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AUSTRALIAN METEORITES

By

T. HODGE-SMITH.

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AUSTRALIAN METEORITES.

By

T. HODGE-SMITH,
Mineralogist, The Australian Museum.

1. INTRODUCTION.

No separate catalogue of the Australian meteorites has been published since 1913, when Dr. C. Anderson, Director of the Australian Museum, presented a catalogue and bibliography of the Australian meteorites.[144] Since that time the number of records of Australian falls has increased considerably, and a good deal more is known concerning them. Further, some errors and contradictions have crept into the literature and the opportunity is taken to rectify some of these misconceptions. It is hoped to include everything up to 31 December, 1937.

The present work is intended to be something more than a catalogue and bibliography, for it is felt that there is a definite need for an introduction to the study of meteorites, more particularly from the point of view of the Australian worker.

Further, in recent years, the collection of meteorites of the Australian Museum has been increased considerably, until today over one hundred falls, including forty-five Australian falls, are presented. The addition of the meteorite collections of the Mining and Geological Museum and the Technological Museum has greatly increased its importance. Of the seventy-seven Australian falls no less than twenty are represented by main masses.

Dr. E. S. Simpson, Government Mineralogist and Analyst, Western Australia, has generously placed at my disposal much data concerning the Western Australian meteorites which otherwise would not have been available. I am also indebted to Mr. L. C. Ball, Chief Government Geologist, Queensland, Mr. D. J. Mahony, Director, National Museum, Melbourne, and Mr. H. M. Hale, Director, South Australian Museum, Adelaide, for much information concerning the meteorites of their respective States. Mr. L. A. Jones, Government Geologist, New South Wales, very kindly gave permission for the maps to be drawn in his department. Dr. A. R. Alderman made available all his photographs of the Henbury Meteorite Craters. All photographs not otherwise acknowledged are the work of Mr. G. C. Clutton, Senior Preparator, Australian Museum. Finally, my thanks are due to Mr. R. O. Chalmers, A.S.T.C., for valued help in the preparation of this memoir.

2. GENERAL.

The definition of a meteorite is, very simply, a meteor which reaches the surface of the earth. It was not until 1803, when Biot completed his report on the fall of stones at L'Aigle, France, that the scientific world fully accepted the cosmic origin of meteorites. The actual place of origin is another question about which no generally accepted solution has been forthcoming, although a great deal has been written on the subject. One of the earliest suggestions made was that they come from the volcanoes of the moon, and it is interesting to note that in 1930 H. C. Mason[182] has revived this theory adducing arguments in its favour. As well as the moon, the sun, comets, the solar system, inter-stellar spaces, and even the ancient volcanoes of the earth have all been suggested as possible sources of meteorites. An excellent summary of all these suggestions has been given by L. Fletcher.[171]

All that can be said with a reasonable degree of certainty is that they come from beyond our atmosphere. It is possible that a number of the suggested sources of origin may contribute toward their number. F. E. Suess[201] presents the following hypothesis. They have originated in the planetary system where there is a complete absence of oxygen or water at a temperature not exceeding 1,500°, and he suggests that they have passed through the following six stages:

(*a*) Astral, forming part of a sun-like body.

(*b*) Apostactic, when the material forming the meteorites is thrown off.

(*c*) Kathartic, separation of material into outer slag and inner metallic portions.

(*d*) Porotic, solidification sets in at the proper rate to form chondrules and Widmanstätten figures.

(*e*) Perihelic, solid bodies travelling round the sun, the heat of which results in the loss of the more volatile constituents.

(*f*) Atmospheric, when they pass through the atmosphere as meteorites.

It has been noted that, while meteorites vary considerably in their physical properties, yet there is a very marked uniformity in some of the characters. Indeed, we may regard the irons and stones as the end members in the products of differentiation of a common magma. This fact certainly points to a similar mode of origin, at any rate for those meteors that reach our earth as meteorites. It must be remembered that it has been variously estimated that meteors enter our atmosphere at rates of from twenty to one hundred million per day, and the total number of known meteorites does not exceed one thousand. It cannot, therefore, be argued that we possess a fair average sample of the meteors, but rather an average of those meteors which are capable of reaching the surface of the earth.

So far as the chemical evidence is concerned it would appear that all the known elements have been found in meteorites. An examination by arc and X-ray spectroscopic methods of a number of meteorites by Ida and W. Noddack[188] revealed the fact that in the metallic portion a number of lithophil elements (Be, Mg, Ca, Sr, Ba, Ti, Zr, Hf, Th, Nb and Ta) were present, often in the same degree of concentration as in the stony portion, suggesting that meteorites were not fragments of a large world.

From all the evidence available it is perhaps more correct to assume that meteors are universally present throughout space, and that the numerous celestial phenomena observed by man are due primarily to the accretion of meteors, including, of course, meteorites. Doubtless the disintegration of any heavenly body may be described in the terms "Irons to irons and stones to stones".

Naturally the question has been raised whether meteorites bring to us any evidence of life beyond the earth. Dr. O. Hahn[173] in 1880 described the chondrules of the stony meteorites as corals, etc., and the Widmanstätten figures of the irons as the imprints of plants, but these structures are purely inorganic in origin.

Carbon up to 1·94 per cent. has been recorded in ten Australian meteorites, all of which are irons, while hydrocarbons have been detected in the Mount Browne aerolite by H. P. White,(95) the Cranbourne siderite by J. L. Smith,(52) and as resinous matter in the Narraburra siderite by A. Liversidge.(114) While the presence of such compounds in terrestrial objects would indicate an organic origin it has to be remembered that they may be formed by inorganic agencies. Further, all the meteorites mentioned were found and not seen to fall, so that contamination is a factor that must be considered.

Professor Charles B. Lipman(178) in 1932 reported the finding of bacteria in certain stony meteorites, thus apparently affirming the suggestion of von Helmholtz and Kelvin that meteorites might have been responsible for bringing the original forms of life to the earth. These results must be accepted with caution, as the risk of contamination is very great. In fact they cannot be accepted as proof without confirmation, and this has not been forthcoming. Indeed, Dr. S. Kumar Roy,(196) who carried out similar experiments on four meteorites, three of which belonged to the same falls as Professor Lipman used in his work, draws quite opposite conclusions.

It is difficult to conceive how a meteorite, considering its mode of formation, its subsequent existence in space, its final entry into our atmosphere, and the subsequent risk of contamination, can possibly bring evidence, either direct or indirect, of life beyond the earth.

3. CLASSIFICATION.

Meteorites grade from almost wholly iron to those which are almost wholly composed of silicate minerals. All students of meteorites have agreed on the threefold classification, thus:

1. Aerolites or stony meteorites, consisting essentially of silicate minerals.
2. Siderolites or stony-iron meteorites, consisting essentially of a network of nickel-iron with silicate minerals filling the interstices.
3. Siderites or iron meteorites, consisting essentially of nickel-iron.

Beyond this many attempts have been made to extend the classification. The earliest was perhaps that made by P. Partsch(191) in 1843. He was quickly followed by C. V. Shepard,(197) K. V. Reichenbach(194) in 1859, G. Rose(195) in 1863, N. S. Maskelyne(179) in 1863, A. Daubrée(165) in 1867, C. Rammelsberg(193) in 1870 and 1879, G. Tschermak(202) in 1872, A. Brezina(162) in 1885, and E. Cohen(164) in 1900.

All the classifications suggested prior to those of Rose and Maskelyne are purely of historical interest. Rose made a twofold classification of siderites including siderolites and aerolites, while Maskelyne recognized the three groups. Tschermak later modified Rose's classification, recognizing the threefold division.

Finally Brezina elaborated on these previous works and constructed a classification that in a modified form stands today. He revived the twofold classification of Rose, dividing the siderolites into siderolites which he included with the aerolites and the lithosiderites (mostly pallasites) with the siderites.

PRIOR'S CLASSIFICATION.

	Group.	1	2	3	4
CLASS.	Nickel-iron. Magnesium silicates. Felspar.	Fe : Ni = 13 and over. Enstatite (and Clino-enstatite). MgO : FeO very high to ∞. Oligoclase.	Fe : Ni = 13–8. Bronzite (and Clino-bronzite) and Olivine. MgO : FeO over 4. Oligoclase.	Fe : Ni = 8–2. Hypersthene (and Clino-hypersthene) and Olivine. MgO : Feo = 4–2. Oligoclase.	—— Pyroxene (mostly mono-clinic) and Olivine. MgO : FeO less than 2. Anorthite.
IRONS. 1	Siderites. Mainly nickel-iron.	Nickel-poor Araxites. Hexahedrites. Coarsest Octahedrites. Coarse Octahedrites.	Medium Octahedrites to finest Octahedrites.	Some finest Octahedrites ? Nickel-rich Ataxites.	Oktibbeha County ?
STONY-IRONS. 2	Siderolites. Nickel-iron in large amount.		Most Pallasites. Siderophyre. Lodranite. Mesosiderites.	A few Pallasites.	
STONES (AEROLITES). 3	Chondrites. Nickel-iron generally in decreasing amount from left to right.	Enstatite-chondrites. Daniel's Kuil (Hvittis) type.	Bronzite-olivine-chondrites. Kroonstad type.	Hypersthene - olivine - chondrites. Baroti and Soko-Banja types.	
4	Achondrites. (Non-chondritic stones.) Nickel-iron in small amount or absent.	Enstatite-achondrites. Aubrites. (Aubres, Bishopville and Bustee).	Clinobronzite - olivine - achondrites. Ureilites.	Hypersthene - olivine - achondrites. Amphoterites (and rodites). Hypersthene-achondrites. Diogenites (Shalka, etc.). Olivine-achondrites. Chassignite.	Calcium-rich Achondrites. Angrite, Nakhlite. Eucrites, Sherghottite Howardites. Mesosiderites.

With increased knowledge of the chemistry of meteorites the more modern attempts at classification have been directed, if not wholly then in part, toward subdivision based on chemical composition. The two most important contributions are those of F. Berwerth(160) in 1914 and G. T. Prior(192) in 1920. The former confined his classification to the iron meteorites, while the latter included all meteorites. Prior's classification is really a modification of that of Brezina, taking into account the chemical composition. He shows that the amount of nickel in the nickel-iron and the amount of ferrous oxide in the magnesium silicates varies widely. In the case of the siderites the structure as revealed by etching has an intimate relation with the nickel content. In regard to aerolites he points out that in any aerolite "the richer in nickel is the nickel-iron, the richer in ferrous oxide are the magnesium silicates". The principal modification made by Prior is the reversion to the threefold division of Maskelyne by grouping Brezina's siderolites and lithosiderites in a separate group under the name siderolite.

Prior's Classification.

I. Siderites.

1. **Hexahedrites** or cubic irons (H). Characterized by Neuman lines. Consist almost wholly of kamacite. Orientated schreibersite. Needles and daubreelite are characteristic of the non-brecciated type. $n = 13$ and over.

Example: Bingara.

2. **Octahedrites** (O). Characterized by Widmanstätten figures. Subdivided into:

Coarsest Octahedrite (Ogg) with lamellae 2–5 mm. in thickness.

Examples: Gladstone, Mooranoppin, Murnpeowie (hexadrite?), Temora.

Coarse Octahedrites (Og) with lamellae 1·5–2 mm. in thickness.

Examples: Cranbourne, Mt. Stirling, Yenberrie, Youndegin, Coolac.

Medium Octahedrite (Om) with lamellae 0·5–1 mm. in thickness.

Examples: Blue Tier, Delegate, Glenormiston (?), Henbury, Kyancutta, Milly Milly, Mount Dooling, Mount Edith, Nocoleche, Nuleri (?), Premier Downs, Rhine Villa, Roebourne, Thunda, Weekeroo (?), Yardea, Youanme.

Fine Octahedrites (Of) with lamellae 0·15–0·4 mm. in thickness.

Examples: Bugaldi, Moonbi, Tieraco Creek.

Finest Octahedrites (Off) with lamellae 0·1 mm. in thickness.

Examples: Arltunga (?), Ballinoo, Cowra, Mount Magnet, Mungindi, Murchison Downs, Narraburra.

Octahedrites may be brecciated as in the case of Glenormiston and Weekeroo.

Unclassified octahedrites: Landor.

3. **Ataxites** or Massive Irons (D). They show no structure. Subdivided into:

Nickel-poor ataxites. The value of n is over 16 and is beyond the limit of hexadrites.

Example: Yarraweyah.

Nickel-rich ataxites. The value of n is about 6 to 2 and beyond the limit of the finest octahedrites.

Example: Arltunga (?).

Unclassified irons: Alikatnima, Castray River, Dowerin, Lefroy, Roper River.

II. Siderolites.

1. **Pallasites** (P). Consisting of olivine crystals, generally rounded or broken, in a network of nickel-iron.

Examples: Alice Springs, Bendoc, Molong, Mount Dyrring.

2. **Siderophyre** (Si). Consisting of nickel-iron (*n* about 9), bronzite (Mg:Fe about 5) and asmanite.

No Australian examples.

3. **Lodranite** (Lo). Consisting of granular aggregates of olivine and bronzite both poor in ferrous oxide, enclosed in a mesh of nickel-iron poor in nickel. Closely related to Ureilites, but differing in percentage of nickel-iron.

No Australian examples.

4. **Mesosiderites** (M). Consisting of nickel-iron enclosing patches of stony matter composed of hypersthene (and clinohypersthene) and anorthite. Olivine is also present generally as separately enclosed.

Example: Bencubbin.

Unclassified siderolites: Mellenbye, Naretha.

III. Aerolites.

A. CHONDRITES.

1. **Enstatite-chondrites** (Cen). Consisting essentially of crystalline nearly non-ferrous enstatite with nickel-iron in large amount (up to 25 per cent.), troilite, and some oligoclase. Characteristic secondary minerals are oldhamite and daubreelite. Chondrules are few and imperfect. *n* about 13.

Examples: Elsinora, Karoonda, Carraweena (Bronzite-chondrite ?), Lake Labyrinth.

2. **Bronzite-chondrites** (Cbi). Consisting essentially of bronzite with clino-bronzite and olivine in approximately equal amounts, with some oligoclase forming a crystalline to tuffaceous aggregate which encloses chondrules (composed of the same minerals with in some cases isotropic material), with grains of nickel-iron and troilite. *n* about 11, MgO:FeO about 5.

Examples: Barratta, Gilgoin, Mount Browne.

3. **Hypersthene-chondrites** (Chy). Of similar composition and structure to group 2, except that the iron is richer in nickel ($n = 7$ to 3) and generally less in amount, and the MgO:FeO in the ferromagnesium minerals is about 4 to 2·5.

Examples: Eli Elwah, Lake Brown, Narellan, Tenham, Yandama, Silverton.

Unclassified chondrites: Hermitage Plains.

B. ACHONDRITES.

(*a*) Calcium-poor Achondrites in which the Felspar, when present, is generally Oligoclase.

1. **Aubrites** (Au). Consisting almost wholly of crystallized granular enstatite (and clino-enstatite) poor in lime and practically free from ferrous oxide with accessory oligoclase. Closely related to enstatite-chondrites.

No Australian examples.

2. **Ureilites** (U). Consisting of detached crystals or crystal aggregates of olivine and a calc-clino-bronzite enclosed in a fine mesh of nickel-iron and

carbonaceous matter. In mineral and chemical composition they correspond to the bronzite-chondrites, though the ferromagnesium minerals have a somewhat higher MgO:FeO ratio. They are closely related to the Lodranites, though containing much less nickel-iron.

No Australian examples.

3. **Amphoterites** (Am). Consisting of crystalline granular aggregates of hypersthene and olivine with a little nickel-iron. In mineral and chemical composition they correspond to the hypersthene-chondrites, though the ferromagnesium minerals have a lower MgO:FeO ratio.

No Australian examples.

4. **Diogenites** (Di). Consisting mainly of hypersthene rich in FeO, and with little or no nickel-iron.

No Australian examples.

5. **Chassingite** (Cha). Consisting mainly of olivine (MgO:FeO = about 2) with little or no nickel-iron.

No Australian examples.

(*b*) Calcium-rich Achondrites in which the Felspar, when present, is Anorthite.

1. **Angrite** (An). Consisting almost wholly of purple calcium-rich titaniferous augite rich in FeO, with a little olivine and troilite.

No Australian examples.

1a. **Nakhlite** (Nk). Consisting mainly of crystalline granular aggregates of green calcium-rich hedenbergite-diopside and brown olivine near to hortonolite. The interstitial felspar is nearer to oligoclase than to anorthite.

No Australian examples.

2. **Eucrites** (Eu). Consisting essentially of calc-clino-hypersthene and anorthite, and in structure doleritic to basaltic.

Example: Binda.

2a. **Shergottites** (She). Consisting essentially of calc-clino-hypersthene with lathes of maskelynite.

No Australian examples.

2b. **Howardites** (Ho). Consisting essentially of hypersthene clino-hypersthene and anorthite. They are generally brecciated and may be considered a brecciated variety of Eucrites.

No Australian examples.

Unclassified Australian aerolites: Accalana, Cadell, Ellerslie, Emmaville, Pevensey, Tenham.

Berwerth's Classification of Iron Meteorites.

1. Kamacite Meteorite. (Rinne's Sublacunite.)

Ni 6 per cent. Kamacite is the only important constituent.

I. 1. *Kamacite* (K). Usually a saturated mixed-crystal with six per cent. of nickel, of large or small dimension, as either single granular aggregates or with octahedral orientation. Good hexahedral cleavage with polysynthetic twinning parallel to (112) (Neumann lines).

I. 1a. *Kamacite-hexahedrite* (KH). Very large or small single individuals of kamacite.

I. 1b. *Granular or Granokamacite-hexahedrite* (k KH). Aggregates of large or small kamacite grains.

I. 1c. *Kamacite-Octahedrite* (KO). Composed of irregular kamacite crystallites but formed in definite large beams and rods and arranged parallel to the faces of the octahedron. The beams of kamacite united with traces of plessite, passing over to the plessite-kamacite meteorites. Included among this group are Brezina's broadest octahedrites (Ogg).

Appendix to I. *Artificial Kamacite-metabolite* (KMe). When kamacite-hexahedrite, granokamacite and kamacite-octahedrite are heated a secondary structure is formed, consisting of shred-like grains, coarse or fine polyhedrons, and compact (cryptocrystalline).

II. Kamacite-Taenite Meteorites. (Rinne's Lacunite.)

Ni 7–26 per cent. Kamacite and taenite are the essential constituents. Both as separate individuals or as a eutectic mixture (plessite) forming a separate structural element.

II. 1. *Kamacite-Plessite Meteorite* (Rinne's Lacunite). Ni 7–14 per cent. With kamacite and taenite bands forming a network with plessite as a groundmass. On etched surface Widmanstätten figures are shown. Kamacite and plessite.

II. 1a. *Octahedrite* (O). Having an octahedral structure, the kamacite bands being parallel to the faces of the octahedron and plessite filling the interstices of the kamacite network.

II. 1a. *Broad Plessite-poor Octahedrite* (Og). Ni 7–7·5 per cent. Width of kamacite bands vary from 1·5 to 2 mm. Kamacite frequently twinned on the octahedron, which forms both the twinning plane and the composition plane.

II. 1a. *Medium plessite-rich Octahedrite* (Om). Ni 7·5—9 per cent. Intersertal structure. Width of kamacite bands from 0·5 to 1·0 mm. The combined lamellae are commonly twinned on the octahedron. Lamellae uniform but usually granular.

II. 1a. *Medium octahedrite with Granular Kamacite Lamellae* (Omk). The kamacite lamellae not uniform and composed of differently oriented grains. The kamacite network has a spotted granular appearance.

Appendix to II. 1a. *Artificial Medium Octahedrite-Metabolite* (OmMe). The kamacite bands are changed into shred-like granular condition when artificially heated.

II. 1a. Fine Plessite-rich Octahedrite (Of). Ni from 9 to 11 per cent. Width of bands from 0·2 to 0·4 mm. Otherwise the same as (Om).

Appendix to II. 1a. *Artificial Fine-Octahedrite-Metabolite* (ofMe).

II. 1a. *Finest Very Rich Plessite Octahedrite* (Off). Ni from 11 to 14 per cent. Intersertal to porphyritic structure. Plessite exists as the groundmass. Width of lamellae 0·2 mm.

II. 1a. *Granooctahedrite* (K, Og, KOm, KOf, Koff). Small to coarse octahedrite complex (brecciated octahedrite).

Appendix to II. 1a. *Artificial Granooctahedrite Metabolite* (kOMe).

II. 1b. *Cubic Octahedrite* (TeO). Octahedral network of kamacite with kamacite lamellae parallel to the cube.

II. 1c. *Dodecahedrite* (Do). The bands of the kamacite lie on the dodecahedron (110).

II. 2. *Plessite-Meteorite* (Pl) (Rinne's *Eutectic Lacunite*). Ni from 14 to 18 per cent. Consisting of plessite with the last traces of kamacite as slender rods. Massive appearance. Microscopic structure dominantly lamellar.

Appendix to II. 2. *Artificial Plessite Metabolite* (PlMe).

II. 3. *Taenite Plessite Meteorite* (TaePl) (Rinne's *Hypeutectic Lacunite*). Ni 26 per cent. Coarse granular taenite aggregates with a few plessite fields disposed in lamellae on the borders.

AUSTRALIAN FALLS.

ABEL, *v.* Cranbourne.

1. **Accalana.** Aerolite. Found 1917.
Lat. 29° 15′ S., Long. 139° 58′ E. Weight 2·8 kilograms (6¼ lb.).
Australian Museum collection: not represented.
Main mass: South Australian Museum, Adelaide.

ADELAIDE, *v.* Rhine Villa.

2. **Alice Springs.** Pallasite. Found 1924 by Dr. H. Basedow.
Burt Plains, ten miles north of Alice Springs, Central Australia.
Lat. 23° 33′ S., Long. 133° 52′ E. Weight 1·08 kilograms (2 lb. 6 oz.).
Australian Museum collection: not represented.
Main mass: British Museum.

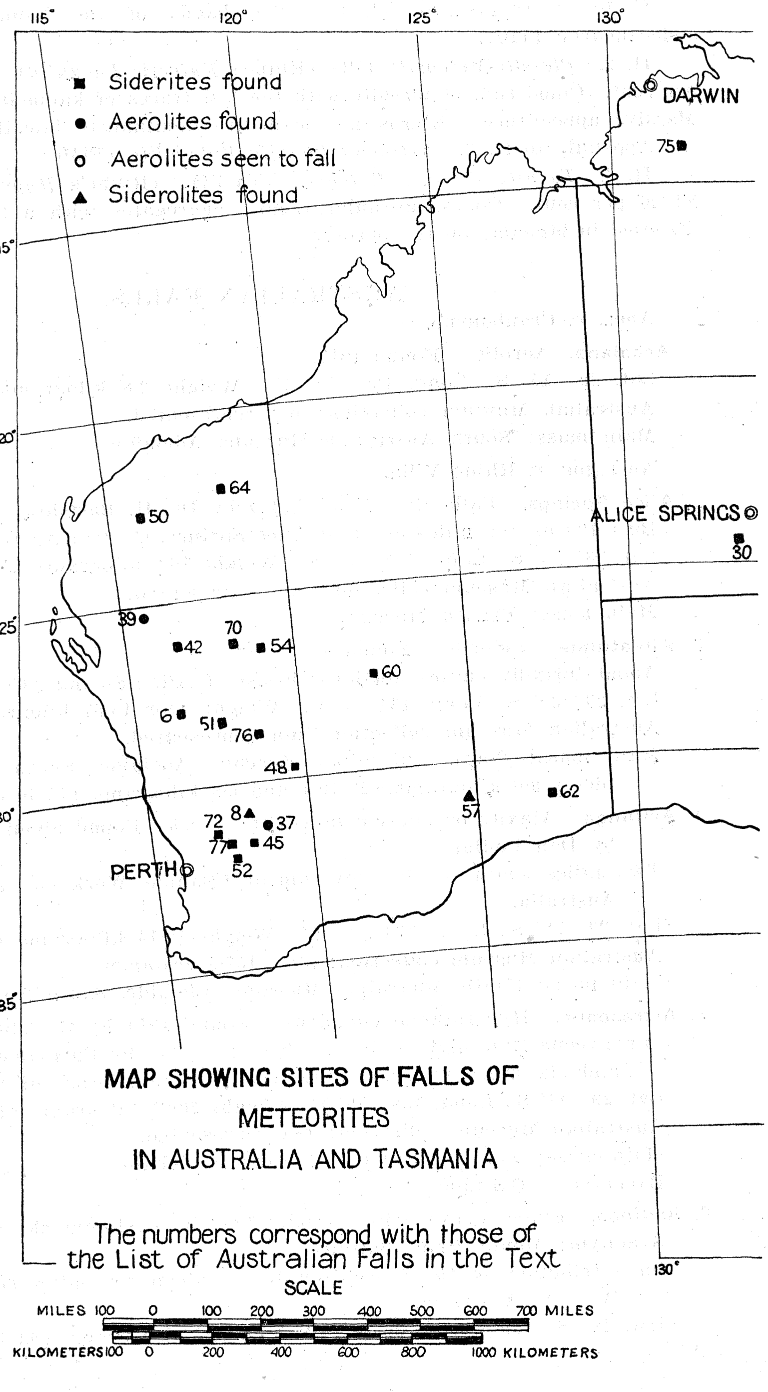
3. **Alikatnima.** Siderite. Found ——.
About forty-five miles north-north-east of Alice Springs, Central Australia.
Lat. 23° 20′ S., Long. 134° 7′ E. Weight over 15·87 kilograms.
Australian Museum collection: not represented.
Main mass: South Australian Museum, Adelaide, South Australia. Two pieces 9·0 kilograms (20 lb.) and 6·8 kilograms (15 lb.).

4. **Arltunga.** Ataxite or micro-octahedrite. *n* 8·6. Found about September, 1908, by Dan Pedlar.
Two miles south of the Government Cyanide Works at Arltunga, Central Australia.
Lat. 23° 28′ S., Long. 134° 34′ E. Weight 18·14 kilograms (40 lb.).
Australian Museum collection: slice 157·5 grammes.
Main mass: South Australian Museum, Adelaide, South Australia.

5. **Artracoona.** Hypersthene chondrite. Found 1914 by G. Amesbury.
Carraweena Run, eight miles north-west of the Old Carraweena Head Station, and six miles west of Artracoona Hill, north-east of South Australia.
Lat. 29° 11′ S., Long. 139° 59′ E. Weight 20·81 kilograms (45 lb. 14 oz.).
Australian Museum collection: not represented.
Main mass: South Australian Museum, Adelaide.

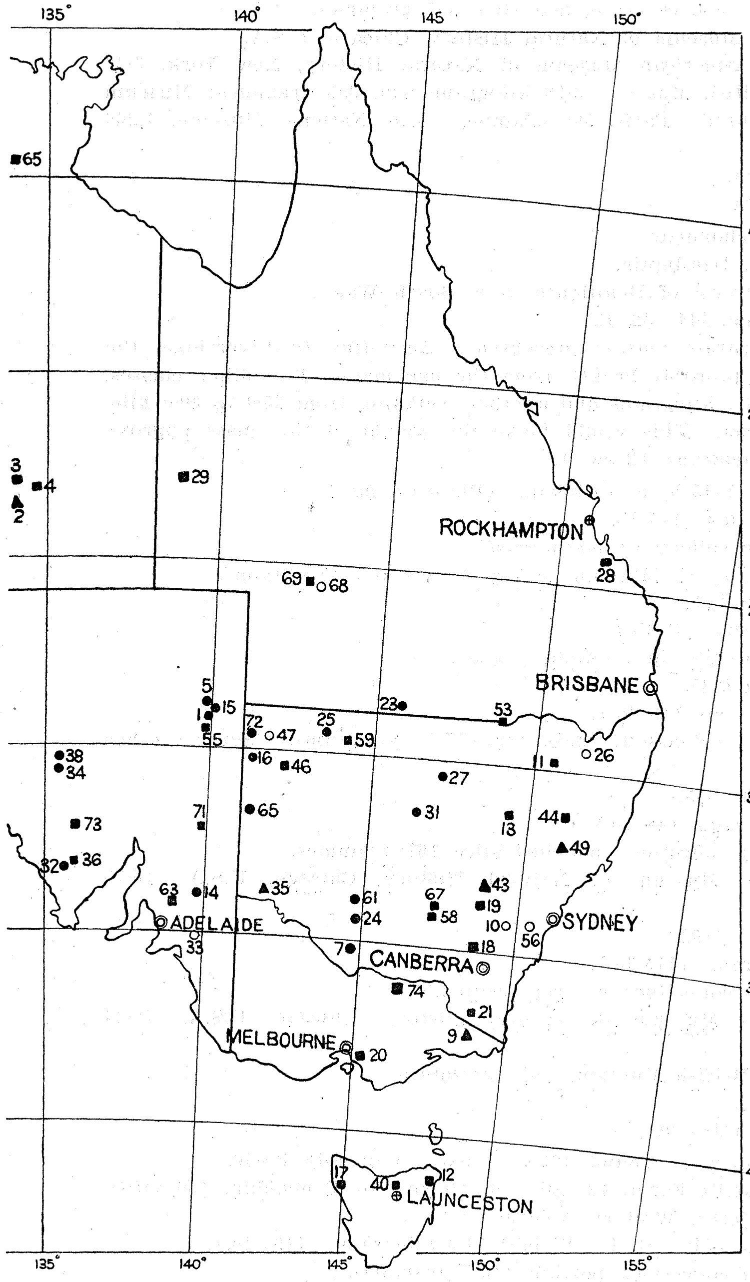
BALLINEE *v.* Ballinoo.

6. **Ballinoo.** Finest octahedrite. Found 1893 by G. Denmack.
Synonym: Mount Erin, Ballinee.
On a tributary of the Murchison River, about ten miles south of Ballinoo, Western Australia.
Lat. 28° S., Long. 116° 30′ E. Weight 42·23 kilograms (93 lb.).



MAP SHOWING SITES OF FALLS OF METEORITES IN AUSTRALIA AND TASMANIA

The numbers correspond with those of the List of Australian Falls in the Text


135°
140°
145
150°
15°
20°
25°
30°
35°
40°
155°
ROCKHAMPTON
BRISBANE
SYDNEY
CANBERRA
ADELAIDE
MELBOURNE
LAUNCESTON
65
3
4
2
29
28
69
68
5
15
1
55
72
47
25
59
23
53
11
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38
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7
18
74
21
9
20
17
40
12

Fig. 1.

Australian Museum collection: etched slice 357 grammes.

Main mass: Field Museum of Natural History, Chicago, U.S.A.

Other collections: American Museum of Natural History, New York, 3·32 kilograms; British Museum, 3·16 kilograms and 395 grammes; Museum d'Histoire Naturelle, Paris, 599 grammes; U.S. National Museum, 1,266 grammes.

BARATTA v. Barratta.

BARRABA v. Bingara.

7. **Barratta.** Bronzite chondrite.

Synonym: Baratta, Deniliquin.

Thirty miles north-west of Deniliquin, New South Wales.

Lat. 35° 16′ S., Long. 144° 32′ E.

There are five separate masses preserved. According to Liversidge, the first three are probably broken from the one mass. Two other masses, one weighing 1·7 kilograms and another weighing from 25·0 to 30·0 kilograms, were lost. This would make the weight of this mass approximately 101·5 kilograms (2 cwt.).

Barratta No. 1. Found 1845 by a stockman. (Plate xv, fig. 1.)

Weight 65·0 kilograms (145 lb.).

Australian Museum collection: main mass.

Other collections: British Museum, 46·5 grammes and 45 grammes.

Barratta No. 2. Found 1899.

Weight 14·0 kilograms (31 lb.).

Australian Museum collection: complete mass.

Barratta No. 3. Found 1845.

Weight 21·77 kilograms (48 lb.).

Australian Museum collection: main mass 7·25 kilograms. Several other pieces.

Barratta No. 4. Found 1845.

Weight 21·77 kilograms (48 lb.).

Australian Museum collection: polished slice 167 grammes.

Main mass: Field Museum of Natural History, Chicago, U.S.A., 16·76 kilograms.

Barratta No. 5. Found 1852.

Weight 79·37 kilograms (175 lb.).

Australian Museum collection: not represented.

Main mass: Field Museum of Natural History, Chicago, U.S.A., 72·34 kilograms.

Other collections: British Museum, 2,678 grammes.

BATHURST *v.* Cowra.

BEACONSFIELD *v.* Cranbourne.

8. **Bencubbin.** Mesosiderite. Found 1930, almost completely buried.

Holland and Breakell's Farm, 12 miles north-west of Bencubbin, 150 miles north-east of Perth, Western Australia.

Lat. 30° 48′ S., Long. 117° 51′ E. Weight 54·0 kilograms (119½ lb.).

Australian Museum collection: portion 143·5 grammes.

Main mass: Western Australian Museum.

Other collections: U.S. National Museum, Washington, 242 grammes.

9. **Bendoc.** Pallasite. *n* 10. Found 1898 by a miner in a sluicing claim of heavy boulder wash.

Synonym: Bendock.

About seven miles from Bendoc, County Croajingalong, Victoria.

Lat. 37° 11′ S., Long. 148° 58′ E. Weight: 27·21 kilograms (60 lb.).

Australian Museum collection: not represented.

Main mass: not known.

BENDOCK *v.* Bendoc.

10. **Binda.** Eucrite (Plate xiv, figs. 1 and 2). Fell (?) 25th May, 1912, found 5th June, 1912, by A. McCormack.

Four miles from Binda and eleven miles north-north-west of Crookwell, New South Wales.

Lat. 34° 18′ S., Long. 149° 25′ E. Weight 5·43 kilograms (12 lb.).

Australian Museum collection: 2·61 kilograms. Main mass.

Rest of this stone, generally listed as Technological Museum, Sydney, appears to be lost.

11. **Bingara.** Hexahedrite. In four analyses *n* 21·3, 16·8, 16·7 and 16·4, but the Fe : Ni-Co 18·5, 15·6, 15·5, 14·4.

Synonyms: Barraba, Warialda, Bingera.

There are four masses known. Bingara No. 2 has not so far been listed, while the Barraba and Warialda masses have been listed as separate falls. From the evidence there is no doubt that all these masses belong to the one fall. *Vide* p. 31, fig. 3.

Bingara No. 1. Found 1880 by some gold miners.

Weight 240·7 grammes.

Australian Museum collection: etched portion, 54·2 grammes.

Main mass: K. K. Naturhistorisches Hofmuseum, Vienna, 85 grammes; British Museum, 15 grammes.

Bingara No. 2. Known February, 1924.

Nine miles north of Bingara, New South Wales.

Lat. 29° 42′ S., Long. 150° 30′ E. Weight 6·4 kilograms (14 lb.).

Australian Museum collection: main mass, 5·43 kilograms (12 lb.).

Other collections: American Museum of Natural History, New York, 267·8 grammes.

Bingara No. 3. Date of find unknown.

Synonym: Barraba.

Exact locality unknown. "Between Barraba and Bingara".

Weight 1·36 kilograms (3 lb.).

Australian Museum collection: portion with etched surface, 291 grammes.

Other collections: K. K. Naturhistorisches Hofmuseum, Vienna, and the British Museum, 107 grammes.

Bingara No. 4. Found 9th September, 1919, by L. J. Armstrong.

Synonym: Warialda.

W. Campbell's property, fifteen miles north of Bingara.

Weight 2·82 kilograms (6¼ lb.).

Australian Museum collection: main mass, 2·54 kilograms.

Other collections: British Museum, 36 grammes; American Museum of Natural History, New York, 93·2 grammes.

BINGERA *v.* Bingara.

12. **Blue Tier.** Medium octahedrite. Known before 1893.
Synonym: Tasmania.
County Dorset, north-east coast of Tasmania.
Lat. 41° 7′ S., Long. 148° 5′ E. Weight 1·36 kilograms (3 lb.).
Australian Museum collection: not represented.
Main mass: Queen Victoria Museum, Launceston.
BOOGALDI *v.* Bugaldi.
BRUCE v. Cranbourne.

13. **Bugaldi.** Fine octahedrite (Plate v). Found 1900 by —. Gould, who followed a furrow and found the iron with the large end buried in the ground.
Synonym: Boogaldi.
Two miles from Bugaldi Post Office and fifteen miles north-west of Coonabarabran, New South Wales.
Lat. 31° 18′ S., Long. 149° 5′ E. Weight 2·05 kilograms (4½ lb.).
Australian Museum collection: main mass with etched surface, 1·18 kilograms.
Other collections: British Museum, 179 grammes.

14. **Cadell.** Aerolite. Found 14th April, 1910.
Three miles from Morgen, on the east side of the Murray River, hundred of Cadell, South Australia.
Lat. 34° S., Long. 139° 45′ E. Weight 3·29 kilograms (7¼ lb.).
Australian Museum collection: portion weighing 20 grammes.
Main mass: South Australian Museum, Adelaide.
CARCOAR *v.* Cowra.

15. **Carraweena.** Enstatite chondrite. Found in 1914 by Mr. G. Amesbury.
About six miles south-west of Old Carraweena, north-east of South Australia.
Lat. 29° 10′ S., Long. 140° 0′ E. Weight 28·8 kilograms (63½ lb.).
Australian Museum collection: not represented.
Main mass: South Australian Museum, Adelaide.

16. **Cartoonkana.** Enstatite chondrite.
Yandama Station, New South Wales.
Lat. 29° 45′ S., Long. 141° 2′ E. Weight 4·65 kilograms (10¼ lb.).
Australian Museum collection: not represented.
Main mass: South Australian Museum, Adelaide.

17. **Castray River.** Siderite. Found 1899 by a miner in auriferous drift.
Bank of Castray River, tributary of the Heazlewood River, north-west Tasmania.
Lat. 41° 35′ S., Long. 144° 55′ E. (approximate). Weight 150 grammes (5 oz.), consisting of three fragments, each of 50 grammes.
Australian Museum collection: not represented.
Main mass: Queen Victoria Museum, Launceston.

18. **Coolac.** Coarse octahedrite (Plate vii, fig. 2). Found about 1874 by T. McMahon.
"Happy Valley" selection, about three miles west of Coolac, New South Wales.
Lat. 34° 58′ S., Long. 148° 7′ 30″ E. Weight 19·28 kilograms (42½ lb.).
Australian Museum collection: etched portion, 510 grammes.
Main mass: privately owned.

19. **Cowra.** Finest octahedrite. $n = 6·5$. Found before 1888 by J. O'Shaughnessy firmly embeded in slate rock.

Synonyms: Bathurst, Carcoar.

Summit of Battery Mountain at the junction of Burrowa and Lachlan Rivers, a few miles east of Cowra, New South Wales.

Lat. 33° 52′ S., Long. 148° 45′ E. Weight 5·65 kilograms (12¼ lb.).

Australian Museum collection: main mass, 3·57 kilograms.

Other collections: British Museum, four pieces, 291 grammes; American Museum of Natural History, New York, 199·1 grammes, 479·2 grammes; U.S. National Museum, 62 grammes.

20. **Cranbourne.** Coarse octahedrite. $n = 12$ to $12·5$.

Synonyms: Abel, Beaconsfield, Bruce, Dandenong, Langwarrin, Melbourne, Victoria, Western Port District, Yarra Yarra River.

Two irons were found in 1854, the larger of which was purchased by a Mr. Bruce and presented to the British Museum, and the other was secured by a Mr. Abel. Abel's iron was sent to the International Exhibition, London, in 1862, and was purchased by the British Museum for £300 and presented to the then colony of Victoria. Later another mass was found at Beaconsfield by a Mr. Feltus, and in 1886 a fourth mass was found at Langwarrin. Two other masses, one preserved in the Geological Survey of Victoria and the other in the National Museum, Melbourne, are in existence, but nothing is known of their history. In 1928 the eighth mass was secured by Mr. D. J. Mahony, Director of the National Museum.

Cranbourne No. 1. Found 1854. (Plate i.)

Synonyms: Bruce, Western Port.

Weight 3,556 kilograms (3½ tons).

Australian Museum collection: portion weighing 2·68 kilograms.

Main mass: British Museum.

Other collections: Museum d'Histoire Naturelle, Paris (Yarra Yarra); U.S. National Museum, 71 and 15 grammes.

Cranbourne No. 2. Found 1854.

Synonyms: Abel, Western Port, Dandenong.

Weight 1,524 kilograms (1½ tons).

Australian Museum collection: not represented.

Main mass: National Museum, Melbourne.

Cranbourne No. 3. Found between 1854 and 1860.

Weight about 6·8 kilograms (15 lb.).

No specimen preserved.

Cranbourne No. 4. Weight about 500 kilograms (about 10 cwt.).

Australian Museum collection: not represented.

Main mass: National Museum, Melbourne.

Cranbourne No. 5.

Weight about 300 kilograms (6 cwt.).

Australian Museum collection: portion weighing 1·36 kilograms (3 lb.).

Main mass: Geological Survey of Victoria.

Cranbourne No. 6. Found 1928.
About three miles west of Pakenham, Parish Berwick, County Mornington, Victoria.
Weight 9·0 kilograms (20 lb.).
Australian Museum collection: not represented.
Main mass: National Museum, Melbourne.

Beaconsfield. Found about 1876.
About two miles east of Beaconsfield railway station, Parish Pakenham, County Mornington, Victoria.
Lat. 38° 31′ S., Long. 145° 30′ E. Weight 75 kilograms (165 lb.).
Australian Museum collection: slice, 78 grammes.
Main mass: Krantz collection.
Other collections: British Museum, 73·5 grammes; American Museum of Natural History, New York, 637·7 grammes; U.S. National Museum, 124 grammes; Museum d'Histoire Naturelle, 681 grammes.

Langwarrin. Found 1886 by A. H. Padley.
About five miles south-east of Langwarrin railway station, County Mornington, Victoria.
Lat. 38° 12′ S., Long. 145° 14′ E. Weight originally 914·44 kilograms (18 cwt.).
Australian Museum collection: not represented.
Main mass: National Museum, Melbourne.
DANDENONG *v.* Cranbourne No. 2.

21. **Delegate.** Medium to coarse octahedrite. $n = 10$. (Plate iv, fig. 1.) Found about 1914, lying on the surface.
Portion 35, Parish Delegate, County Wellesley, south-west of Sawpit Creek, about six miles by road (four miles north-north-east in a direct line) from Delegate, New South Wales.
Lat. 36° 26′ S., Long. 148° 52′ E. Weight 27·66 kilograms (61 lb.).
Australian Museum collection: main mass, 17·92 kilograms (39½ lb.).
Other collections: British Museum, 186 grammes; American Museum of Natural History, New York, 130·3 grammes; U.S. National Museum, 200 grammes.
DENILIQUIN *v.* Barratta.
DIAMANTINA *v.* Thunda.

22. **Dowerin.** Siderite. Found about 1928.
Western Australia.
Lat. 31° 12′ S., Long. 117° E., approximately.
Large number of small fragments.
Australian Museum collection: not represented.

23. **Ellerslie.** Aerolite. Known 1905.
Ellerslie Estate, about 80 miles north of Bourke, New South Wales. The locality is across the Queensland border.
Lat. 28° 25′ S., Long. 145° 53′ E. Weight 10·17 kilograms (22½ lb.).
Australian Museum collection: not represented.
Main mass: National Museum, Melbourne.

24. **Eli Elwah.** Hypersthene chondrite (Plate xv, fig. 2). Found 1888. The finder stated that he saw it fall.

Synonym: Hay.
Eli Elwah Station, 15 miles west of Hay, New South Wales.
Lat. 34° 30′ S., Long. 144° 56′ E. Weight 15·2 kilograms (33½ lb.).
Australian Museum collection: not represented.
Main mass: British Museum, 13·27 kilograms, 11 pieces 774 grammes.

25. **Elsinora.** Enstatite chondrite. (Plate xii, fig. 2.) Found September, 1922, by J. Thue-Johnsen.
Ten miles south-east of Thurloo Downs Homestead, which is about forty miles north-west from Wanaaring on the Paroo River, New South Wales.
Lat. 29° 27′ S., Long. 143° 36′ E. Weight unknown. The stone was broken when found. Only two pieces were preserved, weighing 1·28 kilograms and 517 grammes.
Australian Museum collection: main mass, 1·28 kilograms.
Other collections: British Museum, 297 grammes.

26. **Emmaville.** Aerolite. (Plate xii, fig. 4.) Seen to fall 1900.
Near Emmaville, New South Wales.
Lat. 29° 14′ S., Long. 151° 45′ E. Weight 127 grammes (4½ oz.).
Australian Museum collection: main mass, 99 grammes. The remaining portion does not appear to have been preserved.

27. **Gilgoin.** Bronzite chondrite. (Plate xiii.) Seven stones were found in 1889 and one in 1920.
Gilgoin Station, forty miles east-south-east of Brewarrina, New South Wales.
Lat. 30° 35′ S., Long. 147° 12′ E. Total weight 147·2 kilograms (324½ lb.).

Gilgoin No. 1. Found 1889.
Weight 30·6 kilograms (67½ lb.).
Australian Museum collection: main mass, 7·61 kilograms.
Other collections: U.S. National Museum, 290 grammes; Technological Museum, Sydney, 1·5 kilograms.

Gilgoin No. 2. Found 1889.
Two miles south from Gilgoin No. 1.
Weight 33·7 kilograms (74¼ lb.).
Australian Museum collection: main mass, 33·1 kilograms.
Other collections: U.S. National Museum, 1,299 grammes.

Gilgoin No. 3. Found 1889.
Weight 25·1 kilograms (55¼ lb.).
Australian Museum collection: cast only.
Main mass: formerly Ward-Coonley collection, U.S.A.

Gilgoin No. 4. Found 1889.
Weight 16·8 kilograms (37 lb.).
Australian Museum collection: cast only.
Main mass: formerly Ward-Coonley collection, U.S.A.

Gilgoin No. 5. Found 1889.
Weight 12 kilograms (26½ lb.).
Australian Museum collection: cast only.
Main mass: Field Museum of Natural History, Chicago, U.S.A.

Gilgoin No. 6. Found 1889.
Weight 7·25 kilograms (16 lb.).
Australian Museum collection: main mass, 3·63 kilograms.

Gilgoin No. 7. Found 1889.

Weight 9·86 kilograms (21¾ lb.).

Australian Museum collection: main mass, 3·68 kilograms.

Other collections: British Museum, 261·5 grammes; U.S. National Museum, 155 grammes.

Gilgoin No. 8. Found 1920.

Weight 11·9 kilograms (26¼ lb.).

Australian Museum collection: complete mass.

28. **Gladstone.** Coarse to coarsest octahedrite, $n = 14{\cdot}5$. Found 1894.

Synonym: South Queensland.

Four miles due south of Gladstone, Queensland.

Lat. 24° 10′ S., Long. 151° 17′ E. Weight 736·6 kilograms (14½ cwt.). "South Queensland", 72 grammes.

Australian Museum collection: complete section (etched, 13·15 kilograms).

Other collections: U.S. National Museum, complete section; American Museum of Natural History, 16 kilograms and 23 grammes.

29. **Glenormiston.** Brecciated octahedrite, $n = 10{\cdot}3$. Found about 1926.

Five miles west of Glenormiston Station house, ninety miles west of Boulia, north-west Queensland.

Lat. 22° 54′ S., Long. 138° 43′ E. Weight estimated at about 40 kilograms (about 90 lb.). One piece weighs 39·1 kilograms, two other pieces estimated at 0·9 kilogram.

Australian Museum collection: not represented.

Main mass: Queensland Museum, Brisbane.

HAMMERSLEY, *v.* Roebourne.

HAY, *v.* Eli Elwah and Pevensey.

30. **Henbury.** Medium octahedrite, $n = 12{\cdot}1$, $12{\cdot}8$. (Plates viii and ix.) Known 1931.

Seven miles west-south-west of Henbury Station, Finke River, Central Australia.

Lat. 24° 34′ S., Long. 133° 10′ E. Weight unknown. Hundreds of fragments and complete irons found around thirteen craters.

Australian Museum collection: a complete iron, 47·26 kilograms, a complete section, 935 grammes, torn fragment showing distorted Widmanstätten figures, a collection of fragments, and a collection of fused rock, glass globules and iron shale.

Other collections: *Vide* p. 39.

HERMADALE, *v.* Hermitage Plains.

31. **Hermitage Plains.** Chondrite. Found 1909.

Synonym: Hermadale.

Hermitage Plains, twenty miles south-west of Canbelego, New South Wales.

Lat. 31° 28′ S., Long. 146° 41′ E. Weight about 32 kilograms (about 70 lb.).

Australian Museum collection: two portions, 6·92 and 3·52 kilograms.

Other collections: American Museum of Natural History, 520 grammes.

32. **Kappakoola.** Hypersthene chondrite. Found September, 1929, by F. W. Daniel on top of a sand hill.

About eight miles south of Kyancutta, Eyre Peninsula, Section 11, Hundred of Kappakoola, South Australia.

Lat. 33° 20′ S., Long. 135° 30′ E. Weight 392·5 grammes.

Australian Museum collection: slice weighing 1·3 grammes.
Main mass: Kyancutta Museum, South Australia. British Museum, 45, 2·2 and 1·4 grammes. American Museum of Natural History, New York, 519 grammes.

33. **Karoonda.** Enstatite chondrite. Seen to fall 10.53 p.m. on 25th November, 1930.
Two and a quarter miles east of Karoonda, South Australia.
Lat. 35° 7′ S., Long. 139° 53′ E. Weight estimated at 41·82 kilograms (92 lb.). The mass was shattered at the time of the fall.
Australian Museum collection: portion weighing 151 grammes.
Main mass: South Australian Museum, Adelaide.
Other collections: U.S. National Museum, 23 grammes.

34. **Kingoonya.** Chondrite. (Plate xii, fig. 1.) Found about 1926.
Near the 204 miles post on the Transcontinental railway, five miles east of Kingoonya railway station, South Australia.
Lat. 31° 1′ S., Long. 135° 17′ E. Weight estimated at 2·7 kilograms (6 lb.). The stone was broken into three pieces by the finders. These weighed 2·48 kilograms.
Australian Museum collection: portion weighing 10 grammes.
Main mass: unknown.

35. **Kulnine.** Siderolite. Known 1886.
Kulnine Run, about twenty miles from Wentworth, New South Wales.
Lat. 34° 8′ S., Long. 141° 56′ E. Weight 55·33 kilograms (122 lb.).
Australian Museum collection: not represented.
Main mass: South Australian Museum, Adelaide.

36. **Kyancutta.** Medium octahedrite. Found in June, 1932, by L. G. Gardiner in a sandy paddock.
Twenty-eight miles east-south-east of Kyancutta, South Australia.
Lat. 33° 19′ S., Long. 136° 2′ E. Weight 32·6 kilograms (72 lb.).
Australian Museum collection: portion weighing 1·58 kilograms.
Main mass: Kyancutta Museum.
Other collection: British Museum, 370 grammes.

37. **Lake Brown.** Intermediate chondrite (?), $m = 3{\cdot}5$, $n = 5{\cdot}5$. **Found 1919 by** N. A. Stuckey.
Lake Brown, County Avon, South-West Division, Western Australia.
Lat. 31° S., Long. 118° 30′ E. (approximate). Weight 9·75 kilogams (21½ lb.).
Australian Museum collection: not represented.
Main mass: Geological Survey Museum, Perth, Western Australia.
Other collections: British Museum, 174 grammes.
LAKE GILES, *v.* Mount Dooling.

38. **Lake Labyrinth.** Olivine enstatite chondrite. Found February, 1924, by an aboriginal.
About twenty miles north of Lake Labyrinth, about eight miles north of Peela Rock-hole and well on Wilgena Station, South Australia.
Lat. 30° 20′ S., Long. 135° 20′ E. (approximate only). Weight estimated at 34 kilograms (75 lb.). 25·85 kilograms (57 lb.) fragments recovered.
Australian Museum collection: portion weighing 326 grammes.
Main mass: Kyancutta Museum.

Other collections: British Museum; American Museum of Natural History, New York, 20, 688·2, 12·7 and 155·6 grammes; U.S. National Museum, 995 grammes.

39. **Landor.** Octahedrite. Found 1931.
Near the head of Wooramel River, on Land sheep station, Western Australia.
Lat. 25° 15′ S., Long. 116° 37′ E. Weight about 9 kilograms (20 lb.).
Australian Museum collection: not represented.
Main mass: privately held. Small chips examined by Dr. E. S. Simpson.
LANGWARRIN, *v.* Cranbourne.

40. **Lefroy.** Siderite. Found 1904 by a prospector.
Twenty-seven miles north-west of Launceston, north-west Tasmania.
Lat. 41° 9′ S., Long. 146° 58′ E. Weight 0·2138 grammes (3·3 grains).
Australian Museum collection: not represented.
Main mass: Queen Victoria Museum, Launceston.
MELBOURNE, *v.* Cranbourne.

41. **Mellenbye.** Siderolite. Found about 1929.
Between Mellenbye and Kadji-Kadji Stations, near Yalgoo, Western Australia.
Lat. 28° 51′ S., Long. 116° 15′ E. Weight 337 grammes (12 oz.). Only a fragment found.
Australian Museum collection: not represented.
Main mass: Dr. E. S. Simpson, Perth.
Other collection: British Museum, 81 grammes.

42. **Milly Milly.** Medium octahedrite. Found 1921 by an aboriginal.
Milly Milly sheep station, Murchison River, about 115 miles west by north of Meekatharra, Western Australia.
Lat. 26° 5′ S., Long. 116° 45′ E. Weight 26·5 kilograms (58¼ lb.).
Australian Museum collection: not represented.
Main mass: Geological Survey Museum, Perth, Western Australia.

43. **Molong.** Pallasite. (Plate xv, fig. 3.) Found August, 1912, by J. Williams.
E. Farrell's Selection, twelve miles west of Orange, New South Wales.
Lat. 33° 17′ S., Long. 148° 53′ E. Weight 105·22 kilograms (232 lb.).
Australian Museum collection: main mass, 52·16 kilograms.
Other collections: British Museum, 2,022 grammes; American Museum of Natural History, New York, 453·8, 67·6, 59·9 grammes; U.S. National Museum, 510 grammes; Kyancutta Museum, 1·1 kilograms; Technological Museum, Sydney, 1 kilogram.

44. **Moonbi.** Fine octahedrite, $n = 11·5$. (Plate vi, fig. 1.) Found 1892 by —. Langston, lying on the surface.
Eighteen miles from Moonbi, New South Wales, in the Moonbi Range.
Lat. 31° 9′ S., Long. 151° 1′ E. Weight 13·16 kilograms (29 lb.).
Australian Museum collection: main mass, 5·85 kilograms.

45. **Mooranoppin.** Coarsest octahedrite, $n = 12·5$. Found 1893 by an aboriginal.
Mooranoppin, fifty miles west of Coolgardie, Western Australia.
Lat. 32° 0′ S., Long. 119° 25′ E. Weight: two masses found, one weighing 1·13 kilograms (2½ lb.) and the other 742 grammes.
Australian Museum collection: etched slice, 54 grammes.
Main mass: Geological Survey Museum, Perth.

Other collections: British Museum, 261 grammes; Field Museum of Natural History, Chicago, 173 grammes; American Museum of Natural History, New York, 255·7 grammes; U.S. National Museum, 73 grammes.

46. **Morden.** Siderite. Found (?).
North-west New South Wales.
Lat. 30° 30′ S., Long. 142° 20′ S. Weight 2·72 kilograms (5⅝ lb.).
Australian Museum collection: not represented.
Main mass: South Australian Museum, Adelaide.

47. **Mount Browne.** Bronzite chondrite. Fell 9.30 a.m., 17th July, 1902.
Mount Browne, County Evelyn, north-western New South Wales.
Lat. 29° 45′ S., Long. 141° 46′ E. Weight 9·68 kilograms (25¼ lb.). At least 450 grammes were broken off by the finders.
Australian Museum collection: main mass, 6·68 kilograms.
Other collections: British Museum, 148 and 53 grammes; U.S. National Museum, 400 grammes.

48. **Mount Dooling.** Medium octahedrite, $n = 15{\cdot}5$. Found 1909 by A. P. Brophy.
Synonym: Lake Giles.
Five miles east of Mount Dooling, North Yilgarn, Western Australia.
Lat. 29° 27′ S., Long. 119° 43′ E. Weight 31·30 kilograms (69 lb.).
Australian Museum collection: not represented.
Main mass: Geological Survey Museum, Perth, Western Australia.

49. **Mount Dyrring.** Pallasite, $n = 19$. Found 1903 by an aboriginal, embedded in the soil.
Mount Dyrring, eight miles north of Bridgman, Singleton district, New South Wales.
Lat. 32° 30′ S., Long. 151° 10′ E. Weight 11·34 kilograms (25 lb.) is the total weight of several fragments found.
Australian Museum collection: two fragments weighing 1·13 kilograms and 1·02 kilograms.
Other collections: British Museum, 235 grammes; Field Museum of Natural History, Chicago, 132 grammes; U.S. National Museum, Washington, 190 grammes; American Museum of Natural History, New York, 7 pieces, 20·6 grammes.

50. **Mount Edith.** Medium octahedrite, $n = 9{\cdot}4$. (Plate vii, fig. 3.)
Mount Edith, Ashburton district, eighty miles south-east of Onslow and sixty miles south-west of Roebourne, Western Australia.
Lat. 22° 30′ S., Long. 116° 10′ E. Two masses of the Mount Edith have been found with a total weight of 325·67 kilograms (718 lb.).

Mount Edith No. 1. Found 20th April, 1913, by J. Bourke.
Weight 160·57 kilograms (354 lb.).
Australian Museum collection: slice, 145 grammes.
Main mass: Field Museum of Natural History, Chicago, 10 kilograms.
Other collections: British Museum, 1·04 kilograms and 145 grammes; American Museum of Natural History, New York, 8·75 kilograms; U.S. National Museum, large specimen.

Mount Edith No. 2. Found 1914 by J. Bourke.
Two miles from Mount Edith No. 1.
Weight 165·10 kilograms (364 lb.).

Australian Museum collection: not represented.
Main mass: Geological Survey Museum, Perth.
Mount Erin *v.* Ballinoo.

51. **Mount Magnet.** Finest octahedrite, $n = 6{\cdot}3$. Found 1916, in two fragments which fit together perfectly.
East of Mount Magnet, Murchison Goldfield, Central Division, Western Australia.
Lat. 28° 2′ S., Long. 117° 45′ E. Weight 16·54 kilograms (36½ lb.).
Australian Museum collection: portion weighing 719 grammes.
Main mass: Geological Survey Museum, Perth, Western Australia.

52. **Mount Stirling.** Coarse octahedrite, $n = 6.3$. (Plate ii, fig. 1.) Known 1892.
Twenty-five miles south-east of Mount Stirling, 130 miles east of Perth, Western Australia.
Lat. 31° 58′ S., Long. 117° 55′ E. Weight 91·39 kilograms. One piece, 90·71 kilograms (200 lb.) and the other 680 grammes (1½ lb.).
Australian Museum collection: main mass 67·2 kilograms.
Other collections: British Museum, 1·88 kilograms; Field Museum of Natural History, Chicago, 952 grammes and 57 grammes; American Museum of Natural History, New York, 1,416, 515 and 71 grammes; U.S. National Museum, 272 grammes; Geological Survey Museum, W. Australia, 326 grammes; Technological Museum, Sydney.

53. **Mungindi.** Finest octahedrite, $n = 8$. Two masses, weighing 51·25 kilograms, found together in 1897 by L. Troutman.
Three miles north-north-west of Mungindi Post Office, New South Wales, across the Queensland border.
Lat. 29° 0′ S., Long. 149° 0′ E.
Mungindi No. 1. Weight 28·12 kilograms.
Australian Museum collection: main mass.
Other collections: British Museum, 368 grammes; Field Museum of Natural History, Chicago, 1·36 kilogram and 627 grammes; American Museum of Natural History, New York, 7,300 and 467 grammes; Museum d'Histoire Naturelle, Paris, 419 grammes; U.S. National Museum, large specimen.
Mungindi No. 2. Weight 23·13 kilograms (51 lb.). (Plate iv, fig. 2.)
Australian Museum collection: portion weighing 7·82 kilograms.
Other collections: Kyancutta Museum, 226 grammes.

54. **Murchison Downs.** Finest octahedrite. Found 1925.
Murchison Downs, Murchison Division, Western Australia.
Lat. 26° 40′ S., Long. 119° E. (approximate). Weight 33·5 grammes.
Australian Museum collection: not represented.
Main mass: Geological Survey Museum, Perth, Western Australia.

55. **Murnpeowie.** Octahedrite, $n = 14{\cdot}9$. (Plate vi, fig. 3.) Found August, 1909, by L. L. Smith (not long after it had fallen (?)).
Beltana Pastoral Company's Murnpeowie Run, sixteen miles north-east by east of Mount Hopeless, about five miles west of Lake Callabonna, fifty-three miles east of Murnpeowie Head Station on Twins Creek, South Australia.
Lat. 29° 35′ S., Long. 139° 54′ E. Weight 1,143 kilograms (2,520 lb.).
Australian Museum collection: not represented.
Main mass: School of Mines and Industry Museum, Adelaide, South Australia.

56. **Narellan.** Hypersthene chondrite. (Plate xii, fig. 3.) Fell 7.15 p.m., 18th April, 1928.
Narellan, thirty-eight miles south of Sydney, New South Wales.
Lat. 34° 3′ S., Long. 150° 41′ 20″ E. Weight 367·5 grammes (12¾ oz.).
Australian Museum collection: main mass 189 grammes.

57. **Naretha.** Siderolite. Found 1915.
Near Naretha Railway Station, Transcontinental Line, Western Australia.
Lat. 31° 0′ S., Long. 124° 50′ E. Weight 2·72 kilograms (6 lb.).
Australian Museum collection: not represented.
Main mass: Geological Survey Museum, Perth, Western Australia.

58. **Narraburra.** Finest octahedrite, $n = 9$. Found 1855 lying on hard, stony ground by O'Brien.
Narraburra or Yeo Yeo Creek, twelve miles east of Temora, New South Wales.
Lat. 34° 10′ S., Long. 147° 43′ E. Weight 32·2 kilograms (70 lb. 14 oz.).
Australian Museum collection: main mass 23·1 kilograms.
Other collections: British Museum, 1·91 kilograms; Field Museum of Natural History, 168 grammes; American Museum of Natural History, New York, 41 and 19·25 grammes.

59. **Nocoleche.** Medium octahedrite. (Plate vii, fig. 1.) Known 1895.
Five miles south-west of Nocoleche Station near Wanaaring, forty miles north-west of Bourke, New South Wales.
Lat. 29° 35′ S., Long. 144° 10′ E. Weight about 20 kilograms (about 44 lb.).
Australian Museum collection: main mass 13 kilograms.
Other collections: British Museum, 687 grammes; Field Museum of Natural History, Chicago, 1·12 kilograms; American Museum of Natural History, New York, 2,006·5 and 9 grammes; Museum d'Histoire Naturelle, Paris, 7 grammes.

60. **Nuleri.** Medium (?) octahedrite, $n = 16$. Found about 1902 by a prospector.
Somewhere about two hundred miles east of Mount Sir Samuel, close to or within the boundary of the Nuleri Land District, Western Australia.
Lat. 27° 50′ S., Long. 122° 30′ E. Weight 120·2 grammes.
Australian Museum collection: not represented.
Main mass: Geological Survey Museum, Perth, Western Australia.

PENKARRING ROCK *v.* Youndegin.

61. **Pevensey.** Aerolite. Found between 1868 and 1870.
Synonym: Hay.
Pevensey Station, Old Man Plain, ten miles below Hay, New South Wales, in a paddock fifteen miles south of the Murrumbidgee River.
Lat. 34° 30′ S., Long. 144° 56′ E. Weight 4·31 kilograms (9½ lb.).
Australian Museum collection: not represented.
Main mass: Godfrey collection, Melbourne.

62. **Premier Downs.** Medium octahedrite. Two masses found 1911 by H. Kent, of the Transcontinental Railway Survey party.
Premier Downs, Nullarbor Plains, Eucla Division, Western Australia.
Lat. 31° 1′ S., Long. 127° 23′ E.

Premier Downs No. 1, $n = 12$.
Weight 112 grammes.

Australian Museum collection: not represented.

Main mass: Geological Survey Museum, Perth, Western Australia.

Premier Downs No. 2, $n = 11{\cdot}5$.

Weight 116 grammes.

Australian Museum collection: not represented.

Main mass: Geological Survey Museum, Perth, Western Australia.

QUEENSLAND *v.* Thunda.

QUEENSLAND, SOUTH, *v.* Gladstone.

63. **Rhine Villa.** Medium octahedrite, $n = 10$. Found before November, 1900, by H. W. Payne.

Synonym: Adelaide.

Cambrai (formerly Rhine Villa), Hundred of Angus, about fifty miles north-east of Adelaide, South Australia.

Lat. 34° 20′ S., Long. 139° 10′ E. Weight 3·39 kilograms (7½ lb.).

Australian Museum collection: not represented.

Other collections: South Australian Museum, slice; British Museum, slice 193 grammes; Berlin Museum, Germany, 123 grammes; U.S. National Museum, 118 grammes.

Main mass: said to have been sent to Germany.

64. **Roebourne.** Medium octahedrite, $n = 11$. (Plate vi, fig. 2.) Found 1892 by H. R. Hester.

Synonym: Hammersley.

Two hundred miles south-east of Roebourne, and eight miles east of the Hamersley Range, Western Australia.

Lat. 22° 20′ S., Long. 118° 0′ E. Weight 86·94 kilograms (191½ lb.).

Australian Museum collection: etched sliced 1·13 kilograms.

Main mass: Field Museum of Natural History, Chicago. Consists of four sections, 19·39 kilograms, 13·72 kilograms, 5·22 kilograms, 1·48 kilograms.

Other collections: British Museum, two slices 1·5 kilograms and 114 grammes; U.S. National Museum, Washington, two slices 237 grammes and 145 grammes; American Museum of Natural History, New York, 2,371·3 and 1,497 grammes; Museum d'Histoire Naturelle, Paris, 47 grammes.

65. **Roper River.** Siderite. Found 1921 by an aboriginal.

Fifty miles from Urapunga, on the Roper River, Northern Territory.

Lat. 14° 45′ S., Long. 134° E. (approximate). Weight 6·22 kilograms (13 lb. 13 oz.).

Australian Museum collection: not represented.

Main mass: National Museum, Melbourne, Victoria.

66. **Silverton.** Hypersthene-olivine chondrite. Found about 1883 (?). Rediscovered in 1933 by R. Bedford in the old Museum at Port Adelaide.

Silverton, near Broken Hill, New South Wales.

Lat. 31° 53′ S., Long. 141° 12′ E. Weight 350·7 grammes.

Australian Museum collection: main mass 236·6 grammes.

Other collections: Kyancutta Museum, British Museum.

TASMANIA *v.* Blue Tier.

67. **Temora.** Coarsest octahedrite, $n = 24$ (?). Found about 1880 by a prospector.

Between Temora and Cootamundra, New South Wales, possibly near Narraburra Creek.

Lat. 34° 12′ S., Long. 147° 26′ E. (approximate). Weight unknown.
Australian Museum collection: main mass 17·2 grammes.
Other collections: British Museum, 6·6 grammes; Vienna Museum.
The Temora appears to have been confused with the Narraburra (finest octahedrite) in dealers' catalogues.

68. **Tenham.** Enstatite olivine chondrite. (Plates x and xi.) Fell either February, March or April, 1897.
Synonym: Warbreccan.
Tenham Station, Kyabra Creek, thirty miles south-east of Windorah, Western Queensland.
Lat. 25° 44′ S., Long. 142° 57′ E. Weight: Tenham masses (230 stones) estimated at over 100 kilograms (113½ lb.); largest stone, 5,245 grammes (11½ lb.); smallest stone, 20·7 grammes (¾ oz.); Warbreccan masses, 61·22 kilograms (135 lb.).
Australian Museum collection: nearly complete stone 297·5 grammes.
Other collections: British Museum 102 stones and three Warbreccan masses, Queensland Geological Survey Museum 127 stones (on loan by Miss O. A. Hammond.

69. **Thunda.** Medium octahedrite, $n=11$. Found about 1886.
Synonym: Queensland, Diamantina, Windorah.
Thunda, Windorah, Diamantina District, Queensland.
Lat. 25° 25′ S., Long. 142° 40′ E. Weight 62·13 kilograms (137 lb.).
Australian Museum collection: etched slice 610 grammes.
Main mass: not known.
Other collections: British Museum, two pieces, 5·19 kilograms and 396 grammes; Field Museum of Natural History, Chicago, three pieces, 1·15 kilograms, 181 grammes, 154 grammes; American Museum of Natural History, New York, 93·5 grammes (Queensland), 509·3 and 113·7 grammes (Thunda); U.S. National Museum, Washington, 118 grammes; Museum d'Histoire Naturelle, Paris, 223 grammes; K. K. Naturhistorisches Hofmuseum, Vienna, 1·5 kilograms.
TICRACO CREEK *v.* Tieraco Creek.

70. **Tieraco Creek.** Fine octahedrite, $n=8{\cdot}7$. (Plate ii, fig. 2.) Known before 1922.
Synonym: Ticraco Creek.
Near the head of Tieraco Creek, North Murchison Gold Field, Western Australia.
Lat. 26° 20′ S., Long. 118° 20′ E. Weight 41·61 kilograms (91¾ lb.).
Australian Museum collection: portion weighing 16·47 kilograms (36¾ lb.).
VICTORIA *v.* Cranbourne.
WARIALDA *v.* Bingara.
WARBRECCAN *v.* Tenham.

71. **Weekeroo.** Brecciated broad octahedrite, with silicate grains, $n=12{\cdot}2$. (Plate iii, fig. 1.) Found 1924 by J. Lane.
Weekeroo Station, Mannahill, South Australia.
Lat. 32° 16′ S., Long. 139° 52′ E. Weight 94·1 kilograms (207½ lb.).
Australian Museum collection: main mass 47·06 kilograms.

Other collections: American Museum of Natural History, New York, 3·19 kilograms; U.S. National Museum, 11·99 kilograms.
West Port District *v.* Cranbourne.
Windorah *v.* Thunda.

72. **Yandama.** Olivine hypersthene chondrite. Known 1914.
Blacks' camp, Big Plain, Yandama Station, north-west New South Wales.
Lat. 29° 45′ S., Long. 141° 2′ E. Weight over 5·68 kilograms (over 12 lb. 9 oz.).
Australian Museum collection: not represented.
Main mass: South Australian Museum, Adelaide.

73. **Yardea.** Medium octahedrite. Found November, 1875, by J. Martlew.
Four miles south of Yardea Station, Gawler Range, South Australia.
Lat. 32° 20′ S., Long. 136° 0′ E. Weight 3·4 kilograms (7½ lb.).
Australian Museum collection: not represented.
Main mass: South Australian Museum, Adelaide, South Australia.
Yarra Yarra River *v.* Cranbourne.

74. **Yarroweyah.** Nickel-poor ataxite. Found 1903 by T. Holden.
Between four and five miles south of Yarroweyah Railway Station, Allotment 7, Section A, Parish of Yarroweyah, County Moira, Victoria.
Lat. 36° 0′ S., Long. 146° 23′ E. Weight 9·52 kilograms (21 lb.).
Australian Museum collection: not represented.
Main mass: National Museum, Victoria.

75. **Yenberrie.** Coarse octahedrite. (Plate iii, fig. 2.) Found July, 1918.
Twenty miles south-south-east of Yenberrie, Northern Territory.
Lat. 14° S., Long. 132° E. (approximate). Weight 130·07 kilograms (291 lb.).
Australian Museum collection: main mass 42·29 kilograms.
Other collections: Commonwealth official collection (housed Australian Museum), 32·98 kilograms; Field Museum of Natural History, Chicago, 3·76 kilograms; American Museum of Natural History, New York, 3·76 kilograms; U.S. National Museum, 3·32 kilograms.

76. **Youanme.** Medium octahedrite. Found 1917.
Synonym: Youanmi.
Youanme district, Western Australia.
Lat. 28° 30′ S., Long. 118° 50′ E. Weight 121·5 kilograms (261 lb.).
Australian Museum collection: not represented.
Main mass: Geological Survey Museum, Perth, Western Australia.
Other collections:
Youanmi *v.* Youanme.

77. **Youndegin.** Coarse octahedrite.
Synonym: Penkarring Rock, Yundagin, Yundegin.
Three-quarters of a mile north-west of the summit of Penkarring Rock in the Youndegin district, about seventy miles east of York, Western Australia.
Lat. 31° 50′ S., Long. 117° 55′ E. Six masses found weighing 1,133·54 kilograms (2,499¾ lb.), also a large number of smaller pieces.

Youndegin No. 1. Found 1884.
Weight 11·67 kilograms (25¾ lb.).
Australian Museum collection: not represented.
Main mass: British Museum, 9·82 kilograms and 317 grammes.

Youndegin No. 2. Found 1884.
Weight 10·88 kilograms (24 lb.).
Australian Museum collection: not represented.
Main mass: National Museum, Melbourne, Victoria.

Youndegin No. 3. Found 1884.
Weight 7·94 kilograms (17½ lb.).
Australian Museum collection: not represented.
Main mass: National Museum, Melbourne, Victoria.

Youndegin No. 4. Found 1884.
Weight 2·72 kilograms (6 lb.).
Australian Museum Collection: not represented.
Main mass: British Museum, 2·7 kilograms.

Youndegin No. 5. Found 1891.
Weight 173·5 kilograms (382½ lb.).
Australian Museum collection: etched slice 93 grammes.
Main mass: Field Museum of Natural History, Chicago.
Other collections: British Museum, 740 grammes (3 specimens); American Museum of Natural History, 3·23 kilograms.

Youndegin No. 6. Found 1892. (Plate iii, fig. 3.)
Weight 927·14 kilograms (2,044 lb.).
Australian Museum collection: not represented.
Main mass: K. K. Naturhistorisches Hofmuseum, Vienna.
YUNDAGIN *v.* Youndegin.
YUNDEGIN *v.* Youndegin.

DOUBTFUL.

Australia. Pallasite. Found 1880.
Locality unknown.
A specimen, 21 grammes, very much weathered, in American Museum of Natural History, New York, and another, 90 grammes, in Harvard College.

Macquarie River. Mesosiderite. Found 1857.
New South Wales: a specimen 9·9 grammes, American Museum of Natural History, New York; 1 gramme in Museum d'Histoire Naturelle, Paris.

ADDITIONAL FALLS.

The following list of falls which have been recorded after the preparation of the manuscript are too late to be included in the map.

Box Hole.[1] Medium octahedrite. Found 1936.
Box Hole Crater, about 120 miles north-east of Alice Springs, Central Australia.
Lat. 23° S., Long. 134° E. (approximate).
Australian Museum collection: portion weighing 3·3 kilograms.
Main mass: Kyancutta Museum.

Dalgaranga.[2] Medium octahedrite (?). Found 1923. Said to have formed a crater 75 yards across the top and 50 yards at the bottom, and 15 feet deep.
Dalgaranga Sheep Station, near Yalgoo, Western Australia.

TABLE SHOWING DISTRIBUTION OF FALLS IN AUSTRALIA AND THOSE REPRESENTED IN THE COLLECTION OF THE AUSTRALIAN MUSEUM.

+ Not represented in the Australian Museum Collection.
Figures in italics indicate Main Mass in Australian Museum Collection.

STATE.	SIDERITES.				AEROLITES.			SIDEROLITES.			TOTAL.
	Un-classified.	Hexa-hedrites.	Octa-hedrites.	Ataxite.	Un-classified.	Chondrites.	Achondrites.	Un-classified.	Palassite.	Meso-siderites.	
Queensland ..			28, 29+, *53*, 69		23+	68					6 (4)
New South Wales ..	46+	*11*	*13*, 18, *21*, *44*, *58*, *59*, *67*, *19*		*26* 61+	7, 16+, 24+, *25*, *27*, 31, *47*, *56*, *66*, 72+	*10*	35+	*43* 49		26 (20)
Victoria			20	74+					9+		3 (1)
Tasmania	17+, 40+		12+								3 (0)
South Australia ..			36, 55+, 63+, *71*, 73+		1+ 14	5+, 15+, 32, 33, 34, 38					13 (7)
Western Australia	22+		6, 39, 42+, 45, 48+, 50, 51, *52*, 54+, 60+, 62+, 64, 70, 76+, 77			37+		41+ 57+		8	20 (10)
Northern Territory	3+, 65+		30, *75*	4					2+		6 (3)
Total ..	6 (0)	1 (1)	36 (25)	2 (1)	5 (2)	18 (12)	1 (1)	3 (0)	4 (2)	1 (1)	77 (45)

Lat. 27° 45′ S., Long. 117° 5′ E. Weight: a piece weighing 40 grammes preserved; several small fragments appear to have been lost.

Gundaring.[2] Broad octahedrite. Found May 20, 1937. Thought to have been seen to fall April 6, 1930.

Nine miles north-north-east of Gundaring, Western Australia.

Lat. 33° 18′ S., Long. 117° 40′ E. Weight 112·5 kilograms (248 lb.).

Australian Museum collection: not represented.

Main mass: privately held.

Huckitta.[1] Pallasite. Found 1937.

Huckitta Station, Central Australia.

Lat. 23° S., Long. 135° E. (approximate). Weight about 2,032 kilograms (2 tons).

Australian Museum collection: not represented.

Main mass: South Australian Museum, Adelaide.

Kumerina.[2] Fine octahedrite. Found February, 1937.

Near Batthewmurnana Hill, 20 miles south-south-east of the centre of the Kumerina Copper Field, Western Australia.

Lat. 24° 55′ S., Long. 119° 25′ E. Weight 53·5 kilograms (118 lb.).

Australian Museum collection: not represented.

Main mass: Western Australian Museum.

Other collections: British Museum, about 900 grammes (2 lb.).

Wonyulgunna.[2] Medium octahedrite. Found by an aboriginal in June, 1937.

Bald Hill (formerly Wonyulgunna) Sheep Station, about 21 miles south-east of Mount Wonyulgunna, just west of the 485 mile post on No. 1 Rabbit Proof Fence, Western Australia.

Lat. 24° 55′ S., Long. 120° 0′ E. Weight 37·8 kilograms (83·5 lb.).

Australian Museum collection: portion weighing 260·5 grammes (9 oz.).

Main mass: Western Australian Museum.

Other collections: British Museum, 952·5 grammes (2·1 lb.).

Yalgoo.[2] Chondrite. Known before 1937.

Near Yalgoo, Western Australia.

Lat. 28° 23′ S., Long. 116° 43′ E. Weight 850 grammes (1 lb. 14 oz.).

Australian Museum: not represented.

Main mass: Western Australian Museum.

In the above list of meteorites some departures are made from the previous published lists. The Beaconsfield and Langwarrin are no longer regarded as separate falls, but as masses of the Cranbourne Fall. Their physical and chemical properties and their geographical distribution, as shown in Figure 2, leave no doubt as to their identity. Arltunga is removed as a synonym of the Cranbourne. This iron is an ataxite from Arltunga, Central Australia, some thousands of miles from Cranbourne. Three other Cranbourne irons have been added to the list. Cranbourne No. 4 is kept in the grounds of the National Museum, Melbourne. Mr. D. J. Mahony, the Director, informs me that under these conditions it "keeps" much better than in the collection in the museum. Cranbourne is in the store of the Geological Survey of Victoria. The weight given for these two stones is very

[1] Madigan, C. T.: "The Boxhole Crater and the Huckitta Meteorite (Central Australia)." *Trans. Roy. Soc. S. Aust.*, lxi, 1937, 187–190.

[2] Simpson, E. S.: "Some New and Little-known Meteorites Found in Western Australia", *Min. Mag.*, xxv, 1938, 157–171.

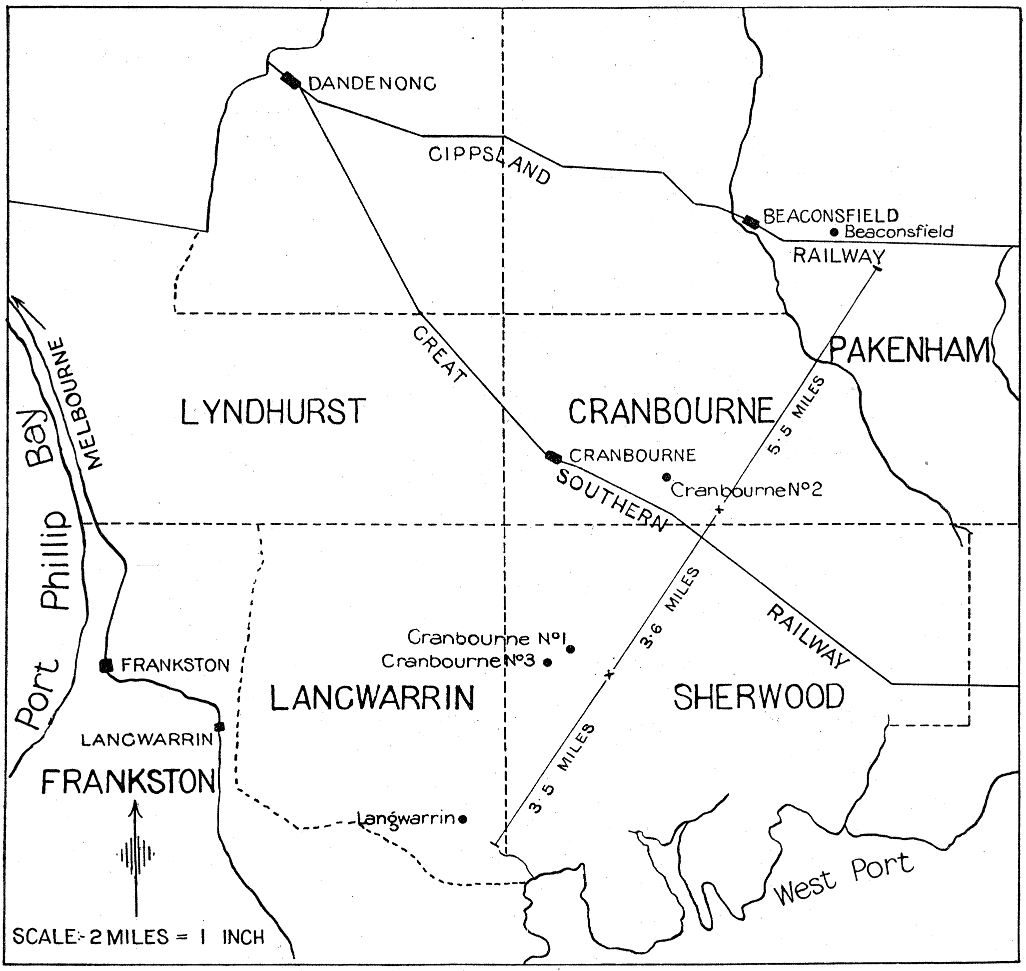

Fig. 2.—Locality map showing the distribution of some of the "Cranbourne" masses. After R. H. Walcott.(58)

approximate, being merely an estimate by myself after inspection. Cranbourne No. 6 is a comparatively new find and was secured by Mr. Mahony.

In the case of the Barratta stones, all previous lists have given only four stones. This has probably arisen from the fact that one of the stones in the Australian Museum is the same weight as one in the Field Museum of Natural History, Chicago, United States of America. Anderson(144) omitted the stone from Chicago from his list, crediting the Field Museum with only one stone instead of two. Apparently the inference has been drawn that he erroniously accredited the Australian Museum with the stone of the same weight in the Field Museum. The fact is that both stones exist. I have therefore listed the two stones in the

Field Museum as Barratta No. 4 and Barratta No. 5, instead of Barratta No. 3 and Barratta No. 4 as formerly.

The Barraba and Warialda are also removed from the list as separate falls, and are included as masses of the Bingara Fall. Incidentally the official spelling

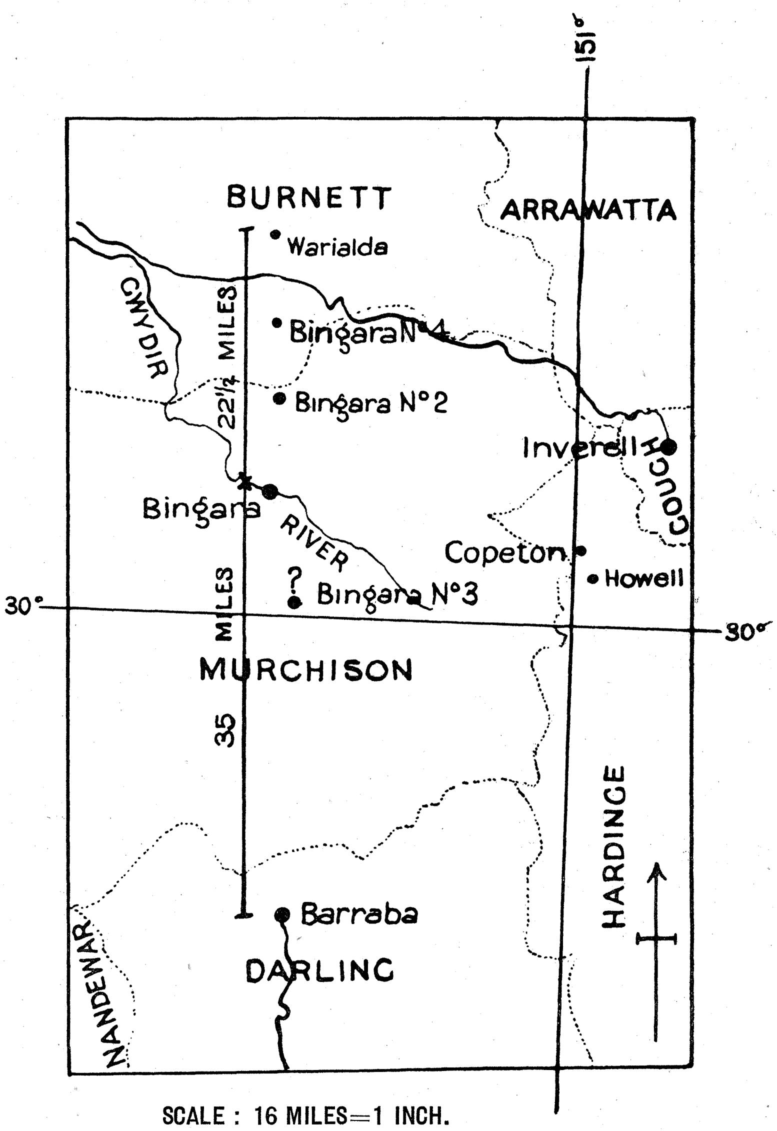

Fig. 3.—Locality map showing the distribution of the "Bingara" masses. The position of No. 1 is not known, while the exact position of No. 3 is very vague.

is Bingara and not Bingera. These irons are similar in their chemical composition which is somewhat rare, and in their geographical distribution as shown in Figure 3. In appearance the Bingara No. 2, the Barraba and the Warialda are quite similar. Bingara No. 1 is very different, being pear-shaped, while the others are the typical thumb-marked irons.

In regard to the South Queensland iron it would appear that it is portion of the Gladstone iron. In Ward's 1904 catalogue is included a specimen of 72 grammes of the "South Queensland" with the statement that the main mass was in the Brisbane Museum. This statement is not correct, for the main mass was never in that museum. In 1925 Ward's purchased the main mass of the Gladstone from Mr. Dunstan, in whose possession it probably was in 1904. Professor Richards[69] records the fact that part of the Gladstone had been missing for many years. He is of opinion that the South Queensland is the missing part of the Gladstone, and all the evidence seems to support this view.

The record of the passage of a meteorite at 0.30 a.m. on the 14th April, 1875, in the vicinity of Haddon, Grenville County, Victoria, by Flight[70] has been responsible for the record of the "Haddon" meteorite. Prior[154] has omitted it in his list. There is no evidence whatever of the finding of any material that may be considered to have any relation with this meteor, and the example of Prior is followed by excluding it from the list.

The original account of the Le Gould's stone is contained in an address given by Mr. Le Gould entitled "Geographical and Geological Observations in Northern Queensland" appearing in the printed record of the monthly meeting of the Queensland Philosophical Society on the 2nd February, 1864. In this address Le Gould records that about the end of November, 1862, he proceeded to Peak Downs, north-western Queensland, under instructions to make a survey of mineral lands said to exist there. No reference is made as to what authority issued the instructions, and inquiry reveals the fact that no record of Le Gould is preserved in the Geological Survey of Queensland. As this so-called aerolite has been included in all published lists of Australian meteorites, and the original description is probably not available to many workers Le Gould's own description is quoted in full.

> I came upon a very large gum-tree, divested of all bark, leaf, and even life, that lay across my track. It had been sharply broken about five or six feet from the ground, through its base, which was three to four feet in diameter. I wondered what could have broken so huge a tree in so sharp a manner, as it had not the appearance of having been struck by lightning. I dismounted to examine it, and found a great bruise or indentation in the trunk on the ground.
>
> I prcoeeded to examine the locality; and about fifty or sixty yards away, saw something which appeared like a large cannon-ball. My surprise was great, believing that no artillery of such a calibre had ever been so far inland. On inspection it proved to be an aerolite. It was of a dark metallic colour, extremely hard, and about ten inches in diameter; in fact it very closely resembled a 10-inch shot, and was about the same weight. It was perfectly round except that one side was slightly flattened; its surface was extremely smooth, and very slightly perforated. The extraordinary appearance of the tree was now clearly accounted for in my mind: it must have been struck by the aerolite on its downward passage to the earth, which evidently caused its fall.
>
> I regret that my limited means of transit did not permit me to bring this extraordinary phenomenon to Brisbane for this society; but my next visit may enable me to do so, as I have planted it for that purpose.

The above is the only evidence of the existence of the Le Gould's stone, and taken by itself without corroborative evidence does not constitute any proof.

I have investigated quite a number of more convincing accounts of the existence of meteorites by people whose integrity could in no sense be doubted only to find that on examination of the so-called meteorite it proved to be terrestrial and not infrequently concretionary.

If all similar accounts of meteorites without expert examination of the actual material were accepted as proof of existence, then the list would have to be enlarged considerably.

A very much more convincing account of a meteorite which is reputed to have fallen in Queensland is given by Tryon,[123] who reports the fall of stones in Rockhampton, Queensland, in the spring of 1895. He records his examination of three of these stones. "No. 1 stone was seen by J. Howe to come during a bright afternoon from a south-westerly direction, between 4 and 5 p.m., and to fall in Candle Street. It buried itself in the ground and was picked up."

The third stone was picked up about 200 yards from the gaol by one of the men's wives resident there. On striking the earth it made a cloud of dust and, apparently striking some hard substance, broke into pieces.

No specimens are now traceable. Inquiries instituted by Mr. G. W. Card in 1925 elicited the fact that one of the stones was probably thrown out as rubbish when the then Curator of the Botanic Gardens took office. It had previously been kept in the office. As there is no material available, the Rockhampton has not been included in the list.

It is surprising that the Le Gould should have been included in all lists and the Rockhampton omitted, as the latter appears to have much more foundation of fact than the former, and its original description appears in a better known periodical.

In the list of 104 Tenham stones given by Dr. Spencer[126] Nos. 5 and 13 are missing. From the photographs the specimen in the Australian Museum does not appear to be either of them. It has no painted number on it and weighs 297·5 grammes, but must have originally weighed about 330 grammes, as a small part has been cut off the specimen. I understand that it was given to the late Professor Sir Edgeworth David, formerly a Trustee of the Australian Museum, by the late Mr. Dunstan. In addition to these are the 127 stones (Plates x and xi) on loan to the Queensland Geological Survey Museum and the property of Miss O. A. Hammond, making a total of 232 stones in existence.

A perusal of the literature shows a number of minor discrepancies, particularly in regard to the weight of meteorites. In two cases the errors in weight were large, but it was possible to be certain of the correct weight in those cases. In some other cases, differences amounting to not more than 110 grammes, it is practically impossible to ascertain the correct figure, though every effort was made to do so.

The Warbreccan has been removed from the list and reduced to a synonym of the Tenham. Dr. L. J. Spencer has shown that these stones are essentially identical in their microscopic and chemical characters with the Tenham stones. He has given very clear evidence that they were taken from the Tenham stones and sold under another name so that no useful purpose is served in perpetuating the fraud whether it was intentional or not.

Incidentally a word of warning would not seem out of place here in regard to the Henbury irons. Practically all the surface material has been removed from the original locality. This material will almost certainly be found in other places. Already an iron has been submitted to me from another locality in Central Australia which has all the characteristics of the Henbury irons. Every such iron coming from the interior should be treated with a great deal of caution. It has to be remembered that the value of meteoric iron is well known, and distances of many hundreds of miles mean very little in these parts.

There is, of course, the Kyancutta iron which is essentially identical with the Henbury irons. It has been included in the list as a separate fall because Dr. L. J. Spencer[82] appears to be satisfied with its identity. I am not at all sure that it is not identical with the Henbury, and such a statement does not necessarily throw any doubt on the *bona fides* of the finder, but the number of cases in which material has been transported to the most inaccessible places by human agencies is most remarkable. To instance one case: A beautifully carved alabaster turtle was found in the desert in Western Australia across the border from Central Australia. The finder, satisfied that it could not have been taken there by any human being, argued that it must be a fossil, and as such wished to present it to the museum.

The Cecil Plains and Glen Osborne meteorites have been included in some lists. Apparently the origin of these two meteorites is a manuscript of Mr. G. W. Card. In Mr. Card's manuscripts, which he very kindly gave to me, I find that these two are listed as "awaiting verification". Such verification has not been forthcoming; therefore these have not been included in the list.

There does not appear to be any information concerning the two falls listed as doubtful other than the fact that specimens so labelled are in the collections mentioned. From the description of the "Australia" it might be a piece of the Mount Dyrring pallasite of which small pieces are included in nearly all private collections examined by me.

It is impossible to localize the "Macquarie River" as this river is some 750 miles in length. No other falls are recorded from this river, and no mesosiderites are known from New South Wales.

4. HISTORICAL.

The first recorded discovery of a meteorite in Australia was made in 1845 by Mr. F. Gwynne at Barratta station, thirty miles north-east of Deniliquin, New South Wales. The record of this discovery was not made until April, 1871,[18] after Mr. H. C. Russell, Government Astronomer, Sydney, had visited Deniliquin. Two conflicting stories are given of the finding of these Barratta stones: One by a stockrider, named Jones, who gives a graphic description of its fall in the month of May some ten or twelve years prior to Mr. Russell's visit to Deniliquin. The other, and generally accepted, account is by Mr. Gwynne, of the adjoining station of Murgah, who claimed to have seen the stone weighing between two and three hundredweight on the surface of the ground in 1845. An examination of the first three stones of this fall tend to confirm the latter story. Liversidge[17] pointed out the fact that they had the appearance of having been broken off the one mass, which would weigh somewhere about two hundredweight (about 101·6 kilograms).

Up till 1875 only seven falls were recorded from Australia. The Coolac was found in 1874, but was not recorded until 1937. Of these, two are worthy of special mention. The Cranbourne No. 1 iron, also known as the Bruce iron, which is the second meteorite to be recorded, was found in 1854 at Cranbourne, near Melbourne, Victoria. It weighed about three and a half tons and is the largest meteorite yet recorded from Australia. Its resting place is now in the British Museum, where it still holds pride of place in the meteorite collection, although the presence of lawrencite is causing a considerable amount of trouble to prevent its disintegration. It is now kept in a specially designed air-tight case in an atmosphere of nitrogen. The nitrogen is supplied from an ordinary commercial cylinder and special precautions have been taken to maintain an internal pressure of nitrogen within the limits imposed by the strength of the glass of the case.[35] The other is known as the Tenham stones (Plates x and xi), numbering at least 230, comprising complete stones and fragments. It constitutes the first record of the fall of a meteorite in Australia. In 1869 H. Hammond and his brothers witnessed the shower of stones on Tenham station, near the junction of Cooper and Kyabra Creeks, Queensland.

The next quarter century (1876–1900) was productive of many meteorite finds; some twenty-four distinct falls being recorded. Only one of these has been reported as having been seen to fall. This is the Emmaville stone (Plate xii, Fig. 4), which has not been described, and the only record of its fall is contained in letters to the late Sir Edgeworth David, which disclose the fact that in the year 1900 it struck a house, the occupants of which heard the noise, and noticed the mark where the wall had been hit, and picked up the meteorite from below. It was perhaps fortunate for them that the stone only weighed four and a half ounces.

Actually another fall has been recorded during this period, that of the Rockhampton stone, which was said to have fallen in the streets of Rockhampton, Queensland. As previously mentioned, nothing has been preserved of this stone and it has not been included in the list of Australian meteorites.

The twenty-five years from 1901–1925 resulted in the discovery of a further thirty-two falls, making the total to that date sixty-four. Strangely enough, during this period again only two meteorites were recorded as having been seen to have fallen.

About 9.30 a.m. on 17 July, 1902, a stone fell at Mount Browne in the north-west of New South Wales. According to Card,[93] "just before the fall an explosion had been heard, immediately after which a hut caught fire. A whizzing sound followed and the meteorite struck the ground some distance from the hut, raising a cloud of dust. It was picked up by W. Jorden a few minutes after its fall and while still warm".

Anderson[22] records that a stone fell on the night of 25 May, 1912, about four miles from Binda, New South Wales, although it was not picked up until 5 June of the same year by A. McCormack. The stone was found partly embedded in the ground at the end of what McCormack took to be a freshly formed rabbit burrow.

Since 1925 there have been eleven falls recorded. Once again only two were observed to fall.

At 7.15 p.m. on 8 April, 1928, an aerolite (Plate xii, fig. 3) fell at Narellan, New South Wales, within eight feet of a man and buried itself about six inches into rocky ground. The man was called outside his cottage by some children to see the illuminations in the sky. He estimated that fully ten minutes elapsed between the time he called out until the weird sounds which he likened to the purring of an aeroplane began overhead. There was a heavy thud and a slight tremble in the ground as he stumbled back into the house.

Perhaps the most interesting fall to be observed is the last one, the Karoonda aerolite, because of the extraordinary manner in which Professor Kerr Grant tracked it to its resting place.

At about 10.53 p.m. on 25 November, 1930, a brilliant fireball was seen travelling at a steep angle in an east-south-east direction.

"When first seen the meteorite compared in brightness with a star of the first or second magnitude, but rapidly (within a few seconds) increased to a brilliancy which gave an illumination comparable to that of daylight even in Adelaide. It was described by many observers as an immense ball of bluish-white colour equal in diameter to the full moon, and having a luminous tail several degrees in length. As it approached the earth showers of sparks issued from the main body."

The nearest observers of the actual point of impact were at Karoonda, two and a quarter miles distance in a westerly direction. They reported "a loud detonation as though a very heavy charge of explosive had been let off underground".

Professor Kerr Grant and his party located the meteorite badly broken lying on a sandy surface on the third day of their search. It had made a crater-like hole in the sand eighteen inches in diameter and about the same depth.

It was the discovery of this stone by Professor Kerr Grant that led to the discovery of the now famous Henbury craters.

5. METEORITE CRATERS.

In 1931 Dr. A. R. Alderman[73] mapped within an area of about half a square mile thirteen meteorite craters at Double Punchbowl, seven miles west-south-west of Henbury station on the Finke River, about one hundred and ten miles south-west of Alice Springs, Central Australia. The largest crater is oval-shaped, measuring 220 by 120 yards, and is between fifty and sixty feet deep. This does not represent the real depth of the crater, as a considerable amount of sand has been washed into it. The other craters are circular in plan, the smallest measuring ten yards in diameter. Close to the main crater with only a wall separating them are two craters measuring eighty yards and from fifty-five to sixty yards in diameter.

Approaching the craters, no indication is given of their presence with the exception of crater No. 6 (Plate ix, fig. 1), which is made prominent by reason of the fact that the tops of the green trees growing on its floor are most conspicuous in such an arid region. The average rainfall of this area is a little over five inches per annum, but the rain is quite irregular, generally coming in rain storms during the summer. The storm waters have broken through the walls of this crater, which acts as a natural reservoir. Thus it supports a rich growth of mulga and acacia trees, the latter reaching a height of forty-five feet.

The walls of the craters consist of Ordovician sandstones and quartzites which have been intensely shattered and crushed in the immediate vicinity of the craters. Dr. Alderman has noted low ridges of the country rock radiating from one or two of the craters resembling the well-known percussion figures in mica. Fused country rock has only been found associated with the main crater. Dr. L. J. Spencer[74] has investigated this fused rock or silica glass which he compares with the silica glass from the craters of Wabar, Arabia. He divides the Henbury glass into two classes:

(*a*) Dark dull brown to black cellular masses.

(*b*) Small bombs with a black glazed surface often beset with pimples and with a brown cellular interior.

The silica glass contains only a very few minute spheres of nickel-iron.

The analysis of this glass and the sandstone at Henbury were made by Mr. M. H. Hey,[74] and the results are as follows.

	Henbury.	
	Silica Glass.	Sandstone.
SiO_2	68·88	86·71
TiO_2	3·64	0·32
ZrO_2	—	nil
Al_2O_3	5·60	3·84
Cr_2O_3	—	nil
Fe_2O_3	8·46	2·84
FeO	7·92	0·46
NiO	0·28	nil
CoO	trace	—
CuO	trace	—
MnO	0·05	0·005
MgO	2·03	0·90
CaO	2·51	1·00
SrO	nil	nil
BaO	—	nil
Na_2O	0·03	0·13
K_2O	1·43	1·15
P_2O_5	nil	nil
Cl	—	nil
SO_3	—	trace
S	—	nil
CO_2	—	nil
H_2O+	0·03	1·85
H_2O-	0·05	0·82
	100·91	100·03
Specific gravity D_4^{22} ..	2·31	2·37

Dr. Spencer, in reviewing the results of his investigations, points out that the Henbury craters and all other known large craters "are not merely dents on the surface of the earth made by percussion of meteorites, but that they are explosion craters". He visualizes at the moment of explosion "bombs of silica sent flying through an atmosphere of silica, iron, and nickel vapours". Subsequent condensation of these vapours produced a drizzle of molten metal into a pool of boiling silica. Thus he explains the presence of cellular silica glass with its included nickel-iron spheres which show no sign of oxidation. He confidently predicts that no large masses of iron will be found below the craters. This prediction, I understand, has been confirmed by geophysical investigations, though nothing has as yet been published.

Many of the fragments of nickel-iron found around the craters show very definite evidence of the violence of this explosion. Some have lost the octahedral structure altogether; others when polished and etched show distorted Widmanstätten figures. Quite a few show evidence of having been flung outwards from the crater in a plastic condition.

The evidence of the direction of the fall is not so clear. Dr. Alderman[72] suggests either a west to east or an east to west direction. In this connection it is of interest to note that the direction of the Tenham fall of stones in western Queensland is approximately a west to east direction.

The evidence of the age of the fall is still less clear. The natives do not show any interest in the craters, which seems to indicate that the fall took place before the arrival of these primitive people. Dr. Alderman, in reviewing the scanty evidence available, suggests that "the age of the craters must be reckoned in terms of thousands of years".

Interesting as these craters are, they cannot compare in size with that at Cañon Diablo (Coon Butte), Arizona, which is circular and measures about three-quarters of a mile in diameter with a depth of 570 feet. Many of the features found at Arizona can be duplicated with those found at Henbury, the principal difference being the number of craters and the shape of the main crater at Henbury.

The largest crater at Henbury, however, exceeds the largest (150 feet in diameter) of the famous Siberian craters, which were formed on 30 June, 1908. There is no satisfactory account of the cause of these craters and no meteoric material has been found. While this may be due to the swampy nature of the ground, it cannot be stated with certainty that they are in fact due to the fall of a meteorite or meteorites.

It is impossible to estimate the weight of iron involved in this fall; much of it has been converted into iron shale. There have been so many collectors and subsequent transfer of material that it is impossible to accurately estimate the amount of unoxidized material there really was. The only thing certain is that practically all the material has been collected and all that remains at Henbury today are the craters. Now that Henbury has been officially proclaimed a meteorite sanctuary, it is probable that the craters will be preserved for posterity.

Two distinct craters have been recorded from Wabar, Arabia, the larger of which is 109 yards in diameter and 40 feet deep. An American crater at Texas is quite shallow, but 530 feet in diameter.

There are a number of other supposed craters, such as those at Ashanti, Estonia, Persia and Argentine, but the evidence of their meteoric origin is not altogether convincing. A general account of all these craters is given by Dr. Spencer.[75]

The following list of material does not purport to be complete by any means.

Collection.	Number of Pieces.	Total Weight.		Weight of Largest Piece.	
		Kilograms.	Lb.	Kilograms.	Lb.
South Australian Museum	800	226·79	500	23·81	52½
Kyancutta Museum	300	299·36	660	97·93	260
Kyancutta Museum, sent to various museums not listed	200	113·39	250	22·68	50
British Museum	647	424·11	935	132·45	292
Australian Museum	35[1]	56·70	125	47·63	105
Queensland Museum	1	43·54	96	43·54	96
U.S. National Museum .. ; American Museum of Natural History, N.Y.	25	56·47	124½	about 40	about 90
Ward's Catalogue	20[2]	3·88	8½	1·34	2½
Totals	2028	1224·24	2,699	—	—

[1] This does not include two pieces obtained by exchange with the South Australian Museum and therefore included in its eight hundred pieces.

[2] Wards list a number of small fragments in their catalogue but do not give details of the actual number in this list.

6. MINERALOGY.

The following list of minerals occurring in meteorites has been arranged according to Dana's "System of Mineralogy". Not all the minerals listed have been recorded from Australian meteorites. Some of the mineral names have very little more than historical interest to justify their inclusion in the list at all, but as these names have appeared as the result of research work on Australian meteorites, no account would be complete without them.

A. Native Elements.

Nickel-iron Alloys. Meteoric iron consists essentially of a nickel-iron alloy in which the nickel content varies from four to twenty-seven per cent. That the alloy is not homogeneous is shown by the etching of a polished surface with dilute nitric acid or other suitable solvent, when a regular pattern is produced known as *Widmanstätten Figures* (Plate xvi). There are three structural elements which make up these Widmanstätten figures, viz.:

1. Kamacite bands arranged parallel to the faces of the octahedron.

2. Taenite bands surrounding the kamacite bands.

3. A fine granulated eutectic mixture of kamacite and taenite, known as plessite, which fills the interstices of the composite kamacite-taenite bands.

Kamacite usually occurs in coarse to fine lamellae, coarse to fine granular massive. It crystallizes in the cubic system. An X-ray determination by Heide and others gave as result: body-centred cubic a 2·859Å. Polysynthetic twinning parallel to (112) is almost invariably present. The twinning lamellae are clearly seen after etching a polished surface with weak acid by a system of lines known as "*Neumann Lines*".[200]

Kamacite contains approximately six per cent. of nickel. It is the principal constituent of a number of Australian siderites, including the Arltunga, Murnpeowie, and the Rhine Villa. In the Glenormiston, crystals are intergrown with taenite and plessite in a manner suggestive of that shown by graphic granite. The kamacite of the Mount Dooling possesses a strong schiller appearance which Simpson[97] considers due to the presence of well-marked solution planes. He further suggests that the flecking may be confined to the outer portion and may be due to heating and recooling. However, artificial heating of meteoric iron does not produce this structure, and it may be that the schiller-like structure is due to twinning on the (112). As there are twelve possible directions parallel to this form, fine twinning in more than one of these directions would be capable of producing this structure. In the Henbury, the kamacite bands are granulated and there is an absence of Neumann lines. When kamacite is artificially heated Neumann lines first disappear and the breaking up of the bands of kamacite into small polyhedrons visibly proceeds from isolated points. The surrounding taenite bands widen and are visible almost to the point when complete homogeneity is reached. The appearance of the kamacite in the Henbury is in conformity with other evidence that considerable heat was generated at the time of its impact with the earth, resulting in the formation of the now famous Henbury craters.

Taenite generally occurs as thin plates surrounding kamacite and separating it from plessite. It is easily recognized by its brilliant lustre and slightly yellowish colour.

It contains approximately thirty-three per cent. of nickel. Analyses have been made of taenite from the Beaconsfield[59] and Youndegin[141] with the following results.

TAENITE ANALYSES.

	I	II	III	IV	V	VI	VII	VIII	IX
Fe	70·138	65·58	46·33	57·70	58·59	(49·38)	(50·92)	51·46	61·87
Ni	29·744	24·10	34·98	35·72	25·60	46·39	47·98	38·97	{ 38·13
Co	—	0·74	1·00	0·80	0·73	0·61	0·63	0·45	{ —
C	—	—	—	—	—	0·45	0·47	—	—
Cu	—	0·17	0·05	0·32	0·24	—	—	0·41	—
P	—	1·23	4·27	2·87	0·94	0·10	—	1·05	—
Residue	—	—	0·91	0·14	2·50	3·07	—	tr.	—
	—	91·82	87·54	97·55	88·60	100·00	100·00	92·34	100·00

I. Cranbourne No. 1.
II-V. Cranbourne No. 2. P. G. W. Bayley analyst.[50]
VI. Beaconsfield. P. G. W. Bayley analyst.[50]
VII. Derived from VI after deducting phosphor-nickel (3·73%).
VIII. Langwarrin. P. G. W. Bayley analyst.[50]
IX. Youndegin. L. Fletcher analyst.[141]

Smith points out that mechanically extracted taenite contains from 25 to 30 per cent. nickel, while chemically extracted taenite contains from 38·13 to 38·5 per cent. He suggests that taenite is a eutectic substance in fixed proportion consisting of kamacite (nickel-poor) and a nickel-rich constituent containing not less than 37 per cent. of nickel. Up to date there does not appear to be any confirmation of this view, but rather the reverse.

Neumann lines are absent in taenite.

Edmonsonite. According to Flight[43] this mineral occurs in the Cranbourne siderite as thin paper-like pliant plates which lie on the faces of the tetrahedra of nickel-iron and between the large plates of crystals of nickel-iron. They are in the form of equilateral triangles or are lozenge-shaped. Strongly magnetic with a pure white colour. Soluble in hydrochloric and nitric acids.

Analysis:	Fe	70·138
	Ni	29·744
		99·882

This agrees approximately with the formula Fe_5Ni_2.

This mineral is undoubtedly identical with taenite as is the Tänite of Rose[196] and the Meteorin of Zimmerman,[59] which he describes as occurring in the Abel mass of the Cranbourne and as containing no copper, nickel, or cobalt.

TÄNITE *v.* Taenite.

METEORINE *v.* Taenite.

Plessite. X-ray studies by Derge and Kommel[168] show that this mineral is not a eutectic mixture of kamacite and taenite. It generally fills the interstices of the composite kamacite-taenite bands and is readily distinguished by its dull grey colour and fine granular structure.

THE STRUCTURE OF THE NICKEL-IRON ALLOYS.

The relationship of kamacite, taenite and plessite as revealed by the Widmanstätten figures has been investigated and a considerable amount of experimental work has been undertaken by Gürtler, Tammann, Osmond, Belaiew and others.

From the work of Gürtler and Tammann[172] it would appear that the system iron-nickel is composed of the two series of mixed crystals, thus:

1. Mixed crystals, with from 0 to 35 per cent. of nickel, which are isomorphous with γ-iron and represent solutions of nickel in this type of iron.

2. Mixed crystals with from 35 to 100 per cent. of nickel.

As meteoric iron has a nickel content varying between 4 and 26·5 per cent., it belongs therefore to the first series of mixtures and representatives of the other series are unknown in meteorites.

The difference between artificial and meteoric iron is essentially:

1. The magnitude of the elements of the structure in meteoric iron is much greater than in artificial iron.

2. Meteoric iron, unlike the artificial alloys, consists not of one but of two crystal types of nearly constant composition, kamacite and taenite.

It is generally agreed that these differences are due to the difference between cosmic and terrestrial conditions. When meteoric iron is heated the Widmanstätten figures are lost and the iron becomes identical in all respects with artificial nickel-iron alloys of the same composition. This change takes place at temperatures of the γ-field and may take place in the α-field, but owing to the long time required to effect the change in this field it cannot be definitely established.

Figure 4 graphically illustrates Osmond's hypothesis. Above the curves *ab* and *bc* lies the region of homogeneous mixed crystals of γ-iron and β-nickel. In the process of cooling the transformation into the α-state commences as soon as the temperatures of the curves *ab* and *bc* are reached. The change is completed when the temperatures fall to those of the curves *ad* and *c'e*. At this stage the composition of the changed α-crystals will have reached that of the originally present γ-β-crystals. Alloys of this composition must consist wholly of kamacite

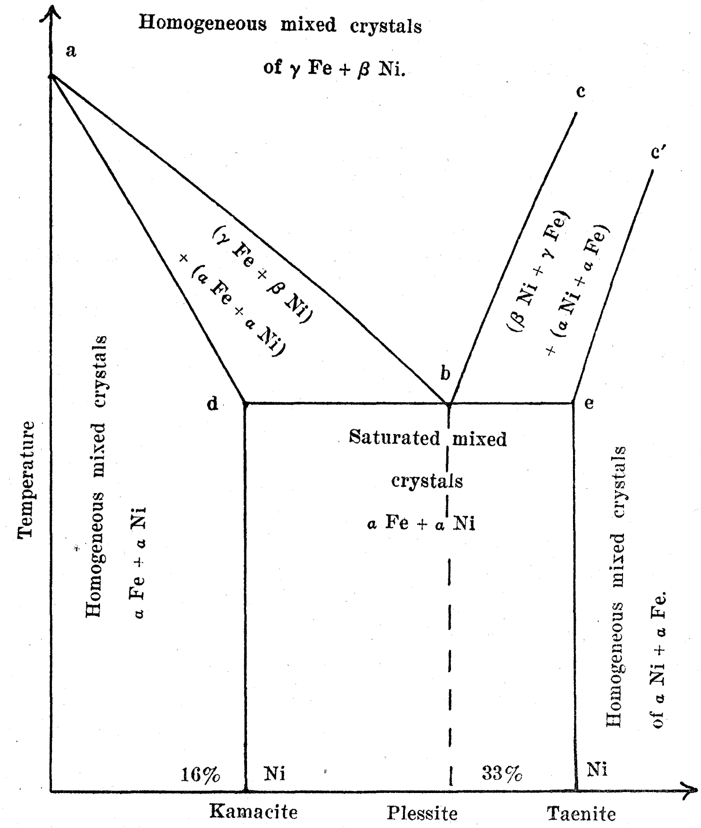

Fig. 4.—Diagram illustrating the hypothesis of Osmond-Roozeboom.

or wholly of taenite. If, however, the nickel content amounts to more than six per cent. and less than thirty-three per cent. and the crystals in the change have reached a concentration of kamacite or taenite there remains behind a remnant of the composition *b*. With decreasing temperature the α-state breaks up into a eutectic mixture of saturated mixed crystals of kamacite and taenite, that is, plessite. Thus alloys between *d* and *e* must contain primary kamacite, and between *b* and *e* primary taenite surrounded by secondary plessite, while an alloy with the composition *b* will consist wholly of plessite.

These conditions are actually found in meteoric irons except that taenite is never primary but always secondary and always surrounds kamacite. With increasing nickel content the width of the taenite bands increases at the expense of the width of the kamacite bands, and in this respect Osmond's hypothesis appears to fail.

Belaiew, comparing the results of his experiments on carbon steel, with which he was able to produce figures similar to the Widmanstätten figures, with those on nickel-iron alloys, concludes that meteoric iron must have remained at a very high temperature below the temperature of fusion resulting in a large granulation followed by a relatively rapid cooling resulting in a quick separation of the kamacite and taenite.

In spite of the valuable information that experimental work has afforded, its failure to produce artificial Widmanstätten figures identical in every respect with those of meteoric iron leaves the question of the origin of the structure so characteristic of siderites not completely solved.

Recent work by Derge and Kommel[(168)] on the crystalline structure of the Cañon Diablo and Amalia Farm irons by X-ray methods suggests a somewhat different explanation of the Widmanstätten figures.

They point out that in the Cañon Diablo iron the Widmanstätten figures are coarse and imperfect while the crystal lattice of any individual lamella is perfect. In the Amalia Farm iron the reverse conditions exist, that is, a perfect Widmanstätten figure and a badly distorted crystal lattice. They suggest that in the case of the former iron the large plates indicate a slower cooling so that stress relief by annealing occurred during the formation of kamacite permitting the formation of a more perfect crystal lattice, while in the case of the latter iron the kamacite plates were forced to follow the pattern dictated by the octahedral planes of the well-formed taenite matrix with consequent distortion of the kamacite lattice.

They have produced an artificial nickel-iron alloy containing twenty-seven per cent. of nickel which was allowed to cool from 1,400° C. to room temperature in twelve hours, giving well-developed Widmanstätten figures on a very small scale judging from their photograph. In discussing the formation of the Widmanstätten figures by eutectoid decomposition in the nickel-iron system as described above, they point out that X-ray studies show that such a eutectoid does not exist.

They offer the following explanation of the structure characteristic of meteoric iron: "Below approximately 1,400° C. the entire mass will be in the f.c.c.γ form, and these alloys have a pronounced tendency to form large grains at these temperatures, thus accounting for the huge taenite crystals required for the formation of the Widmanstätten pattern. On further cooling . . . it will begin to transform to the b.c.c. α phase, forming the kamacite plates. During this process the remaining γ will become richer in nickel until it contains about 25 per cent. Material containing more nickel than this, does not transform readily at ordinary temperatures and will be the component known as taenite. Some of this taenite will have a composition in the two phase $\alpha+\gamma$ field and will therefore transform slowly on further cooling, either partially or completely, depending upon its composition and rate of cooling, giving rise to various forms of plessite."

Graphite. The carbon present in Australian meteorites as determined by analysis has not in many cases been examined as to its physical properties.

Berthelot determined the carbon in the Cranbourne iron as graphite. In the Bruce mass of the Cranbourne the graphite occurs sometimes enclosing troilite, sometimes in large sheet-like masses up to eight square inches in area, and only rarely as nodules. An analysis of this graphite by Flight[43] gave the following result:

C.	H.	Residue.	Total.
89·661	0·257	10·412	100·330

Berthelot, noting the frequent association of graphite with troilite, suggested that this may be due to the action of sulphide of carbon on incandescent iron.

The carbon in the Glenormiston siderite appears to occur as minute segregations throughout the kamacite.

The carbon content as determined in the Australian meteorites varies from a trace in the Ballinoo, Henbury, Mount Dooling, Mount Magnet and Roebourne to 0·24 per cent. in the Glenormiston. The average per centage is about 0·05. The Gladstone and Murnpeowie appear to be the only ones in which the absence of carbon has been definitely recorded.

In only one case, the Karoonda aerolite, has the carbon been recorded definitely as amorphous.

The carbon of the Bingara siderite was examined under the microscope and found to bear a rough resemblance to crystals, but with very jagged and irregular outlines.

Diamond. This mineral has been recorded as being present in the Cañon Diablo siderite, Carcote aerolite, and as constituting one per cent. of the Novo-Urei aerolite, but so far there is no record of its presence in any Australian meteorites. The diamonds, so far found, are not of gem quality, varying from grey to black in colour.

Cliftonite. This mineral was first recorded from the Youndegin siderite by Fletcher.[139] Its composition is carbon and it crystallizes in the cubic (holohedral) system. The forms noted are the cube; cube with edges truncated by the dodecahedron; rounded tetrakis-hexahedron; cube faces replaced by a very obtuse, almost flat square pyramid; and in one case only the cube with re-entrant edges.

Hardness 2·5. Specific gravity 2·12. No cleavage. Streak is black and shining. Powder of the crystals is scaly. The average thickness of the larger crystals is about ·25 mm.

The mineral is localized in one or more parts of the mass, and is not uniformly distributed throughout it.

Brezina[163] has recorded similar crystals from the Magura siderite and he considers that they are pseudomorphous after diamond. Fletcher on the other hand inclines to the belief that they are polymorphous with diamond and graphite.

Gold. This mineral was first detected in meteorites by Liversidge[17] in 1902, when he recorded its presence in the Bugaldi siderite. Since that time gold has been detected in the Gilgoin No. 1 aerolite,[17] Narraburra siderite,[114] Mount Dyrring pallasite.[27]

Platinum. The amount of platinum and platinoid minerals found in some Australian meteorites is very considerable. The Tieraco Creek siderite[131] contains the equivalent of 36 oz. per ton and the Delegate siderite[62] 56 oz. per ton.

It would appear that platinum has been found whenever looked for. In addition to the above two meteorites it has been recorded as present in the Henbury siderite,[74] Mount Dyrring pallasite,[27] Murnpeowie siderite,[111] Barraba,[27] Cowra[27] and Bendoc.[21] The Bingara No. 2 contains 114 oz. of iridium per ton of nickel-iron.

B. Carbides.

Cohenite. This mineral was first identified by Weinschenk[205] in 1889. It is a carbide of nickel-iron (Fe, Ni, Co)$_3$C occurring in tin white crystals, probably cubic. On exposure it tarnishes to a bronze yellow colour. The hardness is between 5 and 6, and the specific gravity is 6·9.

The mineral has been recorded as occurring in the Moonbi siderite; in masses never exceeding 8 mm. by 3 mm. dotted irregularly throughout the meteorite and surrounded either by a layer of schreibersite alone or by a further layer of kamacite in the Mount Magnet; in small oval grains in the Murchison Downs siderite;[106] associated with rhabdite in kamacite in the Temora siderite.[23]

In a list of minerals occurring in meteorites by Shepard[199] in 1867 he includes the name *chalypite*, a carbide of iron which he suggests may have the formula Fe_2C. There does not appear to be any confirmation of the existence of such a mineral, and it is probable that it is identical with cohenite.

Chalypite *v.* **cohenite.**

C. Sulphides.

Troilite. This name was first given to ferrous sulphide by Haidinger,[175] which he found as nodular masses in the Albareto (Italy) aerolite. It is perhaps one of the commonest mineral constituents of meteorites. It has only been found massive in meteorites; artificially it has been obtained in crystals in hexagonal plates and in either pyramids or rhombohedrons. The hardness is 4, specific gravity 4·75–4·82. The colour is dark brown to almost black, and the streak is black.

Troilite from the Bruce mass of the Cranbourne siderite has been analysed by Flight.[43]

	I	II	III	IV	Mean.	Theoretical.
Insoluble	0·215	2·297	—	—	—	—
Fe	—	62·150	63·613	—	63·613	63·64
S	36·543	—	36·207	36·250	36·333	36·36
Ni	—	0·446	—	—	—	—
Co	—	0·079	—	—	—	—
Cl	—	0·130	—	—	—	—

Meunier and others have insisted on troilite being identical with terrestrial pyrrhotite. Analyses of the latter mineral give as general formula $Fe_nS_{(n+1)}$ in which n varies from 5 to 16. From experimental data there is little doubt that pyrrhotite is a monosulphide of iron with variable amounts of sulphur contained in solid solution up to approximately six per cent. Troilite can then be considered as the end member of a series which contains no sulphur in solid solution and pyrrhotite with the formula Fe_5S_6 the other end member containing six per cent. sulphur in solid solution.

A suggestion was made by Rose that troilite might be the mineral present in the irons and pyrrhotite in the stones. But the work of Ramsay and others appears to show clearly that troilite is the mineral characteristic of meteorites, whether they be aerolites or siderites.

Troilite has been recorded in a large number of Australian meteorites, and the only records of its absence are in the Youndegin siderite[138] and the Mount Magnet siderite.[103]

In the Bruce mass of the Cranbourne siderite, masses of the mineral up to more than five centimetres have been recorded by Flight.[43] These masses are usually covered with a thin layer of graphite and sometimes surrounded by daubreelite. Occasionally an ill-defined cleavage plane is present. In the Warialda mass of the Bingara siderite masses up to four centimetres are noted. The mineral occurs as veins in the Rhine Villa siderite and the Murnpeowie siderite. In the Karoonda aerolite it is concentrated around the borders of the chondri. It forms compound granules with schreibersite in the Glenormiston siderite. In the Tieraco Creek siderite nodules of troilite are partly surrounded by schreibersite and contain included crystals of the same mineral.

Oldhamite. This mineral was first recorded by Story-Maskelyne[180] as occurring in the Bustee (India) aerolite. It is found as pale brown grains, somewhat rounded, with a distinct cubic cleavage. The crystal system is cubic. Specific gravity is 2·58. The composition is calcium monosulphide, CaS. On exposure it may become coated with a gypseous oxidization product. Boiled in water it is decomposed, yielding a bright yellow solution and an insoluble residue.

So far the mineral has not been recorded for any Australian meteorites.

Daubreelite. This mineral was first recorded by Lawrence Smith[199] in 1876 as occurring in the Coahuila (Mexico) siderite associated with troilite.

It is crystalline with a good cleavage in one direction. The colour and streak are black, the lustre is brilliant metallic. It is brittle, with a specific gravity of 5·01. Non-magnetic. It is an iron chromium sulphide, $FeS.Cr_2S_3$. The theoretical composition is sulphur 44·3 per cent., chromium 36·3 per cent., and iron 19·4 per cent. It can be separated from troilite with which it is associated by treatment with hydrochloric acid.

Its presence has been recorded in the Arltunga siderite[3] as a few tiny patches, circular in outline; and also in the Cranbourne siderite.[43]

D. Phosphides.

Schreibersite. The name was first used by Haidinger[176] in 1847 for a nickel-iron phosphide occurring in the Magura (Czechoslovakia) siderite. It is interesting to note that Shepard in 1844 used this name to describe a mineral occurring in small deeply striated prisms which by means of blowpipe tests he determined as Cr_2S_3. The description is so incomplete as to preclude any subsequent recognition. In a list of minerals published by him in 1867 schreibersite is given as a nickel-iron phosphide and no mention is made of the sesqui-oxide of chromium. Shepard also lists the name *dyslytite*, which he describes very briefly as a brownish black powder with the composition of phosphide of iron-nickel and magnesium.

Schreibersite crystallizes in the tetragonal system. The colour is steel grey and the lustre metallic. Hardness is 6·5 and the specific gravity varies from 6·32 to 7·22. It is brittle except in thin plates which are flexible. Strongly magnetic and dissolves with difficulty.

It is essentially a phosphide of iron and nickel; the formula most commonly used is $(Fe, Ni)_3P$; a little cobalt is often present.

The following are analyses of nickel-iron phosphide from various Australian meteorites.

	I	II	III	IV	V	VI	VII	VIII
Insoluble	—	—	0·85	—	—	—	—	—
Fe ..	66·92	41·54	51·45	69·55	56·12	49·33	62·27	64·12
Ni ..	18·16	42·16	34·10	14·41	29·18	38·24	21·69 }	24·60[1]
Co ..	0·62	0·80	trace	—	—	—	0·46 }	
P ..	14·88	15·05	13·09	16·04	13·51	12·95	15·53	11·28
Sn ..	—	—	—	—	—	—	trace	—
Total	100·58	100·00	99·49	100·00	98·81	100·52	99·95	100·00

[1] By difference.
I. Cohen, E.,[39] Beaconsfield. Analyst, Sjostrom.
II. Cohen, E., [39] Beaconsfield. Analyst, Sjostrom.
III. Mingaye,[27] Cowra. Bright grains of steel-grey colour.
IV. Flight,[43] Cranbourne. Large crystal (brassy-gold colour).
V. Flight,[43] Cranbourne. Brittle powder.
VI. Flight,[43] Cranbourne. Prisms.
VII and VIII. Mingaye,[27] Barraba.

The molecular ratios from the above analyses are:

	I	II	III	IV and V	VI	VII	VIII
Fe, Ni, Co : P ..	3·16	3·05	3·33	2·88	3·67	2·98	4·32

It will be seen from the work carried out on material from Australian meteorites that there is a considerable variation in regard both to the chemical composition of the nickel-iron phosphide and its specific gravity.

The material of analyses I, II, III, IV, V and VII conform to the usual formula $(Fe, Ni, Co)_3P$, but that of analyses VI and VIII more nearly agree with the formula $(Fe, Ni, Co)_4P$. An analysis of schreibersite from the Toubil (Siberia) siderite by Antipoff[157] gave as result $(Fe, Ni)_5P$. Borgstrom[161] suggests that the varying composition of the nickel-iron phosphide may be explained by assuming the normal composition to be Fe_2NiP which forms an isomorphous mixture with Fe_3P, Ni_3P and also Co_3P, analogous with the occurrence of $CaCO_3$, $MgCO_3$ and $(Ca, Mg)CO_3$.

The only crystallographic work carried out on this mineral is that on a single crystal from the Tieraco Creek.[131] In this case the measurements agreed substantially with the results obtained by Mallard on crystals of rhabdite formed by combustion in the coal mines of Commentary, France. No analysis of the Tieraco Creek material was made, but the specific gravity was determined at 7·01. While these results cannot be taken as conclusive, they definitely point to a similarity in crystallization of the schreibersite characterized by a higher specific gravity and rhabdite with its lower gravity.

The somewhat meagre data available does point to an isomorphous series, but until more work has been carried out on this mineral its exact composition must remain uncertain. For the present the name schreibersite might be used to include the nickel-iron phosphides found in meteorites.

Schreibersite has been recorded from the following Australian meteorites:

Arltunga; Barratta; Bingara; Cowra as bright grains and porous crystals of considerable size, surrounded by an envelope of taenite in a ground mass of thick grey plessite; Cranbourne (Bruce Mass); Glenormiston as irregular nodules filling interstices, showing cleavage faces, and also as compound nodules with troilite; Mount Dooling: Mount Edith sometimes encasing nodules of troilite and amounting to 2·10 per cent. by weight of the meteorite; Murchison Downs; Narraburra amounting to 3·61 per cent. by weight of the meteorite: Nuleri; Premier Downs; Rhine Villa; Tieraco Creek; Youndegin as plates 2·5 cm. long and 3 mm. deep from which thin cracks filled with schreibersite traverse the meteorite in irregular directions.

Dyslytite *v.* **schreibersite.**

Rhabdite *v.* **schreibersite.**

E. Chlorides.

Lawrencite. This mineral was first identified by Lawrence Smith, and was named in his honour by Daubrée.[167] It is the ferrous chloride $FeCl_2$, and occurs as greenish to brown masses. It readily decomposes on exposure, forming brownish red drops of ferric chloride $FeCl_3$. It is perhaps the greatest cause for worry to curators of museum collections as the decomposed products readily attack the nickel-iron, often causing disintegration of the meteorite.

Its presence has been noted in quite a number of Australian meteorites. The Molong pallasite so readily disintegrates that the main mass has to be kept in a bath of liquid paraffin in order to preserve it. The difficulty of preserving the largest Australian meteorite, the Cranbourne, is due to the presence of this mineral. Its presence in the Yenberrie siderite causes a constant scaling off of iron oxide from the outside. A complete slice of the Gladstone in the Australian Museum collection continues to exude drops of ferric chloride in spite of repeated coatings of colourless lacquer and soaking in linseed oil.

The nickel-iron of the Mount Dyrring pallasite has been practically completely oxidized. Analysis indicates that the oxidation has been materially accelerated by the presence of Lawrencite. The mineral has been recorded from the Kyancutta and the Nuleri.

The Bingara masses do not contain the mineral.

F. Oxides.

Asmanite. This is the name given to a form of silica found in the Steinback (Saxony) siderolite by Maskelyne[181] where it occurs in minute grains constituting about one-third of the siliceous minerals. So far it has not been recorded in any Australian meteorites.

Orthorhombic with axial ratios 1·7437:1:3·3120. Observed forms (100), (001), (110), (013), (012), (023), (011), (043), (116), (112) and (223). The basal cleavage is good, while there is present a much less perfect prismatic cleavage. Hardness is 5·5 and the specific gravity 2·245. The lustre is resinous. Colourless, optically biaxial negative. 2E 107° to 107·5°. Dispersion.

Tschermak and others regard asmanite as identical with tridymite, which forms at temperatures between 870° and about 1,470°. There are two modifications of tridymite with inversion points between 117° and 163°. The low temperature form α-tridymite is orthorhombic and the high temperature form β-tridymite is hexagonal. It would appear that the crystallography of asmanite needs further investigation, as the proximity to hexagonal symmetry is shown in the following comparison.

Asmanite.	β-Tridymite.
$(110)\wedge(110)$ 59° 41′	$(10\bar{1}0)\wedge(10\bar{1}0)$ 60°
$(001)\wedge(011)$ 62° 14′	$(0001)\wedge(10\bar{1}1)$ 62° 21′
$(001)\wedge(112)$ 62° 21′	

Quartz. The presence of this mineral has been detected in only a very few meteorites. In Saint Marks (South Africa) chondrite small idiomorphic quartz was revealed in a thin section. There is no record of the presence of quartz in Australian meteorites. Berwerth suggests that quartz is secondary due to the breaking up of pyroxene by heating.

Chromite. This mineral is a common constituent of meteorites, and it is perhaps strange that its presence in Australian meteorites has been recorded as present only in the Gilgoin, Binda and Karoonda aerolites.

Magnetite. The only record of magnetite as a primary mineral in Australian meteorites is from the Karoonda aerolite. It has been recorded as forming an oxidization crust on the surface of meteorites, which is considered to have formed by surface fusion during the flight of the meteorite through the atmosphere. This oft repeated assumption may not necessarily be true. Fusion only takes place in the uppermost regions of the atmosphere where it is very doubtful whether there is enough oxygen to cause oxidization of the fused metal. Indirect evidence that there is no oxidization of the metal during fusion is to be found in the minute blebs of the metal found in meteoric dust.

It would seem that any oxide would be formed subsequent to fusion, and is therefore due purely to the ordinary terrestrial processes of oxidization. The oxide formed under these conditions is most probably hematite or limonite, which may owe its magnetic properties to admixed iron or to the presence of magnetic ferric oxide.

Magnetite has been recorded as forming the coating of the Karoonda aerolite, the Nuleri siderite, and the Warialda mass of the Bingara siderite, and admixed with hematite the Mount Dooling siderite.

G. Carbonates.

Breunnerite. This mineral is one of the ferriferous varieties of Magnesite containing up to 30 per cent. of $FeCO_3$, and is the only carbonate to be recorded as occurring as a primary mineral in meteorites. The Orgueil (France) aerolite is the sole meteorite in which it occurs.

H. Silicates.

Felspar. Comparatively little work has been carried out on the felspars of meteorites. No orthoclase has been detected, and only the basic to intermediate plagioclases—anorthite, labradorite and oligoclase—have been determined.

Twinning is often absent, particularly in chondritic aerolites where the felspar fills the interstices between other silicate minerals as irregular grains. Indications of twinning have been observed in the Elsinora chondrite. This felspar has a higher refractive index than Canada balsam, and the composition according to the norm would be $Ab_{78}An_{22}$, and is probably oligoclase.

On the other hand lathe-shaped crystals of felspar showing well-defined twinning are commonly observed in some varieties of achondrites. The felspar of the Binda achondrite (Eucrite) is anorthite. The normative felspar in this aerolite amounts to 25·7 per cent. The Narellan chondrite contains a little oliglocase exhibiting polysynthetic twinning. The presence of felspar is indicated by analysis in the Hermitage Plains and Bencubbin aerolites.

Maskelynite. This name was given by Tschermak to an isotropic, colourless mineral abundant in the Sherghotty (India) aerolite. Its exact nature is uncertain, but may possibly represent a refused felspar with the composition of labradorite and not a primary glass. This mineral has not been recorded from any Australian meteorites.

Pyroxene. There are two main divisions of the pyroxenes, the Orthorhombic pyroxenes and the monoclinic pyroxenes.

The orthorhombic pyroxenes are represented by *enstatite*, *bronzite* and *hypersthene*. These three minerals are members of an isomorphous series of which enstatite has a theoretical composition of $MgSiO_3$, although it always contains a little iron. With an increase of FeO content up to about 15 per cent. enstatite passes into bronzite, while with a further increase beyond 15 per cent. hypersthene is formed. While the first two minerals are very common constituents of meteorites there is no certainty that hypersthene is found at all, although the ferrous iron content of the Silverton aerolite does indicate its presence. The pyroxene in this aerolite occurs as large fissured crystals and also as fibrous associated with porphyritic olivine in the chondrules. The *chladnite* of Shepard[(199)] and the *shepardite* of Rose are identical and represent the purest type of enstatite. The *victorite*[(186)] occurring as radiating acicular crystals in the Copiapo (Chile) siderite are probably identical with enstatite. The Weekeroo siderite, which is the only other meteorite of the copoapo type, contains similar acicular radiating crystals which have been determined as enstatite. Enstatite is the chief constituent of the Mount Browne and Gilgoin aerolites. In the Bencubbin aerolite it occurs as a greyish white mass, generally single crystals which often show multiple twinning. As a fibrous constituent of chondrules it is found in the Barratta, Elsinora and Narellan aerolites.

The monoclinic pyroxenes are represented by *clinoenstatite*, *clinohypersthene*, *diallage* and *augite*.

Clinoenstatite possesses polysynthetic twinning, a prismatic cleavage at 88° 8′, and the extinction $Z\wedge c = 22°$, $\alpha = 1{\cdot}651$, $\beta = 1{\cdot}654$, and $\gamma = 1{\cdot}660$. $2V = 53°\ 30'$. The composition is the same as that of enstatite, with displacement of magnesium by iron, the mineral grades into clinohypersthene which possess a higher extinction angle and refractive indices. Both are rare minerals and the latter has only been found in meteorites.

Clinohypersthene is characteristic of the eucrites and may be present in the stony portion of the mesosiderites. Clinobronzite is characteristic of the bronzite chondrites of the Kroonstad type, and the clinobronzite achondrites of the Novo-Urei type. Clinoenstatite with enstatite characterizes the enstatite achondrites.

There does not appear to be any record of these minerals in Australian meteorites and they appear to be less common in meteorites generally than the dimorphous orthorhombic forms. It is true that their optical properties are quite different, but their mode of occurrence and small size makes their exact determination somewhat difficult. It is quite probable that they do occur closely associated with orthorhombic pyroxenes in some of the Australian meteorites.

Amphibole. The only record of the presence of an amphibole in meteorites is by Haidinger[174] in 1860 when he described *piddingtonite* from the Shalka (India) aerolite in which it occurs as ash grey masses. It has two cleavages at 70°, a hardness of 6·5, and a specific gravity of 3·412–3·66. It contains inclusions of chromite. An analysis by Hauer gave the following result:

SiO_2	Al_2O_3	FeO	MgO	CaO	Total
57·66	trace	20·65	19·00	1·53	98·84

From the composition this mineral is close to anthophyllite, one of the terrestrial orthorhombic amphiboles.

Olivine. This is one of the common minerals occurring in meteorites, and has been recorded in many Australian falls. It is the essential silicate mineral in the pallasites, of which there are four representatives among the Australian meteorites, the Alice Springs, Bendoc, Molong and Mount Dyrring. It occurs as rods and nodules in the troilite of the Mount Edith siderite, as phenocrysts in both the ground mass and chondrules of a number of aerolites.

It varies in colour from dark brown (Mount Dyrring) to pale lemon-yellow in the Molong. Usually it is much fractured, but a small clear piece free from fracture was secured from the Molong pallasite and cut into a gem weighing about a quarter carat and preserved in the Mining and Geological Museum, Sydney.

The following analyses have been made of olivine from Australian falls:

	I	II	III	IV
SiO_2	40·40	37·24	31·49	16·60
Al_2O_3	0·17	—	—	—
FeO	9·59	16·30	27·16	9·62
Fe_2O_3	0·45	—	—	—
MnO	0·20	—	—	—
MgO	47·70	43·88	24·44	18·09
NiO, CoO ..	0·06	1·26	—	—
Na_2O	0·03	—	—	—
H_2O-	0·12	—	—	—
H_2O	1·52	—	—	—
FeS, etc.	—	—	—	10·53
Insol.	—	—	—	44·68
Total.. ..	100·24	99·30	—	99·68

I. Molong pallasite. Analyst, J. C. H. Mingaye.[88]
II. Alice Springs pallasite. Analyst, M. H. Hey.[2]
III. Narellan aerolite. Analyst, T. Hodge-Smith.[112]
IV. Warbreccan. Analyst, G. T. Prior.[132]

From the above analyses the formulae of the olivines may be expressed approximately in the following ratio:

	I	II	III	IV
$(Mg_2SiO_4):(Fe_2SiO_4)$	9	5	2	3

Weinbergite. This is the name given by Berwerth[159] to a mineral occurring as spherical aggregates of radiating fibres in the Kodaikanal (India) siderite. It is described as orthorhombic with a probable composition of $NaAlSiO_4 . 3FeSiO_3$, and as black in colour. Prior considers it to be a mixture of oligoclase, iron oxide and a little pyroxene.

Chantonnite. Shepard gave this name to a supposed black mineral occurring as veins in the Chantonnay (France) aerolite. Meunier[186] has shown that the substance is not a definite mineral, but merely a structure probably due to heat.

Sphenomite. Listed by Shepard as occurring with pyroxene and anorthite in the Juvenas (France) aerolite.

Iodolite. Another of Shepard's minerals, described as vitreous semi-transparent, and possessing a smalt-blue colour.

7. PETROLOGY.

All aerolites with the exception of tektites and the stony portion of the siderolites are composed almost entirely of crystalline material. The main division of the aerolites into achondrites and chondrites is based on the structure of their constituents. The achondrites more nearly resemble terrestrial rocks, particularly those with little or no nickel-iron. The only representative of this group among Australian meteorites is the Binda, which contains anorthite and clino-enstatite with some chromite and a very few specks of nickel-iron. The two main constituents occur as large plates, sometimes with ophitic fabric, and also as small grains filling the interstices. It resembles an anorthite gabbro in appearance.

The chondritic or nodular structure of chondrites is not found in terrestrial rocks. The chondrites are generally more or less rounded and are bound together by the material of the same mineralogical constitution. They vary in size from that of a walnut down to microscopic dimensions. In the Kappakoola they measure up to 1 mm. in diameter, and in the Barratta up to 3 mm., while in the Karoonda they exceed 10 mm. The number of chondrules to be found in any one aerolite also varies considerably. In the Kappakoola, Narellan and Warbreccan only a very few chondrules are present, while the Gilgoin is crowded with both complete and fractured chondrules. When they are fractured they may be difficult to distinguish from a holocrystalline ground mass as in the case of the Lake Brown aerolite. The Lake Labyrinth and the Silverton also contain broken chondrules.

The commonest type of chondrule is composed of a crystal or crystals of olivine occasionally intergrown with glass.

Another common type consists of fibrous enstatite. This differs from the radiating spherulites of terrestrial rocks in that the fibres do not radiate from a central point but are arranged in an eccentric manner, or may be sub-parallel. The Elsinora contains chondrules which consist of one individual crystal of olivine, a granular mass of olivine, or fibrous enstatite. In the Karoonda the chondrules consist of granular aggregates and to a lesser extent of radial lamellar olivine with some impregnation of troilite which mineral concentrates around the borders of the chondrules. In the Lake Labyrinth a thin vein of nickel-iron passes through an enstatite chondrule and extends into the surrounding matrix. In the Tenham they consist of fibrous enstatite and olivine in concentric rings.

One chondrule has been observed to consist of detached grains of olivine in glass, with black inclusions surrounded by a broad ring of olivine in optical continuity with the internal grains. I have observed a similar structure in a broken chondrule of the Gilgoin No. 7. The few chondrules of the Narellan consist of fibrous enstatite, while those of the Kappakoola consist of lath-shaped crystals of olivine, finely granular olivine and fibrous enstatite.

8. CHEMISTRY.

Of the minor constituents of the Australian meteorites copper must be regarded as a normal constituent, measurable amounts being found in seventeen, with a maximum of 0·28 per cent. in the Bingara No. 2 iron. Chromium was found whenever looked for with one exception, as much as 0·75 per cent. being recorded in the Binda stone. Doubt has been thrown on the occurrence of tin in meteorites, but Mingaye definitely records it in measurable amounts in the Barraba and Moonbi irons.

In the researches of Professor F. Paneth[189][190] on the helium content and radium values of meteoric iron his results on the Thunda iron are of particular interest. He found that the helium content per gramme in 10^{-6} c.c. is 28·57, and the radium value per gramme in 10^{-14} gm. is 2·3. From these results he estimates the age of the Thunda iron as 2,800 million years, an age that is only exceeded by the Mount Ayliff iron (2,900 million years) in the twenty-eight irons investigated by him.

Other occluded gases have been looked for only occasionally, Mingaye finding hydrogen and nitrogen in the Moonbi iron, and Flight finding carbon dioxide, hydrogen, nitrogen, etc., in the Cranbourne iron.

Many excellent analyses of Australian meteorites have been published, and in the following tables the meteorites are grouped according to the three main divisions.

SIDERITES.

	1	2	3	4	5	6
Fe	88·06	89·91	89·34	93·47	93·52	93·76
Ni	10·22	8·85	9·87	5·55	5·53	4·39
Co	1·01	0·74	0·60	0·52	0·50	0·67
Cu	—	trace	0·06	0·01	—	trace
Mn	—	—	—	trace	trace	—
Sn	—	—	0·02	0·01	—	trace
Pt and Ir	—	—	—	trace	trace	—
Cr	0·26	—	—	—	—	—
C	—	trace	—	0·03	0·02	0·14
P	0·24	0·50	0·48	0·27	0·24	0·20
S	n.d.	trace	0·03	absent	absent	absent
Si	—	trace ?	—	0·01	0·01	—
Insoluble	0·01	—	—	—	—	0·55
Total	99·80	100·00	100·40	99·88	99·82	99·71
Fe : Ni	8·5	10·0	9·0	17·0	17·0	21·0
Specific gravity	7·848	7·8	7·843	7·761	—	7·834

1. Arltunga. Analyst, Chapman.[3]
2. Ballinoo. Analyst, Mariner and Hoskins.[9]
3. Ballinoo. Analyst, O. Sjöström.[6]
4. Barraba mass of the Bingara. Analyst, J. C. H. Mingaye.[27]
5. Barraba mass of the Bingara. Analyst, J. C. H. Mingaye.[27]
6. Bingara No. 1. Analyst, A. Liversidge.[26]

	7	8	9	10	11	12
Fe	94·27	93·50	93·39	91·14	85·31	85·22
Ni	4·75	5·54	5·68	8·05	13·18	13·28
Co	0·79	0·51	0·78	0·48	1·04	1·00
Mn	—	trace	—	—	trace	—
Sn	—	0·02	absent	—	trace	—
Au	—	—	—	present	—	—
Pt and Ir	trace	trace	present	—	—	—
Pt	—	—	—	present	—	—
Cr	0·01	—	—	present	—	—
C	0·01	0·04	0·12	present	0·02	0·03
P	0·14	0·26	0·22	present	0·22	0·23
S	absent	—	trace	present	0·01	—
As	—	—	—	present	—	—
Si	absent	0·01	absent	—	—	—
Cl	absent	—	absent	—	—	—
Insoluble	—	—	—	0·04	—	—
Total	99·97	99·89	100·19	99·99	99·81	99·76
Fe : Ni	20·0	17·0	16·5	11·5	6·0	6·5
Specific gravity ..	7·797	—	7·769	7·85	7·805	—

7. Bingara No. 2. Analyst, H. P. White.[29]
8. Bingara. Analyst, J. C. H. Mingaye.
9. Warialda mass of the Bingara. Analyst, J. C. H. Mingaye.[28]
10. Bugaldi. Analyst, A. Liversidge.[17]
11. Cowra. Analyst, J. C. H. Mingaye.[27]
12. Cowra. Analyst, J. C. H. Mingaye.[27]

	13	14	15	16	17	18
Fe	85·63	91·08	92·34	92·56	92·28	(89·879)
Ni	6·98	8·11	6·38	7·34	6·24	9·25
Co	—	0·50	0·75	0·48	0·58	0·55
Cu		0·01	0·02	0·02	0·06	0·008
Mn	trace	—	—	—	—	0·003
Pt	—	—	—	—	—	trace
C	1·94	—	—	0·05	—	0·02
P	0·23	0·11	0·19	0·26	0·17	0·28
S	2·21	—	0·18	0·04	—	absent
Si	—	0·17	—	—	—	0·01
Cl	trace	—	—	0·01	—	—
Mg	—	—	—	—	—	trace
CaO	—	—	—	—	—	trace
H_2O	2·10	—	—	—	—	—
Insoluble	—	—	—	—	0·32	—
Total	99·29	99·98	99·86	100·76	99·65	100·00
Fe : Ni	12·3	13·5	13·5	12·5	15·0	10·0
Specific gravity ..	—	7·46	—	—	—	7·325

13. Cranbourne.
14. Cranbourne No. 1. Analyst, W. Flight. Results modified by R. H. Walcott.[58]
15. Cranbourne No. 2. Analysts, P. G. W. Bailey and A. G. Hall.
16. Beaconsfield. Analyst, O. Sjöström.[39]
17. Langwarrin. Analyst, R. H. Walcott.[58]
18. Delegate. Analyst, J. C. H. Mingaye.[60] [61]

	19	20	21	22	23	24
Fe	92·9	89·74	93·04	91·54	90·57	91·35
Ni	6·4	8·71	7·26	7·54	7·30	7·89
Co	0·10	0·21	0·22	0·37	0·39	0·56
Cu	—	—	0·04	—	trace	trace
Sn	—	—	—	—	—	0·003
Pt	—	—	trace	—	—	—
Cr	—	—	absent	—	—	trace
C	absent	0·24	trace	0·01	0·13	0·07
P	0·18	0·36	absent	0·08	absent	0·22
S	absent	0·30	0·06	0·01	1·12	absent
Cl	—	—	trace	—	trace	—
SiO_2	—	—	—	—	—	0·04
Combined C	—	—	0·06[1]	0·03[1]	—	trace
Total	99·58	99·56	100·68	99·58	99·73	100·13
Fe : Ni	14·5	10·3	13·0	12·0	12·4	11·5
Specific gravity ..	—	7·621	7·69	7·53	7·73	7·833

[1] Insoluble.
19. Gladstone. Analyst, F. Connah.(69)
20. Glenormiston. Analyst, F. Connah.(69)
21. Henbury. Analyst, M. H. Hey.(74)
22. Henbury. Analyst, A. R. Alderman.(71)
23. Kyancutta. Analyst, M. H. Hey.(82)
24. Moonbi. Analyst, J. C. H. Mingaye.(90)

	25	26	27	28	29	30
Fe	90·82	93·17	89·50	85·66	92·08	87·96
Ni	7·21	5·96	9·45	13·56	6·72	10·99
Co	0·88	0·64	0·63	0·77	0·81	0·88
Cu	—	0·02	0·01	—	—	—
Mn	—	absent	absent	—	—	—
Cr	—	—	—	—	—	0·03
C	0·67	trace	0·02	trace	0·24	—
P	0·42	0·27	0·32	0·05	0·17	0·17
S	absent	0·09	0·005	trace	0·06	0·21
Si	0·01	trace	0·005	—	0·01	—
Cl	—	trace	—	—	—	—
Mg	—	trace	—	—	—	—
Total	100·01	100·15	99·93	100·04	100·09	100·32
Fe : Ni	12·5	15·6	9·5	6·5	13·7	8·0
Specific gravity ..	—	—	7·86	7·967	—	—

25. Mooranoppin. Analyst, H. Bowley.(104)
26. Mount Dooling. Analyst, E. S. Simpson.(97)
27. Mount Edith Analyst, J. E. Whitfield.(99)
28. Mount Magnet. Analyst, E. S. Simpson.(103)
29. Mount Stirling. Analyst, H. Bowley.(104)
30. Mungindi. Analyst, R. Knauer.(105a)

	31	32	33	34	35	36
Fe	90·31	93·88	88·61	97·09	96·65	93·57
Ni	8·23	6·32	9·75	2·91	3·61	5·79
Co	1·36	0·32	0·47	0·21		0·41
Cu	—	0·002	0·01	0·07	0·03	trace
Pt	—	0·07	—	—	—	—
Cr	—	<0·005	—	—	—	—
C	0·01	—	—	0·01	—	0·01
P	0·09	<0·005	0·43	—	—	0·13
S	trace	0·006	trace	—	—	trace
Si	trace ?	—	—	—	—	absent
Mg	—	—	—	—	—	0·09
Ge	—	0·007	—	—	—	—
Resinous matter	0·008	—	—	—	—	—
Cl	—	—	—	—	—	trace
Insoluble	—	0·20	0·72	0·09	0·07	—
Total	100·00	100·815	99·99	100·37	100·44	100·00
Fe : Ni	10·0	15·0	9·0	33·0	27·0	16·0
Specific gravity	7·4	7·78	7·57	7·796	—	7·79

31. Mungindi. Mariner and Hoskins.[9]
32. Murnpeowie. Analyst, M. H. Hey.[111]
33. Narraburra. Analyst, A. Liversidge.[114]
34. Nocoleche. Analyst, T. Cooksey.[116]
35. Nocoleche. Analyst, T. Cooksey.[116]
36. Nuleri. Analyst, E. S. Simpson.[119]

	37	38	39	40	41	42
Fe	91·68	88·51	88·85	90·91	95·79	91·54
Ni	7·46	7·58	9·07	8·33	4·11	8·49
Co	0·64	0·89	0·34	0·59	—	0·56
Cu	trace	0·13	—	—	—	0·02
Mn	trace	absent	—	trace	—	—
Cr	—	—	—	—	—	0·01
C	absent	1·06	—	trace	—	—
P	0·21	0·31	0·27	0·16	—	0·17
S	0·04	absent	0·75	trace	—	0·02
Si	0·01	absent	—	0·01	—	—
Mg	trace	—	—	—	—	—
Cl	absent	absent	—	—	—	—
Combined C	0·04	1·41	—	—	—	—
Insoluble	—	—	0·03	—	—	—
Total	100·04	99·89	99·31	100·00	99·90	100·81
Fe : Ni	12·0	11·5	10·0	11·0	23·0	10·5
Specific gravity	—	—	7·693	7·78	—	—

37. Premier Downs No. 1. Analyst, E. S. Simpson.[97]
38. Premier Downs No. 2. Analyst, H. Bowley.[119a]
39. Rhine Villa. Analyst, W. S. Chapman.[120]
40. Roebourne. Analyst, Mariner and Hoskins.[9]
41. Temora. Analyst, —— [23]
42. Thunda. Analyst, J. Fahrenhorst.[7]

	43	44	45	46	47	48
Fe	89·06	91·40	92·78	92·35	92·67	91·67
Ni	9·66	6·89	4·95	5·98	6·46	7·01
Co	0·72	0·46	0·81	1·43	0·55	0·93
Cu	trace	—	0·10	0·02	trace	0·02
Pt	0·001	—	—	trace	—	—
Cr	trace	—	—	—	—	—
Mn	—	—	—	—	absent	—
C	0·01	0·01	—	0·07	0·04	absent
P	0·20	trace	0·20	0·16	0·24	0·30
S	0·14	1·02	0·04	trace	absent	trace
Si	absent	—	—	—	absent	0·01
SiO_2	—	—	—	0·14	—	—
Mg	—	—	—	—	0·42	—
Silicates	—	0·79	—	—	—	—
Cl	absent	—	0·02	0·003	—	—
C combined	—	—	—	—	absent	0·15
Insoluble	—	—	0·19	—	—	—
Total	99·79	100·57	99·09	100·15	100·57	100·09
Fe : Ni	9·5	12·5	18·5	15·5	14·5	13·0
Specific gravity ..	7·59	—	—	7·304	7·851	—

43. Tieraco Creek. Analyst, H. P. White.(131)
44. Weekeroo. Analyst, T. Hodge-Smith.(133)
45. Yarraweyah. Analysts, P. G. W. Bayley and A. G. Hall.(59)
46. Yenberrie. Analyst, J. C. H. Mingaye.(135)
47. Youndegin No. 1. Analyst, L. Fletcher.(139)
48. Youndegin No. 2. Analyst, H. Bowley.(8)

SIDEROLITES.

	49	50	51	52	53
Fe	92·28[1]	—	55·35	87·51	—
Ni..	7·27	—	4·36	5·78	0·13
Co	0·20	—	0·12	0·63	0·02
C	—	—	—	—	trace
P	absent	—	—	—	—
S	0·21	—	0·13	0·74	—
Insoluble	—	—	—	0·75	—
H_2O, sol. SiO_2, O, MgO by diff.	—	—	—	4·59	—
SiO_2	—	37·24	15·02	—	47·44
TiO_2	—	absent	—	—	0·19
Cr_2O_3	—	—	—	—	0·38
Al_2O_3	—	—	—	—	4·13
Fe_2O_3	—	—	—	—	1·10
FeO	—	16·92	6·82	—	7·06[2]
MnO	—	—	—	—	0·56
MgO	—	43·88	17·69	—	34·99
CaO	—	1·26	0·51	—	2·68
Na_2O	—	—	—	—	0·10
K_2O	—	—	—	—	absent
H_2O	—	—	—	—	2·76
Total	99·96	99·30	100·00	100·00	101·54
Fe : Ni	12·5	—	—	15·0	—
MgO : FeO	—	4·5	—	—	8·5
Specific gravity ..	7·78	3·41	5·16	5·32[3]	—

[1] Some of this present as ferric oxide.
[2] Approximate, owing to the presence of metallic iron and carbon.
[3] Specific gravity of the complete siderolite.
49. Nickel-iron of Alice Springs. Analyst, M. H. Hey.(2)
50. Olivine of Alice Springs. Analyst, M. H. Hey.(2)
51. Alice Springs, bulk composition calculated from 1 and 2.
52. Bencubbin, magnetic portion. Analyst, D. G. Murray.(19)
53. Bencubbin, non-magnetic portion. Analyst, D. G. Murray.(19)

	54	55	56	57	58
Fe	78·29	21·96	87·35	—	—
Ni	7·81	—	8·30	—	—
Co	0·53	—	0·62	—	—
Cu	trace	—	0·01	—	—
Pt	—	—	trace	—	trace[2]
Au	—	—	absent	—	trace
Sn	—	—	absent	—	absent
Mn	absent	—	—	—	—
C	—	—	0·11	—	—
P	0·18	—	0·16	—	—
S	0·46	1·03	0·43	—	—
Cl	—	0·23	0·02	—	0·01
SO_2	1·54[1]	29·35	1·32	40·40	25·64
TiO_2	—	—	—	absent	trace
CO_2	—	0·08	—	—	0·13
Cr_2O_3	—	trace	—	trace	0·11
Al_2O_3	—	2·21	—	0·17	1·32
Fe_2O_3	—	—	—	0·45	29·90
P_2O_5	—	0·09	—	absent	0·51
V_2O_5	—	—	—	absent	absent
FeO	—	—	—	9·59	7·65
NiO	—	0·96	—	—	2·11
CoO	—	trace	—	0·06	trace
MnO	—	trace	—	0·02	trace
CuO	—	0·01	—	trace	trace
MgO	1·87	32·81	1·33	47·70	27·90
CaO	—	trace	absent	trace	0·01
Na_2O	—	trace	—	0·03	0·14
K_2O	—	0·28	—	trace	trace
H_2O at 100°	—	0·84	—	0·12	0·82
H_2O over 100° ..	—	5·35	—	1·52	3·89
SO_3	—	—	—	absent	0·15
Oxygen	9·32	4·90	0·35[3]	—	—
Total	100·00	100·10	100·00	100·24	100·29
Fe : Ni	10·0	—	10·0	—	—
MgO : FeO	—	—	—	9·0	6·5
Specific gravity ..	5·839	3·466	—	—	5·411

[1] Includes insoluble matter.
[2] Includes iridium and palladium.
[3] By difference.
54. Bendoc, metallic portion. Analyst, Mingaye.[(21)]
55. Bendoc, non-metallic portion. Analyst, Mingaye.[(21)]
56. Molong, metallic portion. Analyst, Mingaye.[(88)]
57. Molong, olivine. Analyst, Mingaye.[(88)]
58. Mount Dyrring. Analyst, Mingaye.[(27)]

Aerolites.

	59	60	61	62	63	64
Fe	79·85	91·25	14·97	81·11	—	1·24
Ni	7·34	7·20 (Ni and Co)	4·22	8·53	0·48	—
Co	0·43		trace	0·12	absent	—
Cu	—	—	0·18	—	—	trace
Sn	—	—	absent	—	—	—
C	—	—	trace	—	—	0·07
P	0·24	—	0·67	—	0·07	—
S	trace	—	2·29	—	2·26	0·17
Cl	—	—	—	—	—	absent
SO_3	—	—	—	—	—	absent
SiO_2	—	—	40·28	—	41·67	50·50
CO_2	—	—	—	—	—	absent
P_2O_5	—	—	—	—	—	0·03
Cr_2O_3	—	—	trace	—	—	0·75
V_2O_3	—	—	—	—	—	trace
Al_2O_3	—	—	1·84	—	1·16	8·84
Fe_2O_3	—	—	3·93	—	10·10	—
FeO	—	—	—	—	15·66	15·29
NiO	—	—	—	—	—	absent
CoO	—	—	—	—	—	absent
MnO	—	—	0·73	absent	trace	0·51
MgO	—	—	23·73	—	25·82	16·15
CaO	—	—	1·40	—	2·71	6·15
BaO	—	—	—	—	—	absent
SrO	—	—	—	—	—	absent
Na_2O	—	—	0·10	—	0·61	0·28
K_2O	—	—	1·02	—	0·09	0·13
H_2O at 100°	—	—	—	—	—	0·10
H_2O over 100°	—	—	—	—	—	absent
O by difference	5·52	—	3·79	—	1·16[1]	—
Insoluble	6·62	1·55	—	1·85	—	—
Total	100·00	100·00	100·00	91·61	99·26	100·22
Fe : Ni	11·0	12·5	—	9·5	—	<1·0
MgO : FeO	—	—	7·0[2]	—	3·0	<2·0
Specific gravity	—	—	3·38	—	3·37	3·25

[1] This amount to be deducted representing oxygen equivalent to sulphur and phosphorus.

[2] Analyses 59 to 61 of the Barratta No. 1 do not give very concordant results. The figure for the MgO : FeO was obtained by deducting the amount of iron required to satisfy the sulphur and recalculating the remainder to FeO, which gave as result 6·05 per cent. Two objections to accepting this figure as correct are that there is not enough iron to satisfy the oxygen obtained by difference and there is an extraordinary high amount of nickel.

59 and 60. Barratta No. 1, metallic portion. Analyst, Liversidge.[14]
61. Barratta No. 1, bulk analysis. Analyst, Liversidge.[14]
62. Barratta No. 2, metallic portion. Analyst, Liversidge.[14]
63. Barratta No. 2, non-metallic portion, the mean of two analyses. Analyst, Liversidge.[14]
64. Binda. Analyst, Mingaye.[22]

	65	66	67	68	69
Fe	74·83[1]	—	72·08	9·35	22·71
Ni..	10·09	1·01	5·20	} 0·33	1·31
Co	—	absent	0·08		0·02
Cu	—	absent	trace	—	trace
Sn	—	absent	—	—	—
S	trace	2·99	0·18	1·01	0·78
Cl	—	trace	—	—	—
Insoluble silicates ..	8·98	—	13·34	—	—
Soluble silicates.. ..	6·55	—	—	—	—
SiO_2	—	39·47	3·58	42·59	35·47
TiO_2	—	—	—	0·07	0·05
P_2O_5	—	—	trace	0·13	0·10
Cr_2O_3	—	—	—	0·43	0·34
Al_2O_3	—	2·87	—	2·76	2·02
Fe_2O_3	—	9·18	—	0·22	0·17
FeO	—	17·06	1·54	11·07	9·14
MnO	—	trace	—	0·08	0·07
MgO	—	25·58	3·56	27·59	25·21
CaO	—	1·60	0·25	1·89	1·56
Na_2O	—	0·73	—	1·03	0·82
K_2O	—	0·11	—	0·01	0·01
H_2O	—	—	—	0·52	0·41
Total	100·00	90·60	99·81	99·78	99·71
Fe : Ni	7·5	—	13·5	14·0	14·0
MgO : FeO	—	2·5	—	4·5	4·5
Specific gravity ..	—	—	—	—	3·59

[1] This figure is obtained by difference and includes any cobalt.
65. Eli Elwah, metallic portion. Analyst, G. T. Prior.[62]
66. Eli Elwah, bulk analysis.
67. Elsinora, metallic portion. Analyst, Hodge-Smith.[64]
68. Elsinora, non-metallic portion. Analyst, Hodge-Smith.[64]
69. Elsinora, calculated from 67 and 68.

	70	71	72	73	74	75
Fe	82·45	—	—	—	8·54	23·14
Ni	8·34 {	0·28	—	—	—	1·60
Co		absent	—	—	—	0·14
Cu	—	—	—	—	trace	trace
Pt	—	—	—	—	trace	trace
C	—	—	—	—	0·09	0·23
P	absent	0·13	—	—	—	0·15
S	trace	2·53	—	—	—	—
FeS	—	—	—	—	6·38	5·66
Cl	—	absent	—	—	0·02	0·01
SO_3	—	—	—	—	absent	absent
SiO_2	—	42·69	42·54	42·96	43·60	37·14
Insoluble	1·51	—	—	—	—	—
TiO_2	—	—	—	—	absent	absent
CO_2	—	—	—	—	0·44	0·11
P_2O_5	—	—	—	—	0·28	—
Cr_2O_3	—	—	0·25	0·15	0·44	0·30
V_2O_3	—	—	—	—	absent	absent
Al_2O_3	—	4·98	—	—	4·58	2·96
Fe_2O_3	—	6·78	—	—	—	—
FeO	—	12·66	—	—	—	—
NiO and CoO ..	—	—	—	—	0·48	—
MnO	—	trace	—	—	0·21	0·19
MgO	—	12·66	26·30	26·91	27·33	23·02
CaO	—	17·53[1]	2·04	2·16	2·07	1·68
BaO	—	—	—	—	absent	absent
SrO	—	—	—	—	trace[2]	trace[2]
Na_2O	—	0·74	—	—	0·83	0·75
K_2O	—	0·10	—	—	0·16	0·21
H_2O at 100° ..	—	—	—	—	0·32	0·15
H_2O over 100° ..	—	—	—	—	1·65	0·85
O by difference ..	7·69	—	—	—	2·58	1·71
Total	100·00	101·02	—	—	100·00	100·00
Fe : Ni	10·0	—	—	—	—	10·5[4]
MgO : FeO	—	—	3·0[3]	—	—	6·0[4]
Specific gravity ..	—	—	—	—	—	—

[1] A re-examination of the calcium content by Mingaye proves this figure to be much too high. See analysis 72.

[2] Spectroscopic determination.

[3] This figure was obtained by using Mingaye's magnesia content and Liversidge's ferrous iron content.

70. Gilgoin No. 1, metallic portion.

71 and 72. Gilgoin No. 1, non-metallic portion.

73. Gilgoin No. 6, non-metallic portion.

74. Gilgoin No. 7, non-metallic portion.

75. Gilgoin No. 7, bulk analysis.

[4] These ratios were obtained by calculating the amount of iron necessary to satisfy the oxygen obtained by difference. This gave as result a total of 7·60 per cent. of FeO, of which 0·15 per cent. is required to satisfy the chromium sesqui oxide, leaving total iron as 17·15 per cent.

	76	77	78	79	80	81
Fe	—	19·19	0·42	63·79	—	6·10
Ni	—	2·06	0·02	11·27	—	1·08
Co	—	0·08	—	0·60	—	0·06
Cu	—	absent	—	—	—	—
C	—	—	0·08	—	—	—
P	—	0·01	—	—	—	—
Cl	—	trace	—	—	—	—
FeS	—	4·05	3·98	—	6·75	6·26
SO_3	—	trace	—	—	—	—
SiO_2	56·17	37·96	34·36	3·17	42·51	39·43
TiO_2	—	absent	trace	—	0·38	0·35
ZrO_2	—	absent	—	—	—	—
CO_2	—	0·10	—	—	—	—
P_2O_5	—	—	0·25	—	0·33	0·31
Cr_2O_3	0·42	0·29	0·49	—	0·19	0·18
V_2O_3	—	trace	—	—	—	—
Al_2O_3	7·33	2·95	5·55	—	2·16	2·00
Fe_2O_3	1·20	—	—	—	3·94	3·65
FeO	9·36	—	26·99	—	12·93	11·99
NiO	—	—	—	—	0·35	0·32
MnO	—	0·16	—	—	0·27	0·25
MgO	17·89	24·87	24·85	—	27·11	25·15
CaO	4·76	2·86	2·58	—	2·03	1·88
BaO	—	absent	—	—	—	—
SrO	—	absent	—	—	—	—
Na_2O	2·54	0·97	0·71	—	0·87	0·81
K_2O	0·33	0·21	0·26	—	0·11	0·10
H_2O at 100° ..	} 0·32	1·31	} 0·13	—	0·54	0·50
H_2O over 100° ..		0·43		—	0·08	0·08
O by difference ..	—	2·41	—	—	—	—
Insoluble	—	—	—	10·73	—	—
Total	100·32	100·00	100·88	—	100·55	100·50
Fe : Ni	—	—	21·0	—	5·5	—
Mgo : FeO	—	—	1·5	—	—	3·5
Specific gravity ..	—	—	3·5	—	—	3·505

76. Hermitage Plains, insoluble silicate. Analyst, H. P. White.(78)
77. Hermitage Plains, bulk analysis. Analyst, H. P. White.
78. Karoonda. Analyst, A. R. Alderman.(3)
79. Lake Brown, metallic portion. Analyst, G. T. Prior.(84)
80. Lake Brown, non-metallic portion. Analyst, G. T. Prior.(84)
81. Lake Brown, bulk analysis. Analyst, G. T. Prior.(84)

	82	83	84	85	86	87
Fe	—	—	28·84	76·01	1·65	8·58
Ni	—	—	1·78	10·30	} 0·29	1·21
Co	—	—	0·26	0·24		0·02
C	—	—	0·11	—	—	—
P	—	—	0·11	—	—	—
S	—	—	2·02	—	—	—
FeS	14·40	—	—	1·42	7·83	7·28
Cl	—	absent	—	—	—	—
SiO_2	28·81	54·38	34·81	1·73	41·92	38·45
TiO_2	—	—	trace	—	0·15	0·13
ZrO_2	—	—	absent	—	—	—
P_2O_5	—	—	—	absent	0·46	0·41
Cr_2O_3	—	0·50	0·02	—	0·49	0·44
V_2O_3	—	—	trace	—	—	—
Al_2O_3	—	6·58	2·27	—	2·41	2·20
Fe_2O_3	1·03	absent	—	—	3·76	3·41
FeO	17·09	8·73	—	1·30	14·41	13·36
MnO	—	—	trace	—	0·53	0·48
MgO	37·12	24·16	23·35	1·61	22·95	21·11
CaO	0·76	3·70	2·24	absent	1·71	1·56
BaO	—	—	absent	—	—	—
SrO	—	—	absent	—	—	—
Na_2O	—	1·97	1·17	—	0·66	0·60
K_2O	—	0·26	0·24	—	0·27	0·24
H_2O	—	—	—	—	0·03	0·02
O by difference	—	—	2·78	—	—	—
Insoluble	—	—	—	7·13	—	—
Undetermined	0·79	—	—	—	—	—
Total	100·00	—	100·00	99·75	99·52	99·50
Fe : Ni	—	—	9·0[1]	7·0	—	—
Mgo : FeO	—	—	4·5[1]	—	3·0	—
Specific gravity	—	—	—	—	—	3·45

[1] Obtained by distributing the iron to satisfy the sulphur and oxygen to form ferrous sulphide and oxide.

82. Mount Browne, soluble silicates. Analyst, H. P. White.[95]
83. Mount Browne, insoluble silicates. Analyst, H. P. White.[95]
84. Mount Browne, bulk analysis. Analyst, H. P. White.[95]
85. Narellan, metallic portion. Analyst, Hodge-Smith.[112]
86. Narellan, non-metallic portion. Analyst, Hodge-Smith.
87. Narellan, bulk analysis calculated from 85 and 86.

	88	89	90	91	92	93
Fe	63·79	—	6·03	83·8	20·2	7·43
Ni	11·23	—	1·06	11·8	0·9	1·05
Co	0·85	—	0·08	1·2	trace	0·02
FeS	1·07	6·90	6·40	—	0·3[1]	5·0
SiO_2	3·91	43·13	39·86	1·5	38·4	37·8
TiO_2	—	0·23	0·21	—	—	—
P_2O_5	—	0·28	0·26	—	0·3[2]	0·7
Cr_2O_3	—	0·45	0·41	—	—	—
Al_2O_3	—	1·87	1·71	—	1·9	1·9
Fe_2O_3	—	2·35	2·15	—	—	—
FeO	2·23	13·78	12·84	—	—	13·6
NiO	—	0·13	0·12	—	—	—
MnO	—	0·43	0·39	—	0·4[2]	0·5
MgO	4·19	26·57	24·75	—	25·3	24·9
CaO	trace	2·19	2·01	—	1·9	1·9
Na_2O	—	1·01	0·92	—	—	—
K_2O	—	0·08	0·06	—	—	—
H_2O	—	0·87	0·80	—	—	—
O by difference ..	1·19	—	—	} 1·7[3]	8·9[3]	5·2[3]
Insoluble	11·19	—	—			
Total	100·00	100·27	100·06	100·0	100·0	100·0
Fe : Ni	5·5	—	—	—	—	—
MgO : FeO	—	3·5	—	—	—	—
Specific gravity ..	—	—	3·48	—	—	—

88. Warbreccan, metallic portion. Analyst, Prior.(132)
89. Warbreccan, non-metallic portion. Analyst, Prior.(132)
90. Warbreccan, bulk analysis from 88 and 89.
91. Tenham, coarse portion 0·46 gram. Analyst, Queensland Chemical Laboratories.(126)
92. Tenham, fine portion 30 grams. Analyst, Queensland Chemical Laboratories.(126)
93. Tenham, calculated bulk composition.

[1] This figure is for sulphur and not FeS.
[2] This figure is for the element, not the oxide.
[3] This includes oxygen and undetermined.

The Norms Calculated from Analyses.

Analysis No.	64	66	69	75	78	81	87	90
Orthoclase	0·56	0·5	0·56	0·55	—	—	1·11	0·33
Albite ..	2·62	4·5	6·81	6·29	—	—	5·24	7·81
Anorthite..	22·52	5·5	1·67	4·17	—	—	2·78	0·36
Felspar ..	(25·70)	(10·5)	(9·04)	(11·01)	12·0	8·0	(9·13)	(8·50)
Bronzite ..	—	23·5	22·52	32·13	—	—	40·12	33·54
Diopside	6·58	—	—	—	—	—	—	—
Hypersthene	64·76	—	—	—	—	—	—	—
Pyroxene	—	—	—	—	—	38·0	—	—
Olivine ..	0·48	52·5	42·30	30·12	82·0	36·0	27·35	39·80
Apatite ..	—	—	0·31	—	0·67	—	1·01	0·59
Chromite	1·12	—	0·45	0·45	0·67	—	0·67	0·60
Ilmenite ..	—	—	0·15	—	—	—	0·30	0·39
Magnetite	—	—	0·23	—	—	—	—	—
Carbon ..	—	—	—	0·23	0·08	—	—	—
Nickel-iron	0·45	8·0	19·56	18·89	0·44	7·0	9·81	7·17
Troilite ..	0·96	6·5	4·78	5·66	3·98	6·0	7·28	6·40
Water, etc.	—	—	0·41	1·31	—	5·0	3·91	3·07
Total ..	100·05	101·0[1]	99·75	99·80	99·84	100·0[1]	99·58	100·06

[1] Approximate only.

64. Binda.
66. Eli Elwah.
69. Elsinora.
75. Gilgoin No. 7.
78. Karoonda.
81. Lake Brown.
87. Narellan.
90. Warbreccan.

9. TEKTITES.

The question of the origin and occurrence of tektites has created considerable interest in the scientific world for a great number of years. During this period a large volume of literature has been produced and a number of theories have been suggested for their origin, but no positive evidence has been discovered as yet. It is therefore necessary to bear in mind that the more generally accepted meteoric origin of these interesting objects is based purely on negative evidence.

Perhaps the most striking feature is their restricted geographical distribution, and the varietal names are derived from the localities in which they have been found. Thus the moldavites come from the Moldau River area, Czechoslovakia, and the Billitonites were first recorded from the Island of Billiton, though they have been found later in the Malay Archipelago, Indo-China, Netherlands East Indies and the Philippine Islands. From Australia we have australites and also Darwin glass (queenstownites) from the restricted area of Mount Darwin and Queenstown, Tasmania.

It has been pointed out by David, Summers and Ampt[207] that these localities all lie in a belt 20° wide, the centre of which forms a great circle passing through Moldau River, the Island of Billiton and Tasmania.

While it has been amply demonstrated that there are striking similarities between the various varieties, yet each has its own distinct characters. It is unnecessary here to repeat detailed descriptions of these varieties, particularly as we are more concerned with the Australian varieties, the australites and Darwin glass.

The first record of australites was made by Charles Darwin in 1865 when he described a button-shaped form presented to him by Sir Thomas Mitchell. This specimen came from the sandy plains between the Darling and Murray Rivers, New South Wales. Later the Rev. W. B. Clarke recorded specimens from the Turon River and the Rocky River in the same State. In the former locality a specimen was secured from a depth of thirty feet below the surface. Since these early records australites have been recorded from every State, including the Northern Territory of the Commonwealth, though only a comparatively few specimens have been recorded from outside the belt 20° wide, referred to above. Referring to the distribution map compiled by Dr. Fenner[209] and reproduced in Figure 5, it will be seen that they occupy an area of many thousands of square miles. They occur in far greater numbers in an area occupying the south-eastern portion of Western Australia and the south-western part of South Australia.

Professor Franz E. Suess[218] gave the first record of Darwin glass in 1914. Later David, Summers and Ampt[207] gave a very complete description of this material. It is found most abundantly at the Ten Mile on the spur of Mount Darwin, where it occurs most immediately under a superficial covering of peat about nine to eighteen inches in thickness. Curiously enough it is not found anywhere above 1,300 feet above sea level.

It is mostly found in broken fragments. Only very rarely are forms found that even approach the symmetrical shape of the australites. Stalactitic forms often showing a spiral twist appear to be the most common, though smaller forms belong to the tear-drop type.

Dr. L. J. Spencer[213][214] appears to have solved the problem of the Darwin glass. He found that the silica glass of Henbury and Wabar contained small spheres of nickel-iron as does the Darwin glass. It is to be remembered that Darwin glass is purely of local occurrence and that its chemical composition is quite different from that of the australites, billitonites and Indo-China tektites. In spite of the fact that no meteoric material and no crater have been found in the locality, Dr. Spencer's suggestion that the Darwin glass is formed in the same way as silica glass of Henbury and Wabar, that is, it is fused country rock produced by the explosive force of a meteorite, explains the known facts.

Moldavites are mostly much more irregular in shape than the australites, and their surface is generally very deeply scored. This difference was first noted by Stelzner[217] in 1893, who suggested that the surface sculpture of the moldavites was secondary and that of the obsidian bombs (australites) is primary. Recently Lacroix,[212] in his monograph on the tektites of Indo-China, elaborated the views

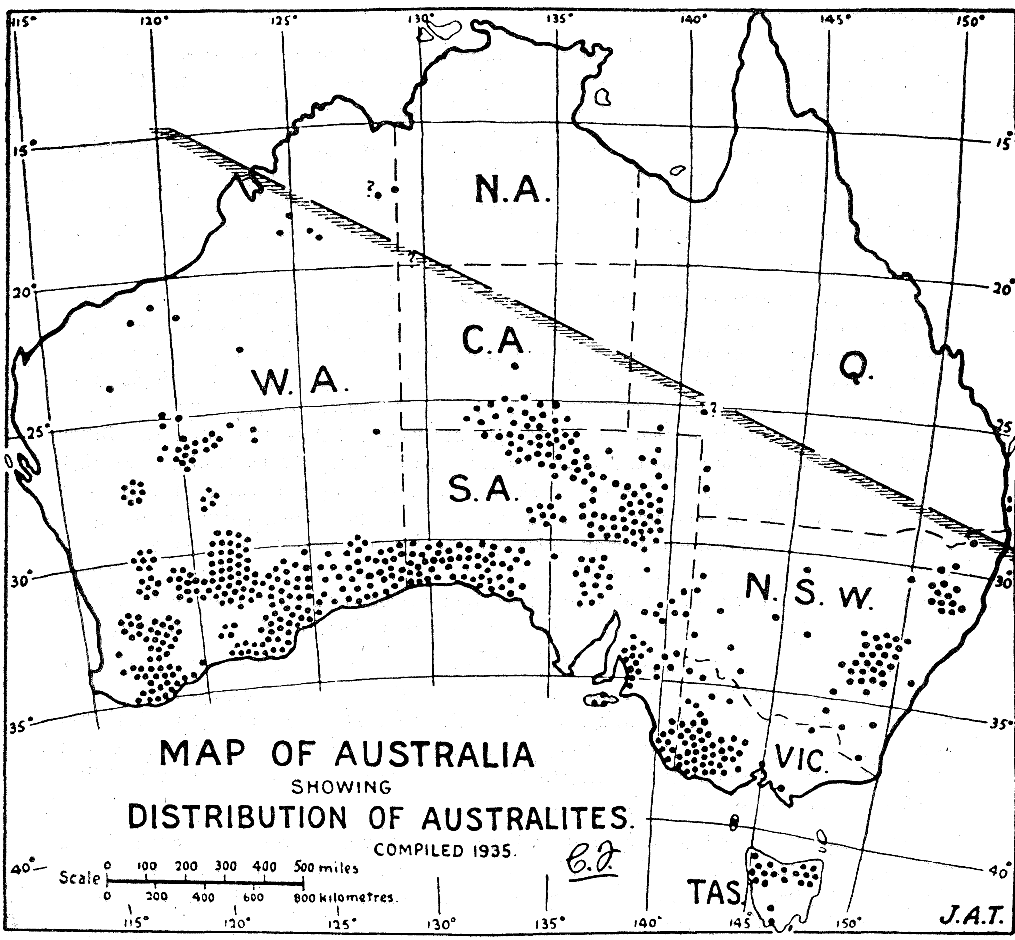

Fig. 5.—After Dr. C. Fenner.[209]

expressed by Van der Veen that the surface sculpture of the moldavites and billitonites was due to chemical erosion.

In describing the billitonites from the Philippine Islands I[210] pointed out that the smooth surfaced crevasses or grooves so characteristic of the billitonites were sometimes more or less circular forming "islands" having a striking resemblance to some types of australites. I suggested that they were formed by shrinkage of the glass during the cooling process.

Dr. Fenner[209] has made the most exhaustive examination of the form of australites. He divides them into two main groups. Group A (whole specimens) consists of buttons, lenses, ovals, boats, canoes, dumb-bells, teardrops. Group B (broken pieces) consists of round forms, elongate forms, and unclassified fragments. The seven classes of his group A are further sub-divided into fifty subclasses. He estimates that between one and ten million have fallen in Australia.

Up to recent times their prehistoric age has never been questioned, and they were generally accepted as being late Tertiary or Quaternary. Dr. Fenner suggests a post-Pleistocene age. The tektites of Java are found in the same horizon as the Pithecanthropus skull which is considered as Middle Pleistocene. The reasons that the "One Fall Theory" has been questioned may be briefly summarized as follows.

(*a*) Many australites are found in the desert sandy country and the "gibber" country of Australia. "Gibber" country is plain country and so-called because of the innumerable stones or gibbers strewn about the surface. These are all more or less uniformly polished and exhibit arid weathering, but the australites found with them vary considerably in their degree of weathering; some show no sign of weathering whatever while others possess only a trace of their original form. There can be no doubt that the gibbers and the australites have been exposed to the same conditions. The physical properties of the australites are constant, and if they were all of the same age they would be uniformly weathered as the gibbers are.

(*b*) There are a number of reports by residents of the australite area of actual falls. In the collection of the Australian Museum there is a specimen of an australite and a letter from a lady in which she declares that she heard it fall on the iron roof of the verandah of her home where she was seated one afternoon. Unfortunately she did not find it until the next day. The specimen (Plate xix, Fig. 3) is boat-shaped, weighing ·93 grammes. It possesses an exceedingly fine flange and is beautifully fresh, and in appearance supports the lady's story.

In discussing this question with the late Professor Sir Edgeworth David he told me of a case which he had carefully investigated and was convinced that the statements made were true. A man had been in the habit of leaving his homestead at the Mt. Cameron Water-Hole, near the Pioneer Mine, north-eastern Tasmania, on horseback each morning and passing through a particular gate. One morning he was attracted by an object lying in the middle of the path near the gate. It proved to be an australite with three fine filaments of glass radiating from it. The man was convinced that it could not have been there before. The fine glass filaments were broken and not preserved, and the australite (Plate xix, figs. 1 and 2) is now in the collection of the Melbourne University.

While in the northern part of South Australia and the southern part of Northern Territory I made numerous inquiries about tektites. Naturally the majority knew little or nothing about them, but there were some who were most emphatic as to their cosmic origin, and one government official and a missionary both independently declared that they had been seen by the natives to fall. On the other hand Professor A. P. Elkin, Department of Anthropology, University of Sydney, informs me that so far as he knows nothing in aboriginal folklore would indicate that they had fallen from the sky. Usually they were referred to as emu eyes.

Lastly comes the definite record of an australite observed to fall near Lake Grace, Western Australia. Apparently Dr. E. S. Simpson, who made the record,[213] has thoroughly investigated the report and is satisfied with its reliability. With the experience and record that Dr. Simpson has it seems futile to dismiss his definite statement with a curt "not convincing".

Dr. Fenner[209] calls all this "one small item of evidence" and dismisses it because of "so comprehensive a volume of evidence against it". He states that the following three facts are incompatible with a theory of continuous falls:

"1. Their chemical composition, quite distinct from any terrestrial rocks and from other tektites.

"2. Their small series of curious form-type, unlike any other known petrological objects, even those of other tektite series.

"3. Their definite restriction to Australia, and to that part of Australia south of a particular line."

In regard to his first "established fact" I need only quote three analyses previously quoted by me.[210]

	1	2	3
SiO_2	70·88	70·62	70·92
Al_2O_3	12·33	13·48	12·20
Fe_2O_3	1·20	0·85	1·07
FeO	4·32	4·44	5·42
MgO	2·62	2·42	2·61
CaO	3·97	3·09	3·78
MnO	trace	0·42	0·14
Na_2O	1·61	1·27	2·46
K_2O	2·39	2·22	2·49
TiO_2	0·86	0·90	—
Loss on ignition	0·18	0·07	—
	100·36	99·75	101·75

1. Tektite from Bulacan Province, Philippine Islands. H. P. White, analyst.
2. Australite near Coolgardie, Western Australia. Traces of nickel and cobalt present.
3. Billitonite, Tebrung, Dendang. C. V. John, analyst.

The similarity in chemical composition is even more strikingly brought out when these analyses are converted into the C.I.P.W. classification.

In regard to the second statement I have shown that a structure found in australites does occur in the tektites of the Philippine Islands. His teardrop type can be matched with my drop type of the same islands. Some of the tektites from Java do bear a resemblance to some of the australites.

His third established fact is a serious objection to any theory of continuous falls. Under this theory it is necessary to postulate a continuous supply and only two sources seem possible. Firstly a stream of these objects are travelling along an orbit that passes periodically close to the earth. Under these conditions it seems impossible to conceive that they would always fall on the same spot. Secondly, if there is some particular type of meteor capable of producing australites it is difficult to understand how they would fall only in Australia.

It is much more simple to postulate a comet-like body passing close to the earth during Middle or Post-Pleistocene times, leaving a trail of glassy meteorites along the well-marked belt previously referred to. Had it not been for the fact that people have declared that they have seen them fall and two of these declarations have been examined by men of ability and high scientific standing and accepted by them, those who advocate the cosmic origin of tektites could ask for no better explanation of their existence than the Pleistocene comet.

The rejection or acceptance of the "continuous falls" theory depends on whether we believe the statements that they have been seen to fall or not. One is reminded of the story of an American president who said that it was easier to believe that two Yankee professors would lie than to believe that stones would fall from the sky. Yet, today, everyone accepts the cosmic origin of meteorites as tomorrow they will accept the continuous falls of australites.

Only rarely are australites found to be hollow; mostly they are quite solid, except for a few scattered vesicles of microscopic size. Walcott[219] describes one hollow australite, and he points out that the cavity has not had any influence on the external form which is of the spherical type. The walls of the hollow have a high polish and a perfectly smooth surface. Incidentally Dunn's bubble theory that australites are the blebs of glass bubbles thrown out by volcanoes must be rejected on purely physical grounds. The melting point of australites is 1,324° C., so that on cooling down to ordinary temperatures the contraction of gas would be so great as to form practically a vacuum. The thickness of the envelope would have to be so great that it would be impossible for the bubble to float in the way the bubble theory suggests.

Australites, in common with all other varieties, show a complete absence of crystallization. Microscopic examination reveals the presence of vesicles but never microlites. While birefringence has been observed in all varieties, all observers are agreed that its presence is due to strain. Examination by X-ray methods confirms the amorphous nature of the material.

The specific gravity and refractive index are directly related to the chemical composition of a substance. In comparing the chemical composition of rocks the norm is a much more satisfactory guide than the percentage weights of the individual oxides. In the norm of the tektites perhaps the most striking feature is the amount of free silica and free alumina present. The figures in the following table are averages, except in the case of the specific gravity, taken from the works of Summers[216] and Lacroix.[211]

Variety.	n (Na).	Specific Gravity.	Normative.	
			Silica.	Alumina.
Moldavites	1·4901	2·318–2·385	58·46	3·67
Australites	1·5074	2·376–2·490	45·73	2·67
Indo-china tektites ..	1·5100	2·421–2·445	39·96	2·65
Billitonites	1·5188	2·443–2·503	38·20	2·00
(Darwin Glass)	1·4790	2,290	80·61	5·35

Where averages have been taken as in the case of the refractive index, normative silica and alumina it will be seen that there is a gradation from moldavites to billitonites. If, however, figures for individual specimens are taken, as in the case of specific gravity, it would be found that there is a considerable overlapping, but even here the gradation is apparent. It is at once clear that Darwin glass differs substantially from the true tektites, particularly in its normative silica.

Summers[216] has noted the fact that the specific gravity of the australites varies inversely to the silica content and he suggests the following division according to specific gravity.

A. Under 2·390, Peake Station type.
B. 2·391–2·410, Hamilton Type.
C. 2·411–2·440, Mount Elephant Type.
D. 2·441–2·470, Kalgoorlie Type.
E. Over 2·470, no record.

Chemically there is a distinct family relationship between all types of tektities, while it is only in rare cases that igneous rocks are found that chemically resemble them. This relationship is brought out more clearly by means of the C.I.P.W. classification. Lacroix[211] has illustrated this in the following manner:

I·2·2-3·1-2, Moldavites.
I·2·2·2, Moldavites.
I (II)·2-3·3·3, Australites.
I (II)·3·3·3, Australites and Billitonites.
II·3·3·3, Indo-China Tektites.
(I·1-2·1-2·1-2, Darwin Glass.)

11. LITERATURE.

The following list of literature is divided into four parts. The first part deals with literature descriptive of Australian meteorites, and full use has been made of Anderson's bibliography of Australian meteorites.[144] The usual arrangement of a bibliography, according to authors in alphabetical order, has been departed from because this work is primarily for the use of the student of Australian meteorites; it is felt that the classification of the literature under the various falls is much more convenient. When different masses of the one fall are given various names they are included under the name of the fall.

The second part is simply a list of catalogues, the third is arranged according to the usual custom and contains all references used in the text, and the fourth part refers to tektites.

All references are numbered consecutively and in the text are referred to by that number.

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12. APPENDIX.

The following is a list of foreign meteorites in the collection of the Australian Museum.

ADELIE LAND (Antarctica) aerolite. Found 5 December, 1912. Main mass 875 grammes.
ALFIANELLO (Italy) aerolite. Found 1883. Weight 117 grammes.
ALLEGAN (U.S.A.) aerolite. Fell 10 July, 1899. Weight 195 grammes.
ARISPE (Mexico) siderite. Found 1898. Weight 206 grammes.
AUMIERES (France) aerolite. Fell 3 June, 1842. Weight 1·5 grammes.
AUSSON (France) aerolite. Fell 9 December, 1858. Weight 7 grammes.
BACHMUT (Russia) aerolite. Fell 15 February, 1814. Weight 3 grammes.
BETHANY (S.W. Africa) siderite. Found 1899. Weight 514 grammes.
BJURBOLE (Finland) aerolite. Fell 12 March, 1899. Weight 191·9 grammes.
BORGO SAN DONNINO (Italy) aerolite. Fell 19 April, 1808. Weight 1 gramme.
BRENHAM (U.S.A.) siderolite. Found 1886. Weight 119 grammes.
CANGAS DE ONIS (Spain) aerolite. Fell 6 December, 1866. Weight 9 grammes.
CANON DIABLO (U.S.A.) siderite. Found 1891. Weight 238 grammes.
CARLTON (U.S.A.) siderite. Fell April, 1888. Weight 375 grammes.
CARTHAGE (U.S.A.) siderite. Found 1840. Weight 82·5 grammes.
CASAS GRANDES (Mexico) siderite. Prehistoric. Weight 155 grammes.
CHARCAS (Mexico) siderite. Known 1804. Weight 52·5 grammes.
CHARSONVILLE (France) aerolite. Found 1810. Weight 63 grammes.
CHATEAU-RENARD (France) aerolite. Fell 12 June, 1841. Weight 5 grammes.
COAHUILA (U.S.A.) siderite. Found 1882. Weight 183 grammes and 132 grammes.
COLD BOKKEVELD (South Africa). Fell 13 October, 1838. Weight 2 grammes.
COSBY CREEK (U.S.A.) siderite. Found 1837. Weight 21·4 grammes.
CRAB ORCHARD (U.S.A.) siderolite. Found 1887. Weight 33 grammes.
DANDAPUR (India) aerolite. Fell 5 September, 1878. Weight 0·75 gramme.
DHURMSALA (India) aerolite. Found 1860. Weight 0·75 gramme.
DJAUL ISLAND (New Guinea) aerolite. Fell 31 January, 1933. Main mass 199 grammes.
DOLGOVOLI (Poland) aerolite. Fell 26 June, 1864. Weight 0·75 gramme.
DURALA (India) aerolite. Fell 18 February, 1815. Weight 1·5 grammes.
EL TLAHI (Arabia) aerolite. Weight 38 grammes.
ERGHEO (East Africa) aerolite. Fell July, 1889. Weight 159·5 grammes.
ESTACADO (U.S.A.) aerolite. Found 1883. Weight 4,425 grammes.

ESTHERVILLE (U.S.A.) siderolite. Fell 10 May, 1879. Weight 88 grammes.
FARMINGTON (U.S.A.) aerolite. Fell 25 June, 1890. Weight 134 grammes.
FINMARKEN (Norway) siderolite. Found 1902. Weight 453 grammes.
FOREST CITY (U.S.A.) aerolite. Fell 2 May, 1890. Weight 134 grammes.
FORT DUNCAN (U.S.A.) siderite. Found 1882. Weight 132 grammes.
GRAND RAPIDS (U.S.A.) siderite. Found 1883. Weight 194 grammes.
HESSLE (Sweden) aerolite. Fell 1 January, 1869. Weight 26 grammes.
HOBA (South West Africa). Found 1920. Weight 680 grammes.
HOLBROOK (U.S.A.) aerolite. Fell 19 July, 1912. Weight 968 grammes.
HOMESTEAD (U.S.A.) aerolite. Fell 12 February, 1875. Weight 878 grammes.
IMILAC (Chili) siderolite. Found 1822. Weight 65 grammes.
JUVINAS (France) aerolite. Fell 15 June, 1821. Weight 3·5 grammes.
KENTON COUNTY (U.S.A.) siderite. Found 1889. Weight 254 grammes.
KERNOUVE (France) aerolite. Fell 22 May, 1869. Weight 21 grammes.
KNYAHINNA (Hungary) aerolite. Fell 9 June, 1866. Weight 46 grammes.
KULESCHOVKA (Ukraine) aerolite. Fell 12 March, 1811. Weight 2 grammes.
L'AIGLE (France) aerolite. Fell 26 April, 1803. Weight 29 grammes.
LENARTO (Hungary) siderite. Found 1814. Weight 34 grammes.
LIXNA (Latvia) aerolite. Fell 12 July, 1820. Weight 5 grammes.
MACKINNEY (U.S.A.) aerolite. Fell 1870. Weight 483 and 39 grammes.
MAGURA (Hungary) siderite. Found 1844. Weight 45 grammes.
MENOW (Germany) aerolite. Fell 7 October, 1862. Weight 35·5 grammes.
MERCEDITAS (Chili) siderite. Found 1884. Weight 93·5 grammes.
MERN (Denmark) aerolite. Fell 29 August, 1878. Weight 4 grammes.
MOCS (Hungary) aerolite. Fell 3 February, 1882. Weight 464 grammes.
MORRISTOWN (U.S.A.) siderolite. Found 1887. Weight 33 grammes.
NAMMIANTHAL (India) aerolite. Fell 27 January, 1886. Weight 2 grammes.
NOVA UREI (Russia) aerolite. Fell 4 September, 1886. Weight 2 grammes.
OLIVENZA (Spain) aerolite. Found 1924. Weight 103 grammes.
ORGUEIL (France) aerolite. Found 1864. Weight 27 grammes.
PILLISTFER (Latvia) aerolite. Fell 8 August, 1863. Weight 28·5 grammes.
PULTUSK (Poland) aerolite. Fell 30 January, 1868. Weight 56 grammes.
RAKOVKA (Russia) aerolite. Fell 30 November, 1878. Weight 0·5 gramme.
SACRAMENTO MOUNTAINS (U.S.A.) siderite. Found 1896. Weight 1,634 grammes and 618 grammes.
SAN ANGELO (U.S.A.) aerolite. Found 1897. Weight 24 grammes.
SANTA CATHERINA (Brazil) aerolite. Found 1875. Weight 221 and 89 grammes.
SAO JULIAO DE MOREIRA (Portugal) siderite. Known 1883. Weight 283 grammes.
SEELASGEN (Prussia) siderite. Known before 1847. Weight 72 grammes.
SHALKA (India) aerolite. Fell 30 November, 1850. Weight 5 grammes.
SLOBODKA (Russia) aerolite. Known 1839. Weight 0·75 gramme.
SOKO-BANJA (Servia) aerolite. Fell 13 October, 1877. Weight 32 grammes.
STAUNTON (U.S.A.) siderite. Found 1858-1859. Weight 1346 grammes.
TABORY (Russia) aerolite. Fell 30 August, 1887. Weight 35·5 grammes.
TOLUCA (Mexico) siderite. Known before 1776. Weight 2,631 grammes.
TOURINNES-LA-GROSSE (Belgium) aerolite. Fell 7 December, 1863. Weight 7·5 grammes.
TRENZANO (Italy) aerolite. Fell 12 November, 1856. Weight 16 grammes.
VACA MUERTA (Chili) siderolite. Found 1888. Dona Inez mass 17 grammes and Llano dell Inca mass 14 grammes.
VOUILLE (France) aerolite. Fell 13 May, 1831. Weight 4 grammes.
WARRENTON (U.S.A.) aerolite. Fell 3 January, 1877. Weight 0·75 gramme.
WICHITA COUNTY (U.S.A.) siderite. Known before 1836. Weight 63·5 grammes.

EXPLANATIONS OF PLATES.

PLATE I.

The "Cranbourne No. 1" siderite. Weight 3½ tons. The largest individual mass yet found in Australia. Found near Melbourne, Victoria. Photograph, British Museum (N.H.).

PLATE II.

Fig 1.—The Mount Stirling siderite, Western Australia. Weight 91·39 kg. (200 lb). Height 42·5 cm. (17 inches).

Fig. 2.—The "Tieraco Creek" siderite, Western Australia. Weight 41·61 kg. (91¾ lb.). Length 47·5 cm (19 inches). Note the hole through the iron.

PLATE III.

Fig. 1.—The "Weekeroo" siderite, South Australia. Weight 94·1 kg. (207½ lb.). Height 48·7 cm (19½ inches).

Fig. 2.—The "Yenberrie" siderite, Northern Territory. Weight 130·07 kg. (291 lb.). Height 42·5 cm. (17 inches). Two pieces of this iron were found. The smaller portion (the top part) was found to fit on to the larger portion and the photograph is taken of a cast showing the two portions in their correct position.

Fig. 3.—The "Youndegin No. 6", Western Australia. Weight 927·14 kg. (2,044 lb.). Photograph, Geological Survey of Western Australia.

PLATE IV.

Fig. 1.—The "Delegate" siderite, New South Wales. Weight 27·66 kg. (61 lb.). Length 42·5 cm. (17 inches). Photograph, Geological Survey of N. S. Wales.[61]

Fig. 2.—The "Mungindi No. 2" siderite, Queensland. Weight 23·13 kg. (51 lb.).

PLATE V.

The "Bugaldi" siderite, New South Wales. Weight 2·05 kg. (4½ lb.). Height 13 cm. (5¼ inches).

Fig. 1.—Side view of the iron showing the flow of the molten oxidized iron from the forward end (thick end) to the tail.

Fig. 2.—View of the forward end showing the waves formed in the molten surface of the iron during flight. Photograph, G. W. Card.

PLATE VI.

Fig. 1.—The "Moonbi" siderite, New South Wales. Weight 13·16 kg. (29 lb.). Photograph, J. M. Curran.[90]

Fig. 2.—The "Roebourne" siderite, Western Australia. Weight 86·94 kg. (191½ lb.). Height 55 cm. (22 inches).

Fig. 3.—The "Murnpeowie" siderite, South Australia. Weight 1,143 kg. (2,520 lb.). Photograph, after L. L. Smith.[109]

PLATE VII.

Fig. 1.—The "Nocoleche" siderite, New South Wales. Weight 20 kg. (44 lb.). Width 25 cm. (10 inches).

Fig. 2.—The "Coolac" siderite, New South Wales. Weight 19·29 kg. (42½ lb.). Width 22·5 cm. (9 inches).

Fig. 3.—The "Mount Edith No. 2" siderite, Western Australia. Weight 165·1 kg. (364 lb.). Width 60 cm. (2 feet).

PLATE VIII.

The Henbury Siderite.

Fig. 1.—A complete individual mass. Weight 43·6 kg. (96 lb.).

Fig. 2.—A complete individual mass. Weight 53·5 kg. (105 lb.).

Fig. 3.—A collection of the curiously torn fragments found in thosuands around some of the craters. Photograph, A. R. Alderman.

Fig. 4.—Portion of the wall of the main crater at Henbury Cattle Station, Finke River, Central Australia. Over the edge are seen the tops of trees growing in the water crater. Photograph, A. R. Alderman.

PLATE IX.

The Henbury Craters.

Fig. 1.—Looking into the main crater.

Fig. 2.—View from the south of three of the craters. The larger trees are in the water crater which with another hides the full extent of the main crater.

Photographs, A. R. Alderman.[72]

PLATE X.

Portion of the Hammond collection of the Tenham stones in the Queensland Geological Survey Museum, Brisbane. Photograph, Geological Survey of Queensland.

PLATE XI.

The remainder of the Hammond collection of 27 stones in the Queensland Geological Survey Museum. So far a total of 230 stones has been preserved.

PLATE XII.

Fig. 1.—The "Kingoonya" aerolite, South Australia. The three broken pieces put together. Estimated weight 2·7 kg. (6 lb.). Length 13·8 cm. (5½ inches). Photograph, courtesy of G. W. Card.

Fig. 2.—The larger of the two portions of the "Elsinora" aerolite, New South Wales, that have been preserved. Weight 1·28 kg. (2 lb. 10 oz.). Height 12·5 cm. (5 inches). Note the band of nickel iron in the centre.

Fig. 3.—The "Narellan" aerolite, New South Wales. Weight 367·5 gr. (12¾ oz.). Height 6 cm. (2⅜ inches).

Fig. 4.—The "Emmaville" aerolite, New South Wales. Weight 127 gr. (4½ oz.). Length 6·3 cm. (2½ inches).

PLATE XIII.

Part of the collection of the "Gilgoin" aerolites, New South Wales. Portion weighing 17 lb. of "Gilgoin No. 1" is not shown.

Fig. 1.—Portion of No. 6 weighing 3·6 kg. (8 lb.).

Fig. 2.—No. 3 weighing 25 kg. (55¼ lb.).

Fig. 3.—Portion of No. 7 weighing 3·68 kg. (8 lb. 2 oz.).

Fig. 4.—No. 8 weighing 11·9 kg. (26¼ lb.).

Fig. 5.—No. 2 weighing 3·1 kg. (74 lb).

Fig. 6.—Cast of No. 4. Weight 16·8 kg. (37 lb.).

PLATE XIV.

The "Binda" Aerolite, New South Wales.

Fig. 1.—The only portion that appears to have been preserved. Weight 2·6 kg. (5¾ lb.). Length 15 cm. (6 inches).

Fig. 2.—A portion, somewhat enlarged, showing radiating ridges of secondary crust.

PLATE XV.

Fig. 1.—The "Barratta No. 1" aerolite, New South Wales. Weight 65 kg. (145 lb.). Length 62 cm. (24¾ inches). Photograph, after A. Liversidge.[14]

Fig. 2.—The "Eli Elwah" aerolite, New South Wales. Weight 15·2 kg. (33½ lb.). Height 19·4 cm. (7¾ inches). Photograph, Geological Survey of N. S. Wales.

Fig. 3.—The "Molong" pallasite, New South Wales. Weight 105·2 kg. (232 lb.). Height 35 cm. (14 inches).

PLATE XVI.

Fig. 1.—Etched surface of the "Arltunga" micro-octahedrite, Central Australia. Magnified 100 diameters. Photograph, after D. Mawson.[3]

Fig. 2.—Etched surface of the "Tieraco Creek" fine octahedrite, Western Australia.

Fig. 3.—Etched surface of the "Nocoleche" medium octahedrite, Now South Wales.

Fig. 4.—Etched surface of the "Thunda" medium octahedrite, Queensland.

Fig. 5.—Etched surface of the "Kyancutta" medium octahedrite, South Australia.

Fig. 6.—Etched surface of the "Glen Ormiston" brecciated octahedrite, Queensland. Photograph, after H. C. Richards.[69]

Plate XVII.

Fig. 1.—Etched surface of the "Youndegin" coarse octahedrite, Western Australia. Photograph, Geological Survey of Western Australia.

Fig. 2.—Etched surface of "Bingara No. 3" ("Barraba").

Fig. 3.—Etched surface of "Bingara No. 4" ("Warialda").

Fig. 4.—Etched surface of "Bingara No. 1".

Fig. 5.—Polished surface of the "Molong" pallasite, New South Wales. The olivine is the dark portion and the nickel iron the light.

Plate XVIII.

Micro-photographs of Australian Aerolites. Magnification 25 diameters.

Fig. 1.—The "Gilgoin No. 1" aerolite, New South Wales. Showing a large chondrule of fibrous enstatite. A little above the centre is a broken chondrule of olivine surrounded by nickel iron. The black includes both nickel iron and black glass which cannot be differentiated in the photograph. The plain white fragmental material is mostly olivine.

Fig. 2.—The "Elsinora" aerolite, New South Wales, showing chondrules of olivine (lightest) and enstatite in a groundmass of both minerals with nickel iron, and a little troilite and felspar.

Fig. 3.—The "Carraweena" aerolite, South Australia. At the bottom left-hand is a broken chondrule of fibrous enstatite, the parts being separated by nickel iron and black glass. Two granular olivine chondrules can be seen at the left centre and bottom right. Other chondrules are enstatite mostly separated by nickel iron and glass.

Fig. 4.—The "Barratta" aerolite, New South Wales. The large chondrule consists of fibrous enstatite. The white granular broken chondrule in the centre is olivine. The black is nickel iron. These minerals are all represented in the groundmass.

Fig. 5.—The "Narellan" aerolite, New South Wales. Chondrules are scarce. An olivine chondrule (very rare) may be seen at the top left, while the greyish patches at the top constitute a chondrule of fibrous enstatite. The groundmass consists of these two minerals with felspar and practically no glass. The black is nickel iron.

Fig. 6.—The "Kingoonya" aerolite, South Australia. At the bottom right hand is a veined chondrule of finely fibrous enstatite, while at the top is a chondrule consisting of olivine and a much decomposed mineral (dark grey). The groundmass consists of fragmental material of these two minerals. Many of the fragments are surrounded by a black glass which also invades them along cracks.

Plate XIX.

Tektites, Variety Australite.

Figs. 1 and 2.—The obverse and reverse views of an australite said to have fallen in recent times at Mount Cameron Water Race near Pioneer Mine, north-eastern Tasmania. Photographs, courtesy of the late T. W. Edgeworth David.

Fig. 3.—Boat-shaped variety said to have fallen at Booanya, Balladonia, via Norseman, Western Australia.

Fig. 4.—Central Australia.

Fig. 5.—Stannifer, New South Wales.

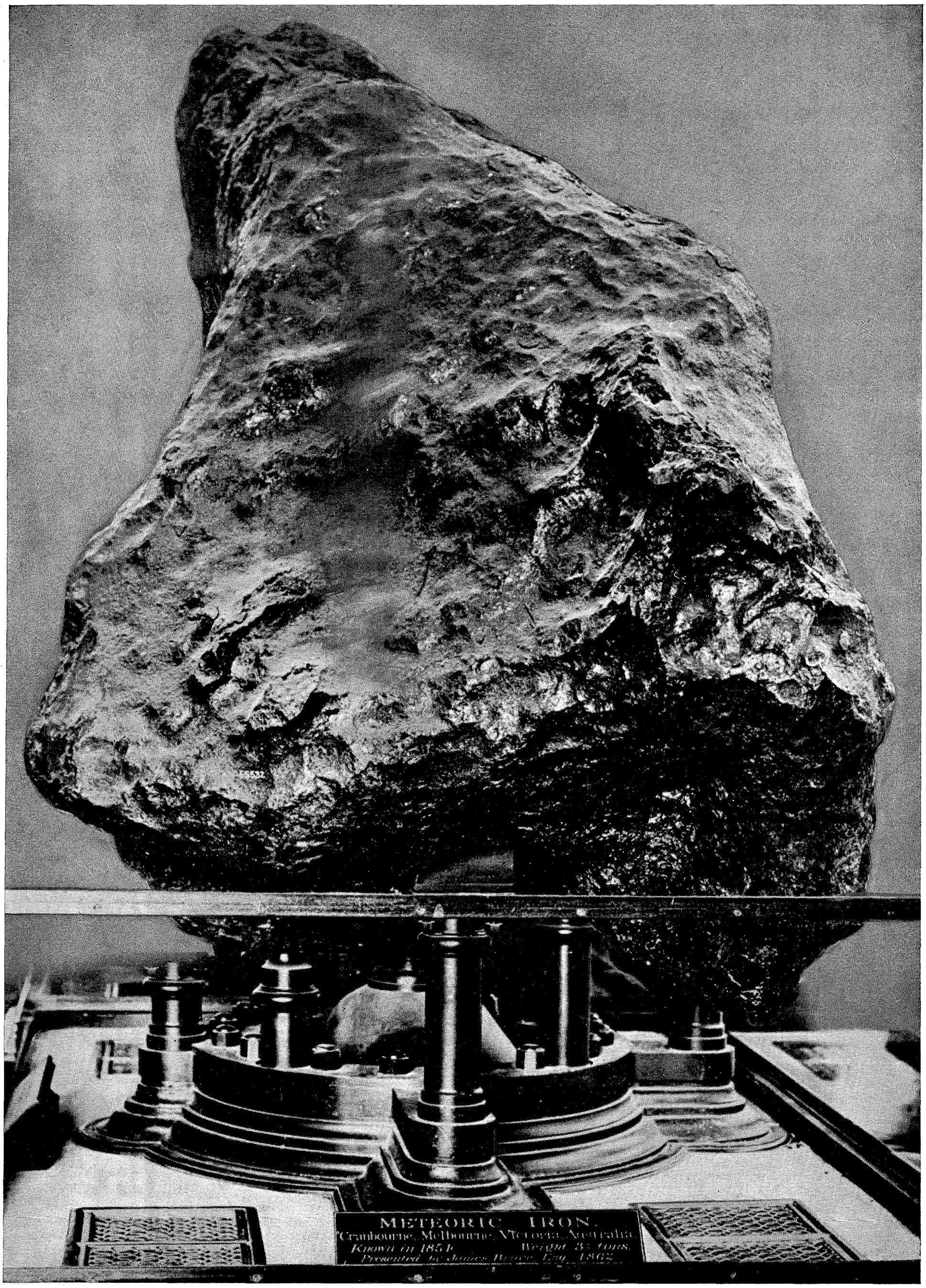
Fig. 6.—Tumberumba, New South Wales.

Fig. 7.—Granite Creek, Mount Leonora, Western Australia.

Fig. 8.—Near Uralla, New South Wales.

Fig. 9.—Mount Hope, New South Wales.

Fig. 10.—Murremarang, New South Wales.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Cranbourne, Melbourne, Victoria, Australia.
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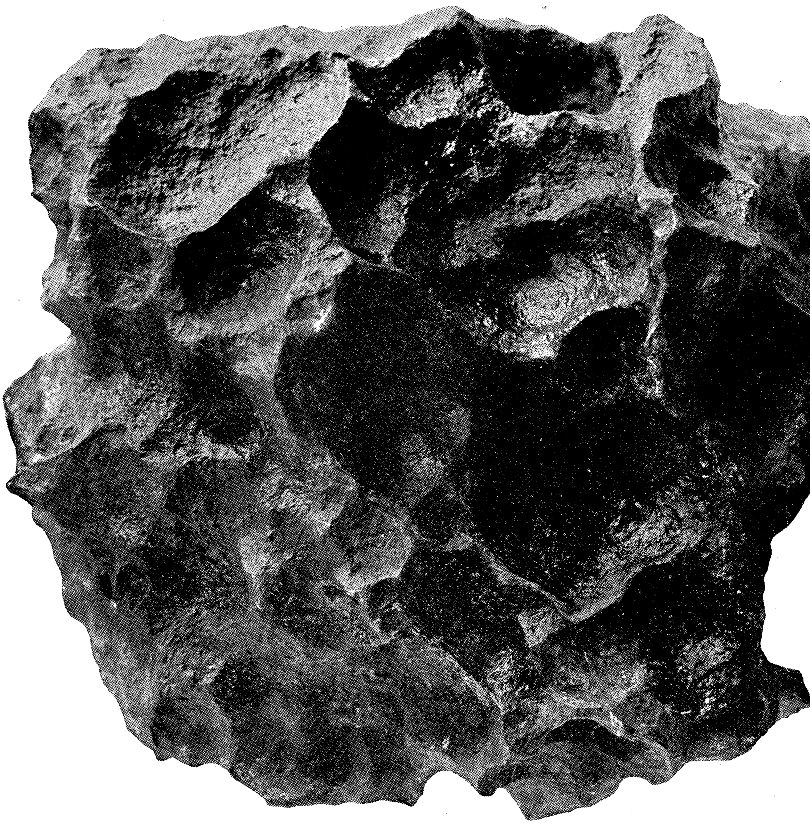

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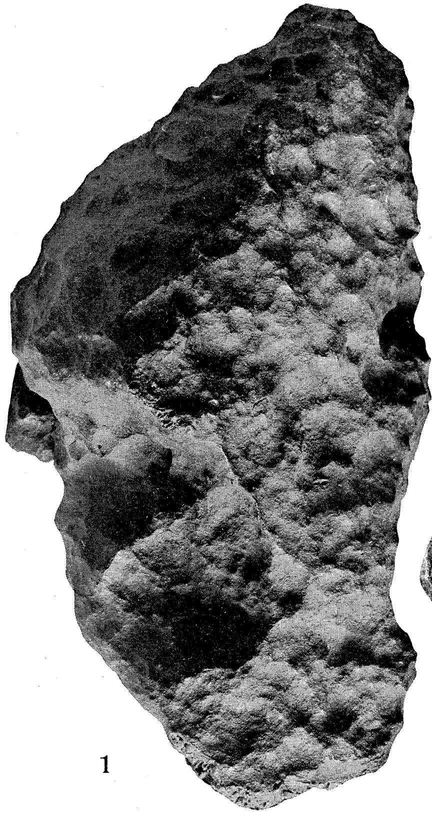

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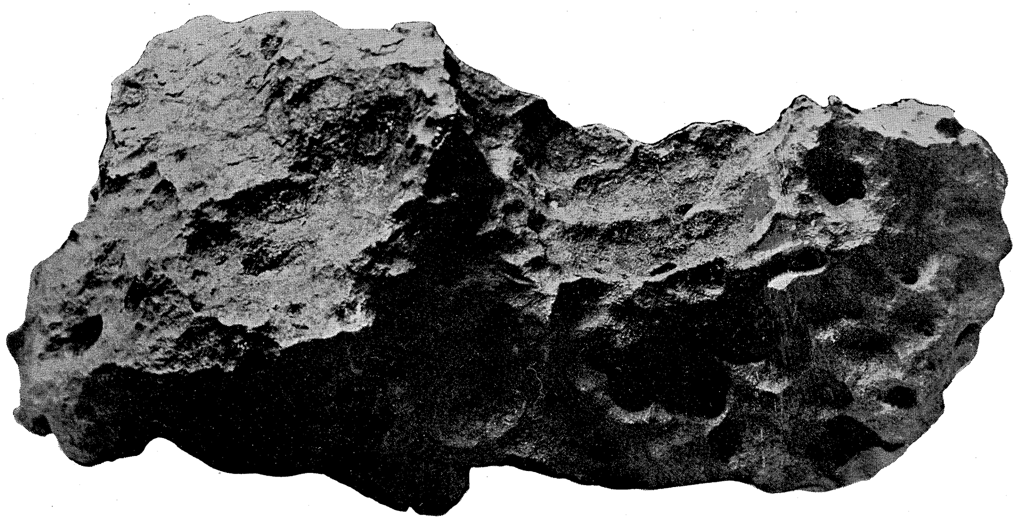

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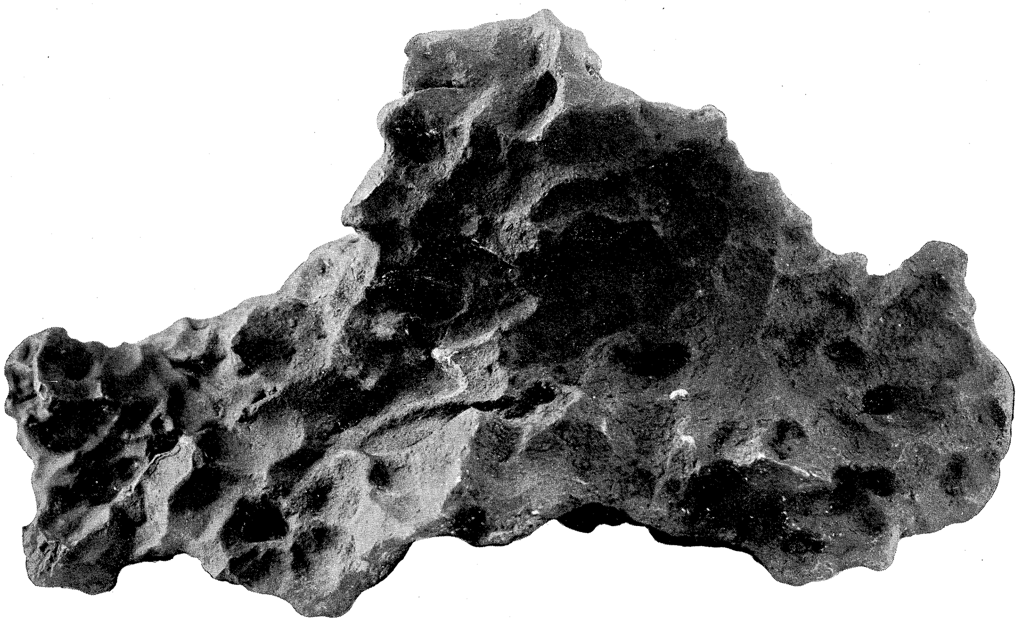

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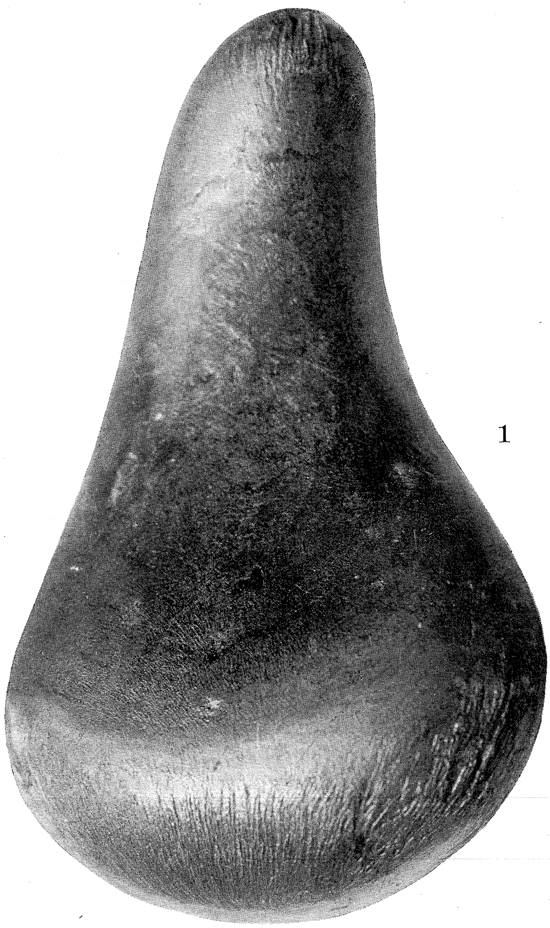

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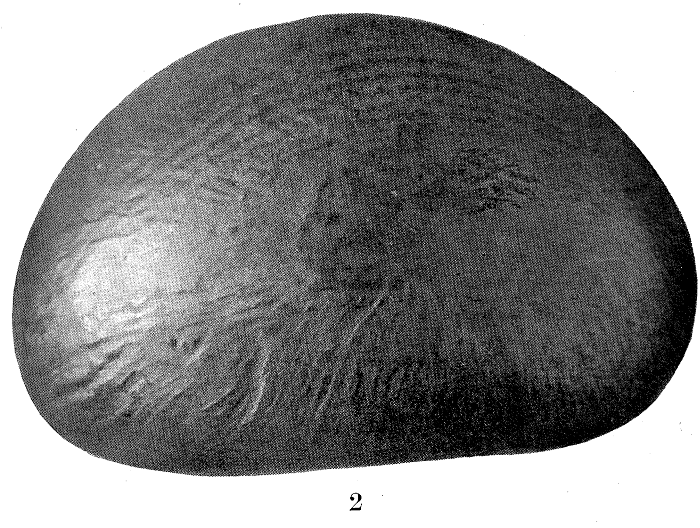

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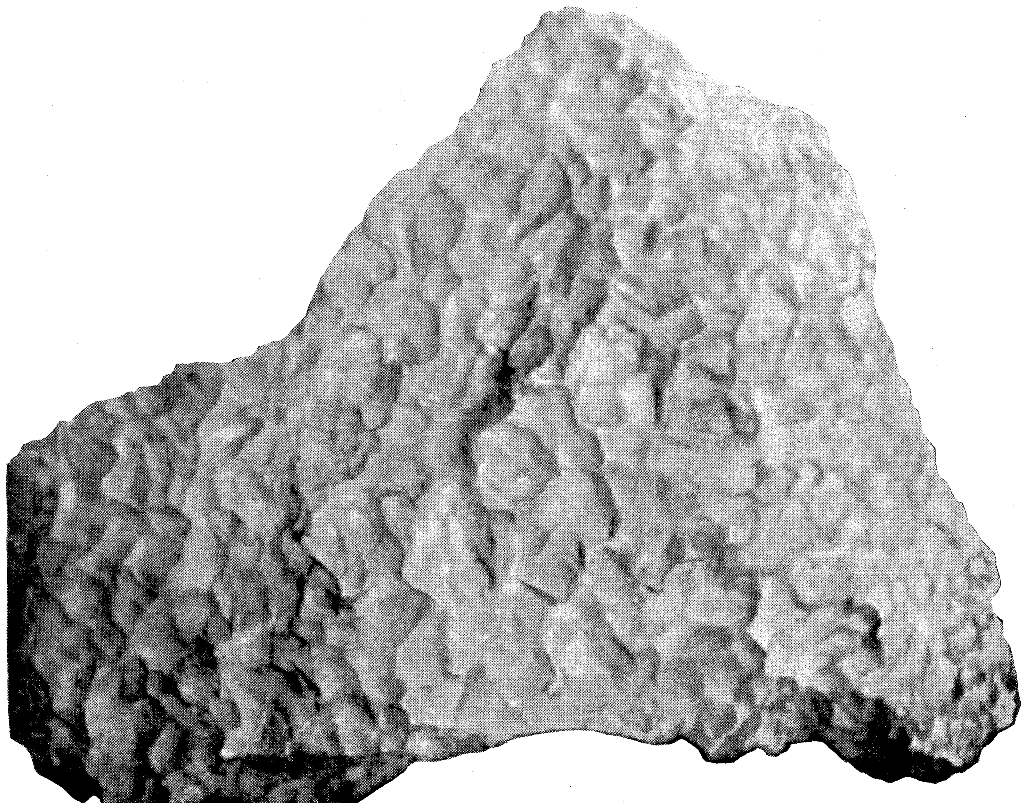

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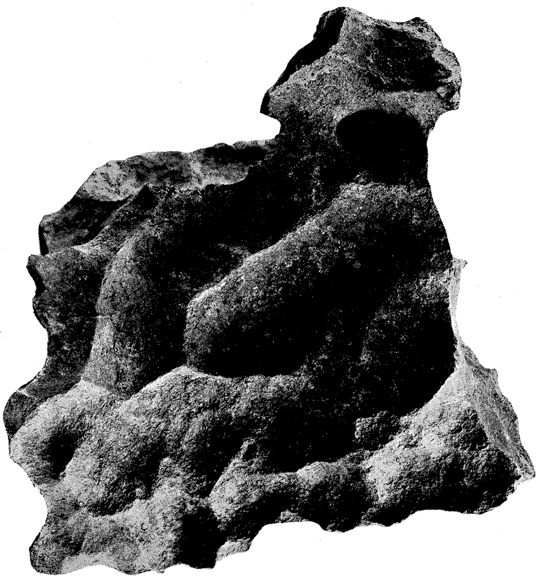

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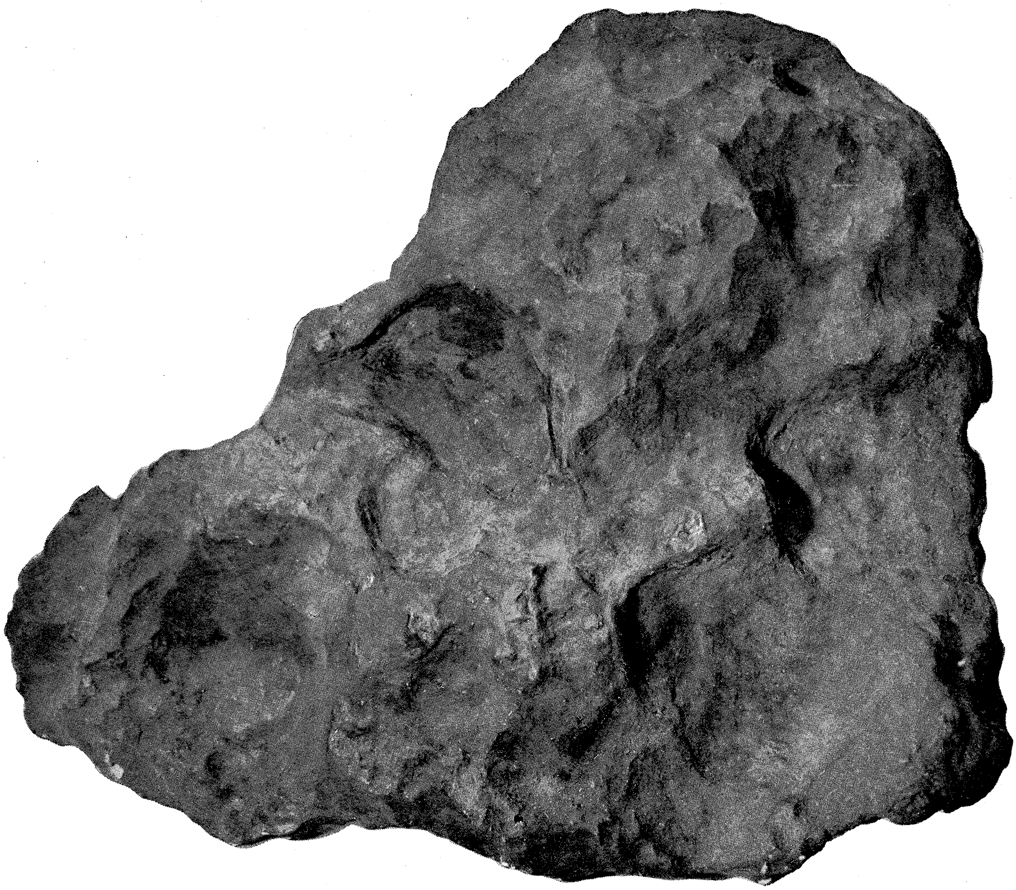

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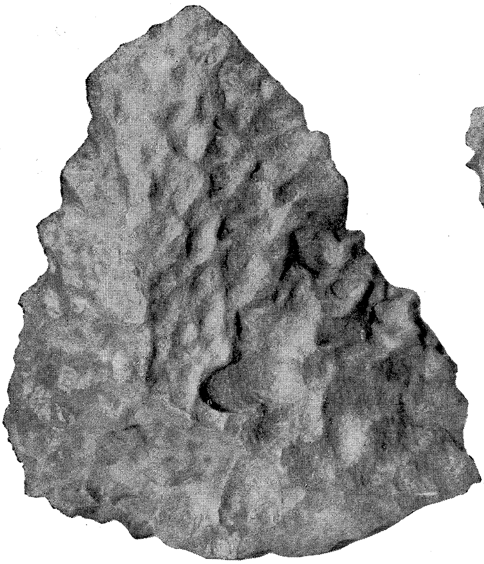

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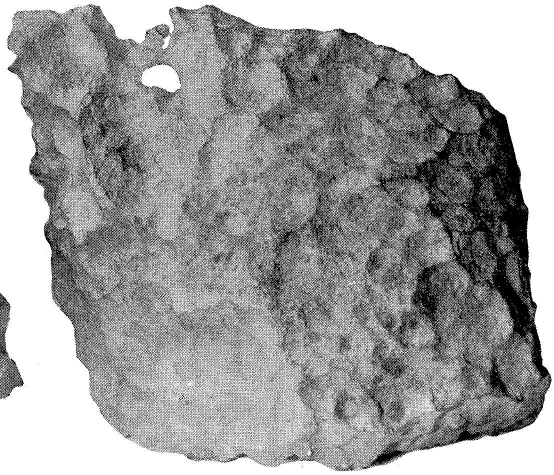

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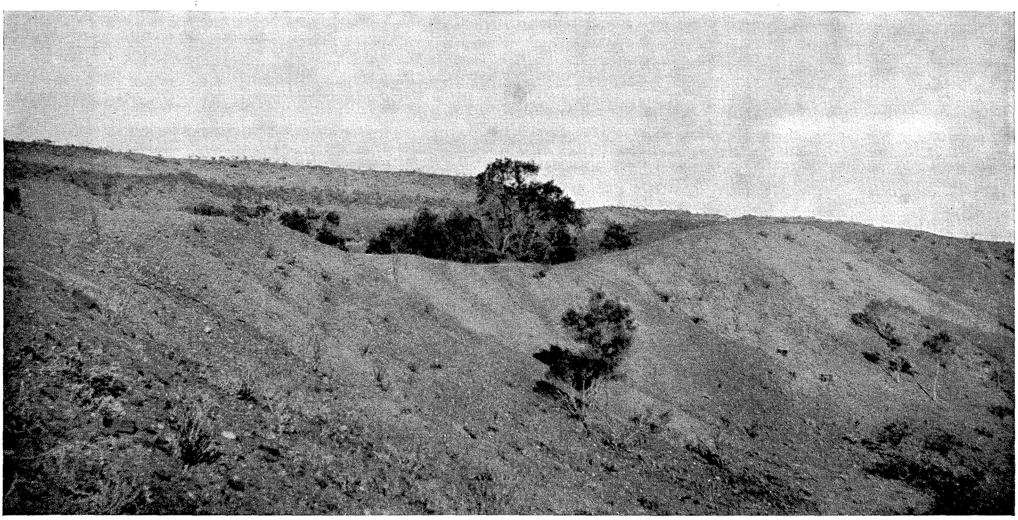

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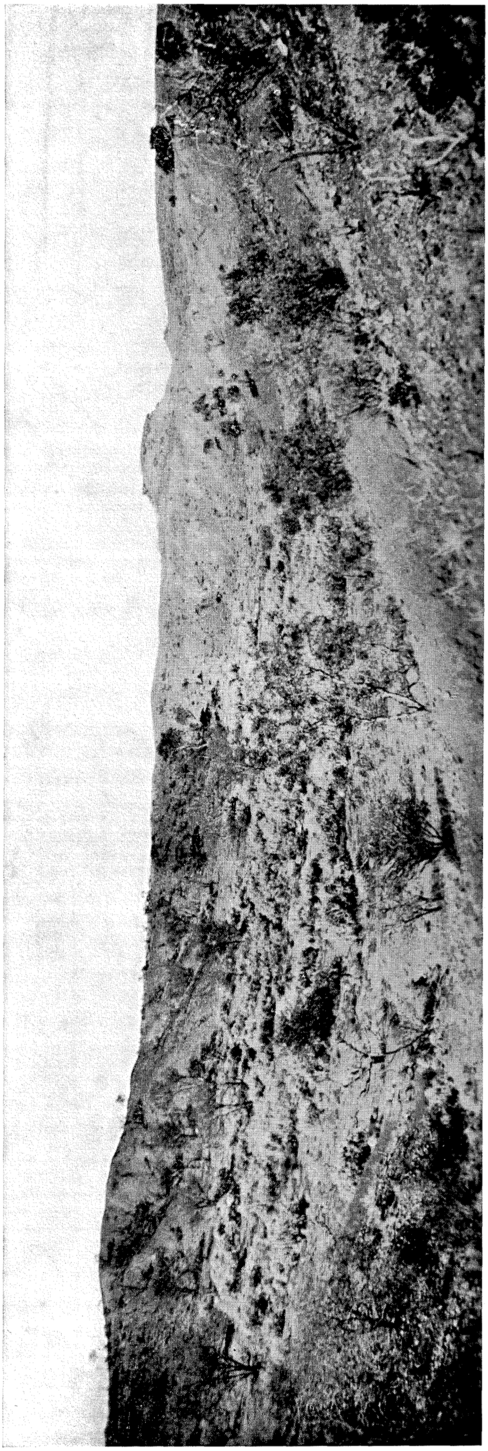

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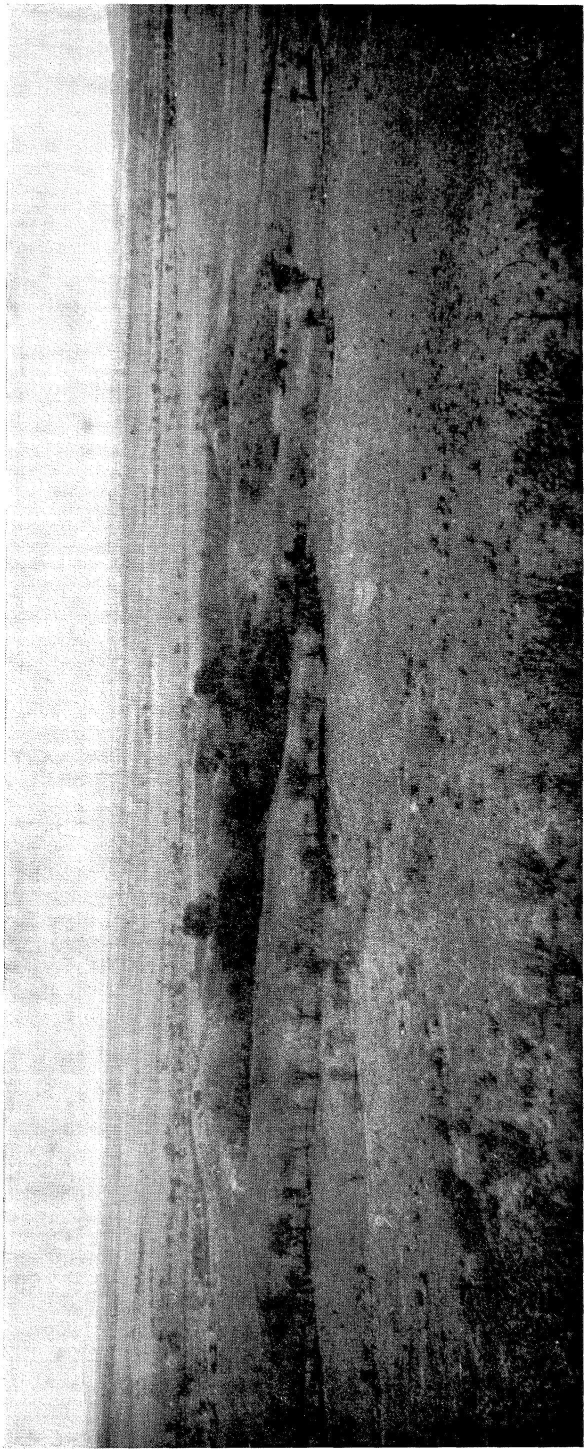

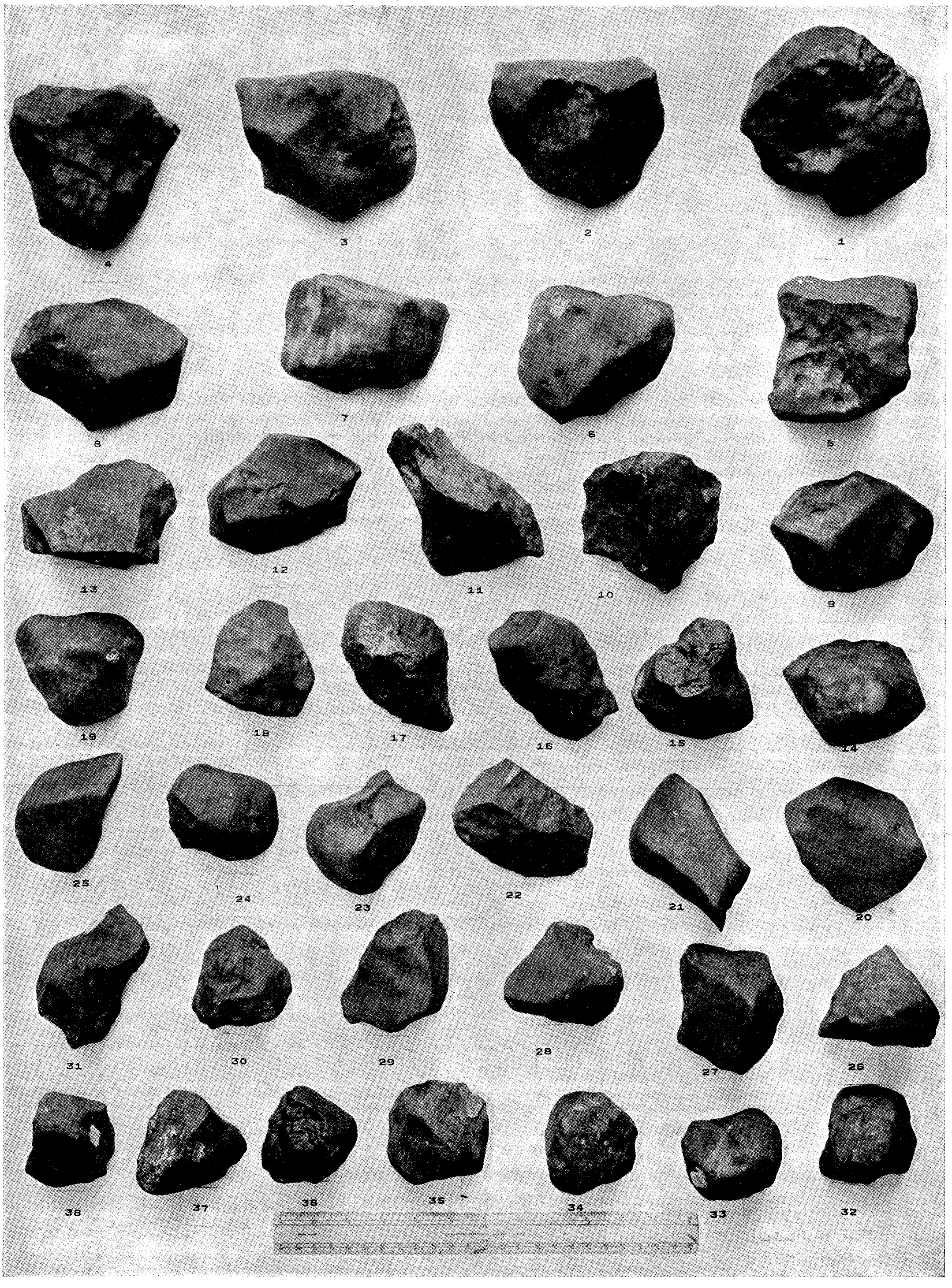
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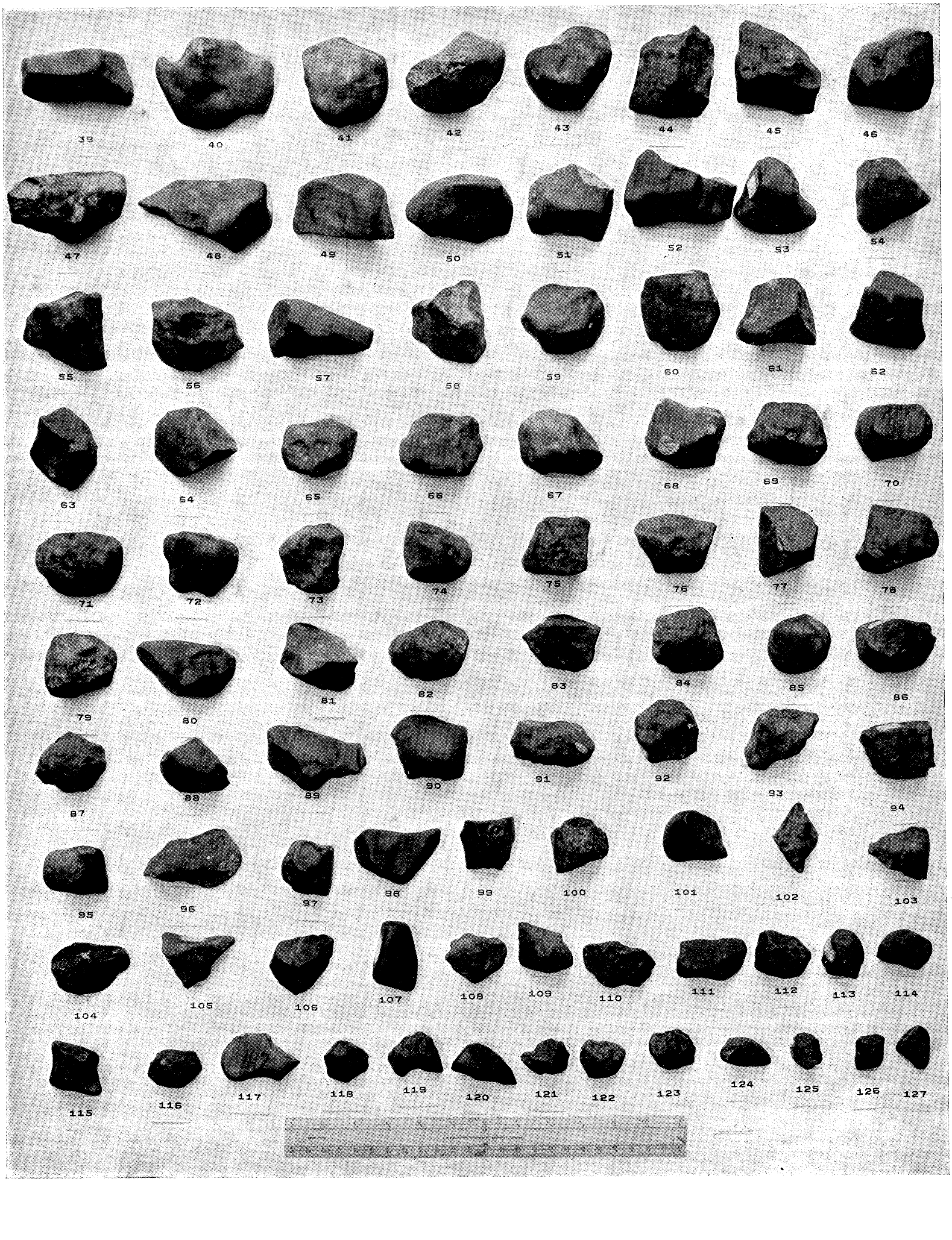
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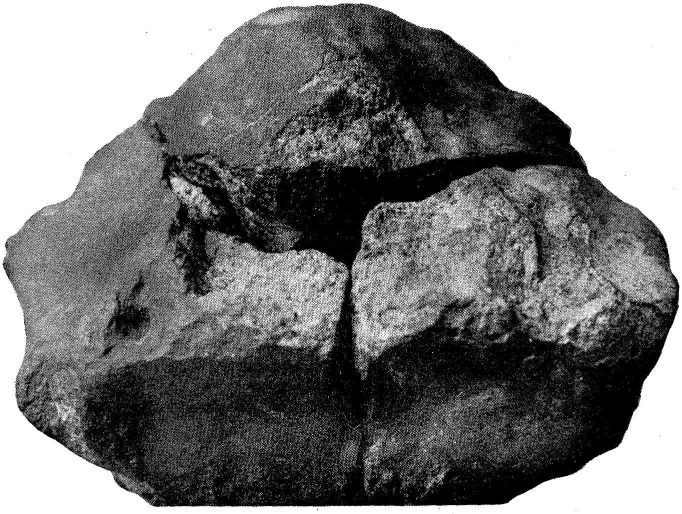

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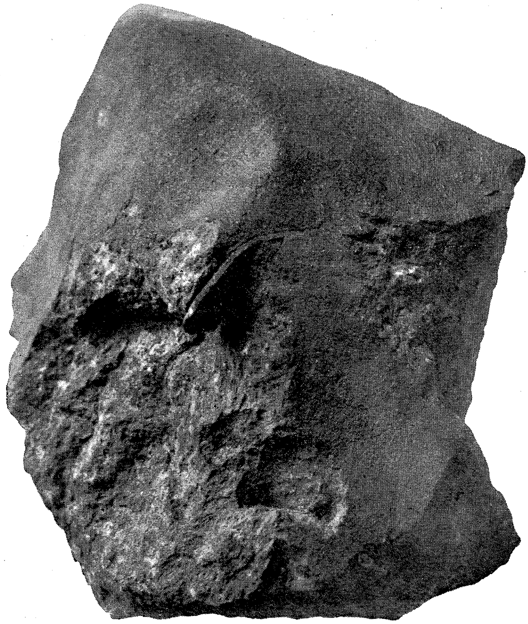

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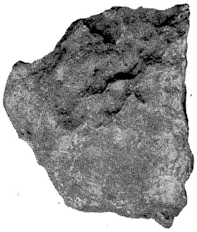

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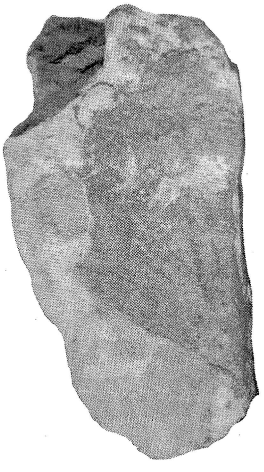

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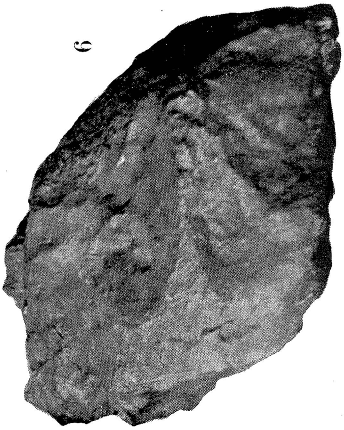

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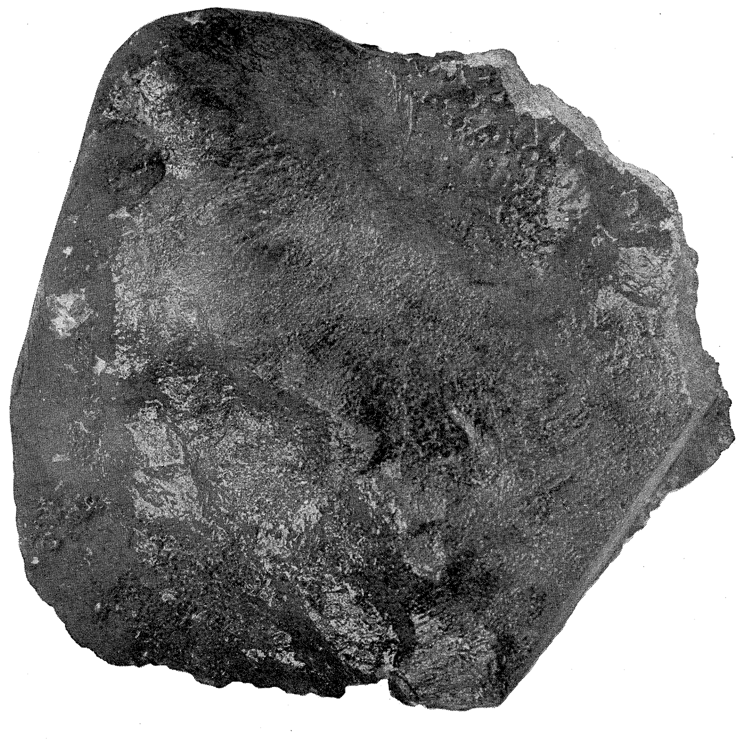

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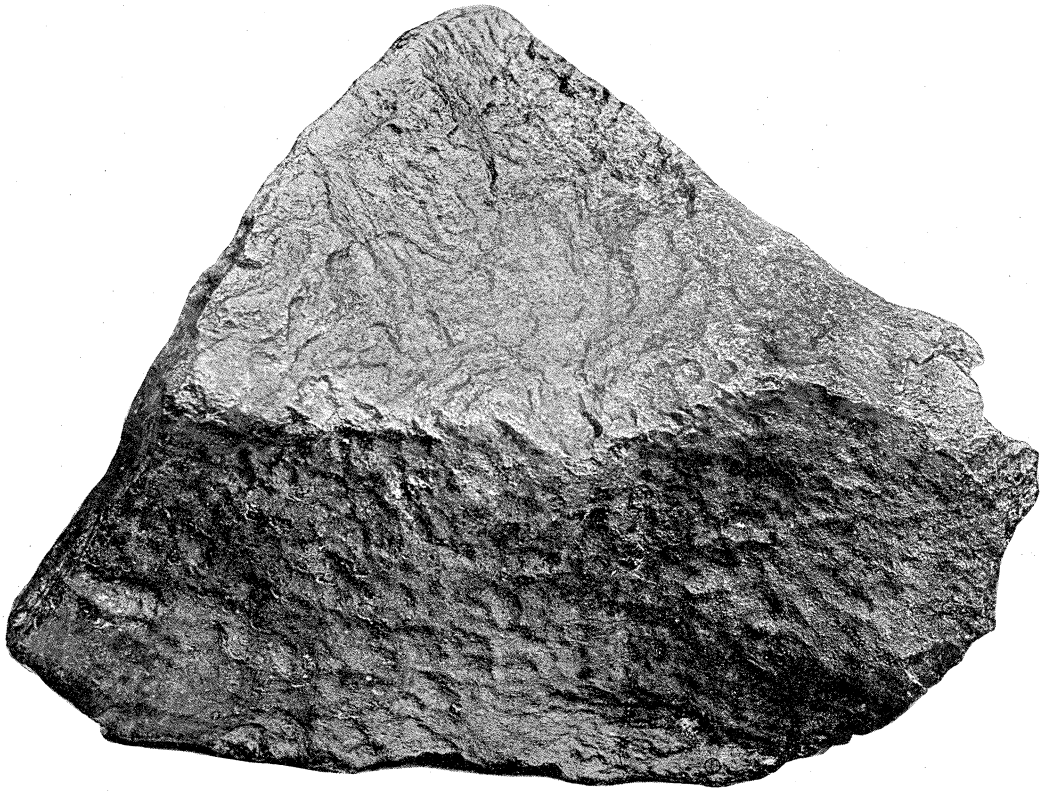

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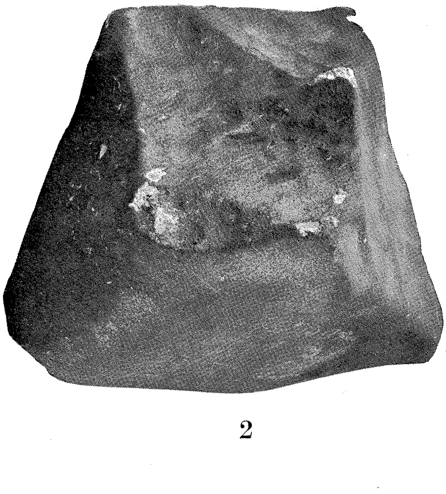

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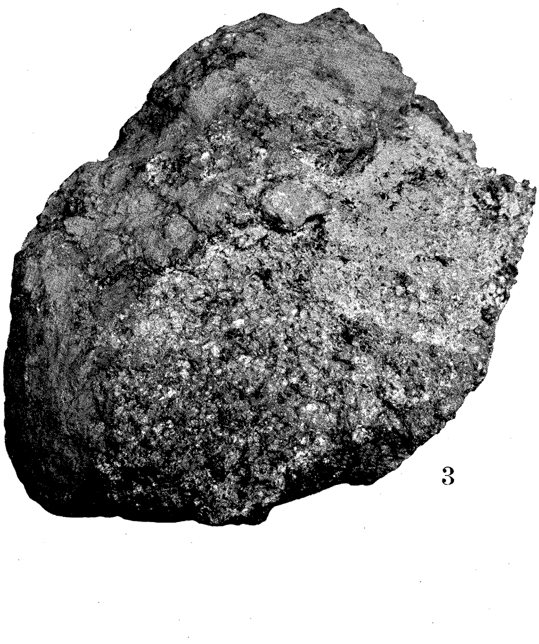

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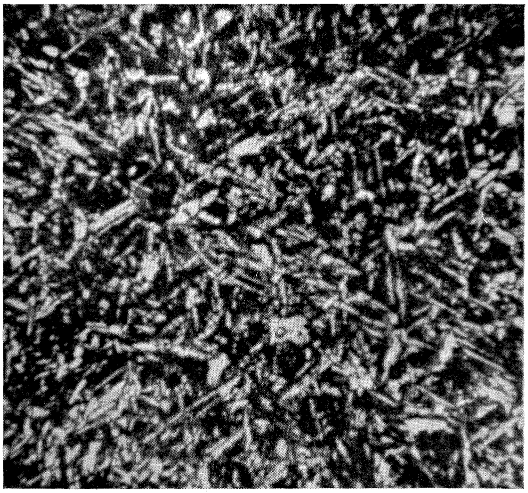

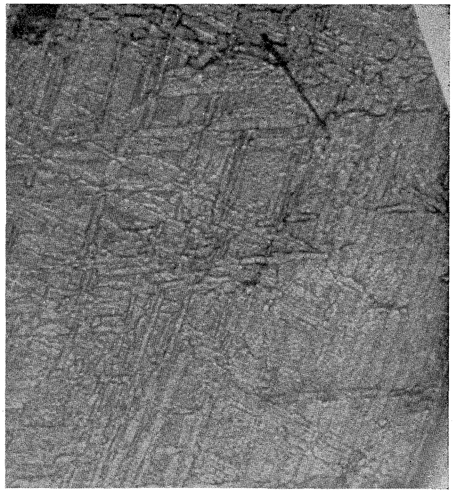

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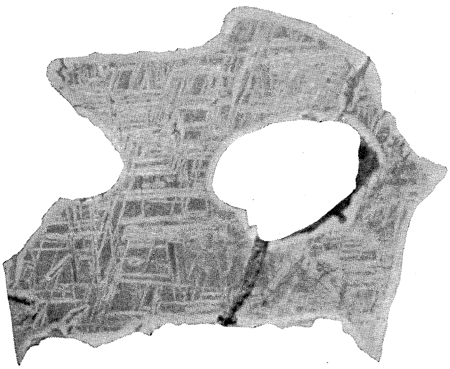

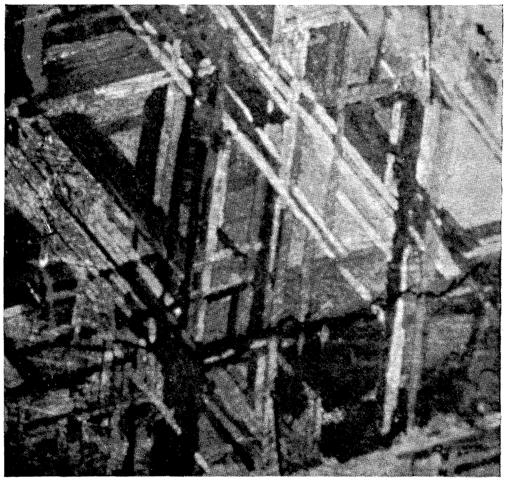

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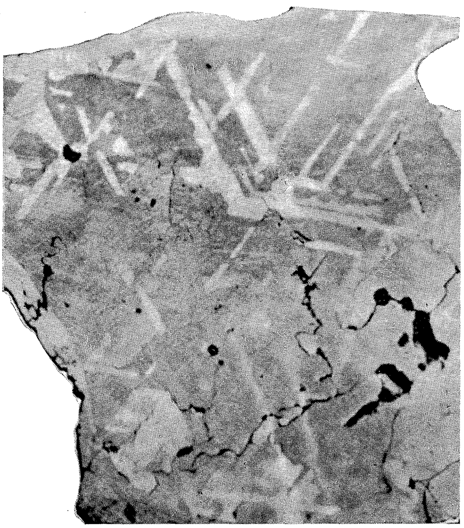

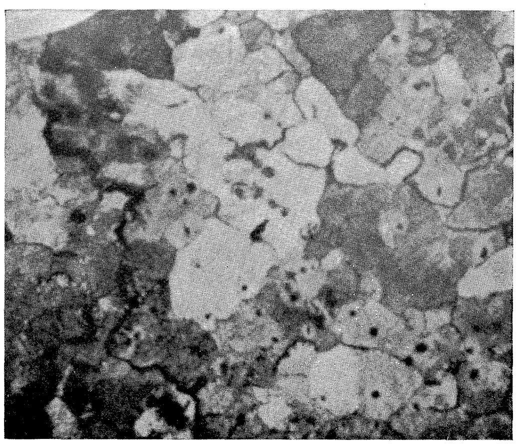

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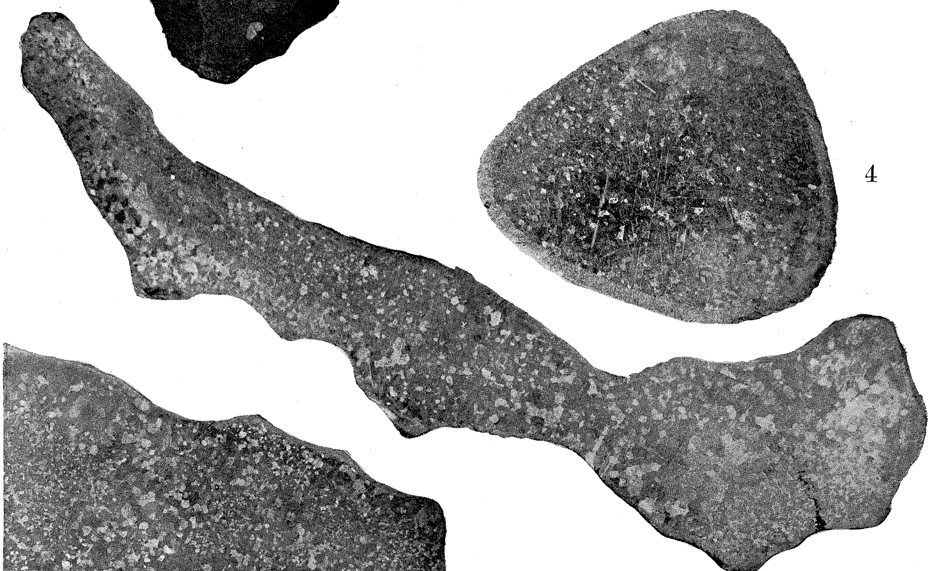

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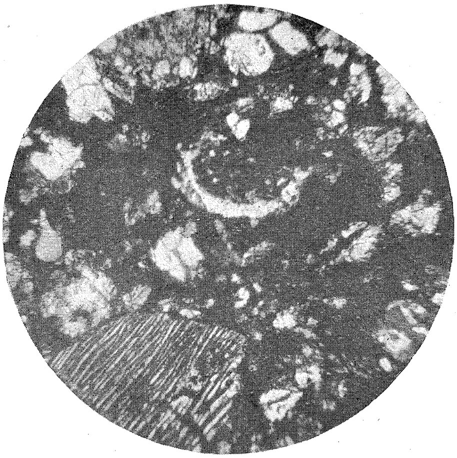


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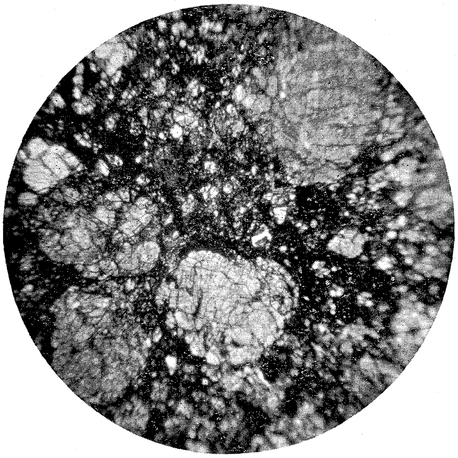

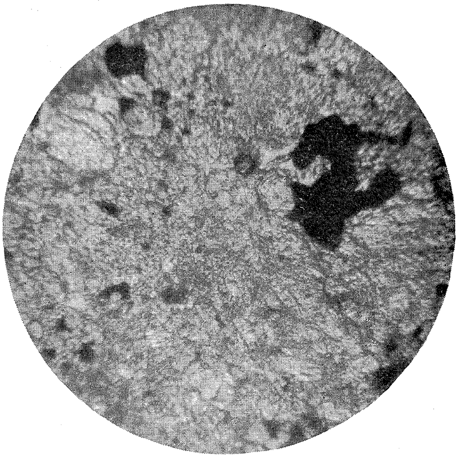
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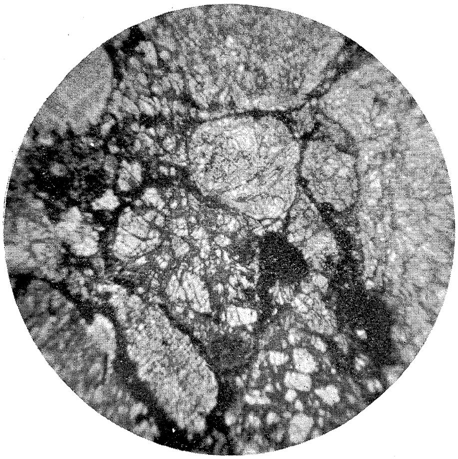


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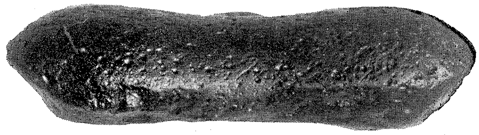
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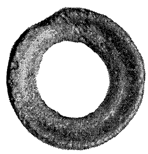
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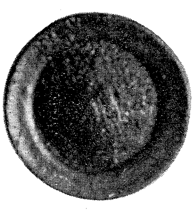
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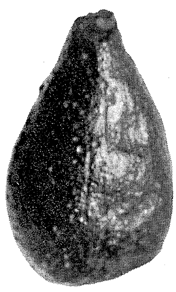
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