decomposed by hydrochloric acid. Cohen thinks that they were derived from olivine. There were also present a number of colourless, transparent grains, which were undoubtedly quartz. They were soluble in hydrofluoric acid and insoluble in the microcosmic bead, and gave brilliant interference colours. The presence of quartz splinters in the stilpnosiderite, formed by the decomposition of troilite, has been mentioned. In the residue, after treating with hydrofluoric acid, were some six-sided opaque crystals, which, as they gave chromium reaction, might have been chromite. Besides these, he noticed minerals resembling augite, hypersthene, tourmaline, and a zircon microlith.

LANGWARRIN METEORITE. PLATE III.

Class.—Siderite.—Broad Octahedrite.

Weight.—Originally 18 cwt.

Locality.—About 5 miles S.E. of Langwarrin railway station, (Lat. 38° 12′ S., Long. 145° 14′ E.), section 94, Parish of Langwarrin, County of Mornington.*

Date of Discovery.—1886.

Date of First Record.—1886.

Collection.—National Museum, Melbourne.

References.—1 (p. 60), 15, 45, 57 (pp. 268, 271, 272).

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* The position was not exactly known at the date of Anderson's paper (1, p. 60).

This meteorite was discovered in 1886, near the (?) Ordovician outcrop, on the property of Mr. A. H. Padley, which is situated between 4 and 5 miles S.E. from the Langwarrin railway station, by an employé while engaged in ploughing an orchard. Padley, not recognising the character of the find, rolled the specimen aside, thinking it part of the outcrop of an iron-ore deposit, just as had been thought by others in the case of the two Cranbourne meteorites. It remained there until recognised by Mr. Murray, the Government Geologist at that time, who had visited the locality to report upon iron and other deposits. Padley, acting upon a suggestion of Murray, generously presented the meteorite to the Melbourne Technological Museum, where it was exhibited in the year of its discovery. In 1899, when the National Museum collections were removed to the Technological Museum building, the meteorite was transferred to the former institution.

When discovered the specimen weighed 18 cwt. Subsequent scaling has reduced this by an amount which has not been ascertained by actual weighing. The loss has been roughly estimated at half a hundredweight, but probably this is too liberal an allowance, and half of that amount would be more correct.

The meteorite is roughly of a spindle-shaped form, with one end blunt and the other rather pointed. From the pointed end a piece was cut for the investigation. Before removal of the point the specimen measured about 3 feet in length, and the diameter now varies between 20 and 22 inches. There are no faces, such as occur on the Cranbourne No. 2, which could be attributed to fracturing. When first seen by the writer in 1893 the meteorite retained none of its original surface, it being completely covered with an oxidized crust, which, as already mentioned, had scaled away to a very considerable extent. A triangular face measuring about 20 cm. along each side was formed by chiselling when the specimen was first brought to the Museum, and this has exposed a thick vein of troilite with associated minerals, which will be dealt with under their respective names.

General analysis:—

Iron	92·28
Nickel	6·24
Cobalt	0·58
Copper	0·06
Phosphorus	0·17
Residue	0·32
	100·17

Amount used .. 0·50

NICKEL-IRON.—The etched section showed the kamacite plates to be generally long and regular, the stoutest of them attaining a uniform thickness of about 2 mm. In these respects they differ notably from most of those seen in the section of the Cranbourne No. 2, but at places this regularity was not maintained, and then the structure of the two meteorites bore a much greater resemblance. The plessite and taenite occur in the same manner as in that meteorite, but, if anything, the latter is less conspicuous and does not form the continuous lines observed in the Cranbourne No. 2. The taenite lamellæ likewise showed prismatic crystals of (?) rhabdite, and angular metallic particles of (?) schreibersite, and the lamellæ were so similar when examined under the microscope that it was not possible to say, without knowing it, from which meteorite they came. They were extremely thin, and it was scarcely possible to collect a sufficient quantity from the dilute hydrochloric acid residue to enable an analysis to be made. No taenite could be found in the crust.

Analysis of taenite :—

Iron	51·46
Nickel	38·97
Cobalt	0·45
Copper	0·41
Phosphorus	1·05
Residue	very small
	92·34

Amount used .. 0·0581

In the above analysis the material was obtained entirely by chemical means (solution of the nickel-iron in dilute hydrochloric acid). The same difficulty was observed in the analysis as is discussed under the Cranbourne No. 2 taenite (*q.v.*), and indicated by the low summation.

Troilite.—The thick vein of troilite exposed in the polished face of the meteorite measures about 17 cm. in length, by from 1¼ cm. to 2 cm. in breadth. It is slightly curved, with angular ends, and a short branch is given off from the convex side.

The troilite has a brecciated appearance, produced by the presence of angular patches in a lighter ground, as though incipient decomposition were taking place. The nodule is surrounded by the usual layer of graphite, in this instance a very thin one, and this again by a fairly uniform envelope of schreibersite, attaining a maximum thickness of 1½ mm. Decomposition has proceeded in the nickel-iron along the outside of the schreibersite envelope, resulting in the formation of a thin shell of ferric oxide.

On three other nodules the presence of ferric oxide prevents an accurate idea of the arrangement of the minerals being obtained.

In another, again, about 4½ cm. by 1½ cm., the core is formed of graphite, which is almost completely surrounded by troilite. Schreibersite, in small quantity, is very irregularly distributed as an external layer.

Finally, one nodule does not appear to be associated with graphite at all.

The section cut from the point of the meteorite for etching and examination has not cut through a single piece of troilite, and if this were the only exposed part of the meteorite, very erroneous conclusions might be drawn as to the presence and mode of occurrence of the mineral constituents.

Analyses :—

	I.	II.
Iron	61·07	62·14
Nickel	1·02	0·18
Cobalt	0·24	0·09
Copper	0·05	Trace
Phosphorus	0·20	0·01
Sulphur	32·76	34·37
Chromium	Trace	Trace
Carbon	—	0·53
Water + (combustion)	—	0·94
Water – (105°C.)	—	0·26
Residue	0·17	0·38
	95·51	98·90
Amount used	1·40	1·60

Analysis No. I. was made from part of a small nodule consisting of troilite and graphite, and No. II. from a portion of the thick vein described above, exposed on the polished face. The amount of material made available for No. II. analysis permitted Bayly to make a fuller examination than was possible in the case of No. I. The hygroscopic moisture (0·26 per cent.) was determined at 105°C., and then a further portion of material was heated in a combustion tube with lead chromate, and the total water evolved weighed in a calcium chloride tube. This amount being in excess of the hygroscopic water indicated either the presence of combined water, which is unlikely, or possibly, as suggested by the inclusion of carbon, of a hydrocarbon, forming water on combustion.

DAUBRÉELITE.—From the detection of chromium in the troilite analyses, the presence of daubréelite may be assumed. Apparently it is the mineral which forms extremely fine veins traversing the thick vein of troilite.

SCHREIBERSITE.—The presence of schreibersite in connexion with the troilite nodules has just been noted; apart from this it is found in the residues after solution of the nickel-iron. No plates of it, such as were found in the Cranbourne No. 2 between the nickel-iron plates, were noticed, although this fact might easily be accounted for by the small amount of material examined. The taenite lamellæ showed, in a similar manner to those of the Cranbourne No. 2, the crystals referred to schreibersite. Generally, the mineral, however, was not plentiful as in the Cranbourne No. 2 meteorite, it seemingly having been replaced by cohenite.

RHABDITE.—This mineral permeates the iron in fine prismatic crystals and differs in no way from its mode of occurrence in the Cranbourne No. 2, except that it was not nearly so plentiful. In the Cranbourne No. 1 and the Beaconsfield meteorites the mineral apparently also shows no divergence in its form and manner of disposal. Similarly, as in the Cranbourne No. 2, fine prismatic crystals occur on the taenite lamellæ which can, in all probability, be correctly referred to rhabdite.

COHENITE.—In the residues after solution of the nickel-iron in dilute hydrochloric acid, a quantity of brittle, coarse, slightly porous powder remained behind with the taenite, schreibersite, and rhabdite, and, being tarnished, it imparted a much darker appearance to the residues than was noticed in those from the Cranbourne No. 2; so much so, that it afforded an easy means of distinction between the two. This fact led to an examination being made for cohenite on similar lines to those made for it in the residues from the meteorite just mentioned. Some of the grains were dissolved in aqua regia and tested for phosphoric acid with negative results. Solid carbon particles were obtained by treatment with copper-ammonium chloride, which burned with deflagration on ignition. In the section of the meteorite no crystals were seen such as could be referred to cohenite. A group of small irregularly oval patches occurred, however, on one part of it, having the characters common to that mineral and schreibersite. They were granular and broke up during treatment into a powder. Judging by the abundance of cohenite in the residue compared with schreibersite it is very probable that the patches in question consisted of the former mineral.

Analysis :—

Iron	80·47
Nickel	7·80
Cobalt	0·20
Copper	Trace
Phosphorus	4·75
Carbon	7·08
	100·30

The analysis was made on material left as a residue after treatment of some powdered crust with dilute hydrochloric acid. It was allowed to stand in copper-ammonium chloride solution until all the cohenite was decomposed, and the carbon liberated was then washed off and determined by combustion. The amount of phosphorus present (4·75 per cent.) clearly points to the impurity of the powder used in the analysis. The amount, however, is too large to be regarded as wholly derived from schreibersite, on account of the insufficiency of the nickel contents.

LAWRENCITE.—This ingredient is very abundant in the Langwarrin meteorite. Since the specimen has been in the Museum, that is from 1886, or over 26 years, it has been constantly exuding chloride of iron from all parts of its surface, which has resulted in a serious loss by scaling. The scaling has been checked to a great extent by coating with shellac and using driers in the case. The large chiselled face rusts within a very short time of being cleaned, owing to the sweating out of the chloride all over its surface, and on the face of the section cut off for examination the chloride of iron accumulates in drops along the junction of the nickel-iron and taenite lamellæ. On the contrary, the artificial face on the Cranbourne No. 2 remains fairly bright continuously, although exhibited in the open and unprotected from fingering by visitors.

There is no doubt that the disintegration of these meteorites is brought about by the physical and chemical action of the chloride of iron exerted between the plates of nickel-iron. Atmospheric agencies alone on the other siderites in the Museum appear only to have produced a uniform oxidation of the surface, resulting in the production of a coating or thin crust of ferric oxide without any sign whatever of disintegration. This fact is well illustrated by the total absence of disintegration on the "thumb-marked" part of the surface of the Cranbourne No. 2 where no exudation of iron chloride has taken place, whilst elsewhere, although in a slight degree only, traces of chloride of iron are to be found, as well as evidence of scaling.

GRAPHITE.—Graphite forms a thin envelope to most of the troilite nodules, and in one rather large oval nodule it takes the place usually occupied by the troilite, and is itself surrounded by the latter. The variation in its mode of occurrence in connexion with these nodules is quite similar to that observed in the Cranbourne No. 2.

UNDETERMINED SULPHIDE, HYDROCARBON, SULPHUR, AND DAUBRÉELITE.—In dealing with a hydrocarbon and sulphur from the Cranbourne No. 2 meteorite, in conjunction with Bayly, it was mentioned that the quantity of material was not sufficient to enable the tests to be completed, and a similar substance from the Langwarrin meteorite was utilized. The Langwarrin material was part of the residue obtained from a considerable quantity of powdered oxidized crust, by prolonged treatment with hydrochloric acid. The residue thus obtained was non-magnetic, and consisted of dull black, carbonaceous-looking grains (the substance of investigation), a little greyish-black graphite, and extraneous quartz. The black grains turned red and fused to a black magnetic globule when heated on charcoal by the blowpipe flame. Digested with strong nitric acid and fused in the borax bead, the reactions were quite similar to those characteristic of the Cranbourne No. 2 material. It was thought that the rather severe hydrochloric acid treatment the powdered crust had received, would have removed all the troilite. Apparently, however, that mineral occurred as a fine impregnation throughout the black grains, and was only partly dissolved out, for after grinding and further digestion with hydrochloric acid, copious sulphuretted hydrogen was given off and the solution strongly reacted for iron. It was evident, therefore, that the behaviour on charcoal was at least partly owing to the presence of troilite.

Some of the powder which had been treated with hydrochloric acid until reactions for iron and sulphur ceased, was treated with petroleum ether for twenty-four hours.

The residue from this treatment was then submitted to hot, strong nitric acid, which completely decomposed it with the separation of free sulphur. In addition to sulphur, strong reactions were obtained for nickel and iron in the nitric acid solutions, while cobalt was found in smaller quantity, and chromium was unmistakably present. Taking the chromium as representing daubréelite, the tests show the compound to be a sulphide of nickel and iron with some cobalt. As mentioned under Cranbourne No. 2, the substance is likely enough identical with the unknown cobalt compound referred to by Smith in his work on a graphitic nodule from Cranbourne No. 1. The evidence seems definite enough to justify the inclusion of the substance as a meteoric constituent. The ether solution was allowed to evaporate. In the first place small crystals adhering to the side of the beaker appeared when about half of the ether had evaporated; secondly, on complete evaporation, similar but larger crystals, including some acute octahedra of a pale yellow colour, and white acicular crystals, forming feathery aggregates, were deposited. The crystals which adhered to the beaker produced a copious sulphur sublimate when heated in the closed tube. Heated in the open, a not unpleasant odour was first detected, and this was succeeded by a smell of sulphur. The crystals from the first treatment of the Langwarrin material showed many simple, acute, apparently rhombic octahedra, besides others more or less modified. At times also the oscillation of the octahedra produced long constricted crystals, tending to develop into acicular forms, which seemed to merge into the white aggregates. The latter were for the greater part confined to the upper part of the evaporating dish, but everywhere were more or less mixed with the yellow crystals. Gently heated, the yellow crystals darkened, and the white ones assumed a yellow tint. Further heating melted them all into clear globules at apparently the same temperature. Some of the mixed crystals, it not being possible to separate them, were heated in a closed tube, with the result that a heavy sulphur, and a white amorphous sublimate were formed, accompanied by a strong smell of sulphuretted hydrogen. On further heating the sulphuretted hydrogen was succeeded by a smell of sulphur, and a blotchy, blackish deposit was left covering the bulb of the tube. At the bottom of the tube some solid black particles also remained. The crystals, warmed with sulphuric acid, broke up into carbon particles and globules of sulphur, while the solution assumed a dark colour. Another part of the mixed crystals was treated with absolute alcohol, and, although the solvent action was not apparent to the eye even after prolonged treatment, clumps of short, pearly-white crystals, mostly acicular in form, were deposited when the liquid was carefully poured off and evaporated. These crystals, when heated in the closed tube, gave the smell of sulphuretted hydrogen and sulphur that had been emitted by the mixed crystals, besides a very similar sublimate, but a brownish solid residue was left in the bottom of the tube. When the solution from a second treatment with ether was evaporated a deposit consisting almost entirely of yellow octahedra crystallized out. Some of these, heated in a closed tube, behaved very similarly to the mixed crystals, with the exception that the sublimate was nearly all sulphur, and the residual solid, black particles, were absent. The third treatment, curiously enough, resulted in products in no way different from those derived from the first treatment. A fourth treatment produced a thin white deposit, closely adhering to the watch glass, which carbonized on heating, and gave off an organic smell.

The foregoing tests point almost certainly to the presence of two distinct substances soluble in petroleum ether, one being sulphur in great preponderance, and the other a carbon compound of unknown composition. The matter is thus left very much in the position it was at the time Smith's work was carried out, and, as far as the writer is aware, nothing has since been done. It may reasonably be assumed that the hydrocarbon, for which the sulphuretted hydrogen and carbonaceous matter in the sulphur crystals was responsible, was there only as an impurity, and not in combination, and that the acicular crystals and aggregates are only a form of the sulphur carrying a slightly larger amount of the hydrocarbon.

The presence of substances of such a nature as these suggested the idea that they were not original constituents, and the association of lawrencite indicated a possible agent in their production. Experiments were accordingly made with some Langwarrin troilite. The mineral was finely ground and treated for ether soluble subtances. After some days, the solution was poured off and evaporated, when it yielded a faint deposit which gave a slight smell on heating. The powder was washed with ether, dried and allowed to remain in ferric chloride solution for several days. It was then thoroughly washed with water, and treated with ether for a similar period. The ether solution was then poured off, and on its evaporation, crystallized products were obtained, identical in all respects with those dissolved by the same agent out of the black grains of the undetermined sulphide. Tests proved them to be pure sulphur. It is evident from this that the presence of free sulphur may be brought about by the action of lawrencite on troilite. In all probability, in no instance does sulphur occur as an original constituent in meteorites. It may be noted here that pyrrhotite behaved in exactly the same way when submitted to similar treatment. In regard to the hydrocarbon it was thought that decomposition of the cohenite by lawrencite may have, in some way, brought about its formation, but experiments with ferric chloride gave only negative results. It is possible that this failure was owing to the treatment not being continued over a period long enough to allow the chloride to take effect. Some significance, however, may be attached to the fact that Hall in dissolving the Langwarrin cohenite in aqua regia for analysis, found that a brownish substance was formed, which produced effects in filtering similar to those obtained by treating some pure iron ore ground up with bituminous brown coal with aqua regia.

Fletcher,* also, in his paper on the taenite of the Youndegin meteorite, refers to some insoluble reddish-purple pulverulent matter left after dissolving taentie in aqua regia, which disappeared on ignition. He regarded it as an organic compound, and that it was possibly due to the action of aqua regia on a trace of cohenite.

Silicious Residue.—The difficulty of obtaining residues free from contamination was even greater than in the case of the Cranbourne No. 2, for the crust in places enclosed a large percentage of quartz sand and possibly also other minerals, and there was no knowing how far some of these extraneous bodies may have found their way into the part of the meteorite used in the tests.

Some of the taenite, showing the fine prismatic and other crystals, was dissolved, and the residue left behind contained fine transparent particles of quartz and opaque white ones of a similar appearance to those observed in the residue of the Cranbourne No. 2.

BENDOC [BENDOCK] METEORITE.

Class.—Siderolite.

Weight.—About 60 lbs.

Locality.—About 7 miles from Bendoc (Lat. 37° 11′ S., Long. 148° 58′ E), close to N.S.W. border and 63 miles N.E. from Orbost, county of Croajingolong.

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* Min. Mag., 1899, Vol. XII, pp. 173–74.

Date of Discovery.—(?) 1898.
Date of First Record.—1899.
Collection.—Not known.
References.—1 (p. 55), 40, 41.

Mr. J. C. H. Mingaye, analyst to the New South Wales Department of Mines, states (41) that in 1899 a small sample, consisting largely of metallic iron much oxidized, also a number of brittle stones, were submitted to a qualitative analysis, and reported to be of meteorite origin.

Mr. J. A. Stansleigh, in a letter to the Department, dated 27th December, 1900, says that the specimen was found about 7 miles from the place of writing (Bendoc) in a sluicing claim in heavy boulder-wash. When just discovered the meteorite was reported to have weighed about 60 lbs. Inquiries were made, with a view to obtaining the balance of the meteorite, but nothing further was heard. In a private communication Mingaye mentions that of the portion sent to the Department of Mines only two or three grams remained after completion of the analyses.

A chemical examination was made of the metallic and non-metallic portions, the result of which was as follows :—

METALLIC PORTION.—This consisted mainly of metallic iron, iron oxide, and nickel. The mass had undergone considerable oxidation, and was thickly coated with rust, portions of the material being readily broken on the application of slight pressure.

Chemical Composition—

Silica and insoluble matter ..	1·540
Iron	78·288
Nickel	7·814
Cobalt	·526
Copper	Minute trace
Magnesia (MgO)	1·874
Sulphur	·461
Phosphorus	·184
Oxygen, &c.	9·313
	100·000
Specific gravity	5·839

In his Departmental report (40) Mingaye states that platinum was found to be present, the amount being estimated as under 2 dwts. per ton. This fact was unfortunately omitted from his subsequent paper (41) from which the above analyses have been taken. He also mentions, in a private letter, that he had detected platinum in another meteorite examined later than the one from Bendoc.

Non-Metallic Portion.—On treatment with hydrochloric acid, the powder gave off a copious evolution of sulphuretted hydrogen. Decomposed by acids, with separation of gelatinous silica, 96·4 per cent. of the material was found to be soluble in hydrochloric acid. On treating some of the fine powder with distilled water, and filtering, the clear solution gave a reaction for chlorine, iron, lime, and magnesia. Under a 1-inch objective small grains of a yellowish mineral, inclined to green, and resembling olivine were observed; also grains of a mineral clear-white in colour, enclosing material of a reddish tinge. Several pieces of mineral of a dark colour, and somewhat resembling troilite were noticeable.

Chemical Composition—

Moisture at 100 C	·840
Water over 100 C	5·350
Silica	29·350
Alumina	2·208
Iron sulphide	5·816
Iron	17·170
Copper oxide	·012
Chromium sesquioxide	Trace
Manganese monoxide	Trace
Nickel protoxide	·960
Cobalt protoxide	Minute trace
Lime	Trace
Magnesia	32·806
Potash	·277
Soda	Trace
Phosphoric acid	·095
Carbon dioxide	·080
Chlorine*	·227
Oxygen	4·901
	100·092
Specific gravity (mean of three determinations)	3·466

Mingaye says, " From the above analysis it will be seen that the non-metallic portion is essentially a silicate of magnesia and iron, with iron sulphide. Some of the olivine has undergone alteration, and is changed into hydrous magnesium silicate, as shown by the material containing 6·19 per cent. of water."

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* Less oxygen equivalent to chlorine, 0·047.

YARROWEYAH METEORITE. PLATE IV.

Class.—Siderite—Ataxite.

Weight.—Originally 21 lbs.

Locality.—Between 4 and 5 miles S. of Yarroweyah railway station (Lat. 36°, Long. 146° 23′ W.), Allotment 7, Section A, Parish of Yarroweyah, County of Moira.

Date of Discovery.—1903.

Date of First Record.—1903.

Collection.—National Museum, Melbourne.

A note from Numurkah reporting the discovery of this meteorite appeared in the Melbourne *Age* on the 13th April, 1903, in which it stated—"An aerolite weighing over 20 lbs. has been brought into the town by Mr. T. Holden, whose boys found it in one of their father's paddocks. The aerial visitor has evidently been lying in the earth for many years, as its surface has been considerably worn by rain. The meteoric stone is composed of metallic iron and silicate, and bears evidence of having been fused in course of descent."

Correspondence was opened with Mr. Holden, now of Sandmount, with the result that the meteorite was acquired by the Museum in February, 1913. Holden stated that it had been found on his property in the parish of Yarroweyah, about 4 miles southerly of the township and railway station of the same name, which are some 4 or 5 miles from the river Murray. He gave the weight of the meteorite as 21 lbs., but said that he had broken off a small piece weighing about 2 lbs. and had sent it to Professor J. Gregory, then professor of geology in the Melbourne University. This piece is probably still in the possession of Professor Gregory.

When received at the Museum the meteorite weighed exactly 20 lbs., so that the piece sent to Gregory could not have been so heavy as Holden imagined, or else his weighing was inaccurate. Since its arrival at the Museum, for the purpose of making this investigation, two plates weighing about 5 ounces were cut off parallel to the rough face made in breaking off Gregory's fragment.

The meteorite measures 22¼ cm. by 15¼ cm. by 16 cm. The last dimension, however, was taken through the place from which the fragment and plates had been removed, and, therefore, it does not represent the original diameter in this direction. The specimen has a very coarse jagged appearance, due to prominent points and ridges being emphasized by large saucer-like depressions. It is coated all over with a thin skin of brown ferric oxide and bears evidence of slight scaling at numerous small spots on all parts of the surface. As far as the writer is able to form an opinion, the iron seems to have the characteristics of the Babbs Mill Group.

General analysis:—

Iron	92·78
Nickel	4·95
Cobalt	0·81
Copper	0·10
Phosphorus	0·20
Sulphur	0·04
Chlorine	0·02
Residue	0·19
	99·09

Amount used, 1 gram.

Nickel-Iron.—The texture of the iron as seen on the broken surface is coarsely granular, and the mass itself looks homogeneous. The iron is also very soft and gave much less difficulty in sawing off a piece for examination than did the iron of the Langwarrin meteorite. In cutting both these meteorites it was noticeable that the iron on the outside was harder than that of the inside of the specimens. This variation in the hardness may have been brought about by the rapid cooling of the highly-heated external layer of the meteorites, comparable to the similar hardening met with on the surface of iron castings. In one of the plates, besides two small nodules of troilite, several patches, apparently somewhat harder than the ground mass, could be just distinguished when the plate was held at a certain angle. Within 24 hours those patches occurring on the edge of the plate, that is towards the outside of the meteorite, were brought into prominence by becoming first black and afterwards brown through the exudation and oxidation of the chloride of iron. After the plate had been cleaned, the patches were distinguishable from the ground mass by being thickly pitted, owing to the chloride of iron having dissolved out some easily soluble constituent which was, in all probability, troilite.

Etching the plate with dilute hydrochloric acid created innumerable very small cavities all over the surface, evidently attributable to the removal of the same soluble constituent. These cavities were of varying form; some angular, but none of them quite regular. They showed an ochre-yellow lining representing the residue left by the dissolved substance. The surface of the plate otherwise had the appearance of being finely cracked all over. After immersion in stronger acid the surface became covered with a dull black coat having, if anything, a slight greenish tinge, and exhibited a fine honeycombed structure in which dark cavities were traced out by a delicate network of brighter iron. It was not quite clear whether the formation of this cavernous structure was aided by the acid enlarging the small holes left by the removal of the soluble constituent (? troilite). The iron was very much more rapidly attacked by the acid than the Cranbourne No. 2 or the Langwarrin, and this fact may, to some extent, support the suggestion that the etched structure was, in part, due to the removal of troilite. During etching the pitted patches disappeared, leaving cavities with finely jagged boundaries. This may be accounted for by the porous condition of the iron in these particular areas permitting a more rapid action of the acid than the dense iron, when the intermittent attachment of the porous iron to the ground mass would leave jagged boundaries to the cavities. These jagged edges seemed to be outlined by a bright-white nickel-iron having generally a uniform thickness, and which resembled the silver-white taenite-like nickel-iron envelope noted in association with some of the troilite nodules in the Cranbourne No. 2 meteorite, only differing in not being quite so regular and well defined. The edges assumed a pinkish colour after being in a dilute acid solution for some little time, while the remainder of the surface of the plate showed an iridescent tarnish.

Troilite.—On the cut face of the section of the meteorite two small patches of troilite occur, one near the centre, in the form of a narrow interrupted vein about 1½ cm. long by 1 mm. wide, and the other of irregular oval form, on the edge of the face. The chloride of iron exuded along the margin of the troilite nodule occurring on the edge of the section, but the vein in the centre of the section only showed a darkening in colour, and no chloride was visible.

The slight scaling observed at many places on the surface of the meteorite has no doubt resulted from the decomposition of the troilite, both as segregated impregnations and as solid nodules, under the influence of the chloride of iron. No minerals were noted in association with troilite, it being directly in contact with the nickel-iron without the intervention of either graphite or schreibersite.

Schreibersite.—On complete solution of the nickel-iron a small residue remained containing very small bright silvery-white metallic particles. These dissolved in aqua regia and the solution gave reactions for phosphoric acid, so that the mineral was probably schreibersite, but the very restricted amount available was insufficient for a quantative analysis. The mineral evidently occurs generally and finely disseminated through the mass, and also, perhaps, as occasional small segregations scattered here and there.

Lawrencite.—This constituent has been mentioned in connexion with its association and influence upon the troilite. As far as observation went lawrencite did not exude from the solid iron. This fact may be attributed to the more open texture of the patches impregnated with troilite and to the comparatively imperfect contact between the troilite nodules and the dense ground-mass providing channels for the ingress of moisture and subsequent flow of the chloride in the liquid state to the surface. Practically all the exudation took place along the outside of the cut face, perhaps, on account of the patches being more freely in communication with the air, for, as stated, the central vein of troilite showed no exudation. The incipient effects caused by the expansion of lawrencite in the disintegration of a meteorite, is interestingly displayed in one of these patches and one of the troilite nodules, in showing longitudinal cracks extending right through them into the adjacent iron. Cracks thus formed must bring about a constantly increasing amount of disintegration by the increased facilities they afford for access of air and flow of the chloride.

Silicious Residue.—Besides the schreibersite and flocculent carbon left behind after treatment with hydrochloric acid there were a few small silicious particles. These consisted of transparent, angular particles, and milky-white grains, such as were noticed in both the Cranbourne No. 2 and Langwarrin meteorites, and apparently similar to those mentioned by Cohen in his description of the Beaconsfield meteorite. The milky-white ones, he says, resembled residual silica derived from the decomposition of a silicate, probably olivine. As in the case of the other meteorites it cannot be definitely asserted that this residue was not of extraneous origin.

KULNINE METEORITE.

Class.—(?) Siderolite.

Weight.—122 lbs.

Locality.—Kulnine Run (Lat. 34° 8′ S., Long. 141° 56′ E.), County of Millewa, about 20 miles from the township of Wentworth, N.S.W.

Date of Discovery.—Known 1886.

Date of First Record.—1913.

Collection.—South Australian Museum, Adelaide.

Reference.—1 (p. 60).

Dr. Stirling, Director of the South Australian Museum, has very kindly given the following particulars, which are all that were supplied to him (3rd July, 1911):—"It was found about 3 miles from the Murray River midway between the South Australian border and Mildura. No stone of any kind is to be found for miles around the spot. It fell on fairly hard soil on a 'boxwood' tree flat, and a hollow was scooped out about 12 feet wide. It was first seen by a Mr. J. L. Thompson about 25 years ago, and then lost sight of, though Mr. Arthur Crozier had since tried several times to locate it. Mr. Gordon Crozier, a son of Mr. Arthur Crozier, the proprietor of the Kulnine Station, came across it a few months ago whilst mustering sheep. The spot where it fell is about 4 miles a little south by west from the station (Kulnine). Weight, 122 lbs."

The specimen has not yet been described, but in Anderson's record (1 p. 60) it has been placed as a doubtful siderolite.

REPORTS OF METEORITES, INCLUDING THE HADDON METEORITE.

In addition to the private reports of the finding of meteorites investigated by the writer, and which, without exception, proved unauthentic, the following have come under his notice:—Mr. P. Baracchi, Government Astronomer, very kindly permitted access to letters and newspaper cuttings relating to meteoric phenomena, which have been filed in the Observatory since the year 1887. Among these were three reports of the discovery of meteorites. The first was a private letter, and referred to a find at Burwood, which was among those previously investigated by the author. The second report concerned the Yarroweyah meteorite described in this paper. The third report was from Timmering, and was published in the Melbourne *Age* of the 4th July, 1903. It related to the discovery of a meteorite at Elmore. After some trouble the specimen was procured for examination and found to be a well-known form of an aboriginal pounding stone. The following account of the finding of a supposed meteorite was first published as a newspaper* report, and afterwards recorded in scientific literature† without authentication:—A beautiful meteor, seen half an hour after midnight on the 14th April, 1875, was reported from Melbourne and various other places in Victoria. Mr. Gill, of the George Hotel, Haddon, about 10 miles from Ballarat, stated that—"He watched the meteor, and thought he saw some of it fall close by. In the daytime he searched the locality, and found a lump of melted matter of light weight, and in colour nearly black, and a portion of a yellowish-brown substance, like cinders from iron smelting. There were two bits like coal-coke, quite black, and also a small bit of a yellow colour."

THE CRANBOURNE, BEACONSFIELD AND LANGWARRIN METEORITES PROBABLY ONE FALL. PLATE V.

Cohen (11 pp. 1049, 1050) has discussed the question as to whether the Beaconsfield meteorite represents an independent body or whether it belongs to the Cranbourne fall. He says the distance between the two places where they were found offers no obstacle to the latter explanation. On comparing a slice of the Cranbourne No. 1, lent to him by the K. K. Hofmuseums, Vienna, Cohen found that its structure was very similar to the parts of the Beaconsfield meteorite, not containing cohenite. Only unimportant differences were noted, and these did not vitiate the similarity when the imperfect condition of the sections of the last-mentioned meteorite was taken into consideration. Allowances must also be made in the comparison for the relatively small extent to which the Cranbourne No. 1 has been opened up for examination.

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* *Illustrated Australian News*, 17th May, 1875, p. 74; woodcut, p. 68.

† Flight, W., *Geol. Mag.*, 1882, IX., p. 107.

Knowing that a variation is exhibited in the different sections of the Beaconsfield, decided enough, in the opinion of Cohen, for the sections to have come from two different siderites, it is easy to realize how a single section of one siderite might show material differences from a section taken from another, although both siderites were generally of the same structure and composition. In dealing with the chemical aspect Cohen is not satisfied with some of Flight's analyses. He also mentions that a similarity in general analyses does not necessarily mean identity of structure in the octahedrites, and, conversely, differences in the analyses may not point to differences in structure on account of the irregular distribution of some of the constituents. As far as he was able to express an opinion, Cohen thought it not improbable that the two meteorites were of the same fall. Comparing the results of the examination of the Cranbourne No. 2 and the Langwarrin with the particulars given by Cohen, a great resemblance is noticed between the former meteorite and the Cranbourne No. 1, which, as we have just seen, is in close agreement with the parts of the Beaconsfield, in which cohenite is absent, and in which the structure differs from those parts containing abundant cohenite. The fact that the Cranbourne No. 2 yielded a section differing from the Langwarrin is probably of no importance. The portions taken for examination, compared to the sizes of the meteorites, are quite insignificant, and had sections been taken from other parts of the specimens an identity of structure may have been noted, or the structural differences reversed. The physical character of the mineral constituents of the Cranbourne No. 2 and Langwarrin was quite similar, so that if samples from the two were exchanged, the fact could not be detected by examination. The relative proportions of the mineral constituents certainly vary, but as the irregular distribution of the mineral constituents is a common feature, no objection can be taken on this ground to the similarity of the meteorites. Neither can the variation in the composition of the different constituents be held of any importance. Comparatively little work has been done in this direction, and apart from the true variation in the composition of a species, the elements of error are considerable, and arise, not only from dealing with extremely small quantities of material, but from the great difficulty of making certain that the material used is pure.

General analyses are also of little value as they are not made on average samples.

If the chemical composition and physical structure of these four meteorites do not materially affect the probability of their having originated from one source, then the question arises as to whether they represent fragments of one cosmic body which burst on entry into the earth's atmosphere, or whether they are independent individuals which formed part of a group of meteoric bodies. The distance between the two most remote meteorites is about 13 miles, so that if they originated from a single explosion taking place midway between these points the fragments must have been scattered over a radius of not less than 6½ miles. The fracture-like faces on the Cranbourne No. 2 have been described, but, such surfaces are not necessarily evidence that this meteorite formed part of a body from which the others also originated. They may have been produced by that meteorite casting off parts from itself. One rather interesting fact which was brought out prominently by mapping the positions of the meteorites, which discounts the idea of a single explosion, is that four of them—the Cranbourne No. 3 is excluded, for its relative position is not known—were discovered in places occurring almost in a straight line bearing about S. 30° W. from the Beaconsfield, which is the most northerly one (see plate V.). This may be nothing more than a mere coincidence, although it is certainly suggestive of the direction of flight either of one large body casting off fragments in its passage through the air, or of a cluster of independent meteorites of which the individuals have reached the earth at intervals. It appears probable that in either of these cases, other, but perhaps smaller pieces, are yet to be discovered. The Cranbourne No. 3 is likely enough only one of such specimens, and it might have been derived from the Cranbourne No. 1.

Then again it is surely more than a coincidence that out of the six meteorites, the characters of which are definitely known, the four allied in structure and composition should have occurred in the same locality within a few miles, while the two found in parts remote from these not only differ from them, but are quite distinct from one another. Further, it is practically certain that of the undescribed meteorites the Cranbourne No. 3 is identical with the other Cranbourne meteorites and that the Kulnine, the most distant from them, does not belong to the same class. On the whole of the evidence it appears that there is very good reason for believing that the meteorites found in the neighbourhood of Cranbourne have originated from a common source, but whether this was a single large cosmic body or an associated cluster of independent bodies of identical nature cannot be decided.

NOTES ON CHEMICAL PROCEDURE.

Mr. P. G. W. Bayly supplies the following notes on the methods used in the chemical investigation of the Cranbourne No. 2, Langwarrin, and Yarroweyah meteorites :—

"General Method of Analysis.—Solution was best effected by dilute nitric acid, followed by hydrochloric acid, the solution evaporated just to dryness with hydrochloric acid, taken up with the same acid and water, boiled and filtered.

The iron (with phosphoric acid) was precipitated by ammonia and filtered, dissolved in hydrochloric acid, and precipitated by the basic acetate method and filtered, dissolved in nitric acid, reprecipitated by ammonia, ignited and weighed. The use of basic acetate is necessary, and the procedure adopted proved satisfactory in separating the nickel. The iron precipitate, after weighing, was dissolved and tested for nickel, a trace only being found.

Phosphorus (P) was determined in the iron precipitate except where sufficient material was available for a separate test. The phosphorus was separated by double precipitation with ammonium nitromolybdate, according to the method of Woy. The combined filtrates from the iron separation were concentrated, the copper, cobalt, and nickel precipitated as sulphides and ignited. The copper was then separated in acid solution as sulphide, and determined by colorimetric method as ferrocyanide.

The cobalt was precipitated by potassium nitrite, and weighed as Co_3O_4, or as sulphate. The nickel was precipitated by dimethylglyoxime, filtered through a Gooch crucible and weighed.

Troilite.—The sulphur of the troilite was determined by fusion with sodium carbonate and potassium nitrate.

Schreibersite.—This substance was isolated by continuous treatment of the fragments of the meteorite with hydrochloric acid. The taenite flakes were picked out, and the light carbonaceous residue washed off from the schreibersite. The mineral was treated continuously with copper-ammonium chloride until no further action was observed—indicated by the absence of liberated carbon. The residue consisted of schreibersite and rhabdite, and the latter was removed as far as possible by sifting over unglazed paper, which served to retain the light, acicular crystals. The amount of rhabdite obtained from the Cranbourne No. 2 meteorite was not sufficient for analysis, while the Langwarrin contained only a trace. The residual schreibersite was a bright, pyritic-looking material of silvery lustre, with a small amount of fine quartz grains, from which the schreibersite was removed by the magnet. In the analysis the schreibersite was dissolved in aqua regia, the action of nitric acid alone being very slow.

Cohenite.—On solution of this substance in aqua regia, a reddish-brown flocculent residue was observed, which was partly but not completely, soluble in strong hydrochloric acid. It filtered clearly, but on washing with pure water the precipitate ran through the filter, and separated out as a dark brown colloidal solution in the filtrate. This was due to the condition of the carbon in the cohenite, and difficulty was observed subsequently in neutralization for the basic acetate separation. An exactly similar effect and difficulty in filtering was obtained on grinding up a pure iron ore with a minute quantity of bituminous brown coal."

TABLE OF IDENTIFIED MINERAL CONSTITUENTS.

	Cranbourne 1.	Cranbourne 2.	Langwarrin.	Beaconsfield.	Bendoc.	Yarroweyah
Nickel-iron ..	..	..	..	..	×	×
Kamacite ..	×	×	×	×	..	
Plessite ..	×	×	×	×	..	.
Taenite ..	×	×	×	×	..	..
Troilite ..	×	×	×	×	×	×
Daubréelite ..	×	..	?	..	..	.
Graphite ..	×	×	×	×	..	..
Rhabdite ..	×	×	×	×	.	..
Schreibersite ..	×	×	×	×	.	×
Cohenite ..	..	?	×	×	.	..
Chromite ..	..	..	..	?	.	..
Augite ..	..	..	..	?	.	..
Hypersthene ..	..	..	..	?	..	..
Tourmaline ..	..	..	..	?	..	..
Zircon	..	..	..	?	..	..
Lawrencite ..	×	×	×	×	..	.
Olivine ..	?	?	?	?	×	?
Quartz.. ..	?	?	?	×	..	?
Hydrocarbon (celestialite)	×	×	×	..	..	..
Platinum ..	..	..	..	..	×	..
Sulphur ..	×	×	×	..	.	..
Undetermined Sulphide	?	×	×	..	..	..

TABLE OF ANALYSES OF MINERAL CONSTITUENTS

F = W. Flight. B. & H. = P G W. Bayly and Alan G. Hall. S. = O. Sjöström.

Constituent.	Bulk.					Taenite.							Troilite.					Rhabdite.		Schreibersite.			Cohenite.		Graphite.	
	Cran. 1.*	Cran. 2.	Beac.	Lang.	Yarrow.	Cran. 1.	Cranbourne No. 2.				Beac.	Lang.	Cran. 1.	Cran. 2.	Beac.	Lang.		Cran. 1.	Beac.	Cran. 1.	Cran. 2.	Beac.	Beac.	Lang.	Cran. 1.	Beac.
							1	2	3	4						1	2									
Iron ..	[91·08]	92·34	92·56	92·28	92·78	70·13	65·58	46·33	57·70	58·59	[49·38]	51·46	63·61	61·46	57·49	61·07	62·14	49·33	[41·54]	56·11	70·05	66·92	88·66	80·47	..	..
Nickel ..	8·11	6·38	7·34	6·24	4·95	29·74	24·10	34·98	35·72	25·60	46·39	38·97	0·44	0·52	4·30	1·02	0·18	38.24	42·61	29·17	22·35	18·16	3·81	7·80	..	..
Cobalt ..	0·50	0·75	0·48	0·58	0·81	..	0·74	1·00	0·80	0·73	0·61	0·45	..	0·19	1·50	0.24	0·09	..	[0·80]	..	0·40	0·62	0.30	0·20	..	..
Copper ..	0·01	0·02	0·02	0·06	0·10	..	0·17	0·05	0·32	0·24	..	0·41	0·07	0·04	..	0·05	trace	..	..	..	0·10	..	..	trace	..	..
Chromium ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	trace	trace	..	..	..	..	..	..	..	..	..
Phosphorus ..	0·11	0·19	0·26	0·17	0·20	0·68	1·23	4·27	2·87	0·94	0·10	1·05	..	0·21	trace	0·20	0·01	12.95	15·05	13·50	6·93	14·88	1·45	4·75	..	..
Sulphur ..	..	0·18	0.04	..	0·04	..	..	..	..	..	..	..	36·33	34·00	35·71	32·76	34·37	..	..	..	..	..	..	..	..	..
Carbon ..	..	..	0·05	..	..	..	..	..	..	..	0·45	..	..	n.d.	..	n.d.	0·53	..	..	..	..	..	5·51	7·08	89·66	..
Chlorine ..	..	n.d.	0·01	n.d.	0·02	..	..	..	..	..	..	..	0·13	..	trace	..	..	..	..	..	..	..	..	..	..	..
Hydrogen ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·25	..
Silicon ..	0·17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Water + (combustion)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·94	..	..	..	..	..	..	..	..	..
Water − (105° C.)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·26	..	..	..	..	..	..	..	..	..
Residue ..	..	..	..	0·32	0.19	..	..	0·91	0·14	2·50	3·07	..	..	0·87	0·33	0·17	0·38	..	..	..	0·20	..	..	..	10·41	..
Total ..	..	99·86	100·76	100·17	99·09	..	91·82	87·54	97·55	88·60	100·00	92·34	..	97·29	99·33	95·51	98·90	..	100·00	..	100·03	100·58	99·73	100·30	..	..
Amount used	..	..	..	0·50	1·00	..	0·0892	0·055	0·0697	0·100	0·2783	0·0581	..	0·1944	0·3327	1·40	1·60	..	0·0986	..	0·7182	0·4023	..	..	..	..
Sp. Grav. ..	†7·46	..	..	..	..	..	..	..	..	..	7·175	..	..	..	4·73	..	..	6·32–6·78	..	..	7·09	7·17	7·20	..	..	2·25–2·29
Analyst ..	F.	B.&H.	S.	B.&H.	B.&H.	F.	B.&H.	B.&H.	B.&H.	B.&H.	S.	B.&H.	F.	B.&H.	S.	B.&H.	B.&H.	F.	S.	F.	B.&H.	S.	S.	B.&H.	F.	S.
Text Page ..	17	22	32	37	48	17	23	23	23	23	33	38	18	26	34	39	39	18	35	18	27	35	35	40	19	36

* The percentages of the elements due to the rhabdite present (nearly 1 per cent.) not worked out by Flight are included here. His original figures are worked to three places, but for convenience only two are given in this table.

† Mean of four determinations made by Neumayer.

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NOTES ON OBSIDIANITES (AUSTRALITES).

As these interesting bodies are comparatively well known now, and as a considerable amount of literature dealing with them is available, it is only proposed here to touch upon a few points concerning their origin.

It may be stated at once that the writer has seen no reason to alter the opinion expressed in his paper, published in 1898, that all the evidence which could be gathered undoubtedly favoured a meteoric origin. A study of the various terrestrial hypotheses makes it very plain that they have been drawn up either in ignorance of some of the evidence, or else upon an undervaluation of that part of it which does not harmonize with the particular theory advocated. While it must be admitted that we have still no direct evidence of the cosmic origin of obsidianites, this may also be said of many of the accepted meteorites; and, certainly, no direct evidence exists of the terrestrial origin of obsidianites. The forms of obsidianites have been considered a reason for excluding them from meteorites, although such forms have not been observed among terrestrial bodies of unquestionable origin.

Most of the objections raised against the extra-terrestrial origin of obsidianites have been met, or, as we have just seen, may be urged with equal force against the opposing view.

It was said that obsidianites were identical in composition with ordinary obsidian, and that glassy meteorites were not known. Since careful and complete analyses have been available, it is seen that there is a divergence from ordinary obsidian, and that a similar composition is only met with in terrestrial rocks of rare occurrence.

Then, as regards their glassy nature, a note by A. Brezina* on an observed fall of a meteorite is particularly interesting. At Halle, in Saxony, during one evening in January, 1903, a number of people were startled by the glare of a meteor. The following morning a meteorite about the size of a fig was found lying on a piece of charred paper in the yard of a banking-house. It was glassy throughout, and resembled obsidian. Brezina says that this occurrence, and another which he quotes, must remove the doubt as to the aerolithic nature of tektites.†

There are, however, some facts in connexion with the form of obsidianites which are equally difficult to explain, whether these bodies be aerolites or terrestrial products. The most striking thing in this respect is the characteristic form which distinguishes them from the other two groups of glassy bodies with which they are classed. Suess believes that the groups represent three distinct showers, and this appears to be the only logical explanation of the divergence of form and composition, more particularly noticed between moldavites and obsidianites (australites), under a meteoric hypothesis.

Each shower must have been accompanied by certain local conditions, by the agency of which the distinctive forms of its units were assumed.

It is difficult to imagine what this varying factor was, but it might be suggested, for instance, that it was a higher state of fusion in the case of the obsidianites, due to a greater original temperature produced on entry into the earth's atmosphere, or to the difference in their chemical composition, which enabled the glassy fragments to be moulded into the characteristic forms, whilst the moldavites being less plastic, retained more or less their original fragmental shape. Some of the surface sculpturing is not necessarily a sign of a molten condition, for in a few of the obsidianites examined cooling has proceeded far enough to allow fracturing to take place, and the resulting surfaces are covered with superficial markings, indistinguishable from some of those occurring on the original surface. Even if considered as volcanic ejectamenta, peculiar local conditions would have to be also conjectured to account for the divergence of form of the two groups. Suess's idea of three meteoric showers infers contemporaneity of all obsidianites in Australia and Tasmania, and, in the writer's opinion, the acceptance of this view is essential to the theory of cosmic origin. The writer, in his paper on the "Occurrence of so-called Obsidian Bombs in Australia," was inclined to the belief that they were not all of the same age, basing it principally upon

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* "Uber Tektite von beobachtetem Fall." Anzeiger d. K. Akad, d. Wiss, Vienna, 1904, p. 41.

† This term was introduced by Professor F. E. Suess, to cover all the glassy bodies of doubtful origin. These he divided into Moldavites, Australites (= Obsidianites), and Billitonites, in accordance with their geographical distribution.

the fact that obsidianites occurred both on the surface and in certain drifts having the appearance of some antiquity, but positive evidence of which antiquity is lacking. The importance of settling this is very obvious, for there could not have been a selective action operating over indefinite periods, and insuring to each country its own particular type of tektite, consequently, proof of variation in the age of obsidianites would be fatal to the meteoric theory.

Mr. Summers, in his paper on " The Origin of Obsidianites from a Chemical Stand-point," thinks that, so far as the data goes, their chemical composition points to a certain amount of provincial distribution. Should such prove to be the case, it would indicate that the shower of obsidianites originated from clusters of cosmic bodies, the clusters being probably of comparatively small size, and differing somewhat from one another in chemical composition. A provincial distribution could also have taken place under a terrestrial hypothesis, but only if the creative cause of each provincial type were local.

In this case, however, the origin could not have been volcanic, for the evidence is absolutely against such a view, and a true explanation yet remains to be conceived. Surely, if obsidianites be terrestrial volcanic products, as strongly maintained by a few geologists, some indication of their place or places of emission would remain, considering that they must be of recent geological age. The only volcanic vents which have yielded acid glasses, and which could be looked to as a possible source, do not appear to have produced a single specimen resembling obsidianites. This fact alone affords the most weighty reason for not accepting a terrestrial volcanic origin for obsidianites, and until undoubted proof is forthcoming of such a source, all other evidence in support of the theory is of little value.

A suggestion circulated locally a good many years ago has been published recently, and almost simultaneously, by E. J. Dunn* and Professor J. W. Gregory†. It is that obsidianites may have been formed by the fusion of dust in the earth's atmosphere by electric discharges, otherwise that they are aerial fulgurites. No evidence has been advanced in support of this suggestion, but a careful consideration of the facts soon leads to the conviction that the explanation is untenable.

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* " Australites." Geological Survey of Victoria, Bulletin No. 27, 1912, p. 7.

† " Making of the Earth," p. 36.

LIST OF LOCALITIES OF OBSIDIANITES.

The following list of localities in which obsidianites have been found in Victoria, with the exception of Laver's Hill, has been compiled from the author's paper on "The Occurrence of so-called Obsidian Bombs in Australia," published in 1898, from specimens added to the Museum collection since that year, and from E. J. Dunn's paper on "Australites," which appeared in 1912 :—

Localities represented by specimens in National Museum, Melbourne, are marked with an asterisk.

Acheron River.
*Ararat.
*Balmoral.
Ballarat.
Beechworth.
*Birchip.
Bolwarrah
*Boulka (near Ouyen).
Brim Plain.
*Byaduk.
*Caramut.
Condah
Daylesford (Spring Creek).
Edenhope.
Glenelg River.
Grassmere.
*Gymbowen.
Hamilton.
Harrow.
Hard Hills (Buninyong).
*Heidelberg.
*Hochkirch.
*Horsham.
Lake Albacutya.
Laver's Hill (Beech Forest).
*Maroona.
*McKenzie Creek (Horsham).
Mepunga.
*Mortlake.
Mount Eccles.
*Mount Elephant.
Mount Rouse.
*Mount Talbot.
Mount William.
Napoleons.
*Narrarnhuddut (Scott's Creek).
Nerring.
Peterborough.
*Portland.
Raglan.
Retreat Creek (Ingleby).
Rokewood.
*Sherbrooke Creek (Port Campo).
Smythesdale.
Talbot.
*Telangatuk East.
Wannon.
Warrnambool.
*Willaura.

TABLE OF ANALYSES OF OBSIDIANITES.*

—	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
SiO_2	72·39	76·25	77·72	71·22	70·62	71·65	64·68	69·80	73·59
Al_2O_3	13·12	11·30	9·97	13·52	13·48	11·96	16·80	15·02	12·35
Fe_2O_3	·42	·35	·32	·77	·85	6·62	6·57	·40	·38
FeO	4·48	3·88	3·75	5·30	4·44	n.d.	1·01	4·65	3·79
MgO	1·87	1·48	1·59	2·38	2·42	2·09	2·50	2·47	1·80
CaO	3·17	2·60	2·40	3·52	3·09	3·03	3·88	3·20	3·76
Na_2O	1·54	1·23	1·29	1·48	1·27	1·76	tr.	1·29	1·03
K_2O	1·92	1·82	1·96	2·28	2·22	2·40	4·01	2·56	1·93
$H_2O +$	·11	·32	·15	..	·01	..	..	n.d.	·27
$H_2O -$	·02	·02	·04	..	·06	..	..	n.d.	·53
CO_2	Nil	Nil	Nil	..	Nil	..	..	..	..
TiO_2	·76	·65	·86	..	·90	..	..	·80	·70
P_2O_5	Nil	Nil	Nil	..	Nil	..	..	Nil	Nil
MnO	·05	·06	tr.	·28	·42	·16	·20	·18	·15
Li_2O	st. tr.	st. tr.	st. tr.	..	st. tr.	..	..	st. tr.	..
SrO	Nil	Nil	Nil	..	..	..	..	Nil	f. tr.
BaO	Nil	Nil	Nil	..	..	..	..	?	f. tr.
Cl_2	Nil	Nil	Nil	..	tr.	..	..	..	..
SO_3	Nil	Nil	Nil	..	tr.	..	..	?	Nil
Cr_2O_3	?	Nil	?	..	..	..	..	..	..
NiO	·06	·03	tr.	..	tr.	..	..	?	Nil
CoO	tr.		tr.	..	tr.	..	..	..	..
ZrO_2	..	..	..	..	..	..	..	?	·01
Total	99·91	99·99	100·05	100·75	99·75	99·67	99·65	100·37	100·29
Sp. Gr.	2·427	2·398	2·385	2·433	2·454	2·47	?	2·454	2·428

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* Taken from H. S. Summers' paper—"Obsidianites, Their Origin from a Chemical Stand-point." Proc. Roy. Soc., Vict., XXI., 1908, part 2, p. 425.

I. Obsidianite from near Mount Elephant, Victoria. Analyzed by G. Ampt, 1908.

II. Obsidianite from near Hamilton, Victoria. Analyzed by G. Ampt, 1908.

III. Obsidianite from Peake Station, near Lake Eyre, South Australia. Analyzed by G. Ampt, 1908.

IV. Obsidianite from between Everard Range and Fraser Range, South Australia. Analyzed by C. V. John, 1900; Jahrb. d.k.k. Geol. Reichsanst., Vienna, 1900, vol. L., p. 238.

V. Obsidianite from near Coolgardie, Western Australia. Analyzed by A. Hall, 1907. Records of the Geol. Survey of Victoria, vol. II., part 4, 1908, p. 205.

VI. Obsidianite from near Kalgoorlie, Western Australia. Analyzed by E. S. Simpson, 1902. West. Aust. Geol. Survey, Bulletin No. 6, 1902, p. 79.

VII. Obsidianite from near Uralla, New South Wales. Analyzed by J. C. H. Mingaye, 1897. Proc. Roy. Soc. of Victoria, vol. XI., part 1, p. 30.

VIII. Obsidianite from Upper Weld, Tasmania. Analyzed by W. F. Hillebrand, 1905. Report of the Secretary for Mines, Tasmania, for 1905, p. 21.

IX. Obsidianite from Pieman, Tasmania. Analyzed by W. F. Hillebrand, 1905. Report of the Secretary for Mines, Tasmania, for 1905, p. 21.

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EXPLANATION OF PLATES.

Plate I.

Cranbourne No. 1 meteorite in the excavation made for its removal. From a photograph lent by Lady Chas. MacMahon.

Plate II.

Cranbourne No. 2 meteorite, showing the polished artificial face and " thumb-marks."

Plate III.

Langwarrin meteorite, showing polished artificial face.

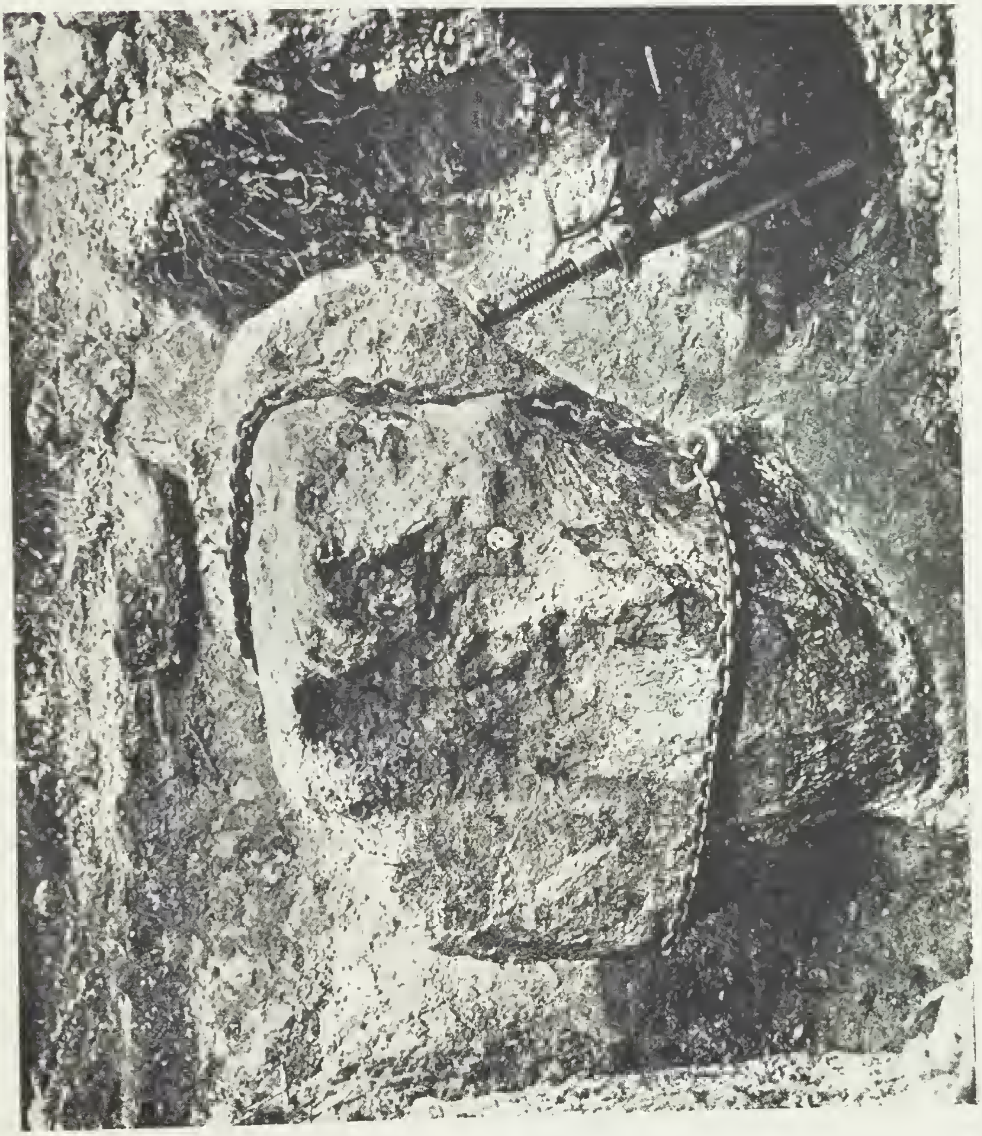
Plate IV.

Yarroweyah meteorite, two views

Plate V.

Map, showing the distribution of the Cranbourne, Beaconsfield and Langwarrin meteorites. Exact distances between meteorites are not certain. The distance between Cranbourne No. 1 and No. 3 was about half-a-mile, but the position of No. 3 relative to No. 1 is assumed.

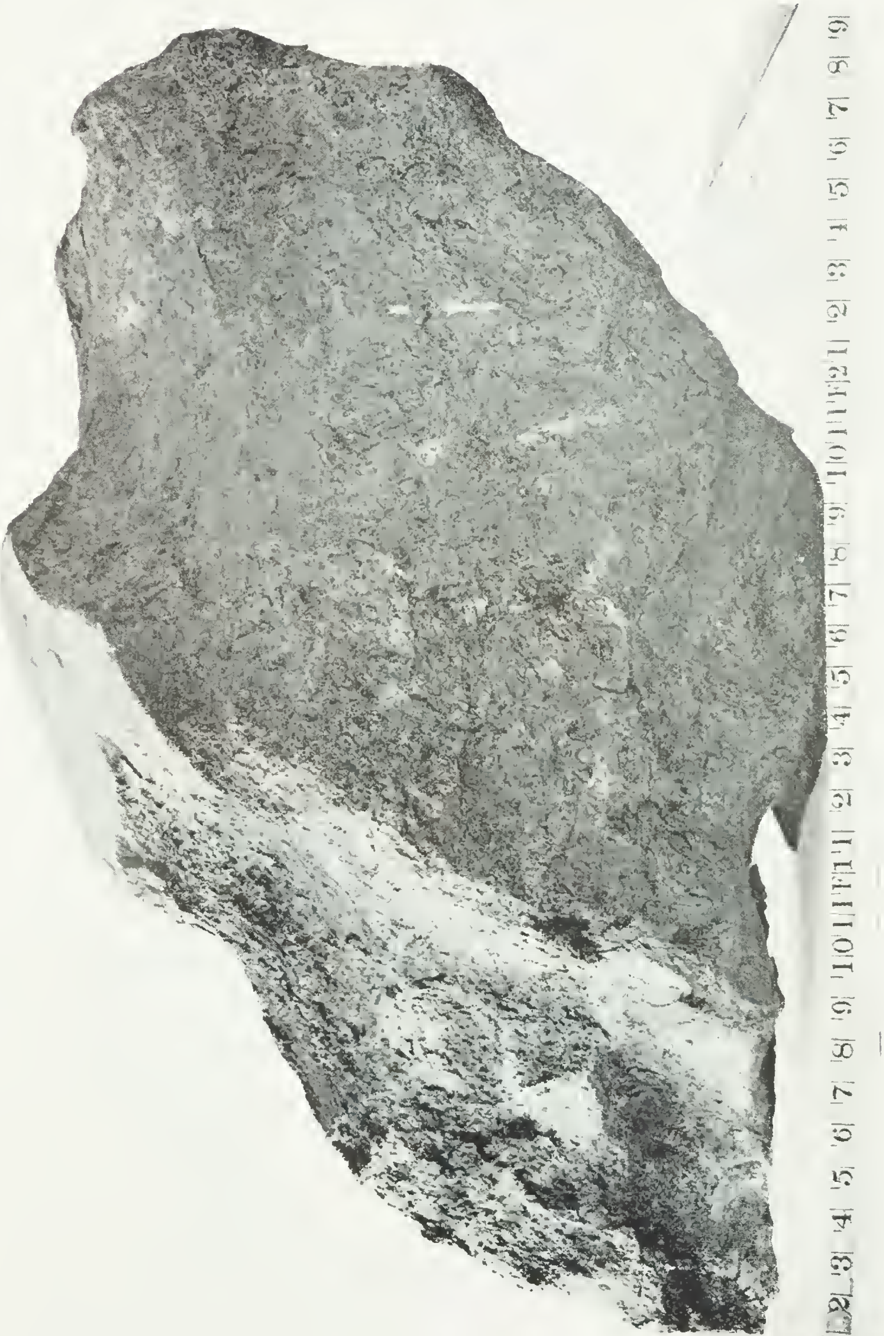
By Authority: Albert J. Mullett, Government Printer, Melbourne.



Cranbourne No. 1 Meteorite before Removal.

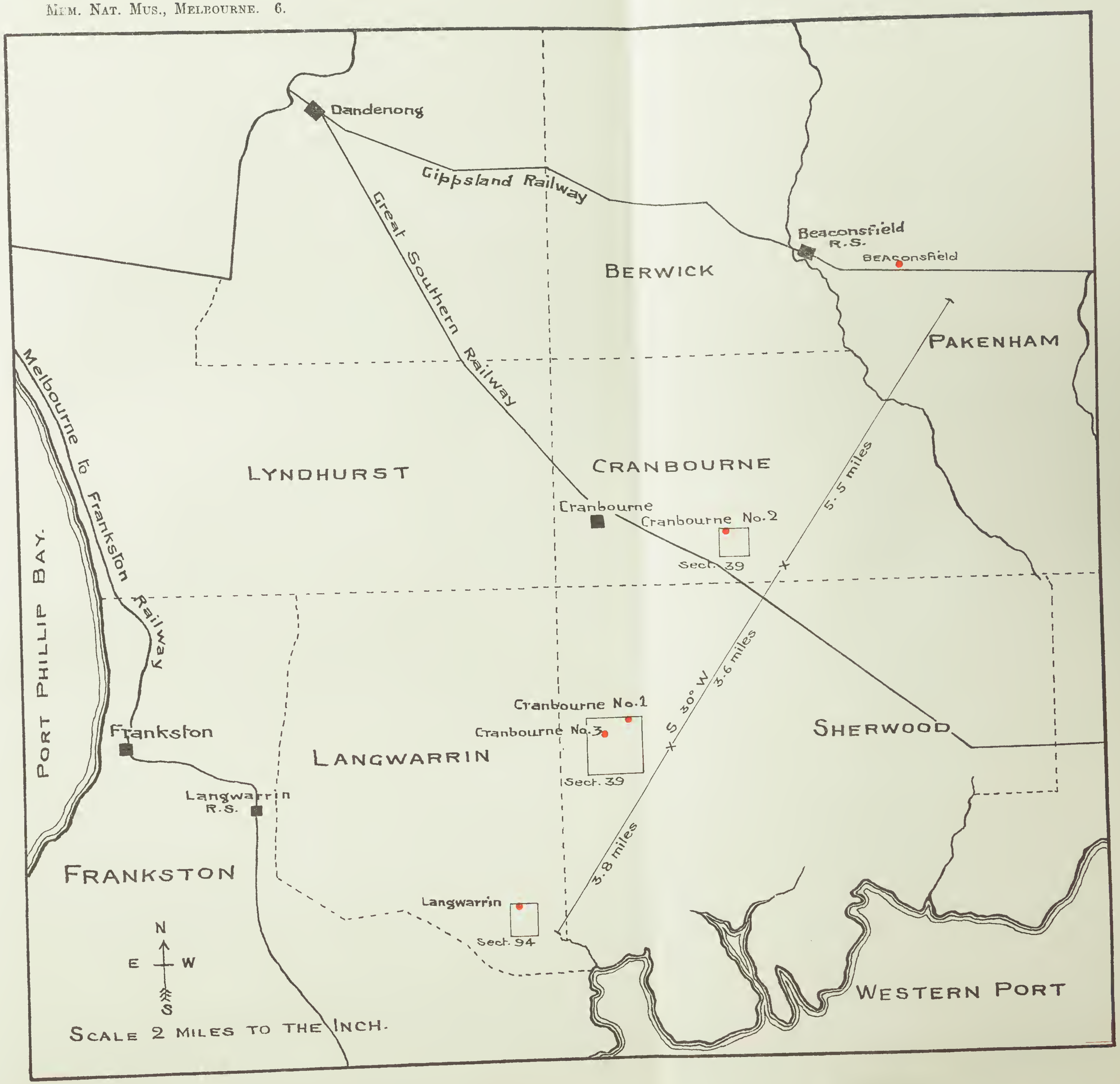
Cranbourne No. 2 Meteorite.

Plate III.



Langwarrin Meteorite.

Yarroweyah Meteorite.



Map showing the Distribution of the Cranbourne, Beaconsfield, and Langwarrin Meteorites.