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A history of Western Australian meteoritics

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Abstract

The first documented Western Australian meteorites were a number of irons, the first of which was found in 1884 when agriculture was being established east of the early settlement at York. These became known as the "Youndegin meteorites" after a police station which was the last outpost of civilisation at the time. Some of these large specimens were taken to London to be sold as scrap metal, but fortunately were recognised as meteorites and acquired by various museums around the world.

Despite the sparse population and relatively recent time of settlement by Europeans, a number of factors have led to Western Australia's excellent record of meteorite recovery. Firstly the large regions of arid country enable meteorites to be preserved for long periods of time and recognised against the country rocks; secondly as far as can be ascertained the Aboriginal people of Australia showed little interest in meteorites; and thirdly Western Australians have presented their discoveries to the Western Australian Museum in recognition of their value to science.

The person responsible for laying the foundation for the State's meteorite collection was Dr E.S. Simpson who, as Government Mineralogist from 1922 to 1939, collected and analysed many of the meteorites which today form the basis of the collection. The first catalogue describing Western Australian meteorites was published in 1965. It described 48 Western Australian meteorites, 29 of which were irons. The large number of irons probably resulted from their long terrestrial ages and the ability of people to recognise them. The small proportion of falls to finds (2 in 48) is probably due to the sparse population of the State. Interest in meteoritics was enhanced in the 1960s so that when the 2nd Supplement to the Catalogue was published in 1972, 92 meteorites were recorded, most of the additional discoveries being stones.

The Nullarbor Region in the Eucla Basin has been a 'happy hunting ground' for meteorite collectors. To date, 78 distinct and well-documented meteorite finds are recorded from this region, and since 1971, in excess of 500 individuals and fragments of meteorites have been recorded from the Eucla Basin. The doyen of Western Australian meteorite collectors is undoubtedly Mr A.J. Carlisle, who has lived and worked in the Nullarbor Region for much of his life. Specimens from approximately 80 distinct meteorites have been found by members of the Carlisle family.

Introduction

In September 1990 the 53rd Annual Meeting of the Meteoritical Society was held in Perth. This was an historic occasion because it was the first time in the history of the Society that an Annual Meeting had ever been held outside North America or Europe. Perth was chosen because of the acknowledged excellence of the meteorite collection,

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the opportunity for field trips in Western Australia, and the presence of a group of meteoriticists who were prepared to organise the meeting.

The Annual Meeting was an undoubted success with approximately 250 delegates in attendance and over 160 papers being presented. A unique 20 day Australian Craters Expedition was organised under the leadership of Drs E.M. and C.S. Shoemaker, with a full attendance of 50 delegates. Other field trips were offered after the Meeting. This meeting of the Meteoritical Society, under the Presidency of Dr S.R. Taylor (ANU), has stimulated meteorite research in Australia and will undoubtedly herald a new era in meteoritics in Western Australia, including an enhanced display of meteorites in the Western Australian Museum. It therefore seems appropriate to record the history of meteorites in Western Australia at this time.

The earliest meteorites found in Western Australia were a number of irons, the first of which was discovered in 1884 when agriculture was being established east of the early settlement at York. These were named the "Youndegin meteorites" after a police outpost in the district, although they were actually found some 1300 metres northwest from Penkarring Rock, now known locally as Pikaring Hill (as shown in Figure 1).

The first specimen (designated *Youndegin I*) was found on 5th January 1884 by a mounted policeman named Alfred Eaton, whilst on duty in the Youndegin area. The Curator of the Geological Museum in Fremantle, the Rev. Charles G. Nicolay, requested the Commissioner of Police in Perth to send Mr Eaton back to Penkarring Rock to search for additional specimens, three of which had been observed at the time of the initial discovery. These fragments (*Youndegin II-IV*), together with a considerable amount of weathered iron oxides, indicated that the specimens had lain on the surface for some time and probably represented a single, disintegrated mass. Reverend Nicolay presented *Youndegin I* and *IV* to the British Museum, and this enabled Fletcher (1887) to confirm that the *Youndegin* irons were in fact meteorites. He also carried out a chemical analysis on *Youndegin I*, and identified a cubic form of graphitic carbon in the specimens, which he called "cliftonite". This was the first scientific publication describing a Western Australian meteorite. Further specimens of the Youndegin meteorite were found in 1891 (*Youndegin V*) and in 1892 (*Youndegin VI*). These masses were sold to a London mineral dealer (Gregory 1892), but the specimens were later acquired by the Field Museum of Natural History in Chicago and the Naturhistorisches Museum in Vienna, respectively. An additional mass, *Youndegin VII*, was found in 1929, as were a number of fragments collectively known as *Youndegin VIII*. One of these fragments was made into a horseshoe which hung in a blacksmith's shop in York for many years (Simpson 1938).

Some iron meteorites found later in the same district were not given the name "Youndegin". In 1892, two pieces of Youndegin were found to the east of Pikaring Hill and were given the name *Mount Stirling*. Other meteoritic fragments named *Mooranoppin I* and *II*, were found to the north of Pikaring Hill in 1893 and 1933, respectively (Simpson 1938). The largest mass of the Youndegin meteorites, a 2626 kg iron, was found in 1903, and named *Quairading*, although it was not presented to the

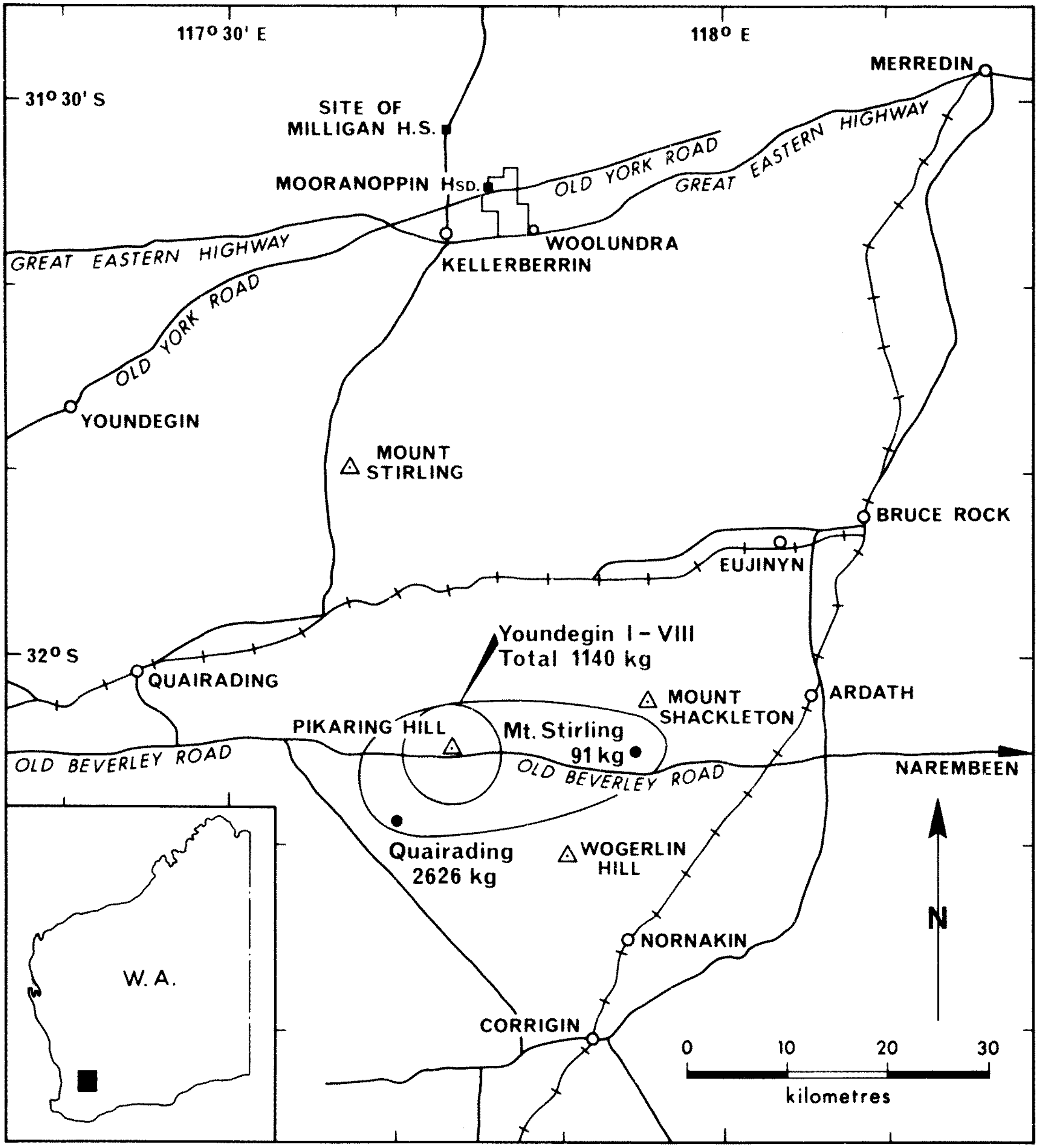

Figure 1 Map of part of Western Australia showing the location of specimens comprising the Youndegin meteorite shower (after Cleverly and Cleverly 1990).

Western Australian Museum until 1954, having been rediscovered during farming operations using a World War II General Grant tank. The most recent member of the Youndegin meteorites, weighing 4.66 kg, was donated to the Quairading District High School in the early 1970's and was identified by De Laeter and Hosie (1985). A detailed examination of the microstructure and chemical composition of the meteorites listed in Table 1 (De Laeter 1973a) showed that they belonged to chemical group IA (Wasson 1974), and were all part of the Youndegin meteorite shower, which probably resulted from the atmospheric disruption of a meteoroid travelling in a south-westerly direction. Cleverly and Cleverly (1990) have recently re-examined the provenance of the Youndegin meteorite shower and delineated a tentative strewnfield (shown in Figure 1), which they believe indicates atmospheric passage in a westerly direction.

It is of interest to compare the elemental concentration in weight percent of nickel and cobalt in the Youndegin meteorites determined by present day analytical methods with the values given by Fletcher (1887) to ascertain the accuracy of the chemical procedures used in the 19th Century. The values given by De Laeter (1973b) vary from 6.47%-7.08% and 0.44%-0.46% for nickel and cobalt respectively, whereas Fletcher (1887) gives corresponding values of 6.46% nickel and 0.55% cobalt for *Youndegin I*. It is apparent that the nickel values compare well, whilst the cobalt abundance determined by Fletcher (1887) is higher than the presently accepted value.

Several thousand specimens from 141 distinct meteorites have been found in Western Australia and described to date. This represents a recovery rate about four times greater than the World average on an aerial basis. More than 50% of all meteorites known from Australia have been recovered from Western Australia (Bevan 1992). A sparse population and relatively short history of settlement by Europeans in Western Australia (from 1829), makes this situation all the more surprising. Furthermore, many of the earliest recoveries of meteorites were sent to the British Museum or sold to other museums. Table 1 indicates that only 4 of the 14 masses of the Youndegin meteorites reside in the State, and only three in the collection of the Western Australian Museum. The absence of a Geological Museum in this State has also been a mitigating factor, for until the 1960s there was little interest in exhibiting meteorites at the Western Australian Museum and until 1985 there was, in fact, no permanent Curator of Meteoritics.

On the other hand, there are a number of factors which have contributed to the excellence of the Museum's collection:

1 The large regions of arid country, which constitute much of Western Australia, enable meteorites to be preserved for long periods of time after falling to the Earth's surface, and to be more easily recognised than in heavily vegetated terrain. The large areas of ploughed farmland also increase the probability of finding meteorites, whilst the vast extent of the Nullarbor Region, with its lack of vegetation and distinctive limestone country rocks, has proved to be an ideal location for finding meteorites.

2 As far as can be ascertained, the Aboriginal people of Australia were not interested in meteorites, either as objects of reverence or for their use as metals, whereas in other countries with ancient civilizations, meteorites have been collected and used for a variety of purposes over many centuries.

3 The excellent record of recovery of meteorites is a tribute to Western Australians who, in the main, have presented their discoveries to the Museum in recognition of their scientific value.

4 The Western Australian Museum Amendment Act of 1973 gives legal ownership of meteorites found in the State to the Crown, whilst the unauthorised export of meteorites from Australia is prohibited by Federal Legislation in the Protection of Movable Cultural Heritage Act (1986).

Table 1: Details of the Youndegin Meteorites

Name	Main Mass Kg	Date of find	Location of main mass
Youndegin I	11.7	1884	British Museum, London: 9.82 kg
Youndegin II	10.9	1884	National Museum, Melbourne: 10.9 kg
Youndegin III	7.9	1884	Western Australian Museum: 5 kg
Youndegin IV	2.72	1884	British Museum, London: 2.7 kg
Youndegin V	173.5	1891	Field Museum, Chicago: 141 kg
Youndegin VI	927	1892	Naturhistorisches Museum, Vienna: 927 kg
Youndegin VII	4.1	1929	Government Chemistry Centre of WA: 3.9 kg
Youndegin VIII	13.6	1891-1929	Private Collections
Mooranoppin I	1.6	1893	Ward-Coonley Collection: 1.1 kg
Mooranoppin II	0.82	1933	Western Australian Museum 0.725 kg
Mount Stirling	92.3	1892	Australian Museum, Sydney: 67.2 kg
	0.68	1892	Australian Museum, Sydney: 0.42 kg
Quairading	2 626	1903	Western Australian Museum: 2 626 kg
Quairading High School Specimen	4.66	1972	Quairading High School: 4.66 kg

Details of the Collection

The first catalogue of Australian meteorites was published by Anderson (1913). Western Australian meteorites listed in this catalogue comprised seven irons, including six specimens of Youndegin. The total number of distinct meteorites in the various Australian collections was 46, including 29 irons. The second Australian meteorite catalogue was published by Hodge-Smith (1939). It lists 20 irons (comprising 27 separately named specimens), one stony-iron and four stony meteorites from Western Australia. All these meteorites are finds, except perhaps for Gundaring which may have been seen to fall on 30 April 1930, although it was not recovered until 20 May 1937 (Simpson 1938). There is sufficient doubt about Gundaring to exclude it as a fall (see Table 2). Simpson (1938) described each of the Western Australian meteorites listed by Hodge-Smith (1939).

The first catalogue of Western Australian meteorites was published by McCall and De Laeter (1965). The number of iron meteorites had by then increased from 20 to 29, the number of stony-irons from one to four, whilst the number of stony meteorites had risen from 4 to 15. Two falls were listed — Gundaring and Woolgorong. Although the number of iron meteorites still dominate the Collection, there are now a significant number of stones. The large number of irons probably resulted from their long terrestrial ages and the fact that they are more easily recognised as meteoritic than are stony meteorites. The small proportion of falls to finds (2 in 48) is undoubtedly due to the sparse population of the State.

Community interest in meteorites was enhanced in the early 1960's, in part by the formation of a Meteorite Advisory Committee, so that when the Second Supplement to the Catalogue was published (McCall 1972), 92 meteorites were recorded, with most of the additional finds being stones. Details of the number and type of meteorites comprising the Western Australian Collection, are given in Table 2. There are presently 28 irons, 8 stony-irons, 101 chondrites and unclassified stones, and four achondrites. Of the total of 141 distinct meteorites currently recognised, only four are falls. These are all stones — Binningup (30th September, 1984), Millbillillie (October, 1960), Wiluna (2nd September, 1967) and Woolgorong (20th December, 1960). There are also three meteorite impact craters associated with meteorites — Dalgaranga, Veevers and Wolf Creek.

The person who was instrumental in laying the foundation for Western Australia's meteorite collection in the first forty years of this century was Dr E. S. Simpson who, for the period 1922 to 1939, was Government Mineralogist and Analyst. Although mostly remembered for his pioneering work on Western Australian minerals, he also collected, analysed and reported details of most of the meteorites found during this period of time, and ensured that they were placed in the Museum's Collection. The present status of the Western Australian Meteorite Collection owes much to the pioneering efforts of Dr Simpson.

During the period 1940 to 1960 a number of meteorites were recovered. These included Dalgety Downs and Mount Egerton (1941), Forrest Lakes (1948), Cocklebiddy (1949), Haig (1951), Duketon and Lake Grace (1956), Wingellina (1958), *Bencubbin II* and Lake Moore (1959), and Woolgorong (1960), in addition to the large '*Quairading*' mass of the Youndegin meteorite (1954).

The most remarkable discovery during this period was undoubtedly the Wolf Creek crater. Recognised from the air in 1947, it was described by Reeves and Chalmers (1949) and Guppy and Matheson (1950). Shale balls, representing the deeply weathered remnants of iron meteorites, were recovered from the site by Cassidy (1954). Taylor (1965) describes unaltered meteoritic material located at the Wolf Creek crater, which is roughly circular in shape with a diameter of 880m. The crater is situated within a roughly circular mound and is 40-55m deep, but is partially filled with wind-blown sand and gypsum (Figure 2).

Figure 2 The Wolf Creek Meteorite Crater which is located some 106 km south of Halls Creek in Western Australia. The diameter of the crater is approximately 880 m and it is 40-55 m in depth

The only other crater known at this time was Dalgaranga, which is approximately 24m in diameter and 3m in depth. It was discovered in 1923 by Mr G.E.P. Wellard, and has stony-iron and metallic fragments associated with it. Simpson (1938) gave a brief description of the crater and details of the chemical analysis of a metallic fragment found in the crater. Subsequently, Nininger and Huss (1960), gave fuller details of the Dalgaranga Crater. Another meteorite crater — Veevers Crater — is located between the Great Sandy and Gibson Deserts. It has a diameter of some 70m (Shoemaker and Shoemaker 1988).

Through the 1960's, interest in meteoritics in Western Australia was revitalised by a group of physicists at the University of Western Australia led by Dr P.M. Jeffery, who was searching for isotopic anomalies in meteorites (e.g. see De Laeter and Jeffery 1965). This research group encouraged G.J.H. McCall, a geologist at the University of Western Australia, to classify the stony meteorites in the Museum's Collection, whilst De Laeter (1973b) undertook a similar task for iron meteorites. An X-ray fluorescence spectrometry technique was established at Curtin University of Technology to measure the nickel, cobalt, gallium and germanium content of the iron meteorites and determine their chemical classification (Thomas and De Laeter 1972).

Owing to the lack of a permanent Curator, the Western Australian Museum formed a Meteorite Advisory Committee to oversee the Collection and to arrange meteorite exchanges with scientists and other Museums. A well known meteoriticist (Dr R.A. Binns), later took over the Chairmanship of the Advisory Committee, and his international contacts proved invaluable in arranging for meteorite exchanges, and in amending the names of some Western Australian meteorites to conform with the guidelines established by the International Meteorite Nomenclature Committee. In 1985 the Western Australian Museum appointed Dr A.W.R. Bevan as the first permanent Curator of Mineralogy and Meteoritics in the State. Previously Dr D. Merrilees, Dr C. Pearson, Dr L.F. Bettenay and Dr K.J. McNamara had acted in the capacity of Curator of Meteoritics to give some oversight to the Collection.

The doyen of Western Australian meteorite collectors is undoubtedly Mr A.J. Carlisle, who has discovered specimens from approximately 80 different meteorites, and donated them to the Western Australian Museum over the last 50 years. The Nullarbor Plain has been a happy hunting ground for meteorite collectors, and Mr Carlisle's collaboration with Mr W.H. Cleverly and Mr M.K. Quartermaine, formerly of the Western Australian School of Mines in Kalgoorlie, has enabled many of these meteorites to be identified and located in the WA Museum. The most remarkable discovery made by Mr Carlisle was the recovery of a small stony meteorite named Lookout Hill. The specimen only measured a few centimetres in diameter and weighed 16.55g. It was covered in red soil, yet was recognised by Mr Carlisle as a meteorite and later confirmed by R.A. Binns to be a CM2 carbonaceous chondrite, the first of its type known from Western Australia.

Western Australian Meteorites

The fall of a meteorite can often be a spectacular event. On the 2nd September, 1967, for example, a stone meteorite fell near Wiluna, a country town in Western Australia. According to witnesses the sky was lit by a flash 'like a welding arc — white and blue'. One man saw 'an object about 20 feet long throwing out balls of fire'. There were reports of 'a terrific rumbling noise' and 'bangs up to six or seven in number' (McCall and Jeffery 1970). These violent explosive reports are caused by atmospheric shock waves akin to sonic booms which accompany the fragmentation of a meteor into several pieces during its passage through the atmosphere.

At 10.10am on 30th September, 1984, a meteorite fell on to Binningup Beach, 143 km south of Perth. The brilliant fireball associated with the fall, which lasted for only a few seconds, streaked across the morning sky and burst into four or five luminous fragments shortly before disappearing. Two loud bangs, like claps of thunder, accompanied the phenomenon. Two women on the beach at Binningup were startled by a whistling noise and a loud thud in the sand about four metres from where they were lying. Investigating further, a small stony meteorite weighing about half a kilogram was found lying in a shallow depression it had excavated on impact with the soft sand (Bevan *et al.* 1988). To date, the Binningup meteorite is the most recently recovered observed fall in Australia.

In 1916, an iron with an unusual horseshoe shape was found near Mount Magnet. It contains a high concentration of nickel (14.7%), although subsequently the Warburton Range iron was discovered and found to contain 18.1% nickel (McCall and De Laeter 1965). Another unusual iron is Redfields, which is a phosphide-rich meteorite with an unusual structure (De Laeter *et al.* 1973). The high phosphide content has apparently inhibited Widmanstätten pattern development, so that although the nickel content is 6.65%, no taenite is present. Furthermore the meteorite has graphite inclusions, about 1 mm across, distributed throughout the metal, giving it a 'raisin-bread' appearance. The unusual structure of this meteorite is thought to be due to such factors as high carbon and phosphorus content, and relatively rapid cooling.

The discovery of the unique Bencubbin stony-iron in 1930 during ploughing operations, gave Western Australia a large meteorite (weight 54.2 kg), of extreme rarity and scientific importance. This was followed by the discovery of *Bencubbin II* (weight 64.6 kg) in 1959, and a third mass (weight 16 kg) which was found by Mr K. Hogan in 1974 on a neighbouring farm to where the previous finds had been located. Bencubbin is an unclassified meteorite breccia which consists mainly of host silicates and metal in the proportion of 2:3 (McCall, 1968). Rare chondritic clasts and a dark xenolith identified by Weisberg *et al.* (1990), suggest that the Bencubbin components are chondritic and were produced in the solar nebula, or alternatively that the components formed as a result of major impact melting on a chondritic parent body (Barber and Hutchison 1991). This meteorite is the subject of numerous ongoing scientific investigations as detailed in the above references.

Mount Padbury is a mesosiderite which was found by W.C. Martin in 1964. Mount Padbury is a polymict breccia containing large olivine crystals together with achondritic enclaves (McCall 1966). This meteorite, of which 272 kg of fragments were recovered, is the second greatest mass of mesosiderite material ever recovered. The rare Mount Egerton meteorite can be regarded as an achondrite with metallic inclusions. When a section of the metallic phase is polished and etched, it gives a curious 'ruled' etch pattern which is thought to be due to the presence of an iron-nickel silicide mineral, perryite (McCall, 1965)

One of the most impressive meteorites which has been found in Western Australia in recent years is the *Mount Manning* iron. Weighing 701 kg, it was discovered in 1979 near the Mount Manning Range. The meteorite has a fan-like shape, and it has been suggested that it may have performed a delta-wing like flight at a high angle of trajectory through the Earth's atmosphere in a stable aerodynamic configuration. One side of the specimen is smooth, slightly concave with a characteristic fusion crust, whereas the reverse surface is rough, convex and pitted with regmaglypts — which is consistent with the aerodynamic postulate. Measurements of the gallium, germanium and nickel composition of the *Mount Manning* meteorite showed that it belonged to the rare 1C class of irons (De Laeter 1980). However two other meteorites, named *Mount Dooling* and *Gosnells*, which are also Group 1C meteorites, were already in the WA Museum's Collection. The Mount Dooling meteorite was found in 1909 not far from the Mount Manning Range, whereas the *Gosnells* iron was found near Perth in 1960. Further examination showed that *Gosnells* and *Mount Manning* were fragments of the Mount Dooling meteorite, and that the *Gosnells* specimen must have been transported from the Mount Manning region by human agency (De Laeter *et al.* 1972). This is possibly one of the very few examples of a meteorite that may have been transported by aborigines.

Table 2: Number and Type of Western Australian Meteorites

	1913	1939	1965	1972	1991**
IRONS	8	20	29 (1)*	32	28
STONY-IRONS	—	1	4	7	8
STONES	—	4	15 (1)*	53 (4)	105 (4)
TOTAL	8	25	48 (2)	92 (4)	141 (4)
CRATERS	—	1	2	2	3

* The numbers in brackets are designated falls. The falls are included in the given numbers.

** The numbers of distinct meteorites are given in this column whereas the other columns are the numbers listed in the Catalogues.

Nullarbor Meteorites

The Nullarbor Region is a flat area of treeless, limestone desert in the south of the Australian continent. The arid to semi-arid climate of the Region, conducive to the preservation of meteoritic materials, combined with the featureless nature of the Region, has made it an ideal "spotting" ground for meteorites (Bevan and Binns 1989 a and b). Some 78 distinct meteorites, comprising three irons, one stony-iron and 74 stones have been recorded from this Region. In fact since 1971 over 2,500 individual meteoritic fragments have been recovered including some 500 specimens of possible new meteorites. The Nullarbor Region is therefore one of the most prolific areas in the world for the recovery of meteorites.

One of the most remarkable meteorite discoveries occurred in the 1960's when two extremely rare achondrites were found within 30 km of each other in the Nullarbor Region. These two ureilites, named North Haig and Dingo Pup Donga, increased the total known number of ureilites then known throughout the world from three to five. Another unusual meteorite named Coorara was found close to the site of Dingo Pup Donga in 1966 (McCall 1972) . This chondrite contains the high pressure minerals ringwoodite and majorite, which are of importance to our understanding of planetary processes.

Meteorites are named after the nearest geographical feature to where they are found, but the Nullarbor Region is not well-endowed with such features, so that meteorites from the Region carry such unusual names as Laundry Rock Hole, Mulga (west), Pannikin and Billygoat Donga. Bevan and Binns (1989a) have proposed a grid of 47 named areas in the Nullarbor Region, and each distinct meteorite is given the name of the area in which it is found, and a three digit number which increases integrally in order of recovery.

In 1911 two small iron meteorites weighing 112g and 116g were discovered by Mr H. Kent on that part of the Nullarbor Region known as Premier Downs. They were given the name of *Premier Downs I* and *II* by Simpson (1912) and Simpson and Bowley (1914), respectively. In 1918 a third iron weighing 99g was found in the same area by Mr A. Ewing. Simpson (1938), in describing this meteorite, noted that it had the same "knuckle-bone" appearance as the two previous meteorites, and named it *Premier Downs III.* He pointed out that all three fragments were part of a meteorite shower. Subsequently another similarly shaped iron was found in 1962. Its weight was 108g and it was named *Loongana Station.* Subsequently Mr W.H. Butler found another 66.5g fragment and it was named *Loongana Station West.* In 1965 Mr W. Crowle found three apparently complete irons of weights 94g, 45g and 39g respectively 16 km north of Mundrabilla Siding on the Trans Australian Railway (See Figure 3).

Then in 1966 R. Wilson and A. Cooney discovered two massive iron meteorites some 180m apart in the same vicinity as the *Loongana Station* meteorite. The two meteorites weighed 11.5 tonnes and 6.1 tonnes and were named Mundrabilla 1 and 2, respectively. They were surrounded by innumerable small irons of the type recovered

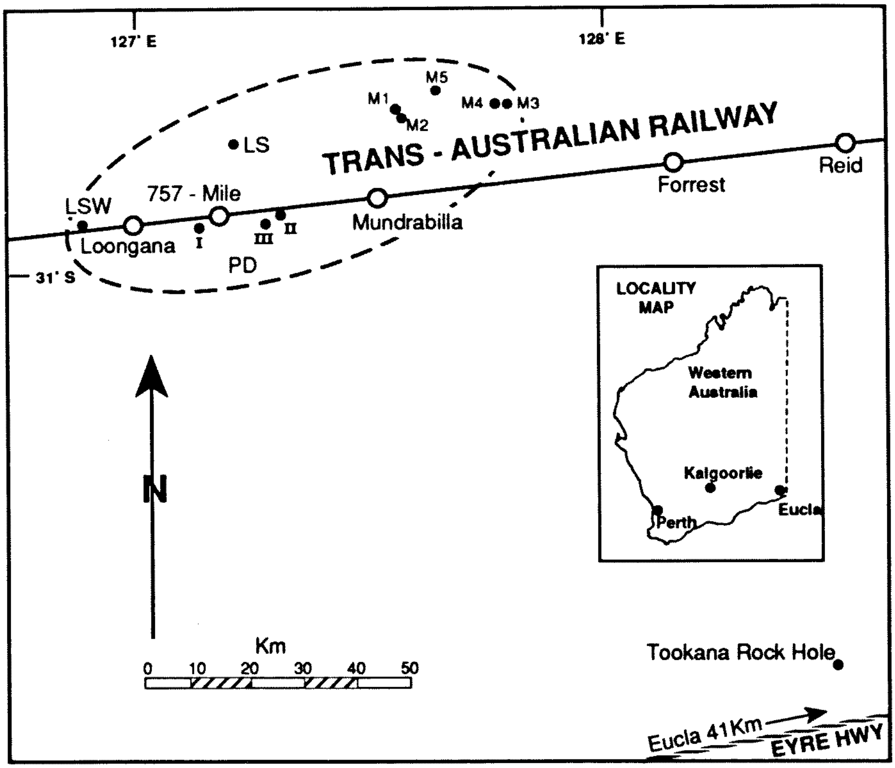

Figure 3 Map of part of the Nullarbor Plain in Western Australia showing the locations of the meteorites comprising the Mundrabilla meteorite shower. The elliptical area contains all the named masses together with many unnamed fragments.

previously in the vicinity. De Laeter (1972) showed that all these meteorites were members of the same shower and were members of Chemical Group 1.

Mundrabilla 2 was sent to the Max-Planck Institut fur Kernphysik at Heidelberg, where several slices were cut using a wire saw. These slices were made available for display in various Museums around the world, and one such slice is on display at the Western Australian Museum. The 11.5 tonne main mass of Mundrabilla 1 is displayed at the Western Australian Museum.

In 1978 Mr A.J. Carlisle discovered about 100 small "knuckle-bone" shaped iron meteorites near Tookana Rock Hole, which is situated 47 km NNW from Eucla on the Eyre Highway (see Figure 3). The heaviest specimen weighed 0.44 kg and the total recovered mass was 3.97 kg. In 1979 Mr Carlisle found another two large specimens of Mundrabilla some 20 km east of the site where Mundrabilla 1 and 2 were found. Both specimens, named Mundrabilla 3 and 4, and which weigh 840 kg and 800 kg respectively, are located in the WA Museum. Chemical analyses showed that all these additional specimens are members of the Mundrabilla meteorite shower (De Laeter and Cleverly 1983). More recent additional recoveries include a 3.5 tonne mass which is now displayed at The WA Museum's Branch at Albany. The "knuckle-bone" fragments from the Mundrabilla shower have presumably been shed in flight due to ablation of the main masses. This is due to the fact that the Mundrabilla meteorites contain a significant amount of troilite, much of which was burnt out in the meteorite's passage through the atmosphere. Thus the characteristic feature of the Mundrabilla meteorites is the deep cavities which can readily be observed on their surface and which have later been enhanced by terrestrial weathering.

De Laeter (1972) suggested that the Mundrabilla meteoroid travelled in an east-north-east direction, and this is confirmed by the discovery of the additional large specimens. The Tookana Rock Hole material does not fit into this flight path, and it is significant that no large specimen has been found in this location. Perhaps these small specimens were transported from the Mundrabilla area to the Tookana Rock Hole by aborigines or other human agency.

Conclusions

The meteorites which have been recovered from the deserts and farmlands of Western Australia represent a rich store of extra-terrestrial material which have been used extensively by scientists, both within Australia and overseas, to study various aspects of the formation and evolution of the Solar System. Meteorites are survivors in the main from the Asteroid belt which have landed on the Earth's surface, and been discovered by observant men and women, in most cases many years after their fiery descent through the Earth's atmosphere. The excellence of the Western Australian Meteorite Collection is a tribute to those people who, realising that these objects have special significance and represent part of our common heritage, have unselfishly reported their occurrence and assisted in their recovery.

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