

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

MINERAL RESOURCES BULLETIN 9

THE LEAD, ZINC AND
SILVER DEPOSITS OF
WESTERN AUSTRALIA



1971

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THE LEAD, ZINC AND SILVER DEPOSITS OF WESTERN AUSTRALIA

by

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Issued under the authority of the Hon. D. G. May, M.L.A., Minister for Mines

PREFATORY NOTE

This is the first Bulletin produced in the Mineral Resources series for over 8 years. The main reason for this long interval between issues has been the rapid increase in exploration for minerals in this State, preventing staff being available for this important work.

Although Western Australia has never been a major producer of lead, zinc and silver there are many occurrences within the State. Production has been recorded on a relatively small scale from many centres, full details of which are given in the production tables.

The author has visited most of the localities from where production has been recorded, and many of the recorded occurrences of lead minerals. With this field information and a wide literature search, he has produced this Bulletin which should become an essential reference and guide for anyone searching for lead, silver and zinc deposits.

This Bulletin contains information on deposits discovered prior to the end of 1969. In 1946 a geologist of this Survey, Mr. W. Johnson, prepared a short manuscript with the same title which was not published at that time owing to lack of finance. Due to the resurgence of lead mining and prospecting between 1948 and 1955, when new deposits were found, and to the more recent geological exploration and mapping, it was considered necessary to prepare a new and expanded text.

26th August, 1971.

J. H. LORD,
Director.

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Introduction

OBJECT AND SCOPE

The object of this bulletin is to summarize all of the available information on base metal deposits in Western Australia which have been worked, or are potentially workable for some combination of the metals lead, zinc, and silver. It deals with those Western Australian mineral deposits which contain significant quantities of galena and/or sphalerite in their primary ore. It is not concerned with deposits of other metals in which lead and zinc are present in uneconomic amounts, nor with the many gold and copper mines in the State which have yielded silver as a by-product. Nevertheless, a list of gold mines in which lead and zinc minerals have been noted is included so that the record of the occurrence of these metals should be as complete as possible, and because of the potential usefulness of lead minerals in dating the ore deposits.

In keeping with the object of the bulletin, speculative discussion on the origin of the ore deposits and allied matters is kept to a minimum, being restricted usually to a summary of published ideas on each field. While it is recognized that determinations of the source of ore metals in any field is a valuable aid to further prospecting, the writer has found that too little work has been done on most Western Australian lead-zinc deposits for any reliable theories to be advanced.

Many of the lead, zinc, and silver deposits in Western Australia have also produced copper ore, and have been described in Bulletin 8 of this series (Low, 1963), in which the emphasis was on copper content. In this bulletin the emphasis is placed on their lead-zinc-silver content, so the reader who is interested in the complete suite of these metals should consult both publications.

SOURCES OF INFORMATION

The information used here is compiled from previously published reports, private reports of mining companies, Mines Department and Geological Survey files, plans held by the Drafting and Geological Survey Branches of the Mines Department, from communications from companies and prospectors, and from field inspections made by the writer in 1968. In each description of a mine or mining group, the relevant sources of information are listed in the introductory statement. There is a bibliography at the end of this chapter, and a catalogue of plans of lead, zinc and silver mines is included as Appendix 2.

LAY-OUT

This bulletin comprises: an introductory section containing general information; followed by descriptions of the State's lead, zinc and silver deposits grouped by their

geographic occurrence in gold or mineral fields or by land divisions; and finally, two appendices of additional information not included in the main text.

The geographic grouping into gold and mineral fields may need some explanation to the reader unfamiliar with Western Australian mining practice. In this State the Mining Act is administered by Mining Wardens, each of whom is responsible for a territory called a Goldfield, where gold is the principal mineral mined, or a Mineral Field where some other mineral is the chief product.* The only such territory defined to include a natural province of lead, zinc and silver deposits is the Northampton Mineral Field. Most other deposits of these metals are in Goldfields, defined on the distribution of gold occurrences. While it is recognized that Goldfields do not necessarily form logical geographic divisions of lead, zinc and silver deposits, their use for this purpose is made almost unavoidable by the practice of listing all mining statistics and much other information by Goldfields. Again, the prospector is more likely to be interested in the administrative rather than the geological province of a deposit, as this governs the town in which he must register his claim. The practice followed here of dividing the lead, zinc and silver deposits by their occurrence in Goldfields is justified on the grounds of tradition and convenience, although it is recognized that the boundaries of these fields may separate some like deposits, or group some of diverse geological occurrence.

The grouping of deposits into Land Divisions is followed only in the southern parts of the State where there are but a few, widely scattered lead and zinc occurrences. The boundaries of goldfields, mineral fields,

and relevant land divisions are shown on Plate 1.

In the descriptions of the deposits, those in the Northampton Mineral Field are treated first because of their importance. Then follow descriptions of the deposits of the Kimberley, West Kimberley, Pilbara, West Pilbara, Ashburton, Gascoyne and Peak Hill Goldfields and South West and Eastern Divisions.

LEAD, ZINC AND SILVER MINING IN WESTERN AUSTRALIA

HISTORY AND PRODUCTION

Lead: The first attempt to mine lead in Western Australia was made in 1846 by the Western Australian Mining Company which sank shallow shafts on the Mundijong prospect. However, the first production of lead ore came from the Geraldine lead mine on the Murchison River in 1850. This mine was discovered in 1848 during an exploratory expedition led by A. C. Gregory, and was the first mine opened up in Western Australia. The discovery predated that of the Wanerenooka copper and lead mine at Northampton, although many official publications give the date of discovery of the latter as 1842. Batty (1913) states: "Thus mining and the production of exportable minerals dates in Western Australia from April 1852. By what was probably a transcription error, the official records place this beginning of Westralia's mining history in 1842, or 10 years earlier. The error is of little importance locally, but unfortunately, it has been copied into publications compiled elsewhere and widely circulated in Europe and America". It seems significant that the earliest mention of the Wanerenooka mine is in a paragraph in the

* In the text these officially proclaimed Fields are denoted by capitalizing the initial letters, e.g., Northampton Mineral Field as opposed to the informal Braeside lead field.

Perth Gazette dated March 14th, 1856, and refers to the mine as being "lately discovered".

Early records of the State's lead production are incomplete. From 1850 to 1899, 33,601 tons (34,140.2 tonnes) of lead ore (probably concentrate) were exported from the Northampton Mineral Field. Existing records indicate that the grade of this was high, probably about 65 to 70 per cent lead, giving a total lead content of about 22,000 tons (22,400 tonnes). Smelted lead exported in the same period was 686 tons (696.9 tonnes), the greater part of which came from smelting operations at the Geraldine mine. Since 1899, when accurate records were first kept, the State has produced a total of 86,943 tons (88,333.7 tonnes) of lead from deposits in the Northampton Mineral Field, and the Kimberley and North West Divisions of the State.

Other discoveries in the Northampton Mineral Field followed, and by about 1870, most of the deposits in that field had been found and exploited to some extent. Lead was reported from the Roebourne district in 1872, but it is not known if it was worked at that time. The first known lead production outside the Northampton Mineral Field was from the Uaroo mine in 1901. The discoveries at Braeside and Narlarla were made at about the same time, but commercial exploitation of these deposits was delayed until 1925 and 1948 respectively, when higher lead prices and better communications rendered them economic. The Kooline lead deposits were not reported until 1948, although they were apparently known to pastoral workers before that time.

The greater part of the State's lead production (about 90 per cent) has come from the Northampton Mineral Field. This Field includes the State's largest mine,

the Baddera, which yielded 14,000 tons (14,200 tonnes) of lead; and four other mines which each yielded more than 10,000 tons (10,200 tonnes) of lead. Outside the Northampton Mineral Field, the largest lead mines are those of Ragged Hills, Uaroo and Narlarla, each of which has produced 2,000 to 3,000 tons (2,000 to 3,000 tonnes).

Lead mining activity in Western Australia has been very much controlled by the price of lead, flourishing in times of higher prices, and almost halting when the price is down (see Fig. 1). As lead was the principal metal sought in most of the lead, zinc and silver deposits worked, its price largely governed the production rate of the other metals as well. The total recorded production of lead in Western Australia is 86,942.64 tons (88,333.72 tonnes) to the end of 1967.

Silver: To the end of 1967, Western Australia produced 11,736,765.8 ounces (365,048,626.67 gm) of silver, of which only 143,451.52 ounces (4,461,772.62 gm) were derived from lead and zinc ores. A further 81,505.1 ounces (2,535,053.12 gm) were obtained from copper ores and the remaining 11½ million ounces (357,680,000 gm) was from gold ores. The only deposit which seems to have been worked at any stage for its silver content alone is the Uaroo mine. In the other deposits, silver was regarded as a by-product of lead and zinc.

The deposits of the Northampton Mineral Field contain very little silver, and it was not until those of the Ashburton and Pilbara Goldfields were exploited that any silver was produced from lead or lead-zinc ores in Western Australia. The lead and zinc mines which have produced most silver are the Uaroo, Narlarla and Ragged Hills with productions of 38,927; 37,373 and 28,094 ounces (1,210,746.4; 1,162,412.4 and 873,807.6 gm) respectively. The de-

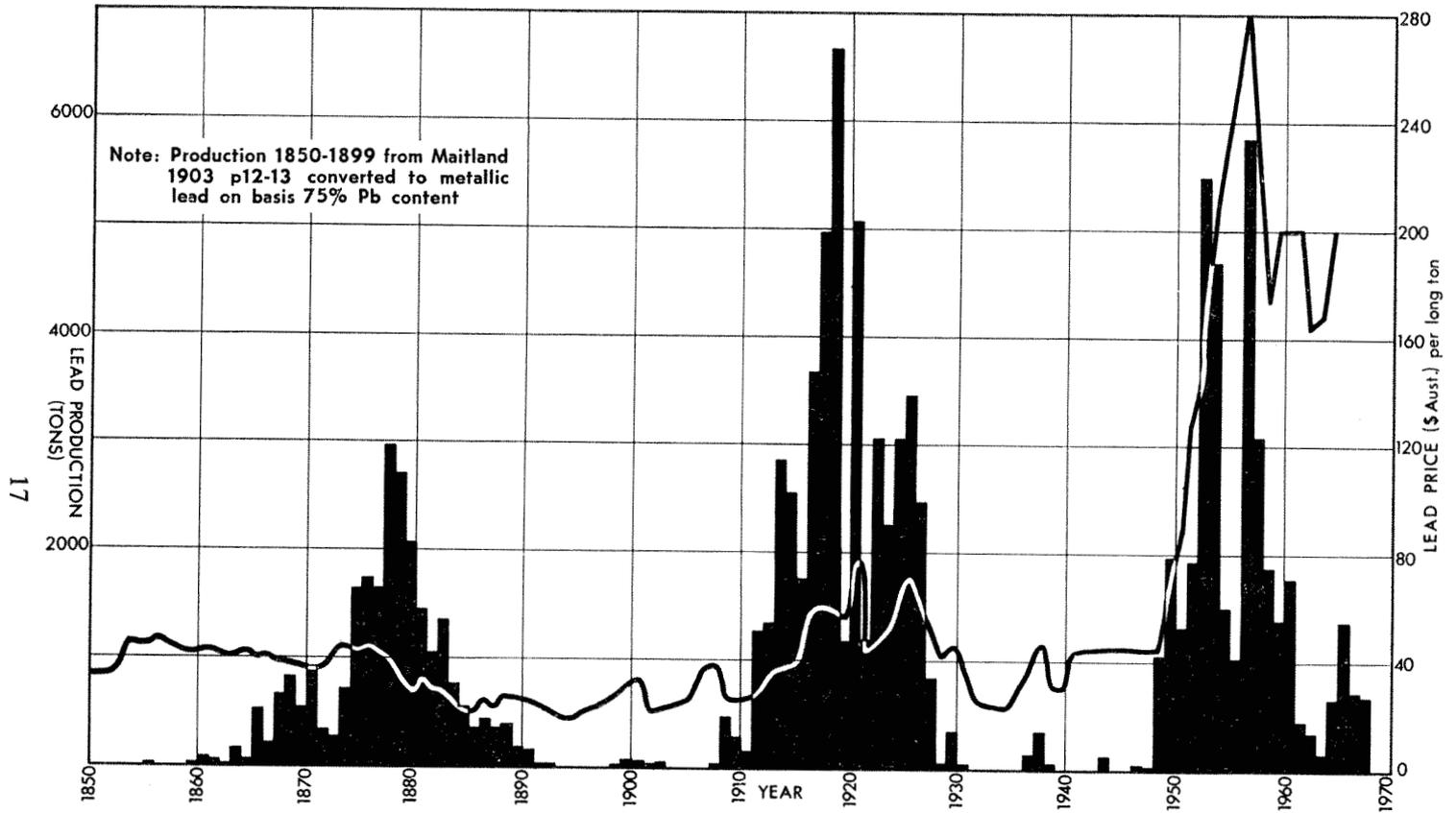


Fig.1: Histogram showing annual lead production from Western Australia compared with the average annual lead price

TABLE I. ANNUAL PRODUCTION OF LEAD AND ZINC FROM WESTERN AUSTRALIA

Year	Ore and Conc. Tons	Lead Tons	Zinc Tons	Value Lead and Zinc \$Aust.	Exports Pig Lead Tons	Exports Zinc and Zinc Conc. Tons	Remarks
1850	5·00	?	110·00	1850 to 1899 production taken from export figures of lead concentrates and pig lead from Northampton Mineral Field. Lead content of concentrates unknown, but believed to be 65 to 70 per cent.
1851							
1852							
1853 ....	?	?	....	8·00	55	....
1854 ....		....	....		122	....
1855	25·00	?	....	500·00	134	....
1856 ....	....	....	....	....	60	....
1857 ....	....	....	....	....	120	....
1858 ....	....	....	....	....	61	....
1859	13·00	?	....	270·00	25	
1860	98·00	?	....	1,970·00		
1861	79·00	?	....	1,580·00		
1862	9·00	?	....	180·00		
1863	230·00	?	....	4,600·00		
1864	80·00	?	....	1,600·00		
1865	703·00	?	....	16,872·00		
1866	273·00	?	....	6,564·00		
1867	902·00	?	....	21,648·00	3	
1868	1,100·00	?	....	26,412·00		
1869	699·00	?	....	16,788·00		
1870	1,209·00	?	....	29,028·00		
1871	420·00	?	....	10,080·00		
1872	364·00	?	....	8,736·00		
1873	965·00	?	....	23,172·00		
1874	2,144·00	?	....	51,550·00		
1875	2,289·00	?	....	54,936·00	4	
1876	2,192·00	?	....	52,596·00	1	
1877	3,956·00	?	....	94,932·00	7	
1878	3,618·00	?	....	86,820·00		
1879	2,775·00	?	....	66,600·00		
1880	1,921·00	?	....	30,736·00	5	
1881	1,401·00	?	....	22,408·00	1	
1882	1,794·00	?	....	28,796·00		
1883	1,038·00	?	....	15,532·00		
1884	696·00	?	....	9,744·00		
1885	465·00	?	....	6,510·00		
1886	611·00	?	....	8,554·00		
1887	471·00	?	....	9,420·00	6	
1888	532·00	?	....	10,640·00	2	
1889	250·00	?	....	5,000·00		
1890	214·00	?	....	4,270·00		
1891	25·00	?	....	500·00		
1892	30·00	?	....	300·00		
1893							
1894							
1895							

TABLE 1 (continued)

Year	Ore and Conc. Tons	Lead Tons	Zinc Tons	Value Lead and Zinc \$Aust.	Exports Pig Lead Tons	Exports Zinc and Zinc Conc. Tons	Remarks
1896							
1897				8 00	1		
1898	5·00	?	....	66·00			
1899	82·75	54·61	....	1,824·00	77		
1900	268·00	51·00	....	1,066·00			
1901	21·05	9·09	....	218·00			
1902	35·85	18·76	....	414·00			
1903-06	nil	nil	....	nil			
1907	10·00	6·50	....	256·00	....	73	
1908	784·25	477·96	....	14,750·00	....	11	
1909	440·00	264·00	....	7,040·00	....	19	
1910	185·10	136·67	....	3,554·00	....	12	
1911	8,194·76	1,263·70	....	35,326·00	....	12	
1912	11,098·50	1,330·82	....	48,824·00	....	14	
1913	26,715·03	2,818·80	....	104,462·00			
1914	16,049·72	2,539·12	....	96,316·00	....	22	
1915	15,977·26	1,717·15	....	67,750·00	13	7	
1916	34,690·17	3,672·58	....	224,370·00	3,523	14	
1917	46,864·54	4,954·86	....	289,368·00	4,661		
1918	47,317·16	6,659·77	....	359,582·00	5,489		
1919	7,600·46	1,196·71	....	65,914·00	1,780		
1920	27,716·40	5,072·68	....	354,976·00	1,930		
1921	10,330·43	1,197·43	....	51,398·00	2,156		
1922	29,602·90	3,040·70	....	144,776·00	2,796		
1923	21,634·50	2,237·27	....	118,388·00	20		
1924	36,750·00	3,026·82	....	202,438·00			
1925	37,946·99	3,457·13	....	242,394·00			
1926	24,063·85	2,467·07	....	148,354·00			
1927	5,903·50	819·69	....	38,636·00			
1928	129·85	33·52	....	1,216·00			
1929	1,075·00	345·00	....	7,534·00			
1930	474·00	25·46	....	1,018·00			
1931-32	nil						
1933	12·19	1·58	....	26·00			
1934	5·00	3·00	....	122·00			
1935	nil						
1936	1,535·00	94·50	....	4,456·00			
1937	6,163·00	277·69	....	14,497·00			
1938	350·00	41·00	....	1,080·00			
1939-42	nil						
1943	1,250·00	110·00	....	2,200·00			
1944-45	nil						
1946	36·21	26·13	....	2,136·00			
1947	22·36	16·96	....	1,973·28			
1948	2,191·55	1,407·78	150·93	226,632·24			
1949	2,922·13	1,972·28	36·88	215,981·76			

TABLE 1 (continued)

Year	Ore and Conc. Tons	Lead Tons	Zinc Tons	Value Lead and Zinc \$Aust.	Exports Pig Lead Tons	Exports Zinc and Zinc Conc. Tons	Remarks
1950	1,865·79	1,301·64	2·54	223,395·76			
1951	2,538·67	1,912·40	8·97	480,352·10	....	....	Also 1·17 tons fertilizer zinc
1952	7,448·98	5,494·91	47·02	1,971,128·64			
1953	6,425·48	4,699·49	68·15	718,685·58	....	....	Also 0·96 tons fertilizer zinc
1954	2,166·97	1,496·19	73·85	202,266·54			
1955	1,415·96	1,006·70	....	199,394·80			
1956	7,612·89	5,828·67	....	1,286,865·76			
1957	4,189·19	3,086·78	....	628,783·18			
1958	2,492·43	1,853·09	20·06	279,404·12			
1959	1,902·89	1,382·19	....	178,006·98			
1960	2,263·69	1,738·63	....	238,593·60			
1961	597·05	433·17	....	51,530·80			
1962	443·03	305·87	....	30,313·20			
1963	184·93	135·87	....	13,070·40			
1964	3,354·17	619·50	825·08	185,263·10			
1965	4,877·93	1,379·01	1,010·16	392,638·40			
1966	2,681·30	705·96	644·11	104,407·65			
1967	909·68	687·89	....	96,893·10			
1968	417·63	311·02	....	39,985·09			

NOTE: 1 ton = 1·01605 tonnes.

TABLE 2. PRODUCTION OF LEAD, ZINC AND ASSOCIATED SILVER FROM GOLDFIELDS AND MINERAL FIELDS IN W.A. TO 1968

Goldfield or Mineral Field	Ore and Conc. Tons	Realized Production			Value \$Aust.
		Lead Tons	Zinc Tons	Silver F. oz.	
Northampton Mineral Field	448,680·28	76,476·06	41·59	6,825·63	8,494,543·51
Kimberley Goldfield	9·26	6·24	....	33·62	1,295·22
West Kimberley Goldfield	10,859·35	2,082·06	2,821·72	37,373·13	505,745·50
Pilbara Goldfield	4,854·76	3,225·01	27·27	29,556·52	616,239·55
West Pilbara Goldfield	260·15	123·26	....	1,397·23	16,427·03
Ashburton Goldfield	7,431·70	5,017·41	....	68,110·90	747,394·50
Gascoyne Goldfield	11·43	8·30	....	94·54	1,643·90
Peak Hill Goldfield	5·50	4·30	....	59·95	587·3
Total	472,112·43	86,942·64	2,890·58	143,451·52	10,383,876·51

NOTE: 1 fine ounce = 31·103 grammes
1 ton = 1·01605 tonnes

posits of the Kooline lead field yielded a total of 26,521 ounces (824,882.6 gm).

Zinc: Zinc was present in the earliest lead deposits worked in the State, but due to poor demand for this metal and to the lack of suitable extraction methods, it was seldom recovered. Although trade returns show that 184 tons (186.9 tonnes) of zinc ingots and concentrates were exported between 1907 and 1916, the source of these products is not recorded, but it is likely that they came from the Northampton Mineral Field where zinc-rich mines were being worked at the time. Department records show no zinc production before 1948, but 2,887 tons (2,933.1 tonnes) of the metal have been produced since that time. Of this amount, 2,821 tons (2,866.1 tonnes) came from the Narlarla mine in the West Kimberley Goldfield.

Production Tables

The details of the State's production of lead, zinc and associated silver are set out in Tables 1 and 2.

TREATMENT OF ORE

Methods used to concentrate ores of lead and zinc in Western Australia have not attained great refinement. None of the deposits has been considered large enough to warrant anything beyond a crushing plant with a gravity concentrator. As a consequence, no separation of the more complex ores has been achieved, except where they were rich enough to be hand-sorted. In many mines, the zinc and copper fractions of the ore were lost during treatment. In others, with a higher zinc content, the ore was concentrated by selective mining or hand sorting, and the mixed concentrates shipped directly to the smelter.

In the early period of the Northampton Mineral Field, attempts were made to smelt

ores close to the mines. The remains of such enterprises can be seen at the Warri-banno Chimney, 3 miles (4.8 km) south of the Geraldine mine, and at McGuire's mine at Isseka. Between 1852 and 1859, 577 tons (586.2 tonnes) of pig lead were exported from the field.

The failure of these smelters was probably due in part to lack of sufficient suitable ore, and to a shortage of natural fuel in the area. The discovery that the complex gold ores from Kalgoorlie could be treated by smelting them with lead ore to recover a matte of bullion and lead, renewed interest in treating the Northampton ores, and a smelter was erected at Fremantle for this purpose. The early attempts to treat the ores proved a costly failure, due to high transport costs of the gold ore, but the smelters were later employed successfully to treat lead ores alone. Some 22,500 tons (22,860 tonnes) of pig lead were exported from the State in the period 1915 to 1923.

The Fremantle smelter closed finally with the decline in lead production that followed the Great War, and since that time, all lead, zinc and silver ore mined in the State has been shipped interstate or overseas for treatment.

GEOLOGICAL SETTING OF DEPOSITS

Most of the lead, zinc and silver deposits in Western Australia are in folded or faulted Proterozoic rocks fringing the more stable blocks within the Precambrian Shield areas. The Northampton Mineral Field covers faulted metamorphic rocks adjacent to the Archaean Yilgarn Block; the Ashburton Goldfield deposits lie in folded and granite-intruded Proterozoic sediments between the Yilgarn and Pilbara Blocks, and marginal to the more stable Hamersley Basin; the Braeside lead field is in Proterozoic rocks at the eastern edge of the Pilbara Block; and the Kimberley deposits

are in the Kimberley Mobile Belt flanking the stable Kimberley Block. The few deposits in other geological settings are the Narlarla mine, in Devonian limestone; the small Andover, Comstock, Nunyerry and Balmoral mines in Archaean rocks of the Pilbara Block; and the Belvedere mine in an Archaean inlier in the Proterozoic Wyloo Group. There has been no recorded production of lead, zinc or associated silver from the Yilgarn Block, and the only deposit of these metals to have been opened up within the block is that at Mundijong near the faulted western edge.

Most of the lead, zinc and silver deposits are clearly associated with igneous rocks: those in the Ashburton Goldfield and Pilbara Block with granite; and those in the Northampton Mineral Field, Braeside lead field and some in the Kimberley Goldfield with dolerite. Almost all of the productive deposits are younger than the main period of gold mineralization in the State, and

there is seldom any relationship between gold and lead-zinc-silver deposits, even where they occur in the same area. In this feature the lead-zinc-silver deposits contrast to the State's copper deposits, many of which are closely associated with gold.

The estimated ages of the more important lead, zinc and silver deposits are listed below (Table 3). For most, the postulated age is that of their host rocks and may be changed by future lead-isotope determinations. Only two deposits, one in the Galena district of the Northampton Mineral Field, and the other at Wyloo in the Ashburton Goldfield have been dated radiometrically.

CLASSIFICATION OF DEPOSITS

The lead, zinc and silver deposits of Western Australia can be conveniently grouped into three classes, namely vein deposits, Mississippi Valley type deposits and conformable or stratiform deposits (Table

TABLE 3. AGES OF WESTERN AUSTRALIAN LEAD, ZINC AND SILVER DEPOSITS

Age	Deposits
Post-Devonian	Narlarla lead-zinc mine
Upper Proterozoic (500-1,000 m.y.)	Deposits of the Northampton Mineral Field (one dated 500 m.y.)
Middle Proterozoic (1,000-1,500 m.y.)	Kununurra deposits, Speewah deposits, Joy Helen prospect, Keep-it-Dark mine, Latham prospect
Lower Proterozoic (1,500-2,300 m.y.)	Uaroo-Range deposits, Kooline deposits, Wyloo deposits (one dated 1,700 m.y.), Braeside deposits, Mt. Amherst deposits
Archaean	Comstock mine, Mons Cupri, Andover mine, Dooleena Gap mine, Nunyerry prospect, Belvedere mine, Lennon Find, Mundijong prospect, and various small veins in the Pilbara, West Pilbara and Ashburton Goldfields

TABLE 4. CLASSIFICATION OF WESTERN AUSTRALIAN LEAD, ZINC AND SILVER DEPOSITS

Type	District or Group	No. of deposits	Recorded Production (approximate)			Remarks
			Lead Tons	Zinc Tons	Silver F. oz.	
Vein deposits	Northampton	80	76,480	40	6,825	Fissure veins in granulite and dolerite
	Braeside	10	3,160	30	29,480	Fissure veins in basalt
	Kooline	30	2,640	....	26,520	Quartz veins in phyllite
	Uaroo-Range....	8	2,140	....	39,400	Quartz veins in schist
	Wyloo	4	220	....	1,480	Quartz veins in dolomite
	Kununurra	1	190	....	?	Quartz veins in dolerite
	Mount Amherst	2	5	....	30	Fissure veins in metamorphics
	West Pilbara	4	125	....	1,400	
Miscellaneous	15	55	....	450		
Totals		154	85,015	70	105,585	
Mississippi Valley type deposits	Narlarla	2	2,080	2,800	37,370	In Devonian limestone
	Joy Helen	1	....	....	....	In Middle Proterozoic dolomite
Totals		3	2,080	2,800	37,370	
Stratiform deposits	Lennon Find	1	....	2.3	....	In calc-silicate rocks
	Ilmars—Little Mount Isa	2	....	....	....	Prospect in calc-silicate rocks
	Mount Stuart....	1	?	....	....	In conglomerate
	Bangemall Basin	....	....	....	....	High zinc and copper values in black shale
	Duffer Creek	1	....	....	....	Gossans in basalt and tuff
	Mons Cupri	1	....	....	....	Mineralized rhyolite breccia
Totals		6	nil	2.3	nil	

NOTE: 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

4). Deposits of the vein and Mississippi Valley type are clearly epigenetic, but stratiform deposits may be syngenetic, or formed by the reconcentration of original syngenetic minerals. Lode deposits, in the sense of a body of sheared rock partly replaced by ore minerals, are almost unknown, and none has produced lead or zinc.

Vein Deposits

Almost all the lead, zinc and silver mines of the State are on transgressive veins. These deposits have yielded over 90 per cent of the State's lead production and about 75 per cent of the silver associated with the lead-zinc ores. They are mainly simple quartz-filled fissure veins, in which

the primary ore minerals galena and sphalerite may be associated with pyrite and chalcopyrite. Other constituents of the gangue may be calcite, barite and rarely fluorite. Galena is usually the most abundant, and in many veins the only sulphide mineral present. Other, more complex types of fissure vein deposits such as stockworks and ladder veins have been worked for lead, but are relatively unimportant.

In many of the fissure vein deposits, there is a close relationship between the richer ore and geological structure. The most common ore control is a curve in the original fissure on which an opening has formed during later movement. However, the larger mines are usually on cymoid loops or diagonal links formed at S-bends or echelon offsets of the controlling fault. These structures are described in Campbell (1965) and standard text books on mining geology. Examples of mines on cymoid loop structures are the Narra Tarra, Protheroe, Baddera, Uaroo and Ragged Hills mines. The largest deposit on a diagonal link structure is the Surprise mine at Galena in the Northampton Mineral Field.

Many of the vein deposits are associated with igneous rocks, and it is likely that all had a magmatic source.

Mississippi Valley Type Deposits

Features characteristic of Mississippi Valley type deposits have been listed by Ohle (1959) as follows:

1. absence of igneous rocks that are potential sources of the ore solutions
2. simple mineralogy
3. anomalous lead-isotope ratios
4. low precious metal content
5. occurrence in limestone or dolomite
6. contain both bedding replacements and veins

7. most commonly located in passive structural regions

8. found usually at shallow depths

9. related to positive structures such as anticlines or basement high-points

10. evidence of solution activity.

The Narlarla mine in the West Kimberley Goldfield has many of these features and is almost certainly of the Mississippi Valley type. The Joy Helen prospect, in the Ashburton Goldfield, has not been developed sufficiently for an accurate determination of its geological relationships, but it also seems to be of this type.

Most of the State's zinc, and about 25 per cent of the silver won from lead-zinc ores, has come from the Narlarla mine.

The origin of Mississippi Valley type deposits has not yet been resolved. Some possibilities are discussed in the description of the Narlarla mine.

Stratiform Deposits

The greater part of the total Australian production of lead, zinc and silver has come from stratiform base-metal deposits, chiefly those at Broken Hill and Mount Isa. However, the contribution made by this type of deposit to the Western Australian production of these metals is negligible, amounting to only 2 tons (2.0 tonnes) of zinc. The known stratiform deposits or occurrences of lead-zinc minerals in the State are listed in Table 4. The deposits at Lennon Find, Ilmars—Little Mount Isa, Duffer Creek and in the Bangemall Basin are associated with limestone, chert or black shale laid down between periods of volcanism. Their ages range from Archaean to Middle Proterozoic. The most likely explanation of the origin of these deposits is that the ore metals were derived from fumarolic discharges into sea water, and were precipitated along with the chemical fraction of the host sediments.

Subsequently the metals may have been concentrated by regional metamorphism or granite intrusion.

The Mons Cupri deposit is in a rhyolite breccia forming a flow and contiguous vents. Mineralization of the breccia was probably effected by late-stage fumerolic fluids trapped by an overlying bed of shale.

MINERALOGY OF THE LEAD-ZINC ORES

A list of ore minerals found in Western Australian lead, zinc and silver deposits is given below. The most common ore minerals are galena and sphalerite in the primary zone, and cerussite, anglesite, pyromorphite, smithsonite, and hydrozincite in the oxidized zone. Silver minerals have been recorded only rarely. The list does not include some rare minerals of the three metals found only in gold deposits (e.g. silver-bearing tellurides) or pegmatites (e.g. lead-bearing uranium minerals).

Lead Minerals

Anglesite $PbSO_4$; beudantite $PbSO_4 \cdot FeAsO_4$; bindheimite $2HPbSbO_4 \cdot 3H_2O$; carmintite $Pb_3Fe_{10}(AsO_4)_{12}$; cerussite $PbCO_3$; crocoite $PbCrO_4$; descloizite $PbZn(OH)VO_4$; galena PbS ; jamesonite $Pb_3FeSb_5S_{14}$; mime-

tite $Pb_3Cl(AsO_4)_3$; mottramite $2PbCu(OH)VO_3 \cdot H_2O$; pyromorphite $Pb_3Cl(PO_4)_3$; wulfenite $PbMoO_4$; perite $PbBeO_2Cl$; hildagoite $PbAl_3AsO_4SO_4(OH)_6$.

Silver Minerals

Argentite Ag_2S ; cerargyrite $AgCl$; native silver Ag .

Zinc Minerals

Descloizite $PbZn(OH)VO_4$; hemimorphite $Zn_2SiO_4 \cdot H_2O$; hydrozincite $Zn_5(OH)_6(CO_3)_2$; smithsonite $ZnCO_3$; sphalerite (blende) ZnS ; schalenblende (colloform sphalerite).

USES OF LEAD, ZINC AND SILVER LEAD

Present Consumption

Metallic lead is used in storage batteries, solder, ammunition, cables, sheathing, caulking, pipes, lead sheets, type metal and kindred alloys, and for many other purposes. Lead compounds are employed as additives to motor spirit, in storage batteries, and pigments. Minor uses of lead are in annealing, galvanizing, lead plating and as weights and ballast. There are no statistics available

TABLE 5. DETAILS OF CONSUMPTION OF LEAD IN THE U.S.A. IN 1966

Product	Lead Used Tons	Percentage of Total
Metallic products	397,175	31
Storage batteries	471,998	37
Pigments	116,699	9
Chemicals (chiefly for motor spirit)	247,493	19.5
Miscellaneous	25,572	2
Unclassified	17,823	1.5
Total	1,276,760	100.0

NOTE: 1 ton = 1.01605 tonnes

of the relative proportions of lead used for each purpose throughout the world, but Table 5 below shows its usage in the United States of America in 1966, and probably reflects that in other industrialized countries. About 45 per cent of the lead used in the U.S.A. is recovered from scrap.

Future Trends

From 1956 to 1966, the world production of lead in ores has risen from 2,420,000 tons (2,457,000 tonnes) to 3,155,000 tons (3,205,500 tonnes), and of smelted lead from 2,370,000 tons (2,408,000 tonnes) to 2,995,000 tons (3,042,900 tonnes), indicating a steady increase in the demand of about 2½ per cent per year. However, current research into fuel cell technology aimed at

ZINC

Present Consumption

Metallic zinc is used in galvanizing, brass and bronze products, die and casting alloys, rolled zinc products (photo-engraving plates, zinc foil and strips) and in light metal alloys. Zinc compounds are used in rubber, paints, ceramics, chemicals, agriculture, photocopying, coated fabrics, and textiles and floor coverings. In the U.S.A., about 250,000 to 400,000 tons (254,000 to 410,000 tonnes) of zinc are recovered as scrap each year.

Future Trends

Since 1956, the world production of zinc has risen from 3,330,000 tons (3,383,000

TABLE 6. DETAILS OF CONSUMPTION OF ZINC IN THE U.S.A.—1966

Product	Zinc Used Tons	Percentage of Total
Galvanizing	495,967	35.0
Brass and bronze	185,552	13.0
Zinc-base alloys	606,036	43.0
Rolled zinc	52,612	4.0
Zinc oxide	41,592	3.0
Total	1,410,197	100.0

NOTE: 1 ton = 1.01605 tonnes

improving the heavy, relatively inefficient lead—lead sulphate battery, could greatly reduce the future use of lead used in accumulators. Another line of research is aimed at substituting lead compounds in motor spirit by some less toxic additive, to prevent eventual poisoning of the atmosphere. If this is successful, it would eliminate a large, dissipative use of this metal, and allow more of the total lead output to be recovered as scrap.

tonnes) to 4,920,000 tons (4,999,000 tonnes) per year, and of smelted zinc from 3,110,000 tons (3,120,000 tonnes) to 4,405,000 tons (4,475,500 tonnes). In 1964, the world reserves were estimated to be sufficient for only 20 years. Subsequently, several large zinc deposits have been discovered in Canada and the U.S.A., but it seems that there is good incentive for further exploration for this metal.

SILVER

Present consumption

Silver is used in coinage, electroplate, sterling ware, jewellery, photographic chemicals, alloys, electrical components, catalysts, dental and medical supplies, mirrors, rocket nozzles, and bearings.

Future Trends

Since about 1955, world consumption of silver has been greater than the production. The deficiency has been met from reserves held by various countries. The shortage has caused the price to rise and, partly as a result of this and partly to conserve silver for its important industrial uses, some nations have reduced the quantity of silver in their coins. Despite this saving, industries used 400,000,000 ounces (12,400,000,000 gm) of silver in 1966 and the demand is increasing yearly. In con-

trast, the supply of silver has remained fairly constant at about 250,000,000 ounces (7,776,000,000 gm) per year for some time. As silver is usually mined as a by-product of other metals, mainly lead and zinc, there is little prospect of making up the deficiency unless the demand for, and production of, these metals is also increased.

It is expected that the demand for silver will increase even further in the future, and it may be necessary to abandon some of the traditional, but non-essential uses of this metal.

EXPLORATION

Recent discoveries of lead and zinc at Prairie Downs Station and at Kununurra, indicate that not all outcrops of these metals were located by the intensive prospecting activity of the past. This is probably due to the relatively inconspicuous appearance

TABLE 7. DETAILS OF CONSUMPTION OF SILVER IN THE U.S.A.—1966

Product	Silver Used Troy oz. x 1,000	Percentage of Total
Coinage	53,582	22.7
Electroplate	21,486	9.1
Sterling ware	30,895	13.0
Jewellery	6,349	2.7
Photographic materials	48,435	20.4
Dental and medical supplies	2,457	1.0
Mirrors	2,956	1.2
Bronzing alloys and solders	18,419	7.8
Electrical batteries	12,517	5.3
Electrical contacts and conductors	33,676	14.2
Rocket nozzles	700	0.3
Catalysts	2,683	1.1
Bearings	569	0.2
Miscellaneous	2,546	1.0
Total	237,278	100.0

NOTE: 1 troy ounce = 31.103 grammes

of secondary lead-zinc minerals, and to the low prices these metals usually bring. It is likely that further outcrops remain to be found in the more remote, less prospected parts of the State, but the writer believes that the best chance of locating new finds is by using modern techniques to search for concealed ore bodies in the established lead fields.

A proposed prospecting programme for lead-zinc ore bodies in Western Australia could take one of two extreme forms: (1) a search for vein deposits in an established mining area with a fair chance of success, but a small likely target, or (2) a search for stratiform or Mississippi Valley type deposits with less chance of success, but a larger possible target.

Areas most suited to the first type of programme are the Northampton Mineral Field, Kooline lead field and Braeside lead field. Geological units suited to the second type of programme are the Devonian Napier Formation (West Kimberley Goldfield), Irregularly Formation (Ashburton Goldfield), the Biscay Formation (Kimberley Goldfield), the sedimentary units within the Warrawoona Greenstones (Pilbara and West Pilbara Goldfields) and the Fords Creek Shale in the Bangemall Group (Ashburton, Gascoyne and Peak Hill Goldfields).

Wildcat prospecting for new lead, zinc and silver vein deposits would best be confined to Proterozoic rocks. Likely areas are: Kimberley Goldfield, along major faults cutting the Lamboo Complex and Hart Dolerite; Ashburton Goldfield, (a) near granite intrusions, (b) along a line connecting Ashburton Downs and Boolaloo Stations, suspected to contain subjacent granite intrusions, and (c) in the faulted zone of Wyloo Group rocks close to the western edge of the Hamersley Range.

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Northampton Mineral Field

INTRODUCTORY STATEMENT

LOCATION AND ACCESS

The Northampton Mineral Field (see Plate 1) extends from 10 to 75 miles (16 to 121 km) north of Geraldton, and averages about 20 miles (32 km) in width. The North-West Coastal Highway runs meridionally through the area, and numerous minor roads and tracks provide good access to most parts of the field. Although still shown on many maps, the railway lines which formerly connected the mining townships of Northampton, Ajana and Nabawa to the port of Geraldton are now abandoned and dismantled.

Most lead mines in the Northampton Mineral Field are clustered about three centres, Galena, Northampton and Nabawa, though a belt of weak mineralization extends southwards from Northampton to White Peak. Plate 2 shows the distribution of the lead mines with respect to principal roads and towns and to the regional geology.

FACILITIES

Most townships within the field are served with normal postal, telephone and telegraph services, and regular road transport services connect the main centres to Geraldton. Towns in the southern part of the field are supplied by electric power from the State Electricity Commission grid.

Despite an average rainfall of about 20 inches (50 cm), supplies of potable water are often difficult to obtain. Surface water is often salty; groundwater supplies are inadequate and the water is often mineralized. Mining companies in the past have obtained water for their treatment plants from surface catchments and from mine workings, but it is reported that water shortages often delayed operations.

HISTORY AND PRODUCTION

Mining in the Northampton Mineral Field began with the discovery of lead in the bed of the Murchison River by a member of A. C. Gregory's exploratory expedition in 1848. This led to the development of the first lead mine in the field, the Geraldine.

The field has been mined intermittently since 1850 and the periods of greatest activity coincided with higher lead prices. There have been three distinct periods of production. Most of the recorded lead mines were discovered and worked in the period 1865 to 1890. Unfortunately, records of this period are sparse, and accurate information on the production or underground development of the old mines is lacking. Table 1 lists the annual exports of lead ore from the field from 1850 to 1899, before accurate records of mine productions were begun. About 33,600 tons (34,140 tonnes) of ore were sent overseas during

TABLE 8. ANNUAL PRODUCTION OF LEAD AND ZINC FROM THE NORTHAMPTON MINERAL FIELD

Year	Ore and Conc. Tons	Lead Tons	Zinc Tons	Value \$Aust.
1850-98	See Table 1	....	....	....
1899	82·75	54·61	....	1,824·00
1900	268·00	51·00	....	1,066·00
1901-06	....	....	....	....
1907	10·00	6·50	....	256·00
1908	57·00	41·61	....	922·00
1910	185·10	136·67	....	3,554·00
1911	8,194·76	1,263·70	....	35,326·00
1912	11,098·50	1,330·82	....	48,824·00
1913	26,589·53	2,740·99	....	100,948·00
1914	15,334·62	2,074·08	....	76,702·00
1915	15,678·30	1,519·83	....	58,792·00
1916	34,578·34	3,607·81	....	221,744·00
1917	46,801·97	4,929·50	....	297,950·00
1918	47,079·68	6,509·37	....	352,660·00
1919	7,385·70	1,055·64	....	59,682·00
1920	27,716·40	5,072·68	....	354,966·00
1921	10,330·43	1,197·43	....	51,298·00
1922	29,602·90	3,040·70	....	144,676·00
1923	21,634·50	2,237·27	....	118,388·00
1924	26,750·00	3,026·82	....	202,438·00
1925	37,865·99	3,403·38	....	228,598·00
1926	23,973·35	2,426·20	....	145,744·00
1927	5,809·50	758·67	....	34,694·00
1928	112·00	21·00	....	630·00
1929	1,075·00	345·00	....	7,534·00
1930	474·00	25·46	....	1,018·00
1931-33	....	....	....	....
1934	5·00	3·00	....	122·00
1935	....	....	....	....
1936	1,535·00	94·50	....	4,456·00
1937	6,163·00	277·69	....	14,497·00
1938	350·00	41·00	....	1,180·00
1939-42	....	....	....	....
1943	1,250·00	110·00	....	2,200·00
1944-45	....	....	....	....
1946	36·21	26·13	....	2,136·00
1947	5·89	4·60	....	652·00
1948	1,345·19	1,044·82	....	184,982·06
1949	1,910·40	1,308·85	36·88	206,213·54
1950	1,064·88	754·32	1·68	135,530·16
1951	1,521·62	1,185·80	2·02	296,136·10
1952	5,699·39	4,389·16	1·01	1,566,371·94
1953	4,776·11	3,667·85	....	579,154·28
1954	1,338·94	1,002·53	....	140,740·86

TABLE 8 (continued)

Year	Ore and Conc. Tons	Lead Tons	Zinc Tons	Value \$Aust.
1955	1,069·04	762·11	....	136,627·94
1956	6,330·75	4,955·16	....	1,104,643·78
1957	3,322·51	2,504·70	....	511,941·70
1958	2,312·92	1,743·59	....	262,498·04
1959	1,440·52	1,080·28	....	139,257·88
1960	2,259·86	1,736·02	....	238,377·50
1961	597·05	433·17	....	51,530·80
1962	443·03	305·87	....	30,312·20
1963	184·93	135·87	....	13,070·40
1964	....	....	....	....
1965	1,253·89	892·45	....	209,255·60
1966	644·30	460·96	....	88,451·65
1967	909·68	687·89	....	96,893·10
Total	456,458·43	76,476·06	41·59	8,549,167·57

NOTE: 1 ton = 1·01605 tonnes

TABLE 9. PRODUCTION OF LEAD, ZINC AND SILVER FROM THE NORTHAMPTON MINERAL FIELD, BY DISTRICTS

District	Period	Realized Production				Value \$Aust.
		Ore & Conc. Tons	Lead Tons	Zinc Tons	Silver Fine oz.	
Galena	1899-1967	129,045·48	20,538·00	30·42	912·03	1,502,002·24
Northampton	1899-1967	172,377·29	29,439·75	9·15	5,579·22	3,003,422·31
Nabawa	1899-1967	147,057·09	26,403·36	2·02	317·62	4,028,828·70
Miscellaneous Deposits	1926-1967	200·42	107·01	....	16·76	18,537·46
Total Northampton Field	....	448,680·28	76,476·06	41·59	6,825·63	8,552,790·71

NOTE: Prior to 1899—33,601 tons of lead ore, estimated to average 65 to 70 per cent of lead were exported from the Northampton Mineral Field.

1 fine ounce = 31·103 grammes
1 ton = 1·01605 tonnes

that period. From figures given in Montgomery (1908) it can be reasonably assumed that ore averaged from 65 to 70 per cent of lead, and therefore contained about 20,000 to 23,000 tons (20,300 to 23,400 tonnes) of metallic lead. Since 1899, the total recorded production from the field has been 76,476.06 tons (77,699.67 tonnes) of metallic lead from 448,680.28 tons (455,859.16 tonnes) of ores and concentrates. The total recorded zinc production is 41.59 tons (42.26 tonnes) of metal, and the field has produced a recorded total of 6,825.63 ounces (212,297.56 gm) of silver. Annual productions of lead and zinc are given in Table 8, and detailed production figures from individual mines are tabulated under the various districts in Table 9.

GEOLOGICAL SUMMARY

PREVIOUS GEOLOGICAL INVESTIGATIONS

The Northampton Mineral Field has been the subject of many reports by geologists and engineers, both private and Government. The most comprehensive accounts of the regional geology are those by Maitland (1903), Prider (1958) and Jones and Noldart (1962). Summarized reports on numerous mines within the field are given in Woodward (1895), Maitland (1903), Montgomery (1908a), Campbell (1910), Wilson (1926), and Berliat (1954), the most comprehensive being that by Wilson. Individual accounts of some mines have been published, and these are referred to in the descriptions of the properties concerned. The petrology of the Precambrian rocks of the area has been described by Prider (1958). An analysis of the structural controls of the ore bodies in the field is given by Campbell (1965), derived from a more detailed unpublished account by the same author in 1952.

Regional geological maps covering all or part of the Field have been published by Maitland (1903), Prider (1958), and Jones and Noldart (1962). Geological maps covering the Field on a scale of 1:50,000 are being published at the time of writing; three of the sheets, Wokatherra, Northampton and Nanson, are already available. Mapping on a scale of 1:250,000 is being carried out over that part of the Field lying in the Geraldton 1:250,000 Sheet area.

REGIONAL GEOLOGY

The ore bodies of the Northampton Mineral Field are in the Greenough Block which is an inlier of crystalline Precambrian rocks, surrounded by younger Palaeozoic, Mesozoic and Tertiary rocks of the Perth and Carnarvon sedimentary basins. The inlier is largely bounded by faults, but on the southwestern side, Precambrian rocks are overlapped by the younger deposits. About one-half of the area of the inlier is overlain by a thin cover of younger rocks, comprising Jurassic sandstone and conglomerate, Tertiary laterite and sandplain, and Quaternary alluvium, outwash and sand dunes.

Most of the older Precambrian rocks in the Field are rather uniform, weakly banded, garnet granulites of general granitic composition and appearance. Within the granulites are bands of basic granulite (charnockite), sillimanite gneiss, graphitic schist and quartzite. There are also bands of metamorphosed conglomerate in a few places. Prider (1958), arguing on the basis of bulk chemical composition, concludes that the granulites are metasediments of general greywacke to black shale composition, but with some meta-basic igneous rocks. Field evidence, especially the quartzite and conglomerate bands within the granulites, supports this conclusion. The granulites contain numerous concordant

segregations of microcline pegmatite, and in places these are common enough to justify the term "migmatite" in describing the rocks. Horwitz (pers. comm., 1968) has mapped a granite sill in the southern part of the inlier, and notes that all of the mineralization in that area is stratigraphically below the intrusion. A radioisotope age determination of a pegmatite from Mullinya gave an age of 1,000 million years (Wilson and others, 1960), which is probably the date of the metamorphism.

In general, the foliation of the granulites trends northwesterly, but folding has caused many other trends. The foliation is usually parallel to the bedding of the metasediments. Detailed structural mapping of the granulites is made difficult by the lack of marker beds, and the complexity of the folding.

Throughout the extent of the Field the metamorphic rocks are intruded by swarms of parallel dolerite dykes, thought to be late Proterozoic or early Palaeozoic in age. The dykes follow a set of fractures striking northeasterly and are believed to be due to geanticlinal uplift of the block about a northeast axis. Most of these faults dip steeply west, but some have an easterly dip. Tear faults, striking north-northwest and displacing the dolerite dykes have been mapped in the vicinity of Galena, but are not known further south than Ajana.

ORE CONTROLS

The copper and lead lodes of the Northampton Mineral Field are mostly in the northeast fractures, parallel to the dolerite dykes, although some follow other fracture directions or the banding of the granulites. A northwest-striking tear fault has been mineralized at Galena, and Campbell (1952) and other workers have recognized a northwesterly alignment of mining groups in various parts of the Field. Early workers,

such as Maitland (1903), were impressed by the association of the ore bodies with the dolerite dykes. Later workers such as Montgomery (1908) pointed out that the larger ore bodies of the Field were in granulite, well removed from any dolerite dykes, although usually oriented parallel to the dyke trend. Of the 80 mines and prospects examined during the preparation of this Bulletin, only 24 were closely associated with dolerite, two contained a biotite schist which may have been an altered dolerite, and 54 were in gneiss, at least 50 feet (15 m), and usually much further, from the closest dolerite. Of the seven mines within the Field which have produced more than 2,000 tons (2,000 tonnes) of metallic lead, none is close to a dolerite intrusion.

The mineralized shears in the Northampton Mineral Field often persist for several miles, but ore shoots are confined to sections from 50 to 900 feet (15 to 270 m) long. The shoots are usually located on curves in the shear planes, or on diagonal link structures between echelon offsets of the shears. Campbell (1952, and 1965) recognizes two main types of structural control: the cymoid loop (or split-shear lens) and the diagonal link (or breccia link). Ore within the cymoid loop structures may occur in the two bounding shears, in link shears cutting through the enclosed lens of rock, or in the brecciated thin ends of the lens. The diagonal link structures normally consist of a zone of brecciation traversed by irregular tensional gashes containing most of the ore. Campbell cites the Protheroe mine as an example of the cymoid loop structure, and the Surprise mine at Galena as an example of the breccia link structure.

Most of the larger mines in the Field conform to one or other of these structural types, but many smaller mines have a

simpler structure. In these, lenses of ore formed within a curved shear where the orientation of the shear was such that the movement on it forced the walls apart and left room for ore deposition. Most ore bodies of this type are on normal faults and the more steeply dipping parts contain the ore shoots.

The cause of the curves or echelon displacement of a mineralized shear can usually be ascribed to changes in the mechanical properties of the country rock that lies in its path. These changes are usually due to differences in rock type and many ore bodies are located on the intersection of a fault with a band of quartzite or pegmatite within the granulites. Sometimes the change is more subtle, the necessary difference in mechanical properties being due to folding or silicification of the granulites. The association of many ore bodies with pegmatites is structural rather than genetic.

The lodes of the Northampton Field are brecciated zones which vary from about 1 to 10 feet (30 cm to 3 m) wide, and rarely reach 30 feet (9 m). They are seldom mineralized over their whole widths, but contain veins of sulphides along one or both walls. Less commonly, veins of sulphides may lie within the breccia zone. The veins vary from 3 inches (7.6 cm) to over 3.5 feet (1 m) wide and consist mainly of massive sulphides, though they may contain vugs several feet long and as wide as the vein. The veins occupy tensional openings within the breccia zones, and usually prove to be lenticular when mined. In some parts of the lode, veins of sulphides may overlap, and in others the lode may be barren. Galena may also be present in the lodes as thin ramifying stringers or in disseminated form. Curved cleavage faces on the galena, and other features of the lode,

suggest that some movement on the faults took place after deposition of the ore.

No ore shoot worked in the Northampton Mineral Field has persisted for more than about 500 feet (150 m) in depth and most have bottomed at 300 feet (91 m) or less. This is thought to be due to the limits placed on the size of individual shoots by their structural controls. There seems to be no reason why further shoots of similar sizes should not be found at greater depths than 500 feet (150 m), although these will probably not extend to the surface. The Protheroe ore body (Fig. 2) is an example of a large ore body which was almost "blind" in outcrop.

COMPOSITION OF THE ORE BODIES

In the Northampton Field, lead and copper have usually been won from separate ore bodies, although most copper ore contains a little lead, and some lead ore bodies contain a little copper. Where lead and copper have been mined from the one mine, each mineral has occupied a distinct part of the lode and there has been little mixing. For example, in the Narra Tarra mine, copper was confined to the southern part of the ore body and lead to the northern part. In the Wanerenooka copper mine, lead was present on the hanging wall side of the lode only. The copper mines in the Northampton Field have been described in Bulletin No. 8 of this series (Low, 1962) and are only included in this volume if they have also produced a significant amount of lead.

Sulphide minerals found in the lead ore bodies are galena, sphalerite, pyrite, marcasite and chalcopyrite. In the oxidized zone, usually quite shallow in the Northampton Field, lead occurs as cerussite (often with cores of galena), anglesite and pyro-

morphite. The Field is noted for the occurrence of large (up to 5 cm) crystals of galena in vugs within the lodes. The gangue of the lodes is siliceous, ranging from quartz crystals in vugs, through crystalline quartz and quartz-filled breccia, to grey, flinty chalcedony. Although sphalerite is common in the lead lodes, only a small amount of zinc has been won from the Field. This seems to be due to the lack of suitable concentrating plants; the gravity separators used being unable to obtain a commercially acceptable concentrate of the zinc blende. The silver content of the galena is quite low, averaging only about 1 ounce per ton (31 gm per tonne) and much of the silver recovered from the ores has not been profitable. Gold has been recorded from the Baddera mine (Cullingworth, 1915), and from the bed of the Bowes River.

WALL-ROCK ALTERATION

Wall-rock alteration about the ore bodies of the Northampton Field is often marked, producing haloes of kaolin or chlorite. Garnets within the granulites near some ore bodies are altered to chlorite, producing a distinctive green-spotted rock. Dolerites near lodes are uralitized and chloritized.

HISTORY OF PROSPECTING

To date, all of the mines worked in the Northampton Mineral Field have been surface discoveries. Prospecting methods have consisted of searching for gossans or outcrops of "trap-rock", a type of siliceous billy formed over the lodes. Some lodes were found accidentally when exposed by farmers or earth movers.

Geophysical prospecting methods have been tried at various times since 1930, but

until the introduction of the induced polarization techniques, results were discouraging; there is no magnetic mineral in the ore and the electrical conductivity of the siliceous lodes is low; saline groundwater interferes with many of the older methods. Induced polarization has been used in the area by some companies, and although successful in defining the lode shears, has not produced a new ore body. It is likely that geophysical techniques will have to be refined even further before they are useful in locating the comparatively small ore bodies of the Northampton Mineral Field.

Geochemical prospecting has been carried out by some companies working in the Field. The method successfully traces lines of mineralization beneath soil cover, but has not discovered any new ore. It is likely to be most useful in the northern part of the Field where the soil has not yet been disturbed by cultivation. In the southern districts, most of the prospective land is farmed and the consequent disturbance of the soil and addition of fertilizer, sometimes with trace element additives, complicates geochemical prospecting.

ORIGIN OF THE LEAD ORES

The various lead, zinc and silver deposits of the Northampton Mineral Field are either hydrothermal fissure veins or tectonic breccia fillings. Their characteristic mineral assemblages and accompanying wall-rock alteration indicate a low to medium temperature for ore deposition. The source of the mineralizing solutions has been ascribed to the ubiquitous pegmatites by some workers (e.g. Feldtmann) and to the dolerites by others (e.g. Jones and Noldart).

Field evidence is against the pegmatites being the source of the metals; the ore is demonstrably younger than the dolerite

dykes which are in turn younger than the metamorphism during which the pegmatites segregated from the granulites. This conclusion is supported by radioactive isotope studies which have indicated an age of 1,000 million years for the pegmatites and about 500 million years for the lead ores.

Support for the theory that the dolerites introduced the ore minerals has been derived from the close association of many dykes and ore bodies, and from the observation that even where not closely associated, dykes and lodes follow the same set of fractures. The age of the dolerite dykes, as determined from their stratigraphic relationships to sediments of the Perth Basin, is thought to be Upper Proterozoic or Lower Phanerozoic. This agrees with the 500 m.y. lead isotope age (Prider 1958).

The coarse grain-size of the ores, and the presence of vugs within the ore bodies, have been used as arguments to support an origin by deposition from comparatively cold groundwaters, the metals being derived from leaching of either the granulites or of some metal-rich bed in the overlying sediments. Such a theory could not explain the chlorite-grade wall-rock alteration surrounding some deposits, nor the presence of such medium-temperature minerals as chalcopyrite in the ore.

The writer believes the ores have been deposited by hot solutions given off during the last stages of the intrusion of the dolerite dykes.

NORTHAMPTON DISTRICT

The mines of the Northampton district are in a large area of granulite and gneiss exposed by the downcutting action of the headwaters of the Bowes River. Most of the mines are clustered either about Northampton itself, or in an area extending

northwards to about 2 miles (3 km) north of Baddera. A few scattered mines or deposits such as Nonga Hill to the northwest of Northampton and Normans Well to the southeast have been included in the district, although they are outside the main belt of mineralization.

Mining in the Northampton district started with the discovery of the Wanerenooka mine in about 1856. The district includes the largest lead mine in the State, the Baddera, and other mines of past or present importance, such as the Gurkha, Wheal Fortune, Wheal Ellen and Nooka. The production of the various groups of mines in the district is set out in Table 10.

Plans: The Northampton district is covered by Mines Department lease plans N-4 and N-5, and the locations of the mines are shown on the Northampton 1:50,000 Geological Map (Sheet 1841-111S Zone 1).

BADDERA GROUP

General Information

The Baddera group is on Location 1472, 5.5 miles (8.8 km) north of Northampton and a mile (1.6 km) by dirt road east of the highway. Two mines have been worked on the property, the Baddera and Baddera North; they are also called the Old Baddera and the New Baddera respectively. The southern extension of the Baddera ore body has been worked as the Baddera South.

The Baddera mine was discovered in 1873 and worked for about 10 years to a maximum depth of 100 feet (30 m). No production figures are available for this period, save for a record of 677 tons (687.8 tonnes) of concentrate averaging 72 per cent lead. The mine was reopened from 1910 to 1920 and produced almost 14,000 tons (14,200 tonnes) of lead from 130,000 tons (132,000 tonnes) of ore giving an average grade of about 11 per cent

TABLE 10. PRODUCTION OF LEAD, ZINC AND SILVER FROM NORTHAMPTON DISTRICT

Mine or Group	Lease No.	Lease Name or Lessees	Period	Estimated Mine Production		Realized Production				Est. Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore or Conc. Tons	Lead Tons	Silver F. oz.	Zinc Tons		
Baddera Group	Loc. 1472	Baddera mine	1910-15	75,783·26	....	....	8,439·48	....	....	300,626·00	Old Baddera 129, 264·36 tons ore for 13,888·33 tons lead New Baddera
	Loc. 1472	Fremantle Trading Co. Ltd.	1916-20	53,481·30	....	....	5,448·85	....	....	334,636·00	
	ML's 31PP 220, Loc. 1472	Northampton Mining & Development Co. Ltd.	1948-56	15,363·00	1,088·00	1,059·04	720·38	558·63	8·14	129,308·00	
	ML 257	South Baddera	1951-53	387·00	78·69	78·28	56·39	39·63	1·01	8,278·42	
	Loc. 1472	Mitchell, G. H.	1964-66	716·75	74·55	96·02	64·29	....	....	13,664·41	
Total Baddera Group			....	145,731·31	....	....	14,729·39	598·26	9·15	786,512·83	
Gurkha	ML 51	Alma lead mine	1899	....	....	19·00	12·54	....	....	424·00	Silver valued at \$2,620·00
	ML 256	Gurkha lead mine	1952-61	33,863·75	6,617·32	6,739·90	5,227·93	3,419·71	....	898,476·12	
Total Gurkha			....	33,863·75	....	6,758·90	5,240·47	3,419·71	....	898,900·12	
Kathleen Hope...	ML 263	Kathleen Hope lead mine	1957-59	190·00	30·43	27·54	18·68	26·51	....	2,661·40	Silver realized \$20·80
	MC 48	Kathleen Hope lead mine	1965	176·74	8·80	8·21	4·57	....	....	835·20	
Total Kathleen Hope			....	366·74	39·23	35·75	23·25	26·51	....	3,496·60	
Kirtons Group...	ML's 127, 128, 129	Kirtons leases	1915-19	....	....	2,136·76	379·89	....	....	15,144·00	Silver not payable
	ML 12PP	Kirtons main lode....	1916	....	....	15·39	10·02	....	....	454·00	
	PA's 211, 212	Merritt & Coates	1949	....	....	2·02	1·34	1·82	....	285·30	
	ML 250	Kirtons	1952-53	340·00	16·00	24·52	17·98	7·45	....	2,906·26	
Total, Kirtons Group			....	....	....	2,178·69	409·23	9·27	....	18,789·56	
Lucy	ML 58PP	Lucy	1956	133·75	7·16	7·07	5·36	....	....	534·60	
May Bell	ML 277, 37PP	Gabalong Asbestos Co. Pty. Ltd.	1948-56	1,698·00	103·96	100·07	70·45	42·82	....	13,853·58	Silver valued at \$4·80
McGuire's	Loc. 832, ML 268	Isseka Mining Pty. Ltd.	1950-59	4,371·00	744·76	763·43	563·26	156·02	....	102,834·94	Silver valued at \$76·20

McGuire	East Iode	Loc. 2932	Camp and Party	1965-66	105.00	14.90	14.24	9.74	....	....	1,931.21	
Mulligans	....	ML 39PP LTT 132IH ML 66PP	Mulligans mine S. G. Camp Lucky Strike lead mine	1949-52 1955-56 1959	711.00 41.25	114.06 3.49	112.56 2.69 81.71	85.86 1.75 62.65	30.31 1.43 ....	.... .... ....	19,296.90 372.60 6,998.00	Silver not payable Silver valued at \$1.30
Total, Mulligans		....	....	....	....	....	196.96	150.26	31.74	....	26,667.50	
Nooka Group	....	ML 142 LTT 128IH ML 276 ML 284 MC 28	Nooka Lead Mining Co. N.L. R. James & S. Camp Nooka Mining Syndicate Nooka lead mine Chiverton	1917-18 1954-55 1960-62 1964-67 1955-56	.... 32.00 2,250.00 8,236.00 34.25	.... 1.48 423.57 1,156.00 4.68	876.12 1.40 400.84 1,107.21 4.00	176.40 1.00 262.25 775.86 2.60	.... .... 158.84 2.12	.... .... .... .... ....	6,698.00 155.86 26,229.80 161,028.89 580.94	Tailings treatment Silver valued at \$134.80 Silver valued at \$1.70
Total, Nooka Group		....	....	....	10,552.25	1,585.73	2,389.57	1,218.11	160.96	....	194,691.49	
Normans Well	....	PA 149 MC 6 PA 250, LTT 1287H	Normans Well Lead Mining Syndicate Normans Well Syndicate Camp and Party	1930 1950-51 1954-55	436.00 310.00 169.50	38.00 13.00 26.38	38.00 29.96 24.40	25.46 19.88 17.20	.... 16.73 14.54	.... .... ....	1,018.00 6,865.80 2,997.54	Silver not payable Silver not payable
Total, Normans Well		....	....	....	915.50	77.38	92.36	62.54	31.27	....	10,881.34	
Wheal Fortune	....	Loc. 334.... Loc. 436.... Loc. 436.... Loc. 436.... Loc. 436.... Loc. 436.... Loc. 436....	Wheal Fortune Wheal Fortune Extd. Syndicate Furtuna Exploration N.L. Wheal Fortune Extd. Paringa Wheal Fortune Pty. Ltd. Wheal Fortune Extd. Wheal Fortune Extd.	1950-56 1917-18 1918-20 1949-53 1952-56 1957-60 1965-66	816.78 9,399.00 24,629.00 8,097.50 1,106.25	56.04 1,417.50 294.55 1,493.99 96.35	83.73 125.82 123.38 1,226.94 2,952.75 1,409.92 89.52	56.78 43.13 51.17 915.28 2,202.20 1,033.86 55.74	32.06 185.11 697.55 ....	.... .... .... .... .... .... ....	10,394.30 1,586.00 2,632.00 279,638.22 312,368.22 140,965.50 10,597.90	Silver not payable Silver unpayable Silver valued \$551.06
Total, Wheal Fortune Group		....	....	....	44,048.53	3,358.43	6,012.06	4,358.16	914.72	....	758,182.14	
Rhyhope	....	PA 73PP.... Loc. 2366	Rhyhope mine Rhyhope	1952-53 1965	321.00 112.25	64.75 9.90	61.59 9.52	44.68 5.81	30.79 ....	.... ....	7,567.58 1,097.40	Silver unpayable
Total, Rhyhope		....	....	....	433.25	74.65	71.11	50.49	30.79	....	8,664.98	
Uga	....	ML 126 ML 223 LTT 5263H	Uga Uga mine G. H. Mitchell	1916 1949 1965	.... .... 92.25	.... .... 5.95	121.03 7.11 5.52	83.80 4.25 3.84	.... 5.90 ....	.... .... ....	3,992.00 838.60 771.30	Silver unpayable
Total, Uga		....	....	....	....	....	133.66	91.89	5.90	....	5,602.00	

TABLE 10 (continued)

Mine or Group	Lease No.	Lease Name or Lessees	Period	Estimated Mine Production		Realized Production				Est. Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore or Conc. Tons	Lead Tons	Silver F. oz.	Zinc Tons		
Wanerenooka	ML 71PP	Roger Malray copper mine	1958	11·74	4·67	22·21	564·00	Silver valued at \$17·90 Mine worked mainly for copper
Wheal Ellen	Loc. 1146	Wheal Ellen: Fremantle Trading Co. Ltd.	1917-24	22,033·28	1,818·71	104,912·00	Concentrates smelted at Fremantle
	Loc. 1146	Corderoy Mines Ltd.	1954-56	129·25	6·88	7·42	4·69	924·94	Wheal Ellen North
	Loc. 1146	Camp and Party	1965-66	530·00	41·10	34·69	22·34	....	....	4,294·58
	MC 76	Mitchell, G. H. and J.M.	1967	482·00	61·00	91·23	57·95	....	....	7,446·28
Total, Wheal Ellen				23,174·53	1,903·69	117,577·80	
Yiapa	ML 62	Yiapa	1900	30·00	15·00	390·00	Silver valued at \$60·50
	PA 51PP....	Yiapa Syndicate	1949	....	....	2·86	1·94	....	....	422·00
	PA 38PP....	Yiapa	1949-55	146·25	?	14·29	9·46	....	....	1,246·46
	ML 266	Yiapa lead mine	1961-62	401·25	88·20	84·32	58·89	65·52	....	5,995·30
	MC 47	Yiapa	1966-67	619·00	155·00	342·00	260·52	....	....	37,112·86
Total, Yiapa				1,166·50	473·47	345·81	65·52	45,166·62	
Sundry Producers	Loc. 437....	Simpson & Hyde	1951	30·00	3·73	2·73	1·85	511·60	South of Wheal May
	PA 244	Woodcock & Chisholm	1951	....	....	0·74	0·48	....	....	117·10
	PA 251	R. Reynolds	1955-56	161·75	10·67	8·57	4·54	718·80	North-East of Paringa Wheal Fortune mine North of Nonga Hill, Silver valued at \$51·08
	PA 257	AGM Syndicate	1957-58	58·00	8·55	7·78	3·94	63·52	....	587·80
		Sundry Claims	1915-29	....	....	437·12	171·14	....	....	6,334·00
	Sundry Claims	1951	....	....	1·83	1·23	....	....	301·70	

NOTE: 1 fine ounce = 31·103 grammes
1 ton = 1·01605 tonnes

lead for the mine. This is the largest production from any lead mine in Western Australia. The Baddera North mine was worked from 1948 to 1956 and yielded 720 tons (731.0 tonnes) of lead from 15,000 tons (15,200 tonnes) of ore, an average grade of about 5 per cent lead.

References: Maitland (1903), Feldtmann (1922), Cullingworth (1915), Wilson (1926), and Berliat (1954).

Plans: Mines 24/1; G.S.W.A. 5745, 5746, 5747, 5748.

Geological Occurrence

The ore bodies of the Baddera mines are on cymoid loop structures developed where the lode shear has intersected two bands of massive, glassy quartz. These bands strike at about 300 degrees and seem to trend across the local strike of the gneisses. They are probably quartz veins or zones of silicification following faults of the north-northwest system, but may represent a highly recrystallized variety of quartzite. The cymoid loop is well exposed at the south end of the Baddera mine where the two branches of the shear can be followed in the surface workings and are seen to re-join in the southernmost open-cut.

The principal lodes on the lease strike at about 50 degrees and dip 73 degrees west on the average, but in the Baddera mine, a branch lode striking at 175 degrees and dipping about 65 degrees west was worked over a length of 250 feet (76 m). At the south end of the same mine, the main lode met, and turned along a narrow shear zone, which also trends at about 175 degrees, and dips between 67 and 77 degrees west. The direction of these cross structures is parallel to the banding of the metamorphic rocks in the vicinity of the mine.

The wall rocks of the lodes are granulite, pegmatite and quartz; there is no dolerite in the vicinity of the workings.

Baddera Mine

The surface workings on the Baddera mine extend for about 450 feet (137 m), of which the northern 200 feet (61 m) are largely covered by tailings. At the southern end of the ore body, there are two lines of workings about 30 feet (9 m) apart, one on each branch of the cymoid loop structure. The workings on the hanging wall shear are the more extensive, and the lode consists of an 8-foot (2.4 m) wide zone of crushed granulite cut by thin veins of iron-stained quartz and siliceous breccia carrying lead and traces of copper. The footwall lode is seen to comprise 1 to 1.5 feet (30 to 46 cm) of quartz, dipping westerly. Massive quartz reefs cross the southern end of the workings and are apparently contiguous with those forming the nearby ridges. A well-defined shear at the south end of the workings is probably the surface extension of the fault along which the lode turned before terminating.

Underground, the ore was mined from a main shaft sunk about 100 feet (30 m) west of the lode outcrop and 280 feet (85 m) northeast of the southwest corner of Location 1472. The shaft was 450 feet (137 m) deep with levels at 150, 234, 341 and 442 feet (45.7, 71.3, 103.9 and 134.7 m). The 150-foot level (45.7 m) was driven 560 feet (171 m) north and 440 feet (134 m) south of the main shaft and stoped above over a distance of about 290 feet (88 m) north and 280 feet (85 m) south of the shaft. Driving on the 234-foot (71.3 m) level extended 530 feet (162 m) north and 400 feet (120 m) south of the main shaft, with overhead stopes to within 40 feet (12 m) of either end. The 341-foot (103.9 m) level extended 520 feet (158 m) north and 320 feet (98 m) south of the shaft, and was stoped above over most of its length. Only 400 feet (120 m) of driving was carried

out on the 442-foot (134.7 m) level, to 200 feet (60 m) either way from the main shaft. Most of the lode was mined out above this level although Wilson (1926) states that the ore was patchy and values generally cut out at about 420 feet (128 m).

The branch lode, which joins the main lode at 460 feet (140 m) north of the main shaft on the 234-foot (71.3 m) level, was developed for 140 feet (46 m) on this level, for 220 feet (67 m) on the 341-foot (103.9 m) level, and for 100 feet (30 m) on the 442-foot (134.7 m) level. Owing to the westerly dip of the branch lode, its intersection with the main lode progressed south on each successively deeper level. The position of the junction on the 442-foot (134.7 m) level was not exposed by the mine development.

Feldtmann (1922) gives the following description of the lodes:

“The main shear zone ranges from about 5 to fully 33 feet (1.5 to 10 m) in width, probably averaging 16 feet (4.8 m); the lode channel ranges from 1 to 33 feet (30 cm to 10 m), averaging probably 4 or 5 feet (1.2 to 1.5 m); the ore shoots (including veins) ranged from a thread to about 33 feet (10 m)—at the junction with the branch lode above the 234-foot (71.3 m) level, where the ore shoot apparently occupied the full width of the shear zone—but only in a few places attained a width of more than 4 feet (1.2 m). Owing to lack of data, it is impossible to estimate the width of the branch shear zone, which appears to be less defined than the main shear zone; the lode channel ranges from a thread—near the junction at the 150-foot (45.7 m) level—to about 24 feet (7 m)—at a point about 28 feet (9 m) below the branch drive at the 341-foot (103.9 m) level, where the ore shoot apparently occupied the full width of the channel; the

average width of the ore shoot in the branch lode was probably between 2 and 3 feet (60 to 90 cm).

“The shear zones in which the lodes and ore shoots occur are the results of earth movements which sheared and brecciated the gneiss and dyke (pegmatite) rocks along comparatively narrow channels, the rock along the line of most intense shearing, usually near the middle of the shear zone, being crushed into angular fragments of varying size. Shear planes, generally parallel to the brecciated zone but in places running into it at an acute angle, were formed on both sides of that zone. In places the rock for a few inches on the footwall side of the shear planes was crushed to a fine powder. Joints approximately at right angles or acute angles to the main zone of shearing were formed in the rock for a few feet outside that zone. The brecciated zone and the shear planes subsequently formed paths for the ore-bearing solutions which deposited quartz, galena, blende, pyrite and chalcopyrite in the open spaces, the resulting ore bodies consisting, in the body of the lode, of irregular masses, small lenses, and veinlets of galena, with a little pyrite in places, in a gangue composed of fragments of gneiss or pegmatite cemented by quartz. Where there were open spaces, the quartz is white or milky, and coarsely granular; where the spaces between the rock fragments were filled with powdered rock, the quartz is dense and fine grained, and usually of a greyish colour. Where the solutions carried insufficient material to fill the open spaces completely, the galena and quartz found room to form crystals. Along the shear planes, galena and quartz were deposited, in places to form veins of varying size. Blende which is present only in small quantities in this mine, occurs as a rule along shear planes or joints near the limits of the shear zone or

in those portions of the lode in which galena is practically absent. Pyrite occurs in disseminated grains in the quartz matrix of the lode breccia, particularly around the rock fragments; occasionally as small lenses of finely granular material in the galena veins, usually in the centre; and rarely as narrow veins of more coarsely crystalline material, in places containing a little galena, in the poorer portions of the lode. In the larger veins, galena usually occurs as irregular interlocking groups of coarse imperfect cubic crystals, but where vugs occur, forms octahedral and cubo-octahedral crystals, which however, are seldom perfect.

“The veinlets in the body of the lode are usually composed of more finely crystalline material. A very fine-grained, massive variety occurs in a few places as seams along narrow zones of intense shearing.

“According to the early descriptions of the mine, a fair amount of lead carbonate . . . was obtained from the surface workings, but no particulars are available as to the depth to which it extended.”

From the information available, it seems likely that the ore body in the Baddera mine has been worked out.

Baddera North

The Baddera North mine is in the northeastern corner of Location 1472 and extends into M.L. 31PP. It is on the same line as, and 2,000 feet (610 m) northeast of the Baddera mine. Originally shallow workings extended over a length of 300 feet (90 m), but these are now largely obscured by dumps and tailings from later operations. The mine was reopened in 1917 and again in 1948. The description here is based on the reports of Wilson (1926) and Berliat (1954).

Two lodes, about 30 feet (9 m) apart on the surface have been worked. These

are probably the two branches of a cymoid loop structure, but the evidence here is not conclusive. The two branches apparently separated even further at depth. In the footwall lode, the ore is disseminated over a width varying from 4 to 15 feet (1.2 to 4.5 m); the galena forms well-defined, southerly-pitching shoots along the hanging wall. Up to four seams with an overall width of 4 feet (1.2 m) were located, individual seams ranging from 6 inches to 2 feet (15 to 61 cm) in width. In places, the seams converged to form a solid vein of galena.

Workings on the footwall lode consist of an inclined shaft sunk to a depth of 150 feet (46 m) from which drives were put in for distances of 70 feet (21 m) north and 200 feet (61 m) south. Stopping extended for 170 feet (52 m) along the south drive and reached the surface over a distance of about 60 feet (18 m). Values were poor, averaging about 6 to 7 per cent lead. Older workings on the footwall lode comprised an intersection in a crosscut from the hanging wall lode at the 84-foot (25.6 m) level. Most of the deep mining on the footwall lode was done during the later period of production.

Early workings on the hanging wall lode consist of an inclined shaft (now collapsed) about 104 feet (31.6 m) deep, and a level at 84 feet (25.6 m), on which at least 130 feet (40 m) of driving was done. The shaft is about 200 feet (60 m) north-northeast from that on the footwall lode. Later development on the hanging wall lode was done from a cross-cut 93 feet (28.3 m) long, driven from the footwall lode at the 160-foot (48.7 m) level. Driving from the cross-cut was carried out over a length of 270 feet (82 m). A stope near the south end of the drive has a length of 60 feet (18 m) and more stoping was done 100 feet

(30 m) north of the cross-cut. The Baddera North mine closed down in 1956.

GURKHA MINE

The Gurkha mine, formerly known as the Alma mine, is 6 miles (9.6 km) north of Northampton and immediately west of the highway, on M.L. 256. It was worked in a small way in about 1899, but reopened in 1952 to become one of the larger mines in the Field. Total production is 5,240 tons (5,323 tonnes) of lead and 600 ounces (18,660 gm) of silver from about 34,000 tons (34,500 tonnes) of ore.

References to the mine have been published by Maitland (1903), and Berliat (1954).

Plans of the workings are held by the Mines Drafting Branch (Ref. 486/1 to 4) and a long section was published by Jones and Noldart, 1962 (G.S.W.A. 2449).

The lode, which was only weakly mineralized at the surface, follows a shear zone in gneiss, strikes at about 30 degrees and dips 60 to 75 degrees west. There are no exposures of the ore on the surface, but Berliat, who saw the mine shortly after it reopened, describes it as "lode matter and lenses of solid galena up to 2 feet (60 cm) thick . . . in a shear zone 4 to 6 feet (1.2 to 1.8 m) wide". He adds: "Hard quartz, together with some barite, is found along the footwall". Apparently the better grade ore was encountered at a depth of about 50 feet (15 m) in the workings. From the section in Jones and Noldart it can be seen that the shoot then increased in length, reaching a maximum of 500 feet (150 m) below the 140-foot (42.6 m) level. At the 240-foot (73.1 m) level, it divided into two prongs, one 100 feet (30 m) long and the other about 150 feet (46 m) long. The mine closed shortly after the section was drawn,

and it seems likely that the ore body bottomed at a short distance below this level. The ore shoot had an overall southerly plunge.

The main shaft of the mine was sunk to a depth of about 260 feet (80 m), and levels were established at 60, 90, 140 and 240 feet (18.2, 27.4, 42.6 and 73.1 m). The 140-foot (42.6 m) level was driven 340 feet (104 m) north and 140 feet (43 m) south. On the 240-foot (73.7 m) level, the north drive was 340 feet (104 m) long and the south drive 500 feet (150 m). Winzes were sunk from the 240-foot (73.1 m) level at positions 220 feet (67 m) south and 270 and 410 feet (82 and 125 m) north of the main shaft, the deepest being the last-mentioned which went to 60 feet (18 m) below the level. A short sub-level was driven from the southern winze at a depth of 35 feet (10.6 m) below the 240-foot (73.1 m) level.

Apart from the main shaft, there were other surface openings to provide ventilation or to act as sand-passes.

Minerals found in the Gurkha ore body are galena, pyrite, and marcasite. A specimen of pyrite and marcasite assayed 0.54 per cent nickel, suggesting the presence of pentlandite.

WHEAL FORTUNE GROUP

General Information

The three mines which make up the Wheal Fortune group are on Locations 334 and 436, about 3 miles (5 km) west of Northampton. They can be reached from the Port Gregory road, or by a track leading from the Nooka mine across the Northampton Common. Mineral rights of both blocks are alienated from the Crown under an old land title. In this report, the most south-westerly of the ore bodies is called the Wheal Fortune, the next in line is termed the Wheal Fortune Extended, and the most northeast-

erly of the mines is the Paringa, short for its one-time name of Paringa Wheal Fortune Extended. In earlier reports there was some confusion between these names. The following short history of the group may help to clear the matter.

The Wheal Fortune mine on Location 334 was worked between 1862 and 1868 and was chiefly a copper producer, although the ore body contained an appreciable amount of lead. During mining, the 180-foot (55.8 m) level was extended north-easterly in search of new ore, and encountered a body of lead ore at a distance of about 320 feet (98 m) from the main shaft. This was developed from a shaft, known as Sampson's Shaft or the Whim Shaft, located 23 feet (7.0 m) inside the boundary of Location 436 and became known as the Wheal Fortune Extended mine while Location 436 was called the Wheal Fortune Extended block. About 1,200 feet (370 m) northeast of Sampson's Shaft were some old diggings shown as Rhys mine on old maps. These were reopened in about 1949 and called, at that time, the Wheal Fortune Extended. Later, the Paringa Wheal Fortune Pty. Ltd. company took over the block, and developed the Paringa mine on this site.

The total production from the group since 1899 is 44,048 tons (44,752.7 tonnes) of ore containing 4,358 tons (4,427.7 tonnes) of lead and 914 ounces (28,428.1 gm) of silver. Details are set out in Table 10; estimates of ore won from the Wheal Fortune mine in the period 1862 to 1868 vary, but the most reliable seems to be that in Wilson (1926, p. 66) which gives the figures as 2,968 tons (3,015.4 tonnes) of lead ore assaying 75 per cent lead, and 2,639 tons (2,681.2 tonnes) of copper ore averaging 17 per cent copper.

References to the group can be found in Maitland (1903), Montgomery (1908), Wilson (1926), Tomich (1955) and Low (1963). Both Montgomery and Wilson reproduced a set of reports dated about 1900, on the older workings. Some of them contain obvious inconsistencies, but one by James Penberthy, a former manager of the Wheal Fortune mine, seems fairly reliable. Mr. Penberthy wrote the account some 30 years after the mine had closed, but apparently had access to old plans and records to assist his memory. The assessment of the old records prepared by Alex Benson and reproduced along with the other reports also seems reliable, as it is reputedly based on authentic data. Although it is realized that there is some risk involved in accepting these reports too literally, they are the best available information on the old workings and have been drawn on extensively in the descriptions below, of the Wheal Fortune and the Wheal Fortune Extended mines. Tomich's report (1955) has been used as the basis of the present description of the Paringa mine.

Plans: Mines 71/1 and 2; G.S.W.A. 5488, 10821, 10822. A plan and section appear in Tomich (1955).

Geological Information

The ore bodies of the Wheal Fortune group have formed in a line of shearing striking at 40 to 50 degrees and dipping from 70 degrees southeasterly to almost vertically. No detailed map of the lode exists, but it is believed to be made up of a number of closely parallel or en echelon shears with the overall trend indicated above. Ore controls are not known precisely, although Tomich records that the richer sections are found where the shears cut pegmatites, and earlier reports suggest that the lode is poor where it traverses beds of micaceous schist.

Individual oreshoots pitch southerly and the widths of ore range from about 1½ feet to 4 feet (46 cm to 1.2 m).

Ore minerals seen or recorded in the group are galena, sphalerite, chalcopyrite and pyrite in the primary zone, and cerussite, malachite, azurite, chalcocite, covellite and native copper in the oxidized parts of the lode. The gangue of the lodes is made up of quartz and puggy clay and the wall rocks are the usual granulites of the field. The closest dolerite dyke forms a ridge about 600 feet (180 m) west of the mines.

Wheal Fortune Mine

The workings of the Wheal Fortune mine are now completely inaccessible, and the following information is based mainly on the reports of Penberthy and Benson, in Wilson (1926). It should be noted that the long section of the workings, mentioned but not printed in that reference, is now missing.

Description of Workings: Early work on the mine was done from an underlay shaft following the dip of the lode to a depth of 240 feet (73 m). Later, a vertical shaft was sunk to intersect the lode below the 240-foot level (73.1 m). The eventual depth of this new shaft was about 300 feet (91 m). The ore body was worked from levels at 48, 180, 240 and 300 feet (14.6, 54.8, 73.1 and 91.4 m). The 180-foot (54.8 m) level extended for about 560 feet (171 m) northwards to connect to Sampson's Shaft on the Wheal Fortune Extended block and southwards for 170 feet (52 m). On the 240-foot (73.1 m) level, workings extended for 200 feet (61 m) north and 70 feet (21 m) south of the shaft. No details are available about the other levels, except that they existed and that stoping was carried out from them.

Details of ore sections: On the 180-foot (54.8 m) level, a shoot of copper ore extended 84 feet (25.6 m) south from the shaft. It was later stoped to the surface. Part of the shoot was probably stoped on the north side of the shaft. The remainder of the south drive at the 180-foot (54.8 m) level was in barren ground. The old main shaft was in the copper ore body between the 180 and 240-foot (54.8 and 73.1 m) levels. On the 240-foot (73.1 m) level the ore body extended 430 feet (131 m) north and 70 feet (21 m) south of the shaft. The lode was 2 to 3 feet (60 to 90 cm) wide and averaged about 6 per cent copper (2 to 3 tons (2 to 3 tonnes) of 17 per cent concentrate per fathom).

The next 100 feet (30 m) of the 240-foot (73.1 m) level north drive was in barren quartz, but in the final 70 feet (21 m) the lode contained disseminated lead ore which dressed to 80 per cent concentrate. Stoping was carried out on this ore body from a winze connecting the 180 and 240-foot (54.8 and 73.1 m) levels.

A cross-cut into the hanging wall of the lode, from 60 feet (18 m) southwest of the old main shaft on the 180-foot (54.8 m) level, cut a lode at a distance of 30 feet (9 m). This was driven on for 30 feet (9 m) northeast and a few feet south.

Benson, in Wilson (1926), lists the average widths and value (in £s per fathom) of ore mined in the various stopes of the Wheal Fortune mine. As the term "fathom" referred to a volume of ore 6 by 6 feet (1.8 by 1.8 m) by the width of the lode, these figures can be converted to an approximate value per ton, and then compared to present day prices, which are about four times those used by Benson.

Benson used prices of £13 and £11 respectively for 17 per cent copper and 75 per cent lead concentrate, equivalent to

TABLE 11. VALUE OF ORE RAISED FROM VARIOUS PARTS OF THE WHEEL FORTUNE MINE

Point of Operation	Average Width Feet	Value \$A/ton
48-foot level—northeast of shaft—		
Driving	1 $\frac{3}{4}$	3.80
No. 1 stope—back	1 $\frac{1}{8}$	7.70
48-foot level—southwest of shaft—		
No. 1 stope—back	2	5.50
180-foot level—northeast of shaft—		
Driving	3	4.40
No. 1 stope	2 $\frac{3}{4}$	6.65
No. 2 stope—back	2 $\frac{1}{2}$	5.90
No. 2 stope—bottom	3	4.10
180-foot level—southwest of shaft—		
Stopes—southwest lode	1 $\frac{3}{4}$	8.40
No. 1 stope—back	2 $\frac{1}{8}$	10.10
No. 2 stope—back	2 $\frac{3}{4}$	7.35
No. 1 stope—bottom	2	10.05
No. 2 stope—bottom	2	5.50
180-foot level—southeast lode—		
No. 1 stope—back	2	12.90
No. 2 stope—back	2 $\frac{1}{4}$	9.65
Winze—bottom	1 $\frac{1}{2}$	7.30
240-foot level—southwest of shaft—		
No. 2 winze	2 $\frac{1}{4}$	7.70
240-foot level—underlay shaft—		
Southwest stopes—bottom	2 $\frac{3}{4}$	7.10
300-foot level—northeast of shaft—		
End	3	4.30
No. 1 stope—back	1 $\frac{1}{4}$	9.50
No. 2 stope—back	1 $\frac{1}{2}$	6.75
300-foot level—southwest of shaft—		
End	2	1.15
Stopes	2 $\frac{1}{4}$	2.30

NOTE: 1 foot = 0.3048 metres
1 ton = 1.01605 tonnes

\$1.55 per unit for copper and \$.30 per unit for lead.

An approximate average grade of ore won can be obtained if Penberthy's statement is accepted, that the proportion of copper to lead concentrate won from above the 180-foot (54.8 m) level was 2 to 1. The (unweighted) average value of all ore mined from stopes above the 180-foot (54.8 m) level is about \$7.80 per ton,

equivalent, at a 2 to 1 copper-lead concentrate ratio to about 8 per cent lead and 3 $\frac{1}{2}$ per cent copper.

The figures listed in Table 11 show that the value of ore fell off below the 180-foot (54.8 m) level. This could be due to a reduction in overall metal content, or to copper having given way to the less valuable lead ore at depth, a possibility suggested in Woodward's report of 1895.

Wheal Fortune Extended

Production: The Wheal Fortune Extended mine contributed a significant, but unknown proportion of the ore reported from the Wheal Fortune mine between 1862 and 1868, and probably some part of the ore produced between 1917 and 1920 from the Wheal Fortune Extended Location 436.

Details of workings: The Wheal Fortune Extended ore body was worked from Sampson's shaft, sunk 23 feet (7.0 m) from the western boundary of Location 436 near the northern end of the ore shoot. The shaft was about 240 feet (73 m) deep with levels at 72, 120, 180 and 240 feet (21.9, 36.5, 54.8 and 73.1 m), the depths being related to the workings of the Wheal Fortune mine. Both the 72 and 120-foot (21.9 and 36.5 m) levels were driven southwards from the shaft into the ore body, but their lengths are not known. A little work, apparently in barren ground, was carried out north of the shaft on the 72-foot (21.9 m) level. The 180-foot (54.8 m) level connected with the Wheal Fortune mine to the southwest, and was driven about 50 to 60 feet (15 to 18 m) northeast.

Stoping and winzing were carried out from the 240-foot (73.1 m) level southwest of the shaft, but no details are recorded.

Details of ore sections: In the 180-foot (54.8 m) level, the ore shoot was reported to be 140 feet (43 m) long, 3 to 4 feet (90 cm to 1.2 m) wide, and to have produced about 1 ton (1 tonne) of concentrate for every 3 tons (3 tonnes) of ore mined. Lead ore made up most of the mine's output, although some copper was also produced. The ore shoot pitched southwards, probably at an angle of about 60 degrees. It extended from the surface to below the 180-foot (54.8 m) level and most of it was subsequently mined out.

The northeast drive from the 180-foot (54.8 m) level exposed a lode up to 3 feet (91 cm) wide with specks of galena in quartz. The lode was apparently thinner or poorer where it crossed a band of mica schist within the granulites.

Benson, in Wilson (1926, p. 69), has tabulated the grades of ore won from different parts of the mine in terms of £s per fathom. Table 12 below reproduces this data, but the values have been converted to dollars per ton. The last column in the table lists the lead grade equivalent to this value, the assumption being that most of the production was lead concentrate valued at 30 cents per unit.

The figures listed in the table suggest that the grade of ore decreased below the 180-foot (54.8 m) level.

Paringa Mine

The information given in this section is based mainly on the report of Tomich (1955) and on plans held by the Department.

Details of lode: The lode follows a line of shearing which cuts garnet granulites invaded by dykes and irregular masses of pegmatite. Ore occurs on shears striking at 030 degrees and 040 degrees in an echelon link arrangement. Other prominent shears striking at 050 degrees are barren and appear to fault the ore, although one shear on this course held good ore in a stope. Owing to the closeness of strike, this interplay of shears had little adverse effect on the mining of the ore. Most of the work was done on one ore body only, although parallel and branch lodes were known. One parallel lode, 120 feet (37 m) west of the main shear carried quartz, pyrite, chalcopyrite and sphalerite. On long sections, the ore body is seen to have a southerly pitch.

TABLE 12. VALUE OF ORE RAISED FROM VARIOUS PARTS OF WHEEL FORTUNE EXTENDED MINE

Point of Operation	Average Width Feet	Value \$A/ton	Equivalent Lead per cent
Whim shaft—			
Sinking	1½	3·10	10·0
72-foot level—southwest of shaft—			
Driving	2½	7·60	25·0
No. 1 stope—back	3½	7·30	24·0
No. 2 stope—back	1¾	8·75	29·0
72-foot level—northeast of shaft	1¾	....	....
120-foot level—southwest of shaft—			
Driving	2¼	4·95	16·5
No. 1 stope—back	2¼	7·90	26·0
No. 2 stope—back	3¾	6·75	22·5
180-foot level—northeast of shaft—			
Driving	3¾	1·45	5·0
180-foot level—southwest of shaft—			
No. 1 stope—back	2¼	8·15	27·0
No. 2 stope—back	3	7·10	24·0
No. 3 stope—back	2¼	6·95	23·0
240-foot level—southwest of shaft—			
No. 1 stope—back	4¾	4·25	14·0
No. 2 stope—back	6	4·10	13·5
No. 3 stope—back	2	7·70	26·0
No. 4 stope—back	2	4·10	13·5
Winzes—southwest of shaft—			
Surface	1½	7·70	26·0
72—foot level	2	8·75	29·0
120—foot level	3	4·90	16·5
180—foot level	5	2·70	9·0
180—foot level—No. 2	2½	4·05	13·5
240—foot level	3	....	....

NOTE: 1 foot = 0·3048 metres
1 ton = 1·01605 tonnes

The ore was made up of fairly coarse cubic galena in a gangue of granular quartz. In some places, the galena peppered the quartz, but seams and bunches of nearly pure galena were present in the better grade sections. Sphalerite and chalcopryrite were found in small amounts.

Ore widths varied from a few inches to 5 feet (1.5 m) with an average of about 2.5 to 3 feet (80 to 90 cm). It was not distinctively banded nor conspicuously vuggy.

The walls were often poorly marked, with stringers of galena running off into the country rock.

Good ore was often associated with a pegmatitic wall rock. Alteration of the wall rock was slight.

Description of workings: The old main shaft was 174 feet (53.0 m) deep with levels at 71 and 174 feet (21.6 and 53.0 m). Early workings on the lode were concentrated at the northern end of the mine and com-

prised shafts and narrow open cuts. They were reported to be about 50 feet (15 m) deep. More recent work was at first carried out from the old main underlay shaft, collared near the north end of the lode. The new main shaft, 320 feet (97.5 m) deep, was sunk 90 feet (27 m) out in the hanging wall rock towards the southern end of the ore body and was connected to the 174-foot (53.0 m) level by a cross-cut 90 feet (27.4 m) long. Subsequently a new level was driven at a depth of 280 feet (85.3 m).

Drives on the 71-foot (21.6 m) level extend for about 80 feet (24 m) north and south of the old main shaft, and are connected to the surface by ore passes. The ore body was mined out to the surface for the full length of the drive.

The 174-foot (53.0 m) level is about 660 feet (200 m) long, from 220 feet (67 m) south to 440 feet (134 m) north of the new main shaft. Stopping extends for about 400 feet (120 m) along the drive from a point just south of the old main shaft, to a position 70 feet (21 m) south of the new main shaft. From a point about 80 feet (24 m) south of the new main shaft, a cross-cut was driven northwesterly for 130 feet (40 m) and intersected two narrow shears, each carrying a little mineralization. The first shear, at about 90 feet (27 m) in the cross-cut had a strike of 345 degrees and a westerly dip of 75 degrees. The No. 2 surface winze was sunk on it. The second mineralized shear at 110 feet (34 m) was parallel to the main lode. A diamond drill-hole was put out an additional 339 feet (103.3 m) from the end of the cross-cut, but found no ore.

The 280-foot (85.3 m) level is about 540 feet (165 m) long, extending 270 feet (82 m) either way from a 60-foot (18 m) long cross-cut from the new main shaft.

Plan 10803 shows that the lode was stoped to a height of 10 to 30 feet (3 to 9 m) above the level on either side of the cross-cut, and that some further stoping was carried out from a sub-level at 235 feet (71.6 m) south of the shaft.

Production: Mine production in the period 1949 to 1960 amounted to 42,125 tons (42,799.0 tonnes) of ore containing 5,590 tons (5,679.4 tonnes) of lead, an average grade of 13.2 per cent lead. Earlier production from Location 436 recorded in Table 6 probably includes ore from the Wheal Fortune Extended mine.

Other Workings

About 300 feet (91 m) north of the Paringa mine, and apparently on a different shoot, two shafts 100 feet (30 m) apart have been sunk near the line of the lode. Both are more than 50 feet (15 m) deep and one of them has been worked recently. Water prevented an inspection of the underground workings, but it seems probable that the 1965 to 1966 production from Location 436 came from this shaft. The lode in a nearby pit is 1.5 feet (46 cm) wide.

Conclusions

The Wheal Fortune group is worth prospecting at depth.

WHEAL ELLEN MINE

General Information

The Wheal Ellen mine is 1.5 miles (2.4 km) southwest of Northampton with the main workings on Location 1146, the mineral rights of which are alienated from the Crown. The line of lode extends into M.L. 225 (now M.C. 76) to the northeast. A portion of the underground workings of the mine crosses the southeast corner of old M.L. 33PP, on the western side of M.L. 225.

The mine was first opened in 1872 and worked for about 10 years to produce a reported \$32,000 worth of lead ore, with about 1,000 tons (1,000 tonnes) of contained lead. Subsequent production (Table 10) was 23,174 tons (23,544.7 tonnes) of ore with a lead content of 1,904 tons (1,934.4 tonnes), mostly from the period 1917 to 1924 when the mine was worked by the Fremantle Trading Co. Ltd.

References to the Wheal Ellen mine can be found in almost all of the early reports on the Northampton Mineral Field. The most detailed descriptions are those in Wilson (1926) and Campbell (1952).

Plans of the mine workings are included in both the above reports, and others are held by the Department (Mines 29/1, 2 and 3; G.S.W.A. 1685, 5744, 10836, 10837).

Geological Information

On the surface, the lode can be traced for about 2,500 feet (760 m) diagonally across Location 1146 and M.L. 225. It strikes at 035 degrees and dips westerly at 60 to 80 degrees. On M.L. 225, the lode shear follows the western contact of a thin dolerite dyke, but the dyke pinches out near the northern boundary of Location 1146, and the main part of the mine workings are in sheared, strongly brecciated granulate.

The principal ore shoots are on either side of a prominent S-bend in the lode on which the strike locally changes from 35 to 50 degrees, and the dip steepens from 60 to 90 degrees. Campbell (1952) interprets the strike change as a breccia link, connecting the two parts of an echelon displacement of the lode shear. Only low-grade ore occurs in the breccia link itself, the main shoots being in the offset ends of the lode shear, near where they merge into the breccia zone. A similar but smaller struc-

ture may exist near the old main shaft, and in the northernmost open-cut just outside the boundary of Location 1146. On M.L. 225, ore shoots lie on slight curves in the shear where it cuts different bands in the gneiss. One such shoot is on the intersection of the lode shear and a band of metaconglomerate.

Ore minerals present in the lodes are galena, sphalerite, cerussite, copper carbonates and pyrite. The gangue of the ore is mainly quartz or siliceous breccia. Alteration and silicification of the wall rocks of the lode is more noticeable at the Wheal Ellen mine than in most parts of the Northampton District.

Mine Workings

The surface of the lode has been worked from a number of open-cuts, each about 40 to 50 feet (12 to 15 m) deep. Later, these were probably used as sand passes to fill stopes. The old main shaft is near the southern end of the lode. It has levels at 75 and 140 feet (22.8 and 42.6 m) driven southwards from the shaft for 200 and 100 feet (60.9 and 30.4 m) respectively, with a little stoping near the shaft on each level. Workings north of the old main shaft were inaccessible when the existing plans were made. The new main shaft is 570 feet (174 m) northeast of the old shaft; it is 270 feet (82 m) deep with levels at 125, 195 and 264 feet (38.1, 59.4 and 80.4 m). (The old and the new workings are not connected.)

In the new workings, the 125-foot (38.1 m) level extends 580 feet (177 m) north of the shaft and 480 feet (146 m) south, as measured in long section. Stopes extend between 20 and 70 feet (6 and 21 m) above the level, over a length of 720 feet (219 m) from 300 feet (91 m) south to 420 feet (128 m) north of the main shaft.

The 195-foot (59.4 m) level is from 520 feet (158 m) south to 600 feet (180 m) north of the shaft and is stoped above in two sections 680 feet (207 m) long and 340 feet (104 m) long respectively. North of the shaft the stopes go through to the 125-foot (38.1 m) level over a length of 320 feet (98 m). Elsewhere the stopes stop before reaching the higher level, or break through in only a few places.

The 264-foot (80.4 m) level was driven for 20 feet (6 m) north and 30 feet (9 m) south of the shaft, but abandoned due to the low grade of ore encountered.

Grades of ore

The overall grade of ore realized from the mine since 1899 is 8.25 per cent lead. The sands are reported to contain 2 per cent lead, making the head grade of the ore about 10.2 per cent lead. Campbell (1952, Figure 36) shows the grade to vary throughout the mine from 6.5 per cent to 13 per cent lead, with other sections recorded simply as "low values".

A considerable amount of zinc is present in the ore of the Wheal Ellen mine, but the only recorded assay for this metal is one of 12.4 per cent on the south face of the 195-foot (59.4 m) level.

Ore Reserves

Anglo Westralian Pty. Ltd. sampled the floor of the 195-foot (59.4 m) level and outlined two ore shoots. The northern shoot, starting 180 feet (55 m) north of the main shaft, is 385 feet (117.3 m) long and averages 10.8 per cent lead over a width of 51 inches (129.5 cm). The southern shoot begins 315 feet (96 m) south of the main shaft and averages 8.6 per cent lead over a width of 41 inches (104.1 cm) for a length of 171 feet (52.1 m). The combined potential of the two shoots is

about 220 tons (224 tonnes) per vertical foot.

Apart from the short drives on the 264-foot (80.4 m) level, which were in a structurally unfavourable part of the lode, there has been no attempt to test the mine below the 195-foot (59.4 m) level.

Wheal Ellen North Workings

Towards the northern end of M.L. 225, a section of lode about 450 feet (40 m) long was mined in 1967. Workings consist of groups of open cuts and shafts on three small ore shoots. The lode ranges from 1 to 3 feet (30 to 90 cm) in width; it normally has seams of galena or cerussite on either wall and sometimes disseminated throughout. Lenses of siliceous breccia render it unpayable in some places. The deepest shaft goes down 44 feet (13.4 m), but most work has been done above water level at about 20 feet (6 m).

Conclusions

The Wheal Ellen mine is one that could be worth reopening when the price of lead is high. Apart from its indicated ore reserves, it is in a strong geological structure which could contain further ore bodies.

NOOKA GROUP

General Information

The Nooka group of leases comprising M.L.s 284, 286, 293 and 294 is 1 mile (1.6 km) west of Northampton. Five mines or prospects are included in the leases: the Nooka, Chiverton, Lucky Lou, Nooka South and Nooka West; the Nooka being the most important. The Nooka mine was first worked in the late 1870s when it is reported that 1,000 tons (1,016 tonnes) of ore were raised from workings reaching a maximum depth of 90 feet (27 m). In 1916, the Nooka mine was

reopened, the shaft deepened to 131 feet (39.9 m) and a level cut at 128 feet (39.0 m). This period of operation lasted until 1918, after which the mine lay dormant until 1960 when the Nooka Mining Syndicate reopened it again. It has been operated almost continuously since then. The total reported production of the group is 1,220 tons (1,239 tonnes) of lead and 161 ounces (5,007.5 gm) of silver from 11,400 tons (11,580 tonnes) of ore (counting the 876 tons (890.0 tonnes) of ore and concentrates in 1917 to 1918 as being mainly ore).

References to the Nooka group are to be found in Maitland (1903), Montgomery (1907), Wilson (1926), and Blockley (1969).

Plans: G.S.W.A. 6742 and 10550.

Nooka Mine

The Nooka lode is on a shear which, though striking generally north and dipping 70 degrees west, has many minor variations in direction and inclination. It has been traced on the surface for a distance of about half a mile (1 km) and curves towards the west at the southern end. The shoot worked in the Nooka mine is about midway along the traced extent of the lode and the Nooka South prospect is close to its southern end.

In the Nooka mine an ore body about 200 to 250 feet (60 to 76 m) long is being worked to a depth of 278 feet (84.7 m). Its position is controlled by a bend in the lode shear where it cuts a bed of quartzite in the granulites. Galena forms veins from 6 inches to 3 feet (15 to 90 cm) thick in a siliceous breccia 2 to 4 feet (60 cm to 1.2 m) wide. Other sulphide minerals present are sphalerite (particularly at the northern end of the shoot), pyrite and chalcopyrite. Vugs lined with crystals of quartz, galena and pyrite are common.

Where seen in the sub-level at 228 feet (69.4 m), the sulphide vein is restricted to the hanging wall side of the lode but elsewhere in the mine it is on the footwall side.

The lode was originally worked on the surface by open-cuts extending over a length of 300 feet (90 m), but these are now filled except for a length south of the shaft where the fill was let through into the underlying stopes. Underground mining is carried out from a vertical two-compartment shaft, collared 50 feet (15 m) west of the lode and sunk to a depth of 278 feet (84.7 m) with levels at 128, 191 and 278 feet (39.0, 58.2 and 84.7 m). The 128-foot (39.0 m) level was driven 90 feet (27 m) north and 120 feet (36 m) south and the 191-foot (58.2 m) level for 120 feet (36 m) north and 120 feet (36 m) south. The 278-foot (84.7 m) level extends 60 feet (18 m) south and 185 feet (56 m) north of the shaft. Except for a pillar to support the shaft, all ore above the 191-foot (58.2 m) level has been mined out, and the stopes filled with battery sands. Stopping has been carried to a height of about 60 feet (18 m) above the 278-foot (84.7 m) level and present operations are concentrated on mining the remaining ore between a sub-level at 228 feet (69.4 m) and the 191-foot (58.2 m) level.

The north faces of the upper levels are inaccessible, but it is reported that they all reach the limit of ore grade lead. There is a 6-inch (15 cm) vein of galena in the north face of the 278-foot (84.7 m) level. In the south faces of the 128-foot (39.0 m) and 191-foot (58.2 m) levels the lode has narrowed to a stringer 2 to 3 inches (5 to 7 cm) wide, corresponding to a flattening of the dip from about 75 to 55 degrees. The south face of the sub-level is still in ore about 60 feet (18 m) from the shaft and the south face of the 278-foot (84.7 m)

level at a similar distance from the shaft is also reported to contain ore. Another 50 or 60 feet (15 to 18m) of ore can be expected beyond the present limits of these drives. The ore body continues underfoot at the 278-foot (84.7 m) level and the best chance for the future of the mine lies in development at depth.

Nooka South Prospect

The Nooka South prospect, 1,000 feet (310 m) south-southeast of the Nooka mine, has been called in some earlier reports the Chiverton mine; however the mine now generally called Chiverton is further west, and is described below. In the Nooka South prospect a lode containing low grade copper, but no lead, has been tested by shallow shafts and pits over a length of about 100 feet (30 m). Where exposed in the pits the lode is 2 feet (60 cm) wide and dips westerly.

Nooka West Mine

In the northwest corner of M.L. 286, 1,000 feet (310 m) northwest of the Nooka mine, a lode striking at 65 degrees and dipping 80 degrees west has been tested to depths of 15 to 20 feet (5 to 6 m) over a length of about 100 feet (30 m). The lode shear is in gneiss but diverges northwards from a dolerite dyke striking at 30 degrees. Good grade cerussite ore was seen in the dumps of the shafts.

Lucky Lou Prospect (M.C. 294)

South-southwest of the Nooka West mine, a considerable amount of bulldozing has recently been done on the eastern contact of the same dolerite dyke. Although this contact is sheared and brecciated it seems very poor in ore minerals where exposed. Further south on the same line and just south of M.L. 294 a vein of galena 2 to 4 inches (5 to 10 cm) wide is exposed

over a distance of 80 feet (24 m) in a bulldozed trench. The lode is on the same line as the dolerite dyke which lenses out north of the workings.

Chiverton Mine (M.L. 286)

The Chiverton mine is about 800 feet (240 m) southwest of the Nooka mine. Its recorded production is 34 tons (34.5 tonnes) of ore containing 2.6 tons (2.64 tonnes) of lead, representing an average grade of 7.5 per cent lead.

The workings follow an arcuate link structure developed within a northerly trending shear system and varying in strike from 005 degrees at the south end to 045 degrees at the north end. The lode, which dips from 70 to 80 degrees east, is worked over a length of 150 feet (46 m), and can be traced by shallow workings for a further 100 feet (30 m) to the northeast. The deeper workings consist of an open-cut 20 feet (6 m) long and stopes from an underlay shaft, in which the ore vein varies from 2 to 6 inches (5.0 to 15.2 cm) in width down to water level. Ore minerals seen in the mine and dumps were cerussite and galena. The depth to which the mine has been worked could not be determined, but appears to be probably less than 100 feet (30 m).

KIRTONS GROUP

General Information

The Kirtons group of leases is 4 miles (6.4 km) west-northwest of Northampton and is reached by a road branching northwards from the Port Gregory road immediately east of the crossing of Unandara Creek. The four mines of the group fall on one line of shearing and are called herein (from north to south) Kirtons North Extended, Kirtons North, Kirtons and Kirtons South. Past nomenclature is confusing as

it seems that at various times the name "Kirtons" has been applied to any or all of the mines of the group. Similarly production figures on record are for the group as a whole and cannot be broken down to those from each mine.

Mines of the group were first worked between 1879 and 1887 and it is reported (in Wilson, 1926) that 841 tons (854.4 tonnes) of ore were shipped in that period. The main period of production was from 1915 to 1919 when the Kirtons North Extended mine was in operation. Later work was done on the group in 1952 to 1953. Total recorded production for the group, excluding the 841 tons (854.4 tonnes) prior to 1899, is 409 tons (415.5 tonnes) of lead and 9 ounces (279.9 gm) of silver from about 2,180 tons (2,214 tonnes) of ore and concentrates.

Reference may be made to reports in Maitland (1903), Montgomery (1907), Wilson (1926), and Berliat (1954).

Plan: G.S.W.A. 10847.

Geological Information

The mines of the Kirtons group lie on a line of shearing which can be traced for a distance of 3,500 feet (1,070 m). Individual shoots are slightly offset with respect to one another, indicating some irregularity such as kinking or echelon displacements of the shear zone. To the south of the Port Gregory road the Kirtons line has controlled the valley of Unandara Creek which follows its trend for about 6,500 feet (1,980 m). The lodes strike at 030 degrees and dip easterly at 70 to 80 degrees. Wall rocks are altered gneiss and there is no dolerite on the leases.

Kirtons North Extended Mine (M.L. 251)

The Kirtons North Extended mine is the largest of the group. The lode contains

galena, cerussite, and copper minerals. Visible workings include shafts, open-cuts and surface stopes over a length of 400 feet (120 m). During the main period of production underground mining was carried out from a main inclined shaft, apparently that at the northern end of the workings, 220 feet (67 m) deep. A shoot was stoped 230 feet (70 m) long and 3 to 4 feet (90 cm to 1.2 m) wide on the 160-foot (48.7 m) level, but it lensed out above the 220-foot (67.0 m) level; another was located 145 feet (44 m) south of the shaft on the 220-foot (67 m) level in 1919. As the mine closed in 1919 it is possible that this shoot was not mined out.

The more recent work on the lease was carried out from a shaft sunk at the southern end of the lode about 400 feet (120 m) south of the main shaft. Two levels were driven in the lode, one at 60 feet (18.2 m) and another at 90 feet (27.4 m). At the 60-foot (18.2 m) level the drive exposed thin and irregular veins of galena over a width of 2 feet 6 inches (76 cm). On the 90-foot (27.4 m) level, lode matter 3 feet (91 cm) wide with veins of solid galena up to 1 foot (30 cm) thick was exposed on the hanging wall side over a length of 90 feet (27 m). The ore was stoped to a height of 15 feet (4.5 m) above the level.

Kirtons North Mine (M.L. 250)

Located 1,500 feet (460 m) south-southwest of the Kirtons North Extended, the Kirtons North mine has many similar features. The lode dips easterly at 80 to 85 degrees and was mined discontinuously over a length of about 200 feet (60 m). The deepest present opening is a shaft 100 feet (30.4 m) deep at the northern end of the workings. A two-compartment shaft equipped with poppet legs is located 40

feet (12 m) west of the lode near the southern end of the line, but has been filled to within 10 feet (3 m) of the surface. Mining was carried out from the 100-foot (30 m) shaft and the lode was stoped to the surface over a length of 20 feet (6 m) between 100 and 120 feet (30 and 36 m) south from the shaft. Where mined the ore body was about 2 to 3 feet (60 to 90 cm) wide. Galena and cerussite occurred in the northern shafts, and copper, together with some oxidized zinc minerals in the southernmost shaft.

Kirtons Mine (M.L. 249)

Kirtons mine is 500 feet (150 m) south-southwest of Kirtons North. Shallow workings extend over a length of 300 feet (90 m) but the only deep shaft, 30 feet (9 m), is on a branch lode leaving the main lode on a trend of 360 degrees near the northernmost end of the line. The largest open-cut is situated close to the junction of the two lodes. North of its intersection with the branch lode, the main lode continues as a weak shear.

Kirtons South Mine (M.L. 270)

The Kirtons South lode is about 800 feet (240 m) south-southwest of Kirtons and close to the road. It was worked over a length of about 180 feet (55 m) on the surface and underground by means of two shafts 130 feet (40 m) apart. The northern shaft is about 70 feet (21 m) deep and is inclined steeply eastwards. To the north of it is a surfaced stope 30 feet (9 m) long. The surface between the two shafts is covered by creek deposits and no old workings or lode outcrop can be seen.

UGA GROUP

General Information

The Uga group, 1 mile (1.6 km) west of Northampton, consists of two mines: the

Uga on M.L. 233 and Stricklands on Location 326, an Imperial Grant. The mines are immediately south of the Port Gregory-Northampton road, close to the State Battery. The Uga mine was first opened in 1873, and for a short period it was one of the principal lead producers of the Field. In the present century the mine has been worked for short periods to produce a total of 92 tons (93.4 tonnes) of lead and 6 ounces (186.6 gm) of silver from 134 tons (136.1 tonnes) of ore and concentrate.

References to the mines can be found in Maitland (1903), and Wilson (1926).

A *plan* of the surface workings is held by the Geological Survey of Western Australia (Ref. No. 10862). No underground plans are available.

The lode, which is in gneiss, strikes at 360 degrees and was mined at the surface from open-cuts and stopes for a total distance of 450 feet (137 m). The main shaft is sunk 40 feet (12 m) east of the lode to a depth of 150 feet (46 m), cutting the lode at 80 feet (24 m) and following it on the incline for the remainder of its depth. Judging from the early reports, most of the ore taken from the mine came from above the 75-foot (22.8 m) level. In the open-cuts the lode was mined out over widths of up to 8 feet (2.4 m). Ore minerals seen on the dump were galena and cerussite. At the northern end of the workings the lode shear swings to the northwest and follows the banding of the gneisses for a short distance before dying out completely.

The length and width of the lode mined on the Uga mine, as well as the comparatively shallow depth of development, makes this prospect worth further testing.

Stricklands Mine

The southern continuation of the Uga lode extends into block 326 where it has

been worked as Stricklands mine. Workings comprising shafts, open-cuts, and stopes follow the line of the lode for about 250 feet (76 m). In them the lode is up to 6 feet (1.8 m) wide and dips vertically or steeply east. At the south end of the workings, the lode shear feathers along the banding of the gneiss. Ore minerals seen on the dump were galena and some copper carbonates.

Although Maitland (1903) states that the Stricklands mine produced a considerable proportion of the ore exported between 1873 and 1884, the comparatively small sizes of the surface workings suggest that the mine was never a large one.

WHEAL MAY MINE

The Wheal May mine is 4 miles (6.4 km) north-northeast of Northampton on Location 2224 and is alongside the road to Wundi Well. It is reported to have produced 2,200 tons (2,240 tonnes) of ore averaging 75 per cent lead prior to 1899, but has not been worked since then.

References: Maitland (1903), Montgomery (1908), and Wilson (1926).

Plans: A longitudinal section of the workings is reproduced in Wilson's report and a plan of surface workings is held by the Geological Survey of Western Australia (Ref. No. 10854).

The lode follows a shear zone in metasediments and is parallel to a dolerite dyke cropping out 250 feet (76 m) to the west. It strikes at 040 degrees and dips west at about 80 degrees. The ore body is formed where the lode shear cuts a thick bed of quartzite striking at about 330 degrees and dipping westerly. The lode is from 2 to 4 feet (60 cm to 1.2 m) wide and was reported to have contained a vein of galena 18 inches (45.7 cm) wide which persisted

for almost the whole of the 700-foot (210 m) length of the old workings. Ore minerals seen in the dumps were galena, cerussite, chalcocite and copper carbonate.

Wilson's section shows that the lode was worked from seven shafts spread over a distance of 600 feet (180 m). These were connected by a drive at the 70-foot (21.3 m) level of the pump shaft. As the outcrop of the lode is on the side of a hill the depth of the different shafts to this level varied. Stoping was carried out above this level, at times almost to the surface. Near the northern end there was a short underhand stope. In the southern end of the workings the remaining ore was low-grade and unpromising, but north of the No. 2 shaft which is about 180 feet (55 m) south from the northernmost shaft of the mine, the vein averaged 9 inches (23.0 cm) in width over a length of 75 feet (22.8 m) and 4 to 5 inches (10.0 to 13.0 cm) in width over about 70 feet (20 m).

In about 1907 a new vertical shaft was commenced on the western side of the lode near the south end. It was abandoned at a depth of about 80 feet (24 m). More recently a party of miners from Northampton unwatered the mine and cross-cut to the lode from the bottom of the shaft at the 80-foot (24.3 m) level. They examined the old workings and did some driving on their own account but found only an unprofitably narrow seam of galena.

The Wheal May mine makes a considerable amount of water. Estimates range from 24,000 to 100,000 gallons (109,100 to 454,600 l) a day and it could be an important source of industrial water.

From geological considerations, the lode shear should cut other beds of quartzite at depth and further ore shoots could reasonably be expected.

McGUIRES MINE (Location 832)

General Information

The McGuires mine (also called the Isseka Mine) is on an Imperial Grant 7 miles (11.2 km) south of Northampton. It is reached from Green Gables farm (immediately east of the highway) by way of farm tracks. Two parallel lodes, about 2,000 feet (600 m) apart, were worked on the block with the principal workings being on the westernmost line. The mine is an old one and formerly had a smelter erected on it, but only since 1950 has any production been recorded. The west lode has produced 565 tons (572.8 tonnes) of lead and 156 ounces (4,852.0 gm) of silver from 4,370 tons (4,439.9 tonnes) of ore and the east lode 9.7 tons (9.85 tonnes) of lead from 105 tons (106.6 tonnes) of ore.

References: Maitland (1903), Wilson (1926) and Berliat (1954).

Plans: Mines 150/1 to 9; G.S.W.A. 1682, 5486.

West Lode

The West Lode follows a shear striking at about 045 degrees and generally dipping east, though at the southern end of the workings it has a steep westerly dip. The open-cut and shallow workings mentioned in earlier reports have now been filled in and the only openings are six shafts spread over a distance of 530 feet (162 m).

The main shaft, or No. 1 shaft, is 100 feet (30 m) deep and collared to the west of the ore body near the northern end. It is connected to the water shaft, 60 feet (18 m) north, by a level at 60 feet (18.2 m) and to the No. 2 sand pass, 70 feet (21 m) south, at the 100-foot (30.4 m) level. There are stopes above both of these drives, that to the north reaching the surface.

Two winzes were sunk from the 100-foot (30.4 m) level, one 20 feet (6 m) north of the main shaft and the other 80 feet (24 m) south. In each the grade of ore fell rapidly, from 25 per cent to less than 1 per cent lead in the north winze, and from 16 per cent to 5 per cent lead in the south winze.

The No. 3 shaft, 215 feet (65.5 m) southwest of the No. 1 shaft was sunk on the underlay to a vertical depth of 220 feet (67.0 m). At the 100-foot (30.4 m) level it is connected to the No. 4 shaft, a further 240 feet (73 m) southwest, but this drive does not reach to the 100-foot (30.4 m) level from the main shaft. The 100-foot (30.4 m) level extends from 60 feet (18 m) north of the No. 3 shaft to 50 feet (15 m) south of the No. 4 shaft. Assays on Mines Department plans indicate three blocks of ore on this level, but as the sampling was done 2 or 3 years before the mine closed, these may now be mined out. For the record they are: No. 1, from 30 feet (9 m) north to 20 feet (6 m) south of the No. 3 shaft, average 9 per cent lead over a width of 60 inches (152 cm); No. 2, from 65 feet (19.8m) to 120 feet (37 m) south of the No. 3 shaft, average 11 per cent lead over 48 inches (121.9 cm); and No. 3, from 30 feet (9 m) north to 30 feet (9 m) south of No. 4 shaft, average 7 per cent lead over 60 inches (152 cm). Samples taken in the No. 3 shaft averaged about 13 per cent lead over a width of 4 to 5 feet (1.2 to 1.5 m) from the 100-foot (30.4 m) level to 180 feet (55 m), but declined in grade below 180 feet (55 m).

The No. 4 shaft is 230 feet (70 m) deep with a level at 225 feet (68.5 m) for 90 feet (27 m) north. Except for a section extending 20 feet (6 m) below the 100-

foot (30.4 m) level, assays of the lode in the shaft and drive were generally low.

Diamond Drilling on West Lode

Three holes were drilled by the Anglo Westralian Pty. Ltd. company to test the west lode.

Hole 1 intersected the lode at a vertical depth of 305 feet (92.9 m) immediately below the No. 3 shaft, where the lode channel was about 5 feet (1.5 m) in true width and contained 4 inches (10 cm) of quartz with galena.

Hole 2 cut the lode at a vertical depth of 210 feet (64.0 m) below the water shaft, that is 285 feet (86.8 m) north of diamond drillhole 1, but failed to locate any lead.

Hole 3 cut the lode at 190 feet (57.9 m) vertical depth, 200 feet (60 m) south of the No. 4 shaft, and obtained an intersection averaging 4.2 per cent lead over a true width of 18 inches (45.7 cm).

It seems from the results of the mine sampling and diamond drilling that the mined ore shoots have bottomed. However, a new shoot may exist south of the present workings.

East Lode

McGuire's East Lode crops out along a ridge on the east side of the old railway track and about 2,000 feet (600 m) east of the West Lode. A mineralized shear is exposed in pits and shafts over a length of 500 feet (150 m), but has only been mined at the northern end where there is an open cut 20 or 30 feet (6 to 9 m) long. Here the lode strikes at 030 degrees, dips 75 to 80 degrees west, and consists of sheared and brecciated gneiss 1½ to 2 feet (46 to 61 cm) wide containing disseminated cerussite. Sphalerite is present on the dump of a shaft at the south end of the workings.

Results of Drilling on East Lode

The Anglo Westralian Pty. Ltd. company drilled six holes to test the East Lode. All holes except No. 1 were drilled on a bearing of 114 degrees at a depressed angle of 65 degrees. Results of the drilling are summarized below:

Hole 1 drilled from a site 120 feet (36 m) east of the open cut, on a bearing of 110 degrees and inclined at 65 degrees, terminated at 204 feet (62.1 m). It cut the lode channel between 160 and 178 feet (48.7 and 54.2 m), recovering traces of lead at 161 feet (49.0 m).

Hole 2 sited 170 feet (51.8 m) southwest of Hole 1, was drilled to 309 feet (94.1 m) cutting the lode between 271 and 275 feet (82.6 and 83.8 m). No lead minerals were recovered.

Hole 3 collared 160 feet (49 m) south-southwest of Hole 2, was put down to 301 feet (91.7 m). A barren shear zone, probably corresponding to the lode, was cut from 226 to 234 feet (68.8 to 71.3 m).

Hole 4 150 feet (46 m) north-northeast of Hole 3, went to 314 feet (95.7 m) depth, cutting a barren shear zone between 168 and 170 feet (51.2 and 51.8 m).

Hole 5 sited 170 feet (52 m) north of Hole 4, was drilled to 330 feet (100.5 m), but located only a little galena in cracked and silicified gneiss between 194 and 197 feet (59.1 and 60.0 m).

Hole 6 was drilled from a site 160 feet (49 m) south-southwest of Hole 3 to a depth of 311 feet (94.7 m). It cut the lode channel between 254 and 266 feet (77.4 and 81.0 m), but encountered no lead minerals.

KATHLEEN HOPE MINE (M.L. 263)

The Kathleen Hope mine is 5 miles (8 km) northwest of Northampton and

reached by a road branching westward from the highway at a point 2 miles (3.2 km) north of the town. The last half mile to the mine is over farm tracks. The lode is marked, although not named, on Maitland's map (1903) but the first recorded production from it is in 1957. To the end of 1967 it had produced 23 tons (23.3 tonnes) of lead and 26 ounces (808.6 gm) of silver from 366 tons (371.8 tonnes) of ore.

Reference: There are no published geological reports on the mine although Rowston (1966) describes the results of a geophysical survey carried out on the lease.

The lode strikes 025 degrees and dips easterly at 75 to 80 degrees. Within the lode two shoots 500 feet (150 m) apart have been worked, and between them the line has been tested by numerous pits and costeans.

On the southern shoot the lode is opened up on the surface over a length of 120 feet (37 m). At the northern end, it is 12 feet (3.6 m) wide and contains lead throughout the whole width. Here the edges of the lode consist of siliceous veins, each 1 to 1½ feet (30 to 46 cm) thick, while the central part is made up of brecciated gneiss. The lode cuts across the foliation of the wall-rock gneiss. Underground mining was carried out from a vertical shaft sunk to the east of the outcrop. The shaft is now 44 feet (13.4 m) deep but is probably partly filled. No details of underground workings are available.

The northern shoot was worked over a distance of 75 feet (22.8 m) from three shafts. The southern shaft is on the lode and leads to stopes 2 to 3 feet (60 to 90 cm) wide. The other shafts are 50 and 75 feet (15 and 23 m) respectively from the southern shaft on a bearing of 050 degrees, and seem to have been sunk in country rock. A kidney of ore 60 feet (18 m) long

and 2 to 3 feet (60 to 90 cm) wide is said to have been worked above the 120-foot (36.5 m) level. Although this shoot probably continues below the level, mining was halted due to the unsafe condition of the workings.

WOOMBOARO PROSPECT

(Location 225, M.L. 124)

The Woomboaro prospect (pronounced Woomba Warra) is 4 miles (6.4 km) northwest of Northampton. It has not been worked since the early days of the Field and has no recorded production, although there are a few tons of jig-tailings at the southern end of the workings.

References to the prospect can be found in Woodward (1895), Maitland (1903), and Wilson (1926).

The lode follows the western contact of a dolerite dyke striking at 026 degrees and dipping steeply east. There are three groups of workings spread over a total length of 850 feet (259 m). The southern group, on the south side of a wooded creek, is 180 feet (55 m) long. At its northern end the lode consists of massive quartz with 5 to 10 per cent galena. A little further south, the lode is quartz and quartz breccia with galena, and softer kaolinitic lode material containing cerussite is also present. The old workings consist mainly of pits which, judging by the size of the trees growing in them, are of a considerable age.

The central group of workings consists of one shaft about 8 feet (2.4 m) deep in which the lode dips east and consists of 3 feet (90 cm) of quartz and quartz-filled breccia with kaolin margins. The siliceous parts contain a little galena and the kaolin, especially on the footwall, has some cerussite.

The northern group is 250 feet (76 m) long and comprises shallow pits and one

collapsed shaft. The lode was mined to a width of 4 or 5 feet (1.2 to 1.5 m) in trenches along the strike. The ore was galena and cerussite in a gangue of quartz. A sample of the better material from the central group assayed 4.18 per cent lead and 0.05 per cent zinc over 12 inches (30 cm).

LUCY MINE (M.L. 58PP)

The Lucy mine is 1½ miles (2 km) southwest of the Gurkha mine. It is reached by way of a track branching southwards from the Nonga Hill road at a point 1 mile (1.6 km) west of the highway. The mine was worked in 1956 to produce 5.4 tons (5.48 tonnes) of lead from 134 tons (136.1 tonnes) of ore. There are no published reports or available plans of the Lucy mine.

The lode follows a 3 to 4-foot (90 cm to 1.2 m) wide breccia zone striking at 030 degrees and dipping westwards. The wall rock is altered gneiss and the ore itself consists of quartz-filled breccia with galena, pyrite and a little chalcopyrite. Surface workings extend for 150 feet (46 m) and comprise mainly pits and bulldozed costeans. A vertical shaft about 50 feet (15 m) deep, sunk to the west of the lode, is now used as a well, and is equipped with a wind-pump.

SCOTT AND GALES MINE (Location 312)

Scott and Gales mine is about 1,000 feet (300 m) south of the old Martins Spring copper mine, and on the same Imperial Grant property. It is reached by a continuation of the track to the Kathleen Hope mine.

Reference: Maitland (1903).

The prospect consists of two shafts about 130 feet (40 m) apart on a bearing of 010 degrees. Each shaft is about 25 to 30 feet (8 to 9 m) deep. Both contain malachite, azurite, chalcocite, galena and cerussite. The

lode is poorly defined, being merely a zone of mineralized cracks in a band of metamorphosed conglomerate. In the south shaft, lead and copper minerals are spread over a zone 5 or 6 feet (1.5 to 1.8 m) wide which follows the banding of the metasediments.

There is no official record of production from the prospect, but Maitland (1903) stated that a small parcel of lead ore was raised.

SUNNY CORNER

Several small lead prospects are reported to have been opened up in an area called Sunny Corner, a short distance south of Nonga Hill and 8 miles (12.9 km) northwest of Northampton, but only two were located by the writer.

On M.L. 124 a lode 6 feet (1.8 m) wide is worked to shallow depths over a length of 60 feet (18 m). It strikes north, dips 70 degrees west and carries lead as blebs of cerussite.

The other prospect is on M.L. 130 where a poorly defined lode striking at 015 degrees and dipping 70 degrees west is exposed in two pits 100 feet (30 m) apart.

MINERAL LEASE 267

The mine worked on M.L. 267 is 9 miles (14.4 km) northwest of Northampton and is reached by a road branching from the highway at the Gurkha mine. The only production recorded was in 1957 to 1958 when 69 tons (70.1 tonnes) of ore containing 4 tons (4.0 tonnes) of lead and 63 ounces (1,959.4 gm) of silver were won.

The lode, which strikes at 013 degrees and dips steeply west, was mined over a total length of 110 feet (34 m) from three shafts, and traced a further 250 feet (76 m) northerly by pitting. Two of the shafts have collapsed. In the third, the lode was

stoped out to widths of 4 to 5 feet (1.2 to 1.5 m) to at least the present water level at 30 feet (9.1 m). Timbering in the shaft did not allow the full extent of the stopes to be seen.

Ore minerals on the dumps of the shafts are galena and cerussite.

MAY BELL MINE (M.L. 227 and M.L. 37PP)

The May Bell (or Ukkerheri) mine is about 1 mile (1.6 km) north of the Baddera mine and $8\frac{1}{2}$ miles (13.6 km) north of Northampton, on the boundary of Lot 9 and Mining Reserve 8033. It can be reached by following the Oakarea road eastwards from the highway. The mine is an old one which was reopened in 1949 to 1956 by the Gabalong Asbestos Co. to produce 70 tons (71 tonnes) of lead and 43 ounces (1,337.4 gm) of silver from 1,700 tons (1,730 tonnes) of ore. Production prior to this was not recorded but was probably very small.

Reference: Maitland (1903), and Berliat (1954).

Plans: G.S.W.A. No. 10856.

The lode of the May Bell mine follows the east wall of a dolerite dyke striking at about 030 degrees and dipping at 75 to 80 degrees west. It was worked on the surface by shallow pits and an open-cut over a distance of 500 feet (150 m) and mined at depth from two shafts. The open-cut which is 25 feet (7.6 m) long and 6 to 10 feet (1.8 to 3.0 m) deep exposes a 3-foot (90 cm) width of lode. There may once have been a shaft sunk from the bottom of the cut. The northernmost of the two shafts is 80 feet (24 m) north of the fence along the south boundary of Lot 9. It inclines 80 degrees west and is probably the shaft that Berliat records as being 120 feet (37 m) deep and which at that time (1952) was

being deepened to 200 feet (61 m). At present it is filled to within 15 feet (4.5 m) of the surface.

The southern shaft is 105 feet (32.0 m) south of the fence line and about 45 feet (13.7 m) west of the outcrop of the lode. It is vertical with two compartments and is more than 100 feet (30 m) deep.

Berliat records that in the inclined shaft, veins of ore occurred on nearly vertical shears over widths of 7 to 8 feet (2.1 to 2.4 m). Rich pockets of galena accompanied by some quartz were found on the hanging wall side of the lode at a depth of 120 feet (37 m). No other details of the underground workings are available.

YIAPA MINE (M.L. 266)

The Yiapa mine is 7 miles (11.2 km) north of Northampton and immediately west of the highway. It is an old mine which was worked in a small way at times of higher lead prices. Maitland (1903) reported that 400 to 500 tons (410 to 510 tonnes) of ore were mined prior to 1900. Since that time the mine has yielded 345 tons (350.5 tonnes) of lead from about 1,200 tons (1,220 tonnes) of ore.

References: Maitland (1903), Montgomery (1908), and Wilson (1926).

Plans: G.S.W.A. No. 10587.

The Yiapa lode follows an irregular fracture branching northwards from the western side of a dolerite dyke. The lode strikes at about 005 degrees and dips easterly. The dyke courses 045 degrees and probably dips westerly. The lode has been worked over a length of about 200 feet (60 m) northwards from its intersection with the dyke. South of the intersection, two pits have been sunk on the western contact of the dolerite and it seems that the lode shear turns and follows the contact for about

100 feet (30 m). Near the north end of the ore body a branch lode was open-cut for a short distance along the edge of a pegmatite vein. Ore minerals present in the dumps of the shafts and in the open-cut are galena, chalcopyrite, pyrite and malachite.

Workings on the outcrop of the lode comprise an open-cut, a surfaced stope, a collapsed underlay shaft and a smaller open-cut. North of the open-cut and to the east of the outcrop of the lode there is a vertical shaft about 75 feet (23 m) deep. Another vertical shaft of unknown depth is located 30 feet (9 m) southeast of the open-cut. The main shaft from which the more recent work was done is 80 feet (24 m) east of the lode and 120 feet (37 m) deep. It is collared just west of the dolerite dyke and judging by material on its dump, passed into dolerite at depth. A recent operator of the mine has reported that at a depth of 114 feet (34.7 m) a cross-cut 30 feet (9 m) long was put out to the lode. Drives were then developed in the lode for about 155 feet (47 m) south and 10 feet (3 m) north. An ore shoot was stoped at the southern end of the level and old workings were encountered 40 or 50 feet (12 to 15 m) above. The lode in the stope ranges from 4 to 9 feet (1.2 to 2.7 m) wide. The northernmost shaft on the lode was cleaned out to about 75 feet (23 m) but was thought to be at least 90 feet (27 m) deep. It led to small stopes at depths of 30 and 50 feet (9 and 15 m).

IGA PROSPECT (M.L. 4)

The Iga mine is $3\frac{1}{2}$ miles (5.6 km) north of Northampton and about 200 yards (180 m) east of the highway in cultivated paddocks. Outcrops of the ore bodies and some of the old workings are obscured by farming operations. No official production is recorded although in Maitland

(1903) it is stated that 400 tons (410 tonnes) of ore were shipped from the mine prior to 1899.

References: Maitland (1903) and Campbell (1952).

Three shoots have been worked within a strongly brecciated zone in gneiss. Most work was done on the central shoot where the lode strikes at 025 degrees and dips westward. Workings consist of filled pits and an inclined shaft now used as a well. The depth of the shaft could not be determined but seems to be quite shallow. Lode material on the dumps is siliceous breccia with galena and some barite.

The southern shoot is 500 feet (150 m) on a bearing of 205 degrees from the central shoot and on the same line of shearing. Shallow workings extend over 100 feet (30 m) in a siliceous lode containing galena.

The northern shoot is 700 feet (210 m) on a bearing of 045 degrees from the central shoot. Here the lode strikes at 045 degrees and contains galena and abundant barite. It was worked over a length of 60 feet (18 m), but the openings are now filled and no information on its width or grade could be obtained.

RHYHOPE MINE (Location 2366)

The Rhyhope mine is $2\frac{1}{2}$ miles (3.0 km) west of Northampton and south of the Northampton-Port Gregory road. In two periods of production since 1950 the mine yielded 50 tons (50.8 tonnes) of lead and 31 ounces (964.1 gm) of silver from about 430 tons (437 tonnes) of ore. It is known that the mine operated briefly in 1907, and that the prospector of the time encountered even older workings, but no production figures from this period are available.

References to the Rhyhope mine can be found in Montgomery (1908) and Berliat (1954).

The lode worked in the Rhyhope mine follows a shear zone in gneiss striking at about 025 degrees and dipping easterly. It consists of crushed gneiss with a little quartz, pyrite, galena, sphalerite and barite. It was worked over a total length of 200 feet (60 m) from an open-cut, three shafts and a few pits. The deepest opening is an 85-foot (25.9 m) shaft situated about midway along the line of workings. From the 72-foot (21.9 m) level of this shaft, ore was stoped out over a length of 20 feet (6 m) and a height of 33 feet (10 m).

Montgomery's report describes a 64-foot (19.5 m) deep shaft on the footwall of the lode with levels at 40 and 58 feet (12.1 and 17.6 m). He states that where cut in the bottom cross-cut, the lode was 18 inches (46 cm) wide and poor in grade though well defined; but in driving south for about 12 feet (4 m) it improved and widened out to 4 feet (1.2 m), carrying a good percentage of clean galena. The drive eventually struck some old workings. It is not clear which shaft Montgomery was referring to in this description.

WANERENOOKA COPPER MINE (Location 27)

The Wanerenooka copper mine is immediately north of the township of Northampton and within the townsite boundary. It was discovered in about 1856 (not 1842 as has been widely published) and was worked for copper in the early period of the Northampton Mineral Field. The mine was dewatered in 1957, and small amounts of copper and lead ores were raised. At the time the mine was called the Roger Malray.

References: Maitland (1903), Wilson (1926), and Low (1963).

Plans: Mines 563/1; G.S.W.A. 1672 and 7497.

The lode worked in the Wanerenooka Mine ranges from 27 to 39 feet (8.2 to 11.8 m) in thickness and may be on a cymoid loop structure. Copper ore was worked from veins 1 foot (30 cm) thick on the hanging and footwall sides of the lode, but lead ore was found only in the hanging wall vein.

Surface workings consist of lines of shallow open-cuts and surfaced stopes. At depth, the mine was developed from a three-compartment shaft 240 feet (73 m) deep with levels at 80 feet, 140 and 180 feet (24.3, 42.6 and 54.8 m). The workings extend for about 400 feet (120 m) along the lode.

Two holes were drilled in about 1960 to test the lode beneath the old stopes, but results were disappointing and no further work was done.

NORMAN KING MINE (M.C. 6)

The Norman King mine, known also as Norman's Well, Normantine or Pages mine, is 6 miles (9.6 km) southeast of Northampton and north of the Northampton to Nabawa road. Described by Maitland (1903) as old and abandoned, the mine was reopened for short periods in 1908, 1928, 1950 and 1954. The recorded production of 62.5 tons (63.5 tonnes) of lead and 31.3 ounces (973.52 gm) of silver from 915 tons (929.6 tonnes) of ore dates only from 1930, although Montgomery (1908) reports that 31.5 (32.0 tonnes) of ore were sold in about 1907 and Maitland (1903) writes "a good deal of lead must have been raised".

References to the mine can be found in Maitland (1903), Montgomery (1908), Wilson (1926), and Wilson (1928).

A plan and section of the main group of workings is held by the Drafting Branch of the Mines Department (Ref. No. 160/1 and 2) and a surface plan of the workings by the Geological Survey of Western Australia (No. 10855).

The Norman King mine is of interest because it is one of the few mines in the Northampton Mineral Field in which mineralization follows the bedding of the metasediments for any appreciable distance. Two ore bodies 1,900 feet (580 m) apart have been worked on the contacts of a 75-foot (23 m) thick band of quartzite, striking at 035 degrees and dipping westwards at about 70 degrees. However the writer believes that this relationship of mineralization to bedding has no genetic implication, but the contacts between the harder quartzite and the softer granulites have been lines of weakness initiated by original bedding slip during folding and reopened by later regional faulting on the northeast direction.

The *northern ore body* is on the hanging wall of the western side of the quartzite bed. Lead minerals are disseminated through a 7-foot (2.1 m) wide zone of brecciation developed on a minor flexure on the contact. The ore shoot so formed is about 150 feet (46 m) long, and has been mined from an open cut about 20 feet (6 m) deep and stoped to depths of up to 80 feet (24 m) from a 50-foot (15 m) deep shaft sunk 20 feet (6 m) to the west of the open-cut. Mr. S. Camp, a member of the party which worked the mine in 1954, reports that the lode was low-grade in the underhand stope below the 50-foot (15 m) level.

The *southern shoot* is on the eastern or footwall side of the quartzite bed and was worked over a length of 180 feet

(55 m). Lead was mined from a lode in a crushed, 15-inch (38 cm) thick bed of kaolin (?original shale) sandwiched between the main quartzite vein to the west and a 9-inch (23 cm) thick bed of quartzite to the east. The lode is reported to have been worked to a maximum depth of 80 feet (24 m), probably from the shaft at the southern end, but the deepest present opening is about 30 feet (9 m).

Numerous pits were sunk on the contacts of the quartzite between and beyond the two shoots, and it is likely that sporadic mineralization is present over a length of at least 2,000 feet (610 m) along the edges of the quartzite bed.

MULLIGANS MINE (M.L. 66PP)

Mulligans mine, otherwise known as the Lucky Strike lead mine, is 7 miles (11 km) southeast of Northampton. Access is by a track branching southwards from the Isseka-Nabawa road at a point about 3 miles (5 km) east of Isseka. The total production recorded from the mine is 150 tons (156 tonnes) of lead and 32 ounces (995.2 gm) of silver from about 200 tons (203 tonnes) of concentrate.

There are no published reports on Mulligans mine and no plans.

The lode worked is in gneiss but parallel to a dolerite dyke cropping out a little distance to the west. It consists of siliceous breccia with quartz-lined vugs and contains galena and some copper minerals. It strikes at 050 degrees and dips westerly. Surface workings are mainly pits, but a shaft with a depth greater than 100 feet (30 m) was sunk on the lode; the large size of the dump about this opening indicates that the underground workings are extensive.

CAMP HILL PROSPECT

What is believed to be the Camp Hill prospect mentioned by Maitland (1903) is situated on Location 359, on the western side of the highway about a mile (2 km) south of the Northampton post office. The lode is a southwesterly continuation of that worked in the Gwalla copper mine. Shallow workings extend for about 600 feet (180 m) on a bearing of 35 degrees, and some stoping has been done from two shafts about 500 feet (150 m) apart. The presence of dolerite boulders on the dump suggests that the lode follows a dyke of this rock, though dolerite was not recognized in surface exposures. The lode seems to have been worked mainly for copper, though Maitland (1903) mentions that lead was won from it.

JOHNNY WALKER PROSPECT

The Johnny Walker prospect is 50 chains (1,000 m) northeast of the Baddera North mine on M.L. 34PP. It has no recorded production, but is of some significance because of its position on the strike extension of the lode worked in the Baddera group.

The prospect comprises a 2 to 3-foot (60 to 90 cm) wide vein of quartz and quartz breccia carrying a small amount of galena. The vein has been tested by an inclined shaft, since used as a well, and by a small pit 40 feet (12 m) south of the shaft. A further exposure of the lode in a creek bed 30 feet (9 m) south of the pit contains no lead minerals. The lode is in granite gneiss and courses at 040 degrees with a dip of 65 degrees west.

GALENA DISTRICT

The lead-zinc deposits of the Galena District are in an inlier of the Precambrian granulite exposed along the valley of the

Murchison River and its tributaries. To the east and west the block is faulted against Silurian sediments, and to the north and south it is overlain by sandplain.

The district includes the earliest lead mine worked in the State, the Geraldine, and several important deposits such as the Surprise group, the Mary Springs mine and the Three Sisters group. Details of recorded production from the District are given in Table 13.

Plans: Reference may be made to the following plans: Mines Department Lease Plan (40 chains to 1 inch), Nos. N-1 and N-2 (Galena and Ajana); Geological Survey of Western Australia 1:50,000 Geol. Sheet Ajana (1842-111, zone 1).

SURPRISE GROUP

General Information

The Surprise group of lead mines is on the west side of the North West Coastal Highway about 800 yards (730 m) south of the Murchison River. It includes the Surprise mine (M.L. 214), the Galena mine (M.L. 205), the Surprise South mine (also on M.L. 205), and the Two Boys mine (M.L. 209).

Since it was first worked in 1918 the group has produced a total of 117,636 tons (119,518.1 tonnes) of ore with a recovered metal content of 14,904 tons (15,142.4 tonnes) of lead, 19.52 tons (19.83 tonnes) of zinc, and 690 ounces (21,461.0 gm) of silver. It has been the largest lead producer in the Galena district and second only to the Baddera group in the Northampton Field.

References: General reports on the mines of the group appear in Wilson (1926), Larcombe (1925), Campbell (1952, 1965), and Berliat (1954). Diamond drill logs are recorded in Larcombe (1929).

TABLE 13. PRODUCTION OF LEAD, ZINC AND SILVER FROM GALENA DISTRICT

Mine or Group	Lease No.	Lease Name or Lessees	Period	Estimated Mine Production		Realized Production				Est. Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore or Conc. Tons	Lead Tons	Zinc Tons	Silver F. oz.		
Block Seven	Loc. 7	Thring & Green	1921-29	...	...	3,538.38	1,104.25	...	...	51,456.00	
Dingo	ML 239	F. Latham	1951	...	...	13.18	8.93	...	...	2,188.50	
Ethel Maud	ML 80	Ethel Maud	1907	...	...	10.00	6.50	...	...	256.00	Silver realized \$2.70
	ML 224	Ethel Maud	1949-50	...	...	105.36	56.40	10.90	120.83	8,174.40	
	MC 45	Camp & Party	1965	56.75	7.35	7.21	5.17	...	...	1,084.50	
Total Ethel Maud			...	...	212.57	68.07	10.90	120.83	9,514.90		
Geraldine	Loc. 1	Geraldine mine	1917-19	...	...	774.59	257.13	...	...	10,278.00	Estimated to have produced 6,500 tons of concentrate prior to 1899. Recorded production is from dumps and surface workings
	Loc. 1	R. S. Atkinson	1951	235.00	6.60	6.00	4.05	...	...	1,264.00	
	Loc. 1	F. Latham	1957-58	...	...	87.97	55.38	...	...	6,477.00	
Total Geraldine			...	...	868.56	316.56	...	...	18,019.00		
Geraldine North	ML 222	R. S. Atkinson	1949-56	3,545.00	237.80	232.03	164.49	...	65.60	38,844.76	Some ore from nearby leases may be included in this total
Geraldine South	ML 203	Geraldine South	1929	...	...	155.00	50.00	...	...	900.00	Silver not payable Silver not payable ? 500 tons of conc. prior to 1899
	PA 210	Beaton P. C.	1949	...	...	6.41	3.52	...	2.21	487.90	
	MC 43	Camp & Party	1965	13.50	2.05	1.97	1.20	...	...	227.20	
Total Geraldine South			...	...	163.38	54.72	...	2.21	1,615.10		
Great Western...	ML 253	E. Seymour	1952	...	...	1.98	1.46	...	...	330.14	
Long Lode	ML 189	(= ML 182) Long Lode	1922	...	...	38.00	11.62	...	...	172.00	
	PA 218	(= ML 182) C. H. Martin	1949	...	...	1.02	0.64	...	...	129.40	
Total Long Lode			...	...	39.02	12.26	...	...	291.40		

TABLE 13 (continued)

Mine or Group	Lease No.	Lease Name or Lessees	Period	Estimated Mine Production		Realized Production				Est. Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore or Conc. Tons	Lead Tons	Zinc Tons	Silver F. oz.		
Mary Springs Group	ML 112	Kingdom Come	1908	....	....	57·00	41·61	....	....	922·00	Silver valued at \$181·10
	PA's 118 & 194	Jenkins & Camp	1947-48	....	....	34·36	23·39	....	....	3,955·60	
	ML 234	T. A. Bridson	1951-67	7 133·00	1,767·00	1,587·56	1,208·27	....	....	196,004·64	
	ML 265	Chequers lead mine	1957-58	....	....	9·64	6·71	....	....	1,116·00	
Total Mary Springs			....	....	....	1,688·56	1,279·98	....	....	201,998·24	
Springvale	ML 24PP	Tarcoola Blocks Mines N. L.	1925-27	5,640·00	....	5,640·00	618·79	....	....	37,066·00	
Surprise Group	ML 150	Surprise	1918-22	25,393·53	....	....	6,570·53	....	....	374,130·00	Surprise shoot 93 834 tons ore for 13 019·33 tons lead
	ML's 148 150 etc.	Surprise leases	1923-26	68,440·50	9,440·00	....	6,448·80	....	....	411,288·00	
	ML 158	Surprise South	1919 & 1934	....	....	19·00	8·41	....	....	462·00	Surprise South Shoot
	ML's 205, 209, 214 etc.	Galena Lead Mines N.L.	1946-53	6,795·00	712·00	733·60	462·79	19·52	505·13	67,731·96	Silver and zinc unpayable, mainly Galena Shoot
	ML's 205, 209, 214 etc.	Surprise Mines, 1955	1955-58	6,619·00	757·50	501·77	345·31	....	94·80	68,309·28	Silver realized \$17·20
	ML 197	Two Boys Lead Mining Co. Ltd.	1925-27	9,745·25	....	....	942·16	....	....	56,984·00	Two Boys Shoot—some production included with Galena Shoot
	MC 42	Camp, S. G., Camp, F. S. & Hyde, H. P.	1964-65	643·25	181·52	170·53	126·38	....	....	33,191·60	
Total, Surprise Group			....	117,636·53	....	....	14,904·38	19·52	689·93	1,012,096·84	
Leaders	ML 140	Surprise	1916	....	....	0·71	0·44	....	....	18·00	Mainly a copper mine
Three Sisters Group	ML 54	Lady Maud	1899-1900	....	....	76·75	9·00	....	....	1,706·00	} Three Sisters Shoot
	ML 153	Three Sisters (Ajana Lead Mines Ltd)	1918-26	8,732·25	1,313·00	....	896·82	....	....	61,462·00	
	ML 235	(= ML 153) Victory	1950-51	230·00	17·00	16·57	11·59	....	....	2,909·30	
	ML 200	Grand Junction	1926-29	....	....	267·50	53·19	....	....	1,774·00	} Grand Junction Shoot
	ML 207	Grand Junction mine	1936-37	7,348·00	438·40	....	342·19	....	....	18,213·00	

	ML 252	Three Sisters North	1953-55	882.00	69.00	68.02	54.31	....	10.78	10,037.92	Silver unpayable
	PA 198	(= ML 166 Three Brothers)	....	....	....	1.69	1.23	....	0.34	266.00	
	Total, Three Sisters		....	17,192.25	1,837.40	1,743.53	1,368.33	....	11.12	96,368.22	
Welcome	ML 159	Welcome lead mine	1918	....	....	5.74	3.59	....	....	136.00	
	ML 202	Welcome Two Boys Lead Mining Co.	1926-27	1,263.00	169.50	....	115.21	....	....	6,548.00	
	Total, Welcome		....	1,263.00	....	....	118.80	....	....	6,684.00	
Wheal Ina	ML 19PP	Wheal Lily	1920-21	....	....	44.75	30.79	....	....	1,484.00	
	ML 23PP	Wheal Ina	1923-27	....	....	513.00	85.27	....	....	3,754.00	
	PA 50PP...	Salter, Davis & Salter	1949	....	....	15.57	11.72	....	....	2,475.94	
	ML 33PP	Wheal Ina	1950-56	627.00	47.82	48.36	32.08	....	....	6,694.20	
	PA 285	W. M. McKinnon	1965-66	53.75	6.00	8.42	4.83	....	....	932.00	
	Total, Wheal Ina		....	....	....	630.10	164.69	....	....	15,340.14	
Miscellaneous	PA 200	McCarthy & O'Brien	1949	....	....	2.24	1.38	....	2.01	176.70	Location uncertain Silver valued at \$4.10
	PA's 202, 208, 209	Murchison View Syndicate (Scattered PA's)	1949	....	....	12.03	8.75	....	20.33	1,284.30	
			1917-29	....	....	657.04	299.65	....	....	8,700.00	

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

Plans: Plans and section of all of the mines are bound with Campbell (1952) and of the Surprise mine alone in Wilson (1926). The Department holds several plans of the group which can be inspected. The G.S.W.A. reference numbers of these are: 5490, 5491, 5743, 7197, 10305, 10808, 10816, 10817, 10835.

Geological Information

The Surprise, Galena and Surprise South mines are on a left-hand tear fault with a horizontal movement of about 3,000 feet (900 m), a strike of 340 degrees and a

Surprise Mine

The Surprise mine is the largest and most northerly of the group. It was worked between 1918 and 1926 to yield 93,834 tons (95,335.3 tonnes) of ore containing 13,019 tons (13,227.3 tonnes) of lead. Production ceased when the ore body bottomed at about 300 feet (90 m).

Structure of ore body: The Surprise ore body occupies an intensely crushed and fractured zone at an echelon offset of the north-northwest fault. Both cymoid loop and diagonal link structures are apparent in the level plans, and the openings produced

TABLE 14. DETAILS OF ORE SHOOTS WORKED IN THE SURPRISE MINE

Ore Shoot	Length Feet	Ave. Width Feet	Grade Per cent Lead
Main Shoot at 200-foot level	241	10	11.5
West Branch Shoot at 110-foot level	185	10	12
Penna Shoot at 110-foot level	94	4	9
East Shoot at 110-foot level	64	5	8
Model Shoot at 110-foot level	68	5	12
West Shoot at 110-foot level	120	10	11

NOTE: 1 foot = 0.3048 metres

dip of about 70 degrees westerly. Ore shoots appear on bends or echelon offsets of the fault. The Two Boys mine is on a parallel fault 550 feet (170 m) to the east. A small copper mine has been worked on M.L. 205 on another parallel shear 300 feet (90 m) west of the Galena mine. Apart from the faulted end of a dolerite dyke in the northern part of the Surprise mine, the wall rock of the lodes is granulite. Both the wall rocks and lode channels show an unusually large amount of brecciation and alteration.

Primary minerals present in the lodes are galena, sphalerite, marcasite, chalcopryrite, barite and quartz.

on these have been the loci for the ore. The lode consisted of a massive body of brecciated granulite (and possibly some dolerite) traversed by branching and looping shears and tension gashes which held the main part of the lead. Each of these mineralized fractures is termed a "lode" in earlier reports, but for consistency with the rest of this Bulletin, the term "shoot" has been substituted in the description below.

Six shoots were worked on the 110-foot (33.5 m) level of the mine. The Main shoot and the West branch shoot were on the two parts of a cymoid loop formed on the principal link structure. The East shoot, West shoot and Model shoot were

on diagonal link structures and the eastern-most Penna shoot was on a fracture parallel to the general link direction but outside the main zone of fracturing.

Size and grade of ore shoots: The data in Table 14 above is taken from Wilson (1926).

The six ore shoots total 455 tons (462.2 tonnes) per vertical foot and average about 11 per cent lead.

On the 300-foot (91.4 m) level the Main ore shoot was only about 12 feet (3.6 m) long. One section of it in the north drive assayed 10 per cent lead over 51 inches (129.5 cm) and the cross-cut from the main shaft intersected 25 feet (7.6 m) of lode averaging 5 to 6 per cent lead. The greater part of the ore in the Main shoot bottomed at about 240 feet (73 m).

Details of workings: On the surface the complex of ore shoots was mined from an open-cut about 200 feet (60 m) long by 100 feet (30 m) wide and 50 or 60 feet (15 to 18 m) deep. Underground the lode was mined from a 10 x 4-foot (3 x 1 m) main shaft with levels at 110, 200 and 300 feet (33.5, 60.9 and 91.4 m).

On the 110-foot (33.5 m) level the ore shoots were worked from a network of drives and cross-cuts. The longest drive was that on the Main shoot which extended for 380 feet (120 m) north and 150 feet (46 m) south of the shaft. It was taken beyond the limits of the ore shoot to test the north-northwest fault either way from the ore body. Most drives on the other ore shoots stopped at the limits of the ore.

The 200-foot (60.9 m) level consisted of a drive on the Main shoot extending 130 feet (40 m) either way from the main shaft and 100 feet (30 m) of driving north of the shaft on the West shoot. Two cross-cuts connected the drives and other cross-cuts penetrated the hanging wall and

footwall sides of the lode complex. Most of the ore shoots worked on the 110-foot (33.5 m) level either pinched out or joined the Main shoot or West shoot before reaching the 200-foot (60.9 m) level.

The 300-foot (91.4 m) level was driven 94 feet (28.6 m) north and 119 feet (36.2 m) south of the main shaft, but apart from a short section immediately north of the shaft was in low-grade ore. Cross-cuts were put out to the east and the west but failed to locate further ore. A winze sunk 65 feet (19.8 m) south of the shaft to a depth of 70 feet (21.3 m) below the level encountered ore-grade material between depths of 45 and 55 feet (13.7 and 16.7 m). A west cross-cut 12 feet (3.6 m) long from the bottom of the winze found only low-grade lode material, and a drillhole from the end of the cross-cut failed to locate more ore. Rises from the level showed that most of the ore had bottomed at 240 feet (73 m), and an intermediate level was put in at that depth to open up the ore body for stopping.

Diamond drilling: In 1928 the Mines Department drilled two holes to test for depth extensions of the Surprise ore body.

Hole 1 sited about 460 feet (146 m) on a bearing 060 degrees from the main shaft was drilled at azimuth 086 degrees, inclination 55 degrees to 922 feet (281.0 m). It cut altered dolerite between 415 and 628 feet (126.4 and 191.4 m) but located no definite lode formation.

Hole 2 sited 250 feet (76 m) on bearing 280 degrees from the main shaft was drilled on azimuth 086 degrees and depression 55 degrees to 450 feet (137 m). At 262 feet 6 inches (80.01 m) it cut 3 inches (7.6 cm) of granulite with a little pyrite and galena. From 262 feet 9 inches (80.08 m)

to 325 feet (99.0 m) it intersected altered dolerite. Again no definite lode was located.

Core recovery was poor in both holes.

Galena Mine

The Galena mine is 500 feet (150 m) south-southwest of the Surprise mine and on the same line of shearing. It was worked from 1946 to 1958 to produce 808 tons (820.9 tonnes) of lead from 13,414 tons (13,628.6 tonnes) of ore.

The ore body is on a small cymoid loop structure and on the 190-foot (57.9 m) level was reported to be 170 feet (52 m) long, 6 feet (1.8 m) wide and to contain irregularly distributed ore shoots up to 18 inches (46 cm) thick. On the 92-foot (28.0 m) level, the ore body was 120 feet (37 m) long and at the surface about 70 feet (21 m) long.

Workings consist of an open-cut 90 feet (27 m) long leading into old stopes and a main shaft 7 x 3 feet (2.1 m x 91 cm) with levels at 92 and 190 feet (28.0 and 57.9 m). The 92-foot (28.0 m) level extended for 190 feet (58 m) north and 120 feet (37 m) south of the main shaft and the lode was stoped above it over a distance of 120 feet (37 m) northerly from 40 feet (12 m) north of the shaft.

Surprise South Mine

The Surprise South ore body is 400 feet (120 m) southwest of the Galena mine on another S-bend on the same shear zone. Recorded production was 8 tons (8.1 tonnes) of lead, although it is likely that further ore from the mine was treated along with that of the Surprise mine. The ore shoot was worked to a maximum depth of 170 feet (52 m) over a length of about 160 feet (49 m) on the 100-foot (30.4 m) level from three inclined shafts. It was fully

developed only on the 100-foot level (30.4 m) where it was 150 feet (46 m) long and averaged about 8 per cent lead. No details of widths of ore or stope outlines are available.

Two Boys Mine

The Two Boys mine is 750 feet (229 m) east of the Galena mine alongside the highway. Recorded production since the mine's discovery in 1925 has totalled 10,388 tons (10,554.2 tonnes) of ore containing 1,068 tons (1,085 tonnes) of lead. Some further production was included with that from the Galena mine.

The ore body appears to be a west-plunging pipe-like zone of breccia formed at the intersection of a north-northwest fault with a more northerly striking shear. Distribution of lead ore within the breccia zone is not known but it appears to have been dispersed throughout.

At the surface the ore body was mined from an open-cut 80 feet (24 m) long, 50 feet (15 m) deep and averaging 45 feet (14 m) wide. A shaft 130 feet (40 m) deep was sunk on the western side of the open-cut and cross-cuts to the ore body were put in at 46 and 121 feet (14.0 and 36.8 m). The cross-cut at 46 feet (14.0 m) extended for 24 feet (7.3 m) east of the shaft and cut a reported 21-foot (6.4 m) width of lode averaging 16 per cent lead. The cross-cut at 121 feet (36.8 m) extended 30 feet (9.1 m) east and 55 feet (16.7 m) west of the shaft. It cut lode averaging 6 per cent lead over an unrecorded width. Two drives were made along shears intersected in the west cross-cut at distances 20 and 45 feet (6 and 14 m) respectively from the shaft. Values in both drives were low and neither was extended for more than 45 feet (14 m) from the cross-cut.

When the mine was reopened in 1964 the main shaft was cleaned out to 80 feet (24 m), a cross-cut was put in to the lode and about 600 tons (610 tonnes) of ore were mined.

Conclusions

The Surprise group of mines is in a strongly fractured area which could contain further ore bodies. Prospecting along the prominent north-northwest fault by geophysical and geochemical methods seems warranted.

MARY SPRINGS GROUP

General Information

The Mary Springs group of mines is 4 miles (6.4 km) north of Galena on the west side of the highway. It includes the Mary Springs mine, Chequers mine and Gallagher's pyromorphite lodes. The Mary Springs mine was first worked by the Geraldine Company in the early days of the Field, and a large quantity of ore was reported to have been won during that period. It was reopened briefly in 1908, again in 1947, and has been worked almost continuously since 1951. The history of the other mines of the group is not known. The production of the Mary Springs group came mainly from the Mary Springs mine itself. It amounts to 1,280 tons (1,300 tonnes) of lead from 1,690 tons (1,717 tonnes) of concentrate derived from the treatment of about 7,500 tons (7,620 tonnes) of ore. Recently the mine was bought by Canadian Southern Cross Limited and the company is sinking a new shaft to exploit two ore shoots proved by diamond drilling.

References: Published reports on the Mary Springs mines are to be found in Maitland (1903), Montgomery (1908), Wilson (1926), and Berliat (1954).

Plans and sections are held by the Drafting Branch of the Mines Department (Reference 145/1-4) and the Geological Survey Branch (Reference 4897, 10813).

Mary Springs Mine (M.L. 234)

On the Mary Springs mine (also known as the Kingdom Come), three ore shoots on parallel lodes have been mined. The two more important shoots lie on either side of a 60-foot (18 m) thick dolerite dyke, while the third shoot is about 160 feet (50 m) west of the dyke. The three lodes each strike at 030 degrees and dip westerly at about 70 degrees. The workings on the western lode, which lies partly in a creek bed, are now filled in but are reported to have been only about 45 feet (14 m) deep.

The shoot on the western or hanging wall side of the dolerite dyke has been worked to a depth of 100 feet (30 m) from a vertical shaft. At the 100-foot (30.4 m) level the shoot was driven on for a distance of 290 feet (88 m) south of the shaft and stoped above for all but 65 feet (19.8 m) of this, the unstoped section lying between 50 and 115 feet (15.2 and 35.0 m) south of the shaft. The ore was mined to an average width of 7 to 8 feet (2.1 to 2.4 m) with a maximum width of about 11 feet (3.3 m).

Where seen in pillars, the ore is 4 to 5 feet (1.2 to 1.5 m) wide consisting of quartz and sulphides with 30 to 40 per cent galena. Veins of massive galena up to 1 foot (30 cm) thick are present usually on the footwall side of the lode. Crystallized vugs are common. The poorer sections of the lode are on the flatter dipping parts of the shear, the dips ranging from 75 degrees west on the better section to 55 degrees on the poorer. At the southern

end of the drive the lode cuts into the dolerite dyke and dies out. However it is possible that further lode matter could be located by cross-cutting to the wall of the dyke. About one-third to one-half of the ore above the 100-foot (30.4 m) level is stoped out.

Footwall Shoot

The eastern or footwall shoot was worked to a depth of 100 feet (30 m) from an underlay shaft sunk at its southern end. A cross-cut at the 100-foot (30.4 m) level through the dolerite dyke connects the hanging wall and footwall drives at about 90 feet (27 m) south of the underlay shaft. The 100-foot (30.4 m) level on the eastern lode was driven for about 120 feet (37 m) southerly from the shaft and stoped for about 40 feet (12 m) above the level over an average width of 4 to 5 feet (1.2 to 1.5 m), with a range from 3 to 7 feet (90 cm to 2.1 m).

The best ore is on the footwall side of the lode and it commonly contains vugs lined with crystals of galena. The dolerite exposed in the cross-cut has a few thin bands of galena, and it is reported that elsewhere in the mine dolerite is sufficiently well mineralized to be mined as ore.

Ore Reserves

Diamond drilling carried out by Canadian Southern Cross Limited has shown that the footwall shoot is 300 feet (90 m) long, averages 5.7 feet (1.7 m) in width, and bottoms at a vertical depth of 250 feet (76 m). The hanging wall shoot is 320 feet (97.5 m) long, averages 5.0 feet (1.5 m) in width and continues to a depth of 300 feet (90 m). The company reported ore reserves of about 80,000 tons (81,300 tonnes) averaging 17 per cent lead in the two shoots.

Gallagher's Pyromorphite Lode

In the vicinity of the Mary Springs mine there are two lodes, each containing pyromorphite, which have been named after the original discoverer, Gallagher. One, about 700 yards (640 m) south of the mine is a lode consisting of anglesite and pyromorphite, striking at 035 degrees. The other, about a quarter of a mile east of the Mary Springs mine has an outcrop striking at 050 degrees containing pyromorphite. Two shallow shafts were sunk on this lode 140 feet (43 m) apart. The northern shaft had 18-inch (46 cm) seams of high-grade ore at the surface which pinched out at a depth of about 6 feet (2 m). The dump of the other shaft contained only some low-grade pieces of copper-stained quartz with galena and pyromorphite.

Chequers Lead Mine

Chequers lead mine is on M.L. 265 (formerly P.A. 153 shown on the lease plan), and is about 1,000 feet (300 m) southwest of the Mary Springs mine. Production recorded from the mine is only 9 tons (9.1 tonnes) of concentrate containing 6.7 tons (6.8 tonnes) of lead but the size of the old workings suggests that considerably more ore than this has been produced.

A plan of the surface workings is held by the Geological Survey of Western Australia (Ref. 10826).

The lode which follows the eastern contact of the dolerite dyke exposed in the Mary Springs mine, strikes at 025 degrees and dips at about 80 degrees westerly. It has been worked over a length of 300 feet (90 m) and ranges from 1.5 feet to 4 feet (46 cm to 1.2 m) in width, averaging about 2.5 feet (76 cm). Two portions have been stoped, each apparently to depths of 40 or 50 feet (12 to 15 m). The northern stope is about 50 feet (15 m) long and

the southern part about 100 feet (30 m) long.

The geological control of the lode is uncertain, but the position of the mine corresponds to a bulge in the dolerite dyke from 40 to 60 feet (12 to 18 m) thick. Only oxidized lead minerals were seen on the dumps and no high-grade ore was noted.

GERALDINE LEAD MINE

General Information

The Geraldine lead mine was the first lead deposit to be discovered in the Northampton Mineral Field and the earliest mine in the State to be brought into production. Mining started in about 1850, but the chief production period was between 1867 and 1878, since when it has remained idle. The lode cropped out in the bed of the Murchison River and the first shafts, sunk on the outcrop, were consequently flooded when the river flowed. Later work was carried out from a main shaft on the northwest bank of the river, but even this was collared below high flood level and the mining operations had therefore to be suspended when the river ran high.

No accurate production figures are available for the mine. Montgomery (1908) reported that at least 6,500 tons (6,600 tonnes) of ore were shipped in the early period of mining, but this probably included production from some nearby mines, such as the Three Sisters and Lady Florence, which were worked by the same company. Production recorded from Location 1 since 1899 has almost certainly come from Gallaghers lode, 1,400 feet (430 m) northeast of the Geraldine mine, or from the treatment of dumps. It has amounted to 868 tons (881.8 tonnes) of ore with a lead content of 316 tons (321.0 tonnes). In 1966 the Mines Department subsidized a drilling programme at the mine, the results of which are given below.

References: Reports on the Geraldine mine can be found in Gregory (1848), Woodward (1895), Maitland (1903), Montgomery (1908), Wilson (1926), and de la Hunty (1967).

Plans of the surface workings are contained in the reports of Wilson and de la Hunty, and one is filed in the Mines Drafting Branch (Ref. 119/1).

Geological Information

The lode at the Geraldine mine is too poorly exposed for any assessment to be made of possible ore controls. Campbell (1952) states that it may be a strong breccia-link structure, but also notes the poor outcrop and scanty records. All that can be said from the information available, is that the lode followed a shear zone in granulite parallel to nearby dolerite dykes. The lode strikes at about 025 degrees and dips westerly. The nearest dolerite dyke is 300 yards (270 m) to the southeast.

Gregory (1848) stated that at the surface the ore body was 960 feet (293 m) long, averaged 12 inches (30 cm) wide, ranging from 8 to 24 inches (20 to 61 cm), and consisted of nearly solid galena. The outcrop ran along the bed of the river. Specimens from mine dumps indicate that the lode consisted of sheared, brecciated and chloritized garnet granulite with galena, sphalerite, pyrite, chalcopyrite and quartz. According to Woodward, the ore comprised massive galena with zinc blende, pyrite, cerussite, blue slaty clay, and quartz. The lode at 320 feet (97.5 m) depth was reported by Montgomery to be 2 feet 8 inches (81 cm) wide and to average 65 to 75 per cent of lead; and by Woodward to be decreasing in grade, although becoming wider at this depth. Drillhole results show that the galena tended to be restricted to the hanging wall of the lode and the sphalerite to the footwall.

Description of Workings

Surface workings on the lode consist of seven filled shafts extending over a distance of 1,000 feet (300 m). Three shafts are grouped within a distance of 200 feet (60 m) on the northwest bank of the river, while the others are in the bed of the river. No details of the underground workings are available except for statements by Woodward and Montgomery that the lode was worked to a depth of 320 feet (97.5 m) on the underlay (about 300 feet (90 m) vertical depth) from two inclined shafts. Otherwise the extent, or for that matter, the exact position of the underground workings is unknown. The grouping of shafts and facilities at the southern end may indicate that the main workings were there, or it may have been an expedient for reducing the effects of the floods.

Results of Diamond Drilling

The results of three Government subsidized diamond drillholes were reported by de la Hunty (1967). The holes were drilled from the northwest bank and sited on the assumption that the main ore body did not extend far from the main shaft. Collar locations are shown in the plan which accompanies de la Hunty's report.

All holes were drilled on a bearing of 120 degrees and depressed at 60 degrees.

Hole 1 sited opposite the main shaft, 200 feet (60 m) west of the stone ruin, intersected the lode between 417 and 421 feet (127.1 and 128.3 m) at a vertical depth of 350 feet (107 m). It encountered a total of 2.5 inches (6.35 cm) of high grade galena and 6.75 inches (17.14 cm) of high-grade sphalerite.

Hole 2 drilled from a point 200 feet (60 m) on a bearing of 30 degrees from Hole 1, cut the lode between 446 and 454 feet (135.9 and 138.3 m) at a vertical depth

of 380 feet (115.8 m). The mineralized zone here contained a total of a quarter of an inch (0.63 cm) of galena and 4.125 inches (10.47 cm) of lode carrying 30 per cent sphalerite.

Hole 3 sited 150 feet (46 m) on a bearing of 210 degrees from Hole 1, intersected the lode between 409 and 421 feet (124.6 and 128.3 m) at a vertical depth of 350 feet (107 m). A total of 12 inches (30.4 cm) of the lode contained low-grade galena and there were 1.75 inches (4.44 cm) with high-grade sphalerite. The drill struck a 3-foot (90 cm) cavity at 412 feet (125.5 m) which was attributed to a vug in the lode, although the possibility of the gap being an old stope at a depth greater than the reported maximum of 320 feet (98 m) is not discounted.

Gallagher's Lode

The workings on Gallagher's lode are on the southeast bank of the Murchison River, about 1,400 feet (430 m) northeast of the old buildings at the Geraldine mine. It is likely that most of the recorded production from Location 1 came from this lode. The old workings have been filled with silt from the river, but in some recently bulldozed trenches the lode is seen to be 2 to 4 feet (60 cm to 1.2 m) wide and to contain galena at quite shallow depths. The lode can be followed for 300 feet (90 m); about 100 feet (30 m) from the southern end it is offset about 20 feet (6 m) to the right. No details of the former deeper workings are available.

Assays: The results of two samples taken from the mine are: No. 7762 from a dump of ?picked ore, assayed 58.8 per cent lead and 0.10 per cent zinc; No. 7763 from a channel sample over 2 feet (60 cm) width assayed 2.17 per cent lead and 0.18 per cent zinc.

THREE SISTERS GROUP

(M.L.s 153, 216, 186 and 252)

The Three Sisters group of mines is about 1.25 miles (2 km) northeast of Galena and is reached by travelling just over a quarter of a mile along a road branching easterly from the highway, 200 yards (180 m) north of the Murchison River bridge and then branching northeasterly on a track which leads directly to the mines. The four mines which comprise the group are the Three Sisters, the Grand Junction, the Three Sisters North and the Three Brothers. Mines of the group were first worked by the Geraldine Company in the 1870s. Since 1899 the group has produced a total of 1,368 tons (1,389.8 tonnes) of lead and 11 ounces (342.1 gm) of silver from about 17,200 tons (17,480 tonnes) of ore. Details of production from each lease are shown in Table 13.

References to the group can be found in Woodward (1895), Maitland (1903), Wilson (1926), and Campbell (1952).

Plans and sections of the workings of the Three Sisters mine are held by the Drafting Branch of the Mines Department (Ref. 417/1-3) and plans of the workings of the various mines are held by the Geological Survey of Western Australia (Ref. Nos. 810, 811, 1679, 1680, 10842, 10843, 10844).

Geological Information

With the exception of the Three Sisters North, all of the mines are on the western contact of a thin dolerite dyke striking at about 040 degrees and dipping 70 to 80 degrees west. Another, thicker, dolerite dyke which lies to the west of the lode, on a parallel strike has been seen in diamond drill cores, but is rarely exposed on the surface. Ore bodies formed where the lode

shear was offset or curved by bands of more massive or harder rock lying in its path. Wider zones of brecciation developed on these irregularities in the main shear and provided channels for the ore solutions. The Three Sisters North mine, on the other hand, follows a line of shearing along the western contact of a band of basic granulite within the gneiss. If projected southwards this line would intersect that of the other mines at about the position of the Grand Junction mine.

Three Sisters Mine

The Three Sisters (or Lady Maud or Victory) mine is the principal mine of the group. It worked an ore body formed where the lode shear is offset to the right across a band of quartzite. The ore body is about 180 feet (55 m) long, up to 12 feet (4 m) wide and is stated to have averaged 12 per cent lead after sorting. Surface workings consist of an open-cut 180 feet (55 m) long and about 90 feet (27 m) deep.

Underground mining was done from a 100-foot (30 m) deep shaft from the bottom of which a drive was put in along the lode from distances of 250 feet (76 m) north and 200 feet (61 m) south. A shoot of ore 150 feet (46 m) long exposed at the 100-foot (30.4 m) level was stoped through to the open-cut. A winze 39 feet (11.8 m) north of the shaft was sunk to a depth of 41 feet (12.4 m) in low-grade ore. At this depth an east cross-cut was put out 14 feet (4.2 m) to the footwall, and this proved to be in lode material averaging about 5 per cent lead. Another winze 26 feet (7.9 m) south of the shaft was sunk to a depth of 41 feet (12.4 m) on low values. At this depth an east cross-cut was put out 8 feet 6 inches (2.6 m) to the footwall and lode material containing about 4 per cent lead was intersected. The operating company

ceased work shortly afterwards and the lode found in these winzes is probably still underfoot, although by the standards of the Field it is too poor to be payable.

Diamond Drilling on the Three Sisters Lease

In about 1957, the Anglo Westralian Pty. Ltd. company drilled three holes to test the Three Sisters ore body.

Hole 1 located on a bearing 320 degrees and a distance of 135 feet (41.1 m) from the main shaft, was drilled on a bearing of 131 degrees and a depression of 65 degrees to a total depth of 427 feet (130.1 m). It intersected no definite lode channel but between 346 and 380 feet (105.4 and 115.8 m) encountered galena and sphalerite in cracks in the gneiss. Small stringers containing sulphides were also encountered at about 187 and 260 feet (56.9 and 79.2 m), and the section 290 to 291 feet (88.3 to 88.6 m) contained sphalerite in small vugs.

Hole 2 located 196 feet (59.7 m) from the shaft on a bearing of 140 degrees, was drilled at an azimuth of 122 degrees and a depression of 65 degrees to a depth of 305 feet (92.9 m). Between 157 and 187 feet (47.8 and 56.9 m) it intersected the lode channel which assayed 2.6 per cent lead between 157.5 and 185 feet (48.0 and 56.3 m).

Hole 3 sited 346 feet (105.4 m) on a bearing of 220 degrees from the main shaft, had an azimuth of 122 degrees and an inclination of 65 degrees. It reached a depth of 210 feet (64.0 m) and cut the lode channel between 180 and 182 feet 6 inches (54.8 and 55.6 m). The average grade of this section was 1.2 per cent lead.

Grand Junction Mine

In the Grand Junction mine, 1,500 feet (460 m) northeast of Three Sisters, ore has been mined from three shoots located at an echelon offset of the lode shear where it cut a massive pegmatite dyke. The main or western lode is on a brecciated link structure connecting the opposite ends of the main shear. It is about 80 feet (24 m) long, 10 to 12 feet (3.0 to 3.6 m) wide and consists largely of brecciated, mineralized pegmatite. The eastern lode can be seen in a cross-cut from the eastern wall of the open-cut. It is 2 to 3 feet (60 to 90 cm) wide and follows the edge of a thin dolerite dyke. Where intersected in a cross-cut from the old main shaft, it averaged 8 per cent lead over a width of 36 inches (91 cm). The third lode, between the other two, is mentioned in reports by Wilson and Berliat. It consists of stringers of galena over a width of 30 inches (76 cm) and probably follows a second, weaker, link structure between the two offset ends of the main shear. A lode on the northern part of the stepped-shear structure was worked in the northern half of the open-cut. At the very northern end of the open-cut another link-type shear branching to the west is mineralized over a width of about 1.5 feet (46 cm). All the shoots strike between north and northeast and dip about 70 degrees west.

Surface workings consist of an open-cut, 120 feet (37 m) long which is connected to the 40-foot (12.1 m) level of the mine. Near the bottom is a drive from the old shaft which extends a further 40 feet (12.1 m) to the southwest along the east lode. The main shaft is more than 100 feet (30 m) deep, but details of underground workings from it are not known. It seems likely that the ore body was worked out.

Three Brothers Mine (M.L. 166)

The Three Brothers mine is 1,000 feet (300 m) south-southwest of the Three Sisters and about 60 feet (18 m) from the northern boundary of the lease. It is on a southern extension of the same line as the Three Sisters and Grand Junction mines. The lode is on the western side of a dolerite dyke which is the easternmost member of a group of five such intrusives in the area of the lease.

Surface workings consist of a few costeans and a 75-foot (23 m) deep inclined shaft in which the lode is 3 to 4 feet (90 cm to 1.2 m) wide. The 75-foot (22.8 m) level in this shaft extends for 16 feet (4.8 m) north and 20 feet (6 m) south. Good ore was reported in the northern drive, but to the south the lode was stated to be poor. Rich ore was also reported from the sump-hole in the shaft.

Anglo Westralian Pty. Ltd. drilled one hole to test the lode. It was collared 110 feet (34 m) west-northwest of the shaft and drilled on a bearing of 120 degrees at a depression of 65 degrees to a depth of 191 feet (58.2 m). It intersected dolerite between 0 and 108 feet (0 and 32.9 m), 113 and 118 feet (34.4 and 35.9 m), 130 and 150 feet (39.6 and 45.7 m), and 157 and 161 feet (47.8 and 49.0 m). From 150 to 157 feet (39.6 to 45.7 m) the core contained silicified gneiss with pyrite, but no lead minerals.

Three Sisters North Mine (M.L. 252)

The Three Sisters North mine is 1,700 feet (520 m) north of the Grand Junction mine to which it is connected by an old track. The lode is on the eastern side of a band of basic granulite and follows a sinuous course in a northerly direction for 420 feet (128 m). Two parts of it have been worked at depth; one at the northern end of the line and one at the southern end.

The southern workings extend over a strike length of 120 feet (37 m) and reach a depth of about 50 feet (15 m). The lode there was stoped from three shafts over a width of 4 to 5 feet (1.2 to 1.5 m) and contained galena, pyrite, chalcopyrite, and copper and lead carbonate. Garnets in the wall rock gneiss are altered to chlorite, indicating a moderately high temperature of ore deposition.

The northern workings followed the lode for 110 feet (34 m). They consisted of 2 or 3 shafts, and a collapsed stope on the site of another shaft. According to Wilson (1926) this stope was 80 feet (24 m) deep. A shaft 60 feet (18 m) further south was reported to contain streaks of rich ore in a drive at the 34-foot (10.3 m) level.

Conclusions

The area of the Three Sisters group seems a good one for geophysical and geochemical investigations. There seems a good possibility of locating ore shoots at least as large as those already mined.

BLOCK SEVEN MINE

General Information

The Block Seven mine is in the eastern part of Location 7, 4 miles (6.4 km) southwest of Galena. Access is by way of a track following the surveyed stock route from the Murchison River to Northampton. The mine was first worked from 1888 to 1890 and was then reported to have yielded about 700 tons (710 tonnes) of ore. It was worked again between 1921 and 1929, during which time it yielded 3,540 tons (3,597 tonnes) of ore and concentrates containing 1,104 tons (1,121.6 tonnes) of lead.

References: Brief descriptions of the mine workings are given by Maitland (1903) and Wilson (1926). These are now out of date as a fair amount of work was done after Wilson's account.

Plans: A plan of the workings is given by Wilson, and further plans are held by the Drafting Branch (Ref. 7/1 and 2) and the Geological Survey Branch (Ref. 4897, 10852).

Geological Information

Two intersecting lodes have been worked in the Block Seven mine. The main lode strikes at 010 degrees, dips at 80 to 85 degrees west and was worked over a length of 450 feet (137 m). At its southern end it is in gneiss, but at about 200 feet (60 m) northwards it intersects a dolerite dyke and the northernmost 250 feet (76 m) of the lode has dolerite walls. The branch lode follows the eastern contact of the dolerite and the principal workings extend 230 feet (70 m) south of its intersection with the main lode. It strikes at 030 degrees and dips steeply west. North of the intersection there are a few pits along the contact of the dolerite, but no extensive workings. The width of the main lode varies from 3 to 6 feet (90 cm to 1.8 m) where seen on the surface, and that of the branch lode from 2 to 3 feet (60 to 90 cm).

Description of Workings

The earlier work on the mine was done from an underlay shaft 122 feet (37.1 m) deep sunk immediately north of the intersection of the two lodes. From the shaft, drives were put in on the main lode at 95 and 122 feet (28.9 and 37.1 m). The 95-foot (28.9 m) level extended for 110 feet (34 m) northerly and 230 feet (70 m) southerly. A rich shoot of ore was stoped from a point 30 feet (9 m) north to 70 feet (21 m) south of the shaft. The 122-foot (37.1 m) level was driven for 95 feet (28.9 m) south of the shaft. An examination of the surface workings indicates that some stoping was also carried out from two shafts

at the northern end of the main lode, but the extent of this work is not known.

Later work (after 1926) was done from a vertical three-compartment shaft collared 20 feet (6 m) east of the branch lode near the southern end of the workings, and sunk to a depth of 120 feet (36.5 m). Cross-cuts east and west from the bottom of the shaft intersected both branches of the lode. A little driving was done on each branch from the cross-cuts, particularly on the eastern or main line, but apparently no connection was made with the workings from the old main shaft.

SPRINGVALE MINE (M.L. 24PP)

The Springvale mine is 2 miles (3.2km) northwest of Ajana and is reached by farm roads from that centre. It was found in the early 1920s when galena was pulled up by a harrow during farming operations and was worked from 1925 to 1927 to produce 5,640 tons (5,730 tonnes) of ore containing about 618 tons (627.8 tonnes) of lead.

References to the mine can be found in Wilson (1926), Wilson (1928), and Campbell (1952).

Plans: The Drafting Branch of the Mines Department holds plans of the workings (Ref. 10/1-4) and plans and sections are contained in the report by Campbell.

In the Springvale mine, lead ore occurs in a vertical fracture in a block of brecciated gneiss 900 feet (270 m) long and 50 feet (15 m) wide. On the surface the lode has been traced by a series of pits, costeans and shafts in the direction of 030 degrees over a distance of 500 feet (150 m). In the underground workings ore was stoped over a total length of 350 feet (107 m) to a depth of 100 feet (30 m). Two shafts were sunk to a depth of 100 feet (30 m), the main shaft near the centre of the shoot and a

northern shaft about 100 feet (30 m) further north.

Two levels, at 35 feet (10.6 m) and 100 feet (30.4 m) were driven from the main shaft. The 35-foot (10.6 m) level extends for 120 feet (37 m) north and 110 feet (34 m) south of the shaft and connects with the northern shaft. The 100-foot (30.4 m) level extends for 180 feet (55 m) north and 200 feet (60 m) south of the main shaft, and also connects with the northern shaft. The lode was stoped almost to the surface for about 170 feet (52 m) south of the main shaft and for a short distance above the 100-foot (30.4 m) level, just north of the northern shaft. Sampling carried out by Anglo Westralian Pty. Ltd. indicated two ore shoots on the 100-foot (30.4 m) level.

The southern shoot commences about 50 feet (15 m) south of the main shaft, is 120 feet (37 m) long and averages 10.4 per cent lead over an average width of 5 feet (1.5 m). The northern shoot commencing about 80 feet (24 m) north of the main shaft, has a length of 78 feet (23.7 m) and averages 16.2 per cent lead over an average width of 5 feet (1.5 m).

Two winzes were sunk to test the indicated ore shoot below the 100-foot (30.4 m) level. The No. 1 north winze, 135 feet (41.1 m) north of the main shaft, was sunk to 135 feet (41.1 m) below the level. In it the lode averaged 8 per cent lead over a mean width of 50 inches (127 cm). A drive northwards from the winze at the 222-foot (67.6 m) level exposed lode averaging 5.8 per cent lead over a mean width of 36 inches (91 cm) and a length of 45 feet (13.7 m). In a drive southward from the winze at the same level, the lode averaged 4.5 per cent lead over a width of 36 inches (91 cm) and a distance of 60 feet (18 m).

The No. 1 south winze is 110 feet (34 m) south of the main shaft and was sunk to a depth of 130 feet (40 m) below the 100-foot (30.4 m) level in lode averaging 5.6 per cent lead over a mean width of 51 inches (129 cm). A drive northwards for 50 feet (15 m) at the 222-foot (67.6 m) level revealed lode assaying an average 4.8 per cent lead over a mean width of 36 inches (91 cm). A south drive at this level was also 50 feet (15 m) long and contained lode assaying 3.6 per cent lead over 36 inches (91 cm) width.

Diamond Drilling

Three holes were drilled by Anglo Westralian Pty. Ltd. to test the lode.

Hole 1 cut the lode at a vertical depth of 250 feet (76 m) at a point 120 feet (36 m) south of the main shaft. It intersected 36 inches (91 cm) true width of lode assaying 21.3 per cent lead.

Hole 2 cut the lode at a vertical depth of 245 feet (74.6 m), but recovered no lead minerals. Its intersection with the lode is about 105 feet (32 m) north of the main shaft.

Hole 3 intersected the lode 265 feet (80.7 m) north of the main shaft at a vertical depth of 250 feet (76 m). No lead minerals were encountered.

Conclusions

Both ore shoots worked in the mine bottom above the 222-foot (67.6 m) level, but there is a small amount of good ore underfoot in the 100-foot (30.4 m) level. Other similar ore shoots could exist in the fracture zone, but any attempt to locate them would require closely spaced drill-holes.

GERALDINE COPPER MINE

The Geraldine copper mine, which has also been called the Geraldine North mine, Mitchell's Four Mile Pool mine and (wrongly) the North Geraldine lead mine, is on M.L. 222, immediately west of the highway about 1 mile (1.6 km) north of the Murchison River. Although worked in the early days of the Field, and again at the turn of the century, for copper, the mine was reopened in 1949 as a lead producer. From 1949 to 1956, the mill at the mine was used to treat ore from surrounding prospects as well as from the lease, so the production recorded from the lease, of 3,545 tons (3,602.2 tonnes) of ore with a lead content of 164.5 tons (167.13 tonnes), may be misleading.

References: Reports on the mine are found in Woodward (1895), Maitland (1903), Wilson (1926), Berliat (1954), and Low (1963).

Plans and sections of the workings are held by the Drafting Branch (Ref. 119/3 and 4).

The lode on the lease is close to a dolerite dyke, strikes at 045 degrees and dips northwest at 70 degrees. Where seen in an open cut to the east of the main shaft, it is only 3 to 4 feet (91 cm to 1.2 m) wide, but it is stated to have been 30 feet (9 m) wide at depth. Berliat reported that three lenses of galena 10 to 15 feet (3.0 to 4.5 m) long and up to 2 feet 6 inches (76 cm) wide were exposed on the 112-foot (34.1 m) level, but generally values were low and patchy. A piece of ore from the 140-foot (42.6 m) level consisted of copper glance with galena and sphalerite.

The following description of the workings is taken from plan 119/4.

Four shafts were sunk on the lode, one of which was in the position of the

present open-cut. The main shaft is 140 feet (42.6 m) deep and has levels at 30, 60, 80, and 108 feet (9.1, 18.2, 24.3, and 32.9 m), and a cross-cut to the lode at 140 feet (42.6 m). Most development was done on the 60-foot (18.2 m) and 108-foot (32.9 m) levels. On the former, drives were carried for 100 feet (30.4 m) south and 57 feet (17.3 m) north, and on the latter, for 100 feet (30.4 m) south and 48 feet (14.6 m) north. (A later report indicated a total of 174 feet (53.0 m) of driving). The lode was intersected in the shaft at 130 feet (39.6 m). The central shaft is 170 feet (52 m) northeast of the main shaft and is 113 feet (34.4 m) deep with a south drive 135 feet (41.1 m) long at the 112-foot (34.1 m) level. Most of this development was evidently done in unpayable ore, as the only stoping shown is on a short shoot near the main shaft.

LADY FLORENCE MINE

The Lady Florence mine on Location 2 is about 1.25 miles (2 km) west-southwest of the Geraldine mine from which it may be reached by a track leading from the ruins of the former manager's house. The mine was worked at the same time as the Geraldine and its ore shipped along with that of the larger mine; hence no certain production figures are available from it.

Reference: A brief report on the mine is given by Maitland (1903).

A *plan* of the surface workings is held by the Geological Survey of Western Australia (Ref. No. 10846).

The lode worked at the Lady Florence mine follows the eastern contact of a dolerite dyke for a distance of 800 feet (240 m). It strikes at between 035 and 045 degrees and dips steeply west. The principal workings on the line are situated

where the contact arches to the west. South of the workings the dolerite dyke is displaced by a northwest fault.

The workings are shallow open-cuts, surfaced stopes and inclined shafts. Maitland (1903) reported their depths to be from 60 to 80 feet (18 to 24 m). Judging from the old stopes the ore ranged from between 1 to 3 feet (30 to 90 cm) in width averaging about 2 feet (60 cm). Ore minerals seen on the dumps were galena and cerussite.

This mine deserves more attention from prospectors and mining companies.

GREAT WESTERN MINE

The Great Western mine, on former M.L. 253, is 2 miles (3.2 km) northwest of Galena, near the northwest corner of Location 33. It is best reached by following a track northwesterly from the Dingo mine for three-quarters of a mile (1.2 km) through a gate in a north-trending fence, and westerly for about 25 chains (500 m). The mine is obviously a very old one, but the only production recorded from it was in 1952, when it was reopened for a short period to yield 1.4 tons (1.42 tonnes) of lead.

Reference: Berliat (1954).

Plans: G.S.W.A. No. 10848 shows surface workings.

Two lodes have been worked on the lease, one on either side of a 130-foot (40 m) thick dolerite dyke. They strike at 035 degrees and dip between 70 and 85 degrees west. No obvious structural controls could be deduced from the surface exposures, but the mine is only about 700 feet (210 m) south of a northwest tear fault.

The principal workings are on the western (hanging wall) lode which was the one opened up in 1952. Berliat reports that it was 14 feet (4.2 m) wide, with lenses of

galena up to 2 feet 6 inches (76 cm) thick developed at the contact of the dolerite and gneiss. The general width of the ore mined, as judged from surface exposures, seems to have been 2 to 3 feet (60 to 90 cm). Workings consist of four underlay shafts sunk on the lode to depths of 30 to 40 feet (9 to 12 m) over a distance of 180 feet (55 m), and a 70-foot (21 m) deep vertical shaft sunk to the west of the outcrop of the lode near the southern end of the line. A drive was put in for a distance of 34 feet (10.3 m) south from the bottom of the shaft, and from it ore was stoped over a width of 3 feet (90 cm) and a height of 20 feet (6 m).

The eastern or footwall lode can be traced for 180 feet (55 m) in shafts and shallow pits, but most work has been concentrated on a 50-foot (15 m) length near the centre of the line. Two shafts, one 40 feet (12 m) deep, and the other 40 feet (12 m) to the north, 12 feet (3.6 m) deep, were sunk on the outcrop of the lode. There is a third shaft, now collapsed, 15 feet (4.5 m) south of the deeper shaft. Near the surface, the lode has been worked over widths of 1.5 to 2 feet (46 to 60 cm). No details of underground workings are available.

DINGO MINE (M.L. 239)

The Dingo, or Wheel Rose mine, is on M.L. 106 (later M.L. 239), about 1.5 miles (2.4 km) northwest of Galena. Access is by way of a track branching north from the Galena—Geraldine road about half a mile (0.8 km) west of the highway. The only recorded production was in 1951 when 13 tons (13.2 tonnes) of ore and concentrate containing 9 tons (9.1 tonnes) of lead were won from the mine. However the mine is an old one and earlier production was probably considerably more than this.

Reference: Wilson (1926).

Plans: G.S.W.A. 10850 is a surface plan with a long section. Wilson (1926) published a long section.

The lode which strikes at 050 degrees and dips 80 degrees west, is located on a slight curve on the eastern edge of a dolerite dyke. It has been worked over a length of 140 feet (43 m) and to a depth of about 40 feet (12 m) from three underlay shafts, and it can be traced a further 60 feet (18 m) southwest in shallow pits. The lode shear is from 2 to 3 feet (60 to 90 cm) wide, and Wilson records a vein of good ore 12 inches (30 cm) wide within it. Some stoping was done between the two northern shafts, over a distance of 40 or 50 feet (12 to 15 m).

Lode material on the dumps contains brecciated dolerite with galena and cerussite. Barite is present in the gangue. Pegmatite is common in the granulite adjacent to the lode and the ground about is strewn with crystals of microcline. It is likely that the pegmatite-rich zone has some control on the location of the ore shoot.

LADY TILLEY MINE (M.L. 44)

The Lady Tilley mine is about 2.5 miles (4 km) northwest of Galena and is reached by an old track branching from the highway at the Geraldine copper mine. There are no official production figures for the mine, although Maitland (1903) reported that 120 tons (122 tonnes) of ore were raised some time before 1899.

Reference: Brief reports on the mine were made by Maitland (1903) and Campbell (1952).

A plan of the surface workings is held by the Geological Survey of Western Australia (Ref. No. 10828).

The lode of the Lady Tilley mine strikes at 040 degrees, dips steeply west and is

parallel to a dolerite dyke cropping out 60 feet (18.2 m) to the west, but the lode itself is in gneiss.

Workings consist of two shafts (one collapsed and the other 50 feet (15 m) or more deep), at the southern end of the lode and an open cut or collapsed stope at the northern end. In the workings, the lode is 3 feet (90 cm) wide and 100 feet (30 m) long.

A sample cut over the south face of the open cut assayed 1.6 per cent lead and 0.07 per cent zinc over 38 inches (97 cm).

The lode was tested by a diamond drill-hole sited about 200 feet (60 m) northwest of the workings. No details are available but local reports indicate that the results were not encouraging.

WHEAL INA MINE (M.L. 33PP)

The Wheal Ina or Wheal Lily mine is three-quarters of a mile (1.2 km) southwest of Galena and immediately south of the surveyed stock route, which is the best access to the mine. It is an old mine that in the present century has been worked intermittently since 1920 to produce 165 tons (167.6 tonnes) of lead from 630 tons (640.0 tonnes) of ore and concentrate.

References to the mine can be found in Maitland (1903), Wilson (1926), and Campbell (1952).

A plan of the surface workings is held by the Geological Survey of Western Australia (Ref. 10858).

The lode worked in the Wheal Ina mine follows a sinuous tension fracture with an average trend of about 010 degrees and a dip of 75 to 85 degrees westerly. It can be traced for 240 feet (73 m) on the surface and ranges in width from 2.5 feet (76 cm) on straight parts of the shear to 11 feet (3.3 m) on an S-bend in an open-cut. Lode

material in the dumps and the open-cut is made up of quartz and siliceous breccia with galena, sphalerite and a trace of copper. Many of the older workings are now filled. Present openings in the lode comprise two inclined shafts, a two-compartment vertical shaft, a small ventilation shaft, and a small open-cut.

From Wilson's report it seems that 150 feet (46 m) of driving was done at the 72-foot (21.9 m) level to connect three shafts, the northernmost of which was probably situated in the present open-cut and can no longer be seen. The northern shaft was sunk to 90 feet (27 m) and at this level drives cut 50 feet (15 m) south. The lode at this level was reported to average 20 per cent lead over 36 inches (90 cm) and consist mainly of cerussite. Mr. S. Camp, who worked the mine in about 1954, reported that the lode had been stoped out to a depth of 90 to 100 feet (27 to 30 m) over a distance of 150 feet (46 m), and that little good ore remained either in the faces or underfoot.

NORTH GERALDINE LEAD MINE

(Location 4)

The North Geraldine mine is 1.5 miles (2.4 km) west of Galena and 200 yards (180 m) south of the road leading from Galena westwards along the south bank of the Murchison River. There is no vehicle track to the mine, which is best reached by following up a creek bed that cuts the road 1.3 miles (2.1 km) west of the Surprise mine. The mine was worked in the early days of the Field by the Geraldine Company, but has no recorded production.

References: A brief report on the mine was given by Maitland (1903). Woodward (1895) described a mine he called the North Geraldine, but from the location and des-

cription given it is believed that the mine referred to was in fact the Geraldine copper mine (M.L. 222).

A plan of the surface workings is held by the Geological Survey of Western Australia (Ref. No. 10852).

The ore body follows the eastern or footwall side of a dolerite dyke, strikes at 032 degrees and dips 75 to 80 degrees west. It contains galena and much quartz. Alteration of the wall rocks about the ore is marked, both granulite and dolerite being strongly kaolinized.

Underlay shafts and stopes follow the lode for a distance of 250 feet (76 m). Most are now collapsed but Maitland reported that the deepest was only 50 feet (15 m), a depth confirmed by the present size of the dumps. In the workings the ore is 2 to 3 feet (60 to 90 cm) wide.

WELCOME MINE (M.L. 202)

The Welcome mine is about half a mile (1 km) southwest of the Surprise mine at Galena from which it can be reached by an old track. The mine was worked in two periods between 1918 and 1927 to produce a total of 119 tons (120.9 tonnes) of lead from 1,260 tons (1,280.1 tonnes) of ore.

A reference to the mine can be found in Wilson (1926), page 78.

The Welcome mine is on a short shoot of ore on a link structure in a shear. The shoot strikes generally north and dips westerly at about 55 to 65 degrees, and the link shear strikes at 170 degrees and dips at 65 degrees to the west. The shoot was worked from an open-cut about 45 feet (14 m) long and mined out over a width of 12 to 15 feet (3.6 to 4.5 m). A shaft on the hanging wall side of the lode was sunk to a depth of 40 feet (12 m) and at that level about 55 feet (17 m) of driving was done on the

shoot. The wall rock of the lode is altered gneiss.

The small size of the controlling structure makes this prospect unattractive for testing at depth.

ETHEL MAUD MINE (M.C. 45)

The Ethel Maud, or Lady Shenton mine, is on M.C. 45 (old M.L. 224), 1.5 miles (2.4 km) west-southwest of Galena. It can be reached by a track branching south from the road that follows the southern side of the Murchison River, the turn-off being at a distance of about 1.25 miles (2 km) from the highway. Total production from the mine is recorded as 212 tons (215.3 tonnes) of ore and concentrates containing 68 tons (69.0 tonnes) of lead, 11 tons (11.1 tonnes) of zinc and 120 ounces (3,732.3 gm) of silver.

References: Campbell (1910).

Plan: G.S.W.A. No. 10852.

The ore body, which strikes at 060 degrees and dips northwest, was worked from two shafts 30 feet (9 m) apart, and tested by shallow pits for another 60 feet (18 m) to the northeast. A creek bed obscures the lode to the southwest. The wall rock is garnet granulite and the ore body itself, as judged from material on the dumps, is not well defined, but consists of cracked and jointed granulite with veins of sulphide minerals. Wall-rock alteration is slight and the lode structure does not appear strong. Ore minerals present on the dumps are galena and sphalerite, and there is a little barite in the gangue.

At the time of inspection, water level was almost to the collar of the shaft. Mr. S. Camp, the present owner of the mine, reported that the deepest workings were at 50 feet (15.2 m) and that the lode was widening at depth, reaching 12 feet (3.6 m) at the 50-foot (15.2 m) level.

GERALDINE SOUTH MINE (M.C. 43)

The Geraldine South mine on M.C. 43 is 1 mile (1.6 km) south of the Geraldine mine and 3.5 miles (5.6 km) southwest of Galena. It is reached by a track branching west from the surveyed stock route at a point about 3.5 miles (5.6 km) from the highway. When opened up in the early days of the Field it was reported to have produced 500 tons (508 tonnes) of high-grade concentrate within a few months. However, official production from the mine is only 8 tons (8.1 tonnes) of concentrate containing 4.7 tons (4.77 tonnes) of lead, won during attempts to reopen the mine in 1949 and 1965.

References: Woodward (1895), Maitland (1903), Wilson (1926), and Campbell (1952). In Maitland (1903), Appendix A, the mine was called the South Geraldine and wrongly placed on Location 9, some distance to the south. Campbell (1910, p. 18), published a correction of this error. As far as can be ascertained from a search of the ground, and by discussion with local residents, there is no mine on Location 9.

A *plan* of the surface workings is held by the Geological Survey Branch (Ref. 10824) and a longitudinal section of the workings by the Drafting Branch (Ref. 119/2).

The lode has been traced on the surface for a distance of 180 feet (55 m), and developed at depth for a length of 120 feet (37 m). It follows a curved fracture, probably of a tensional link type, striking at about 080 degrees and dipping at 90 degrees. The wall rock is altered gneiss, and the ore body is a siliceous breccia with galena, sphalerite, pyrite and chalcopyrite.

On plan 119/2 in the Department's collection there are shown three shafts, of which the most easterly (the main shaft) is 70 feet (21 m) deep. The middle shaft

is 80 feet (24 m) west of the main shaft and is also 70 feet (21 m) deep, but the old main shaft, a further 40 feet (12 m) west, is only 60 feet (18 m) deep. A more recent shaft 42 feet (12.8 m) deep has been sunk midway between the main shaft and the middle shaft. The old main shaft is now unrecognizable being within a collapsed stope, and the middle shaft has also collapsed into the stope, though it can be identified on the surface.

Near the surface, the ore body was 2 to 3 feet (60 to 90 cm) wide and is stated to have been of very high grade. However, S. Camp who re-entered the old workings in 1965, reported that the ore was only 4 to 5 inches (10.1 to 12.7 cm) wide at the 70-foot (21.3 m) level and that most of the ore had been stoped out above the level, that remaining underfoot being too poor to warrant mining.

There is a diamond drill collar 200 feet (60 m) on a bearing of 338 degrees from the main shaft, but no details of the hole are available. The work was probably done for Anglo Westralian Pty. Ltd. who were interested in the prospect at one time.

MINERAL CLAIM 15

The mine on Mineral Claim 15 is about 1,000 feet (300 m) south of Location 10 and 4.5 miles (7 km) west-southwest of Galena. It can be reached by following a left-hand branch from the track to Deebles mine at about a quarter of a mile (0.4 km) from Deebles. Neither the history nor the production of the mine is known, although Anglo Westralian Pty. Ltd. investigated it in 1952.

Reference: Campbell (1952).

Plan: G.S.W.A. 10853, Mines 399/2.

The lode on M.C. 15 has been traced for about 250 feet (76 m) by a line of

collapsed shafts and narrow open-cuts. Where seen in the workings, it is about 2 feet (60 cm) wide but has been mined to a width of 6 feet (1.8 m) in one place. This wider section corresponds to a flatter dip of the lode shear. Ore in the dumps is a siliceous breccia with galena and a trace of copper.

Drilling Results: Anglo Westralian Pty. Ltd. drilled two holes to test the lode. Hole 1 was collared about 80 feet (24 m) west of the old open-cut and drilled on a bearing of 085 degrees and an inclination of 65 degrees. It intersected sheared gneiss with a little galena between 168 and 176 feet (51.2 and 53.6 m). Hole 2 sited about 110 feet (34 m) north of Hole 1 and 80 feet (24 m) west of the lode, was put down on a bearing of 085 degrees and an inclination of 65 degrees to a total depth of 188 feet (57.3 m). It encountered no lode or recognizable shear.

DEEBLES MINE

Deebles (or Fox or Giles) mine is about 1,200 feet (370 m) northeast of M.L. 140, on Location 111 in the Murchison District. Access is by way of a track running along the south side of the Murchison River from Galena, with a southerly turnoff to the mine at a distance of 0.8 miles (1.2 km) past the Geraldine mine. No surveyed mineral leases or claims correspond to the position of the mine and the ground seems to have been held only as Prospecting Areas. No production records are available for this mine, although the size of the tailings dump suggests that at least several hundred tons of ore were mined and treated. A local resident reported that the mine was worked in about 1924 to 1925, and again in the early 1950s. There is no published report on the mine.

Plan: G.S.W.A. No. 10849.

Deebles lode strikes at 050 degrees and dips vertically. On the surface it can be traced in shallow workings over a distance of 340 feet (104 m), but most of the production came from a shoot 70 to 100 feet (20 to 30 m) long on a slight S-bend in the central part of the line. The lode shear cuts through a dolerite dyke which strikes at 030 degrees. The southern end of the workings is close to the western contact, and the northern end is about 80 feet (24 m) from the western edge of the dyke. The wall rocks of the ore shoot are coarse-grained dolerite, altered to chlorite and veined by siderite near the lode. There is garnet granulite on the dump of one of the shafts in the dolerite, suggesting that either the dyke contained a xenolith of country rock, or there is a cross-cut at depth to the wall of the dyke.

The principal workings on the lode comprise two inclined shafts 40 feet (12 m) apart, each leading to stopes 2 to 3 feet (60 to 90 cm) wide, and a surfaced stope 15 feet (4.5 m) long at a distance of 15 feet (4.5 m) south of the more southerly shaft. The north and south shafts are 32 and 25 feet (9.7 and 7.6 m) deep respectively.

Minerals on the dumps include galena, sphalerite, undetermined oxidized lead minerals and traces of copper carbonates.

LONG LODGE GROUP

General Information

The Long Lode group comprises two mines; one on M.L. 189 and the other on M.C. 11. Each mine has at some time been called the "Long Lode", and they seem to have been included in one lease at one time.

In order to distinguish between them, they are called here the Long Lode East and the Long Lode West mines respectively, though these names are not in general use. The total recorded production of the two

mines amounts to 13.7 tons (13.9 tonnes) of lead from 41 tons (41.6 tonnes) of ore. It is uncertain which was the producer, although the more recent work is on M.C. 11. The production recorded for P.A. 200 may have come from the Long Lode West mine.

Reference: Campbell (1952) reported on the Long Lode East mine.

Plans: G.S.W.A. 10845, Mines 399/1. *Long Lode West Mine (M.L. 182)*

The Long Lode West mine follows the east side of a 15-foot (4.5 m) thick dolerite dyke striking at 025 degrees and dipping steeply west. The ore has an average width of about 2 feet (60 cm) and has been worked over a length of 200 feet (60 m) to a maximum depth of about 30 or 40 feet (9 to 12 m).

Long Lode East Mine (M.C. 11)

The Long Lode East mine is about 1,000 feet (300 m) east-southeast of the Long Lode West and on a different shear. Two converging lodes have been worked on the claim. The principal lode strikes at 060 degrees and dips northwest at about 75 degrees while the branch lode, worked about 50 feet (15 m) to the north, strikes at 085 degrees and dips 75 degrees south. The two shears should meet at a point about 100 feet (30 m) east of the workings and the intersection should pitch westerly. Workings on the main lode consist of two shafts and two pits over a total length of about 100 feet (30 m). One of the shafts is collapsed and the other is 70 feet (21 m) deep. The branch lode was worked or tested over a length of about 35 feet (11 m) by means of a shaft from which there was a little stoping, and some pits.

Anglo Westralian Pty. Ltd. drilled one hole to test the mine. It was sited 140 feet (43 m) on a bearing of 325 degrees from the 70-foot (21 m) deep shaft and drilled

TABLE 15. PRODUCTION OF LEAD, ZINC AND SILVER FROM NABAWA DISTRICT

Mine or Group	Lease No.	Lease Name or Lessees	Period	Estimated Mine Production		Realized Production				Est. Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore or Conc. Tons	Lead Tons	Zinc Tons	Silver F. oz.		
Protheroe Group	Loc. 833....	Narra Tarra lead mine	1913-14	....	....	744·05	540·13	....	....	20,636·00	} Narra Tarra mine
	Loc. 833....	Narra Tarra Fremantle Trading Co. Ltd.	1916-26	125,685·45	....	....	11,837·14	....	....	702,854·00	
	Loc. 833....	Jupp and others (Tributors)	1927-28	....	....	846·00	129·60	....	....	4,586·00	
	Loc. 833....	Protheroe lead mine Heinsen Bros.	1946-51	11,516·00	2,789·00	2,825·94	2,193·34	2·02	24·82	375,452·20	} Silver and zinc not payable. Protheroe mine. Silver not payable.
	Loc. 833....	Protheroe lead mine Anglo Westralian Mining Pty. Ltd.	1950-58	73,990·00	14,562·00	14,661·28	11,427·95	....	292·80	2,917,606·50	
	Locs. 118 and 119	Lauder & Raven (Tributors)	1918-20	....	....	106·21	60·02	....	....	2,690·00	Narra Tarra East mine
	Loc. 119....	Heinsen Bros.	1937-43	....	....	1,950·00	181·00	....	....	4,120·00	Shepherds mine
Total Protheroe Group		....	....	211,191·00	....	....	26,369·98	2·02	317·62	4,027,944·70	
Sundry Claims....	....	Nabawa District	1900-20	....	....	238·16	34·18	....	....	884·00	

NOTE: 1 fine ounce = 31·103 grammes
1 ton = 1·01605 tonnes

towards the shaft on a bearing of 149 degrees and a depression of 65 degrees to a depth of 203 feet (61.8 m). No lode was intersected, but unless the shear dips at less than 75 degrees west the hole was not drilled far enough to intersect the channel.

NABAWA DISTRICT

The mines of the Nabawa District are in a narrow strip of gneiss exposed between sandplain to the west and the alluvium of the Chapman River to the east. They include the Protheroe and Narra Tarra mines which between them have yielded a large proportion of the lead and copper produced from the Northampton Mineral Field. All of the mines are in a single zone of shearing striking at 030 degrees and extending for at least 2.5 miles (4 km).

The production of lead and silver from individual mines in the district is given in Table 15. The group has also yielded 23,882 tons (24,264.1 tonnes) of copper ore with a content of 1,796 tons (1,824.7 tonnes) of copper metal.

Plans: Mines lease plan N-6 and the Naraling and Wokatherra 1:50,000 Geol. Sheets show the positions of the mines in the district.

PROTHEROE GROUP

General Information

The Protheroe group of lead and copper mines is 12 miles (19.3 km) south-east of Northampton and 2 miles (3.2 km) west of Nabawa Siding on Locations 118, 119 and 833. It includes the Narra Tarra and Protheroe mines, which are among the largest in the Northampton Mineral Field, and two smaller mines known as the Narra Tarra East and Shepherds.

The history of the group goes back to the period 1874 to 1880 when the Narra Tarra mine was first worked to yield lead

ore valued at \$120,000. At about the same time the Narra Tarra East mine was worked for copper. Shepherds mine was first opened in 1906 and the Protheroe in 1946 (on the site of some older shallow workings). Mineral rights belong to the owners of the land and much of the area of the group is cultivated for wheat.

References: There are many published descriptions of the mines within the group. The most detailed are those given by Montgomery (1908), Talbot (1914), Wilson (1926), Campbell (1952), and Low (1963). Kuenecke (1956) reported on the results of a geophysical survey of the group.

Plans: Mines plans 56/1 to 26 (except 56/7), 317/1 and 2, and G.S.W.A. plans Nos. 2450 and 5489 contain much information on the workings and drilling results within the group.

Geological Information

Three nearly parallel lines of lode traverse the area of the group.

The *west lode*, which includes the ore body worked on the Narra Tarra mine, can be traced on the surface for about 800 feet (240 m) and an old shaft about 1,600 feet (490 m) farther north appears to be on the same line. The lode strikes at 030 degrees and dips easterly at 70 degrees. Southwards it disappears beneath sandplain country, but to the north it is obscured only by shallow soil.

The *middle lode* is 950 feet (290 m) east of the west lode, strikes at 035 degrees and dips westerly at 70 degrees. It contains the Protheroe ore body near its northern end and the Protheroe South prospect about 2,000 feet (610 m) further south. The lode has been traced for a distance of 4,500 feet (1,370 m) by geophysical methods.

The *east lode* is about 700 feet (210 m) east of the middle lode and includes

the ore bodies worked in the Narra Tarra East mine and Shepherds mine. It strikes at 040 degrees, dips at 70 degrees westerly and for a considerable part of its length is obscured by a remnant of Jurassic sandstone capping a prominent mesa.

The wall rocks of all three lodes are garnet-gneiss and granulite with concordant bodies of pegmatite. No dolerite is associated with the west lode or the middle lode, but a band of biotite schist in the east lode has been interpreted as a sheared, metasomatized dolerite by some geologists. A dolerite dyke was mapped by Campbell (1952, pl. 2) northeast of the Protheroe mine on about the continuation of the middle lode.

Campbell (1952) reported that the principal ore bodies of the group were formed on split-shear lens structures (cymoid loops) within the lodes where the controlling shears intersected pegmatite or contorted gneiss. The main ore shoots formed in link fractures between the two parts of the split shear and the lodes generally comprised wide zones of brecciated, altered gneiss with lenses of ore minerals. In the Narra Tarra and Narra Tarra East mines, copper was mined from the southern end of the ore bodies and lead from the northern ends. Wilson (1926) stated that the boundary between the two types of ore was quite sharp and thought that the copper was later than the lead. Minerals found in the ore are galena, chalcopyrite, cerussite, pyromorphite, malachite and chalcocite. Oxidation of the lodes has taken place in depths of over 100 feet (30 m), making the Protheroe group one of the few localities in the Northampton Mineral Field where galena is not found close to the surface.

The line of faulting which controls the Protheroe mines continues northeasterly to the Cow Rock and Mendip prospects.

Narra Tarra Mine

The Narra Tarra mine has produced a reported 12,506.9 tons (12,707.01 tonnes) of lead from about 126,000 tons (128,016 tonnes) of ore, from an ore body 850 feet (259 m) long extending to a depth of 550 feet (168 m). Production is reported to have ceased because the grade of ore declined appreciably in the lower levels.

Where exposed in the open-cuts the lode is an altered breccia 20 to 30 feet (6 to 9 m) wide traversed by shear zones up to 5 feet (1.5 m) wide. The underground workings are now inaccessible, but the fresh lode was described by Talbot (1914) as: "simply a highly-sheared zone of the gneissic granite which forms the country rock in which lenses of lead ore, of varying width, have been deposited". He also states: "One lens of ore on the 250-foot (76.2 m) level was reported to be 400 feet (120 m) long and 3 feet (90 cm) wide, consisting of massive galena".

Early work on the ore body was carried out from several open-cuts and from a shaft sunk on the outcrop of the lode for 20 feet (6 m) on the underlay and then vertically on the footwall side of the ore body to 165 feet (50.2 m). Levels were driven at depths of 45, 105 and 165 feet (13.7, 32.0 and 50.2 m). When the mine was reopened in 1913, the owners sank a new main shaft 142 feet (43.2 m) east of the older shaft, with levels at depths of 250, 350, 450 and 550 feet (76.2, 106.6, 137.1 and 167.6 m). The better grade ore pitched southwards and the 550-foot (167.6 m) level was driven 300 feet (90 m) southwards before entering payable ore, although some lower grade material was evidently mined between the shaft and the ore shoot. The existing long section of the mine shows that most of the ore between the 165 and

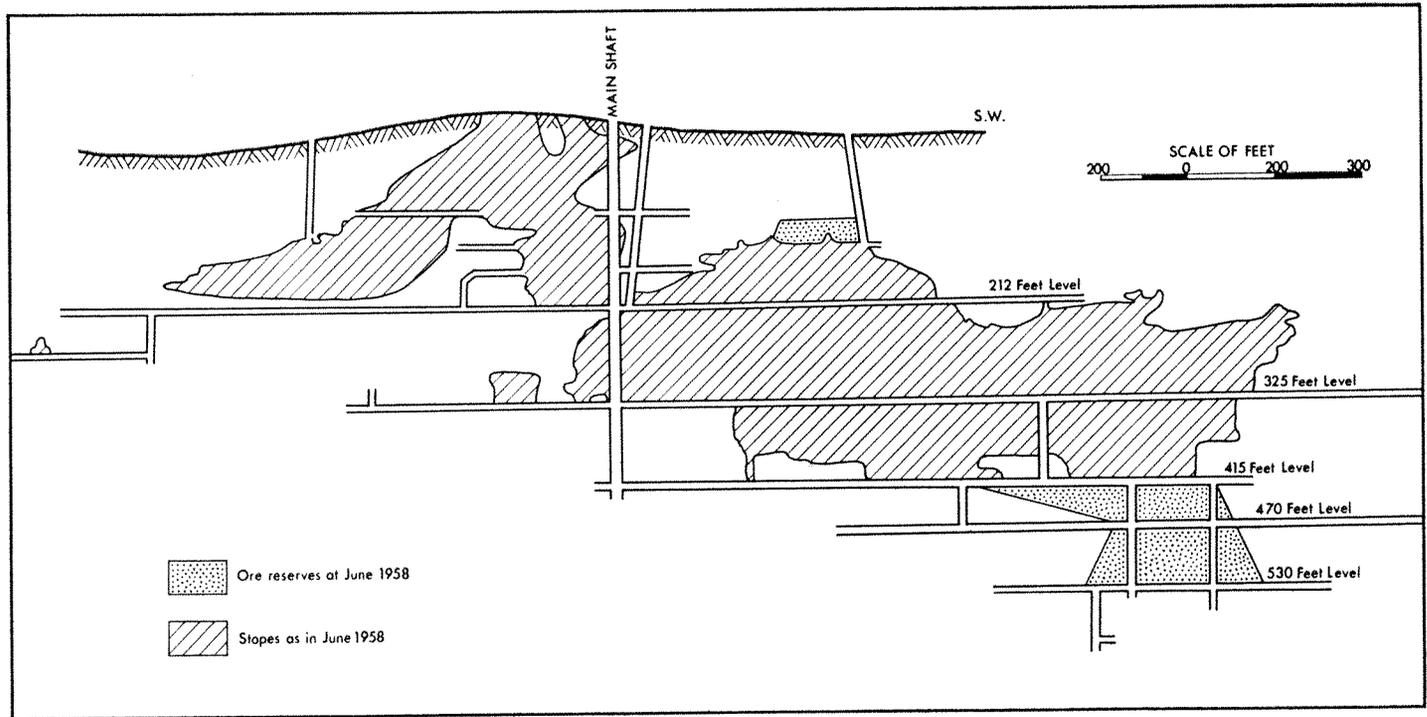


Fig.2: Longitudinal projection of the Protheroe lead mine. Owing to its insignificant outcrop, this orebody was ignored for many years. When finally developed it became one of the largest lead producers in the Northampton Mineral Field

550-foot (50.2 and 167.6 m) levels was mined out over a length of 850 feet (259 m) from 250 feet (76 m) north to 600 feet (180 m) south of the main shaft. At a distance of 400 feet (120 m) south of the main shaft on all four levels the lead ore gave way to copper ore. Plan 317/2 dated 1926 shows a considerable amount of unmined lode above the 165-foot (50.2 m) level, but it is known that tributors worked the mine in 1927 to 1928 and it is likely that their work is not shown. From the results of development work reported by Montgomery (1908) this part of the mine does not seem promising.

Campbell (1952) analyzed the ore controls in the Narra Tarra mine and concluded that the link structure which carried the better ore died out at the 550-foot (167.6 m) level. He pointed out that it is theoretically possible for new links to develop at greater depths, but the positions of these could not be predicted accurately.

Protheroe Mine

Between 1946 and 1958, the Protheroe mine yielded 85,500 tons (86,868 tonnes) of ore containing 13,621 tons (13,838.9 tonnes) of lead from an ore body which was barely exposed at the surface. The main ore shoot was not met until development had reached a vertical depth of 100 feet (30 m) (see Fig. 2).

Early work on the mine was done from an open-cut (or surfaced stope) about 50 feet (15 m) long and from an inclined shaft sunk on the lode with levels at 108, 170 and 212 feet (32.9, 51.8 and 64.6 m). Later a vertical shaft was sunk 170 feet (51.8 m) west of the outcrop of the lode and connected to the 170 and 212-foot levels (51.8 and 64.6 m), while a new level was established at 325 feet (99.0 m). A level at 425 feet (129.5 m) was driven from an

internal shaft put down 500 feet (152.4 m) south of the main shaft on the 325-foot (99.0 m) level. The ore body was 500 feet (150 m) long on the 212-foot (64.6 m) level, 780 feet (238 m) on the 325-foot (99.0 m) level and 250 feet (76 m) on the 425-foot (129.5 m) level. It bottomed at about 550 feet (168 m).

The principal ore shoot was in a link fracture between the two halves of a cymoid loop structure, but ore was also mined from the bounding shears and the main shear outside the split section was mined near the surface. Between the 212 and 325-foot (64.6 and 99.0 m) levels, the main ore shoot was stoped over a length of 700 feet (210 m). The widths of the mineralized zones within the lode varied from 3 to 5 feet (90 cm to 1.5 m). The ore body had a southerly pitch which could not be explained by the known structural controls. It bottomed where the link shear died out at depth although the cymoid loop structure was still present.

Several diamond drillholes were put down to test the ore body of the Protheroe mine; all known details are given in Table 16.

Holes 1 and 2 cut the lode at distances of 900 feet (270 m) south and 150 feet (46 m) north of the main shaft at vertical depths of 590 and 560 feet (179.8 and 170.6 m) respectively. Each encountered a single, unmineralized shear indicating that the cymoid loop structure did not persist to these positions. Hole 25 intersected the lode 700 feet (210 m) south of the main shaft at a vertical depth of about 620 feet (189 m). It cut both branches of the cymoid loop, showing that the structure was still open at that position, but revealed only a little galena on the hanging wall shear and did not locate a favourable link structure.

The only holes to cut significant lead values were Nos. 7, 9 and 28.

Narra Tarra East Mine

(Location 119)

The Narra Tarra East mine, which has also been called the Narra Tarra copper mine, is on the east lode about 2,100 feet (640 m) south-southeast of the Narra Tarra mine. It was worked for copper in the early days of the Field, but the only production definitely attributed to it is 106 tons (107.6 tonnes) of ore containing 60 tons (60.9 tonnes) of lead mined on tribute by Lauder and Raven in 1918 to 1920.

The lode is a zone of schist and breccia 12 feet (3.6 m) wide from which lead and copper were mined from veins 2 to 3 feet (60 to 90 cm) wide on the walls. The early workings were on the hanging wall side of the lode and reached depths of 50 or 60 feet (15 or 18 m). In about 1926 a shaft was sunk 85 feet (25.9 m) out on the west side of the lode to 109 feet (33.2 m) and a level put in at 102 feet (31.0 m) from a cross-cut 45 feet (13.7 m) long. The north drive of the level was 320 feet (97.5 m) long and is said to have been in low-grade ore for all of that distance. The face at 320 feet (97.5 m) was estimated to contain 6 per cent lead. At a position 46 feet (14.0 m) north of the cross-cut, a winze was sunk 41 feet (12.4 m) in the hanging wall of the lode on a vein of galena 12 inches (30 cm) wide. About 250 feet (76 m) north of the cross-cut an overhead stope was started just south of Lauder and Raven's workings on the surface. The south drive of the level was 208 feet (63.3 m) long and was in low-grade material for the first 150 feet (45.7 m), but thereafter the metal content increased and the section was mined to the end of the drive, the width of the ore being 3 feet (90 cm).

Anglo Westralian Pty. Ltd. reopened the mine in about 1950 and sank a new shaft to a depth of 250 feet (76 m) from a site 135 feet (41.1 m) northeast of the old shaft and 60 feet (18.2 m) out on the hanging wall side of the lode. A cross-cut to the lode at the 102-foot (31.0 m) level encountered collapsed stopes. The shaft passed through the lode at a depth of about 175 feet (53 m) and at the 238-foot (72.5 m) level the lode was intersected in a cross-cut driven westerly from the shaft. A drive on the lode at this level extended for 85 feet (25.9 m) northeast and 100 feet (30.4 m) southwest of the shaft.

Much of the lode exposed in the drive was of poor grade. One shoot 20 feet (6 m) long, centred 20 feet (6 m) southwest of the shaft averaged 5.7 per cent lead over 48 inches (122 cm) and one sample 75 feet (22.8 m) southwest of the shaft assayed 15 per cent lead over 36 inches (91 cm).

Thirty feet (9 m) northeast of the shaft a total width of 12 feet (3.6 m) of low-grade lode was exposed in the drive and a short easterly cross-cut. A 4-inch (10.1 cm) seam of galena, 65 feet (19.8 m) northeast of the shaft, assayed 30.6 per cent lead.

Three diamond drillholes, Nos. 3, 9 and 22 were put down to test the lode at depth. The positions and results of the holes are given in Table 16 below. Only hole 3 returned encouraging results.

Shepherds Mine

Shepherds lead mine is also on the east lode and about 1,800 feet (550 m) northeast of the Narra Tarra East mine. It is on the southern slope of a saddle separating two mesas of Jurassic sandstone. The first known production from the mine was in 1906 when 191 tons (194.0 tonnes) of ore

TABLE 16. RESULTS OF DIAMOND DRILLING AT PROTHEROE GROUP

Hole No.	Coords. Collar		Azi-muth	Dep.	Final Depth Feet	Intersection		Results	Remarks
	North	East				Hole Depth Feet	Vert. Depth Feet		
1	4710	3360	124°	....	....	....	580	Shear barren	Intersection was 900' south of Protheroe main shaft
2	5580	3960	125°	....	....	....	560	Shear barren	Intersection was 150' north of Protheroe main shaft
3	2500	2900	135°	55°	290	250	210	14·1% lead over 36" true width	Intersection was 150' north of Narra Tarra East main shaft
5	5800	4550	125°	....	....	....	....	Not available	Intersection was about 620' north of Protheroe main shaft
6	4100	3220	124°	....	....	....	170	Some lead	Intersection was 1,400' south of Protheroe main shaft
7	4100	3220	124°	....	....	....	250	32·3% lead over 15"	Intersection was 1,400' south of Protheroe main shaft
8	....	....	....	....	....	....	300	Strong shear	Intersection was 1,700' south of Protheroe main shaft
9	....	....	....	....	....	....	290	3·6% lead over 90"	Intersection was 220' south of Narra Tarra East main shaft
10	5580	3750	124°	....	....	....	650	Nil	Intersection was 300' south of Protheroe main shaft
13	4330	3300	124°	....	....	....	310	7% lead sulphide	Intersection was 1,250' south of Protheroe main shaft
14	4420	3350	124°	....	....	....	350	15% lead over 1·5"	Intersection was 900' south of Protheroe main shaft
15	4430	2970	125°	....	....	....	630	Shearing	Intersection was 1,400' south of Protheroe main shaft
22	....	....	....	....	....	....	210	No value	Intersection was 270' north of Narra Tarra East shaft
24	6220	3590	300°	45°	90	82	65	Lode channel	Intersection was of east lode 2,000' north of Narra Tarra mine
25	4977	3311	124°	60°	....	867	760	H.W. shear, little galena	Intersection was 700' south of Protheroe main shaft
26	7051	5285	125°	65°	343	262	235	Sheared with no lead	Intersection was 2,150' north of Protheroe main shaft
27	6961	5142	125°	65°	526	327	295	Sheared country	Intersection was 1,950' north of Protheroe main shaft
27A	6961	5142	125°	65°	526	432	390	Specks of galena over 1'	
28	6080	4580	125°	70°	....	....	250	7·5% lead over 30"	Intersections were 900' north of Protheroe main shaft
28	6080	4580	125°	70°	....	....	400	19·2% lead over 23"	
29	6220	4640	124°	....	....	....	....	No intersection?	Hole drilled was 1,050' north of Protheroe main shaft

NOTE: 1 inch = 2·54 centimetres
1 foot = 0·3048 metres

containing 60 tons (60.9 tonnes) of lead were reported by Wilson (1926), but it is not in the official statistics. The Heinsen Brothers worked the deposit between 1937 and 1943 and took out 1,950 tons (1,981.2 tonnes) of ore averaging 11.8 per cent lead.

The lode is a 12-foot (3.6 m) wide zone of biotite schist and breccia dipping westwards, with ore chiefly on its footwall side. It was worked to a depth of 60 feet (18 m) from a shaft sunk near its outcrop, with levels driven southwards under the hill at 20 and 57 feet (6.0 and 17.3 m). The 20-foot (6.0 m) level was put in for 200 feet (61 m) and the 57-foot level for 120 feet (36 m). Above the 20-foot (6.0 m) level the ore body was stoped over a length of 170 feet (52 m), the stopes reaching the surface in places. Between the two levels the ore was mined over a length of 100 feet (30 m) only.

In 1952, Anglo Westralian Pty. Ltd. sank a new shaft 55 feet (16.7 m) west of

the lode and put in a level at 120 feet (36.5 m). From 30 to 108 feet (9.1 to 32.9 m) south of the shaft the lode averaged 10.8 per cent lead over a width of 60 inches (152 cm) and from 108 feet (32.9 m) to the end of the drive at 153 feet (46.6 m) it averaged 3.4 per cent lead over the same width. This development indicated about 2,000 tons (2,030 tonnes) of ore averaging 10 to 11 per cent lead which, as far as is known to the writer, have not been mined.

Protheroe South Prospect

About 2,600 feet (790 m) south of the Protheroe mine on the middle lode are some workings known as the Protheroe South prospect.

Development carried out on the prospect by Anglo Westralian Pty. Ltd. consisted of an inclined shaft 190 feet (58 m) deep with a level at 183 feet (55.7 m) driven 125 feet (38 m) northeast and 150

TABLE 17. ELECTROMAGNETIC INDICATIONS IN PROTHEROE AREA

Traverse	Position of Indication	Strength of Indication	Remarks
00	625W	Strong	On middle lode
1000S	560W	Medium	On middle lode
1200S	550W	Medium	On middle lode
2000S	500W	Medium	On middle lode near old shaft
2000S	950W	Medium	Previously unknown shear
2200S	550W	Weak	On middle lode near old shaft
2400S	550W	Medium	Middle lode
2600S	25W	Medium	Narra Tarra East mine
2600S	550W	Medium	Middle lode
2800S	110W	Medium	Near east lode
2990S	200W	Medium	Between east lode and middle lode
3400S	150W	Medium	? East lode
3600S	225W	Medium	? East lode
1125N	470W	Medium	Middle lode

feet (46 m) southwest of the shaft. Twenty feet (6 m) north of the shaft a cross-cut was made 45 feet (13.7 m) westwards, and a hole was drilled at an inclination of 32 degrees for a further 130 feet (40 m). The only mining done on the lode seems to have been from a stope 35 feet (10.6 m) long and 15 feet (4.5 m) high, 100 feet (30 m) south of the shaft, on ore containing 10 per cent lead.

Diamond Drilling

Anglo Westralian Pty. Ltd. drilled about 30 holes in the area of the Protheroe Group and the Department has records of 19 of these. The results of some have already been mentioned in the descriptions of the mines concerned and all known details are given in Table 16. The origin of the co-ordinates used is the southwest corner of Location 118, and north is true. The grid is reproduced on Plate 2 of Kuenecke (1956).

Geophysical Investigations

In 1953 the Bureau of Mineral Resources carried out a geophysical survey in the Protheroe area using an electromagnetic induction method together with some trial magnetic traverses. The electromagnetic methods successfully located the shear zones while the magnetic traverses picked up dolerite dykes. Table 17 lists the locations of the stronger anomalies found in the electromagnetic survey. The base line of the traverses was oriented at 034 degrees and the zero reference point was at mine co-ordinate 4480N and 4410E, about 850 feet (259 m) on a bearing of 160 degrees from the Protheroe main shaft.

COW ROCK PROSPECT (M.L. 52PP)

Although the Cow Rock, or Brown Cow, or Old Cow Rock prospect has no

recorded production of lead, its position on the northerly extension of the Protheroe group makes it of some interest. It is located about 3,500 feet (1,070 m) south-southwest of the Mendip mine and to the south of the Nabawa-Protheroe road.

References: Maitland (1903), Montgomery (1908), Wilson (1926), and Campbell (1952).

Plan: G.S.W.A. No. 10861 shows the surface workings and the outcrop of the lode.

At the Cow Rock prospect a strong shear zone expressed by breccia and caprock can be traced for over 1,200 feet (370 m). The shearing is complex with many branches and link structures developed along the length of the outcrop. Several shafts have been sunk on showings of lead, zinc and copper, but economic minerals are generally scarce. The two main groups of workings are about 600 feet (180 m) apart. Of these the more northerly is close to Cow Rock (a bold outcrop of ferruginous breccia) and follows the lode for about 300 feet (90 m). On the dump of a 60-foot (18 m) shaft at the north face of the rock there is lode matter comprising siliceous breccia with 5 to 10 per cent galena.

The southern workings are in a cultivated paddock and consist of two shafts and a small stope. Galena and sphalerite are present on the dumps.

In 1901 the Mines Department put down a drillhole on the lease, the results of which are recorded by Maitland (1903) and Wilson (1926). The hole was sited a few chains north of Cow Rock, but its exact position is now uncertain. It was drilled to a depth of 600 feet (180 m) on a bearing of 284 degrees and cut the target lode between 82 and 91 feet (24.9 and 27.7 m), encountering a little copper at 83 and 90 feet (25.2

and 27.4 m), and a stringer with galena and sphalerite at 239 feet (72.8 m), but results were disappointing. In the light of more recent knowledge of the habit of ore bodies in the Field it seems that the hole was sited too far north and too close to the lode to test effectively the mineralization exposed in the shaft at Cow Rock.

The shear structures at Cow Rock are strong, but on the surface they are too flatly dipping to be favourable for ore. If they steepen at depth, a condition difficult to predict, ore shoots may be present. The prospect seems a good one to test by geophysical methods.

MENDIP MINE (M.L.s 53PP and 54PP)

The Mendip mine is 1.5 miles (2.4 km) northwest of Nabawa and immediately north of the Nabawa-Protheroe road. No production has been recorded from the mine, although several shafts have been sunk on the lode. The mine is on the same line of shearing as the Protheroe group and for this reason has been of interest to mining companies.

References to the mine are Montgomery (1907), Wilson (1926) and Campbell (1952).

A *plan* of the surface workings and sections of the underground workings are given in Campbell (1952), and Mines plan 56/7.

On the Mendip leases two lodes have been worked within a zone of shearing and brecciation striking at 030 degrees. The northern lode has been tested by two shafts about 60 feet (18.2 m) apart. The southernmost of these was sunk on a small ore body developed on a tensional link fracture. It is 70 feet (21.3 m) deep with levels at 31 feet (9.4 m) for 44 feet (13.4 m) south, and at 70 feet (21.3 m) for a total of 94 feet (28.6 m) north and south. Small

patches of galena and cerussite were encountered at each level in a lode ranging between 1 and 4 feet (30 cm to 1.2 m) in thickness.

The northern shaft on this lode was sunk vertically to connect with the 70-foot (21.3 m) level and then continued as an inclined shaft to about 193 feet (58.8 m) vertical depth. A level at 183 feet (55.7 m) extends for 100 feet (30 m) north and 120 feet (37 m) south of the shaft. Cross-cuts were put out from the drive at 90 feet (27 m) north and 80 feet (24 m) south of the shaft. The northern cross-cut was driven 30 feet (9 m) westerly, while the southern cross-cut extends for 30 feet (9 m) east and 15 feet (4.5 m) west of the drive. An unspecified length of the lode between the shaft and the south cross-cut contains traces of lead and 5 per cent zinc. The dump of the shaft contains sphalerite and a little galena, cerussite and pyrite.

The southern lode is 850 feet (259 m) south-southwest of the first. Two underlay shafts 90 feet (27 m) apart were sunk on it, the north shaft to 50 feet (15.2 m) and the other to 30 feet (9.1 m). In the shafts the lode is about 1 foot (30 cm) wide and dips steeply west. Sphalerite and pyromorphite were noted on the dumps.

Two drillholes were put down by Anglo Westralian Pty. Ltd. on the northern lode.

Hole 1 was collared 310 feet (94 m) on a bearing of 300 degrees from the 70-foot (21.3 m) shaft and drilled on a bearing of 120 degrees and a depression of 65 degrees. It intersected broken pegmatite with pyrite at 366 to 386 feet (111.5 to 117.6 m) at a vertical depth of about 340 feet (104 m).

Hole 2 drilled from a point 355 feet (108.2 m) on a bearing of 272 degrees from the 70-foot (21.3 m) shaft, intersected altered gneiss with abundant pyrite, but no

TABLE 18. PRODUCTION FROM MISCELLANEOUS MINES IN NORTHAMPTON
MINERAL FIELD

Mine or Group	Lease No.	Lease Name or Lessees	Period	Estimated Mine Production		Realized Production				Est. Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore or Conc. Tons	Lead Tons	Zinc Tons	Silver F. oz.		
Saxon	Loc. 470	Camp and Party	1954-55	866.00	134.73	126.17	78.32	....	15.68	14,064.76	Silver valued at \$12.70
Oakabella	PA 71PP....	Elphick & Monk	1953	25.00	2.83	2.78	2.22	....	1.08	327.66	Silver not payable
Oakajee	Loc. 311	Oakajee	1955-56	159.50	18.70	17.68	13.07	....	....	3,048.94	
Lady Samson	ML 27PP LTT 1125H	Lady Samson	1926	....	....	45.00	7.25	....	....	264.00	
		Shanks E.	1949	....	....	8.79	6.15	....	....	832.10	
Total Lady Samson		....	....	....	....	53.79	13.40	....	....	1,096.10	

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

lead, between 465 and 493 feet (141.7 and 150.2 m), corresponding to a vertical depth of about 440 feet (134.1 m). A thin dolerite dyke was intersected in the foot-wall of the lode channel.

OTHER DEPOSITS

A few scattered lead deposits which do not fall into any readily definable groups have been worked in the southern part of the Northampton Mineral Field. The Gelirah, Oakajee, Saxon and White Peak mines are close to the old railway connecting Northampton and Geraldton, while the Lady Samson mine is in the extreme south-eastern corner of the Northampton Mineral Field.

SAXON MINE (Location 470)

The Saxon, or Grey's mine is 1 mile (1.6 km) north-northeast of the former railway siding of White Peak. It is on private property and can be reached by way of farm tracks. It was worked in 1866 and a considerable quantity of ore is said to have been raised. When reopened in 1954, a further 742 tons (753.8 tonnes) of ore containing 78 tons (79.2 tonnes) of lead were mined. One of the operators of that time reported that about 300 tons (305 tonnes) of this ore was cerussite which had been used to fill the old stopes.

References: Woodward (1907b) and Wilson (1926).

The lode of the Saxon mine follows the sheared eastern side of a band of feldspathic quartzite. Ore was confined to a part about 70 feet (21 m) long which has a steeper than average dip to the west. In an open cut at the north end of the ore body the lode thins from 5 to 2 feet (1.5 m to 60 cm) where the dip flattens from 75 to 60 degrees west. A similar relationship between

the dip and width of the lode probably exists at the southern end, but exposure is not sufficiently good to be certain of this. The lode consists of crushed quartzite with galena, cerussite, sphalerite and copper carbonate.

Mining was carried out from two underlay shafts and an open cut extending for about 70 feet (21 m) along the outcrop of the ore body and to depths of up to 40 feet (12 m). A vertical shaft 43 feet (13.1 m) deep was sunk to the west of the lode and 30 feet (9 m) north of the other openings.

OAKAJEE MINE (Location 311)

The Oakajee mine is 14 miles (22.5 km) south of Northampton and about three-quarters of a mile (1 km) north-northeast of the old Oakajee rail siding. It is alongside a road joining Oakajee siding to the Nanson-Nabawa road and is on Imperial Grant property. The mine is reported to have produced several hundred tons of ore prior to 1870, but the only production officially recorded was in 1955 to 1956 when 13 tons (13.2 tonnes) of lead were produced from 160 tons (162.5 tonnes) of ore.

References to the Oakajee mine are Maitland (1903) and Wilson (1926).

No plans of the leases are available.

The lode strikes at 30 degrees and dips westerly. It is made up of siliceous breccia and gneiss impregnated with galena and a considerable quantity of pyrite. Wall-rock alteration is slight and fresh garnets were seen in contact with pyrite. Maitland states that the lode channel is not well defined, but this cannot be confirmed from the present exposures.

The mine was originally worked over a length of 105 feet (32 m) from two shafts each about 40 feet (12 m) deep. The southernmost shaft is now collapsed and

the more recent work was done from the northern shaft which is 45 feet (13.7 m) deep.

The lack of a strongly defined ore channel and the absence of wall-rock alteration suggest that the ore is not likely to continue in depth.

GELIRAH COPPER MINE (Location 3287)

Although chiefly a copper producer, the Gelirah mine contains some lead and can be considered as a lead prospect. The mine is 12 miles (19.3 km) north of Geraldton and about half a mile (0.8 km) east of the old railway track.

References to the mine are Maitland (1903), Wilson (1926), and Low (1963).

Two echelon lodes have been worked on the property. The west lode strikes at 043 degrees, dips steeply west and averages about 18 inches (46 cm) wide in the 180-foot (55 m) length exposed in the workings. It contains galena, sphalerite, malachite, azurite and chalcocite. The wall rocks are gneiss and granulite. In one cut, two parallel shears are exposed east of the lode, but these have little mineral content.

The east lode is 1,000 feet (300 m) northeast of the first. It has a parallel strike but dips less steeply to the west. In the 240-foot (73 m) length exposed in the workings, it varies from 2 to 6 feet (60 cm to 1.8 m) in width. Maitland records that the mine was worked from shafts varying from 40 to 120 feet (12 to 36 m) deep, but the deepest present opening is about 35 feet (10.6 m). There has been some recent work near the surface, apparently for copper ore.

Two samples cut from the east lode returned the following results: No. 7780 from the eastern side of the lode assayed 0.42 per cent lead, 0.26 per cent zinc and

11.5 per cent copper over 3 feet (90 cm); No. 7781 from the western side of the lode in the same section as 7780 assayed 0.17 per cent lead, 0.35 per cent zinc and 1.81 per cent copper over 3 feet (91 cm) width.

LADY SAMSON MINE (M.L. 27PP)

The Lady Samson mine in the extreme southeastern corner of the Northampton Mineral Field is about 6 miles (10 km) north of the rail siding of Northern Gully from which it can be reached by following the Northern Gully road. The mine is about 100 yards (90 m) west of this road in a cultivated paddock. It is evidently an old mine, reopened in 1926 and again in 1949 to produce a total of 13.4 tons (13.61 tonnes) of lead from 53.8 tons (54.66 tonnes) of ore.

Reference and plan: Wilson (1926) reported on the mine and also gave a plan and longitudinal section of the workings.

The lode is a siliceous breccia zone in gneiss striking at 335 degrees and dipping steeply east and it reaches widths of 8 feet (2.4 m) where exposed in a cross-cut from the main shaft. The wall rocks of the lode are much altered to chlorite. The main shaft has a depth of 100 feet (30.4 m) at which level drives were put in for 30 feet (9 m) north and 90 feet (27 m) south. Stopping was carried out between the main shaft and a pass 50 feet (15 m) to the south.

On the 100-foot (30.4 m) level the lode in the south drive is reported to have averaged 15 per cent lead over the width of the drive (Wilson, 1926, p. 79), and that in the north drive 4 to 6 per cent lead over the same width. The full width of the lode was not exposed in these drives. The other two shafts still discernible on the surface are 80 and 170 feet (24 and 52 m) re-

spectively south of the main shaft. Good ore was reported from the first of these but in the second the lode was poor. There are also two filled shafts: one 30 feet (9 m) north of the main shaft was 30 feet (9 m)

deep and was reported to be in ore; the second filled shaft 150 feet (46 m) north of the main shaft was about 20 feet (6 m) deep and contained some lead carbonates in a poorly defined lode.

Kimberley and West Kimberley Goldfields

SUMMARY

In the Kimberley and West Kimberley Goldfields, deposits of silver, lead and zinc have been recorded from rocks of Lower Proterozoic, Middle Proterozoic and Devonian ages. All of the deposits are in or adjacent to the belt of igneous and metamorphic rocks which flanks the southern margins of the Kimberley Block. Most of the occurrences in Lower Proterozoic rocks are closely related to major faults. Deposits in Middle Proterozoic rocks are confined to dolerite sills within the sediments and appear to be magmatic segregations or tension gash fillings. The two deposits worked in Devonian rocks are of the Mississippi Valley type and have yielded most of the silver-lead and all of the zinc won from the Kimberley Division.

At the time of writing, stratiform copper-lead-zinc deposits are being investigated in the Ilmars—Little Mount Isa area north of Halls Creek.

To the end of 1968 the recorded production of lead, zinc and associated silver from the Kimberley Division was 10,859 tons (11,032.7 tonnes) of ore yielding 2,082 tons (2,115.3 tonnes) of lead, 2,822 tons (2,867.1 tonnes) of zinc and 37,373 ounces (1,162,416.4 gm) of silver. Details of this production are set out in Tables 19 and 20.

WEST KIMBERLEY GOLDFIELD

NARLARLA MINE

(Lat. 17° 16' S, long. 124° 43' E).

General Information

The Narlarla silver-lead-zinc mine, known also as the Devonian lead mine or the Barker Gorge deposit, is in the Napier Range about 2 miles (3 km) by road southeasterly from Napier Downs homestead and about 85 miles (137 km) by road from Derby. It was the largest base metal mine in the Kimberley Division and the largest producer of zinc in Western Australia. It is also the State's best known example of a lead-zinc deposit of the Mississippi Valley type.

The deposits were first pegged in 1901, and again in 1908, but because of the remote locality were not worked until taken up by Devonian Pty. Ltd. in 1948. From 1948 until work ceased in 1966 the mine produced 2,082.06 tons (2,115.37 tonnes) of lead, 2,821.72 tons (2,866.87 tonnes) of zinc and 37,373.13 ounces (1,162,416.46 gm) of silver from 10,859.35 tons (11,033.09 tonnes) of ore from two ore bodies.

Early work was concentrated on the oxidized ores in the gossans of the deposits, but in 1964, with the advent of a process for treating mixed lead-zinc ores, open-cast mining of the sulphide ore of the No. 2 deposit was started. The mine was dormant

TABLE 19. ANNUAL PRODUCTION OF LEAD AND ZINC FROM KIMBERLEY AND WEST KIMBERLEY GOLDFIELDS

Year	Ore and Conc. Tons	Lead Tons	Zinc Tons	Value \$Aust.
1948	717·53	278·41	150·93	27,196·26
1949	35·84	21·29	....	4,234·10
1950	7·83	3·48	0·86	410·90
1951	49·03	22·07	6·95	5,135·50
1952	319·20	134·79	46·01	30,215·46
1953	444·61	184·17	63·77	16,258·18
1954	279·26	93·03	73·05	5,202·44
1964	3,354·17	619·50	825·08	185,236·10
1965	3,624·04	486·56	1,010·16	183,382·80
1966	2,037·00	245·00	644·11	15,956·00
Total	10,868·61	2,088·30	2,821·72	473,237·86

NOTE: 1 ton = 1·01605 tonnes

between 1954 and 1963, and is idle at present.

References: Woodward (1907a), Simpson and Gibson (1907), Finucane and Jones (1939), Low (1963), Hutton (1965) and Halligan (1965), described the ore bodies. Prider (1941) and Simpson (1951) gave additional information on the mineralogy of the deposits. The regional geological setting was described by Playford and Lowry (1966).

Plans: Mines 180/1-5, G.S.W.A. No. 8652. There are plans and sections in the reports by Finucane and Jones, Halligan, and Hutton. The location of the mine is shown on the Lennard River 4-mile geological sheet.

In 1968 the mine was abandoned and the workings filled with water. The following description is based on the reports referred to above and on information supplied by mining companies.

Geological Information

The Narlarla silver-lead-zinc deposits are in the fore-reef facies of an Upper

Devonian reef complex forming part of the Napier Formation on the northern edge of the Canning Basin. The host rock is limestone which, near the deposits, rests directly upon Precambrian metamorphic rocks of the Halls Creek Group.

The limestone comprises generally well-bedded calcarenite and calcirudite with some thin beds of greenish siltstone. Hutton (1965) noted the occurrence of stromatolitic limestones beneath the ore bodies. On the lease the limestone beds dip at 20 to 30 degrees west and form a gentle anticline with an axis plunging southwesterly. From considerations of the regional geology it is believed that both the dips and the flexure are depositional in origin.

Both Hutton and Halligan record the existence of small faults within the No. 2 ore body and note that at least some of the movement on them is post ore emplacement. The faults have movements of only a few feet and do not penetrate far into the country rock beyond the limits of the ore. In the walls of the open-cut above present water level, they are narrow, irregular

TABLE 20. PRODUCTION OF LEAD, ZINC AND ASSOCIATED SILVER FROM
KIMBERLEY AND WEST KIMBERLEY GOLDFIELDS

Mine or Group	Lease No.	Lease Name or Lessees	Period	Est. Mine Production		Realized Production				Est. Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore or Conc. Tons	Lead Tons	Zinc Tons	Silver F. oz.		
Mount Amherst (Kimberley)	PA 135	Black and Gliddon....	1948-49	....	....	6.53	4.51	....	18.54	715.64	} Same Ground
	Crown Land	.... ..	1952	....	....	2.73	1.73	....	15.08	589.26	
Total, Mount Amherst ....		.... ..	....	....	....	9.26	6.24	....	33.62	1,295.22	
Narlarla (West Kimberley)	MC 29	Devonian Pty. Ltd.	1948-66	....	....	10,859.35	2,082.06	2,821.72	37,373.13	505,745.50	

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

breaks, resembling joints and are completely devoid of ore minerals.

Description of ore bodies

The two ore bodies worked on the Narlarla lease lie about 1,600 feet (490 m) apart in different stratigraphic positions within the limestone. The smaller, more northerly deposit is called the No. 1 ore body, while the southern deposit is referred to as the No. 2 ore body.

The *No. 1 ore body* has been worked out. It consisted of a low hill of gossan containing cerussite and hydrozincite with minor galena, sphalerite, malachite and azurite. Several layers or lenses of chamosite were present in the ore. The deposit measured about 100 feet (30 m) long, 35 feet (11 m) wide and varied in thickness from 5 to 7 feet (1.5 to 2.1 m). Beneath the gossan was a vein of sulphide varying from a few inches to 2 or 3 feet (60 to 90 cm) in width striking 110 to 140 degrees and dipping about 15 degrees southwest. It has been exposed in a trench about 60 feet (18 m) long.

In a pit at the western end of the trench, the vein pinches out, but another appears a few feet above it and seems to be worth following down dip. The footwall of the vein is a layer of slickensided chamosite, suggesting that the vein follows a shear. Hutton recorded that an ore shoot within the vein plunged at 17 degrees westerly. A tail of secondary ore forms an off-shoot from the southwestern corner of the gossan for about 75 feet (23 m) in a southwesterly direction. This ore has probably formed within a bed of country rock mineralized by supergene processes.

Finucane and Jones estimated that the No. 1 ore body contained about 1,130 tons (1,148 tonnes) of ore averaging 38.67 per cent lead, 5.71 ounces of silver per ton

(177.59 gm per tonne) and 0.58 per cent copper.

The *No. 2 ore body* cropped out as a low hill of gossan measuring about 110 feet (34 m) in length, 60 feet (18 m) in width and about 18 feet (5 m) in thickness. It dipped at about 25 degrees westerly. Beneath the gossan were irregular shoots of ore plunging at 17 degrees in a direction of 280 degrees.

The deposit was originally worked from a shaft but was later mined from an open-cut 150 feet (46 m) long and up to 100 feet (30 m) wide.

The gossan consisted of manganese-stained, cellular and massive iron oxides with irregular bodies of chamosite and shoots and pockets of secondary ore. Box-works, relic sulphides and calcite-filled vugs were common within the gossan. The principal ore minerals present were hydrozincite, smithsonite and cerussite.

The upper part of the secondary ore beneath the gossan comprised a soft yellow material with nodules of limonite and consisted of about 50 per cent smithsonite. At a vertical depth of 15 to 20 feet (4.5 to 6.0 m), this passed into a distinctive reddish-brown coherent rock which contained about 75 per cent smithsonite and formed a layer about 10 feet (3 m) thick over the sulphide ore.

The main bodies of primary ore were pods and irregular masses of sulphides within grey dolomite, but minor sulphides occurred as disseminations and small veinlets through the dolomite. Ore minerals in this zone were chiefly galena and sphalerite. The grey dolomite host rock is younger than the surrounding limestone and has both brecciated and finely bedded varieties. Hutton interprets it as a cave filling, although it has some features not normally associated with such deposits.

Drilling carried out for the Zinc Corporation suggests that the ore bottoms at about 60 feet (18 m) vertical depth. Halligan estimated ore reserves of 11,500 tons (11,680 tonnes) of which most has now been mined. The grade of oxidized ore was estimated by Finucane and Jones at 31 per cent lead, 17 per cent zinc, 0.6 per cent copper and 4 ounces (124.4 gm per tonne) of silver per ton. The results of 17 samples taken by the Zinc Corporation averaged 35.5 per cent lead, 21.2 per cent zinc, 0.65 per cent copper and 5.6 ounces of silver per ton (174.17 gm per tonne). A representative sample of the sulphide ore stockpiled in 1964 assayed 23.2 per cent lead, 30.9 per cent zinc, 0.48 per cent cadmium, 0.10 per cent antimony and 5.2 ounces of silver per ton (161.73 gm per tonne).

Composition of the Ores

The ore consisted chiefly of minerals of lead and zinc, but contained minor silver, copper, cadmium and antimony. Primary sulphide minerals noted by Hutton were sphalerite (massive and as the variety schalenblende), galena, chalcopyrite, pyrite and marcasite. Secondary ore minerals were smithsonite, hydrozincite, cerussite, anglesite, malachite, azurite, and aurichalcite. The gangue of the primary ore was mainly host dolomite, but in the secondary zone also included limonite, hematite, psilomelane, chamosite and calcite.

The most distinctive features of the primary ore are a commonly colloform texture given by the prevalence of schalenblende, and the drusy appearance of the massive ore. The ore is generally fine grained and individual mineral grains are difficult to distinguish in hand specimen.

The paragenetic sequence of the sulphide minerals as determined by Hutton

(1965) is, from older to younger, diagenetic pyrite, marcasite, pyrite, galena, schalenblende, chalcopyrite, marcasite, pyrite, sphalerite and galena. A little sphalerite also accompanied the second marcasite stage. Some of the later sphalerite has exsolution intergrowths of chalcopyrite. Lead isotope determinations carried out on the galena indicate an anomalously high content of radiogenic lead.

Wall-rock Alteration

For distances of up to 5 feet (1.5 m) from the ore body, the host limestone is converted to dolomite. Hutton believes this change to have accompanied the formation of the dolomite host rock within the ore zone and hence to have preceded the ore deposition. Analyses of bedrock samples from a grid laid out over the lease, show primary dispersion haloes of the ore metals about the ore bodies. The limestone near the ore deposits contains numerous calcite-filled veinlets. The boundary between ore and wall rock is generally sharp.

Geological Controls of Ore

Geological controls of the Narlarla deposits are obscure. Woodward (1907a) believed the deposits to be conformable and to have been formed by the replacement of favourable beds within the limestone. Subsequent mining showed that in fact the ore bodies cut the bedding when examined in detail, although they conform broadly to the attitude of the strata.

Halligan (1965) postulated a fault control for the ore. As mentioned above, the faults are unmineralized in the present walls of the open-cut, do not extend far beyond the ore bodies and are in part later than the ore. They could have been formed by collapse of the host rocks due to ore-forming

processes, or to subsequent solution of the sulphide lenses.

Hutton (1965) advanced the hypothesis that the deposits were cave fillings, having been formed in part by deposition of the sulphides in open spaces and in part by replacement of a pre-existing dolomite fill. Most of the observed features of the ore bodies are explained by this hypothesis. The caves could be expected to follow the more soluble beds within the limestone and therefore to have a roughly stratiform disposition. However the origin of the finely laminated dolomite constituting the cave filling seems to be inadequately explained, and until this material is accounted for the hypothesis cannot be accepted in full.

Another possible geological control advanced for similar deposits in other countries, but so far not for the Narlarla deposits, is that they formed in slump deposits within the limestone. Playford and Lowry (1966) note that submarine slides occurred commonly in the fore-reef facies, and the two "filled caves" figured in Hutton (1965, plates 52 and 53) closely resemble scour-and-fill structures. This explanation does not preclude others; for instance caves or solution channels could form preferentially within the more permeable slumps.

Temperature of Ore Deposition

Hutton (op. cit.) estimated a low temperature of ore formation on the basis of "the absence of alteration in the host sediment, the absence of high temperature zinc sulphides, the presence of colloform textured sulphides and the presence of chalcopyrite exsolved from sphalerite". However it should be noted that normal sphalerite is stable to temperatures of about 1,020°C and that some workers consider exsolution textures of chalcopyrite in sphalerite as evidence that the temperature at

which the mineral formed exceeded 350° to 400° C (Edwards, 1954, p. 98).

Origin of the Deposits

The general uncertainty of the origin of Mississippi Valley type lead-zinc deposits is reflected in the number of hypotheses advanced to explain the Narlarla deposits. Finucane and Jones (1939) state: "There is no evidence of post-Devonian igneous activity in the area and it is probable that the ores were formed by deposition from waters of meteoric origin".

Prider (1941) has suggested that there might be a connection between the ore deposits and the igneous activity which produced the volcanic plugs of leucite-rich rocks at Mount North, Mount Percy and other places in the Fitzroy basin. However no igneous rocks of this type are known within about 15 miles (24 km) of the deposits.

Halligan (1965) considers the lead and zinc to have been derived from veins in the underlying Precambrian rocks and to have been deposited in their present position by circulating groundwaters. He points to the presence of a number of known lead-zinc veins in the older rocks and to the anomalously high content of radiogenic lead in the galena at Narlarla to support this idea.

Hutton (1965) similarly advocated an origin of deposition from groundwaters, but thought the source of the metals to be syngenetic concentrations within lagoonal facies limestone. The circulating groundwaters were concentrated towards the anticlinal flexure and then into the caves. High lead and zinc contents of recent spring tufa near the deposits were believed to show the capability of groundwater to dissolve the trace amounts of lead and zinc in the original sediments.

OTHER OCCURRENCES IN DEVONIAN LIMESTONE

Matheson and Guppy (1949) note the occurrence of veinlets of galena within Devonian limestone 2 miles (3.2 km) west of trigonometrical station J5 in the Pillara Range on Margaret Downs Station. A sample of the galena assayed 1.25 ounces of silver per ton (38.88 gm per tonne).

Traces of galena were reported in B.M.R. bore No. 2 (Laurel Downs Station). It was present in thin calcite stringers in a core obtained between 3,714 and 3,725 feet (1,132.0 and 1,135.3 m). The bore is 6 miles (9.6 km) from a plug of leucite lamproite known as Oscar Plug and it is possible that the galena was derived from this source.

Playford and Lowry (1966) observed gossanous patches in a number of localities in the limestone ranges and some of these had been opened up by prospecting pits. Lead minerals recorded from Fossil Downs and the Oscar Range may have come from the Devonian limestone, but there is no confirmation of this.

KIMBERLEY GOLDFIELD

KUNUNURRA DEPOSITS

General Information

The Kununurra deposits of lead, zinc, copper, silver and gold were discovered by P. Costeo in June 1967. Despite considerable excitement and publicity resulting in a minor rush to peg claims, the only deposits which have been worked to date are those on Costeo's original claim M.C. 38, now known as the Shangri La mine.

Access to the deposits is afforded by the bituminized road connecting Kununurra to the port of Wyndham. M.C. 38 is 200 yards (183 m) north of the road at a point about 13 miles (21 km) from Kununurra

and 52 miles (84 km) from Wyndham. At the time of inspection, water was being carted to the claims from Kununurra. The deposits are about 10 miles (16 km) from the diversion dam on the Ord River.

Reference: Sofoulis (1968).

Plans: G.S.W.A. No. 9960 is of the deposits on M.C. 38. The Cambridge Gulf 1 : 250,000 Geol. Sheet includes the area of the deposits.

Geology and Mineralization

The mineralized veins in and around M.C. 38 are in a thick dolerite sill (Hart Dolerite) intruding the Valentine Siltstone formation of the Speewah Group. Near the claims the sill and associated sediments have been cut by a number of small faults. One such fault striking about 360 degrees, brings the dolerite into contact with the Valentine Siltstone in the western part of M.C. 38. The large Ivanhoe Fault passes about 4 miles (6 km) east of the claim and displaces both Proterozoic and Palaeozoic rocks.

The mineralized veins are quartz-filled tension gashes within the dolerite. They contain galena, sphalerite, chalcopyrite, bornite and tetrahedrite where fresh, and cerussite, anglesite, bindheimite, hemimorphite, azurite, chrysocolla, chalcocite and covellite where oxidized. Gold and silver are associated with the copper rather than the lead minerals. There are minor amounts of antimony present in the ore.

The ore minerals have no well-defined distribution within the quartz reefs, but form disseminations or lie in irregular bands or patches. The richest ore is crystallized in vugs.

Shangri La Mine (M.C. 38)

On M.C. 38, six mineralized veins have been mined or tested. They are arranged in a crude left-hand echelon manner and

lie in a zone striking west-northwest. The strikes of individual veins range from west to northwest and their dips from 10 to 35 degrees northerly. Workings consist of two open-cuts and a number of pits and trenches. Conwest (Aust.) N.L. did 4,760 feet (1,450 m) of waggon drilling in the area of the deposits and estimated ore reserves of 34,000 tons (34,500 tonnes) averaging 7.6 per cent lead, 9.7 ounces of silver per ton (301.69 gm per tonne) and 0.18 ounces of

F" which crops out over a length of 150 feet (46 m). The western end of the reef has been stripped with a bulldozer and can be seen to pinch out completely with no surface connection to the reef E. Only the eastern, worked, part of reef F contains appreciable ore. In the cut the vein has been worked over a length of about 60 feet (18 m) for about 40 feet (12 m) down dip.

About 100 feet (30 m) west of the main open-cut is a reef ranging from 2.5 to

TABLE 21. ASSAY RESULTS—SHANGRI LA MINE

Locality	Silver F. oz./ Ton	Gold F. oz./ Ton	Copper Per cent	Zinc Per cent	Lead Per cent
Reef F	7.75	0.11	0.37	1.25	8.87
Reef E	15.21	1.38	0.78	0.27	4.98
Reef D	0.82	0.13	0.84	0.05	1.03
Reef B	11.24	0.12	0.51	0.23	10.40
1st grade ore dump	96.23	1.08	4.04	0.76	34.80
2nd grade ore dump	28.83	1.10	1.75	0.74	11.70
Margin Reef F	1.24	0.012	0.18	0.11	5.93

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

gold per ton (5.59 gm per tonne) distributed in three ore shoots.

The larger open-cut is on a reef about 130 feet (40 m) long and up to 13 feet (4 m) thick, called "reef E" in Sofoulis' report. It is made of up two more or less parallel quartz veins each 2 to 4.5 feet (60 cm to 1.3 m) thick, separated by 3 to 4 feet (90 cm to 1.2 m) of dolerite and dipping at 10 to 15 degrees northerly. The greatest thickness of quartz seen in any section was 9 feet (2.7 m). The reef has been worked for a distance of about 70 feet (20 m) down dip in the open-cut. The smaller open-cut is about 200 feet (60 m) east of the larger, on the eastern end of "reef

3.5 feet (76 cm to 1 m) thick and cropping out over about 140 feet (43 m). It is the southern part of "reef D" of Sofoulis' report. It dips at 30 degrees to the northeast and contains only small patches of ore minerals. Workings on it are restricted to one pit and a trench.

The three other mineralized reefs are respectively 175, 300 and 400 feet (53, 90 and 120 m) westerly from the main cut. Each crops out over a length of 30 to 40 feet (9 to 12 m) and is about 1.5 to 2.5 feet (46 to 76 cm) thick. All contain copper and lead, although none seems to be of high grade. They have been tested by some pits and bulldozed cuts.

Assays of the various reefs and of ore dumps given by Sofoulis are listed in Table 21.

Prospecting Areas 187, 188

P.A.s 187 and 188 adjoin M.C. 38 to the south and contain mineralized quartz veins of the same type. The largest of these strikes at 030 degrees and dips flatly to the southeast. It is about 2.5 feet (76 cm) thick, 75 feet (23 m) long and carries galena, cerussite, bindheimite and copper carbonates. Workings comprise one pit 2.5 feet (76 cm) deep.

MOUNT AMHERST DEPOSITS

General Information

Two deposits of silver-lead with traces of copper are known in the vicinity of Mount Amherst Station. One recorded a production of 6.24 tons (6.34 tonnes) of lead and 33.62 ounces (1,045.68 gm) of silver from 9.26 tons (9.41 tonnes) of ore, while the other has not been worked. For the purpose of this report the first is called the Black and Glidden prospect and the other the Dead Horse Creek prospect.

Mount Amherst Station is about 60 miles (97 km) by road west of Halls Creek through Moola Bulla Station. The track to Mount Amherst through Margaret River Station is now disused and difficult to follow.

Reference: Jones (1938).

Plans: Mount Ramsay 1:250,000 Sheet shows the location of the larger deposit and the regional geology; G.S.W.A. No. 10827 is of the Dead Horse Creek prospect.

Black and Glidden Prospect

(Lat. 18° 23' S, long. 126° 58½' E.).

The prospect worked by Black and Glidden is 1 mile (1.6 km) southwesterly from Mount Amherst Station homestead, on

the north side of a prominent ridge and about 50 yards (46 m) east of a fence. The spine of the ridge is formed by a silicified fault zone to which the lode shear is probably related. The country rocks are metamorphosed arkose, greywacke and amphibolite of the Halls Creek Group.

The lode is exposed in two shallow open-cuts over a length of 40 feet (12 m) and comprises a 6-foot (1.8 m) wide stockwork of thin quartz veins within sheared amphibolite and arkose. It strikes at 240 degrees and dips steeply north. Galena, cerussite and traces of copper carbonates are restricted to the quartz veins which make up about 15 per cent of the lode. The crushed rock material between the veins is apparently barren.

Other small quartz veins cropping out over a total distance of 150 feet (46 m) in the vicinity of the mine carry galena, cerussite and copper carbonate.

Dead Horse Creek Prospect

(Lat. 18° 23' S, long. 126° 56' E).

The larger of the two Mount Amherst deposits is 7 miles (11.2 km) northwest of the homestead and about 0.3 of a mile (0.5 km) north of Dead Horse Creek. It can be reached by following the bed of Dead Horse Creek for 5 miles (8.0 km) upstream from a cattle yard or by travelling 3 miles (4.8 km) across country northwards from the nearest point on a track which follows the telegraph line. Both routes are difficult.

The lode is in granite, migmatite and metasediments of the Halls Creek Group. It follows a fault which cuts crystalline rocks and the overlying sediments of the Middle Proterozoic Kimberley Group. It strikes at 155 degrees, dips steeply west and is made up of quartz and calcite with galena, cerussite and oxidized copper minerals.

The outcrop of the lode runs for about 310 feet (94 m) along the spine of a low ridge and averages about 10 feet (3 m) in width. At its southern end it pinches to a narrow vein which can be followed a further 50 feet (15 m). The northern end of the lode is in the bank of a small creek and any further extension northwards is obscured by alluvium. Narrow lodes with lead and copper minerals branch from the western side of the main lode on a bearing of 170 degrees.

Assays of the samples are listed in Table 22; Nos. 1 and 2 were taken by Jones (1938), Nos. 3 and 4 are the writer's samples, and Nos. 5 and 6 were reported by Simpson (1951).

The Dead Horse Creek prospect is on a strong geological structure and there is a good chance that the lode extends northwards beneath alluvium. It deserves more attention than it has received in the past.

SPEEWAH DEPOSITS

General Information

The Speewah silver-lead deposits are in the Speewah Valley north of the abandoned Speewah Station homestead. Access to the homestead is by a track from Dunham River Station. There are no tracks from the homestead to the deposits.

Although discovered in about 1924, and investigated in some detail at that time, the deposits have not been exploited commercially.

References: Blatchford (1928), and Dow and others (1964) described the geology of the deposits. Moore (1928) gave the results of metallurgical tests carried out on the ore.

Plan: The positions of the deposits are shown on the Lissadell 1 : 250,000 Geological Sheet.

The deposits were not examined by the writer and the following information is taken from the reports cited above.

TABLE 22. ASSAY RESULTS—DEAD HORSE CREEK PROSPECT

No.	Position	Width Inches	Lead Per cent	Zinc Per cent	Copper Per cent	Silver F. oz./ Ton	Gold Dwts/ Ton
1	Near north end of lode	52	15.69	....	....	2.34	....
2	Middle of lode	144	7.27	....	....	1.45	....
3	From pit 40' from north end of lode	36	37.7	2.74	0.25	5.9	....
4	From outcrop 150' from north end of lode	36	1.25	0.81	0.04	0.5	....
5	? Concentrate ....	....	80.1	....	....	3.62	tr
6	? Concentrate ....	....	58.2	....	....	1.59	nil

NOTE: Nos. 1 and 2 from Jones (1938)

Nos. 5 and 6 from Simpson (1951)

1 inch = 2.54 centimetres

1 foot = 0.3048 metres

1 pennyweight = 1.55517 grammes

1 fine ounce = 31.103 grammes

1 ton = 1.01605 tonnes

Martins Silver-Lead Prospect

(Lat. 16° 12' S, long. 127° 58' E).

Martins (or Duracks) silver-lead prospect is 17 miles (27 km) north of Speewah homestead on the extreme eastern slope of a low ridge, similar in form to a river terrace. It is separated from the cliffs of the Durack Range by a wide river flat.

The lode is on the upper contact of a dome-shaped intrusion of a differentiated dolerite-granophyre sill. It consists mainly of quartz with galena, cerussite, malachite, azurite and some native silver distributed throughout in patches. It strikes northerly and dips flatly eastwards at almost the same angle as the slope of the hillside. Consequently a large apparent width of the vein is exposed, but costeans show that the greatest true width is 3.5 feet (1 m). Blatch-

ford believed it to be a flattish mineral segregation at the top of the laccolith.

Assays listed in Table 23 have been published in various reports on the prospect.

Speewah Prospect

(Lat. 16° 21' S, long. 127° 57' E).

The Speewah prospect has also been called Martin's fluorite prospect. It is 5 miles (8 km) north-northwest of Speewah homestead.

Galena and fluorite occur in lenticular quartz veins within a shear striking north and dipping vertically. The shear can be traced for about 10 miles (16 km), but the galena and fluorite are restricted to a length of 400 feet (120 m). The host rock is Hart Dolerite, being part of the same sill

TABLE 23. ASSAY RESULTS—MARTINS SILVER-LEAD PROSPECT

Location or Author's Number	Lead Per cent	Silver F. oz./ ton	Gold Dwt/ ton	Copper Per cent	Reference
A	72.3	6.35	Tr	....	Simpson (1951)
B	65.7	6.70	Tr	....	" "
C	39.1	4.29	nil	nil	" "
D	32.4	47.58	0.35	2.77	" "
E	25.0	4.64	Tr	nil	" "
F	13.4	58.97	nil	nil	" "
G	8.0	0.25	nil	nil	" "
1. Centre costean bottom section over 2 feet	3.87	23.21	0.20	3.03	Blatchford (1928)
2. Centre costean top section over 1 foot 6 inches	0.09	3.23	0.04	0.72	" "
3. North costean over 2 feet	4.61	5.17	1.62	Tr	" "
4. South costean over 1 foot 6 inches	2.53	18.18	1.62	1.94	" "
Bulk sample	12.08	56.53	2.6	3.61	Moore (1928)

NOTE: 1 foot = 0.3048 metres
 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

that forms the footwall of Martins silver-lead prospect.

MISCELLANEOUS DEPOSITS

Of the following small lead deposits scattered within the Kimberley and West Kimberley Goldfields, only Boxers prospect on Argyle Downs Station was inspected by the writer. Information on the others was taken mainly from Simpson (1951) and from reports on the regional geology of various mapped areas.

BOXERS PROSPECT

(Lat. $16^{\circ} 17\frac{1}{2}'$ S, long. $128^{\circ} 40'$ E).

Boxers lead, fluorite and barite prospect is 11 miles (17.7 km) southwest of Argyle Downs homestead in the eastern

Galena, fluorite and barite occur in a quartz vein 10 to 15 inches (25 to 38 cm) wide and about 20 feet (6 m) long, striking at 230 degrees in coarse-grained granite. It is close to the Halls Creek Fault. Thirty feet (9 m) on a bearing of 60 degrees from the eastern end of the vein there is a pit exposing fluorite and quartz which may be on an extension of the reef.

Assays: Simpson gave two assays of samples from the vein. Sample A contained 8.3 per cent lead, 0.96 ounces per ton (29.85 gm per tonne) of silver, trace gold and nil arsenic and antimony. Sample B contained 24.3 per cent lead, 2.23 ounces per ton (69.35 gm per tonne) of silver, 0.21 pennyweights per ton (0.326 gm per tonne) of gold, and nil arsenic and antimony.

TABLE 24. ASSAY RESULTS—OSMOND CREEK OCCURRENCE

Sample	Lead Per cent	Silver F. oz./ ton	Gold Dwt/ ton	Copper Per cent
A 	52.1	7.64	nil	trace
B 	3.4	1.03	trace	0.5

NOTE: 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

part of the Kimberley Division. It is reached by travelling eastwards for 1 mile (1.6 km) from a point 4.5 miles (7.2 km) south of the yard at Argyle Lagoon on the track to Lincoln Yard. The vein crops out in flat, featureless country and is difficult to find without a guide. It is expected that the area of the prospect will be flooded when the main dam on the Ord River is completed.

References: Simpson (1951) and Dow and others (1964).

A sample of picked ore taken during the present investigation assayed 7.77 per cent lead, 0.03 per cent zinc, 30.8 per cent barium and 1.4 ounces per ton (43.54 gm per tonne) of silver.

OSMOND CREEK

On Osmond Creek between Mount Parker and Mount Buchanan a quartz vein carrying some galena and chalcopyrite has been prospected. Assays of two samples are shown in Table 24.

TURKEY CREEK

(Lat. 17° 00' S, long. 128° 15' E).

A specimen said to have been obtained 8 miles (12.8 km) north of the Police Station at Turkey Creek consisted of galena with fluorite and quartz. It assayed 8.99 ounces of silver per ton (279.61 gm per tonne) and nil gold. The lead content was not ascertained.

DIXON RANGE

There are some highly argentiferous quartz-galena veins between the Dixon Range and Doughboy Hill. Assays of three samples made in 1926 are shown in Table 25.

Other minerals associated with the galena in small amounts were kaolin, limon-

An average sample contained 68.0 per cent lead, 2.20 ounces of silver per ton (68.43 gm per tonne) and 0.42 pennyweights of gold per ton (0.653 gm per tonne).

MOUNT DOWERA

A specimen of galena obtained from Mount Dowera assayed 68.6 per cent lead, 4.26 ounces of silver per ton (132.49 gm per tonne) and 0.58 pennyweights of gold per ton (0.901 gm per tonne). The locality of Mount Dowera is unknown.

GRANTS PATCH

(Lat. 17° 50' S, long. 127° 55' E).

Galena is found in the gold-bearing quartz reefs at Grants Patch on the old telegraph line north of Halls Creek. The veins

TABLE 25. ASSAY RESULTS—DIXON RANGE OCCURRENCE

Sample	Lead Per cent	Silver F. oz./ ton	Gold Dwt/ ton
A	73.0	167.49	nil
B	72.6	1.42	nil
C	30.3	4.21	nil

NOTE: 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

ite, fluorite, malachite, anglesite, cerussite, chalcopyrite and psilomelane.

E. T. Hardman (1885) noted small pockets of galena in the limestone a little south of Johnson's base line on the Ord River. It was said to be associated with blende and to carry a little silver.

FOSSIL DOWNS STATION

On Fossil Downs Station in the country northeast of Fitzroy Crossing, a vein of quartz and galena was prospected in 1927.

are mostly no more than a few inches thick, but exceptionally may reach 1.5 to 2 feet (46 to 60 cm). Assays have shown several ounces of silver per ton apparently from the galena, as gold values are mostly low.

Harms (1959) records a lead-bearing vein 6 miles (9.6 km) south of Alice Downs Station near the old telegraph line and about 1 mile (1.6 km) from an old yard. On the surface the vein cropped out as an iron-stone reef, but pits and a 10-foot (3.0 m)

deep shaft showed it to contain cerussite and pyromorphite at depth. The lode is sub-parallel to the enclosing schists which strike at 60 to 80 degrees and are almost vertical; the lode dips at 45 degrees south-east and is from 12 to 18 inches (30 to 45 cm) wide.

BIGELLEAS YARD

(Lat. 17° 38' S, long. 125° 53' E).

Galena has been reported from 2 miles (3.2 km) north of Bigelleas Yard on the Lennard River 1:250,000 Sheet. It is at the southern end of a razor-back ridge formed by a series of echelon quartz veins trending northerly. The galena is present as small crystals in thin veinlets within a brecciated, massive quartz gangue. Old mining tools in the vicinity indicate a small production in the past, but the deposit has not been worked for many years.

LEOPOLD DOWNS STATION

(Lat. 17° 50' S, long 125° 56' E).

A quartz reef with erratically distributed crystals and patches of galena is recorded by Harms (1959) on the east bank of the Fitzroy River about 3 miles (5 km) northeast of the old homestead on Leopold Downs Station. The reef is usually 12 to 18 inches (30 to 45 cm) wide with a maximum width of 3 feet (90 cm) and can be traced with minor gaps for a total length of about 30 chains (603 m), the strike being approximately north. The country rocks are sheared granite and schist.

ILMARS—LITTLE MOUNT ISA PROSPECTS

General Information

In 1963 a combined mapping party of geologists from the Bureau of Mineral Resources and the Geological Survey of Western Australia discovered stratiform

copper-lead-zinc-bearing gossans in the Biscay Formation within the Lower Proterozoic Halls Creek Group. The initial discovery was named Ilmars prospect and another smaller gossan 1 mile (1.6 km) southwest was called the Little Mount Isa prospect.

The prospects are about 21 miles (34 km) northeast of Halls Creek and are reached by a track 6 miles (10 km) long (part of the Ding Dong Downs Station road) branching from the Great Northern Highway 18 miles (29 km) north of Halls Creek.

Shortly after their discovery, the prospects were pegged by Peko Mines N.L. who drilled five holes to test the better copper showings. Results were evidently disappointing and the company relinquished its leases in 1966. The ground was then taken up by Pickands Mather and Co. International, who had previously held T.R. 2687H surrounding the leases. This company has carried out an intensive programme of geology, geochemistry, geophysics and diamond drilling in the area of the gossans.

The writer made a brief inspection of Ilmars prospect in 1968, but the following information is taken mainly from reports by geologists of Pickands Mather and Co. International.

Reference: Gemuts (1963).

Plans: G.S.W.A. No. 7615; Gordon Downs 1:250,000 Geological Sheet.

Geological Information

The gossans forming the Ilmars and Little Mount Isa prospects are in a wedge of Biscay Formation rocks cropping out between the Halls Creek Fault to the west and the Sophie Downs Granite to the east. In the area of the prospects, the Biscay Formation

is subdivided into five members which, from oldest to youngest, are:

1. A unit of quartz-biotite schist grading upwards into graphitic schist followed by a thick sequence of basic volcanics (1,500 feet (457 m) thick)

2. Graphitic schist with marble and chert beds and intercalated volcanic rocks (800 feet (244 m) thick)

3. Acid volcanics with some more basic types and interbanded siliceous sediments (1,000 feet (305 m) thick)

4. Quartz-chlorite schist with limey and cherty bands, grading along strike into more lime-rich sediments (400 to 800 feet (122 to 244 m) thick) and

5. Graphitic schist, black limestone and chert with interbedded volcanic rocks, grading upwards through laminated tuffs and calc-schist into acid and basic lavas.

The horizon containing the gossans is in the fourth member where the better showings of economic minerals are in the lime-rich parts.

The rocks of the Biscay Formation were folded prior to consolidation by slumping westerly from the Sophie Downs dome and were later disrupted by several cross faults. They were metamorphosed to the mid greenschist facies during a period of regional folding and granite intrusion.

Ilmars Prospect

The gossans forming Ilmars prospect occupy the northernmost 5,000 feet (1,500 m) of a mineralized horizon traced for 20,000 feet (6,100 m) and occur where there is a change in facies of the host sediments from quartz-chlorite schist to calc-silicate rocks with interbanded chert beds. They crop out along a prominent ridge and attain thicknesses of up to 60 feet (18 m). The host sediments strike at 010 degrees and dip from 45 to 60 degrees west.

Both the calc-silicate and chert beds have been mineralized, but the more prospective gossans are restricted to the siliceous rocks. These siliceous gossans comprise limonite, hematite, and quartz with impregnations of malachite, azurite, cuprite and rare cerussite and smithsonite. Assays of up to 19 per cent copper, 5.2 per cent zinc and 0.8 per cent lead have been obtained from surface samples.

Little Mount Isa Prospect

The gossan of the Little Mount Isa prospect crops out as a steep ridge cut at its mid-point by a gully. It is immediately east of the Halls Creek Fault and conforms to the strike of the enclosing rocks. It is very siliceous and seems to be a locally mineralized portion of a more continuous chert horizon. The sediments dip at 60 degrees west.

The gossan has a maximum thickness of 50 feet (15 m) and is made up of a western zone with a continuous outcrop of 1,600 feet (490 m), separated from a narrower, discontinuous eastern zone by up to 20 feet (6 m) of chlorite schist.

Correlation of the mineralized zones at the Ilmars and Little Mount Isa prospects is uncertain, but the close similarity of the stratigraphic succession about each suggests that they are probably in the same horizon.

Composition of the Mineralized Zones

In diamond drill cores, the main sulphide minerals in the mineralized zones were pyrite and pyrrhotite. There were some narrower sections of sphalerite and galena, and others carrying chalcopyrite. Quartz was usually the most common gangue mineral in most of the mineralized cores, but calcite predominated in some cases. Other minerals in the gangue were tremolite and chlorite. The widths of the mineralized

zones encountered in the drilling ranged from 3 feet 6 inches to 51 feet (1 to 15.5 m). All but one of the mineralized zones were in siliceous rocks.

Assays: Zinc was the most abundant economic metal in the cores. The best assay of this metal was 8.25 per cent zinc over a width of 5 feet 4 inches (1.6 m). Averaged assays of some of the better mineralized sections were 3.55 per cent zinc over 16 feet (4.8 m), 4.51 per cent zinc over 11 feet 4 inches (3.4 m), 4.25 per cent zinc over 3 feet 6 inches (1.1 m) and 5 per cent zinc over 6 feet 10 inches (2.1 m). The two sections richest in lead contained 1.25 per cent lead over 6 feet 10 inches (2.1 m) and 0.93 per cent lead over 16 feet (4.8 m) respectively. Despite the showings of copper minerals in the gossans, there was very little copper in the sulphide sections cut by the drill holes. The best weighted average assay was 1.0 per cent copper over 6 feet 10 inches (2.1 m) and all other sections contained less than 0.3

per cent copper. The silver content of the mineralized rock was negligible.

Origin of the Sulphide Minerals

The sulphide minerals of the Ilmars and Little Mount Isa prospects are believed to have been deposited syngenetically but perhaps remobilized at some later time. Their components are thought to have come from contemporaneous volcanic extrusions and to have been deposited chemically when the sea water became saturated with the metallic ions.

Conclusions

Although no economic base metal deposits have yet been proved in the area of the Ilmars and Little Mount Isa prospects, the occurrence here of stratiform sulphides, in a geological environment similar to that at Mount Isa and to other large copper-lead-zinc mines, is of considerable importance. It is possible that continued exploration in the Biscay Formation will result in the discovery of an ore body.

Pilbara Goldfield

SUMMARY

Silver-lead-zinc deposits have been known in the Pilbara Goldfield since about 1901, and they have been mined intermittently since about 1925. Most of the lead and zinc produced from the Pilbara Goldfield has come from the Braeside lead field, 80 miles (129 km) east of Marble Bar, although small quantities have been mined

at Abydos Station, Dooleena Gap, Meentheena Station, North Pole and Lennon Find.

The deposits are exclusively in rocks of Precambrian age, the Braeside mines being in basalt of the Lower Proterozoic Fortescue Group and the others in Archaean granite or greenstone. In all but three of the deposits inspected the lead and zinc minerals are in quartz veins. The exceptions are

TABLE 26. ANNUAL PRODUCTIONS OF LEAD AND ZINC FROM THE PILBARA GOLDFIELD

Year	Ore and Conc. Tons	Lead Tons	Zinc Tons	Value \$Aust.
1925	51.00	35.75	....	2,536.00
1926	90.50	40.87	....	2,610.00
1927	36.00	25.02	....	1,584.00
1929-46 ....	....	....	....	....
1947	16.47	12.36	....	1,221.28
1948 ....	....	....	....	....
1949	235.15	159.49	....	22,205.90
1950	445.22	308.61	....	42,719.10
1951	301.72	213.21	....	51,384.60
1952	420.30	262.64	....	73,653.14
1953	488.19	342.46	4.38	52,926.94
1954	155.27	108.59	....	15,357.06
1955	330.60	232.85	....	49,773.68
1956	1,117.94	750.90	....	157,458.70
1957	657.62	422.44	....	95,875.38
1958	70.06	24.07	20.06	2,452.70
1959	420.87	273.23	....	34,078.00
1960-67 ....	....	....	....	....
Total	4,854.76	3,225.01	24.44	597,422.48

NOTE: 1 ton = 1.01605 tonnes

TABLE 27. PRODUCTION OF LEAD, ZINC AND ASSOCIATED SILVER FROM PILBARA GOLDFIELD, BY CENTRES

Locality	Lease No.	Name of Lease or Operator	Period	Est. Mine Production		Realized Production				Est. Value \$Aust.	Remarks	
				Ore Tons	Conc. Tons	Conc. Tons	Lead Tons	Zinc Tons	Silver F. oz./Ton			
Meentheena Station	MC 198	C. Challenger	1949	...	...	5.54	3.91	...	...	15.17	481.60	
Abydos Station	Crown Land	G. Lamont	1949	...	...	0.98	0.77	...	...	6.44	85.90	
Doooleena Gap	MC 330	E. J. Reek	1955	...	...	8.04	4.78	...	...	45.78	893.86	
North Pole	PA 2274	Duncan & Dorrington	1949	...	...	1.04	0.59	...	...	9.10	72.30	Locality unknown
Lennon Find	...	St. Patricks	1951-53	...	...	98.50	48.23	2.21	...	...	100.00	With 20.7 tons copper ore
Sundry Claims	...	See Table 28	1925-59	...	...	4,750.66	3,166.73	25.06	...	29,480.03	611,587.89	
Braeside	...	...	1925-67	...	...	4,854.76	3,225.01	27.27	...	29,556.52	616,239.55	
Total, Pilbara Goldfield												

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

the deposits at Lennon Find and Pilgan-goorra, where the lodes are mineralized limestone and the Duffer Creek prospect in which copper, lead and zinc gossans are found as lenses within a sequence of basalt, tuff and chert.

To the end of 1968 the Pilbara Goldfield had produced 3,225 tons (3,276.6 tonnes) of lead and 27.3 tons (27.73 tonnes) of zinc with 29,556 ounces (919,280.2 gm) of associated silver. The annual production since 1925 is given in Table 26 and details of production from each centre are given in Table 27.

BRAESIDE LEAD FIELD

(Lat. 21° 00' to 21° 20' S, long. 121° 00' to 121° 15' E)

GENERAL INFORMATION

The Braeside lead field is 80 miles (129 km) east of Marble Bar and about 200 miles (320 km) by road from Port Hedland. It is in the Gregory Range on the western edge of the Great Sandy Desert, and covers a belt of country 21 miles (33.7 km) long by 4 miles (6.4 km) wide, elongated in a north-northwest direction (see Plate 3). The Ragged Hills mine is at the southern end of the field and Barker Well at the northern end. The field takes its name from the abandoned Braeside pastoral lease in which the deposits lie.

Access to the Ragged Hills mine is by a graded road branching from the "manganese" road (connecting the manganese mines at Woodie Woodie to Eginbah Station on the Great Northern Highway) at a point about 12 miles (19 km) south of the crossing of the Oakover River. Disused tracks lead from the Ragged Hills mine to the other deposits.

Ore of lead and silver was first discovered in the vicinity of Braeside in 1901 and a small parcel was sent to London. No serious attempt was made to develop the field until 1925, when higher lead prices drew prospectors to the area. However, the remoteness of the deposits prevented large scale mining at that time. The main period of mining activity in the field was from 1947 to 1959 when high lead prices and improved transport methods enabled profitable exploitation of some ore bodies. All but 240 of the 3,166 tons (3,216.6 tonnes) of lead won from the field came from the Ragged Hills mine. Details of production are given in Table 28.

Adequate supplies of water for domestic and mining purposes were obtained from bores and wells sunk in the alluvium of the west-flowing creeks which drain the ranges. If required, larger supplies could be drawn from the alluvial flats of the Oakover River, 6 miles (9.6 km) west of the deposits. There are many potential sites for small dams within the ranges.

References: There are reports on various mines within the group by Blatchford (1925), Finucane (1938) and Low (1963). Accounts of the regional geology were given by Noldart and Wyatt (1962) and de la Hunty (1965). Graphic logs of some Government sponsored drillholes were published in the Mines Department Annual Report for 1928. Larcombe (1930) recorded brief petrographic descriptions of bore core from the field.

Plans: Maps showing the regional geology were published in the reports of Finucane, Noldart and Wyatt and of de la Hunty and there are larger scale plans of the various deposits in Finucane's report. Mines plans 573/1 and 2 give the relative positions of the deposits and the surveyed leases and claims are shown on Mines lease

plans Braeside 40-1 and 40-3 and Wandy Wandy 40-1.

GEOLOGICAL SETTING

Stratigraphy and Rock Types

The host rocks of the silver-lead deposits at Braeside are basalt, tuff and intrusive dolerite of the Lower Proterozoic Fortescue Group, which in this part of the Proterozoic basin has been named the Little de Grey Lava. Three stratigraphic units have been recognized and are correlated with units mapped on the Roy Hill 1:250,000 Sheet to the southwest. From oldest to youngest they are: the Kyleena Basalt Member composed of greenish, vesicular and amygdaloidal basalt; the Tumbiana Pisolite made up of tuff, pisolitic tuff, tuffaceous siltstone and *Collenia* limestone; and the Nymmerina Basalt Member composed of vesicular and amygdaloidal basalt. The Tumbiana Pisolite forms a good marker horizon within the otherwise uniform succession of lava flows which make up the greater part of the exposed bedrock in the field.

Southwest of the mineral deposits the volcanic rocks are overlain conformably by the Carawine Dolomite, a 300 to 400-foot (90 to 120 m) thick sequence of dolomite and marl. East of the deposits the lavas are faulted against the acid igneous rocks which make up the Isabella Range and which are known collectively as the Gregory Range Granite, but which probably comprise acid lavas near the lead field.

Many dolerite dykes intrude the basalt and tuff of the Fortescue Group and near Lightning Ridge there is a large wedge-shaped intrusion of gabbro which disrupts the continuity of the beds.

Structure and Ore Controls

Throughout the Braeside lead field, the lava and tuff bands have a general

TABLE 28. PRODUCTION OF SILVER, LEAD AND ZINC FROM BRAESIDE LEAD FIELD

Mine or Group	Lease No.	Name of Lease or Lessee	Period	Realized Production				Est. Value \$Aust.	Remarks
				Ore and Conc. Tons	Lead Tons	Zinc Tons	Silver F. oz.		
Ragged Hills	ML 288	Ragged Hill	1925-26	28.50	18.53	....	....	1,254.00	
	MC 189	Ragged Hills Lead mine	1949-59	4,338.76	2,905.45	24.44	28,070.69	574,113.62	
	MC 206	S. Stubbs	1951	4.41	3.18	....	23.15	796.80	
Total	....	....	....	4,371.67	2,927.16	24.44	28,093.84	576,164.42	
Ragged Hills East Line	MC 184/190	O. B. Brockhoff	1949	18.99	14.18	....	....	1,859.60	Includes Silver valued at \$42.10
	MC 184	T. Collins	1953-55	16.24	10.71	....	....	1,807.64	Includes Silver valued at \$71.50
	MC 193	D. Chamberlin	1952	6.69	2.72	0.62	....	300.00	Includes Silver valued at \$5.04
	MC 203	J. O'Callaghan	1949	4.75	3.30	....	22.96	560.40	
	MC 227	S. Adams	1952-53	32.35	19.89	....	145.83	5,831.40	
	PA 2256	C. W. Challenger	1949	14.73	9.86	....	70.82	1,331.80	
	MC 450	J. O'Callaghan	1958	11.06	6.37	....	48.54	723.60	
Total	....	....	....	104.81	67.03	0.62	288.15	12,415.24	
Devons Cut	ML 297	Oakover	1926-28	20.85	14.32	....	93.48	694.00	
	MC 267	R. C. Midgely & G. Baker	1955	9.82	7.22	....	56.63	1,115.66	
	PA 2511	O. Engstrom	1956	16.67	12.76	....	90.42	2,888.30	
Total	....	....	....	47.34	34.30	....	240.53	4,697.96	
Mount Brockman Group	MC 170/171	S. Kennedy	1947-49	38.65	26.51	....	262.91	3,407.28	
	MC 185/186	H. Hansen	1949	31.21	20.59	....	242.81	28,73.70	
	MC 185	A. Reick	1955	5.65	3.69	....	44.99	698.00	
	PA 2399	J. Bennett	1953	2.57	1.50	....	15.92	224.36	
Total	....	....	....	78.08	52.29	....	566.63	6,843.34	
Lightning Ridge	MC 215	I. D. McArtney	1949	4.19	2.73	....	13.13	363.20	
	MC 255	O. Engstrom	1953-54	14.08	9.74	....	42.97	1,477.64	
	PA 2366	O. Engstrom	1952	10.68	6.48	....	30.43	1,934.70	
Total	....	....	....	28.95	18.95	....	86.53	3,775.57	

Barker Well Group	MC 194	....	B. Hedley	....	....	1949-50	17.90	7.36	....	23.50	659.30	
	MC 249	....	O. Engstrom and D. Rogers	....	....	1952	4.88	2.68	....	23.67	561.70	
	PA 2375	....	E. Rogers	....	....	1952	13.73	6.87	....	32.25	1,870.30	
	MC 216	....	D. Rogers	....	....	1950	6.41	4.37	....	44.97	687.40	
Total	....	....	....	....	....	42.92	21.28	....	124.39	3,778.70		
Koongalin Hill Group	ML 295	....	Koongalin Silver-Lead	....	....	1925-27	46.00	32.04	....	....	2,280.00	
	MC 195	....	Flynn & Rogers	....	....	1949	3.10	2.13	....	9.00	291.40	
Miscellaneous Tenements	PA 2257	....	I. Adams	....	....	1949	0.69	0.51	....	4.21	114.00	2 miles North of Ragged Hill mine
	PA 2258	....	E. O'Callaghan	....	....	1949	0.74	0.56	....	3.83	127.50	2 miles North of Ragged Hill mine
	PA 2263	....	D. Rogers	....	....	1949	4.41	2.18	....	15.20	278.90	Precise location unknown
	PA 2295	....	W. Simpson	....	....	1949	3.90	2.69	....	13.11	368.80	Precise location unknown
	PA 2336	....	O. Engstrom	....	....	1951	5.20	3.64	....	27.61	900.70	Precise location unknown
Crown Land	ML 289	....	Federal South	....	....	1925	1.50	1.04	....	....	70.00	Precise location unknown
	....	....	V. Lazar	....	....	....	1.35	0.93	....	....	175.36	
Total Braeside District, 1925-59							4,750.66	3,166.73	25.06	29,480.03	611,587.89	

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

north-northwesterly strike and a dip of from 5 to 30 degrees westerly, although there are local variations on folds. Recumbent folds have been mapped near Mount Sydney, south of the field, but are unknown near the lead deposits.

The silver-lead deposits follow steeply dipping, silicified faults forming the spines of prominent ridges. Some faults can be traced for several miles, but lead minerals are restricted to shoots of 500 feet (150 m) or less in length. The largest ore body worked on the field (Ragged Hills) was on a cymoid loop structure, but the structural controls of most of the smaller deposits are obscure.

Where present in the larger faults, lead minerals are confined to marginal veins which form only part of the whole fault zone and seem to be later than the main period of quartz injection. In the smaller, narrower reefs, lead may be present throughout the width of the veins.

Many of the mines in the area are close to the outcrop of the Tumbiana Pisolite Member, and this unit may have had some influence, either structural or chemical, on ore deposition.

Form and Composition of Ore Bodies

The silver-lead ore is found either as massive lenses 6 inches (15.2 cm) to 5 feet (1.5 m) in width, or as disseminations through quartz and quartz-filled breccia. The galena is fine grained (1 to 2 mm) and often appears to have been crushed by later earth movements. In most mines the zone of weathering is shallow, ranging from nil to 50 feet (15 m). The main sulphide mineral in the primary ore is galena, which occurs with small amounts of sphalerite, chalcopyrite, bornite and pyrite. The oxidized ore minerals are chiefly cerussite and anglesite with minor amounts of pyromor-

phite. Some deposits contain significant quantities of malachite and cuprite and the vanadium minerals mottramite, descloizite and vanadinite have been recorded from the field.

RAGGED HILLS MINE (M.C. 288 and 206)

The Ragged Hills mine is the largest of the Braeside lead deposits. The main workings on M.C. 288 have produced 2,927 tons (2,937.4 tonnes) of lead and 2,800 ounces (87,090 gm) of silver, while the northern extension of the lode on M.C. 206 has yielded 3 tons (3.0 tonnes) of lead and 23 ounces (715.4 gm) of silver.

Plans: Mines 113/1 and 2 show the underground workings of the mine.

Geological Information

On M.C. 288, two quartz-filled faults striking 340 degrees and dipping 80 degrees east form a 100-foot (30 m) high ridge on the crest of which is the lode. The western fault splits to form a cymoid loop structure with the ore body on the western branch of the split. The wall rock of the lode is sheared lava and tuff.

The reef carries lead minerals over a length of 1,000 feet (300 m) and has been mined to depth over a distance of 500 feet (150 m). Reported ore widths range from 2 to 7.5 feet (61 cm to 2.3 m) in a lode channel up to 14 feet (4.2 m) wide.

Description of Workings

Early work in the period 1925 to 1928 was done from two shafts, one 40 feet (12.1 m) and the other 110 feet (33.5 m) deep, sunk on the cap of the lode. Mining carried out from 1947 to 1950 was from an open-cut near the south end of the shoot and from two adits driven into the side of the ridge. In 1950, Anglo Westralian Pty.

Ltd. took an option over the claim and, after digging a large number of costeans to test the surface of the lode, sank a vertical shaft on the west side of the ridge to a depth of about 115 feet (35 m). The collar of the shaft was 45 feet (13.7 m) below the outcrop of the reef, so when a cross-cut was driven 110 feet (34 m) easterly from the shaft at 105 feet (32.0 m), it cut the reef 150 feet (45.7 m) below its cap. The 150-foot (45.7 m) level was driven for 210 feet (64 m) north and 190 feet (58 m) south of the cross-cut. After the Company relinquished its option, the mine owners stoped out the reef from the 150-foot (45.7 m) level to the surface, but there is no record that they mined deeper than 150 feet.

Diamond Drilling

Five diamond drillholes were put down to test the lode on M.C. 288; two in 1928 by the Mines Department in conjunction with private interests and three by Anglo Westralian Pty. Ltd. in about 1951.

Government drillhole No. 1 sited 225 feet (69 m) on a bearing of 189 degrees from the main shaft, was drilled on an azimuth of 066 degrees at a depressed angle of 43 degrees to 500 feet (152.4 m). It cut

quartz between 386 and 394 feet (117.7 and 120.1 m). Part of the core between 388 and 394 feet (118.2 and 120.1 m) assayed 2 per cent lead and 10 grains of silver per ton (0.65 gm per tonne), but the width of the mineralized section is not recorded.

Government drillhole No. 2 was drilled from a position 410 feet (124.9 m), bearing 311 degrees, from the main shaft on an azimuth of 078 degrees and a depressed inclination of 43 degrees. It cut sulphide minerals between 323 and 332 feet (98.5 and 101.2 m). Sections of the core were assayed with the results shown in Table 29.

The true width of the intersection was about 6 feet (1.8 m).

Anglo Westralian Hole No. 1 was drilled from a site 315 feet (96.0 m), bearing 066 degrees, from the main shaft on an azimuth of 245 degrees and a depression of 60 degrees. It cut the reef at a vertical depth of 350 feet (106.6 m) below its outcrop. The intersection assayed 1.5 per cent lead and 0.5 per cent zinc over a drill length of 36 inches (91 cm) or about 2 feet (61 cm) true width.

Anglo Westralian Hole No. 2 drilled from the same site as number 1, but depressed at only 45 degrees, cut the lode at 240

TABLE 29. ASSAY RESULTS, GOVERNMENT DRILLHOLE NO. 2, RAGGED HILLS MINE

Section (feet)	Lead Per cent	Silver F. oz./ ton	Gold Dwts/ ton	Zinc Per cent
323 to 327	Tr	0.10	0.21	2.98
327 to 329	Tr	0.12	0.21	5.51
329 to 332	6.5	0.38	nil	3.11

NOTE: 1 foot = 0.3048 metres
 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

feet (73.1 m) vertical depth beneath the outcrop. Its intersection assayed 8.1 per cent lead, 4.6 per cent zinc and 0.2 ounces per ton (6.2 gm per tonne) of silver over a horizontal width of 6 feet (1.8 m).

Anglo Westralian Hole No. 3 sited 270 feet (82.2 m) on a bearing of 022 degrees from the main shaft, was drilled on an azimuth of 240 degrees at an angle of 66 degrees to cut the lode at a vertical depth of 250 feet (76.2 m) below the outcrop. The lode intersection assayed 1.2 per cent lead, 2.7 per cent zinc and nil silver over a horizontal width of 93 inches (236 cm).

A fourth hole drilled by Anglo Westralia was abandoned before reaching the reef.

Assays: Finucane (1938) reported the positions and assay results of about 22 samples taken from the reef. As the part of the lode sampled has now been mined out, the details are not repeated here. The average of all the samples was 27.12 per cent lead and 3.56 ounces per ton (110.72 gm per tonne) of silver over a mean width of 43 inches (106 cm).

Mineral Claim 206

Two small shoots of lead and copper ore have been worked to shallow depths on M.C. 206.

The *northern shoot* is about 100 feet (30 m) long and 4 feet (1.2 m) wide with patches of galena. It was mined from an open-cut 20 feet (6.0 m) long. Two samples from the shoot assayed respectively 7.0 per cent lead with 0.5 ounces per ton (15.55 gm per tonne) of silver over 40 inches (101 cm) and 3.33 per cent lead with 0.2 ounces per ton (6.22 gm per tonne) of silver over 50 inches (127 cm). A Government sponsored hole drilled beneath the shoot encountered quartz and sheared basalt, but no ore minerals.

The *southern shoot* has been tested by a few pits and one diamond drillhole. It is 80 feet (24 m) long and contains chiefly copper minerals. Two samples assayed 22.5 per cent copper with 1.07 ounces of silver per ton (33.28 gm per tonne) and 7.6 per cent copper with 0.7 ounces of silver per ton (21.77 gm per tonne). Government drillhole No. 3 drilled from a position 200 feet (69 m) west of the shoot, intersected low-grade reef comprising quartz with galena between 402 and 433 feet (123.5 and 132.0 m). No assays are available, but it was stated that no payable ore was found.

RAGGED HILLS EAST LINE

(M.C.s. 8, 450 etc.)

A total of 67 tons (68.0 tonnes) of lead was mined from a number of small shoots on a line of echelon quartz reefs located northeast of the Ragged Hills mine. These workings have been called the East Line by earlier writers, but the more specific name "Ragged Hills East Line" is preferred. The northern part of the line is in M.C. 8, and the southern part has been covered by a number of tenements at various times.

The ore shoots are all on quartz veins striking north-northwest and dipping steeply eastwards in a coarse-grained dolerite host rock. The terminology used for the shoots here follows as closely as possible, that employed by Finucane (1938). However, there are changes due to work done on the field since Finucane's report.

Northern Shoot

The northernmost shoot on the East Line is on M.C. 8, immediately north of a pool on a bend in Yownama Creek. Patches of galena are scattered throughout a quartz vein 1 to 3 feet (30 to 91 cm) wide and about 400 feet (122 m) long. The better

TABLE 30. ASSAY RESULTS FROM NORTH SHOOT, RAGGED HILLS EAST LINE

Location (feet)	Width (inches)	Lead Per cent	Silver F. oz./ ton
0	48	0.22	0.17
20	26	8.67	0.34
40	18	0.63	0.20
75	16	2.39	0.24
100	24	12.38	0.73
150	12	1.78	0.14
180	34	Tr	0.02
230	28	2.98	0.11
290	24	14.99	1.20
330	28	0.39	0.06
Average...	26	4.0	0.41

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

section of the reef has been trenched for a distance of 200 feet (61 m).

Assays of 10 samples reported by Finucane are listed in Table 30 above. Their locations are given as the distance from the southern end of the exposure of the reef.

No. 1 Shoot

One thousand feet (300 m) south-southeast of the northern shoot, a reef 6 to 24 inches (15 to 61 cm) wide has been opened up over a length of 140 feet (43 m) to a maximum depth of 10 feet (3 m).

TABLE 31. ASSAY RESULTS FROM NO. 1 SHOOT, RAGGED HILLS EAST LINE

Location Feet N or S	Width Inches	Lead Per cent	Zinc Per cent	Silver F. oz./ ton
180 N	16	0.13	....	0.16
160 N	12	17.69	....	0.97
150 N	12	7.08	0.33	0.62
140 N	18	11.98	....	0.58
100 N	16	8.08	....	0.45
75 N	24	Tr	....	0.10
5 N	9	2.44	....	0.10
20 S	24	14.49	....	0.65
50 S	17	11.11	....	0.70
70 S	16	26.96	....	1.39

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

TABLE 32. ASSAY RESULTS FROM NO. 2 SHOOT, RAGGED HILLS EAST LINE

Position Feet N	Width Inches	Lead Per cent	Silver F. oz./ ton
10	14	29.82	2.28
30	34	8.01	0.49
60	21	31.28	1.93
90	13	28.77	2.05
150	16	12.54	0.92
210	18	27.55	2.04
240	12	31.49	2.25
260	12	8.37	0.59
290	22	25.75	1.39
320	20	7.55	0.50
360	9	5.30	0.29
400	12	14.60	0.45
450	9	20.38	1.68
480	16	1.56	0.02
520	14	1.42	0.01

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

Southwards from the workings the reef was tested for a further 200 feet (60 m) by shallow workings and this section includes the No. 1 Shoot of Finucane.

Assay results of 10 samples from the reef are given in Table 31. Their locations are given with respect to a small gully which cuts the outcrop of the vein.

No. 2 Shoot

About 700 feet (213 m) south of the workings on the No. 1 Shoot is a line of open-cuts 285 feet (86.8 m) long on a galena-bearing quartz reef 15 inches (38.1 cm) wide striking at 335 degrees and dipping steeply east. The depths of the cuts range from 2 to 20 feet (61 cm to 6.0 m). Northwards from the cuts the reef can be traced for 160 feet (49 m) and contains small amounts of galena over much of that

distance. South of the cuts the vein disappears beneath creek sediments.

Assays of samples taken by Finucane are listed in Table 32; their positions are given with respect to the creek at the south end of the workings.

The average of the reef from 0 to 450 feet (137 m) north is 19 per cent lead and 1.3 ounces of silver per ton (40.43 gm per tonne) over 16 inches (40.6 cm).

One sample from an ore dump on the shoot returned 19.8 per cent lead, 0.39 per cent zinc and 1.83 ounces of silver per ton (56.92 gm per tonne).

No. 3 Shoot

The No. 3 Shoot is 400 feet (120 m) south of the No. 2 Shoot and on the same line of reef. It has been mined over a length of 140 feet (43 m) from trenches and an

TABLE 33. ASSAY RESULTS FROM NO. 3 SHOOT, RAGGED HILLS EAST LINE

Position from N. end of Reef	Width Inches	Lead Per cent	Silver F. oz./ ton
20 S 	18	25.84	2.19
55 S 	9	45.67	5.06
70 S 	12	53.94	5.89
100 S 	16	45.59	5.14
125 S 	12	34.03	3.09

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

open-cut 60 feet (18 m) long and 12 feet (3.6 m) deep. The reef ranges from 6 to 18 inches (15.2 to 45.7 cm) in width, strikes at 335 degrees, dips 80 degrees east and is in coarse-grained dolerite.

Assay results of samples taken by Finucane showed the reef to average 39.7 per cent lead and 4.1 ounces per ton (127.52 gm per tonne) of silver over a length of 100 feet (30.4 m). Details of the samples are listed in Table 33, although it should be noted that the sampled part of the

reef has since been mined to a depth of 10 or 12 feet (3 or 4 m) below the outcrop.

One sample taken in 1968 from the bottom of the open-cut assayed 50.6 per cent lead, 0.22 per cent zinc and 7.2 ounces per ton (223.94 gm per tonne) of silver over a width of 6 inches (15.2 cm).

No. 4 Shoot

Four hundred feet (120 m) south of the No. 3 Shoot, a reef has been trenced over a length of 200 feet (60 m) to depths

TABLE 34. ASSAY RESULTS FROM NO. 4 SHOOT, RAGGED HILLS EAST LINE

Position, Feet S. of North End	Width Inches	Lead Per cent	Silver F. oz./ ton
20 	12	9.86	0.40
40 	10	24.20	1.17
60 	12	9.92	0.48
110 	12	4.64	0.25
130 	9	9.60	0.46
170 	14	26.49	1.31

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

of up to 6 feet (1.8 m). This is the No. 4 Shoot. Galena is disseminated more or less evenly throughout the quartz. Samples of the outcrop taken by Finucane averaged 14.4 per cent lead and 0.7 ounces per ton (21.77 gm per tonne) of silver over a mean width of 11 inches (27.9 cm) and a length of 150 feet (47 m).

Assay results of the outcrop samples are listed in Table 34. One sample from the dump of the trench assayed 15.5 per cent lead, 0.02 per cent zinc and 0.9 ounces per ton (27.99 gm per tonne) of silver.

No. 5 Shoot

Southwards from the No. 4 Shoot the reef contains only low lead values for a distance of 300 feet (90 m), but beyond this there is another richer section called the No. 5 Shoot. It is 130 feet (40 m) long and averages 15.2 per cent lead and 0.81 ounces per ton (25.19 gm per tonne) of silver over a mean width of 26 inches (79.3 cm).

Assays of samples taken by Finucane are listed in Table 35. Their positions are

given with reference to the north end of the shoot which is 100 feet (30 m) south of a small gully crossing the outcrop of the reef.

DEVONS CUT WORKINGS (M.C. 267)

The workings known as Devons Cut are 6.5 miles (10.5 km) north-northwest of the Ragged Hills mine and are reached from there by a faint track. Total production from the workings is 34 tons (34.5 tonnes) of lead and 240 ounces (7,464.7 gm) of silver.

Several large quartz reefs traverse the area of M.C. 267 and of the adjacent M.C. 78 to the south. Workings are restricted to a length of 100 feet (30 m) on the main reef, although lead minerals are present over about 150 feet (46 m). The reef strikes at 325 degrees and dips 80 to 85 degrees east where worked.

The deepest opening is a shaft sunk to 60 feet (18.2 m) at the northern end of the shoot. Twenty-five feet (7.6 m) south of the shaft there is an open-cut 30 feet (9.1 m) long and 20 feet (6.0 m) deep. The remainder of the reef has been tested only by pits.

TABLE 35. ASSAY RESULTS FROM NO. 5 SHOOT, RAGGED HILLS EAST LINE

Position (feet S)	Width (inches)	Lead Per cent	Silver F. oz./ ton
0	12	9.02	0.54
25	27	16.82	1.07
50	28	21.43	1.40
75	24	4.79	0.31
100	30	22.22	0.83
125	18	1.31	0.02

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

Minerals seen in the mine were angle-site, cerussite and oxidized zinc and copper minerals.

Assays of eight samples are listed in Table 36.

MOUNT BROCKMAN GROUP

Three small mines located 3 miles (4.8 km) north-northwest of Devons Cut form the Mount Brockman group. Total production from the group is recorded as 52 tons (52.8 tonnes) of lead and 566 ounces (17,604.2 gm) of silver, but the contribution made by each mine is not recorded.

Mineral Claim 170

Mineral Claim 170 is the easternmost claim of the group and covers the area described by Finucane as "M.C. 77 and vicinity". It includes some shallow workings extending for 150 feet (46 m) along the top of a ridge formed by a silicified fault zone. The vein, which is on the footwall side of the fault, strikes at 320 degrees and dips 75 degrees northeast. At its north-eastern end it has been trenched to a depth of 5 feet (1.5 m) over a distance of 25 feet

(7.5 m). In the ends of the trench the vein is from 6 to 12 inches (15.2 to 30.4 cm) wide, but probably a pod 3 feet (91 cm) wide was mined from the central part of the trench. Finucane estimated the grade of the shoot to be 18 per cent lead and 1.5 ounces per ton (46.65 gm per tonne) of silver over a width of 23 inches (58.4 cm) and a length of 30 feet (9 m).

One hundred feet (30 m) south of the trench the silicified fault forms a prominent outcrop from which about 6 inches (15.2 cm) of galena-bearing quartz has been stripped over a length of 40 feet (12 m). The vesicular basalt which makes up the wall rock has been leached for several feet from the fault zone.

Assays of three samples taken at 15-foot (4.5 m) intervals are from north to south: 13.27 per cent lead and 0.81 ounces per ton (25.19 gm per tonne) of silver over 17 inches (43.1 cm); 30.68 per cent lead and 3.48 ounces per ton (108.23 gm per tonne) of silver over 18 inches (45.7 cm); and 13.49 per cent lead and 0.77 ounces per ton (23.94 gm per tonne) of silver over 33 inches (83.8 cm).

TABLE 36. ASSAY RESULTS—DEVONS CUT WORKINGS

Position	Width (inches)	Lead Per cent	Zinc Per cent	Silver F. oz./ ton
Bottom 60-foot shaft	31	0.45	....	0.05
10 feet south of shaft	46	7.81	....	0.43
25 feet south of shaft	56	18.18	....	1.90
45 feet south of shaft in bottom of former 22-foot shaft	56	30.59	....	3.28
60 feet south of 60-foot shaft	60	18.87	....	1.03
100 feet south of 60-foot shaft	40	7.23	....	0.18
North face of open-cut at 20-foot depth	20	9.43	12.6	1.17
South face of cut at 15-foot depth	27	15.6	0.52	0.26

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

Mineral Claim 171

Mineral claim 171 (formerly M.L. 325) is 1 mile (1.6 km) west of M.C. 170 on a prominent line of quartz reefs. Near the centre of the lease, galena is present over a length of 190 feet (58 m) on the footwall of the reef which dips east. It has been worked from an open-cut 50 feet (15.2 m) long, 12 feet (3.6 m) deep and 4 feet (1.2 m) wide and further tested by several pits. Four samples taken by Finucane averaged 29 per cent lead and 1.6 ounces per ton (49.76 gm per tonne) of silver over a mean width of 30 inches (76.2 cm).

Floater of high grade galena can be picked up along the outcrop of a narrow reef for a distance of 20 or 30 feet (6 or 9 m) near the northern boundary of the claim.

Assays of the samples taken by Finucane are listed in Table 37. One further sample of the galena float at the northern end of the claim assayed 54.8 per cent lead, 0.01 per cent zinc and 1.0 ounces of silver per ton (31.10 gm per tonne).

Drillhole No. 5 put down by the Government in 1928 was sited 200 feet

(60 m) southwest of the reef and drilled at a depressed angle of 47 degrees to 425 feet (129.5 m). No galena or other ore minerals were found in the core.

Mineral Claim 185

The workings on M.C. 185 (formerly M.L. 325) are 1 mile (1.6 km) north-northwest of M.C. 171 on the same line of quartz veins. Lead minerals have been mined from a section 12 to 30 inches (30.4 to 76.2 cm) wide on the hanging wall side of the main reef which here strikes at 330 degrees and dips 80 degrees east. Mining was carried out from either side of an underlay shaft over a total length of 20 feet (6.0 m) and a depth of 25 feet (7.6 m).

Assays: Two samples taken by Finucane yielded 29.8 per cent lead with 1.70 ounces per ton (52.87 gm per tonne) of silver over 50 inches (127.0 cm) and 12.5 per cent lead with 0.5 ounces per ton (15.55 gm per tonne) of silver over 33 inches (83.8 cm) width respectively. One recent sample taken over 12 inches (30.4 cm) from the south end of the open-cut assayed 30.7 per cent lead, 0.02 per cent zinc and 1.73 ounces per ton (53.81 gm per tonne) of silver.

TABLE 37. ASSAY RESULTS—M.C. 171 BRAESIDE

Location	No.	Width (inches)	Lead Per cent	Silver F. oz./ ton
North end of shoot	1	15	39.1	2.44
20 feet S of (1)	2	30	33.2	1.81
20 feet S of (2)	3	45	19.5	1.17
50 feet S of (3)	4	31	33.9	1.49

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

Drilling done by the Government in 1928 consisted of one hole (No. 8), sited 200 feet (60 m) east of the shoot and drilled at an angle of 55 degrees to 350 feet (106.6 m) which located silicified basalt between 305 and 320 feet (92.9 and 97.5 m) but found no galena.

LIGHTNING RIDGE GROUP

(M.C. 215 etc.)

The Lightning Ridge group of lead mines has also been called Moxom Well workings. It is 3.5 miles (5.6 km) north of M.C. 185 and reached by a faint, and in many places, washed out track. Total production from the group is 19 tons (19.3 tonnes) of lead and 86 ounces (2,674.7 gm) of silver.

The mines follow a quartz-filled fault which can be traced for 3,500 feet (1,070 m) on a bearing of 290 degrees. The dip of the fault ranges from steeply north to steeply south. Traces of lead and copper minerals are present in many parts of the reef, but mining is restricted to a few richer patches, the chief of which is near the western end of the outcrop. Other small shoots spread over a length of 2,600 feet (790 m) have contributed but little ore.

Western Shoot

The western shoot is on the footwall side of the fault zone which at this point is 15 to 20 feet (4.5 to 6 m) wide. Workings extend for about 100 feet (30 m) easterly up the side of a ridge from a small creek which cuts the reef. They comprise open-cuts and stopes sunk to water level, which varies from 5 feet (1.5 m) at the western end to 20 feet (6.0 m) at the eastern end of the shoot. The average width of the vein is about 15 inches (38.1 cm).

At the eastern end of the open-cut the vein is 12 inches (30.4 cm) wide and has a central galena-rich band 6 inches (15.2 cm) wide, flanked by bands containing both copper and lead minerals. Ore minerals noted on the dumps and in the workings were galena, chalcopyrite, bornite, covellite and malachite. A little pyrite was also present.

Assays of five samples are listed in Table 38 below.

Middle Shoot

The middle shoot which is 1,300 feet (400 m) east of the western shoot, has been benched over a length of 80 feet (24 m) where exposed on a near dip-slope on the steep side of a spur formed on the

TABLE 38. ASSAY RESULTS FROM WESTERN SHOOT, LIGHTNING RIDGE

Location	Width (inches)	Lead Per cent	Zinc Per cent	Silver F. oz./ ton
Midway along shoot	10	29.0	....	1.0
East end of stope	12	16.3	0.29	1.6
Grab from dump (1938) ....	....	25.4	....	1.0
Grab from dump (1968) ....	....	19.4	1.32	0.8
Pit 250 feet east of stope	10	33.8	....	1.2

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

fault. Patches of galena are present in the vein, but it is likely that mining was possible only because of the ease with which the vein could be stripped from its outcrop. The width of the vein is from 3 to 5 inches (7.6 to 12.8 cm).

About 250 feet (76 m) further east the same vein was trenched for 10 feet (3 m) where it is 15 inches (38.1 cm) wide with a seam of galena on its footwall side.

Eastern Shoot

The eastern shoot is 1,200 feet (370 m) east of the middle shoot. A few pits up to 6 to 8 feet (1.8 to 2.4 m) deep extend over about 150 feet (46 m) and are the only workings.

Assays of two samples taken by Finucane returned values of 15.75 per cent lead with 0.25 ounces (7.77 gm) of silver and 27.6 per cent lead with 0.7 ounces per ton (21.77 gm per tonne) of silver over widths of 28 and 27 inches (71.1 and 68.6 cm) respectively.

GOSSAN HILL PROSPECT (M.L. 327)

Gossan Hill, 4 miles (6.4 km) north of Lightning Ridge, is a prominent ridge formed on a 40-foot (12.1 m) wide fault zone striking 325 degrees. The fault zone comprises iron and manganese-stained siliceous breccia which has some resemblance to a true gossan, but contains no identifiable boxworks after sulphides. The iron and manganese minerals and the vugs may have resulted from the leaching of original carbonate minerals in the breccia.

Two shafts were sunk 480 feet (146 m) apart on the outcrop of the fault breccia, the northern one to 23 feet (7.0 m) and the southern one to 135 feet (41.1 m). Assays of samples from each shaft returned negligible values of lead and silver.

BARKER WELL GROUP (M.C. 194 etc.)

The Barker Well group includes the area of M.L. 291 reported on by Finucane (1938). It is 8.5 miles (13.7 km) north of the Lightning Ridge group and at the northern end of the Braeside lead field. Most of the 21 tons (21.3 tonnes) of lead recorded from the group has come from M.C. 194 and the remainder from M.C. 216. There was no recorded production from M.C. 79, the third claim in the group. Two Government sponsored drillholes were bored on M.C. 194 in 1928.

Mineral Claim 194

Mineral Claim 194, formerly M.L. 291, covers three small ore shoots in a group of quartz veins striking at 340 degrees. A dolerite dyke crops out to the west of the ore bodies.

The *north shoot* is about 100 feet (30 m) long and 2.5 feet (76 cm) wide. It has been worked over a distance of 80 feet (24.3 m) by shallow pits and one shaft 20 feet (6.0 m) deep. It contains galena and a trace of copper.

The *middle shoot* is on a vein which has been traced for 210 feet (64 m) on the surface, but only tested by a few pits. Two narrow parallel veins which crop out 25 and 27 feet (7.6 and 8.2 m) east of the main reef also carry some galena.

The *southern shoot* is on a vein 200 feet (60 m) long which has been mined at its southern end, where it is 2.5 feet (76 cm) wide from a 24-foot (7.3 m) deep shaft and a shallow open-cut.

Assays of samples taken from the claim are listed in Table 39 below.

Diamond drilling: Government drill-hole No. 9 was drilled from a site 170 feet (51.8 m) east of the south shoot to a depth of 400 feet (121.9 m) at a depressed angle

TABLE 39. ASSAY RESULTS FROM M.C. 194, BRAESIDE LEAD FIELD

Location	Width (inches)	Lead Per cent	Zinc Per cent	Silver F. oz./ ton
North shoot	55	21.7	0.9	....
North shoot ore dump	....	43.7	0.6	1.5
Middle shoot	22	28.8	....	1.1
Middle shoot, vein 25 feet E	19	33.5	....	0.9
Middle shoot, vein 27 feet E	16	18.6	....	0.6
South shoot (pit)	24	12.2	....	0.4
South shoot, average of 3 samples in shaft	60	21.0	....	0.5

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

of 58 degrees. Four inches (10.2 cm) of core at 366 feet (111.5 m) assayed 2.2 per cent lead and 0.06 ounces per ton (18.66 gm per tonne) of silver.

Government drillhole No. 10 was sited 25 feet (7.6 m) west of the north shoot and drilled at an angle of 68 degrees to 209 feet (63.6 m). Between 92.7 and 100 feet (28.25 and 30.5 m) it cut reef matter assaying 48.6 per cent lead, 5.5 per cent zinc and 1.30 ounces per ton (40.43 gm per tonne) of silver over a true width of 32 inches (81.2 cm).

Mineral Claim 216

On M.C. 216, about 25 chains (500 m) south-southwest of the workings on M.C. 194, a little lead has been mined from a quartz vein 6 to 12 inches (15.2 to 30.4 cm wide), striking 320 degrees and dipping steeply east. Galena is present in patches over a distance of 200 feet (61 m). Workings consist of a 6-foot (1.8 m) deep pit and shallow potholes over a length of 50 feet (15.2 m).

Assay results of a sample from the pit returned 9.6 per cent lead, 0.03 per cent

zinc and 0.3 ounces per ton (9.33 gm per tonne) of silver over a width of 12 inches (30.4 cm).

Mineral Claim 79

Sixty chains (1,210 m) north of the workings on M.C. 194 and on a continuation of the same reef, galena has been prospected over a distance of 140 feet (43 m). In general the grade is low and the reef narrow, but some good-grade ore has been gouged from a few shallow pits.

KOONGALIN HILL DEPOSITS

(M.C.s 186 and 195)

The Koongalin Hill (or Koongalling Hill) deposits comprise one former mine and one prospect. They are 2 miles (3.2 km) east-northeast of the Lightning Ridge group, but access is by way of a track from the Barker Well group. Finucane called the main deposit Koongalin Hill and the prospect, Koongalin North. On the Mines Department lease plans, the main deposit is called Koongalin North. This report retains Finucane's names.

TABLE 40. ASSAY RESULTS FROM KOONGALIN HILL MINE

Location (feet S)	Width (inches)	Lead Per cent	Zinc Per cent	Silver F. oz./ ton
0	10	24.0	....	0.6
10	15	67.3	....	6.7
150	15	37.2	....	5.6
165	12	29.0	0.04	4.9
175	10	49.8	....	6.0
260	20	35.6	....	6.6
300	21	15.5	....	2.4
440 (top of shaft)	6	71.0	....	7.1
440 (middle of shaft)	32	35.5	....	3.4
440 (bottom of shaft)	32	27.1	....	1.9
500	12	20.7	....	5.7
540	35	16.6	....	2.5

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

Total recorded production from the deposits is 34 tons (34.5 tonnes) of lead and 9 ounces (279.9 gm) of silver.

Koongalin Hill Mine

The ore worked in the Koongalin Hill mine follows a quartz vein striking 300 degrees and linking two barren quartz veins which trend at 340 degrees. The vein has been worked over a length of about 600 feet (180 m) from two shafts (now collapsed) and several shallow open-cuts. The vein varies from 6 to 12 inches (15.2 to 30.4 cm) wide and carries patches of galena and a trace of copper. The host rock is vesicular basalt.

Assays: The positions of the assayed samples listed in Table 40 are given with respect to the deeper shaft at the north-western end of the workings.

The average of all samples except the 6 inches (15.2 cm) of galena at the top of the shaft at 440 feet (134.0 m), is 31.7

per cent lead and 3.8 ounces per ton (118.18 gm per tonne) of silver over a mean width of 19 inches (48.3 cm).

North Koongalin Prospect

Approximately 1.3 miles (2 km) north of the Koongalin Hill mine is a prominent ridge formed by a group of quartz veins. One vein contains patches of galena and some copper carbonates over a length of 580 feet (177 m). The only openings on the reef are two or three shallow pits.

Assays of four samples taken by Finucane are listed in Table 41; the positions of the samples are given with reference to the southern-most pit on the line.

PROSPECTING AREAS 2257 and 2258

Two miles (3.2 km) north of the Ragged Hills mine on the northern extension of the Ragged Hills East Line, about 5 tons (5 tonnes) of lead were mined from a

TABLE 41. ASSAY RESULTS FROM NORTH KOONGALIN PROSPECT

Position (feet N)	Width (inches)	Lead Per cent	Silver F. oz./ ton
0	15	27.1	0.6
110	27	12.9	0.4
310	27	24.6	0.8
450	27	22.4	0.4
Average	24	21.1	0.56

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

number of shallow openings within P.A.s 2257 and 2258. The largest working is a trench 50 feet (15 m) long on a 3 to 4-inch (7.6 to 10.1 cm) wide quartz vein carrying patches of galena. On a parallel line 300 feet (90 m) north and 150 feet (46 m) west of the first, galena and copper minerals in a vein 6 to 12 inches (15.2 to 30.4 cm) wide were mined from a trench 30 feet (9 m) long and 5 feet (1.5 m) deep.

OTHER DEPOSITS IN THE PILBARA GOLDFIELD

DOOLEENA GAP MINE (M.C. 330)
(Lat. 20° 55' S, long. 119° 43' E).

The Dooleena Gap mine (called also the Coongan Siding mine) is 1.5 miles (2.4 km) north-northeast of Dooleena trigonometrical station and about 3 miles (4.8 km) by track southwesterly from Eginbah Station homestead. The mine was worked in 1955 to produce 5 tons (5.1 tonnes) of lead and 45 ounces (1,399.6 gm) of silver.

Reference: de la Hunty (1958).

Plan: G.S.W.A. No. 10888 shows the surface workings and geology.

On M.C. 330, lead minerals were mined from a fault zone which brings a 500-foot (150 m) thick sill of serpentinite on the east side into contact with metasediments and intrusive ultrabasic rocks on the west. The fault strikes at 038 degrees and dips 55 degrees easterly. It is parallel to a prominent dolerite dyke cropping out 30 chains (600 m) east of the mine.

In the vicinity of the workings the fault zone is from 20 to 30 feet (6 to 9 m) wide and is made up of sheared country rock with quartz veins and stockwork lenses. Mining activity was concentrated on the hanging wall side of the fault where a quartz vein 9 to 12 inches (22.8 to 30.4 cm) wide crops out for over 200 feet (60.9 m). Workings on this vein consist of two shallow open-cuts and a 62-foot (18.8 m) deep vertical shaft spaced over a total length of 130 feet (39.6 m). The other veins and stockworks were costeamed in places but were too low grade to be mined.

Assay results of three samples taken from the mine are listed in Table 42 below.

TABLE 42. ASSAY RESULTS FROM DOOLEENA GAP MINE

Location	Width	Lead Per cent	Zinc Per cent	Silver F. oz./ ton
Ore dump	....	37.6	0.02	6.8
Stockwork outcrop	10'	8.9	0.01	1.4
Open-cut on hanging wall vein	12"	40.1	0.01	6.8

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

LENNON FIND PROSPECT (M.C. 232 etc.)
 (Lat. 21° 22' S, long. 120° 14' E).

The Lennon Find copper, zinc and lead deposits are 4.5 miles (7.2 km) northeast of the Yandicoogina gold mining centre and 9.5 miles (15.2 km) south-southeast of Mount Edgar trigonometrical station. Access is by way of a track branching northwards from the Meentheena Road (leaving the Great Northern Highway 3 miles (4.8 km) south of Mount Edgar Station homestead) at Wilina Well. The deposits are about 2 miles (3.2 km) from the well and 38 miles (61.2 km) by road from Marble Bar. They lie on the northern slope of a line of north-east trending ridges.

Although discovered in about 1907 and worked in a small way at that time, the only recorded production is in the period 1951 to 1960 when about 30 tons (30.5 tonnes) of copper ore and 20 tons (20.3 tonnes) of zinc ore were raised, to realise 4.9 tons (4.97 tonnes) of copper and 2.2 tons (2.24 tonnes) of zinc. Lead, silver and gold have been recorded in assayed samples of the ore, but none has been won commercially from the deposits.

At the time of writing, the deposits are being investigated by Cominco Exploration

Ltd., who have carried out a geophysical survey and plan some drilling to test the primary ore zone.

References: Montgomery (1907), Simpson (1951 and 1952), and Low (1963).

Plan: The Nullagine 4-mile to 1 inch Geological Sheet shows the regional geological setting of the deposits.

Geological Information

The Lennon Find copper-lead-zinc deposits are stratiform, lenticular bodies within a unit of fine-grained sericite schist and calcisilicate rocks, forming part of a sequence of metamorphosed sediments, lavas and tuffs of Archaean age. A large granite pluton intrudes the metamorphic rocks north and west of the deposits. The beds which enclose the ore lenses strike 055 degrees and dip 40 to 60 degrees southeast.

Ore deposits have been worked on two horizons within the metasediments. The main horizon varies from 5 feet (1.5 m) to almost nothing in thickness and where mineralized is represented by ferruginous gossan. Where barren it may consist of marble, sugary quartz, or nothing. Immediately below the main horizon is a persist-

TABLE 43. STRATIGRAPHIC SECTION ABOUT LODGE HORIZONS, ST. PATRICK MINE

Description	Thickness (feet)
Schistose basalt and basic tuff	Large (1,000+)
Prominent chert bed	2
Interbedded calc-silicate rock and fine-grained sericite schist	80
Main lode horizon comprising gossan, marble or quartz	0 to 5
Calc-silicate rock with thin chert beds near top	15
Lower lode horizon	1
Fine-grained, white sericite schist with lenses of sheared volcanic rocks	30
Medium to coarse-grained quartz-muscovite schist	160+

NOTE: 1 foot = 0.3048 metres

ent group of thin chert beds, which serve as a stratigraphic marker and allow the horizon to be traced where other features are absent. The main horizon has been traced for a total distance of 12,000 feet (3,660 m) and has been worked in five places along its outcrop.

The second horizon, 15 feet (4.6 m) stratigraphically below the first, is about 1 foot (30 cm) thick. It contains copper minerals in several places, but has been worked in only one spot. A section measured about the lode horizons near the Saint Patrick mine is documented in Table 43.

Geologists of Cominco Exploration Ltd. report the same horizon to be present near the old Yandicoogina gold workings and have traced it for over 1 mile (1.6 km) in that locality.

Mineralogy of the Ore

None of the openings on the gossans penetrate below the oxidized zone, so the mineral content of the primary lode material is not known. Oxidized ore minerals noted in the deposits are malachite, chrysocolla, anglesite, cerussite and hemimorphite. Box-works after pyrite can be seen in places.

Description of Ore Shoots

Four groups of workings on richer sections of the lode were examined by the writer. Montgomery (1907) described a fifth shoot on the Ribbon lease at the northern end of the line. In the absence of lease pegs it was not possible to relate the workings to the descriptions in previous reports. However, it is thought that the No. 3 shoot described below is the old Saint Patrick mine and the site of the original find by Lennon.

The *No. 1 shoot* is probably on former M.L. 149 and is the most southwesterly deposit worked on the line. The lode is 4.5 feet (1.3 m) wide and comprises granular and massive quartz, calcite and iron oxides with anglesite, cerussite and hemimorphite. It is about 100 feet (30 m) long, pinching out in either direction from the workings. The only openings are one or two pits and an inclined shaft 12 feet (3.7 m) deep.

The *No. 2 shoot* is 1,500 feet (460 m) northeast of the first and on the same horizon. It has been worked to shallow depths for about 500 feet (150 m) along the strike and contains copper, lead and zinc minerals.

The *No. 3 shoot* as mentioned above is probably the old Saint Patrick mine. It is 4,000 feet (1,220 m) northeast of the No. 2 shoot and on the main lode horizon. Where worked it is from 1.5 to 2.5 feet (46 to 76 cm) wide, dips 55 degrees southeast and contains copper and zinc minerals. Lead is less abundant than in the more southerly shoots. The shoot has been worked at intervals over a length of 250 feet (76 m) from three open-cuts ranging from 10 to 25 feet (3.0 to 7.6 m) in depth.

Five hundred feet (150 m) northeast of these workings, a shaft has been sunk 15 feet (4.5 m) in the lower lode horizon on a vein of copper ore about 1 foot (30 cm) wide.

The *No. 4 shoot*, 1,000 feet (300 m) further northeast along the line of lode, has an average width of about 3 feet (91 cm) and has been mined from an open-cut 40 feet (12 m) long and 20 feet (6 m) deep. Another lens of lode carrying copper, lead and zinc crops out 400 feet (120 m) north-

east of the No. 4 shoot, but has been tested only by small pits.

The *Ribbon shoot* on former M.L. 143, is stated by Montgomery (op. cit.) to be 1 mile (1.6 km) north of the Saint Patrick mine. It is made up of 12 to 24 inches (30.4 to 60.9 cm) of lode in a much wider body of silicified malachite-stained schist.

Assays: The results of 10 assays given by Montgomery and of two samples analyzed recently, are listed in Table 44.

Origin of the Deposits

The most likely origin of these strictly stratigraphic ore bodies seems, to the writer, to be from sulphide minerals deposited during a period of chemical sedimentation between two stages of volcanic activity. The source of the metals and sulphur was probably fumerolic discharges into the sea water. Other explanations, such as replacement of a favourable bed by hydrothermal fluids derived from the granite or from later vol-

TABLE 44. ASSAY RESULTS—LENNON FIND DEPOSITS

Location	Copper Per cent	Lead Per cent	Zinc Per cent	Silver F. oz./ ton	Gold F. oz./ ton
St. Patrick lease	14.61	0.39	16.33	23.17	0.035
St. Patrick lease	17.20	1.66	6.93	20.93	0.027
St. Patrick lease	5.33	2.79	5.52	4.69	0.035
P.A. 151, north of St. Patrick lease	6.68	3.85	4.45	2.42	0.035
P.A. 151	6.40	5.55	8.37	12.07	0.035
Ribbon lease	6.01	0.36	0.86	5.41	0.02
M.L. 149	nil	13.89	0.37	39.72	0.081
St. Patrick?	11.10	2.39	....	6.09	0.027
St. Patrick?	12.81	2.57	....	21.12	0.027
St. Patrick from 7 tons of ore	18.23	0.76	....	22.61	0.051
No. 1 shoot chip sample over 4.5 feet	....	3.0	0.01	11.7	....
No. 1 shoot ore dump	....	6.6	0.03	595.0	....

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

canic rocks, are possible and the correct explanation is only likely to be found after a detailed examination of lode material obtained from beneath the oxidized zone.

BARRAMINE DEPOSIT

(Lat. 20° 56' S, long. 121° 03' E).

An old mine, 7.6 miles (12.1 km) south of the abandoned Barramine homestead, is reputed to have produced a small quantity of lead ore (Blatchford, 1925; Finucane, 1938). The mine is on the northern extension of the Braeside lead field on a quartz vein 3 to 4 feet (91 cm to 1.2 m) wide, striking 320 degrees and dipping steeply east in basic volcanic rocks of the Fortescue Group. Workings extend for 100 feet (30 m) along the vein. They consist of a shaft 35 feet (10.7 m) deep and a trench for 70 feet (20 m) along the outcrop. Although the dumps contain a fair amount of copper carbonate and chalcocite, no lead minerals were seen. Chemical tests of dump material showed only traces of lead.

Galena has been reported from the sludge of a water bore 0.6 miles (1 km) northwest of Barramine homestead. When inspected by the writer there was only one piece of galena in the vicinity of the bore

and this seemed too large to have come from the bore cuttings. Barramine was once on the route to the Braeside lead field and it is likely that the galena was left at this spot by travellers from that area.

NORTH POLE PROSPECT

In 1949, about 0.6 of a ton (0.61 tonne) of lead was produced from P.A. 2274 in the North Pole mining centre, 24 miles (38.0 km) west-northwest of Marble Bar. The location of the deposit is not recorded, but it is probably the same one that Simpson described at this locality. The vein contained coarsely crystallized galena associated with quartz and a little cerussite, malachite and barite.

Assays of several hand-picked concentrates published by Simpson are reproduced in Table 45.

ABYDOS PROSPECT

(Lat. 21° 36' S, long. 118° 55' E).

Local information suggests that the small production of lead ore from Crown Land on the Abydos pastoral lease came from a prospect located 2.7 miles (4.3 km) northwest of Woodstock outstation, about 200 yards (183 m) south of the road con-

TABLE 45. ASSAY RESULTS—NORTH POLE PROSPECT

Lead Per cent	Silver F. oz./ ton	Gold Dwts/ ton	Copper Per cent
84.7	6.12	Trace	n.d.
79.9	11.72	0.72	0.68
77.6	8.74	Trace	0.48
50.3	16.36	0.42	n.d.
16.3	13.54	5.00	2.46

NOTE: 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

necting the homestead to the Wittenoom-Port Hedland road.

The prospect is a narrow quartz vein cutting granite gneiss on a strike of 150 degrees and a dip of 90 degrees. Lead is present as galena, cerussite and anglesite disseminated in small bunches through the quartz. The vein was worked over a length of 100 feet (30 m) by means of a trench ranging from 1 to 8 feet (30 cm to 2.4 m) deep. Most of the quartz was of low tenor and the miners evidently picked out the small amount of better grade ore for shipment.

MEENTHEENA PROSPECT (M.C. 198)

(Lat. 21° 17' S, long. 120° 40' E).

Mineral Claim 198, reported as 20 miles (32 km) southeast of Meentheena homestead and 40 chains (205 m) north of Steel Well, produced 4 tons (4.1 tonnes) of lead. The station is now abandoned and no accurate description of the location of the deposit or of Steel Well could be obtained. Consequently the deposit was not inspected and no further details are known.

MISCELLANEOUS MINOR OCCURRENCES

Of the following lead occurrences, only those at Hillside, Duffer Creek, Lynas Find and Pilgangoora were inspected by the

writer. Details of the others are taken from Simpson (1951). Many of the localities given by the original prospectors when submitting their samples for assay are imprecise and the same occurrence may be included under more than one heading. For example the Cooglegong occurrence may be the same as the Hillside one.

Hillside Station

(Lat. 21° 37' S, long. 119° 26' E).

On the western slope of the Black Range, 7 miles (11.3 km) north-northwest of Hillside Station, two pods of coarse galena were found alongside a quartz vein in granite gneiss. The occurrence is about 50 feet (15 m) from the contact of the large dolerite dyke which forms the spine of the Black Range. Westward along its strike the quartz vein and some associated pegmatites contain tin and tantalum minerals.

Cooglegong

(Lat. 21° 37' S, long. 119° 30' E).

Some galena with quartz obtained from the Cooglegong district in 1910 was highly argentiferous, with an assay showing 69.3 per cent lead, 60.83 ounces per ton (1,891.89 gm per tonne) of silver and nil gold. A later sample from the same district

TABLE 46. ASSAY RESULTS—COOKES CREEK OCCURRENCE

	Lead Per cent	Silver F. oz./ ton	Gold Dwt/ ton
A 	21.8	0.37	Trace
B 	2.5	0.11	nil

NOTE: 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

TABLE 47. ASSAY RESULTS—MARBLE BAR OCCURRENCE

	Lead Per cent	Silver F. oz./ ton	Gold Dwt/ ton	Copper Per cent
A 	67.0	35.33	Trace	Trace
B 	18.2	11.41	0.21	Trace

NOTE: 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

in 1932 contained only 1.28 ounces of silver per ton (40.10 gm per tonne).

Cookes Creek

(Lat. 22° 05' S, long. 120° 35' E).

Galena has been found at Cookes Creek in veins of fluorite. Assays of two samples are listed in Table 46.

Greens Well

(Lat. 21° 05' S, long. 118° 55' E).

In 1928 a lead lode was found in McPhees Range near Greens Well. It consisted of galena with a little cerussite, anglesite and blende in a gangue of fluorite and quartz. A typical sample assayed 44.76 per cent lead, nil silver and nil gold. The total absence of silver is remarkable.

Marble Bar

(Lat. 21° 05' S, long. 119° 40' E).

A lode of argentiferous galena with a little blende and the oxidation products of these minerals, occurs about 1 mile (1.6 km) west of Marble Bar. Assays are listed in Table 47.

The principal gangue mineral is quartz.

Nullagine

(Lat. 21° 50' S, long. 120° 07' E).

Twenty miles (32.1 km) north of Nullagine, M. Doherty in 1923 found a

lead lode consisting of galena with some cerussite, anglesite, quartz and limonite. An assay showed 44.7 per cent lead, 6.25 ounces (194.38 gm) of silver and traces of gold.

Galena with a little limonite, quartz, kaolin, anglesite and chalcopryrite, was also found 6 miles (9.7 km) south of Nullagine in 1926. A picked sample assayed 80.8 per cent lead, 9.91 ounces (311.02 gm) of silver and 0.29 pennyweights (0.451 gm) of gold.

The galena was rather finely granular, the grains being 1 to 3 mm in diameter.

Sandy Creek

(Lat. 21° 50' S, long. 119° 50' E).

On Sandy Creek, east of Nullagine, galena with some blende has been found in a gangue of fluorite and quartz. A sample with a small amount of associated anglesite and cerussite contained 53.9 per cent lead, 1.04 ounces per ton (32.34 gm per tonne) of silver, a trace of gold and 6.02 per cent zinc.

Tabba Tabba

(Lat. 20° 40' S, long. 118° 52' E).

A sample of galena taken from a vein 10 miles (16.0 km) from the tin and tantalite Tabba Tabba centre, in 1927, assayed

80.3 per cent lead, 4.63 ounces per ton (144.01 gm per tonne) of silver and 0.12 pennyweights (12.662 gm) of gold.

Warrawagine Station

(Lat. 20° 50' S, long. 120° 45' E).

A sample of galena stated to have come from "West of Warrawagine" on the Oakover River was examined in 1927. It assayed 80.8 per cent lead, 11.53 ounces per ton (498.58 gm per tonne) of silver and a trace of gold.

Wodgina

(Lat. 21° 25' S, long. 118° 30' E).

In a 5-foot (1.5 m) quartz reef in granite at West Wodgina, finely granular galena is fairly abundant, though not in commercial quantities. It is associated with blende, whilst close to the surface the sulphides are replaced by a mixture of angle-site, cerussite, smithsonite and hemimorphite.

A few miles southeast of Wodgina some very coarsely crystallized galena has been obtained. A specimen assayed 74.6 per cent lead, 2.12 ounces per ton (65.94 gm per tonne) of silver and 0.54 pennyweights per ton (0.820 gm per tonne) of gold.

Pilgangoora

(Lat. 21° 04' S, long. 118° 20' E).

The ore from a small copper prospect on the northern edge of Water Right 115 at Pilgangoora contains an appreciable amount of lead and some zinc. The lode appears to be a mineralized limestone bed within the Warawoona succession, but due to poor outcrop conditions its exact relationships could not be determined. A sample assayed 3.74 per cent copper, 1.38 per cent

lead, 0.24 per cent zinc and 8.3 ounces per ton (258.14 gm per tonne) of silver.

Duffer Creek (M.C. 884)

(Lat. 21° 13' S, long. 119° 45' E).

A copper, lead and zinc prospect, 4 miles (6.4 km) southeast of Marble Bar was investigated by Planet Metals Pty. Ltd. in 1968. It is close to former G.M.L. 647, in a range of steep hills forming the western side of the valley of Duffer Creek, and is reached by a graded track branching westerly from the road to Corunna Downs, 3 miles (4.8 km) south of Marble Bar.

The prospect comprises several lenticular, stratiform gossans within a sequence of metamorphosed basalt, tuff and chert of the Archaean Warawoona succession. The gossans occur over a strike length of about 1,500 feet (457 m) and a stratigraphic interval of 300 feet (91 m), within host rocks striking 195 degrees and dipping 60 degrees west. The largest gossan is 200 feet (61 m) long and 10 to 15 feet (3.0 to 4.5 m) thick. At the northern end of the prospect the gossans have formed between basalt flows, but further south they are lower in the sequence, in interbedded tuff and chert.

The gossans consist of iron and manganese oxides with chalcedony and carbonates and silicates of copper, lead and zinc. A chip sample from the richest looking gossan assayed 1.79 per cent copper, 7.47 per cent lead, 0.93 per cent zinc and 13.0 ounces per ton (404.34 gm per tonne) of silver.

Lynas Find (M.C. 881)

(Lat. 20° 58' S, long. 118° 56' E).

On mineral Claim 881, about 1 mile (1.6 km) southwest of the Birthday Gift gold mine at Lynas Find, a quartz vein striking at 150 degrees and dipping 80

degrees east in granite gneiss, contains galena and cerussite over a length of 50 feet (15 m). A small, but unreported amount of hand-picked ore was taken from

an open-cut 25 feet (7.6 m) long and 3 to 5 feet (91 cm to 1.5 m) deep. The grade of the vein material remaining in the cut is quite low.

West Pilbara Goldfield

SUMMARY

Silver-lead ore was discovered in the West Pilbara Goldfield in about 1872, but recorded production has been restricted to a few short periods between 1915 and 1957 and has come from only four deposits.

Most of the known occurrences of lead and zinc minerals in the Goldfield are in Archean rocks. All but two are fissure vein deposits, the exceptions being the occurrences of zinc with some lead in the stratiform Whundo and Mons Cupri copper deposits.

The total production of lead from the West Pilbara Goldfield is 123 tons (124.9 tonnes), with which were associated 1,397

ounces (43,450.8 gm) of silver. The annual production figures for lead are given in Table 48 and the production of lead and silver by centres, is in Table 49.

PRINCIPAL DEPOSITS

COMSTOCK LODGE (M.L. 172)

(Lat. 20° 53' S, long. 117° 48' E).

General Information

The lead mine known now as the Comstock lode and earlier as the Colorado silver-lead mine, is 3.5 miles (5.6 km) south-southwest of Whim Creek and immediately south of the Mons Cupri copper mine. Access is by way of a graded track turning

TABLE 48. ANNUAL PRODUCTION OF LEAD FROM THE WEST PILBARA GOLDFIELD

Year	Ore and Conc. Tons	Lead Tons	Value \$Aust.
1916	44.00	22.00	1,540.00
1917	62.57	25.36	1,518.00
1918-47	....	....	....
1948	2.07	0.94	124.02
1949	15.32	7.96	906.80
1950	2.24	1.04	159.40
1951	18.14	12.95	4,577.50
1952	30.79	21.41	7,351.90
1953	3.29	1.28	55.26
1954-56	....	....	....
1957	1.63	1.15	242.60
1958-67	....	....	....
Total	180.05	94.09	15,465.48

NOTE: 1 ton = 1.01605 tonnes

TABLE 49. PRODUCTION OF LEAD AND SILVER FROM WEST PILBARA GOLDFIELD, BY CENTRES

Locality or Mine	Lease No.	Name of Lease or Operator	Period	Est. Mine Production		Realized Production			Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore and Conc. Tons	Lead Tons	Silver F. oz.		
Comstock	ML 172	Comstock (Whim Creek)	1916-17 ... ..	...	...	104.00	46.00	...	2,980.00	Not reported
			1915 ... ..	...	...	80.10	29.17	883.92	667.00	
	PA 200	G. Sheffler	1950 ... ..	...	...	1.12	0.52	12.76	81.60	
	PA 229	G. Tyrer	1953 ... ..	...	...	3.29	1.28	28.25	68.08	
Total, Comstock ...	...	...	...	...	...	188.51	76.97	924.93	3,796.68	
Andover	MC 69	C. Radley	1949-50 ... ..	...	...	9.61	5.08	34.90	521.50	
	MC 73	Leevers & Horn	1951-52	570.0	48.85	48.93	34.36	393.25	11,179.08	
	PA 887H	L. L. Rogers	1949 ... ..	...	...	3.16	1.82	8.09	174.00	
	PA 854H	D. L. Gordon	1948-49 ... ..	...	...	5.15	2.21	21.70	358.92	
Total, Andover ...	...	...	...	...	...	66.85	43.47	457.94	12,233.50	
Nunyerry	MC 91	D. C. Watkins (Reward)	1957 ... ..	...	...	1.63	1.15	12.26	252.00	
Balmoral	PA 872H	Ryan and Speck ... ..	...	...	...	0.59	0.31	2.10	66.70	
Sundry Claims ...	...	...	1917 ... ..	...	...	2.57	1.36	...	78.00	
Total, West Pilbara	...	...	...	...	...	260.15	123.26	1,397.23	16,427.03	

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

from the North West Coastal Highway on the south side of the Whim Creek airfield. The workings follow the crest of a prominent ridge known as Comstock Hill.

A trial parcel of ore was said to have been shipped from the mine in 1898, but the first recorded production was in 1915. Since that time the mine has yielded 77 tons (78.2 tonnes) of lead and 925 ounces (28,770.2 gm) of silver.

References: Woodward (1911), Maitland (1919a), and Simpson (1951).

Plans: Roebourne 1:250,000 Geol. Sheet shows location of mine. Mines plan 151/1 gives details of the surface workings and assays of the reefs.

Geological Information

On the Comstock lease, lead minerals are present in a group of branching and intersecting quartz veins within an elliptical area elongated west-northwest and measuring 1,200 feet (366 m) by 300 feet (91 m). Most of the veins are widely spaced and have been mined individually from narrow cuts. However in the central part of the lease several veins coalesce to form a ladder-vein deposit which has been worked on a larger scale. The outcrop of this deposit measures 150 by 40 feet (46 by 12 m).

The host rock of the lead veins is an andesite flow 350 feet (107 m) thick, dipping about 50 to 60 degrees southwards. Stratigraphically above and below the flow are slates which seem to be unfavourable host rocks. Small cross faults cut the andesite and may have had some control over ore deposition.

Mineralogy of the Ore

Economic minerals recorded from the lode are galena, anglesite, cerussite, pyromorphite, malachite and azurite.

Description of Workings

The main workings on the lease are two open-cuts on the ladder-vein deposits. Each is about 10 to 15 feet (3.0 to 4.5 m) deep, the larger being 40 by 30 feet (12 by 9 m) in area and the smaller 20 by 15 feet (6 by 4.5 m).

There are also eight narrow open-cuts ranging from 10 to 30 feet (3 to 9 m) long, on shoots within a group of sub-parallel quartz veins south of the main cuts. The reefs worked in these were from 1 to 3.5 feet (30 cm to 1.0 m) wide. Other reefs have been tested by pits and costeans and many of these contain small amounts of lead minerals.

Assays: The assays listed in Table 50 are taken from the references cited above and from Mines plan 151/1. Only the more significant, or more representative of the samples shown on the plan are quoted.

One sample of picked ore contained 2.5 per cent copper, and traces of gold were found in a number of the others.

ANDOVER LEAD MINE (M.C. 73)

(Lat. 20° 53' S, long. 117° 06' E).

General Information

The Andover lead mine, known also as the Brothers United, or Woolcock mine, is 7 miles (11.2 km) south-southwest of Roebourne and 2.5 miles (4.0 km) northwest of Woodbrook (Old Andover) Station homestead. Access is by track from the homestead.

The deposit was one of the earliest discovered in the West Pilbara Goldfield (probably in about 1872) and was worked in a small way before 1911. However there are no records of production until the period 1948 to 1952 when the mine was reopened to yield 43.5 tons (44.19 tonnes) of lead. The average grade of the ore treated by a

small battery on the lease in 1951 to 1952 was 16.5 per cent lead and 0.7 ounces per ton (21.77 gm per tonne) of silver.

Water is present at a shallow depth in the workings and at the time of Montgomery's visit was causing the operators some trouble.

References: Montgomery (1907), Woodward (1911), Maitland (1919a), and Simpson (1951).

Plans: The Roebourne 1:250,000 Geol. Sheet shows the position of the mine. G.S.W.A. plan No. 10830 shows the surface workings.

Geological Information

The Andover lead mine worked a fissure vein striking at 355 degrees. The lode

crosses the contact between granite to the south and gabbro to the north. The main workings are in granite host rock, where the vein is composed of pegmatite, but further north in the gabbro, the gangue of the vein is almost pure quartz. Dips on the vein range from 85 to 50 degrees easterly and its width from 1 to 6 feet (30 cm to 1.8 m).

Ore minerals present are galena, sphalerite, smithsonite and malachite.

Most of the ore won from the mine came from an open-cut or surfaced stope, 40 feet (12 m) long and 20 feet (6 m) deep, located at the southern end of the line of reef. An old shaft mentioned in Montgomery's report is at the northern end of the cut and there is a record of a drive

TABLE 50. ASSAY RESULTS—COMSTOCK LODGE

Location	Width (inches)	Lead Per cent	Zinc Per cent	Silver F. oz./ton
Picked ore	.....	67.1	.....	27.76
" "	.....	65.0	.....	35.86
" "	.....	58.1	.....	40.13
" "	.....	51.6	.....	26.75
" "	.....	41.3	.....	66.55
" "	.....	41.3	.....	8.34
" "	.....	57.6	.....	16.37
Main cuts, channel samples	.....	18.7	0.7	9.0
" " " "	.....	2.5	0.5	0.5
" " " "	.....	8.7	0.5	2.7
" " " "	60	9.6	1.3	1.5
" " " "	60	5.7	0.6	2.1
Minor cuts, representative samples	42	6.2	0.9	0.7
" " " " "	24	31.5	1.4	3.9
" " " " "	42	20.9	0.7	13.1
" " " " "	24	24.4	0.3	3.6
" " " " "	30	26.7	0.5	3.3
" " " " "	30	3.0	0.5	0.5
" " " " "	30	21.4	0.6	8.3

NOTE: 1 inch = 2.54 centimetres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

north and south from it at a depth of 30 feet (9 m). In the open-cut the reef is 5 to 6 feet (1.5 to 1.8 m) wide, dips at 50 degrees east and is a galena-bearing pegmatite.

At a distance of 120 feet (37 m) north of the main cut, a shaft was sunk in sheared gabbro with some quartz, but there is little sign of lead minerals in the dump. There is no outcrop of the vein for 240 feet (73 m) northwards from the shaft, but thereafter it can be traced a further 450 feet (137 m). At the southern end of this outcrop there is a shaft 37 feet (11.2 m) deep fitted with a windmill pump. Water level is at about 15 feet (4.5 m). North of the shaft are several small cuts in which the vein ranges from 1 to 4 feet (30 cm to 1.2 m) wide and carries lead and copper minerals. The grade of the reef is generally poor, with richer shoots located on slight bends in the vein.

Assays: The assays in Table 51 are mainly from the references cited above, with one additional sample.

Some samples of ore recorded small quantities of gold; the highest value was 22 grains per ton (1.43 gm per tonne).

NUNYERRY PROSPECT (M.C. 91)

(Lat. 21° 41' S, long. 117° 53' E.)

General Information

The Nunyerry, or Flat Rock lead prospect, is 9.5 miles (15.2 km) south of the old Nunyerry chrysotile mine and 7 miles (11.2 km) north of Mount Florance Station homestead. It is about 1 mile (1.6 km) east of the road to the Nunyerry mine.

The prospect was discovered in about 1957 by D. Watkins, who was granted a Reward Claim over the deposit. Production amounts to 1.15 tons (1.16 tonnes) of lead and 12.26 ounces (381.32 gm) of silver.

Reference: Kriewaldt and Ryan (1967).

Plan: The Pyramid 1:250,000 Geol. Sheet shows the position of the prospect.

Geological Information

The prospect is in Archaean granite, close to the unconformity with the over-

TABLE 51. ASSAY RESULTS—ANDOVER LEAD MINE

Description	Lead Per cent	Zinc Per cent	Copper Per cent	Silver F. oz./ton
Clean galena from cuts along reef	67.17	....	0.42	3.92
Zinc carbonate ore	3.51	38.20	0.25	0.55
Ore (? concentrate) sample	77.8	....	....	3.23
" " " "	64.7	....	....	3.14
" " " "	60.1	....	Tr	4.51
" " " "	52.5	....	nil	2.10
Chip sample over 3 feet in south face of main open cut	8.8	0.8	....	0.92

NOTE: 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

lying Proterozoic Fortescue Group. The veins which carry the lead do not penetrate the younger rocks, indicating that the mineralization took place in Archaean times.

In the area of the claim, small pockets of lead have been mined from two intersecting quartz veins. The better ore is on a vein striking at 105 degrees, dipping steeply north, and is associated with pegmatite and aplite dykes. Workings are scattered over a length of 600 feet (180 m), the deepest being an 8-foot (2.4 m) pit on a small pod of galena.

The other line of quartz strikes at 195 degrees, dips steeply west and has generally lower grade ore than the first. It has been worked over a distance of 350 feet (107 m) by a few pits and a 15-foot (4.5 m) deep shaft, sunk on a narrow pipe of quartz and galena formed at the junction of the main vein with a small branch. The pipe is about 2.5 feet (76 cm) wide, 5 feet (1.5 m) long and contains an estimated 15 per cent of galena. Elsewhere along the line the vein is from 6 to 9 inches (15.2 to 22.8 cm) wide.

Assay: A sample of ore from the dump of the 8-foot (2.4 m) pit assayed 62.5 per cent of lead, 0.48 per cent of zinc and 7.2 ounces per ton (223.94 gm per tonne) of silver.

BALMORAL DEPOSIT (P.A. 872H)

(Lat. 21° 03' S, long. 116° 04' E approx.)

The Balmoral lead deposit which yielded 0.31 tons (0.314 tonnes) of lead, is reported to be 14 miles (22.5 km) northeast of Balmoral Station homestead, close to the telegraph line about 1.5 miles (2.4 km) northwest of Eramurra Pool. The writer searched the locality but failed to find the

prospect; local people know its position only by repute.

The area reported to contain the deposit consists largely of sandplain overlying Archaean granitic rocks. The granite is cut by dolerite dykes and quartz veins.

Simpson (1951) described the deposit as being very coarsely crystallized galena associated with quartz, limonite, anglesite and cerussite.

Assays listed by Simpson are reproduced in Table 52.

EVELYN COPPER MINE (M.L. 31)

(Lat. 21° 05' S, long. 117° 51' E).

The old Evelyn copper mine is 3 miles (4.8 km) northeast of Croydon Station homestead and about 25 miles (40.2 km) by road and track from Whim Creek. It was worked from about 1899 to 1907, then abandoned due to an increasingly high zinc content in the ore.

References: Woodward (1911) and Low (1963).

Plan: The Pyramid 1:250,000 Geol. Sheet shows the location of the mine.

Geological Information

A number of small shoots of copper ore on shears on a line trending 040 degrees, have been worked over a length of 800 feet (240 m) within a band of actinolite schist. The largest shoot pitches down the plane of the lode in pipe-like form. At the surface it was 36 feet (10.9 m) long by 16 feet (4.8 m) wide. At the 65-foot (19.8 m) level it was 65 feet (19.8 m) long by 6 feet (1.8 m) wide. At the 85-foot (25.9 m) level it struck primary sulphides, including a large amount of sphalerite which forced the closure of the mine.

TABLE 52. ASSAY RESULTS—BALMORAL DEPOSIT

Lead per cent	Silver F. oz./ ton	Gold Dwt/ton
86.5	2.84	Tr
84.7	2.82	nil
77.2	4.03	Tr
74.0	6.25	nil

NOTE: 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

Minerals seen on the dumps were malachite, azurite, chrysocolla, chalcocite, galena, cerussite, sphalerite and smithsonite. Woodward (1911) reported chalcopyrite, marcasite and blende from the 85-foot (25.9 m) level.

Assay: One sample of transition ore from a shipment of 70 tons (71.1 tonnes) in 1907 assayed 1.7 per cent of zinc and 15.2 per cent of copper. No assays of the zinc-rich ore from the bottom level are recorded.

MONS CUPRI PROSPECT

(Lat. 20° 52' S, long. 117° 48' E).

The old Mons Cupri copper deposit, located immediately north of the Comstock lode near Whim Creek, has been recently tested by Australian Inland Exploration Pty. Ltd. Results published by the company in May, 1969, suggest that the deposit may also be an important lead, zinc and silver prospect. It is estimated to contain 15,000,000 tons (15,240,000 tonnes) of lode material averaging 1 per cent copper, 4 per cent lead plus zinc and 1.5 ounces per ton (46.65 gm per tonne) of silver. Further reserves of 15,000,000 tons (15,200,000

tonnes) averaging 0.65 per cent of copper and 6,000,000 tons (6,100,000 tonnes) of oxidized ore averaging 1.7 per cent of copper, were also reported, but the lead, zinc and silver contents of these, if any, were not recorded. The company is awaiting the results of further drilling and metallurgical work on the ore minerals before finally evaluating the prospect.*

The information given here is based mainly on data supplied by the Project Geologist during an inspection of the prospect by the writer. Previously published information on the deposit is collated by Low (1963).

Drilling has revealed that the Mons Cupri lode is partly strata-bound and partly transgressive to its surrounding rocks. It comprises a mineralized, chloritic zone within a unit of rhyolite-agglomerate, part of which is a "flow" and part a volcanic vent. The agglomerate overlies massive, spherulitic rhyolite and with this unit, makes up the Mount Brown Rhyolite. Towards its top, it grades into a conglomerate containing beds of resorted tuff. The conglomerate is formed mainly of well rounded and smoothed boulders of rhyolite set in a matrix of the same rock type, but a few boulders

* Further drilling done by the Company showed that these reserves were overstated, and work on the prospect has now been abandoned.

of other rock types have been noted. Overlying the conglomerate is a lenticular bed, up to 70 feet (21.3 m) thick, of crystal tuff, which in turn is overlain by dark coloured, phyllitic shale. Above the shale is a flow of andesite and the uppermost part of the succession in the mine area is made up of interbedded shale and andesite. The succession strikes about westerly and dips at from 30 to 50 degrees southerly.

The lode has a maximum thickness of at least 500 feet (152 m) and in the primary zone consists of siliceous chloritic breccia with disseminated pyrite, chalcopyrite, sphalerite, galena and rare tetrahedrite. Galena appears to be concentrated in veins up to 1 foot (30 cm) thick near the upper part of the lode, but the other minerals are disseminated throughout.

Old workings on the Mons Cupri hill include small open-cuts and drives from cross-cutting adits and were generally located on small shears where secondary copper minerals concentrated during oxidation of the lode. They are described more fully by Low (1963).

Geologists of Australian Inland Exploration Pty. Ltd. believe that the ore minerals were deposited by fumerolic fluids which entered during the last phase of the volcanism that produced the host rhyolite-agglomerate, the fluids being at that time trapped within the agglomerate by the overlying shale bed.

MISCELLANEOUS OCCURRENCES

In the West Pilbara Goldfield, lead and/or zinc minerals have been noted at the Whundo copper mine, Turner Creek, Sherlock River, Station Peak and near the Robe River. Information about these occurrences is taken from Simpson (1951) and a report by Westfield Minerals N.L.

WHUNDO COPPER MINE

(Lat. 21° 05' S, long. 116° 55' E).

Diamond drillholes drilled by Westfield Minerals N.L. have encountered zinc minerals in the lode of the Whundo copper mine.

The copper ore at the Whundo mine and the neighbouring Yannery mine is in quartz lenses concordant with the bedding planes of Archaean metasediments. The geology of these deposits has been described by Low (1963).

SHERLOCK RIVER

(Lat. 21° 00' S, long. 117° 35' E).

Near the junction of the Sherlock and Little Sherlock Rivers, fine-grained (1 to 3 mm) galena occurs in stringers and small bunches in a quartz vein. Some typical specimens assayed 24.1 per cent lead, 4.56 ounces of silver per ton (141.83 gm per tonne) and a trace of gold.

STATION PEAK

(Lat. 21° 10' S, long. 118° 10' E).

Montgomery (1907) stated that he was informed of a lode carrying a good deal of galena not far from the Pilgrims Rest gold mine, but time did not permit of his inspecting it. A specimen from the lode is in the Geological Survey collection (G.S.M. 5720).

BEASLEY (TURNER) RIVER

(Lat. 22° 50' S, long. 117° 15' E).

A vein with galena right at the surface was discovered in the Beasley River, 20 miles (32.1 km) west of Rocklea Station homestead in 1937. A sample of hand-picked galena proved to be rich in silver, an assay showing 85.1 per cent of lead, 40.28 ounces per ton (1,252.83 gm per tonne) of silver and 0.42 pennyweights per ton (0.653 gm per tonne) of gold. There has been a little surface work on an old

Prospecting Area for lead, 21 miles (33.7 km) west-northwest of Rocklea homestead (de la Hunty, pers. comm.), in the Pyradie Pyroclastic Member of the Lower Proterozoic Mount Jope Volcanics. No lead minerals or quartz veins were seen but this is probably the locality of the specimen assayed.

ROBE RIVER

(Lat. $21^{\circ} 40' S$, long. $116^{\circ} 25' E$ approx.).

On Mount Enid (Yalleen) Station, a quartz vein carrying galena at the surface was found in 1921. A sample assayed 47.4 per cent lead, 3.72 ounces per ton (115.70 gm per tonne) of silver and a trace of gold.

Ashburton Goldfield

SUMMARY

Since 1901, 5,017 tons (5,097.2 tonnes) of lead and 67,637 ounces (2,103,713.6 gm) of silver have been mined from about 40 deposits in the area of the Ashburton Goldfield. Most of this production came from the Kooline and Uaroo—Range districts, with smaller contributions from deposits at Wyloo and Maroonah-Glen Florrie. Silver-lead deposits have also been found in other parts of the Goldfield, but due either to their small size or remoteness have not been worked commercially. No zinc ore has been produced from the Ashburton Goldfield and most of the silver-lead deposits contain little zinc. Details of production are given in Tables 53 and 54.

Most of the important productive silver-lead occurrences in the Ashburton Goldfield are in Lower Proterozoic rocks of the Wyloo Group, or in granites intruding these, but there are some small lead-bearing veins in the Archaean rocks forming the core of the Wyloo Anticline and two occurrences in the Middle Proterozoic Bangemall Group. All of the mined deposits were quartz veins, but uncommercial silver and lead have been found in replacement lodes at Ashburton Downs, while the Joy Helen prospect on Maroonah Station is probably of the Mississippi Valley type.

It is likely that the ore deposits in the Lower Proterozoic rocks were derived from the intrusive granite and granodiorite bod-

ies. In the Uaroo—Range district, the derivation seems obvious from field relationships of the granite and ore bodies. At Wyloo Station the association of ore and granite is assumed from radio-isotope ages and at Kooline and Ashburton Downs Station, from increases in the number of quartz veins and the higher grade of metamorphism shown by the host rocks, both of which features suggest the presence of sub-jacent intrusions.

PROSPECTING RECOMMENDATIONS

1. The Uaroo mine is worth testing below the present workings.
2. The alluviated plains east and west of the Kooline deposits may conceal further small deposits which could be found by detailed geochemical prospecting, but an increase in the price of lead would be needed to justify this work.
3. The sandplain surrounding the Turtle and Range mines could conceal further deposits and is worth prospecting with either geochemical or geophysical methods.
4. The presence of copper-lead-zinc mineralization of the Mississippi Valley type in dolomite breccias at the base of the Bangemall Group makes the prospecting of this horizon on a regional scale a reasonable venture.

TABLE 53. ANNUAL PRODUCTION OF LEAD FROM THE ASHBURTON GOLDFIELD

Year	Ore and Conc. Tons	Lead Tons	Value \$Aust.
1901	21·05	9·09	218·00
1902	35·85	18·76	414·00
1903-07	....	....	....
1908	727·25	436·35	13,828·00
1909	440·00	264·00	7,040·00
1910-12	....	....	....
1913	125·50	77·81	3,514·00
1914	715·10	465·04	19,614·00
1915	298·96	197·32	8,858·00
1916	67·83	42·77	1,086·00
1917	....	....	....
1918	237·48	150·40	6,922·00
1919	214·76	141·07	6,232·00
1920-24	....	....	....
1925	30·00	18·00	1,260·00
1926	....	....	....
1927	60·00	36·00	2,358·00
1928-47	....	....	....
1948	126·76	83·61	13,937·76
1949	719·92	470·39	71,853·02
1950	345·62	243·19	43,486·20
1951	648·16	478·37	123,118·40
1952	979·20	686·91	193,954·22
1953	713·28	503·73	80,390·92
1954	393·50	292·04	41,066·18
1955	16·32	11·74	1,982·18
1956	156·60	116·92	23,511·08
1957	207·43	158·49	30,733·50
1958	109·45	85·43	14,453·34
1959	41·50	28·68	5,771·10
1960-67	....	....	....
Total	7,431·52	5,016·11	714,482·90

NOTE: 1 ton = 1·01605 tonnes

KOOLINE LEAD FIELD

The Kooline lead field, situated on Kooline pastoral lease, includes about thirty small, geologically similar silver-lead mines. Most of the deposits, including all of the larger mines, are grouped in an area 4.5 miles (7.2 km) by 1.5 miles (2.4 km) centred 16 miles (25.7 km) southeast of Kooline Station homestead. The remaining

deposits are P.A.s 300 and 316 located 9 miles (14.4 km) northwest of the main group, and the Big Chief mine 10 miles (16.0 km) southwest of the principal mines.

Kooline is about 150 miles (241 km) by road from Onslow, the nearest port to the deposits and the unloading point for all supplies and mining requirements. Access to the main group of workings is by way of a

TABLE 54. PRODUCTION OF LEAD AND SILVER FROM ASHBURTON GOLDFIELD, BY DISTRICTS

District	Period	Realized Production			Est. Value \$Aust.	Remarks
		Ore and Conc. Tons	Lead Tons	Silver F. oz.		
Kooline	1948-59	3,580.96	2,637.48	26,521.69	567,834.52	See Table 55 for details See Table 56 for details See Table 60 for details See Table 61 for details
Uaroo—Range	1901-57	3,496.35	2,137.57	39,399.34	132,181.02	
Wylloo	1949-56	319.47	218.65	1,484.19	43,385.22	
Maroonah—Glen Florrie	1949-53	8.21	5.65	40.31	1,091.92	
Sundry Producers (Crown Land)	1953	0.87	0.46	3.04	78.22	
Sundry Producers (Crown Land)	1916	2.83	1.28	74.42	80.00	
Sundry Producers (Crown Land)	1949-57	23.01	16.32	114.67	2,743.60	
Total, Ashburton Goldfield	1901-67	7,431.70	5,017.41	68,110.90	747,394.50	

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

track turning southwards from the Kooline—Ashburton Downs road at a point 10 miles (16.0 km) southeast of Kooline homestead. The positions of the various mines within the field are shown on Plate 4.

The former miners on the Kooline field obtained domestic water from a well sunk alongside a pool in the Ashburton River. Water for mining purposes was pumped from the deeper shafts. At least one bore was sunk in phyllite near the larger mines, but the water obtained is reported to have been too salty for domestic use.

Although the presence of “floaters” of galena in the area was known to stockmen of Kooline Station for some time, it took the post-war rise in the price of lead to interest prospectors in the field. The first mining tenement, P.A. 200, was pegged to cover the area of the later Beadon mine in October 1947, and from 1948 to 1959 the field produced ore containing 2,637 tons (2,679.1 tonnes) of lead and 26,522 ounces (824,913.7 gm) of silver. About two-thirds of the production was from the Gift, June Audrey and Bilrose mines. Each of these had its own treatment plant, consisting of a crusher and a concentrating table. Ore from the smaller deposits was either hand-sorted for direct shipment, or brought to one of the three batteries for treatment. Table 55 gives the production of each mine in the field. As no tenements in the field were surveyed, the positions of many of the smaller mines are uncertain.

In this account the mines of the main group are treated first in their order of importance, and following these, outlying deposits are described. The smaller mines that could not be identified with any former tenement have been numbered from west to east, to allow their descriptions to be related to their positions on Plate 4.

References: Ellis (1951), Daniels (1966c) and Daniels (1969).

Plans: Wyloo 1 : 250,000 Geological Sheet and Edmund 1 : 250,000 Geological Sheet.

GEOLOGICAL SETTING

The silver-lead miners of the Kooline field worked galena-bearing quartz veins within interbedded shale and greywacke of the Lower Proterozoic Ashburton Formation. The sediments are folded about axes trending at 280 degrees and are strongly cleaved parallel to the axial planes. Most of the silver-lead veins are parallel to the axial cleavage, although a few small veins course across this direction, evidently following tensional openings. Some mines of the main group are close to an anticline crest, but otherwise there is no obvious relationship between folds and ore deposits. Similarly there is no correlation between ore and the lithology of the sediments, although these seem to be slightly more metamorphosed near the main group of mines.

The galena-bearing veins are from a few inches to 4 feet (1.2 m) thick and up to 200 feet (60 m) in length. Often several veins form an echelon pattern. Apart from galena and quartz, the only minerals seen in the veins are cerussite, malachite, calcite and barite. In places the wall rocks of a vein may be impregnated with cerussite, but this type of mineralization seems to be restricted to the oxidized zone, as no wall-rock impregnation with galena was noted. In the veins the ore minerals may be disseminated through the quartz or restricted to narrow seams of more or less massive sulphide (or carbonate) at one edge. The average grade of the ore mined was about 10 to 12 per cent of lead and 1 to 1.5 ounces per ton (31.1 to 46.6 gm per tonne)

of silver. The lead ores are thought to be derived from a subjacent granite or granodiorite intrusion.

GIFT MINE (M.L. 122)

(Lat. 23° 07' S, long. 116° 27' E).

The Gift mine is centrally located in the main group of workings. It yielded 932 tons (946.9 tonnes) of lead and 8,362 ounces (260,083.2 gm) of silver from 7,750 tons (7,874.0 tonnes) of ore, an average grade of 12 per cent lead and 1.08 ounces per ton (33.59 gm per tonne) of silver.

Plan: Mines 116/1 shows the underground workings in 1952.

The mineralized vein strikes at 285 degrees, dips north at 70 degrees and is up to 3 feet (90 cm) wide. It comprises quartz with disseminated galena, with veins of massive galena up to 12 inches (30.4 cm) wide on its walls.

Surface workings on the vein are continuous over a distance of 250 feet (76 m) and two further shafts sunk to the east make the total length worked about 500 feet (150 m). At depth the vein was mined from an inclined main shaft sunk to 171 feet (52.1 m) on the underlay (160 feet (48.7 m) vertical depth) and from a number of shallower shafts. A level at 87 feet (26.5 m) (80 feet (24.3 m) vertical depth) extended 160 feet (49 m) east and 150 feet (46 m) west of the main shaft. The No. 1 winze, 85 feet (25.9 m) west of the main shaft on the 87-foot (26.5 m) level was sunk 54 feet (16.4 m). About 12 feet (3.6 m) of driving at the 171-foot (52.1 m) level is shown on plan 116/1, but as the mine was worked for several years after the date of this plan, the level was probably extended beyond this distance.

JUNE AUDREY MINE (M.L. 135)

The June Audrey mine, which has also been called the Redcraze, is 1 mile (1.6 km) west of the Gift mine. It produced 504 tons (512.0 tonnes) of lead and 5,356 ounces (166,587.6 gm) of silver from ore with an average grade of about 11.5 per cent lead and 1.24 ounces of silver per ton (38.56 gm per tonne).

Plan: Mines 161/2 shows the underground workings of part of the mine.

Two ore shoots 600 feet (180 m) apart and about on the same line, were worked on the June Audrey lease. The main workings are on the western shoot which is the June Audrey mine described by Ellis (1951). The eastern shoot has also been called the Cliff Ross show (Daniels, 1966).

On the western shoot, workings extend for 450 feet (137 m) along the vein, strike at 280 degrees and dip steeply south. Bedding of the host greywacke dips at 15 degrees south. Midway along its length the vein is displaced echelon fashion for 50 feet (15 m) to the right and the two parts are linked by a narrow quartz vein. The main shaft on the eastern part of the vein is 136 feet (41.4 m) deep. Stopes were taken for about 120 feet (37 m) east and 100 feet (30 m) west of the shaft, to depths of at least 50 feet (15.2 m). The reef in the stopes ranged from 1.5 to 4 feet (46 cm to 1.2 m) wide. The western displaced part of the vein was worked in a few places to depths of 20 to 40 feet (6 to 12 m) over widths of 1.5 to 2 feet (46 to 61 cm). It is not known if the workings on the two parts of the vein were connected at depth.

The eastern shoot strikes at 105 degrees and dips steeply north. It was open-cut and stoped over a length of 200 feet (60 m) to a depth of at least 50 feet (15 m) and varied from 2 to 4.5 feet (61 cm to

1.3 m) wide. In the central part of the workings, a narrow branch reef was mined over a short distance.

Both shoots contain galena, cerussite, barite and traces of copper.

BILROSE MINE (M.L. 118)

The Bilrose mine, 0.4 of a mile (0.6 km) west of the Gift mine, has yielded 328 tons (333.2 tonnes) of lead and 4,503 ounces (140,056 gm) of silver. Records of the amount of ore treated are incomplete; those existing show an average grade of about 11 to 12 per cent lead.

Plan: G.S.W.A. No. 10863 shows the surface workings.

The western part of the vein worked on the Bilrose mine strikes at 295 degrees and dips at 75 degrees south. At a distance of 180 feet (55 m) from the east end, the vein splits into two branches diverging at an angle of 20 degrees, the southern one on a bearing of 280 degrees and the northern one at 300 degrees. Both branches dip south. Workings on each branch of the lode extend for about 170 feet (52 m) from the junction. The main shaft is close to the join where there is a collapsed stope 30 feet (9 m) long and 10 to 15 feet (3.0 to 4.5 m) wide. Further from the junction, workings on all parts of the lode comprise narrow stopes 40 to 80 feet (12.1 to 24.3 m) long and up to 50 feet (15.2 m) deep. In most of these the reef was from 9 to 18 inches (22.8 to 45.7 cm) wide increasing to about 6 feet (1.8 m) near the join of the branches. The main shaft is 83 feet (25.2 m) deep with an inclination of 70 degrees south. From it the lode was stoped out to the south over a distance of 50 feet (15 m) to a depth of 80 feet (24.3 m). North of the shaft stoping was carried out over a distance of 70 feet (21 m) to a depth of at least 40 or 50 feet (12 to 15 m).

Minerals seen on the dumps include galena, cerussite and barite. The greywacke wall rocks are altered slightly to chlorite near the lode.

DINGO MINE (M.L. 143)

Mineral Lease 143, the Dingo, is 1.7 miles (2.7 km) west of the Gift mine on a low hillock of slate rising out of a wide gravel plain. Production from the lease was 220 tons (224 tonnes) of lead and 2,240 ounces (69,671 gm) of silver from 1,800 tons (1,830 tonnes) of milled ore and 55 tons (55.8 tonnes) of picked concentrate. The grade of the milled ore was thus about 10 per cent of lead and 1.2 ounces per ton (37.32 gm. per tonne) of silver. There are no tailings or battery at the Dingo mine and the ore was probably carted to the Gift mine, held by the same operators, for treatment.

The workings on the Dingo mine follow four sub-parallel shears striking at 105 degrees and dipping steeply south. The main shaft on the easternmost vein is 75 feet (22.8 m) deep with stopes extending 45 feet (13.7 m) east and 40 feet (12 m) west to depths of about 70 feet (21 m). At the western end of the stope, a branch vein striking at 120 degrees was stoped over a short distance and at its junction with the main vein, a shoot 6 to 8 feet (1.8 to 2.4 m) wide was mined out. The other three veins on the lease were worked only by shallow pits and trenches.

RIDGE MINE (M.L. 140)

The Ridge or Windy Ridge mine, is on a prominent hill at the western end of the main group of mines and 2.8 miles (4.5 km) northwest of the Gift mine. Its recorded production of 205 tons (208.2 tonnes) of lead and 1,934 ounces (60,153.2 gm) of silver came from an ore shoot at

the intersection of two quartz veins. The main shaft, 130 feet (39.6 m) deep, is on a vein 2.5 to 3 feet (76 to 91 cm) wide, striking at 145 degrees and dipping at 80 degrees north. The second shaft, about 125 feet (38.1 m) deep, is on the other vein which strikes at 190 degrees, dips steeply east and intersects the first vein 20 feet (6 m) east of the main shaft. Stopes extend eastwards from the main shaft and northwards from the second shaft towards the junction of the veins. The combined length of the stopes is about 35 feet (10.6 m) and their depth is about 125 feet (38.1 m).

Minerals seen on the dumps of the Ridge mine were galena, cerussite, barite and a little cuprite.

BEADON MINE (M.L. 140)

The Beadon mine is halfway between the Gift and Ridge mines, on the crest of an east-trending ridge. It was the first lead vein pegged in the Kooline field and has produced 89 tons (90.4 tonnes) of lead and 780 ounces (24,260.3 gm) of silver.

Silver-lead ore was mined from two open-cuts 20 to 30 feet (6 to 9 m) deep, extending for 120 feet (37 m) along a vein 9 to 30 inches (22.8 to 76.2 cm) wide, striking 105 degrees and dipping 75 degrees south. The vein contains quartz, galena, cerussite and a considerable amount of barite.

SOUTH KOOLINE MINE (M.L. 121)

A set of awry poppet legs on a saddle connecting two ridges 0.4 of a mile (0.6 km) north of the Gift mine, marks the position of the South Kooline mine which produced 60 tons (60.9 tonnes) of lead and 596 ounces (18,537.3 gm) of silver from a quartz vein 200 feet (60 m) long. The reef strikes at 315 degrees, dips steeply south and was stoped over a distance of 50 feet (15 m) from a shaft 50 to 60 feet (15

TABLE 55. PRODUCTION OF LEAD AND SILVER FOR KOOLINE LEAD FIELD

Mine	Lease No.	Lease Name or Operator	Period	Est. Mine Production		Realized Production			Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore and Conc. Tons	Lead Tons	Silver F. oz.		
Gift	ML 122	Camp & Party	1948-57	7,749·00	1,164·00	1,214·69	932·03	8,362·07	213,994·32	Est. mine production incomplete
Bilrose	ML 118	Rose & Davies	1948-59	431·00	72·50	458·99	328·11	4,503·70	67,701·22	
June Audrey	ML 135	Holben & Party	1949-55	3,883·00	431·50	586·49	427·54	4,490·65	95,783·02	
	ML 163	Redcraze (Camp & Party)	1957-58	350·00	55·00	57·80	44·69	394·88	8,268·40	
	PA 213	Bagoes Syndicate	1948-49	.....	.....	20·02	13·56	237·94	2,638·64
	PA 213	Holben & Party	1949	.....	.....	26·64	18·14	233·10	2,403·30
Total, June Audrey	.....	.....	.....	.....	.....	690·95	503·93	5,356·57	109,093·36
Dingo	ML 143	Camp & Party	1951-58	1,799·00	250·00	289·04	209·38	2,318·23	39,009·08	
	MC 3	Camp & Dunlop	1948-49	.....	.....	16·05	10·92	121·24	2,206·36
Total, Dingo	.....	.....	.....	.....	.....	305·09	220·30	2,439·47	41,215·44
Ridge	ML 126	Rose & Johnson	1949-57	.....	.....	263·84	205·11	1,934·79	33,525·18
	ML 155									
Roebuck	ML 156	A. James	1951-56	.....	.....	41·91	29·23	303·74	5,986·86
	PA 315	Jensen	1957	.....	.....	34·20	25·84	253·87	5,769·40
Total, Roebuck	.....	.....	.....	.....	.....	76·11	55·07	557·61	11,756·26
Beadon	ML 140	Hill & Perry	1951-53	.....	.....	102·41	68·57	575·79	18,049·32
	PA 200	Hamilton, Camp, Dunlop	1948	.....	.....	27·52	20·80	203·66	3,271·42
Total, Beadon	.....	.....	.....	.....	.....	129·93	89·37	779·45	21,320·74
South Kooline	ML 121	M. E. Gray	1948-54	.....	.....	93·47	60·56	596·71	10,993·68
Kooline Queen	ML 120	Camp & Dunlop	1948-54	361·00	48·50	79·91	58·58	451·26	11,041·38	
Bandy Peak	ML 119	Perry, Camp, Rose, Davies	1948-51	.....	.....	56·37	45·59	186·18	9,202·88
	PA 232	Bellchambers	1948-49	.....	.....	7·71	5·40	143·06	1,176·00
Total, Bandy Peak	64·08	50·99	329·24	10,378·88	Adjoins ML 119 to north

TABLE 55 (continued)

Mine	Lease No.	Lease Name or Operator	Period	Est. Mine Production		Realized Production			Value \$Aust.	Remarks
				Ore Tons	Conc. Tons	Ore and Conc. Tons	Lead Tons	Silver F. oz.		
Silver King	ML 124	Camp & Party	1948-52	....	....	36.24	24.39	175.48	5,106.08	
Phar Lap	ML 123	B. Perry	1949-53	118.00	16.85	15.55	10.26	137.16	1,868.64	
Rainbow Group	ML 127	Carnegie (J. H. Brown)	1949	....	....	1.73	1.26	15.14	171.20	Same ground?
	ML 138	Rainbow (Camp & Party)	1952-53	....	....	8.19	6.04	59.06	906.60	
	ML 161	Campsite (Camp & Party)	1956-57	55.00	8.25	8.68	6.10	59.41	1,366.70	Same ground?
Total, Rainbow	....	....	....	....	....	18.60	13.40	133.61	2,444.50	
Mount Conspicuous	ML 133	A. Townsend	1949	....	....	0.59	0.43	5.16	58.10	
	ML 142	Gray & Party	1950	....	....	2.04	1.36	13.06	184.10	
Total, Mount Conspicuous	....	....	....	....	....	2.63	1.79	18.22	242.20	
Big Chief	ML 136	J. E. Francis	1950-52	....	....	22.10	7.91	12.94	1,451.20	
North Kooline Deposits	PA 300	Green & Woodsbey	1954	....	....	26.57	18.87	159.41	2,322.24	
	PA 316	Griffiths	1957-58	....	....	10.53	7.44	31.92	1,333.00	
Miscellaneous Deposits	PA 230	Joy & Brennan	1949-51	....	....	24.52	16.71	196.40	3,122.42	
	PA 233	Brennan	1949	....	....	7.88	5.45	68.95	741.00	Same ground
	PA 262	Illingsworth	1951	....	....	7.09	5.68	40.14	1,490.80	
	PA 239	E. Shanks	1949	....	....	9.62	5.81	99.57	1,254.00	Partly same ground
	PA 240	Ballard & Carson	1949	....	....	6.41	4.67	56.09	636.10	
	PA 244	E. Reck	1949	....	....	1.37	1.02	10.37	109.10	
	PA 297	Ballard, Shanks, Howie	1953	....	....	2.16	1.60	11.02	198.18	
	PA 260	Iverson & Crossley	1950	....	....	1.84	1.20	9.73	197.10	
	PA 270	A. J. Jenkins	1952	....	....	2.07	1.57	16.33	496.34	
	PA 283	Jensen & Jacobson	1953	....	....	5.21	3.41	22.03	430.76	
....	Crown Land, J. Downie Eldridge	1952	....	....	2.14	1.31	11.45	321.10		
....	Eldridge	1953	....	....	1.37	0.94	....	175.40		
Total, Kooline District	....	....	....	....	....	3,580.96	2,637.48	26,521.69	567,834.52	

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

to 18 m) deep. Other workings are shallow pits. The ore is galena in a gangue of quartz and barite.

Plan: Mines 161/3 is a sketch of the underground workings.

Assay: A parcel of second-grade ore assayed 23.2 per cent lead and 2.6 ounces per ton (80.86 gm per tonne) of silver.

KOOLINE QUEEN MINE (M.L. 120)

The Kooline Queen mine is 1,700 feet (520 m) northeast of the June Audrey mine. It yielded 58 tons (58.9 tonnes) of lead and 451 ounces (14,027.4 gm) of silver from four small ore shoots spread over a distance of 1,000 feet (300 m), on a line of echelon quartz veins striking at about 110 degrees and dipping steeply north. The average grade of ore milled from the lease was 13 per cent lead.

The main workings on the lease are midway along the line and comprise a 50-foot (15.2 m) deep shaft with a 40-foot (12 m) long stope. In these openings the vein ranges from a few inches to 2.5 feet (76 cm) wide.

Five hundred feet (150 m) west of the main shaft on a reef offset to the south, is a shoot 110 feet (34 m) long worked from three stopes to a depth of about 30 feet (9 m) and a maximum width of 4 feet (1.2 m). The lead vein feathers out at the western end of the stopes.

The third and fourth shoots worked on the lease are 300 and 400 feet (90 and 120 m) respectively east of the main shaft. Each is about 25 feet (7.6 m) long and was mined out to a depth of 20 feet (6.0 m). East of the fourth shoot the vein steps a few feet northwards and can be traced a further 100 feet (30 m) in small pits.

ROEBUCK MINE (M.L. 156)

The Roebuck mine is 2,000 feet (610 m) north of the Gift mine on the south side of a high ridge and about 700 feet (210 m) north-northeast of the South Kooline mine. It yielded 55 tons (55.8 tonnes) of lead and 558 ounces (17,355.4 gm) of silver from a lode made up of schistose sediments and narrow quartz veins, carrying galena, cerussite, barite and calcite. The lode courses 100 degrees, dips between steeply north and steeply south and was mined to a depth of about 50 feet (15 m) over a distance of 150 feet (46 m). It can be traced a further 400 feet (120 m) westwards from the workings in shallow pits. Where worked it ranged from 1.5 to 3 feet (46 to 91 cm) wide but carried lead only in narrow stringers.

Assay: A sample from the western end of the stopes assayed 7.45 per cent lead and 0.7 ounces per ton (21.77 gm per tonne) of silver over a width of 18 inches (45.7 cm).

BANDY PEAK (M.L. 119)

Mineral Lease 119 (Bandy Peak) and the adjoining tenement P.A. 232, are 0.9 of a mile (1.4 km) west-southwest of the Gift mine and 300 yards (270 m) south of the June Audrey mine. They produced 51 tons (51.8 tonnes) of lead and 329 ounces (10,232.8 gm) of silver from a narrow vein striking at 010 degrees and dipping 85 degrees west. The main workings on M.L. 119 are 50 feet (15 m) deep and include a shaft and a stope about 45 feet (13.7 m) long. One hundred feet (30 m) north of the stope and apparently on former P.A. 232, is an open-cut 25 feet (7.6 m) long and 20 feet (6 m) deep. The lode is exposed on a number of shallow pits between the cut and the stope.

SILVER KING MINE (M.L. 124)

What is thought to be the Silver King mine is 0.8 of a mile (1.2 km) south-southeast of the Gift mine, on a narrow saddle separating east and west flowing creeks. In this mine, a narrow vein striking 320 degrees, dipping 80 degrees south and carrying a large proportion of galena was mined over a distance of 50 feet (15 m) to a depth of 12 feet (3.6 m) to produce 24 tons (24.3 tonnes) of lead and 175 ounces (5,443.0 gm) of silver.

RAINBOW GROUP (M.L.s 127, 138 and 161)

The Rainbow group of mines which includes the leases known as the Rainbow, Carnegie and Campsite, is 0.6 of a mile (0.9 km) south of the Gift mine. In the absence of lease pegs it is impossible to relate the former tenements to the existing workings. The mines of the group follow a line of quartz veins parallel to the prominent quartz reef of Mount Conspicuous and have yielded a total of 13 tons (13.2 tonnes) of lead and 134 ounces (4,167.8 gm) of silver.

The veins were opened up by shallow workings over a length of 1,500 feet (460 m), but most of the ore was won from two shoots 800 feet (240 m) apart. The western shoot was worked from an open-cut benched into the side of a hill for 70 feet (21 m), to a maximum depth of 20 feet (6 m). One hundred and fifty feet (46 m) southeast of the cut, a trench 2 feet (61 cm) deep follows the lode for 60 feet (18 m). In these workings the lode is from 1.5 to 2 feet (46 to 61 cm) wide, strikes at 300 degrees, dips 70 degrees southwest and contains galena, cerussite and secondary copper minerals.

In the eastern shoot, galena and cerussite were mined from a lode 2.5 feet (76 cm) wide made up of sheared sediments with quartz stringers. Production came from an

open-cut 50 feet (15 m) long and 25 feet (7.6 m) deep.

PHAR LAP MINE (M.L. 123)

On the Phar Lap lease, 2,000 feet (600 m) west of the Dingo mine, two small ore shoots produced 10 tons (10.1 tonnes) of lead and 137 ounces (4,261.1 gm) of silver.

The shoots are on separate quartz reefs. The westernmost shoot is 45 feet (13.7 m) long, 2.5 feet (76 cm) wide, strikes 110 degrees and dips steeply south. It was stoped out to a depth of 20 feet (6 m) from an inclined shaft. The second shoot 300 feet (90 m) northeast of the first, was worked in patches over a distance of 140 feet (43 m) to a maximum depth of 10 feet (3 m). It is from 1 to 2.5 feet (30 to 76 cm) wide and carries thin veins of cerussite and copper carbonates. A prominent but barren quartz reef crops out between the two shoots.

MOUNT CONSPICUOUS (M.L. 133, 142)

Mount Conspicuous is the informal name of a prominent ridge formed by a large south-dipping quartz reef striking 300 degrees and passing about half a mile (0.8 km) south of the Gift mine. The mine of the same name is on the eastern end of the ridge about 1.3 miles (2.0 km) southeast of the Gift mine. It was worked in 1949 and 1950 to produce 1.8 tons (1.82 tonnes) of lead and 18 ounces (559.8 gm) of silver.

Surface workings on the lease follow the crest of the ridge for about 200 feet (60 m) and were directed at extracting small pods of galena and cerussite 1 to 2 feet (30 to 60 cm) wide, formed on the hanging wall (southeastern) side of the quartz reef.

An adit driven from the northeast side of the ridge on a bearing of 232 degrees cut the reef between 121 and 143 feet (36.8 and 43.5 m) from its portal at a depth of

60 feet (18.2 m) vertically below the eastern end of the outcrop. The greater part of the reef consists of barren, grey, flinty quartz with remnants of sheared sediments, but there is a 2-foot (60 cm) width of white quartz with a little galena at the hanging wall. No attempt was made to drive on the vein, which although low-grade in the adit, could well contain pods of galena along strike to the northwest.

Assays: A sample taken from one of the small surface cuts assayed 12.7 per cent lead, 0.01 per cent zinc and 1.8 ounces per ton (559.8 gm per tonne) of silver over a width of 18 inches (45.7 cm). Another sample cut from the lode in the northwest side of the adit assayed 4.47 per cent lead, 0.01 per cent zinc and 0.4 ounces per ton (12.44 gm per tonne) of silver.

MISCELLANEOUS PROSPECTS WITHIN THE MAIN GROUP

General Information

In addition to the mines described above, 12 small prospects were opened up in the area of the main group of workings in the Kooline field. Most of the prospects cannot be related to any former mining tenement, although many were probably included in the Prospecting Areas listed at the end of Table 55. In this report the prospects have been given arbitrary numbers, so that their descriptions can be more readily related to their positions on Plate 4.

The Prospects

No. 1 prospect comprises a few narrow, lead-bearing quartz veins cropping out along a ridge and tested by some shallow pits.

No. 2 prospect was probably included in former P.A. 240. Several narrow veins parallel to the cleavage of the host sediments have been worked from pits up to 6 feet (1.8 m) deep.

No. 3 prospect is on the western extension of the lode worked in the Roebuck mine and was probably included in P.A. 260. The reef is about 1 foot (30 cm) wide and is trenched to a maximum depth of 8 feet (2.4 m) over a length of 50 feet (15 m).

No. 4 prospect is near the South Kooline mine. A lode striking 270 degrees and dipping 70 degrees north was mined out from an open-cut 50 feet (15 m) long and 12 feet (4 m) deep.

No. 5 prospect is on the line of the Rainbow group about 500 feet (150 m) west of the western shoot. Narrow trenches up to 6 feet (1.8 m) deep follow a vein for about 200 feet (60 m) up the point of a ridge. Galena, cerussite and copper minerals are present on the dumps.

No. 6 prospect is a quartz vein 1 to 6 inches (2.5 to 15.2 cm) wide, striking at 360 degrees and worked in patches over a length of 700 feet (210 m). The workings are mainly narrow open-cuts, the largest of which is 40 feet (12 m) long and 10 to 15 feet (3.0 to 4.5 m) deep. Other openings include a shaft 20 feet (6 m) deep and an adit 25 feet (7.6 m) long driven on the vein where it crosses a ridge.

No. 7 prospect is a lode made up of 4 inches (10.2 cm) of quartz and 18 inches (45.7 cm) of schist, explored by a 20-foot (6 m) deep shaft and two trenches. It strikes at 280 degrees, dips 80 degrees south and has been tested over a length of 100 feet (30 m).

No. 8 prospect is an open-cut 50 feet (15 m) long and 5 feet (1.5 m) deep on a quartz vein striking at 100 degrees, dipping 75 to 80 degrees south and following the crest of a low ridge. On the south side of the ridge a parallel reef was tested by pits over a length of 40 feet (12 m).

No. 9 prospect is on the point of a ridge about 500 feet (150 m) south of the No. 8 prospect. A shaft was sunk 30 feet (9 m) in a 3-foot (90 cm) wide zone of fractured greywacke carrying extremely thin quartz veinlets with a little galena and a trace of copper. The average grade of the lode is very low and a considerable amount of hand sorting would be necessary to obtain a marketable concentrate.

No. 10 prospect is about 1,500 feet (460 m) east of the No. 7 prospect. A lode up to 3.5 feet (1.0 m) wide, striking 115 degrees and dipping 80 degrees south was worked from a 35-foot (10.6 m) deep shaft and an open-cut over a distance of 60 feet (18 m) and by trenches over a further 50 feet (15 m).

No. 11 prospect is 1,200 feet (370 m) south-southeast of the Silver King mine. Several pits were sunk on narrow quartz veins striking at 100 degrees. A local change in the strike of the bedding suggests that a large fault is nearby.

No. 12 prospect is a quartz vein 6 inches (15.2 cm) wide which has been traced over a length of 300 feet (90 m). The largest opening is a cut about 20 feet (6 m) deep and 15 feet (4.5 m) long. The only other workings are a few pits.

NORTH KOOLINE DEPOSITS

(P.A.s 300 and 316)

(Lat. 22° 58' S, long. 116° 21' E).

Two small silver-lead deposits have been worked in a range of hills which abut the Kooline-Ashburton Downs road, 7 miles (11.2 km) from Kooline homestead. Other unworked deposits were reported from the area but were not seen by the writer. Although no lease pegs are available to relate the two worked veins to their former tenements, it seems likely that the more exten-

sive workings are on P.A. 300. The total production from the group is 22 tons (22.3 tonnes) of lead and 165 ounces (5,131.9 gm) of silver.

Prospecting Area 300

The workings on former P.A. 300 are 2,000 feet (610 m) east of the road and on the crest of the southernmost ridge of the range. A line of open-cuts 8 feet (2.4 m) deep follows a narrow vein striking 165 degrees, dipping 80 degrees west for 60 feet (18 m). The remnants of reef left in the cuts range from 3 to 9 inches (7.6 to 22.8 cm) in width and contain a large proportion of galena and cerussite.

Assay: A chip sample of the lode assayed 34.4 per cent lead, 0.01 per cent zinc and 1.6 ounces per ton (49.76 gm per tonne) of silver over 6 inches (15.2 cm).

Prospecting Area 316

The deposit worked on P.A. 316 is 700 feet (210 m) east of the road on the southern side of the same ridge that bears P.A. 300. A shear 6 inches (15.2 cm) wide, striking at 135 degrees, dipping 80 degrees west and containing disseminated galena, was tested by pits over a length of 60 feet (18 m) to depths of 1 to 5 feet (30 cm to 1.5 m).

BIG CHIEF MINE (M.L. 136)

(Lat. 23° 11' S, long. 116° 36' E.)

The Big Chief mine is 10 miles (16.0 km) southeast of the main group of Kooline deposits. It is best reached by a track which branches southerly from the Kooline-Ashburton Downs road at a point about 27 miles (43.4 km) from Kooline homestead, and leads to Bywash Bore on the south side of the Ashburton River. The mine is 1 mile (1.6 km) southwest of the bore.

The mine yielded 8 tons (8.1 tonnes) of lead and 13 ounces (404.3 gm) of silver from a shoot 40 feet (12 m) long, striking 285 degrees and dipping 60 degrees south, being parallel to the bedding of the host sediments. The richest ore is in a narrow bed of shale intercalated between a massive band of quartzite above and a 2-foot (60 cm) thick bed of greywacke below. Differential movement between the beds, possibly during regional folding of the strata, has crushed the shale bed and afforded a site for mineral deposition. Some disseminated cerussite is also present in the hanging wall quartzite and the footwall greywacke.

Although traces of lead can be detected over a distance of 400 feet (120 m), workings were confined to the central shoot which was open-cut to a depth of 15 feet (4.5 m). Lead minerals present are galena and cerussite.

Assays: A sample of the ore dump assayed 24.1 per cent lead, 0.85 ounces per ton (26.44 gm per tonne) of silver and less than 0.01 per cent zinc. A chip sample over 3 feet (90 cm) from the bottom of the open-cut assayed 15.2 per cent lead, 0.02 per cent zinc and 0.23 ounces per ton (7.15 gm per tonne) of silver.

UAROO—RANGE DEPOSITS

GENERAL INFORMATION

The Uaroo—Range deposits are in a north-trending belt of country, 60 miles (96.5 km) long and 20 miles (32.1 km) wide, near the western edge of the Precambrian Shield. They extend from Range Station in the north to the old Monte Carlo mining centre in the southeast corner of the Uaroo pastoral lease. Uaroo, the main centre, is 85 miles (136.7 km) south-south-east of Onslow and close to the North West

Coastal Highway. Most of the other prospects are reached from tracks and roads branching from the highway.

Mining of silver-lead ores in this district commenced in 1901 and continued at irregular intervals to 1957. Most of the total production of 2,137 tons (2,171.1 tonnes) of lead and 39,400 ounces (1,225,458.2 gm) of silver, came from the Uaroo lead mine with smaller contributions from the Monte Carlo group, Thowagee, Nanutarra and the Emu mine. Lead was also won from the Range and Coober Peedy mines, but no records of production are available. Details of production are set out in Table 56.

References: Finucane and Sullivan (1939) and Daniels (1965) describe the geology of parts of the district. References dealing with particular mines are mentioned in the appropriate sections.

Plans: The Wyloo and Edmund 1 : 250,000 Geol. Sheets each cover part of the district. The rest is within the area of the Yanrey 1 : 250,000 Topographic Sheet.

GEOLOGICAL SETTING

The silver-lead deposits of the Uaroo-Range district are in metasediments and granites of Lower Proterozoic age. The metamorphic rocks include slate, chlorite and mica-schist, quartzite and meta-conglomerate and are probably equivalent to the Lower Proterozoic Wyloo Group. Granitic rocks are chiefly granites and granodiorites, belonging to the same period of granite intrusion as the 1,750 m.y. old Boolaloo Granodiorite. The main granite mass has been called the Kilba Granite by Daniels (1965) who notes a relationship between granite intrusions and lead deposits.

All but one of the lead deposits in the district are simple quartz veins. The except-

TABLE 56. PRODUCTION OF LEAD AND SILVER FROM UAROO—RANGE DISTRICT

Mine or Group	Lease No.	Name of Lease or Operator	Period	Realized Production			Est. Value \$Aust.	Remarks
				Conc. Tons	Lead Tons	Silver F. oz.		
Uaroo Lead Mine	ML's 43, 49, 84	Uaroo Silver-Lead mine	1908-19	2,824.05	1,773.48	31,365.92	67,036.00	From Dumps
	ML 3	Rainbow	1901-02	56.90	27.85	982.26	858.00	
	ML 102	Silver Star	1925-27	90.00	54.00	....	3,618.00
	MC 2	G. R. Ibbotson	1948-53	415.29	211.92	6,578.92	46,564.04	
Total, Uaroo Mine	....	....	....	3,386.24	2,067.25	38,927.10	118,076.04
Monte Carlo	MC 1	Nicol & Astrum	1948-49	23.83	14.55	45.93	2,460.72	
	ML 144	Two Dots	1952-53	34.72	21.67	68.63	5,044.94	
	PA 202	McConnell & Moore	1948	4.32	2.37	69.60	333.60	
	Late ML 111	E. Shanks	1949	13.56	8.22	80.10	1,377.50	
Total, Monte Carlo	....	....	....	76.43	46.81	264.26	9,216.76
Thowagee	PA 303	A. M. Hill	1956	19.28	14.98	189.29	2,879.42	
Nanutarra	MC 17	Carlyon & Parker	1956-57	9.95	6.05	....	1,311.60
Emu	PA 285	Donnelly Bros.	1952	4.45	2.48	18.69	697.20	
District Total	....	....	....	3,496.35	2,137.57	39,399.34	132,181.02

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

ion is the Turtle mine in which lead and copper are present in a stockwork.

UAROO MINE (M.C. 2)

(Lat. 22° 46½' S, long. 115° 22' E.)

The Uaroo silver-lead mine has also been called the Silver King, Silver Star or Rainbow mine. It is three-quarters of a mile (1.2 km) northwest of Uaroo Station homestead and about 400 yards (366 m) south of the new route of the North West Coastal Highway. It has been worked intermittently since 1901 to yield 2,067 tons (2,100.0 tonnes) of lead and 38,927 ounces (1,210,746.4 gm) of silver.

References: Maitland (1909, 1919), Finucane and Sullivan (1939), Simpson (1951), Simpson and Gibson (1907) and Blatchford (1913).

Plans: G.S.W.A. No. 1143 and in the reports of Finucane and Sullivan (1939), Maitland (1909), and Blatchford (1913).

Geological Information

The lode worked in the Uaroo mine is on a north-striking, east-dipping quartz vein 800 feet (240 m) long and cuts metasediments which strike northwesterly and dip easterly near the mine. From about 100 to 400 feet (30 to 120 m) from the southern end of its outcrop, the reef bifurcates to form a cymoid loop structure, the western part of which contains the main Uaroo lode. The eastern part has been called the No. 2 lode but seems to be barren.

The main lode is from 15 to 48 inches (38.1 to 121.9 cm) wide and was worked from an adit driven in from the east side

TABLE 57. ASSAY RESULTS—UAROO MINE

Position (feet south of intersection in adit)	Width Inches	Lead Per cent	Silver F. oz./ton
0 (In pillar)	48	Tr	0.289
10 " "	34	Tr	0.614
20 " "	41	0.16	1.054
30 " "	46	7.83	3.735
40 " "	15	1.08	2.048
50 " "	20	11.26	4.964
60 " "	24	11.52	3.960
70 " "	32	32.16	10.354
210 (Since mined)	25	43.93	9.308
220 " "	21	57.71	11.804
230 " "	28	33.80	5.998
240 " "	36	15.64	6.652
Mean of ten galena samples ....	....	66.3	16.18

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

of the hill on a bearing of 230 degrees. The adit cuts the lode 160 feet (49 m) from its portal and then follows it for a distance of 260 feet (79 m) southwards, at about 60 feet (18 m) below its outcrop. The reef has been stoped overhead to the surface over a distance of about 190 feet (58 m) and underfoot to a depth of 70 to 80 feet (21 to 24 m) below the adit, for a distance of about 140 feet (43 m). The ore shoot pitched southerly, following the intersection of the reef and the bedding planes.

Minerals present in the dumps are galena, pyrite, chalcopyrite, cerussite, angle-site and malachite.

Assays: Table 57 lists available assays from the lode. Positions given are in feet south of the intersection of the adit with the reef. A little gold has been recorded from the ores.

Conclusion

There is no record that the Uaroo mine has been tested adequately at depth below the stopes. Its high silver content, favourable geological structure and the close proximity of the new highway, would seem to make the deposit worth further investigation.

MONTE CARLO MINE (M.L.s 111, 113, 114)
(Lat. 23° 03' S, long. 115° 33' E).

The Monte Carlo, or Hancock mine is about 20 miles (32 km) south-southeast of Uaroo. There is no ready access to the deposit. Mines Department returns give the total production from deposit as 47 tons (47.7 tonnes) of lead and 264 ounces (8,211.1 gm) of silver mined between 1948 and 1953, but Finucane and Sullivan (1939) report that at least 19 tons (19.3 tonnes) of ore were raised prior to 1939.

Reference: Finucane and Sullivan (1939).

Plan: A plan of workings appears in the above reference. The position of the mine is shown on the Edmund 1 : 250,000 Geological Sheet.

The mine was not visited by the writer and the following information is taken from the above sources.

Geological Information

The lead-bearing formation is in granite and consists of cherty, brecciated material containing veins of crystalline quartz (with vugs), with small crystals and some large pieces of galena. The reef strikes north-northeast and may be traced over a total length of 2,800 feet (850 m).

The main workings are at the southern end of the outcrop and extend over a distance of about 400 feet (120 m), the width of the lode being about 2.5 to 3 feet (76 to 91 cm). North of the workings the reef is barren for a distance of 950 feet (290 m), then there is another mineralized section about 300 feet (90 m) long, with abundant galena over a width of 2.5 feet (76 cm) at its southern end.

THOWAGEE MINE (P.A. 303)

(Lat. 22° 56' S, long. 115° 02' E).

The Thowagee lead mine is 13 miles (20.9 km) southeast of Uaroo Station homestead and reached by an old track turning southwards from the Uaroo—Glen Florrie road at the boundary fence between the stations. The mine is close to the boundary fence about 4 miles (6.4 km) by track south of the road and 2.2 miles (3.5 km) from the abandoned Thowagee Bore. The only recorded production from the mine is 15 tons (15.2 tonnes) of lead and 189 ounces (5,878.4 gm) of silver in 1956, but

old lease pegs suggest that the mine was worked before that time.

Plan: The location of the mine is shown on the Wyloo 1 : 250,000 Geological Sheet. G.S.W.A. No. 10831 gives the distribution of the workings and reefs.

Geological Information

At Thowagee, lead has been mined from narrow lenticular quartz veins cutting mica and chlorite schists. Two lines of quartz veins are present, one trending north-northeast and the other northwest.

The north-northeast line is 1,200 feet (370 m) long and consists of about 10 separate quartz veins arranged in a general echelon pattern. It was worked by five open-cuts and several pits and trenches. The largest cut, alongside the old battery, is 25 feet (7.6 m) deep and 75 feet (22.8 m) long; other cuts range from 6 to 10 feet (1.8 to 3.0 m) deep and 30 to 80 feet (9 to 24 m) long. In the cuts the lead-bearing quartz veins are almost completely mined out, but seem to have been from 3 inches to a foot (7.6 to 30.4 cm) or more in thickness.

The northwest-trending reef crops out intermittently over a distance of 850 feet (260 m). Two parts of it have been worked; one at the northern end by an open-cut 75 feet (22.8 m) long and 6 to 8 feet (1.8 to 2.4 m) deep and another 250 feet (76 m) further south from an open-cut 100 feet (30 m) long and 5 to 8 feet (1.5 to 2.4 m) deep. Immediately south of the southern open-cut is a shaft 20 feet (6 m) deep with stoping on either side. A further 150 feet (46 m) south of the shaft is a line of pits about 200 feet (60 m) long, on the southernmost outcrop of the vein.

The only ore minerals seen in the Thowagee mine were galena and cerussite.

Assay: A sample taken from a cut on the north-northeast line of workings assayed 17.4 per cent lead, 3.87 per cent zinc and 3.2 ounces per ton (99.52 gm per tonne) of silver.

NANUTARRA MINE (M.L. 17)

(Lat. 22° 41' S, long. 115° 33' E).

The Nanutarra lead mine is about 3 miles (4.8 km) southeast of Mount Alexander and is reached by travelling overland for 2 miles (3.2 km) in a northwesterly direction from Joe Well. Joe Well is 18 miles (28.9 km) by road and track from Nanutarra Station homestead.

Plan: The position of the mine is shown on the Wyloo 1 : 250,000 Geological Sheet.

Geological Information

Lead and copper minerals are present in a quartz vein 6 to 48 inches (15.2 to 121.9 cm) wide which, when traced southeasterly, firstly curves to the east and then swings sharply to a bearing of 190 degrees. The vein is 450 feet (137 m) long but has been worked only near its northern end where it is richest. There the lead minerals are exposed in two narrow seams within the reef by a shaft 15 feet (4.5 m) deep.

Ore minerals noted on the lease were galena, cerussite, chalcopyrite and malachite. The quartz of the vein contains well developed comb structures. At its northern end the vein is in granite but to the south it passes into schist.

EMU MINE (P.A. 285)

(Lat. 22° 47' S, long. 115° 23' E approx.).

The Emu mine is 9 miles (14.4 km) south-southeast of Mount Alexander and 8 miles (12.8 km) by track southeast of Damper Well on Nanutarra Station. The

boundary fence between Nanutarra and Uaroo Stations is about half a mile (0.8 km) south of the mine. About 2.5 tons (2.54 tonnes) of lead and 18 ounces (559.8 gm) of silver were mined from the deposit in 1952, but it is likely that there was some earlier unrecorded production.

Two parallel quartz veins striking 305 degrees and dipping 75 degrees west, in gneiss and amphibolite, contain lead minerals over a total distance of 800 feet (240 m). The eastern line can be traced for about 350 feet (107 m) and was worked to a shallow depth from five longitudinal trenches. Along its length the vein ranges from 6 to 18 inches (15.2 to 45.7 cm) wide, averaging about 9 inches (22.8 cm). It carries disseminated galena and a little chalcopyrite and chrysocolla.

The western vein is from 2 to 4 feet (60 cm to 1.2 m) wide and carries patches of lead and copper minerals over a length of 450 feet (137 m), but has been worked in only two places 450 feet (137 m) apart. The northern opening is a short trench about opposite the southern workings on the eastern vein. At the south end of the reef is an open-cut in which the vein is 2 feet 3 inches (68.6 cm) wide and carries 9 inches

(22.8 cm) of disseminated galena on its hanging wall side.

Assays: Results of seven samples are listed in Table 58.

COOBER PEEDY PROSPECT

(Lat. 22° 42' S, long. 115° 29' E).

The Coober Peedy lead prospect is said to have been worked by a Mr. J. Ryan in about 1950, but no details of the production are recorded. It is 10 miles (16.0 km) northeast of Uaroo and can be reached by an old track from Granite Bore.

Plans: Yanrey 1:250,000 Topographic Sheet shows the location of the mine.

Geological Information

The Coober Peedy prospect is a lead-bearing quartz vein striking at 090 degrees and dipping 70 to 80 degrees north. It was mined from two shafts 160 feet (49 m) apart and from a shallow cut midway between the shafts. In the 33-foot (10.0 m) deep eastern shaft the lode is 18 inches (45.7 cm) wide, where seen above the water table at 15 feet (4.5 m). The western shaft is 27 feet (8.2 m) deep and from it the lode has been stoped on either side. In the cut

TABLE 58. ASSAY RESULTS—EMU MINE

Details	Lead Per cent	Zinc Per cent	Silver F. oz./ton	Gold Dwts/ton
Highest of five samples	82.0	....	6.38	nil
Lowest of five samples	20.7	....	0.76	nil
Mean of five samples	54.5	....	3.02	nil
Grab from dump	17.3	0.05	0.92	....
Chip over 9 inches south cut on west reef	15.1	0.09	0.66	....

NOTE: 1 inch = 2.54 centimetres
 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

the reef is 6 to 9 inches (15.2 to 22.8 cm) wide. The ore minerals present are coarse galena, cerussite and sphalerite.

Assay: A grab sample from a small dump of picked ore assayed 42.6 per cent lead, 5.92 per cent zinc and 6.55 ounces per ton (203.72 gm per tonne) of silver.

RANGE MINE (M.C. 67)

(Lat. 22° 12' S, long. 115° 25' E).

The Range lead mine is 4 miles (6.4 km) north of Range Station homestead and is reached from the North West Coastal Highway by a track branching westwards, 18 miles (28.9 km) north of Nanutarra Station. It is about 60 miles (96.5 km) by road from the port of Onslow. The deposit was first pegged in 1967 and worked during 1968. No production returns have been received at the time of writing, but when inspected in October 1968 there were about 25 tons (25.4 tonnes) of ore at grass.

Reference: Blockley (1969b).

Plan: G.S.W.A. Nos. 10520 and 10597 show the surface workings and the location of the mine.

Geological Information

The lode worked in the Range mine follows a silicified shear zone cropping out

intermittently through a cover of sand and has been traced by costeans over a distance of 1,300 feet (340 m). Mining is restricted to a shoot about 250 feet (76 m) long, some 300 feet (90 m) from the eastern end of the line. The lode here is from 2 to 5 feet (60 cm to 1.5 m) wide, dips 80 degrees south and consists of dense grey quartz carrying finely disseminated pyrite, chalcopyrite and galena. Most of the ore mined came from veins or lenses, up to 1 foot (30 cm) wide, of massive fine-grained galena on the hanging wall side of the lode. Oxidation has affected the lode only near the surface where the economic minerals are malachite and cerussite.

The workings comprise a number of pits and bulldozed costeans, a shallow open-cut 75 feet (22.8 m) long, and four shafts with depths ranging from 10 to 30 feet (3 to 9 m). In the deepest shaft the lode is 3 feet 3 inches (99.1 cm) wide and includes a vein of massive galena 11 inches (27.9 cm) wide on the hanging wall. Seventy feet (21 m) further west, in a shaft 25 feet (7.6 m) deep, the lode widens to about 5 feet (1.5 m) on a roll in the shear. Again it is richest on the hanging wall side and a little gouging has been carried out from the shaft in this rich part.

TABLE 59. ASSAY RESULTS—RANGE MINE

Position	Width	Lead Per cent	Zinc Per cent	Silver F.oz./ton
Ore dump ....	.....	35.5	0.09	4.25
30-foot shaft	2' 3"	32.5	0.03	4.25
25-foot shaft	about 4'	15.5	0.33	3.17

NOTE: 1 inch = 2.54 centimetres
 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

TURTLE MINE (M.L. 158)

(Lat. 22° 12' S, long. 115° 25' E).

The Turtle mine is about 1 mile (1.6 km) northwest of the Range mine and 5 miles (8.0 km) north of the Range Station homestead. It was worked in 1962 as a copper mine to produce 45.14 tons (45.86 tonnes) of ore averaging 4.43 per cent copper. Lead was present in the ore but no assays of this metal were made at the time. Due to its low grade the ore was not readily marketable and production ceased. In 1964, Westfield Minerals N.L. obtained an option over the property and drilled 18 blast-holes to test the size and grade of the lode. The company relinquished the option when results proved disappointing.

Reference: Blockley (1969b).

Plans: G.S.W.A. Nos. 10519 and 10597 show the surface workings of the mine.

Geological Information

The Turtle mine is on a low elongated hummock rising 20 or 30 feet (6 to 9 m) above the surrounding sandplain. Lead and copper minerals are disseminated in lenses of ferruginous quartz within a siliceous stockwork made up of silicified schist cut by many closely-spaced quartz veins. The stockwork extends over a length of 700 feet (210 m) and has a maximum width of 100 feet (30 m). Most of the richer lenses of lode matter are at the northeastern end of the stockwork, although a few patches of ferruginous quartz with traces of lead and copper occur elsewhere. Those lodes which have been tested dip steeply to the east.

The largest lode is 160 feet (49 m) long, averages 12 feet (3.6 m) in width and contains lead and copper throughout. It is richest at its northern end where a section 8 to 10 feet (2.4 to 3.0 m) wide was mined from an open-cut 10 feet (3 m) deep.

Twenty feet (6 m) east there is another lode 1 to 3 feet (30 to 90 cm) wide and about 90 feet (27 m) long. A shaft 27 feet (8.2 m) deep was sunk near the northern end of this lode, where it is widest and richest, but elsewhere it has been tested only by a shallow pit. The other lodes are all small and appear to be low in grade. Ore minerals present in the outcrop are cerussite, cuprite and malachite. Galena was reported in one of the drillholes.

Drilling: Of the 18 holes drilled by Westfield Minerals N.L., only two intersected lodes of possible ore grade. Hole 15, drilled beneath the open-cut, intersected 40 feet (12 m) of lode (true width) averaging 4.6 per cent lead and 3.9 ounces of silver to the ton (121.30 gm per tonne). A section in the middle of the lode contained 3.7 per cent copper over a true width of 8 feet (2.4 m). Hole 3, drilled from a site 50 feet (15 m) southwest of the shaft, cut 10 feet (3 m) of lode (true width) assaying 2.45 per cent lead. Two narrow sections within this each contained 11 per cent copper.

Assay: A sample from the face of the open-cut assayed 6.81 per cent lead, 0.02 per cent zinc, 3.39 per cent copper and 4.7 ounces per ton (146.18 gm per tonne) of silver. Another sample taken from the parallel lode worked in the shaft assayed 4.10 per cent lead, 0.70 per cent copper and 3.2 ounces per ton (99.52 gm per tonne) silver, over a width of 3 feet (91 cm).

WYLOO DEPOSITS

GENERAL INFORMATION

On the Wyloo pastoral lease, silver-lead ore has been mined from veins in Archaean crystalline rocks and others in Lower Proterozoic dolomite. Unfortunately few of

the original tenements were surveyed and the locations of many of the smaller deposits are unknown. Since the last period of mining activity, the prospectors have left the field and the pastoral property has changed hands, leaving no one locally who knows the positions of all of the deposits.

Wyloo Station homestead is about 130 miles (209 km) by road from Onslow. The various deposits are reached by tracks branching from the roads through Wyloo to Rocklea and Kooline Stations.

Lead minerals were first recorded at Mount Edith in the western part of the Wyloo pastoral lease in 1902 and subsequently a number of samples was sent to the Mines Department from localities given as Mount McGrath and Mount de Courcey. The first record of lead production in the area was in 1949 when a rise in price of lead brought prospectors into the area. In the period 1949 to 1953, 218 tons (221.4 tonnes) of lead and 1,484 ounces (46,156.8 gm) of silver were mined from the deposits. Details are given in Table 60.

Ellis (1951) included some of the Wyloo deposits in the Kooline lead field, but as the Kooline deposits are geographically and geologically distinct from those of Wyloo, that scheme is not followed here.

References: Ellis (1951), Forman (1938), and Daniels (1968).

Plan: Wyloo 1:250,000 Geological Sheet shows regional geology.

BELVEDERE MINE (P.A. 199)

(Lat. 22° 37' S, long. 116° 52½' E).

In 1949, ore containing 1.75 tons (1.77 tonnes) of lead and 80 ounces (2,488.2 gm) of silver was taken from the old Belvedere gold mine (G.M.L.s 40, 41 and 42), 7 miles (11.2 km) north-northeast of Wyloo station homestead. Previous pro-

duction of gold from the leases amounted to 454 ounces (14,120.7 gm). A description of the old workings can be found in Forman (1938).

Prospecting Area 199 covers the main workings on G.M.L. 40. Here a quartz reef up to 2 feet (60 cm) wide was mined over a length of 150 feet (46 m) to a depth of 50 feet (15 m). The vein which strikes at 360 degrees and dips 50 to 70 degrees west, is in Archaean metasediments. Lead was present as bunches of galena, cerussite, beudantite and plumbojarosite. All of the workings are in a disused condition and it is likely that the lead ore produced in 1949 came from the dumps.

On G.M.L. 41 to the south, a quartz vein 4 to 6 inches (10.1 to 15.2 cm) wide, which was mined for gold over a length of 200 feet (60 m) contains a little copper and lead.

SILENT SISTERS MINE

(M.L.s 137 and 139)

(Lat. 22° 52' S, long. 116° 20' E).

The Silent Sisters mine is 15 miles (24.1 km) southeast of Wyloo homestead. It was discovered in 1947 and worked by a small syndicate between 1949 and 1953. The mine was equipped with a treatment plant to crush and concentrate the ore and in consequence, ore from two nearby leases, the Theady (M.L. 117) and Theady West (M.L. 116) was carted to the Silent Sisters for treatment. The four leases produced a total of 114 tons (115.8 tonnes) of lead and 443 ounces (13,778.6 gm) of silver, but the contribution of each is unknown; probably most came from M.L. 137.

Reference: Ellis (1951).

Plans: Wyloo 1:250,000 Geological Sheet, Mines 161/1, G.S.W.A. No. 10825.

TABLE 60. PRODUCTION OF LEAD AND SILVER FROM WYLOO DISTRICT

Mine or Group	Lease No.	Name of Operator or Lease	Period	Realized Production			Est. Value \$Aust.	Remarks
				Ore and Conc. Tons	Lead Tons	Silver F. oz.		
Aerial Group	MCs 5 and 6	Aerial Mines Pty. Ltd.	1949-53	114.39	73.40	599.54	13,600.78	
	PAs 236, 237, 249	Smallpage, Rooney Brendahl and Reilly	1949-50	38.31	27.17	273.24	3,908.80	
Total, Aerial Group				152.70	98.57	872.78	17,509.58	
Silent Sisters Group	MLs 116, 117, 137, 139	Ashburton Mining and Mineral Syndicate	1949-53	154.97	110.75	427.64	24,320.16	
	MLs 116, 117	Theady (Neville, Neville and Kempton)	1949	4.55	3.37	15.47	658.00	
Total, Silent Sisters Group				159.52	114.12	443.11	24,978.16	
Belvedere	PA 199	Southie & Shanks	1949	3.91	1.75	80.12	348.90	= GML 40
Miscellaneous	PA 281	J. Sheminant	1952	0.93	0.60	34.34	183.08	Position unknown
Deposits	PA 286	F. Zagar	1952	2.41	1.31	53.84	365.50	Position unknown
Total, Wyloo District				319.47	218.65	1,484.19	43,385.22	

NOTE: 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

Geological Information

Five lead-bearing quartz veins have been worked on the Silent Sisters leases. Four were on M.L. 137 and one on M.L. 139. The veins strike between northwest and northeast and their outcrops cross a ridge of dolomite 120 feet (37 m) high. They dip steeply and cut the bedding of the dolomite. The ore comprises galena and sphalerite in a gangue of quartz, silicified dolomite, barite and calcite. It has ill-defined walls and the veins terminate in irregular stringers of quartz. They are tension gash fillings rather than veins on well-defined shears.

On M.L. 137 most production has come from a vein which trends northeast for 140 feet (43 m) and then turns abruptly northerly for a further 110 feet (34 m). It has been worked at its northern end from open-cuts 10 to 12 feet (3 to 4 m) deep and at its south end by stopes from an adit driven from a bench near the base of the ridge. The differences in elevations between the adit and lowest and highest points on the outcrop of the vein are about 50 and 100 feet (15 and 30 m) respectively, the average difference being about 80 feet (24 m). The adit which is driven on a bearing of 355 degrees, meets the vein 60 feet (18 m) from the portal and there turns and follows it for 140 feet (43 m) in a northeasterly direction. The stoped length of the lode decreases from about 130 feet (40 m) at the outcrop to about 30 feet (9.1 m) at the adit level, indicating that the shoot of payable ore shortens at depth. In the southern end of the adit the vein is from 1.5 to 3 feet (46 to 91 cm) wide, but narrows to 6 inches (15.2 cm) at the northern end.

West of the main reef and starting close to its southern end, a vein 3 to 10 inches (7.6 to 25.4 cm) wide was worked over a length of 150 feet (46 m) in a northwesterly direction. Workings are mainly trenches

along the outcrop but at its southern end the vein has been stoped to about 50 feet (15 m) depth, over a length of 30 feet (9 m) from a cross-cut put in from the main adit.

At a distance of 120 feet (37 m) east of the main reef, a vein striking at 010 degrees and dipping 87 degrees west, was stoped to the surface over a length of 50 feet (15 m) from an adit driven in along the reef. The stope is 25 feet (7.6 m) high at its northern end.

The fourth vein worked on M.L. 137 is 25 feet (7.6 m) to the east and parallel to the northern section of the main reef. It is made up of a few quartz stringers and dolomite, and has been trenched to a depth of 5 feet (1.5 m).

A fifth vein is about 1,000 feet (300 m) west of the others, on M.L. 139, the Silent Sisters West lease. It is a pipe like body on the intersection of two quartz veins, each 1 to 1.5 feet (30 to 46 cm) wide and was mined to a depth of 15 feet (4.5 m) from a circular stope 10 to 15 feet (3.0 to 4.5 m) in diameter.

A concordant body of gossan cropping out near the fifth reef was drilled by Westfield Minerals N.L. but was found to contain only iron minerals at depth.

Assays: A chip sample of the main lode on M.L. 137 taken over 18 inches (45.7 cm) in the adit, assayed 2.74 per cent lead, 0.23 ounces per ton (7.15 gm per tonne) of silver and less than 0.01 per cent zinc.

Theady Leases

The Theady leases were reported by the prospectors to be 4 miles (6.4 km) and 6 miles (9.6 km) respectively northwest of the Silent Sisters. A search by the writer in this area and near the Theady Well, 6 miles (9.6 km) northeast of the Silent Sisters, failed to locate these leases. No local information on their position was available.

AERIAL GROUP

(M.Cs 5, 6; P.As 236, 237, 249)

(Lat. 22° 52' S, long. 116° 37' E).

The Aerial group is 10 miles (16.0 km) west of the Silent Sisters mine and is reached by a track branching southwards from the Wyloo to Rocklea road at Minin-gee Well, 35 road miles (56.3 km) from Wyloo homestead. The first mining tenement over the area was applied for in 1948 and from 1949 to 1953 the group yielded 98.6 tons (100.17 tonnes) of lead and 873 ounces (27,152.9 gm) of silver from workings scattered over a length of about 2 miles (3.2 km). About three-quarters of this production came from the main workings on M.C. 5, the Aerial mine and the remainder from the three Prospecting Areas about 1.25 miles (2 km) to the northeast.

Reference: Ellis (1951).

Plan: G.S.W.A. No. 10801 shows surface workings.

Geological Information

The silver-lead ores worked on the Aerial group have come from small irregular shoots within a 50-foot (15 m) wide north-easterly-trending fault zone in dolomite of the Duck Creek Formation. The materials making up the fault zone are quartz, silicified dolomite and kaolin. Lead is present as cerussite and galena in pods in the kaolin sections and is also disseminated in quartz veins up to 4 feet (1.2 m) wide and 100 feet (30 m) long. In places it is associated with a little copper ore. The shoots are parallel, or at a small angle, to the main trend of the fault zone.

Aerial Mine

The workings on the Aerial mine follow the fault zone more or less continuously for 700 feet (210 m). Most ore came from two open-cuts each 20 feet (6 m) deep near

the battery. The northern cut worked a shoot on two intersecting veins and the southern cut, a 20-foot (6 m) wide lode, formed from closely spaced veins and mineralized intervening host rock. Other workings include three narrow open-cuts 50 feet (15 m) or less in length and a number of shallow shafts and pits. Most of the ore mined was low grade compared to the other lead deposits in the Ashburton Goldfield.

Assay: One chip sample over a shoot 3 feet 9 inches (1.1 m) wide assayed 2.66 per cent lead, 0.3 ounces per ton (9.33 gm per tonne) of silver and less than 0.01 per cent zinc.

Drilling: Westfield Minerals N.L. drilled 63 air-blast holes in the area of the mine and outlined near the southern end of the workings, a possible ore shoot 200 feet (60 m) long with a grade of 18 per cent lead.

Prospecting Areas 236, 237, 249

About 1.25 miles (2.0 km) northeast of the Aerial mine and on the same fault zone, a number of pits were sunk on lenses of galena-bearing quartz. These are probably the deposits covered by former P.As 236 etc. although the reported positions of these tenements is further northeast. Soil covers the fault over much of the area of the workings and no assessment of the lodes could be made. There are signs that a geochemical survey has been done in the area, but details are unknown.

MOUNT DE COURCEY

(P.As 281 and 286)

In 1952 a total of 2 tons (2.0 tonnes) of lead was produced from P.As 281 and 286 in the vicinity of Mount de Courcey. Prospecting Area 281 was reported to be 4 miles (6.4 km) east of Mount de Courcey

and south of the Rocklea road. The other was recorded as being 6 miles (9.6 km) north-northeast of Mount de Courcey. Neither prospect was found by the writer. A local station-hand believed P.A. 286 to be about 2 miles (3.2 km) north of Billaroo Bore, in the valley of Little Metawandy Creek. It is likely that one or both of these deposits provided the material assayed by Simpson from this locality. Two samples of galena showed 75 per cent lead with 9.95 ounces per ton (309.47 gm per tonne) of silver and 74.2 per cent lead with 2.45 ounces per ton (76.20 gm per tonne) of silver, respectively.

MAROONAH—GLEN FLORRIE DEPOSITS

Small amounts of lead were mined from four Prospecting Areas in the area covered by Glen Florrie and Maroonah Stations, and a fifth deposit containing both copper and lead has been tested. Three of the P.As could not be found in their recorded localities and the fourth, when located with assistance from station workers,

was several miles from its reported position. The fifth deposit, the Joy Helen prospect, is small but of considerable geological interest. Details of production from the deposits are given in Table 61.

References: Daniels (1968) and Daniels (1969).

Plans: Edmund and Wyloo 1:250,000 Geological Sheets.

LATHAM PROSPECT (P.A. 252)

(Lat 23° 31' S, long. 115° 40' E)

Prospecting Area 252 is 11 miles (17.7 km) east-southeast of Maroonah homestead on the eastern edge of a ridge formed by a dolerite sill. An old track to the mine branches from a station track (connecting Red Rock Bore to Pindanni Bore) where it crosses the dolerite ridge. The turnoff is difficult to find.

A quartz vein, 9 to 18 inches (22.8 to 45.7 cm) wide, strikes 345 degrees and dips 60 degrees west in a dolerite sill. It is parallel to, and about 50 feet (15 m) from, the eastern edge of the sill which here intrudes dolomite of the Irregully Formation

TABLE 61. PRODUCTION OF LEAD AND SILVER FROM MAROONAH—GLEN FLORRIE DISTRICT

Tenement	Operator	Period	Realized Production			Est. Value \$Aust.
			Ore and Conc. Tons	Lead Tons	Silver F.oz.	
PA 250	Weir	1949	1.06	0.65	7.07	62.80
PA 282	Coombes & Purvey	1952-53	5.05	3.80	27.03	855.72
PA 212	Edwards & Watson	1949	0.97	0.59	3.10	121.00
PA 252	Latham	1950	1.13	0.61	3.11	52.40
Total			8.21	5.65	40.31	1,091.92

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

above and metamorphic rocks of the Lower Proterozoic Wyloo Group below. The vein which can be traced for 200 feet (60 m), was worked from a shallow trench 50 feet (15 m) long and an open-cut 25 feet (7.6 m) long and 6 feet (1.8 m) deep. Ore minerals seen in the vein were galena and malachite.

Assay: A chip sample from the open-cut assayed 3.53 per cent lead, 0.02 per cent zinc and 0.42 ounces per ton (13.06 gm per tonne) of silver.

JOY HELEN PROSPECT (M.L. 267)

(Lat. 23° 15' S, long. 115° 46' E).

The copper-lead-zinc prospect known as the Joy Helen is 21 miles (33.7 km) northeast of Maroonah Station homestead, about 500 yards (460 m) east of the road to Glen Florrie. The turnoff to the mine is 2 miles (3.2 km) north of the crossing of the Henry River. There is no recorded production from the prospect and work to date has been confined to pitting and drilling.

Plan: Edmund 1:250,000 Geological Sheet shows the location of the prospect.

Geological Information

The lodes tested in the Joy Helen prospect are flat-dipping, irregular segregations of copper, lead and zinc minerals in silicified dolomite breccia of the Middle Proterozoic Irregularly Formation. Organic structures are common and the breccia may be part of an algal reef. The breccia unconformably overlies granite to the west and is intruded by dolerite dykes in the vicinity of the prospect.

Due to the irregular shape of the lodes, the sizes of the ore bodies were difficult to determine. The eastern lode strikes at about 030 degrees and probably dips flatly west. It was tested by pits and shallow shafts over

a length of 150 feet (45.7 m). The better grade ore seems restricted to two small parts of the line, one worked by a shallow cut and a flat stope from the bottom of a 20-foot (6 m) shaft and the other from a pit 8 feet (2.4 m) deep. The middle lode, about 250 feet (75 m) northwest of the east lode, strikes at 020 degrees and dips flatly west. A 35-foot (10.6 m) shaft sunk in the south end of the outcrop, passed through about 30 feet (9.1 m) of mineralized rock. The west lode, 100 feet (30 m) southwest of the middle lode, is only a weak showing of copper and lead minerals in brecciated shale and marl. It was tested by a pit 8 feet (2.4 m) deep.

Minerals noted in the workings were cerussite, galena, sphalerite, malachite, azurite, cuprite and chrysocolla.

None of the lodes follow any well-defined structure. They may be parallel to the bedding of the host dolomite (which is known to be flat-dipping in this area), but this could not be verified in the exposures on the lease. The mineralization seems to be of the Mississippi Valley type and the stratigraphic horizon containing the deposits seems worthy of closer investigation.

Drilling: Westfield Minerals N.L. drilled 91 air-blast holes on M.L. 167 and the surrounding area. Only a few patches of ore minerals were located. Some of the better results are listed in Table 62.

Assay: The shaft on the eastern lode cut 8 feet (2.4 m) of lode material assaying 35 per cent lead and 5 per cent copper. The shaft on the middle lode cut 30 feet (9 m) of broken rock assaying 5 to 10 per cent lead. A chip sample taken over 3 feet (90 cm) in a pit on the east lode assayed 23.6 per cent lead, 0.24 per cent zinc, 0.15 per cent copper and 0.62 ounces per ton (19.28 gm per tonne) of silver.

TABLE 62. SELECTED DRILLING RESULTS FROM JOY HELEN PROSPECT

Hole No.	Location	Interval feet	Lead Per cent	Copper Per cent
2	Middle lode	30—35	11.5	1.6
2	Middle lode	35—40	3.2	0.16
20	East lode	5—10	13.7	0.6
17	East lode	0—5	9.0	0.19
17	East lode	5—10	8.6	0.22

NOTE: 1 foot = 0.3048 metres

OTHER DEPOSITS

None of the deposits described below could be found from information available.

Prospecting Area 250

Some lead has been mined from P.A. 250 which was reported as being identical with late M.L. 115, 4 miles (6.4 km) east of Meilga homestead. The writer made a search of this lease which covers an old chrysotile mine, but found no sign of lead ore. The old Meilga gold and copper mine, 8 miles (12.8 km) east of the homestead was also examined for lead minerals, but without success.

Prospecting Area 282

P.A. 282 was reported to be 13 miles (20.9 km) west of Glen Florrie homestead. A local station-hand thought it to be nearer the Henry River and about 20 miles (32.1 km) from Glen Florrie, but was not able to fix the position more accurately.

Prospecting Area 212

A lead deposit reported to be about 25 miles (40.2 km) north of Maroonah Station and half a mile (0.8 km) east of the stock route was once covered by P.A. 212. The local pastoralists know of no lead mine in

this vicinity, but suggested that a copper show near Mountain Creek Bore, about 12 miles (19.3 km) further south, might have yielded some lead.

Glen Florrie Station

A small lead vein about 2 miles (3.2 km) south of Glen Florrie homestead is shown on the Edmund 1:250,000 Geological Sheet. No further details are known.

ASHBURTON DOWNS DEPOSITS

In the period from 1960 to 1963, about 70 small copper deposits were discovered in the Capricorn Range south of Ashburton Downs homestead. A few of the better deposits were opened up by the Ashburton Mining Co. Pty. Ltd. as a source of cupreous ore, but work ceased when either the higher grade oxidized ore was mined out, or in some cases when the ore was found to contain too much lead to be acceptable as fertilizer. Since 1963 the deposits have been investigated by two mining companies who carried out geochemical analyses and did some drilling in the area, but to date there has been no commercial production of lead from the field.

The positions of most of the smaller showings are not recorded. The writer

examined several of the larger deposits and found that two, those on M.Cs 84 and 91, carried significant amounts of lead. The deposits follow shear zones in greywackes and shales of the Lower Proterozoic Capricorn Formation. Some follow the bedding planes of the sediments, but most are transgressive. They are true lodes in the sense of being mineralized fault zone material and not intrusive quartz reefs.

References: Low (1963), Daniels (1969), and private reports by Westfield Minerals N.L. and Pickands Mather International.

Plan: Edmund 1:250,000 Geological Sheet.

ANTICLINE PROSPECT (M.C. 84)

The Anticline prospect, called also the Bali Low prospect, is 6 miles (9.6 km) southwest of Ashburton Downs homestead and is reached by a track branching left from the road to Stockyard Creek, at a fence 6 miles (9.6 km) west of the homestead. No production of lead or copper has been recorded from the prospect.

A shear zone 2 feet (60 cm) wide, striking 280 degrees and dipping 55 to 60 degrees south, carries copper and lead minerals over a distance of 700 feet (210 m). The host rocks are greywacke and shale striking at 260 degrees and dipping 45 degrees south. Secondary ore minerals seen were malachite, azurite and cerussite, while primary ore from the shaft contained galena, chalcopyrite, bornite and pyrite. Workings consist of a few pits and an inclined shaft sunk by Westfield Minerals N.L. to a depth of 110 feet (34 m) (95 feet (28.9 m) vertical depth). From the bottom of the shaft a cross-cut was put out 30 feet (9 m) southerly and drives for 20 feet (6 m) east and 25 feet (7.6 m) west were cut.

Good lead ore was encountered in the shaft between 40 and 80 feet (12 and 24 m), but thereafter the grade dropped appreciably.

Diamond Drilling

Pickands Mather & Co. International drilled one hole 400 feet (122 m) west of the shaft. It intersected a true width of 13 feet (3.9 m) of sheared and brecciated sediments containing pyrrhotite, but no economic minerals, at a vertical depth of 250 feet (76 m) below the outcrop of the lode.

Assay: Results of assayed samples from the shaft are listed in Table 63.

In 1963, cerussite was reported from the outcrop of Casley's lode on M.C. 92, 0.7 of a mile (1.1 km) west of the Anticline prospect on the same line of shearing, but none was seen by the writer in 1968 after the outcrop had been removed by mining.

LEDGE PROSPECT (M.C. 91)

The Ledge prospect on former M.C. 56 is 2.5 miles (4.0 km) west of the Anticline prospect on the south side of a high ridge and about 800 feet (240 m) north of Stockyard Creek. Access is by way of a dogger's track along the creek bed.

Four lodes crop out in the area of the lease. The largest is 170 feet (52 m) long, averages 3 feet (90 cm) in width (ranging to 6 feet (1.8 m)) and strikes at 110 degrees with a dip of 75 degrees south. It was worked by trenches and open-cuts over a length of 100 feet (30 m). The outcrop of the lode contained high-grade copper ore but much of this has now been removed. Ore minerals seen in the lode were malachite, azurite, cuprite, tenorite and black, copper-stained cerussite. Lead is most abundant at the western end of the workings.

TABLE 63. ASSAY RESULTS—ANTICLINE PROSPECT

Location	Type of Sample	Lead Per cent	Zinc Per cent	Silver F. oz/ton
Shaft 20 to 30 feet	Bulk	0.96	....	....
Shaft 30 to 40 feet	Bulk	11.05	....	....
Shaft 40 to 50 feet	Bulk	7.1	....	....
Shaft 60 to 70 feet	Bulk	16.4	....	....
Shaft 70 to 80 feet	Bulk	12.8	....	....
Shaft 80 to 90 feet	Bulk	0.62	....	....
Shaft 90 to 100 feet	Bulk	nil	....	....
Shaft 100 to 110 feet	Bulk	nil	....	....
West Drive 12 feet	Face	nil	....	....
East Drive 0 to 3 feet	Bulk	0.64	....	....
East Drive 3 to 6 feet	Bulk	1.2	....	....
East Drive 6 to 9 feet	Bulk	1.4	....	....
East Drive 9 to 12 feet	Bulk	1.3	....	....
Dump of shaft	Picked (?) ore	23.0	0.70	1.5
Pit 300 feet west of shaft	Chip over 28"	24.4	0.07	7.8

NOTE: 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

Other lodes crop out 150 feet (46 m) west and 50 and 130 feet (15 and 40 m) north of the main lode. They contain copper ore but no lead minerals were seen in them.

Assay: A chip sample taken at the western end of the main lode assayed 31.3 per cent lead, 0.08 per cent zinc, 6.8 per cent copper and 3.6 ounces per ton (111.97 gm per tonne) of silver.

OTHER OCCURRENCES

Lead minerals have been reported from the Station Creek prospect and from an unnamed prospect south of M.C 92.

The Station Creek prospect is 3.5 miles (5.6 km) south of Ashburton Downs homestead. It is a narrow mineralized shear worked over a length of 70 feet (21.3 m) by pits and an open-cut. The hanging wall

of the lode is well defined, but an open stockwork of copper-bearing quartz veins extends for several feet into the footwall shale.

The unnamed prospect contains low grade copper, lead and silver minerals in an irregular shear striking 110 degrees in fine-grained conglomerate.

MISCELLANEOUS DEPOSITS

Simpson (1951) lists some further lead occurrences in the Ashburton Goldfield and details of these and one other are given below. In most cases the localities given are not precise and some difficulty could be expected in relocating the deposits. The only occurrences seen by the writer were those at Mount Stuart and the South Hardey River.

CANE RIVER

A narrow leader of lead ore occurs in the same property as the Cane River copper mine, 20 miles (32.1 km) north of Mount Stuart. Its small size renders it unpayable.

GODFREY RANGE

(Lat. 24° 15' S, long. 150° 00' E).

Four miles (6.4 km) south of the Frederick River Gorge in the Godfrey Range, a lead vein was opened up in 1924. It contains masses of coarsely crystalline galena, crushed in places, in a gangue of quartz. An assay of hand-picked ore showed 71.2 per cent lead, 16.08 ounces per ton (500.14 gm per tonne) of silver and a trace of gold.

HARDEY RIVER

A specimen of galena said to have come from the Hardey River, 10 miles (16.0 km) south of Mount de Courcey, had cleavage faces up to 1 inch (2.5 cm) square and contained 8 ounces per ton (248.8 gm per tonne) of silver.

LYNDON STATION

Three samples of silver-lead ore from 11 miles (17.7 km) northeast of Lyndon Station homestead assayed 72.7, 68.5 and 56.4 per cent lead respectively. Silver contents in the same order were 51.42, 5.62 and 4.20 ounces per ton (1,599.32, 174.79 and 130.63 gm per tonne).

MOUNT ELIZABETH

On M.L. 99, 4 miles (6.4 km) southwest of Mount Elizabeth on Boolaloo Station, there is a vein of galena. A picked sample assayed 78.0 per cent lead and 2.85 ounces per ton (88.64 gm per tonne) of silver.

MOUNT PRICE

A few miles north of Mount Price, some massive galena was taken in 1936 from a vein in rocks of the Ashburton Formation. It assayed 77 per cent lead, 20.1 ounces per ton (625.17 gm per tonne) of silver and had a trace of gold.

MOUNT STUART

A shaft 30 feet (9 m) deep has been sunk on a lode containing carbonates of lead and copper, about 1.5 miles (2.4 km) on a bearing of 235 degrees from the Mount Stuart trigonometrical station. The lode can be traced for about 200 feet (60 m) west and 100 feet (30 m) east of the shaft and follows a bed of sheared conglomerate within sediments of the Wyloo Group, while 650 feet (198 m) east of the shaft there is a costean exposing more copper-stained conglomerate on possibly the same stratigraphic horizon. Outcrop between the two occurrences is obscured by scree, so it was not possible to establish continuity of the lode between the two lots of workings.

It is possible that the copper-lead mineralization at Mount Stuart is conformable and the occurrences seem to warrant further investigation, possibly by geochemical and geophysical methods.

References: Maitland (1909), Simpson (1951).

Assay: A sample from the dump of the shaft assayed 35.7 per cent lead, 0.01 per cent zinc, 4.76 per cent copper and 2.7 ounces per ton (83.97 gm per tonne) of silver.

TOWERA STATION

Galena, very coarsely crystallized and associated with thin crusts of anglesite and cerussite, has been obtained between the Lyndon and Yannarie Rivers on Towera

Station. Assay values of two samples were respectively 73 per cent lead with 5.8 ounces of silver (180.39 gm) and 0.8 pennyweights (1.24 gm) of gold per ton; and 69.6 per cent lead with 6.8 ounces per ton (211.50 gm per tonne) of silver and 0.28 pennyweights of gold per ton (0.435 gm per tonne). The second sample also contained 1.3 per cent copper.

GORGE CREEK

Samples of auriferous lead ore have been reported from a gorge (probably Gorge Creek) in the Capricorn Range, 20 miles (32.1 km) southeast of Mount Mortimer. The vein is said to be 6 feet (1.8 m) wide in places. The ore contains cerussite and galena in a gangue of quartz. Gold values range from less than 1 pennyweight to 1 ounce 8.5 pennyweights per ton (1.55 to 44.32 gm per tonne). A sample of 12 tons (12.19 tonnes) of ore raised in 1937 assayed 55.3 per cent lead, 6.33 ounces per ton (196.88 gm per tonne) of silver and 4.88 pennyweights per ton (7.59 gm per tonne) of gold.

MOUNT PALGRAVE

A quartz vein with galena and a little chalcopyrite has been found 7 miles (11.2 km) southwest of Mount Palgrave. A sample assayed 66.2 per cent lead, 6.27 ounces per ton (195.01 gm per tonne) of silver and 0.79 per cent copper.

SOUTH HARDEY RIVER PROSPECT

(Lat. 22° 58' S, long. 116° 36' E).

A recent discovery of lead ore from 4 miles (6.4 km) south of the Hardey River, is reached by a track from the Aerial mine, passing Wonangarra Well and crossing the Hardey River.

The deposit is in interbedded slate and quartzite of the Ashburton Formation and comprises several lenses of galena, with associated cerussite and copper minerals, formed on shears parallel to the bedding planes of the host rocks. A few pits sunk on the individual lenses are the only workings.

Several quartzite beds near the deposits contain cubical casts after pyrite but these seem to be diagenetic and unrelated to the lead mineralization.

Gascoyne and Peak Hill Goldfields

SUMMARY

Of several small deposits of silver-lead ore scattered throughout the areas of the Peak Hill and Gascoyne Goldfields, only two, the Mangaroon lead mine and the Keep-it-Dark mine, have been worked. The first of these belongs to the same geological province as the deposits of Uaroo—Range in the western part of the Ashburton Goldfield, while the other has a similar occurrence to the copper deposits of Kumarina and Ilgararie. Details of production are given in Tables 64 and 65.

Despite the low production of lead, zinc and silver, parts of these Goldfields have been subjected to intensive investigation by some large mining companies. The areas of interest are those occupied by the

Middle Proterozoic Bangemall Group, some formations of which contain unusually high amounts of copper and zinc. To date no ore bodies are known to have been found by these companies, but work is continuing. Other deposits of potential importance in the Goldfields are those at Prairie Downs and McCarthy Find.

DESCRIPTION OF THE DEPOSITS

MANGAROON LEAD MINE

(Lat. 23° 51' S, long. 115° 44' E).

The Mangaroon lead mine is 9 miles (14.4 km) northwest of the Mangaroon Station homestead and 1 mile (1.6 km) north of the Star of Mangaroon gold mine. It was worked intermittently between 1956

TABLE 64. ANNUAL PRODUCTION OF LEAD FROM GASCOYNE AND PEAK HILL GOLDFIELDS

Year	Ore and Conc. Tons	Lead Tons	Value \$Aust.
1949	5.50	4.30	568.40
1950-55 ....	....	....	....
1956	7.60	5.69	1,262.20
1957-59 ....	....	....	....
1960	3.83	2.61	306.10
Total to 1968	16.93	12.60	2,136.70

NOTE: 1 ton = 1.01605 tonnes

TABLE 65. PRODUCTION OF LEAD AND SILVER FROM GASCOYNE AND PEAK HILL GOLDFIELDS, BY CENTRES

Locality	Lease	Name of Mine or Operator	Period	Realized Production			Value \$Aust.	Remarks
				Conc. Tons	Lead Tons	Silver F. oz.		
Mangaroo Station (Gascoyne GF)	MC 4 ...	Bohan & McDonald ...	1956-60 ...	11.43	8.30	94.54	1,643.90	Also produced 40.09 ounces of gold
Bulloo Downs (Peak Hill GF)	ML 63P ...	Keep-it-Dark ...	1949 ...	5.50	4.30	59.95	589.30	

NOTE: 1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

and 1960 to produce 11.43 tons (11.61 tonnes) of concentrate containing 8.3 tons (8.43 tonnes) of lead, 13.96 units of copper, 94 ounces (2,923.6 gm) of silver and 49 ounces (1,524.0 gm) of gold.

Reference: Daniels (1969).

Plan: Edmund 1:250,000 Geological Sheet for location.

Geological Information

Ore has been mined from three quartz veins containing galena, cerussite, malachite, chrysocolla and free gold within gneiss of probable Lower Proterozoic age. The veins strike at 360 degrees and dip 10 to 15 degrees east. The uppermost vein ranges in width from 4 to 12 inches (10.2 to 30.5 cm) and continues throughout the workings. In the southern face of the open-cut, it has an average width of 10 inches (25.4 cm) over a distance of 30 feet (9 m) and contains from nil to 45 per cent lead, averaging about 15 per cent lead. The lower veins are in echelon arrangement and lie respectively 2 and 4 feet (60 cm and 1.2 m) below the upper vein. In the eastern part of the workings, there is a complementary relationship between the upper vein and the vein 4 feet (1.2 m) below it, the upper becoming thinner as the lower vein thickens. The lower vein in the open-cut varies from 8 to 10 inches (20.3 to 25.4 cm) thick and contains up to 75 per cent lead in one section 10 feet (3 m) long. Another similar section is barren of lead.

The veins have been worked over a strike length of 45 feet (13.7 m), to about 30 feet (9 m) down dip by means of a small open-cut and a flat stope.

Although narrow, the veins contain patches of high-grade galena which should prove profitable to the "gouger" in times of high metal prices. The flat dip of the veins

and the occurrence of free gold should be a further inducement to the miner.

KEEP-IT-DARK MINE

(Lat. 24° 08' S, long. 119° 35' E).

The only lead mine in the Peak Hill Goldfield is the Keep-it-Dark mine, 11.7 miles (18.8 km) south of Bulloo Downs homestead and about 200 yards (183 m) east of the old Bulloo Downs-Ilgararie road.

Reference: none.

Plan: G.S.W.A. No. 10823 shows surface workings.

Geological Information

The lode worked in the Keep-it-Dark mine follows a shear striking at 020 degrees and dipping 75 degrees west and comprises narrow (6 to 12-inch (15.2 to 30.5 cm)) lenses of quartz-filled breccia with galena, cerussite and manganese oxides. The host rock is horizontally bedded shale of the Bangemall Group. A thin, irregular dolerite dyke forms the footwall of the lode over part of its length and a little above the stratigraphic position of the mine the shales are intruded by a thick sill of dolerite.

The principal workings extend over a distance of 95 feet (28.9 m) to a maximum depth of 15 feet (4.5 m) in a small open-cut. Two hundred feet (60 m) north of the main workings, there is a shallow open-cut 20 feet (6 m) long and 5 feet (1.5 m) deep, on what seems to be an extension of the lode. Other small lenses of lode crop out to the north of the cut for a distance of about 80 feet (24 m).

Assays: A sample from the dump of the open-cut assayed 24.3 per cent lead, 0.34 per cent zinc and 0.7 ounces per ton (21.77 gm per tonne) of silver. A chip sample over 9 inches (22.8 cm) from a trench north of the cut assayed 9.34 per

cent lead, 0.32 per cent zinc and 0.13 ounces per ton (4.04 gm per tonne) of silver.

PRAIRIE DOWNS PROSPECTS

(Lat. 23° 42' S, long. 119° 17' E).

The Prairie Downs prospects, 14 miles (22.5 km) southeast of Prairie Downs homestead, were first recorded during the geological mapping of the Newman 1:250,000 Sheet. They can be reached by four-wheel drive vehicles from a track passing about 2 miles (3.2 km) north.

Reference: Daniels and MacLeod (1965), p. 21.

Plan: Newman 1:250,000 Geological Sheet shows locations.

Geological Information

Lead and copper minerals in a gangue of ferruginous quartz and barite are found intermittently over a distance of about 1.5 miles (2.4 km) along the Prairie Downs Fault, which brings Archaean basalts on the north side into contact with Middle Proterozoic sediments of the Bangemall Group on the south. It is estimated to have a vertical displacement of at least 30,000 feet (9,100 m) and is a major geological feature of the area. In the vicinity of the deposits it is expressed by a prominent quartz reef 30 to 40 feet (9 to 12 m) thick, striking at 320 degrees and dipping steeply to the northeast. The lead and copper deposits form veins or lenses on the hanging wall side of the fault zone. In the absence of existing names, the three main deposits are here numbered from east to west.

No. 1 Deposit

The mineralized zone making up No. 1 deposit, comprises a number of overlapping echelon veins of ferruginous quartz

ranging in width from a few inches to 6 feet (1.8 m) and dipping at 70 degrees northeast. The deposit is about 200 feet (60 m) long and strikes at 340 degrees, although the individual veins within it strike at 320 degrees. It is widest near the eastern end where lead and zinc are present over a width of 6 feet (1.8 m). Further west lead and copper minerals occur together, in gossanous veins 6 to 18 inches (15.2 to 45.7 cm) wide.

No. 2 Deposit

The No. 2 deposit about 1 mile (1.6 km) northwest of the No. 1 deposit, is up to 8 feet (2.4 m) wide and 150 feet (46 m) long. It is on the hanging wall side of the main fault zone, which is represented here by a ferruginous quartz reef. The lode is made of up two distinct sections: a 2-foot (60 cm) wide vein of barite in the hanging wall side and a 6-foot (1.8 m) wide zone of gossanous quartz with barite, copper stains and cerussite in the remainder.

No. 3 Deposit

About 500 feet (150 m) northwest of the No. 2 deposit, is a lens of barite and

quartz with a little galena making up the No. 3 deposit. The lens is 10 to 12 feet (3.0 to 3.6 m) wide and about 50 feet (15 m) long with barite forming about 75 per cent of its composition.

Smaller lenses of barite with traces of galena and pyrite crop out along the line of the fault over a distance of about 600 feet (180 m) northwesterly from the No. 3 deposit.

Assays: The assay results of six samples from the deposits are listed in Table 66.

McCARTHY FIND

(Lat. 24° 05' S, long. 116° 45' E).

The McCarthy Find deposit (known also as the Kurabuka Creek or Mount Augustus deposit) is about 18 miles (28.9 km) north-northeast of Bangemall, on the south side of Kurabuka Creek. A track from Mount Augustus woolshed to Deep Well Mill, passes half a mile (0.8 km) east of it. It was discovered in about 1923 and although held as M.L. 13, has no recorded production.

References: Wilson (1925b) and Simpson (1951, p. 309 and 310). It should be noted that Simpson described the deposit

TABLE 66. ASSAY RESULTS—PRAIRIE DOWNS PROSPECT

Location	Width Feet	Lead Per cent	Zinc Per cent	Copper Per cent	Barium Per cent	Silver F. oz./ton
No. 1 lens east end	5	1.77	4.80	0.06	0.02	1.65
No. 2 lens east end	Picked	1.76	11.3	0.09	0.07	1.0
No. 1 lens west end	1.5	32.4	8.37	2.69	0.20	10.6
No. 2 lens	3	0.44	0.18	0.92	14.1	0.3
No. 2 lens	2	0.43	0.08	.....	33.5	0.1
No. 3 lens	12	2.97	0.05	.....	25.9	0.17

NOTE: 1 foot = 0.3048 metres
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

TABLE 67. ASSAY RESULTS—MCCARTHY FIND PROSPECT

Sample	Lead Per cent	Silver F. oz./ton	Gold Dwts/ton
A	82.9	28.26	Trace
B	81.5	28.95	Tr
C	78.9	32.54	Tr
D	64.1	9.82	Tr
E	47.4	12.78	Tr
F	44.8	15.01	Tr
Galena from pit	60.71	16.84	Tr
Best of ten picked samples	85.9	34.07	nil
Poorest of ten picked samples	45.3	10.99	Tr
Mean of ten picked samples	72.6	22.79	Tr

NOTE: 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

twice; once as Kurabuka Creek and again as McCarthy's Find.

Geological Information

The deposit was not examined by the writer and the following information is taken from the sources given above and from private reports of Westfield Minerals N.L.

The deposit is on a low hill of dolomite of the Irregularly Formation rising from flat alluviated country. Veins of quartz with an average of 5 to 10 per cent galena, appear in a 2-foot (61 cm) wide shear zone striking easterly across the hill. Individual veins range in width from a fraction of an inch to 3 inches (7.6 cm). A pothole, 2 feet (60 cm) deep has been sunk on the largest vein and lumps of pure galena could be dug from it. Minerals present are quartz, dolomite, siderite, limonite, cerussite, anglesite, galena, covellite, chrysocolla and malachite. The galena contains a considerable amount of silver.

Assays: Simpson and Wilson give assays of hand-picked ore which are listed in Table 67.

The silver values were closely proportional to the lead values. The galena was almost all very coarsely crystallized. The associated minerals observed were quartz and dolomite in large amounts, with a little anglesite, cerussite, siderite, limonite, covellite, chrysocolla and malachite.

In places, distinct crustification is seen; the walls being coated with quartz to the thickness of a few millimeters and the centre of the vein being filled with galena, which has grown inwards from either wall, forming a distinct wavy junction down the middle.

MISCELLANEOUS DEPOSITS

Information on the following minor deposits is taken from Simpson (1951), Mines Department files, and reports of private companies.

Dalgety Downs Station

(Lat. 25° 15' S, long. 116° 15' E).

An argentiferous lead vein was found in metasediments on Dalgety Downs Station in 1923. The galena which was coarsely crystalline and associated with quartz, assayed 72 per cent lead, 34.5 ounces per ton (1,073.05 gm per tonne) of silver and a trace of gold.

Jimblebar

(Lat. 23° 24' S, long. 120° 04' E).

A quartz vein, near the old gold mining centre of Jimblebar, contained a little fine galena. A sample assayed 10.6 per cent lead, 0.71 ounces of silver per ton (22.08 gm per tonne) and 0.21 ounces per ton (6.53 gm per tonne) of gold.

Mount Isabella

(Lat 24° 21' S, long. 116° 40' E).

On the Upper Lyons River near Mount Isabella, a prospector opened up the outcrop of a lead vein consisting largely of massive anglesite, with some quartz, limonite, cerussite, malachite and galena. A typical sample assayed 45 per cent lead, 2.8 per cent copper, 4.84 ounces per ton (150.53 gm per tonne) of silver and showed a trace of gold.

Gifford Creek Station

(Lat. 24° 05' S, long. 116° 15' E).

Ten miles (16.0 km) northeast of Gifford Creek homestead, lead and copper minerals occur in a lens of porphyry within gneiss. The lens is 150 feet (46 m) long and 2 feet (60 cm) wide.

Mount Palgrave

Copper minerals with associated zinc are exposed at the surface in three localities

near Mount Palgrave and were investigated by Westfield Minerals N.L. At the original find, 290 chains (5.8 km) at 280 degrees from Mount Palgrave, copper occurs immediately below the Discovery Chert, on the east limb of a syncline. One hundred chains (2.0 km) west-northwest of the Mount, copper is widespread at the top of the Prospect Shale and is also found in the middle of the unit. Drill samples returned values of up to 3 per cent copper and 2.4 per cent zinc, but most results were less than 0.2 and 0.5 per cent for copper and zinc respectively. The third exposure of copper is 350 chains (7.0 km) southwest of Mount Palgrave. The drilling results were again disappointing; the best intersections (each from a different hole) assayed 0.67 per cent copper over 6 feet (1.8 m) and 1.3 per cent zinc over 6 feet (1.8 m) respectively.

Mount Vernon Station

(Lat. 24° 15' S, long. 118° 10' E).

Zinc sulphate (goslarite) is present in a white efflorescent coating on graphitic shales, 6 miles (9.6 km) south of Mount Vernon homestead. Geologists of Westfield Minerals N.L. traced the deposit for a distance of 3 miles (4.8 km) over a width of 18 feet (5.4 m). Assays of the efflorescent material averaged 3.8 per cent zinc, 0.48 per cent copper and 0.03 per cent nickel, ranging from a high of 7.2 per cent zinc with 0.96 per cent copper to a low of 1.7 per cent zinc and 0.13 per cent copper. The best drillhole intersection assayed 1.2 per cent zinc and 0.1 per cent copper over 36 feet (10.9 m).

High Range

(Lat. 23° 41' S, long. 115° 39' E).

Daniels (1966b) reports traces of copper, zinc and uranium in the Discovery Chert formation near High Range. The

location is shown in Figure 14 accompanying his report and on the Edmund 1:250,000 Geological Sheet. An assay report on a Departmental file shows 0.56 per cent copper, 0.01 per cent lead, 0.02 per cent nickel, 0.01 per cent uranium and 0.05 per cent zinc.

Copper assaying 0.3 per cent over 30 feet (9 m) with a trace of zinc has been recorded from a black shale (probably equivalent to the Prospect Shale) from this locality.

Mount Augustus

(Lat. 24° 17' S, long. 116° 54' E).

Copper minerals with associated anomalous zinc are reported from near Mount Augustus. Most showings were in the Kiangi Creek Formation.

Thomas River

(Lat. 24° 35' S, long. 116° 25' E).

Zinc values of up to 1,600 parts per million were obtained from samples of Discovery Chert from the northwest closure of a syncline near the Thomas River. Some

copper stains were noted on joints in the locality, which is 18 miles (28.9 km) east of Yinnietharra Station homestead.

BANGEMALL GROUP

Anomalous quantities of copper and zinc have been recorded from many places within rocks of the Bangemall Group. Most are associated with a 100-foot (30 m) thick bed of graphitic shale (known as the Prospect Shale), stratigraphically below the Discovery Chert formation, but some are in other units. Geological and geochemical work on the Bangemall Group is still in progress and much of the information is still confidential. This report is intended to give only a brief indication of the prospects of the Group and is not to be regarded as complete.

Daniels (1969) subdivided the Bangemall Group into nine formations, descriptions of which are summarized in Table 68.

Subsequently, Westfield Minerals N.L. elevated the Kiangi Formation to the status of a sub-group and subdivided it into the formations listed in Table 69.

TABLE 68. STRATIGRAPHIC DIVISIONS OF BANGEMALL GROUP

Unit	Description	Thickness (feet)
Kurabuka Formation	Sandstone, silty shale and shale	?
Fords Creek Shale	Greenish shale with some greywacke and chert	5,700
Coodardoo Formation	Greywacke with minor silt and shale	500-1,200
Curran Formation	Shale with siltstone and chert	250
Ullawarra Formation	Shale, siltstone, rare sandstone and dolomite	5,000-6,000
Devil Creek Formation	Dolomite, dolomitic shale and dolomite breccia	200-1,200
Discovery Chert	Thin bedded black or grey chert	200-1,200
Kiangi Creek Formation	Sandstone with minor shale and chert	2,000
Irregularly Formation	Dolomite, dolomitic shale with sandstone, chert, conglomerate and breccia	3,000+

NOTE: 1 foot = 0.3048 metres

TABLE 69. STRATIGRAPHIC DIVISIONS OF THE KIANGI SUB-GROUP

Formation	Description	Thickness (feet)
Prospect Shale	Graphitic shale with pyrite; white to grey where weathered. Interbedded silts and tuffs	100-400
Togobinna Formation	Pale shale and siltstone, minor quartzite bands with prominent quartzite at top. Missing in places	0-160
Palgrave Formation	Tuffaceous siltstone, shale, calcareous sandstone, sparse pyrite	200
Henry River Formation	Grey, tuffaceous, siliceous, shale and siltstone. Thickens southwards	100-200
Kookhabinna Sandstone	Massive pale quartzite with minor, lenticular shale. Formation lenses out in places	200
Elliot Creek Formation	Massive, grey dolomitic shale, tuffaceous shale and minor siltstone. Equivalent to upper part of Irregularly Formation of Daniels (1969)	?

NOTE: 1 foot = 0.3048 metres

Black shale beds associated with volcanic rocks and chemical sediments, are considered to be favourable sites for the sedimentary accumulation of base metal sulphides and many of the world's major base metal deposits are found in such rocks. Many of the shale beds of the Bangemall Group, particularly the Prospect Shale, were evidently laid down in these favourable con-

ditions and contain unusually large amounts of copper and zinc. The fact that no ore body has yet been found suggests that geological structures, in which the primary metal content of the shales could be concentrated to an economic grade, are absent or rare. However, further investigation of the shales, particularly where affected by folds or faults, seems warranted.

South West Division

(Excluding Northampton Mineral Field)

SUMMARY

No production of silver, lead or zinc has been recorded from the South West Division of Western Australia, outside of the Northampton Mineral Field, although Mines Department records show that several small deposits of these metals have been discovered and opened up and that at least one of these, the Mundijong lead-zinc prospect, was worked commercially. Most of the deposits are in the Darling Range between Culham and the Blackwood River. They are lead or lead-zinc bearing quartz veins cutting granitic rocks, near the western edge of the Precambrian Shield. The only deposits in the Division which are not of this type are those at Hamersley Gorge in the Mount Barren Range, where lead minerals have been found in dolomite.

DESCRIPTION OF THE DEPOSITS

MUNDIJONG LEAD MINE (Location 407)
(Lat. 32° 19' S, long. 116° 01' E).

The Mundijong lead-zinc mine is about 2 miles (3.2 km) east of the Mundijong railway station and half a mile (0.8 km) east of the South Western Highway, and can be reached by a road which follows the route of the former Jarrahdale railway. It is 28 miles (45.0 km) by road from Perth and well situated with respect to port facilities, power and water supplies. The

prospect is on an Imperial Grant, in which the rights to all minerals, other than coal and precious metals, belong to the owner.

The prospect was first worked in about 1846 and subsequently in about 1870, 1907 and 1926. However, there is no record of the amount of ore produced.

References: Brown (1873), Montgomery (1908), Battye (1913), Simpson and Gibson (1907), Esson (1927) and Simpson (1951).

Plans: Lands Department 1 inch to 40 chains litho. 341/C shows the location and access road to Location 470. A geological plan of the prospect is published in the report by Esson.

Geological Information

The prospect is in granite gneiss which is foliated in a north-northwest direction and contains bands of amphibolite and mica schist. Near the prospect the gneiss is intruded by granite and porphyrite, both of probable Archaean age. The igneous and metamorphic rocks are overlain to the east by Proterozoic shale and siltstone of the Cardup Group. Both groups of Precambrian rocks are intruded by dykes of altered dolerite. Much of the hard-rock geology of the area is obscured by laterite.

The lead and zinc minerals occur in quartz veins which cut the granitic rocks, but not the younger sediments or dolerite.

TABLE 70. ASSAY RESULTS—MUNDIJONG LEAD MINE

Sample	Lead Per cent	Silver F. oz./ton	Gold Dwt/ton	Zinc Per cent	Copper Per cent
A	12.6	3.30	trace	7.63	0.40
B	8.3	0.72	trace	5.31	trace
C	7.5	0.45	trace	15.46	0.15
D	4.9	0.95	trace	19.28	trace
E	4.5	0.09	trace	0.55	....
F	78.4	6.90	trace	....	....

NOTE: 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

The veins strike at 335 degrees, parallel to the foliation of the granite gneiss, and dip steeply northeast. They form an echelon pattern with the axis trending north. The largest reef is the only one to carry significant amounts of lead-zinc minerals. Its outcrop, which is between and parallel to the railway and Mundijong Brook, can be traced for about 1,600 feet (490 m). Over much of its length the reef is barren, or contains only small quantities of ore minerals, but near its northern end it splits into two branches and there contains a richer section.

Ore minerals noted in the reef were sphalerite, galena and some copper carbonates. Pyrite and a little fluorite are also present.

Mining of the ore shoot was carried out from a vertical shaft (the Main Windlass shaft of previous writers), sunk to a depth of 86 feet (26.2 m). Levels were cut at 30, 52 and 70 feet (9.1, 15.8 and 21.9 m). Only a little work was done on the 30 and 52-foot (9.1 and 15.8 m) levels, but on the 70-foot (21.9 m) level a cross-cut was put out 23 feet (7.0 m) to the northeast. It cut 16 feet (4.8 m) of nearly massive quartz carrying stringers and

bunches of galena and sphalerite. From the end of the cross-cut, a winze was sunk to a depth of 30 feet (9 m) intersecting a reef with sphalerite, but only minor galena. In both the cross-cut and the winze, the better grade ore was on the footwall of the reef.

Immediately south of the shaft an adit was driven 25 feet (7.6 m) westwards through the vein into the country rock beyond. It exposed 11 feet (3.3 m) of reef composed, from east to west, of 5 feet (1.5 m) of massive quartz, 3 feet (91 cm) of pug with quartz stringers and a further 3 feet (91 cm) of massive quartz. The wall rock on the western edge of the reef is strongly sheared. A little galena has been reported from the reef in the adit, but the grade is very poor.

Assays: The results of six samples assayed by Simpson are listed in Table 70. Assay B has been quoted in the reports of Montgomery and Esson.

OTHER DARLING RANGE DEPOSITS

The following deposits in the Darling Range were not examined by the writer and the information given here is taken from the report of Simpson (1951).

Armadale Deposit

(Lat. 32° 11' S, long. 116° 02' E).

A little galena associated with sphalerite, pyrite and chalcopyrite in two quartz veins in granodiorite, has been reported from a locality about 1 mile (1.6 km) southeast of Armadale. Shafts were sunk on the veins in search of gold, but none was found.

Blackwood River

In 1913 a quartz vein carrying galena was found somewhere on the lower part of the Blackwood River. A hand-picked concentrate assayed 59.4 per cent lead, 0.30 ounces per ton (9.33 gm per tonne) of silver and nil gold.

Culham

(Lat. 31° 25' S, long. 116° 28' E).

One of several quartz reefs found northwest of Culham contained traces of galena.

Harvey River

(Lat. 33° 04' S, long. 115° 55' E).

Some galena was found in the Darling Range east of Harvey. A hand-picked sample assayed 65.6 per cent lead, 1.98 ounces per ton (61.58 gm per tonne) of silver and nil gold.

Serpentine

(Lat. 32° 22' S, long. 116° 00' E).

A quartz vein carrying galena, sphalerite, chalcopyrite and pyrite was opened up in the Darling Range near Serpentine. Assays are listed in Table 71.

MOUNT BARREN RANGE DEPOSITS

Small deposits of silver-lead minerals have been recorded from three centres near the Mount Barren Range, in the extreme southeast corner of the South West Division. The deposits were not visited by the writer, and the following information is taken from Sofoulis (1958), Simpson (1951) and Low (1963).

Bremer Bay

(Lat. 34° 17' S, long. 119° 22' E).

Five miles (8.0 km) north of Bremer Bay an outcrop of lead ore was discovered in 1928. It consisted of quartz and cerussite with a little anglesite. No mining was done on it.

Hamersley Gorge

(Lat. 33° 55' S, long. 119° 55' E).

Lead samples have been obtained from McCulloch's copper prospect, north of the gorge on the Hamersley River. The copper

TABLE 71. ASSAY RESULTS—SERPENTINE DEPOSIT

Lead Per cent	Silver F. oz./ton	Gold Dwt/ton	Zinc Per cent	Copper Per cent
81.7	2.20	nil	0.83	n.d.
13.0	0.70	trace	14.2	4.6

NOTE: 1 pennyweight = 1.55517 grammes
1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

and lead minerals occur in thin quartz veins in Archaean metasediments which include some jaspilite horizons. Further quartz veins carrying chalcopyrite and galena have been noted in the hills west of the Hamersley Gorge.

Assays of three samples from this locality, given by Simpson (1951), are listed in Table 72.

A, B and C were from McCulloch's prospects on the Hamersley River, C being a concentrate from B. A was quartz and schist with galena, B was silicified Precambrian limestone with siderite, galena and a little blende and chalcopyrite.

Naendip

(Lat. 34° 03' S, long. 119° 35' E).

About 2 miles (3.2 km) east-north-east of Naendip, a 6-foot (1.8 m) deep shaft has been sunk on quartz stringers carrying a little galena in an Archaean dolomite host rock. The location of the shaft is shown on Plate 16 of Sofoulis (1958). A sample recorded as coming from 5 miles (8.0 km) east of the Fitzgerald River and half a mile (0.8 km) south of the telegraph line probably came from this prospect. It assayed 12.2 per cent lead, 4.11 ounces per ton (127.83 gm per tonne) of silver and 1.5 pennyweights per ton (2.33 gm per tonne) of gold.

TABLE 72. ASSAY RESULTS—HAMERSLEY GORGE DEPOSIT

Sample	Lead Per cent	Silver F. oz./ton	Gold Dwt/ton	Copper Per cent	Cobalt Per cent
A 	15.3	6.02	0.76	0.65	trace
B 	5.3	4.14	0.37	....	....
C 	50.8	30.09	4.37	....	....

NOTE: 1 pennyweight = 1.55517 grammes
 1 fine ounce = 31.103 grammes
 1 ton = 1.01605 tonnes

Eastern Division

(Excluding portions of Pilbara and
Kimberley Goldfields)

SUMMARY

The Eastern Division of Western Australia includes not only the greater parts of the Archaean Yilgarn and Musgrave Blocks of igneous and metamorphic rocks, but also large areas of Proterozoic sediments and volcanics. It contains most of the State's larger gold mining centres, many of its copper mines and all of the commercial discoveries of nickel. Despite its favourable geological environment, its proven content of base and precious metals and 70 years of active mining and prospecting within its boundaries, the Eastern Division has so far proved lacking in commercial silver-lead-zinc deposits. Many of the gold mines in the Division contain traces of galena and sphalerite, but other deposits of these minerals are few and none are of ore grade. Those occurrences which have been re-

ported are described briefly below. Appendix 1 is a list of gold mines containing lead and zinc minerals.

DESCRIPTION OF THE DEPOSITS

PAYNESVILLE

About 7 miles (11.2 km) south-southwest of Paynesville, in the Murchison Goldfield, there is a quartz vein carrying considerable amounts of argentiferous cerussite, associated at shallow depth with some anglesite, galena, malachite and calcite. Most of the cerussite is massive, varying from almost colourless and transparent to dark grey and opaque, but some of the specimens collected had pyramidal crystal faces.

Assays of carbonate ore from the vein are listed in Table 73.

TABLE 73. ASSAY RESULTS—PAYNESVILLE PROSPECT

Lead Per cent	Copper Per cent	Silver F. oz./ton	Gold Dwt/ton
56.4	trace	21.87	....
38.8	1.0	77.82	0.54
35.4	nil	11.57	0.12
31.7	0.2	43.57	0.41

NOTE: 1 pennyweight = 1.55517 grammes
1 fine ounce = 31.103 grammes
1 ton = 1.01605 tonnes

KOOLYANOBING

(Lat. 29° 53' S, long. 119° 30' E).

Reference: Blatchford and Honman (1917, p. 191).

In greenstone schist about 2 miles (3.2 km) north of Chadwick's Reward, on the track to the Rainbow leases, there is a large body of quartz, 20 feet (6.0 m) wide in places and 500 feet (152.4 m) long, carrying galena and zinc blende.

CUNDEELEE MISSION

(Lat. 30° 40' S, long. 123° 20' E).

Reference: Sofoulis (1962) and pers. comm. (1969).

Metamorphic rocks, including quartzite, amphibolite, and muscovite schist, exposed immediately southwest of the Cundeelee Mission Station, are reported to contain small amounts of finely disseminated galena.

BARROW RANGE

(Lat. 26° 06' S, long. 127° 27' E).

Reference: Daniels (in prep.).

During regional geological mapping of the Talbot 1:250,000 Geological Sheet, a little galena was discovered in the Barrow Range, near the northeast corner of the Sheet area. The following information was supplied by Dr. Daniels of this Branch.

The deposit is about 55 miles (88.5 km) on a bearing of 085 degrees from the Warburton Mission, 4 miles (6.4 km) south

of the road to the Blackstone Range. It crops out near the top of an isolated hill and consists of galena, with a little pyrite and chalcopyrite, disseminated through rhyolite of the Middle Proterozoic Palgrave volcanic association. The sulphides are present in patches throughout the outcrop.

Assay: A sample of the mineralized rhyolite assayed 1.32 per cent lead.

In another nearby occurrence, small amounts of sulphide minerals are disseminated through a granophyre plug. A sample assayed 0.02 per cent copper, 0.34 per cent lead and 0.05 ounces per ton (1.55 gm per tonne) of silver.

MURRIN MURRIN

(Lat. 28° 55' S, long. 121° 40' E).

References: Low (1963), Simpson (1948).

At the old Murrin Murrin copper mining centre, the primary ore below 80 feet (24 m) in the Anaconda and Nangaroo mines, was found to contain appreciable amounts of sphalerite closely associated with pyrite. The sulphides were fine grained and intergrown.

Assay: A typical sample of the zinc-bearing material assayed 14.14 per cent zinc, 24.14 per cent iron and nil copper. Some shipments of sulphide (pyrite) ore made to Perth acid manufacturers, were said to contain from 5 to 15 per cent zinc.

APPENDIX 1

LIST OF GOLD MINES CONTAINING MINOR AMOUNTS OF LEAD AND ZINC MINERALS

Lead and zinc minerals have been found in uncommercial quantities in many gold mines in Western Australia. The mines are listed below, the relevant information being taken mainly from Simpson (1948), Simpson (1951) and Matheson and Miles (1947).

The few mines which have produced both gold and lead-zinc ores are described in the main part of this bulletin. They comprise the Shangri La mine at Kununurra, the Belvedere mine at Wyloo and the Mangaroon lead mine on Mangaroon Station.

GOLD MINES CONTAINING MINOR LEAD AND ZINC

Goldfield	Centre	Mine or Group	Metals Present		
			Lead	Zinc	
Kimberley	Brockmans	Golden Crown	x	x	
		Faugh-a-Ballagh	x		
		Jubilee and others	x		
		Lady Hopetoun	x		
		Hard Labour	x		
		Star of Kimberley	x		
		Scottish Chief	x		
		Lady Kimberley	x		
		Panton Queen	x		
		Brockman King	x		
	Lone Hand	x			
	Ruby Creek	Ruby Queen	x		
	Willy Willy	PA 58	x		
Pilbara	Bamboo Creek	G.M.L. 187	x		
		Kitchener G.M.L. 707	x		
		Prophecy	x		
		Bamboo Queen	x		
		Bonnie Doone	x		
		Nil Desparadum	x		
		Lallah Rookh	Lallah Rookh G.M.	x	
		Middle Creek	Mundalla G.M.L. 103	x	
		North Shaw	Blue Spec		x
			?		
	Pullcunah	Bertha (G.M.L. 431)		x	
		Birthday	x		
	Talga Talga	North Star	x		
	Tambourah	Several veins	x		
		P.A. 1377	x		
	Warrawoona	Cutty Sark (G.M.L. 521)	x		
		Dead Camel (G.M.L. 475)	x		
		Reward Claim 94	x		
	Western Shaw	Extended (G.M.L. 213)	x		
	Wodgina	West Wodgina		x	
	Yandicoogina	Black & White (G.M.L. 544)	x		
Eastern (G.M.L. 451)		x			
Uncle Tom (G.M.L. 250)		x	x		
Yandicoogina (G.M.L. 586)		x	x		

Goldfield	Centre	Mine or Group	Metals Present	
			Lead	Zinc
West Pilbara	Friendly Creek	John Bull (G.M.L. 79)	x	
		Princess May (G.M.L. 100)	x	
Ashburton	Gorge Creek Mount Mortimer	?	x	
		Several veins	x	
Gascoyne	Bangemall	Eldorado		x
Peak Hill	Horseshoe	El Dorado	x	
		P.A. 535	x	
		Groper	x	
	Baumgartens Mount Fraser	? G.M.L. 317	x x	
Murchison	Burnakura Barrambie Coodardy Cue	Federal City (G.M.L. 509)	x	
		Barrambie Ranges	x	
		Big Bell	x	
		Queen of the May (G.M.L. 1151)	x	
		Hidden Treasure (G.M.L. 1783)	x	
		Catalpa (G.M.L. 1088, 1271)	x	
	Day Dawn Cuddingwarra Holdens Find Mount Farmer Mount Maitland Nannine	Leviathen (G.M.L. 183)	x	
		Great Fingall	x	x
		Victory United (G.M.L. 595)	x	x
		Whittakers Reef	x	
		? G.M.L. 37	x x	
Nannine Mine	x	x		
East Murchison	Nungarra Lawlers Sandstone	Groper (G.M.L. 1)		x
		Dobru Serica (G.M.L. 900)	x	
		Floater (G.M.L. 233)	x	
		Other Reefs	x	x
Yalgoo	Fields Find Gnows Nest Melville	?	x	
		Brilliant	x	
		Bradman G.M.	x	
	Paynes Find Yalgoo	City of Melbourne	x	x
		Lake View (G.M.L. 606)	x	x
Ivanhoe and others	x			
Mount Margaret	Chapmans Find Diorite King Erlistoun Freemans Find Jutsons Rock Laverton Leonora	?	x	
		Mount Stirling (G.M.L. 1220)	x	
		Mistake (G.M.L. 795)	x	
		?	x	
		?	x	x
		Ida Sons of Gwalia	x x	x x

Goldfield	Centre	Mine or Group	Metals Present	
			Lead	Zinc
	Teutonic Well	?	x	
	Ulrich Range	?	x	
	Wilson's Patch	Corona (G.M.L. 117)	x	x
North Coolgardie	Comet Vale	Happy Jack (G.M.L. 5300)	x	
		Sand Queen (G.M.L. 5211)	x	x
		Gladstone		x
		Mystery	x	
		Crusoe (G.M.L. 2823)	x	x
		Lady Shenton (G.M.L. 2820)	x	x
		Queensland Menzies (G.M.L. 2836)	x	
	Mulline-Ularring	Dreadnough Vindicator (G.M.L. 3615)	x	
		Lady Gladys (G.M.L. 139)	x	x
		Cardinal (G.M.L. 954)	x	
Mulwarrie	Riverina	x	x	
	Mulwarrie Main Reef (G.M.L. 494)	x		
Yerilla	Ularring Westralia (G.M.L. 6)	x		
	Yerilla King (G.M.L. 693)	x		
Broad Arrow	Broad Arrow	Dixie	x	
		Credo	x	
	Ora Banda	Grants Patch	x	
		Slippery Gimlet (G.M.L. 1336)		x
North-East Coolgardie	Golden Ridge Kanowna	?	x	x
		Gentle Polly (G.M.L. 1062)	x	
		Kanowna (G.M.L. 1019)	x	
		Bulong United (G.M.L. 1160)	x	
		Kanowna Main Reef	x	
	Mulgabbie	Mulgabbie Perseverence (G.M.L. 260)		x
East Coolgardie	Kalgoorlie	Hidden Secret	x	x
		Cassidy Hill (G.M.L. 4)	x	
		Fair Play		x
		Kapai		x
		Hawkes View		x
		Oroya		x
		Kalgurli		x
		South Kalgurli		x
		Perseverence		x
		Ivanhoe		x
		Great Boulder		x
		Boulder Queen Consols		x
		Mount Monger	McLellands	x

Goldfield	Centre	Mine or Group	Metals Present				
			Lead	Zinc			
Coolgardie	Bonnievale	?	X				
		Bendigo & Coolgardie Westralian		X			
	Burbanks	Birthday Gift New Grosmont mine	X	X			
		Carbine Coolgardie	Carbine mine Union Jack (G.M.L. 1385)	X			
	Kunanalling Londonderry		Big Blow Bayleys Tyndals Star of Fremantle (G.M.L. 645) ?	X X X X X	X X X X		
		Yilgarn	Bullfinch	Bullfinch Maries Find Newfield	X X X		
				Eenuinn Jackson	P.A. 4281 Atkinsons Find Riedals Find Boondine Die Hardy Bullseye Clampton Evanston	X X X X X X X	X X X X
			Marda		Butcher Bird (G.M.L. 1933) Standard Great Unknown Mount Jackson	X X X X	X
				Marvel Loch	Marvel Loch G.M. Bohemia (G.M.L. 3393) May Queen	X X X	X
	Southern Cross Westonia				Frazers Central (G.M.L. 890) Edna May	X X	
	Dundas		Norseman	Viking (G.M.L. 26) Ajax (G.M.L. 822) Phoenix	X X X	X	
Phillips River				Kundip	Medic (G.M.L. 66)	X	
Outside Proclaimed Goldfield				Jimperding	Yinnerding Creek	X	

APPENDIX 2

CATALOGUE OF PLANS OF LEAD-ZINC MINES HELD BY MINES DEPARTMENT OR PUBLISHED

Mine	Gold or Mineral Field	Description of Plan	Date	Scale to one Inch	Reference		
					G.S.W.A.	Mines	Publication
				feet			
Aerial	Ashburton	Surface plan	1968	50	10801(T)		
Andover	West Pilbara	Surface plan	1968	100	10830(T)		
Baddera	Northampton	Composite plan and long section	1926	60	1686(P)	24/1(T)	Wilson (1926)
Baddera	Northampton	Geological plan	1928	60	5748(T)		
Baddera	Northampton	Composite plan	1928	60	5747(T)		
Baddera	Northampton	Long section	1920	60	5745(T)		
Baddera	Northampton	Reduction of 24/1	?	100	10847(T)		
Baddera North	Northampton	Plan showing levels	1928	60	5746(T)		
Barker Well	Pilbara	Plan of surface exposures, workings and assays	1938	100	....	....	Finucane (1938)
				feet			
Bilrose	Ashburton	Surface plan and long section	1968	60	10863(T)		
Block Seven	Northampton	Level plan and long section	?	50	10819(T)	7/1(T)	
Block Seven	Northampton	Surface plan (superseded by 10851)	1926	40	1671(P)	7/2(T)	Wilson (1926)
Block Seven	Northampton	I.G.E.S. proposed costeans	1930	100	4897(T)		
Block Seven	Northampton	Surface plan	1968	40	10851(T)		
Chequers	Northampton	Surface plan	1968	40	10826(T)		
Chiverton	Northampton	Surface plan	1921	chains 5	5742(D)		
				feet			
Comstock	West Pilbara	Plan showing reefs, workings and assays	1953	40	10809(T)	151/1(P)	
Cow Rock	Northampton	Plan of surface workings showing outcrops of lode	1968	100	10861(T)	....
Deebles	Northampton	Plan of surface workings	1968	40	10849(T)		
Devons Cut	Pilbara	Plan showing reefs, workings and assays	1938	100	....	....	Finucane (1938)
Dingo	Northampton	Plan of surface and long section of workings	1968	40	10850(T)		
Dingo	Northampton	Long section	1926	40	....	....	Wilson (1926)
Dooleena Gap	Pilbara	Plan of surface geology and workings	1968	40	10888(T)		
Ethel Maud	Northampton	Sketch plan of surface workings	1968	40	10852(T)		
Galena	Northampton	See Surprise group					
Gallaghers	Northampton	Surface plan	1967	100	9388(T)	....	de la Hunty (1967)

Geraldine	Northampton	Surface plan	1926	100 feet	...	119/1(T)	Wilson (1926)
Geraldine	Northampton	Surface plan with drillhole positions and sections	1967	100	9388(T)	...	de la Hunty (1967)
Geraldine South	Northampton	Plan and long section (superseded)	?	40	...	119/2(T)	
Geraldine South	Northampton	Plan and long section	1968	40	10824(T)		
Geraldine South	Northampton	I.G.E.S. plan showing proposed costeans	1930	100	4897(T)		
Geraldine Copper	Northampton	Surface plan	1926	40	1681(P)	119/3(T)	Wilson (1926)
Geraldine Copper	Northampton	Long section and cross section (scales vary)	?	...	...	119/4(D)	
Geraldine Copper	Northampton	Long section (from 119/4)	?	30	10802(T)		
Gift	Ashburton	Composite plan	1952	20	10796(T)	116/1(D)	
Gossan Hill	Pilbara	Surface plan	1938	50	...	...	Finucane (1938)
Grand Junction	Northampton	Surface plan (superseded)	1926	40	1679(P)	...	Wilson (1926)
Grand Junction	Northampton	Surface plan	1968	40	10843(T)		
Great Western	Northampton	Surface plan	1968	40	10848(T)		
Gurkha	Northampton	Lease plans with positions of shafts, plant, etc.	1956	100	...	486/1(P)	
Gurkha	Northampton	Composite level plan	1957	30	10810(T)	486/2(P)	
Gurkha	Northampton	Long section showing stoping	1957	30	...	486/3(P)	
Gurkha	Northampton	Long section showing stoping	1961	40	10811(T)	486/4(P)	
Gurkha	Northampton	Long section showing stoping	1961	100	2449(T)	...	Jones & Noldart (1962)
Iga	Northampton	Surface plan	1952	400	...	...	Campbell (1952)
Ilmars-Little Mount Isa	Kimberley	Geological plan	1963	2,000	7615(T)	...	Gemuts (1963)
Joy Helen	Ashburton	Surface plan	1968	50	10829(T)		
June Audrey	Ashburton	Plan and section	?	40	10818(T)	161/2(T)	
Keep-it-Dark	Peak Hill	Surface plan	1968	40	10823(T)		
Kirtons North Extended	Northampton	Surface plan	1968	40	10847(T)		
Kooline Queen	Ashburton	Surface plan	1968	100	10832(T)		
Koongalin Hill	Pilbara	Surface plan with assays	1938	100	...	...	Finucane (1938)
Lady Florance	Northampton	Surface plan	1968	100	10846(T)		
Lady Samson	Northampton	Plan and long section	1926	80	...	...	Wilson (1926)
Lady Tilley	Northampton	Surface plan	1952	100	...	...	Campbell (1952)
Lady Tilley	Northampton	Surface plan	1968	40	10828(T)		
Lightning Ridge	Pilbara	Surface plan with assays	1938	100	...	...	Finucane (1938)

Mine	Gold or Mineral Field	Description of Plan	Date	Scale to one Inch	Reference		
					G.S.W.A.	Mines	Publication
Long Lode group	Northampton	Surface plans of both groups of workings (east and west)	1968	feet 40	10845(T)		
Long Lode group	Northampton	Surface plan east lode	1952	100	....	....	Campbell (1952)
Long Lode group	Northampton	Plan of east lode showing drillhole	1957	20	....	399/1(P)	
Mary Springs	Northampton	Sketch plan of lease with cross sections on lodes	?	?	....	145/1(T)	
Mary Springs	Northampton	Surface plan and long sections of stopes	?	80	....	145/2(T)	Wilson (1926)
Mary Springs	Northampton	Surface plan	1926	40	1677(P)	145/3(T)	
Mary Springs	Northampton	Surface plan	?	100	....	145/4(T)	
Mary Springs	Northampton	I.G.E.S. plan showing proposed costeans	1931	100	4897(T)		
Mary Springs	Northampton	Composite plan with drill sites	1968	40	10813(T)		
May Bell	Northampton	Surface plan	1968	40	10856(T)		
McGuire's	Northampton	Plan showing drillhole localities	1957	chains 4	....	150/1(P)	
McGuire's	Northampton	Assay plan No. 1 level (100-foot level)	1957	feet 40	10814(T)	150/2(P)	
McGuire's	Northampton	Long section of west lode	1957	40	10800(T)	150/3(P)	
McGuire's	Northampton	Diamond drillhole 1, west lode	1957	40	....	150/4(P)	
McGuire's	Northampton	Diamond drillhole 2, west lode	1957	40	....	150/5(P)	
McGuire's	Northampton	Diamond drillhole 3, west lode	1957	40	....	150/6(P)	
McGuire's	Northampton	Diamond drillhole localities—west lode	1957	40	....	150/7(P)	
McGuire's	Northampton	Diamond drillhole localities—east lode	1957	40	10804(T)	150/8(P)	
McGuire's	Northampton	Surface plan of west lode	1926	40	1683(P)	150/9(T)	Wilson (1926)
McGuire's	Northampton	Surface plan of east lode	1926	40	1682(P)	....	Wilson (1926)
McGuire's	Northampton	Composite plan and long section	1955	40	5486(T)		
Mendip	Northampton	Composite plan with drillholes	1957	40	10798(T)	56/7(P)	
Mineral Claim 15	Northampton	Plan showing diamond drillholes	1957	100	....	399/2(P)	
Mineral Claim 15	Northampton	Plan of surface workings	1968	40	10853(T)		
Monte Carlo	Ashburton	Plan of reefs and workings	1958	100	....	....	Finucane and Sullivan (1939)

Mount Amherst	Kimberley	Surface plan of Dead Horse Creek prospect	1968	40	10827(T)		
Mount Brockman group	Pilbara	Surface plans of reefs and workings showing assays	1938	200	....	....	Finucane (1938)
Mundijong	South-West Division	Geological plan	1926	chains 5	....	....	Esson (1927)
Narlarla	West Kimberley	Geological sketch map	1952	feet 200	10833(T)	180/1(T)	
Narlarla	West Kimberley	Sketch plans and sections No. 1 ore body	1952	20	10834(T)	180/2(T)	
Narlarla	West Kimberley	Plan No. 1 ore body showing position of drillhole	1952	20	....	180/3(T)	
Narlarla	West Kimberley	Surface plan No. 2 ore body with assays	1952	20	10839(T)	180/4(T)	
Narlarla	West Kimberley	Surface plan No. 2 ore body with drill-hole position	1952	20	10815(T)	180/5(T)	
Narlarla	West Kimberley	Section of No. 1 ore body with assays...	1952	20	....	180/6(T)	
Narlarla	West Kimberley	Plans and section	1965	and 10 20	8652(T)	....	Halligan (1965)
Narlarla	West Kimberley	Plans and section with assays	1938	20	....	....	Finucane and Jones (1939)
Narra Tarra	Northampton	Composite level plan	1923	60	....	317/1(T)	
Narra Tarra	Northampton	Composite plan and long section of workings	1926	60	1684(P)	317/2(T)	Wilson (1926)
Narra Tarra East (also called Protheroe East)	Northampton	Plan and long section (superseded)	1926	chains 6	1675(P)	56/26(T)	Wilson (1926)
" " "	Northampton	Locality plan (after Talbot, 1914)	1914	10	1676(P)	....	Wilson (1926)
" " "	Northampton	Long section with drill intersections	1958	feet 40	10807(T)	56/15(P)	
" " "	Northampton	Plans and sections	1952	100	....	....	Campbell (1952)
" " "	Northampton	Plan of 228-foot level	1958	40	10795(T)	56/5(P)	
" " "	Northampton	Cross section on D.D.H. 3	1958	40	....	56/21(P)	
" " "	Northampton	Long section	1926	60	....	56/24(P)	
Nooka	Northampton	Surface plan of lease	1921	chains 5	5742(D)		
Nooka	Northampton	Composite plan and sections	1968	feet 100	10550(T)	....	Blockley (1969a)
Norman King	Northampton	Plan and section of north shoot	?	40	10841(T)	160/12(T)	Wilson (1928)
Norman King	Northampton	Surface plans of north and south shoots	1968	40	10855(T)		

Mine	Gold or Mineral Field	Description of Plan	Date	Scale to one Inch	Reference		
					G.S.W.A.	Mines	Publication
North Geraldine	Northampton	Surface plan	1968	40	10852(T)		Finucane (1938)
North Koongalin	Pilbara	Surface plan showing reefs and assays	1938	40	....	....
Paringa	Northampton	Surface plan and long sections	1954	40	10803(T)	71/1(P)	
Paringa	Northampton	Long section (superseded by 171/1)	1951	40	....	71/2(T)	
Paringa	Northampton	Geological plan of 174-foot level and long section	1958	40	5488(T)	....	Tomich (1954)
Paringa	Northampton	Surface plan	1968	100	10822(T)		
Protheroe	Northampton	Composite level plan 800N-100S	1957	40	....	56/1(P)	
Protheroe	Northampton	Composite level plan 100S-1100S	1957	40	....	56/2(P)	
Protheroe	Northampton	Composite level plan	1955	40	....	56/3(P)	
Protheroe	Northampton	Plan of 470 and 530-foot levels	1958	40	....	56/4(P)	
Protheroe	Northampton	Plan of Protheroe freehold showing drillholes and lodes	1958	400	....	56/8(P)	
Protheroe	Northampton	Assay plan of 212-foot level	1958	40	....	56/9(P)	
Protheroe	Northampton	Assay plan of 325-foot level	1958	40	....	56/10(P)	
Protheroe	Northampton	Assay plan of 415-foot level	1958	40	....	56/11(P)	
Protheroe	Northampton	Long section, southeast workings	1958	40	....	56/12(P)	
Protheroe	Northampton	Long section, northeast workings	1958	40	....	56/13(P)	
Protheroe	Northampton	Long section of workings showing ore reserves and stopes	1958	100	10794(T)	56/14(P)	
Protheroe	Northampton	Geological notes on section 150 feet north	1952	40	....	56/16(P)	
Protheroe	Northampton	Geological notes on cross section 250S	1952	40	....	56/17(P)	
Protheroe	Northampton	Geological notes on cross section 300S	1952	40	....	56/18(P)	
Protheroe	Northampton	Geological notes on cross section 500S	1952	40	....	56/19(P)	
Protheroe	Northampton	Geological notes on cross section 800S	1952	40	....	56/20(P)	
Protheroe	Northampton	Plan and long sections of mines on Location 119	?	6	....	56/26(P)	
Protheroe	Northampton	Long section (after Campbell, 1952)	1952	100	2450(T)	....	Jones and Noldart (1962)

Protheroe	Northampton	Composite plan and long section	1958	40	5489(T)		
Protheroe	Northampton	Plan showing results of geophysical work	1956	200	....	....	Keunecke (1956)
Protheroe South	Northampton	Level plan	1958	40	10797(T)	56/6(P)	
Protheroe South	Northampton	Long section	?	30	....	56/24(P)	
Protheroe South	Northampton	Plan of south workings	?	60	....	56/25(P)	
Ragged Hills	Pilbara	Composite level plan showing drill holes	1952	40	....	113/1(T)	
Ragged Hills	Pilbara	Reduction of 113/1	1952	100	10838(T)		
				feet			
Ragged Hills	Pilbara	Long section with drill intersections	1952	40	....	113/2(T)	
Ragged Hills	Pilbara	Reduction of 113/2	1952	100	10799(T)		
Ragged Hills	Pilbara	Surface plan with assays	1938	200	....	....	Finucane (1938)
Ragged Hills East	Pilbara	Surface plan with assays	1938	200	....	....	Finucane (1938)
Range	Ashburton	Surface plan	1968	40	10520(T)		
Range	Ashburton	Surface plan (with Turtle mine)	1968	100	10597(T)	....	Blockley (1969b)
Shangri La	Kimberley	Surface plan	1967	150	9960	....	Sofoulis (1968)
Shepherds	Northampton	Plan (superseded)	1926	30	....	56/22(P)	
Shepherds	Northampton	Long section (superseded)	1926	30	10812(T)	56/23(P)	
Shepherds	Northampton	Long section	1952	100	....	....	Campbell (1952)
Silent Sisters	Ashburton	Composite plan	1950	50	....	161/1(T)	
Silent Sisters	Ashburton	Composite plan	1968	50	10825(T)		
South Kooline	Ashburton	Plan and sections	1950	20	10806(T)	161/3(T)	
Springvale	Northampton	Plan and long section (superseded)	?	40	....	10/1(T)	
Springvale	Northampton	Assay plan and long section	1957	40	5487(T)	10/2(P)	
Springvale	Northampton	Plan and long section (superseded)	?	40	....	10/3(T)	
Springvale	Northampton	Plan (superseded)	1926	40	1678(P)	10/4(T)	Wilson (1926)
Springvale	Northampton	Plan and section with ore reserves	1952	100	10860(T)	....	Campbell (1952)
Springvale	Northampton	Surface plan	1968	40	10859(T)		
Surprise group	Northampton	Surface plan showing leases, townsite, etc.	?	100	....	223/1(T)	
Surprise group	Northampton	Reduction of 223/1	?	200	10835(T)		
Surprise group	Northampton	Plan and section of workings on leases	?	40	....	223/2(T)	
Surprise group	Northampton	Reduction of 223/2	?	80	10808(T)		
Surprise group	Northampton	Plan and section of lodes within Surprise shoot	?	40	....	223/3(T)	
Surprise group	Northampton	Reduction of 223/3	?	80	10817(T)		
Surprise group	Northampton	Plan and section of workings	?	40	....	223/4(T)	
Surprise group	Northampton	Reduction of 223/4	?	80	10816(T)		
Surprise group	Northampton	Long section, Galena shoot	1956	20	5490(T)		
Surprise group	Northampton	Plan and long section, Surprise shoot	1928	50	5743(D)		

Mine	Gold or Mineral Field	Description of Plan	Date	Scale to one Inch	Reference		
					G.S.W.A.	Mines	Publication
Surprise group	Northampton	Composite plan and cross section, Two Boys shoot	1956	feet 20	5491(T)		
Surprise group	Northampton	Locality plan	?	chains 20	7197(T)		
Surprise group	Northampton	Long section of Surprise South shoot with assays	?	feet 40	10805(T)	223/5(T)	
Surprise group	Northampton	Plan and sections	1952	....	....	....	Campbell (1952)
Surprise group	Northampton	Plan and sections	1920	....	....	....	Wilson (1926)
Surprise South	Northampton	See Surprise group		feet			
Thowagee	Ashburton	Plan of surface workings	1968	200	10831(T)		
Three Sisters	Northampton	Surface plan with drill sites shown	?	....	....	417/1(T)	
Three Sisters	Northampton	Plan and long section of workings	?	....	....	417/2(T)	
Three Sisters	Northampton	Plan and long sections	1968	40	10820(T)	417/3(T)	
Three Sisters	Northampton	Plan and long section	1968	100	10844(T)	....	Campbell (1952)
Three Sisters	Northampton	Composite level plan	1920	20	811(T)		
Three Sisters	Northampton	Long section	1920	20	810(T)	....	Wilson (1926)
Three Sisters North	Northampton	Surface plan	1926	40	1680(P)		
Three Sisters North	Northampton	Surface plan	1968	40	10842(T)		
Turtle	Ashburton	Surface plan	1968	50	10519(T)		
Turtle	Ashburton	Surface plan	1968	100	10597(T)	....	Blockley (1969b)
Two Boys	Northampton	See Surprise group					
Uaroo	Ashburton	Long section (superseded)	?	50	1143(T)		
Uaroo	Ashburton	Plan and section	1939	40	....	....	Finucane and Sullivan (1939)
Uga	Northampton	Surface plan	1968	50	10862(T)		
Wanerenooka	Northampton	Locality plan	?	chains 20	1672(T)		
Wanerenooka	Northampton	Level plans	?	feet 10	....	563/1(T)	
Wanerenooka	Northampton	Long section (older than 563/1)	?	20	7497(D)		
Wheal Ellen	Northampton	Composite plan of surface and levels	?	60	....	29/1(T)	

Wheal Ellen	....	Northampton	....	Reduction of 29/1	....	....	....	?	100	10837(T)		
Wheal Ellen	....	Northampton	....	Composite plan of 125 and 195-foot levels				?	60	....	29/2(T)	
Wheal Ellen	....	Northampton	....	Long section	....	....	....	1925	60	....	29/3(T)	
Wheal Ellen	....	Northampton	....	Reduction of 29/3	....	....	....	1925	100	10836(T)		
Wheal Ellen	....	Northampton	....	Plan and long section (superseded)	....	....	....	?	50	5744(T)		
Wheal Ellen	....	Northampton	....	Plan and long section	....	....	....	?	60	1685(P)	....	Wilson (1926)
Wheal Ellen	....	Northampton	....	Plan and long section with assays	....	....	....	?	100	....	....	Campbell (1952)
Wheal Fortune	....	Northampton	....	Long section Wheal Fortune and Wheal Fortune Extended compiled from descriptions in Wilson (1926)				1968	100	10821(T)		
Wheal Ina	....	Northampton	....	Surface plan	....	....	....	1968	40	10858(T)		
Wheal May	....	Northampton	....	Surface plan	....	....	....	1968	40	10854(T)		
Wheal May	....	Northampton	....	Long section	....	....	....	1926	120	....	....	Wilson (1926)
Yiapa	....	Northampton	....	Surface plan	....	....	....	1968	40	10857(T)		

NOTES: G.S.W.A. denotes Geological Survey of Western Australia collection.
Mines, denotes Mines Drafting Branch collection.
(T) denotes plan held as transparency.
(P) denotes plan held as print.
(D) denotes plan held as original opaque drawing.

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GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
GEOLOGICAL MAP
OF
WESTERN AUSTRALIA
SHOWING LEAD AND ZINC DEPOSITS

SCALE 1:5,068,800
80 40 0 80 160 240 MILES
100 50 0 100 200 300 400 KILOMETRES

	REFERENCE	SYMBOLS
MESOZOIC-CENOZOIC	Cz Marine and continental sediments	— Highway
PALAEOZOIC	C-P Carboniferous and Permian	○ Town
	D Devonian	⊗ Deposit with recorded production
PROTEROZOIC	E-S Cambrian to Silurian	• Mineral occurrence
	Eg Granite	Pb Lead
ARCHAEAN	Em Middle and Upper Proterozoic	Zn Zinc
	El Lower Proterozoic	Ag Silver
PRECAMBRIAN UNDIFFERENTIATED	Ag* Granitic rocks	(Ag Zn) Minor metals present or mined as by-products
	Am Metamorphic rocks	— Watercourse

