

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

MINERAL RESOURCES BULLETIN No. 8

COPPER DEPOSITS
OF
WESTERN AUSTRALIA

by

G. H. LOW, B.Sc.



1963

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ISSUED UNDER THE AUTHORITY OF THE

Hon. A. F. Griffith, M.L.C.,

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PREFATORY NOTE

This Mineral Resources Bulletin represents a compilation of the existing knowledge of the known copper deposits in Western Australia. Although no large copper mines have been developed yet in this State, the locality map at the end of the bulletin shows that copper is widely distributed throughout the State from the Kimberleys in the north to Ravensthorpe near the south coast.

The former Government Geologist, Mr. H. A. Ellis, initiated this compilation, realising that copper could become as important to this State as gold or iron if exploration were successful. The author has not only made a thorough search of all published and unpublished records, but has inspected the majority of the localities mentioned to gather first-hand information.

The copper deposits have been divided according to the standard goldfield divisions. A summary is given for each goldfield, and then the individual centres or mines, which have produced copper, are described. The description includes details of the locality, history, geology, and production to the end of 1961.

Except for one or two deposits, there is insufficient information available to enable estimates of any ore reserves to be given or proposed. In most instances the author has commented on the prospects of each goldfield or centre, and has recommended areas which could be worthy of further prospecting.

This bulletin should be found of great value to those who are prepared to search for copper. The prize, if it could be found, would be worth the effort and expense.

J. H. LORD,
Government Geologist.

20th July, 1962.

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Map of Western Australia showing Copper Producing Localities	At End
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CHAPTER I

GENERAL INFORMATION

GENERAL STATEMENT

Copper deposits have been mined in Western Australia from as far north as the Kimberley Division to as far south as Ravensthorpe near the southern coast. The majority of these have been small producers yielding ore of satisfactory grade only in the oxidised zones from the surface down to about 100 feet, and mining has ceased when these easily won reserves have been exhausted. A few centres have yielded relatively high tonnages. These include Whim Creek, Ravensthorpe, Eulaminna, and Northampton. More recently Copper Hills and Thaduna have been amongst the principal producers.

Most of the known deposits are steeply dipping copper-bearing quartz veins in Archaean metasediments or basic igneous rocks. The proportion in either type is about fifty-fifty, but most tonnage has been mined from deposits occurring wholly or partly in metasediments. Examples are Whim Creek, Thaduna, Eulaminna, and the Elverdton Mine at Ravensthorpe. The Northampton deposits lie in garnet granulite probably derived from Archaean sediments.

The Wanerenooka deposit in the Northampton Field was discovered in 1842, and three years later, when a parcel was shipped to Wales, it became the first locality to provide ore for export. Production from this and other centres followed and up to the end of 1961, 271,864·79 long tons of copper ore and concentrates with a copper content of 30,833·85 long tons worth £A2,631,254 had been recorded.

In addition production of cupreous ore and concentrates* for local use commenced in 1944, and up to the end of 1961, 66,746·51 long tons containing 6,178·33 long tons of copper valued at £A1,022,764·73 had been sold.

Of the total production, 98 per cent. of the metallic copper has come from seven Fields which, in order of importance, are :

West Pilbara Goldfield	.....	.....	.....	35 per cent.
Phillips River Goldfield	.....	.....	.....	31 per cent.
Mt. Margaret Goldfield	.....	.....	.....	13 per cent.
Peak Hill Goldfield	.....	.....	.....	7 per cent.
Pilbara Goldfield	.....	.....	.....	5 per cent.
Northampton Mineral Field	.....	.....	.....	5 per cent.
East Murchison Goldfield	.....	.....	.....	2 per cent.

The Pilbara Goldfield (principally the Copper Hills Copper Mine) and the Peak Hill Goldfield (principally Thaduna) have become increasingly important over the last seven years. There has also been a significant revival of mining at Ravensthorpe.

Most of the tonnage of copper ore was mined during the years preceding World War I, the ore then being treated by direct smelting, or by concentration. The resultant matter was either converted to blister copper—as at Ravensthorpe—or the concentrates were sent to Europe or the Eastern Australian refineries for further treatment. The reduced demand

* The term "cupreous ore" as used in this Bulletin means copper ore which is suitable for application to the light agricultural lands, and is purchased by the fertilizer producing companies for that purpose. Previously, carbonate ores containing not less than 8·5 per cent copper have been the main source of this material, but an increasing proportion of basic copper sulphate, produced by crushing and roasting sulphide ore, is now being accepted. "Cupreous ore" simply means any ore or product which is acceptable to the fertilizer producers.

for copper after this war led to a fall in prices and a decline in production, and by 1927 all major production had ceased. From this time until the end of 1960 only 71,860 long tons of ore were produced, the bulk of this having been raised since World War II.

The improved local market and general rises in copper prices since 1953 have stimulated local mining. Further, the demand for copper for fertilizer purposes in this State should show a steady increase as more of the extensive areas of potential agricultural land, wanting in trace elements, are opened up.

OBJECT AND SCOPE OF THIS BULLETIN

The principal objects of this Bulletin are to gather together in one publication the available information about copper deposits in Western Australia, and to assist in the selection of areas for prospecting.

Information concerning many of the deposits has been published in various annual reports and bulletins of the Geological Survey, and in Commonwealth Government Reports of the North Australian Survey. Other unpublished information has been forwarded to the Mines Department by mines inspectors, by prospectors, by mining companies, and by others interested in mining development. This information has been collated along with the author's own field observations and the result of this study is presented here.

It is divided into two sections. The first summarises general information such as the history of copper exploitation, geographical and geological distribution, mineralogy, and production statistics. No attempt is made to discuss in detail theories of ore genesis and emplacement, production economics, market potential, and the like. The prospector is not usually concerned with the former, and he can readily obtain the other from metal buyers. Large companies interested in prospecting work to their own limits, and for them a generalised statement attempting to cover an area as large as Western Australia is quite useless.

The second section gives information about the various mines and prospects, but no attempt has been made during this investigation to estimate ore reserves. In one or two cases figures have been made available by the company mining or testing a deposit and these are quoted, but usually limited development and lack of testing beyond the workings prevent such estimates being made.

MINERALS IN WESTERN AUSTRALIAN COPPER ORES

The most important ore minerals have been malachite, azurite, chrysocolla, bornite, chalcocite, and chalcopyrite. The first three are found in variable proportions in the oxidised zones in practically every deposit in the State. The others are found close to the surface in some deposits, but are rarely very significant much above the water table.

Minerals which have been found to be important in some deposits are tetrahedrite, tennantite, cuprite, brochantite, atacamite, and native copper.

Other minerals which are fairly widespread in their occurrence but are rarely the principal ones in the ore are weissite, covellite, enargite, tenorite, olivenite, pseudo-malachite, tyrolite, pisanite, tagilite, mottramite, caledonite, and meta-zeunerite.

Silver, lead, gold and zinc have been reported from many deposits, and nickel, cobalt, vanadium, bismuth, and tungsten are known in others.

The principal gangue mineral is usually quartz, with calcite, barite, dolomite, siderite, pyrrhotite, pyrite, and marcasite occurring frequently. At Thaduna a good deal of carbonaceous material is found in the ore.

Simpson's (1948) "Minerals of Western Australia" contains much useful information on local copper minerals. Additional and more recent specific information is available from the Mineralogy, Mineral Technology and Geochemistry Division, Government Chemical Laboratories.

DISTRIBUTION AND MODE OF OCCURRENCE OF THE DEPOSITS

The deposits are widespread through Western Australia, mainly within the proved auriferous belts. The majority are copper-gold-quartz veins occurring in various types of Archaean and Lower Proterozoic metasediments and basic igneous rocks.

These are usually simple fissure veins occurring in shears with well defined walls, and with little replacement of country rock. They are in the hypothermal-mesothermal range and evidently the parts exposed now were originally deeply buried and fairly close to the source.

At Whundo, Yannery, Victoria, Westons, Cane River, and Ashburton Downs parallel quartz veins occupy zones in sheared sediments. At the surface the individual veins are usually separated by variable thicknesses of unmineralised country rock (shales and pelitic schists) but occasionally they coalesce sufficiently to form small lodes.

The Whim Creek deposit is so far unique in this State. This can be called a lode formation, and it appears to be stratigraphically controlled, occurring in a variety of slaty rocks and interbedded felsitic rocks. It is possibly syngenetic.

The Mons Cupri and the Copper Hills Mines have worked shoots of near-surface oxidised ore in disseminated deposits. The country rock in the former is tuff and metasediment, and in the latter it is quartz porphyry.

The deposits in the vicinity of Mt. McLarty occur in Nullagine dolomite which is part of a gently folded sequence of various sedimentary rocks and interbedded volcanics. Copper mineralisation is localised in fractures in the dolomite. Some 60 miles north-east of Mt. McLarty, at Braeside, weak copper mineralisation occurs in lead-and vanadium-bearing quartz veins intrusive into Nullagine lava.

In the Anaconda Mine at Eulaminna, three separate ore bodies were worked in a quartz vein intruded along the contact of metasediment with pillow lava. There is some replacement of country rock and in places mineralisation was found over a width of 40 feet. Rich secondary sulphides found beneath the water table gradually diminished in grade downwards into pyritic sulphide ore carrying some bornite and chalcopyrite.

The Ravensthorpe ore bodies are copper-gold-quartz veins intrusive into Archaean basic igneous and metasedimentary rocks around and near part of the intrusive contact of a large body of soda granite. There is little secondary enrichment in this area, primary ore containing chalcopyrite, pyrite, pyrrhotite, and marcasite being met at shallow depth.

Near Mt. Angelo, 20 miles south-west of Hall's Creek in the Kimberley Goldfield, copper mineralisation occurs in the Hall's Creek Metamorphics (shown as Whitestone on the State Geological Map). On the surface these deposits consist of two large and several smaller copper-bearing gossanous outcrops in metasediments, including limestone, extending over a zone about 1,000 feet long and up to 120 feet wide. The potential of these deposits is being investigated at the present time (May, 1962).

At Arrino and Barker Gorge small copper deposits have been found in Paleozoic sediments. They appear to be the result of the concentration by ground water of copper derived from low-grade dissemination in adjacent older rocks.

The depth of oxidation and accompanying secondary enrichment is variable but is nowhere considerable. Of the deposits worked, secondary enrichment was probably most important in the Anaconda Mine, where secondary sulphides were worked to about 200 feet vertical depth. Work in the Copper Hills Mine is at present restricted at about 150 feet because of the decrease of grade in sulphide ore. In general one can expect that 200 feet is about the maximum depth of any appreciable secondary enrichment in the known copper producing areas of this State, and primary ore is encountered at many places much shallower than this.

Many of the deposits are only poorly represented at the surface by gossan. Two of the important shoots at the Anaconda were not known in outcrop at all. Copper mineralisation in the Nullagine dolomite at Mt. McLarty is accompanied at the surface by irregular patches of manganese and brown iron, and the surface indications of copper at Copper Hills were scattered pale green and blue carbonate stains in the vicinity of irregular patches of bleached porphyry.

The gold and silver content of the ores has been important in many places including Ravensthorpe, Eulaminna, Roebourne, and Gabanintha. Northampton is primarily a lead producing centre, and parts of some ore bodies have been worked for both lead and copper.

The author has tried to avoid indiscriminate use of the term "lode," restricting it to ore bodies where there has been fairly considerable replacement of country rock. However it must be remembered that some ore bodies change from a vein to a lode over a short distance when the conditions within the ore channel are suitable, and distinctions are sometimes hard to make in oxidised ground.

PRODUCTION

The tables shown below give production figures for copper and cupreous ore up to the end of 1961. The first two tables show annual State totals, and the third shows total production in the various gold and mineral fields.

Annual production figures for the various goldfields and individual deposits are given in the second part of the Bulletin. These are complete up to the end of 1960.

All of these have been prepared from information supplied by the Government Statistician.

Table 1

RECORDED COPPER PRODUCTION IN WESTERN AUSTRALIA

By Goldfields

Goldfield or Mineral Field	Copper Ore and Concentrates			Cupreous Ore and Concentrates			Total
	Long Tons	Av. Assay per cent. Copper	Copper Content Long Tons	Long Tons	Av. Assay per cent. Copper	Copper Content Long Tons	Copper Content Long Tons
West Pilbara	83,147·27	13·42	11,201·00	13,607·83	6·43	939·55	12,140·55
Phillips River	112,371·07	10·98	12,348·83	1,014·07	12·14	123·03	12,471·86
Mt. Margaret	47,880·44	9·35	4,455·30	534·56	6·89	36·86	4,492·16
Peak Hill	1,295·27	33·07	428·45	27,268·56	8·33	2,278·68	2,707·13
Pilbara	590·95	24·01	141·91	15,810·25	12·69	2,006·98	2,148·89
Northampton	24,035·69	7·63	1,834·82	21·79	6·96	1·51	1,836·33
East Murchison	649·73	14·97	97·30	4,668·44	10·53	491·40	588·70
Murchison	1,053·61	13·67	144·04	2,353·20	6·80	160·18	304·22
Ashburton	382·66	27·03	103·45	286·45	11·27	32·28	318·73
Yalgoo	91·70	14·36	13·17	825·71	9·64	79·63	905·34
West Kimberley	109·52	23·66	25·92	3·10	17·07	0·52	26·44
East Coolgardie	50·67	13·83	7·01	29·00	3·50	1·01	8·02
Broad Arrow	.....	.....	.....	95·98	8·26	7·93	7·93
Yilgarn	16·00	5·06	0·81	64·97	5·28	3·33	4·14
Gascoyne	4·04	20·29	0·82	10·04	9·10	0·91	1·73
Dundas	.....	.....	.....	12·69	8·36	1·06	1·06
North Coolgardie	6·12	13·39	0·82	7·43	6·90	0·51	1·33
Outside Proclaimed Goldfield	180·05	16·77	30·20	132·44	9·69	12·84	43·04
Total	271,864·79	11·34	30,833·85	66,746·51	9·23	6,178·33	37,012·18

Table 2
ANNUAL PRODUCTION OF CUPREOUS ORE AND CONCENTRATES

State Totals

Year	Ore and Concentrates	Average Assay per cent. Copper	Value
	Long Tons		£A
1944	80·00	12·41	547·00
1945	257·00	11·67	1,974·00
1946	72·00	8·75	447·00
1947	508·00	8·20	3,103·00
1948	258·65	11·36	2,204·00
1949	253·98	9·80	2,820·75
1950	969·85	8·43	8,866·92
1951	1,337·05	9·44	16,104·29
1952	1,643·59	10·52	21,595·12
1953	1,916·90	8·59	21,004·36
1954	4,748·11	8·34	50,381·30
1955	7,736·23	8·65	101,730·78
1956	7,713·31	8·60	113,442·52
1957	4,638·69	10·11	82,126·90
1958	7,643·72	8·99	114,670·20
1959	11,858·80	9·31	184,006·44
1960	7,726·81	9·70	140,252·35
1961	7,383·82	9·87	157,487·80
Total	66,746·51	9·23	1,022,764·73

Table 3
ANNUAL PRODUCTION OF COPPER ORE AND CONCENTRATES

State Totals

Year	Ore and Concentrates	Copper Content	Value
	Long Tons	Long Tons	£A
Prior to 1899	7,018·00	1,085·57	55,270
1899	2,964·00	541·84	35,938
1900	6,183·15	639·61	43,673
1901	9,960·14	1,010·46	69,900
1902	2,262·25	147·86	8,090
1903	20,526·33	1,005·09	56,541
1904	3,968·89	505·02	25,180
1905	2,389·04	322·36	16,266
1906	7,411·66	905·18	50,337
1907	18,978·42	2,607·98	180,387
1908	8,294·30	1,222·67	51,434
1909	15,084·95	1,622·82	95,344
1910	34,351·45	2,765·64	161,606
1911	22,675·80	2,062·81	116,318
1912	13,602·40	1,701·82	120,104

Table 3 *continued*
ANNUAL PRODUCTION OF COPPER ORE AND CONCENTRATES
State Totals

Year	Ore and Concentrates	Copper Content	Value
1913	13,428·68	1,310·84	86,615
1914	12,779·92	1,313·53	81,295
1915	4,498·56	665·74	40,998
1916	6,697·38	734·61	74,376
1917	6,488·65	785·95	93,711
1918	4,982·91	716·10	77,527
1919	1,277·00	246·45	21,530
1920	1,962·16	377·16	37,945
1921	1,150·34	291·07	20,162
1922	1,194·50	248·77	16,133
1923	9,873·30	941·65	63,184
1924	10,754·69	571·35	36,011
1925	2,469·72	138·49	8,952
1926-27	.....	.....	.....
1928	45·00	6·25	400
1929	149·18	17·86	1,394
1930-37	.....	.....	.....
1938	.....	6·41	346
1939	2·00	·59	23
1940	35·87	5·40	357
1941	6·10	2·04	154
1942	48·08	6·81	738
1943	·40	·33	33
1944	46·01	5·59	367
1945	39·57	5·77	364
1946	74·00	1·10	105
1947-48	.....	.....	.....
1949	49·49	4·83	630
1950	48·00	1·41	183
1951	43·13	6·82	758
1952	15·51	6·66	1,188
1953	50·29	15·03	3,199
1954	.....	.....	.....
1955	12·12	3·37	1,001
1956	212·23	45·79	12,742
1957	1,803·97	323·54	58,564
1958	1,801·95	419·34	54,424
1959	4,408·75	1,093·25	230,078
1960	3,552·13	905·96	199,007
1961	6,188·72	1,461·25	320,371
Total	271,864·79	30,833·85	2,631,254

EXPLORATION

Copper prospecting in this State has reached the stage where clear indications at the surface of a good copper deposit cannot normally be expected. However the small-mining man and the individual prospector is restricted, primarily by finance, to areas reasonably close to old mining centres where transport routes and supply points are established. These things are found in the goldmining belts, where two men working together

may still find it profitable to work whatever "tight formation" surface-enriched quartz vein deposits they can find. Development is naturally all in ore and often ceases when advice is received of the first parcel to fall below grade.

Despite the fact that perhaps 90 per cent. of these "prospector shows" never develop to any size, and may only exceptionally yield more than 200 tons of ore, the information they give to those concerned with large-scale prospecting, and its obvious object, large-scale production, is invaluable. It is therefore incumbent upon larger producing companies, metal traders, and authoritative bodies to assist the prospector as much as possible, both technically and financially.

The State geological map shows that the majority of the deposits occur in Archaean "greenstone" belts distributed throughout two extensive areas of granite and granite gneiss. The "greenstones" are the principal host rocks of gold in Western Australia. Between these two areas lies a broad tract of relatively unaltered Upper Proterozoic sediment and lava (Nullagine System) unconformably overlying more strongly metamorphosed Lower Proterozoic sediments (Mosquito Creek System (?)), which trend mostly east-west. The copper deposits in the "greenstone" belts appear to be genetically related to the auriferous veins, and in fact in some places one grades into the other. The few deposits so far found in the broad intervening belt of metamorphosed sedimentary rocks may be younger than these, and may have been deposited generally at a lower temperature and further from the source.

In this latter strip copper deposits have been worked at Victoria, Westons, Uaroo, and Ashburton Downs, in the Ashburton Goldfield; at Ilgarari, Kumarina, and Thaduna in the Peak Hill Goldfield; and in the Warburton Ranges in the Eastern Division. Further north interesting copper occurrences are found in Nullagine dolomite near Mt. McLarty.

The country in the vicinity of these deposits should be worthy of more detailed investigation than it has had in the past. In some areas a widespread soil cover makes the elucidation of structure and mineralisation by surface mapping alone difficult, if not impossible. At these places the application of geophysical or geochemical techniques may pay off. One thing that is certain is that if worthwhile (by world standards) copper deposits are to be found in Western Australia, searchers must scratch more deeply than is possible with reconnaissance surveys, and they must be prepared to spend time and money, and to use proper techniques of sub-surface exploration.

The following list contains areas or localities which the author thinks could repay more detailed investigation than they have had in the past.

The Pilbara Goldfield :

The Copper Hills porphyry belt.

North Pole, around the perimeter of the intrusive granite batholith.

Yandicoogina, for about two miles north-eastwards around the perimeter of the intrusive granite.

McLarty Hills, in Nullagine dolomite.

The West Pilbara Goldfield :

Whim Creek and Mons Cupri, and southwards to Croydon. Yannery and Whundo, and vicinity.

The Ashburton Goldfield :

Uaroo, Westons, Victoria, and vicinity.
Red Hill area.
Ashburton Downs.

The Gascoyne Goldfield :

The belt of metasediments from Mangaroon to Westons.

The Peak Hill Goldfield :

Thaduna and eastwards around the southern edge of the granite.

Ilgarari and Kumarina and vicinity.

Mt. Margaret Goldfield :

Eulaminna, along contact of lava and metasediment north and south of the Anaconda.

Explanation of the prospects in these areas is given in the description of the deposits in the next section.

ACKNOWLEDGMENTS

The subject matter of this report is largely the result of a reconnaissance survey of the majority of the copper-mining centres of this State. Many of the underground workings at these places are now inaccessible and to present as complete a picture as possible reports by the investigators listed in the bibliography have been freely drawn upon. Although in some cases differences of interpretation of the facts have been made, the great value of their work is acknowledged.

The clerical staff of the Geological Survey Branch and the Mines Department Records Section have assisted greatly in the tracking down of ancient records, and the location in the field of many of the older mining leases has been possible only through the enthusiastic assistance of the Mines Survey Examination and Drafting Branch.

In the field many people have readily given valuable information about various subjects including access tracks, water supplies, the mines, and mining conditions, and the author is indebted to them

The manuscript of this report has been checked by various members of the Geological Survey, and this help is much appreciated. So also is the work of Miss M. Cook, technical typist of this Branch, who has efficiently and cheerfully executed an onerous task.

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CHAPTER II

THE COPPER DEPOSITS

INTRODUCTION AND ARRANGEMENT

In the following pages all of the Western Australian deposits which have a record of copper ore production are described. The arrangement is from the West Kimberley Goldfield southwards, except that deposits outside proclaimed gold or mineral fields are grouped together at the end of the Chapter. The various deposits may be referred to the Locality Map at the end of this Bulletin, or to the Geological Sketch Map of Western Australia obtainable from the Mines Department.

Information about the better known deposits has had to be condensed, particularly for deposits in the Northampton and Ravensthorpe Fields, but numerous references are given in the Bibliography.

For each Goldfield there is a summary, a table of annual production figures, and some comments on future exploration. The production figures are complete up to the end of 1960.

THE WEST KIMBERLEY GOLDFIELD

SUMMARY

Recorded copper production from the West Kimberley Goldfield amounts to 109 tons of ore averaging 26 per cent. copper. The bulk of this production has come from the Water Point (Yampi Sound) Deposit where mineralisation occurs in quartz, intrusive into metamorphosed quartz porphyry which is probably younger Precambrian in age.

Further inland near Mt. Nellie, and at Grant's Find, Wilson's Find, and Mondooma, mineralisation occurs in older Precambrian Sediments. The copper occurs with quartz replacing brecciated slate along the beds, or in quartz veins in shear zones. Oxidation extends to about 50 feet depth. The secondary minerals consist of malachite, bornite and cuprite, associated with iron oxides.

At Narlarla (Barker Gorge) copper is associated with silver and lead in calcareous rocks of Devonian Age.

The following table summarises some types of deposits in the West Kimberley.

Table 4

TYPES OF DEPOSITS IN THE WEST KIMBERLEY GOLDFIELD

Deposit		Ore Produced		Remarks
Locality	Tenement	Copper Ore	Cupreous Ore	
Grant's Find	M.L. 227H	4.22	....	Stratigraphically controlled quartz-sulphide mineralisation in slates and phyllites, and quartz-veins with sporadic mineralisation along fault zones.
Oobagooma	M.L. 228H	8.97	....
Wilson's Find	....	....	....
Mt. Nellie (or Mangrove)	....	....	....
Mondooma	....	....	....	Sulphide mineralisation in slates.
Narlarla (or Barker Gorge)	....	....	....	Thin quartz veins carrying sporadic mineralisation, along fault lines.
Yampi Sound (or Water Point)	M.L. 221H	92.86	....	Disseminated silver-lead-copper mineralisation in calcareous rocks.
				Quartz-sulphide mineralisation in a fault zone.

Table 5
COPPER PRODUCTION IN THE WEST KIMBERLEY
GOLDFIELD TO THE END OF 1960

Period of Production	No. of Lease	Registered Name	Ore Produced	Content Metallic Copper	Value
1914	M.L. 221H	Yampi Sound Copper Mine	Long Tons 38.50	Long Tons 9.21	£A 426
1915	M.L. 228H	Oobagooma (Monarch Group)	8.97	1.82	136
	M.L. 227H	Grant's Find (Berylton)	4.22	0.94	64
	M.L. 221H	Yampi Sound Copper Mine	54.36	13.59	1,047
		Sundry Claims	3.47	0.36	36
		Totals	109.52	25.92	1,709

THE LITTLE TARRAJI RIVER COPPER DEPOSITS (INCLUDING GRANT'S FIND, WILSON'S FIND, MT. NELLIE, BERYLTON, OOBAGOOMA AND OOBAGOOMA)

Introduction

These deposits were not examined during the course of preparation of this Bulletin. The information given below has been taken mainly from the following references :

Woodward (1906), Maitland (1919), Simpson (1952), Reid et. al. (1959).

The copper occurrences are located on either side of the Little Tarraji River (previously called Little Taragee), a southward flowing tributary of the Robinson River, in the West Kimberley Goldfield. Approximate geographical co-ordinates are—

Latitude 21°0'S.

Longitude 120°37'E.

Reference may be made to the following maps—

1. Lands Department Lithograph No. 138/300.
2. Lands Department 4 Mile Series, Yampi Sheet.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photomosaics are also available from the Lands Department.

Copper occurrences were first discovered in this area in 1905 a few miles east of Mt. Nellie. The following year a number of leases were taken up on either side of the Little Tarraji River from near its source to near its junction with the Tarraji River.

Access to the area is by graded track as far as Boulder Hill on the Robinson River, and thence northwards by bush track. The total distance from Derby, the nearest port and township, to Grant's Find is about 100 miles.

Geological Information

The area in which the copper-shows occur is occupied by older and younger pre-Nullagine sediments, both of which, in some areas, have been invaded by granite. The regional strike is north-west, with some evidence of minor cross-folding. The rocks generally are folded into a series of anticlines and synclines, with some overturning. The degree of metamorphism is not generally high.

The younger pre-Nullagine rocks consist of conglomerates, quartzites, sandstones, shales, slates, schists, some acid porphyry sills, and huge amphibolite sills, some of which in shattered areas show low-grade copper mineralisation. These rocks are not at present regarded as favourable copper prospects, but the amphibolites and porphyries may have been the source of some of the copper showings.

The older pre-Nullagine sediments are a succession of phyllites, shales, schists and greywackes, with some minor developments of amphibolite similar in composition to those of the younger rocks. The phyllites, slates and sandstones of the older series are the favoured beds for copper mineralisation.

Writing for the 1906 Annual Report, Woodward stated "..... The mineral discoveries are in reality situated at some distance from it (Mt. Nellie) upon the Little Taragee River, which is not shown on the map although it is of considerable size.

The mineral belt, which is schist and slate intersected by quartz reefs and diorite dykes, extends in a north-westerly direction from Mondooma upon the Robinson River to Mt. Nellie, where it is overlaid by a flat-topped quartzite range, from beneath which it again appears to the northward and apparently extends in the same direction towards Yampi Sound.

In this schist belt to the northward of Taragee River and extending up to the base of the quartz range, there are a series of dyke-like mineralised quartzose ridges containing quartz veins usually much copper-stained. These ridges, which are generally of considerable length, have the appearance of being fissure lines which have allowed the flow of the mineral solutions that have altered and silicified the adjoining schistose rocks.

These dyke-like lines are intersected by numerous quartz veins or lodes, some of which are of considerable size and length, being usually copper stained, whilst they sometimes contain copper ore, either in veins, bunches or disseminated through the quartz itself."

Production

Table 6
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1915 1920	M.L. 227H	Grant's Find	Long Tons 4.22	Long Tons 0.94	£A 64
	.....	Sundry claims	3.47	0.36	36
		Up to the end of 1960....	7.69	1.30	100

Assays and Mineralogy

Simpson (1952) comments, "Seventeen bulk samples of ore, collected by agents of a German syndicate in 1911 from leases then being worked, assayed from 2.20 to 16.04 per cent.

of copper, with an average of 7.37 per cent. The chief mineral of all these was malachite, and an analysis of a combined sample showed—

	Per cent.
CuO	9.23
Zn, Bi, Sb	<i>Nil</i>
Pb, Ni, Mn	trace
As	0.04
Fe ₂ O ₃	8.21
Al ₂ O ₃	5.86
CaO	<i>Nil</i>
NgO	0.83
SiO ₂	68.83
CO ₂	2.56
S	0.08
O, H ₂ O, and loss	4.36
	100.00

Selected samples of carbonate ore from this district assayed as follows:—

	Copper	Lead	Gold per ton	Silver per ton
	%	%	Grains	dwts. grns.
Grant's Reward A	34.63	0.72	20	4 22
Grant's Reward B	23.22	<i>Nil</i>	20	1 15
Wilson's Reward	37.58	<i>Nil</i>	20	11 10

“A” and “B” were cellular mixtures of malachite and limonite with a little quartz. The Wilson's Reward ore was massive liver ore with patches of quartz and malachite.

Remarks

The following information is taken from a report written by Mr. D. Reid for Western Mining Corporation at the end of the field season in 1959, and summarises information on what the Corporation regarded at that time as the most important copper occurrences in Temporary Reserve 1593H.

Table 7
TYPES OF DEPOSITS IN THE TARRAJI AREA

<i>Type</i>	<i>Deposit</i>	<i>Possible Value</i>
1. Quartz-sulphide mineralisation in slates and phyllites	1. Townshend River showings	No economic value.
	2. Rough Triangle Prospect	Less than 1% Cu.
	3. Grants Prospect	Moderate tonnage (1,100 tons/v.ft.) at 1.5% to 2% Cu.
	4. Wilsons Prospect	Small showings, no value.
2. Sulphide mineralisation in slates	1. Mangrove Prospect	Probably low grade.
3. Quartz veins, with sporadic mineralisation, along fault zones	1. Copper Creek Fault Zone	Scattered small pods.
	2. Little Tarraji Fault	do. do.
	3. Amphibolite showings	do. do.
	4. Mondooma Prospect	Probably small tonnage of good grade, moderate tonnage of low grade. Erratic values.

These results were based on extensive geochemical, geophysical and geological work extending over the years 1957-1959, and on the results of diamond drilling at Grant's and Wilson's Prospects. Western Mining Corporation surrendered the Temporary Reserve in October, 1960.

In view of the failure to find a commercial copper occurrence after three seasons of extensive field work in this area, it is extremely unlikely that such a deposit occurs anywhere on the surface here. Neither are there, at the present time, any indications of extensive buried deposits.

THE MONDOOMA COPPER PROSPECT, ROBINSON RIVER

Introduction

This deposit was not examined during the course of preparation of this Bulletin. The information given below has been taken mainly from the same references as for the deposits in the vicinity of the Little Tarraji River.

The copper prospect is located on the north side of the Robinson River, near Trig. Station L2, approximately 5 miles westwards from the point where it is joined by the Pandaboora River. Geographical co-ordinates are as follows:—

Latitude 16° 50' S.

Longitude 124° 25' E.

Reference may be made to the maps mentioned in the report on the Little Tarraji River prospects.

In 1910 a copper deposit was opened up about 10 miles south-east of Mondooma Station Homestead. Little work was done at that time, but the lease was again taken up in 1916 when it was inspected by H. P. Woodward. Three leases were taken up on the north side of the River, about two miles from Mondooma Homestead, which is shown on Lands Department Lithograph L472/98. These were M.Ls. 88H, 89H and 90H, and were known as the Robinson River Copper Mine, although there is no official record of production of any ore.

Geological Information

Woodward (1906) wrote "The Napier Range terminates to the northward, a little south of Trig. Station L2, the limestone being replaced by mica schist and diorite dykes, which here strike nearly east-west, and it is at the contact of these latter rocks that a copper-stained ferruginous reef can be traced for a distance at the surface of about 300 yards.

The cap of this reef has been cross-cut at three points in each trench. However, the lode proves to be very small and to carry very little copper ore."

The rocks containing this mineralisation are now known to be older pre-Nullagine sediments, and are an extension of those carrying copper mineralisation at the Little Tarraji River.

From reference to Table 7, prepared by Mr. Reid and quoted in the report on the Little Tarraji prospects, it can be seen that the Mondooma Prospect consists of quartz veins, with sporadic mineralisation along fault zones. There is considered to be probably a small tonnage of good grade, and a moderate tonnage of low grade, with erratic values, in the line of mineralisation.

Production

There are no official records of any production from this prospect.

Remarks

It appears, from surface indications, that this occurrence does not constitute a commercial copper prospect.

THE NARLARLA (BARKER GORGE) COPPER PROSPECT

Introduction

This deposit was not examined during the course of preparation of this Bulletin. The information given below has been taken mainly from Woodward (1906) and Simpson (1907, 1952).

This copper prospect is situated in the Napier Range, at the south end of Barker Gorge. Geographical co-ordinates are as follows:—

Latitude 17° 16' S.

Longitude 124° 40' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph No. 134/300.
2. Lands Department 4-Mile Series, Lennard River Sheet.
3. Geological Sketch Map of Western Australia. Geol. Survey West Australia 1957.

Aerial photographs and photomosaics are also available from the Lands Department.

Woodward (1906) has written, referring to those held by the Marlara Hills Silver Lead Co.—“These properties consisted of the Narlarla Hills silver-lead leases, which are situated in the Napier Range, West Kimberley District (124° 43' E. long. 17° 16' S. lat.), 75 miles due east of Derby upon the south side of the Barker River Gorge at a point a little above that river's junction with the Lennard River, at Narlarla, or Marlara by the native name; and Mandooma Copper leases”

“These leases had, in the early part of the year, been applied for by Mr. Poulton, the Company's representative, who was one of the early settlers of this District and onetime part owner of Mandooma Station.

These discoveries were by no means new, since leases at both localities had been taken up by Mr. Pettigrew as far back as 1900 and 1901 but, as developments did not turn out to his satisfaction, they were abandoned.”

Geological Information

The rocks of the Napier Range (Narlarla Hills) consist of Upper Devonian limestones, striking north-west and south-east, and dipping to the south-west at angles of about 25 degrees. These unconformably overlies older pre-Nullagine metasediments, which crop out to the north, and which are continuous with those (though broken by granitic intrusions) which carry copper mineralisation in the Little Tarraji River area.

The following information is from Finucane and Jones (1939)—

“A. Narlarla Lead-Silver Deposits.

Two outcrops of lead-zinc-silver ore, chiefly carbonates, occur in the Napier Range limestones within one mile south-east of the northern side of Barker Gorge. Though of small dimensions, the deposits are of especial interest as they constitute the youngest known metalliferous ores in Western Australia. In their general mode of occurrence and mineral constituents they are similar to the lead ores of Missouri, except that they contain a little more silver. 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) had suggested that the ore deposit is genetically related to the post-Permian lamproite magma of the Fitzroy River Basin.

Further information on the general geology of the area may be found in Bulletin No. 36 of the Bureau of Mineral Resources (Guppy et al., 1958).

Woodward (1906) wrote "The ore deposits at the Narlarla blocks consist of two small parallel iron-stained blows of carbonate of lead about 20 chains apart, whilst the limestone country between is found, upon close examination, to contain small stains of carbonate of copper here and there which apparently gave rise to the belief that the lode ran in a north and south direction."

Woodward considered these shows only to be silver-lead prospects.

Production

There are no official records of any copper production from the leases in this vicinity.

Assays

Woodward (1906) gives the following information on assays made in the Geological Survey Laboratory of specimens from Narlarla :—

Table 8

Locality	Class of Ore	Copper	Lead	Zinc	Silver per ton	Gold per ton
		%	%	%	oz. dwts. grns.	Grains
Narlarla North Shaft	Oxide	4.43	42.39	4.47	4 8 14	3
Narlarla North Shaft	Sulphide	0.42	13.94	40.83	3 7 0	Nil
Narlarla South Shaft	Transition	0.52	39.66	1.34	5 1 6	Trace

Finucane and Jones (1939) give the following information concerning the grades of the two ore-bodies. The No. 1 ore-body was estimated to contain the following average Grades :—Lead, 38.67 per cent., Copper, 0.58 per cent. and Silver, 5.71 oz. per ton, for an amount of 1,130 tons, which was considered to be higher grade ore. The No. 2 Ore-body was estimated to contain the following average Grades :—Lead, 31.51 per cent., Copper, 1.51 per cent. and Silver, 4.59 oz. per ton, for an amount of 8,373 tons which was considered to be higher grade ore.

Remarks

It is evident that this deposit contains only low-grade copper mineralisation, and on the present information, any copper recovered would be accessory to the silver and lead.

THE YAMPI SOUND COPPER DEPOSIT, WATER POINT

Introduction

This deposit was not examined during the course of preparation of this Bulletin. The information given below is taken mainly from Simpson (1914) and Maitland (1919).

The deposit is located on the coast of Yampi Sound, in the West Kimberley Goldfield, about 6 miles distant from the iron-ore deposits on Cockatoo Island. The access is from the sea. The geographical co-ordinates are as follows:—

Latitude, 16° 15' S.

Longitude, 123° 35' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph No. 138/300.
2. Lands Department 4-Mile Series, Yampi Sheet.
3. Geological Sketch Map of Western Australia, Geol. Survey West Australia, 1957.

Aerial photographs and photomosaics are also available from the Lands Department.

Geological Information

The following information is taken from Maitland (1919). "The lode occurs on the beach and, being not very far from deep water, facilities for mining are good. The ore is mostly chalcocite of good quality, and is associated with a little green carbonate of copper, and quartz. The lode, so far as has been developed, is from 5 to 6 feet wide, and underlies to the east, and so far as may be judged from specimens forwarded to the Department, it occurs in a faulted zone of metamorphic crystalline rocks. The lode is a sericitised and carbonated quartz—porphyry."

The present author considers these rocks to belong to the younger pre-Nullagine succession.

Production

The Government Statistician records production from this deposit over the years 1914 to 1915. The details are as follows:—

Table 9
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Copper Ore	Metallic Copper	Value
1914	M.L. 221H	Yampi Sound Copper Mine ...	Long Tons 38-50	Long Tons 9-21	£A 426
1915	M.L. 221H	Yampi Sound Copper Mine ...	54-36	13-59	1,047

Mineralogy

Simpson (1952) comments as follows:—"Copper Ore, Water Point, Kimberley Division—The ore from this new find contained masses of the rich copper sulphide, Chalcocite, associated with Malachite, Cuprite, Atacamite (copper oxychloride) and Brochantite (basic copper sulphate). The last named mineral has not previously been recorded from this State, though known to occur in New South Wales."

Remarks

The fact that this deposit has not been worked since 1920 suggests that the grade and/or reserves have fallen below economic limits.

FUTURE EXPLORATION

The country surrounding the known copper occurrences in the West Kimberley Goldfield has been fairly thoroughly prospected and, as far as is known at present, contains no economic copper mineralisation.

The older Precambrian sediments appear to be the more favourable host rocks but the bulk of the production to date has come from an ore-body in a shattered quartz porphyry of apparently younger Precambrian age. More detailed study of the mode of occurrence of the Water Point mineralisation, and prospecting along the continuation of the host rocks, may be worth while.

This later deposit has the advantage of being directly accessible from the sea.

THE PILBARA GOLDFIELD

SUMMARY

Copper deposits which have produced ore in the Pilbara Goldfield are confined, with one possible exception, to granitic rocks and pre-granite metasediments and volcanics of Archaean age. The deposits in the Mt. McLarty area are in calcareous rocks which probably belong to the Nullagine (Upper Proterozoic) System.

The ore bodies are principally narrow, lenticular, steeply dipping chalcopyrite-quartz veins, often containing gold and silver, and sometimes zinc and lead. The Copper Hills Copper Mine, the principal producer in the Field, has produced carbonate ore from localised secondary concentrations in fractured quartz-porphyry.

Excepting the Copper Hills Mine, production has come from hand-selected oxidised ore, principally in the form of malachite, from depths less than 60 feet below the ground surface. The average grade of the copper ore has been 24 per cent., and of cupreous ore 12 per cent. The Copper Hills Mine, and the deposit on M.C.47L, 2.5 miles south of this, are the only deposits which have been tested by drilling beyond the present workings.

None of the deposits are marked by a strong development of gossan, but many of them show weak copper mineralisation over varying distances along the strike from the present workings.

The following table summarises the types of deposits in the Field.

Table 10
TYPES OF DEPOSITS IN THE PILBARA GOLDFIELD

Deposit		Ore Produced		Remarks
Locality	Tenement	Copper Ore	Cupreous Ore	
Copper Hills	..... G.M.L. 314L M.C. 34L M.C. 35L	Long Tons 464·71	Long Tons 13,255·15	Widely disseminated chalcopyrite mineralisation in porphyries with local concentrations of oxidised ore in shear zones. Some silver content. Some copper bearing quartz veins.
Copper Hills	..... P.A. 746	.....	2·8	Steeply dipping quartz vein in sheared porphyry.
Copper Hills	..... M.C. 103L	.....	149·48	Steeply dipping quartz vein in sheared porphyry.
Copper Hills	..... M.C. 47L	.....	.....	Steeply dipping quartz vein in sheared porphyry and greenstone remnant.
Copper Hills, 10 miles south of	M.C. 117L P.A. 750L	.....	97·73	Steeply dipping quartz veins in sheared and fractured porphyry. Some impregnation of wall rock.
Marble Bar, 5 miles south of	P.A. 2474	67·42	.....	Steeply dipping quartz fissure vein in fractured basic lavas.
Lionel	..... P.A. 733L M.C. 112L	.....	114·61	Steeply dipping quartz fissure veins in fractured hornblendic greenstone.
Yandicoogina, 7 miles north-east of	M.C. 232 P.A. 2614	5·80	28·46	Steeply dipping concordant quartz veins in bedded metasediments. Some wall replacement. Contains lead, zinc, silver and gold.
North Shaw	..... M.L. 147 P.A. 2492 P.A. 2506 P.A. 2585	7·77	4·98	Steeply dipping quartz veins in massive and carbonated schistose amphibolites. Principally worked for gold.
North Pole	..... M.C. 209	.....	284·99	Steeply dipping quartz vein (concordant?) alongside jaspilitic metasediments. Some wall impregnation. Some silver and gold.
Woodstock	..... G.M.L. 1141	.....	8·95	Steeply dipping quartz fissure vein in granitic gneiss.
Pilgangoora	..... M.C. 439	.....	10·64	Steeply dipping quartz fissure vein in amphibolite.
Boodarric Station, south-east corner	P.A. 2508	.....	1·20	Steeply dipping quartz fissure veins in fractured granite.
Mt. McLarty	..... Various	.....	.....	Secondary mineralisation, generally disseminated but locally concentrated, in calcareous Nullagine (?) rocks.

Table 11
COPPER AND CUPREOUS ORE PRODUCTION IN THE
PILBARA GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1907	7·77	1·90	190
1908-1910 .....	.....	.....	.....
1911	30·10	5·73	316
1912-1919 .....	.....	.....	.....
1920	9·00	4·75	360
1921-1950 .....	.....	.....	.....
1951	13·30	1·32	77
1952	15·51	6·20	1,094
1953	32·93	10·80	2,424
1954 .....	.....	.....	.....
1955	0·53	0·30	134
1956	22·71*	4·07	1,058
1957	459·10	106·84	21,012
1958-1960 .....	.....	.....	.....
Total	590·95	141·91	26,665

Average weighted assay = 24·0%.

* Also contained 0·93 fine ozs. of gold and 51·20 fine ozs. of silver.

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Copper	Value
	Long Tons			£A
1954	310·58	5,468·54	17·93	9,200·09
1955	857·17	12,638·41	14·74	23,868·20
1956	1,853·12	23,196·67	12·52	42,971·75
1957	1,859·93	23,245·98	12·49	41,814·25
1958	1,713·98	20,516·15	11·97	37,891·95
1959	4,902·72	53,371·37	10·89	96,085·94
1960	2,573·86	33,134·61	12·87	71,762·60
Total	14,071·36	171,571·76	12·19	323,594·78

THE COPPER HILLS COPPER MINE, G.M.L. 314L

Introduction

Properties which have produced ore in this general locality include M.Cs. 103L, 117L, M.L.96L, P.A.746L, and the principal mine, G.M.L. 314L which is known as the "Copper Hills Copper Mine." The first recorded production was in 1952 when 48·44

tons of copper ore were recovered from M.C.34L (now G.M.L. 314L) and from M.C. 35L (now M.C. 96L). Up to the end of 1960, recorded production was 464.71 tons of copper ore and 13,505.42 tons of cupreous ore for fertilizer purposes. Since 1955, G.M.L. 314L has been one of the two principal producers of cupreous ore in the State.

Access to Copper Hills is by graded road for 40 miles via the "Comet" Gold Mine and Corunna Downs Homestead. The country in the vicinity is fairly hilly and rugged, and dissected by many small watercourses. A description of the geology of this area has been given by Noldart (1957). A report on a diamond drilling programme carried out to investigate mineralisation at depth is given by Lord (1957). Approximate geographical coordinates are :—

Latitude, 21° 36' S.

Longitude 120° 00' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 98/300.
2. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia, 1957.

Aerial photographs and photo-mosaics are available from the Lands Department.

Geological Information

The rock in which the principal copper mineralisation occurs in this area is a texturally massive, jointed (and sheared in places) quartz porphyry which unconformably overlies metamorphosed sediments and lavas of the Warrawoona succession. In places these older rocks can be seen protruding upward through the porphyry. The actual thickness of the porphyry is not known, but it can not be less than 500 feet.

This belt of porphyry extends over 14 miles in a north-north-easterly direction, and attains a maximum width of 2.3 miles. The "Copper Hills Copper Mine" is located towards the northern end of the porphyry belt, and Kelly's Copper Mine (M.C. 117L) at the southern end, practically on the contact with the older Warrawoona rocks. The porphyry belt is in contact along most of its western side with a major intrusive granitic mass.

Shearing is strongly developed in the direction N.50°-70°W. in the northern (Copper Hills) section, whilst in the vicinity of M.C. 117L at the southern end, the trend is N.30°-50°W.

Copper mineralisation is found in Warrawoona lavas and schistose sedimentary remnants as well as in the porphyry, which is the most favourable host rock. The mineralisation is controlled locally by the above-mentioned directions of shearing.

Some quartz filled shears, oblique to the general pattern, carry some copper mineralisation in places, but these do not appear to be very significant. Mineralisation in the porphyry was evidently initially widely disseminated, but secondary enrichment in favourably located fracture zones has formed ore bodies.

On G.M.L. 314L leached porphyry showing impregnations of copper carbonates has been traced over an irregular zone extending for about 500 feet in a north-east direction, attaining a maximum width at the southern end of about 160 feet. There is very little gossanous material showing at the surface.

The main workings, which have attained a maximum depth of about 140 feet, are located at the southern end, the ore having been worked mainly from adits into the side of the hill, which contains the main ore-body. There are also two shafts, and an open cut where the ore has been stoped through to the surface.

The bulk of the material produced has been carbonate ore, but chalcocite and chalcopyrite is now being worked at the deepest levels. Mineralisation has been extremely irregular and difficult to follow with organized mine development.

Two depressed diamond drill holes, one near the southern end and the other near the northern end of the zone of surface indications, were drilled in a south-westerly direction and penetrated below the outcrop to about 390 and 510 feet vertical depth. They showed no copper values over the assayed sections greater than 0.95 per cent. copper (Lord, 1957). The core from these boreholes consisted of sericitised quartz porphyry (with occasional undigested remnants), carrying small blebs, veinlets and specks of pyrite and chalcopyrite spasmodically distributed throughout. Near the surface, weak copper carbonate mineralisation was encountered.

The ground above the richest concentrations of secondary copper is generally bleached to an off-white by leaching. A detailed study of the relationship of these bleached sections to the heavily mineralised shears might enable predictions to be made about the location of more ore shoots.

Carbonate ore from this mine has been carted as broken to the "Comet" Gold Mine treatment plant for grinding and screening. As the reserves of carbonate ore are becoming depleted, however, more sulphide ore is being mined and treated at the "Comet." A basic copper sulphate is produced and there are indications that this product will be acceptable to the fertilizer companies for mixing with carbonate ores obtained from other sources.

Production

Table 12
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1952	M.C's 34L, 35L	Stubbs & Baker	<i>Long Tons</i> *15.51	<i>Long Tons</i> 6.20	£A 1,093.75
1953	M.C's 34L, 35L	Stubbs & Baker	†32.93	10.80	2,423.92
1956	M.C. 96L	Stubbs & Baker	416.27	102.06	20,192.55
Total to the end of 1960			464.71	119.06	23,192.55

Average assay 25.6% Cu.

* Contains 50.72 fine ozs. of silver.

† Contains 269.46 fine ozs. of silver.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Value
1954	G.M.L. 314L	Stubbs, S. H.	Long Tons 268·09	Long Tons 17·21	£A 7,712·01
1955	G.M.L. 314L	Stubbs, S. H.	458·58	14·63	12,514·16
1956	G.M.L. 314L	Stubbs, S. H.	1,619·62	12·35	36,783·54
1957	G.M.L. 314L	Stubbs, S. H.	1,827·25	12·43	40,992·30
1958	G.M.L. 314L	Stubbs, S. H.	1,681·55	11·85	36,610·55
1959	G.M.L. 314L	Stubbs, S. H.	4,900·55	10·88	96,020·64
1960	G.M.L. 314L	Stubbs, S. H.	2,499·41	12·69	68,566·95
Total ....	.....	.....	13,255·15	.....	299,200·15

Assays

No detailed assays are available for the ore from G.M.L. 314L, but the average grade of ore produced, as indicated by the above production figures, is about 12 per cent. The ore in the higher levels consisted of mainly malachite, with azurite, while below 100 feet chalcocite and chalcopyrite, with a little bornite, become increasingly important. The results of assays of 24 samples taken from No. 1 Hole showed that the maximum copper content detected was 0·95 per cent. over 5 feet, and from 16 samples from No. 2 Hole, 0·13 per cent. over 10 feet. (Lord, 1957.) Most of the samples assayed for gold showed only a trace (less than 0·20 dwts. per ton).

Reserves

No estimate of reserves has been made by the Geological Survey on this deposit. In April, 1961, however, Mr. S. H. Stubbs indicated to the Mines Department that the carbonate-ore reserves were rapidly being exhausted, but that it was estimated that there could be 10,000 tons of sulphide ore (from which basic copper sulphate could be produced) still available from the present workings.

Remarks

In view of the erratic distribution of the ore in this mine, and since no particular confining structure has been defined, it is not impossible that further blocks of ore could be found, perhaps by drilling from underground. It seems well worth while to prospect by drilling beneath any bleached sections in the vicinity of the present workings.

P.A. 746, COPPER HILLS AREA

Introduction

This P.A. is located 1·5 miles west of G.M.L. 314L and is reached by a track branching off the Copper Hills Road a short distance west of M.C. 96L. The only production is for the year 1956, when 2·8 tons of cupreous ore are recorded as being produced from P.A. 746.

Geological Information

Copper mineralisation occurs in a quartz vein up to 2 feet wide, occupying a shear in quartz porphyry. The vein strikes N.60°W. and dips steeply at 65° to the south. At the surface

it carries some green carbonate and silicate, and in places is capped by a brownish-black, spongy, iron oxide gossan.

Excavations on the line of mineralisation consist of a trench 30 feet long, 9 feet deep and up to 4 feet wide. Copper stainings in quartz extend for about 60 feet past each end of the workings, beyond which the vein is obscured by surface soil and rubble.

Production

Table 13

Period of Production	No. of Lease	Registered Name	Cupreous Ore Produced	Average Assay per cent. Copper	Units Copper	Value
1956	P.A. 746	Martin, W. M.	Long Tons 2·80	13·17	36·84	£A 70·0

Remarks

Although this deposit occurs in the same porphyry belt as G.M.L. 314 and within two miles of it, it is a quartz vein type of limited extent and, consequently, of minor importance.

M.C. 103L, COPPER HILLS AREA

Introduction

This deposit is located 2·3 miles slightly west of north from the Copper Hills Copper Mine, G.M.L. 314L. The host rock is "Copper Hills Porphyry" of Warrawoona age. This deposit may be reached by a track which branches northwards across Emu Creek, about 1 mile north-west of the Copper Hills Mine.

Production from M.C. 103L amounts to 149·48 tons, assaying 17·33 per cent. of cupreous ore during 1955 and 1956.

Reference may be made to the maps listed for the Copper Hills Mine.

Geological Information

Mineralisation is in the form of a copper-bearing quartz vein occupying a shear in sericitised quartz porphyry rock. The shear strikes north-west and dips close to vertical. Mine workings consist of a shaft with some open cutting.

The ore consists of carbonates of copper, with sulphides appearing at depth.

Production

Table 14

Period of Production	No. of Lease	Registered Name	Cupreous Ore Produced	Average Assay per cent. Copper	Value
1955	M.C. 103L	Baker, J. C. & M. C.	Long Tons 100·40	18·95	£A 3,756·93
1956	M.C. 103L	Baker, J. C. & M. C.	49·08	14·04	1,330·45
Total to the end of 1960			149·48	....	5,087·38

Remarks

Surface indications of copper mineralisation along the controlling shear are weak, the seam is narrow, and the indications are that this deposit would not develop into an important producer.

M.C. 47L, COPPER HILLS AREA

Introduction

This deposit is located about 2 miles south of the Copper Hills Copper Mine, a few chains west of the track running from Copper Hills to Kelly's M.C. 117L. The general introductory remarks in the report on Copper Hills may be applied here.

Geological Information

A shear zone striking 300 degrees and dipping 80 degrees west to vertical occurs in coarse-grained felspar porphyry, and also partly in a small Warrawoona greenstone remnant. The shear is occupied in places by a chalcopyrite and pyrite bearing quartz vein which splits in places, forming parallel lenses which include sections of country rock.

At places on the surface, gossan and copper staining extend up to a width of about 20 feet. Surface copper mineralisation, in the form of malachite and azurite, is weak and occurs intermittently over a distance of about 20 chains.

At the time of the author's visit, two shafts had been sunk, about 470 feet apart. The north-western one was about 30 feet deep, and the south-eastern one about 40 feet deep. Dump material from these showed carbonates in quartz and wall rock, the exposed quartz vein being up to 3 feet wide.

Two depressed diamond drill holes, located 5 chains apart, intersected the mineralised shear at vertical depths of approximately 100 and 150 feet (Lord, 1957). Hole No. 1 (vertical depth of intersection about 150 feet) intersected two 12 inch sections of quartz veins, carrying chalcopyrite and pyrite with some remaining porphyry, separated by 5 feet of porphyry containing a trace of mineralisation. Hole No. 2 intersected two similar narrow sections of mineralisation, separated by 15.5 feet of porphyry. Small veinlets and blebs of pyrite and chalcopyrite occur spasmodically throughout the core.

Lord (1957) stated "The dip of the shear, according to the drill intersections, has flattened as compared with the apparent dip observed at the surface. There may be a steep southerly plunge associated with the mineralisation."

Production

No production has been recorded against this Claim, but judging by the remaining dump material, it seems likely that a few tons were removed.

Assays

Lord (1957) gives the following information :—

Table 15

Sample No.	Borehole Depth		Width of Sample	Percentage Copper (Trace = under 0.01%)	Gold dwts./ton (Trace = under 0.20 dwts.)
	From	To			
Hole No. 1—	Ft.	Ft.	In.		
C.H. 41	171	172	12	3.33	Trace
C.H. 42	172	177	69	Trace	n.d.*
C.H. 43	177	178	12	5.31	Trace
C.H. 44	178	182	48	Trace	n.d.
Hole No. 2—					
C.H. 45	156½	158½	24	0.68	n.d.
C.H. 46	158½	162	42	Trace	n.d.
C.H. 47	162	174	144	0.31	n.d.
C.H. 48	174	175	12	1.05	Trace

* n.d. = not determined.

Remarks

Traces of copper mineralisation and gossan have been observed at the surface over about 20 chains on, and in the vicinity of, M.C. 47L. Drilling showed that weak pyrite-chalcopyrite mineralisation in thin quartz veins in a narrow sheared zone persists to at least 150 feet vertical depth.

From the available information, this Prospect does not warrant further investigation at the present time.

M.C. 117L, 10 MILES SOUTH OF COPPER HILLS

Introduction

The general information given in the introduction to the description of G.M.L. 314L is also partly applicable to this deposit.

M.C. 117L is located on a continuation of the same porphyry copper belt as the Copper Hills Mine, near the contact of the porphyry with the older Warrawoona rocks. Access is by a graded track for 10 miles south of Copper Hills, which track is a continuation of the road from the "Comet" to Copper Hills.

Geological Information

Copper mineralisation occurs in faulted and jointed quartz porphyry rock, and has been shown to extend on the surface over 550 feet in a zone up to 50 feet wide trending 325 degrees. This zone appears to be confined mainly between two almost parallel faults which have been penetrated by copper-bearing and iron-bearing siliceous solutions, the one on the north dipping at about 70 degrees north-east, and the one on the south dipping at about 85 degrees south-west. When viewed from the north-western end, the hill in which the copper occurs appears to be an anticline with the crest missing, but the texturally massive nature of the porphyry seems to make this unlikely. It is most probably a wedge-shaped faulted block.

Sympathetic cross-shearing and jointing between these two outside faults carries some of the leached copper material derived

mainly from the edges of the zone. The fracture pattern is complex, but the three main directions appear to be 295 degrees, 325 degrees and 360 degrees, dipping at 80 degrees south-west, variably steep, and 78 degrees south-east respectively.

These shears and some joint planes carry carbonates and oxides of copper. Some siliceous material from the deepest workings carries pyrite.

The workings consist of two shafts, 37 and 33 feet deep, and three cuts, to a maximum depth of 8 feet, into the sides of the hill, and some smaller excavations at various points around the hill.

The occurrence of copper mineralisation in the various planes is sporadic and, to date, no really large development has been encountered. There is some iron oxide at the surface along the line of strike, but it is poorly developed and there is very little spongy iron box-work.

Examination of the wall rocks of the two shafts indicates that the grade of mineralisation falls off with depth, although the bottom of the deepest one would still be some 40 feet above the general level of the surrounding country, and thus, presumably, still in the oxidised zone.

About 540 feet north-west of Kelly's present workings on the eastern slope of a hill composed of jaspilite and quartz porphyry, a shaft 55 feet deep has been sunk on a quartz filled shear striking north and dipping at 60 degrees to the east. Weak copper stainings can be traced on the surface for about 30 feet north and south of the shaft, and blue and green carbonate was seen in dump material from the shaft. There are other scattered small excavations along this line, and about 200 feet north there is a small open cut from which a few drums of ore have been selected. These were still standing at the site at the time of the inspection.

Production

Table 16

Period of Production	No. of Lease	Registered Name	Cupreous Ore Produced	Average Assay per cent. Copper	Value
			Long Tons		£A
1955	P.A. 750L	Stream & Kelly	31.96	19.13	1,401.65
1956	M.C. 117L	Stream & Kelly	37.26	20.20	1,735.60
1957	M.C. 117L	Stream & Kelly	28.51	17.72	813.75
Total to the end of 1960			97.73	19.01	3,951.00

Remarks

Workings on this deposit are shallow to date, and although the exposed mineralisation and structure is not strong, it cannot be said to have been completely tested.

THE MARBLE BAR DEPOSIT, P.A. 2474

Introduction

This ground was held early in the century as M.L. 185, and it is recorded that 11 tons of copper ore were produced in 1911. P.A. 2474 on the same deposit was taken out in 1955, and in that year 56.42 tons of cupreous ore were produced and sold to fertilizer manufacturers.

The P.A. may be reached by proceeding 5 miles southwards from Marble Bar along the Warrawoona Road, and thence one-quarter mile westwards by graded track to the line of hills which mark the contact between a belt of granitised Archaean rocks and metamorphosed basic lavas of the Warrawoona Series. Approximate geographical coordinates are:—

Latitude 21° 13' S.

Longitude 119° 46' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 109/300.
2. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Geological Information

The copper occurs in a quartz vein which crops out near the ridge and, at places, down the eastern slope of the hill. The vein averages about 1 foot in width and occupies a fracture in schistose greenstone which is classified as belonging to the Warrawoona System. The vein outcrop is poorly defined, and there is very little iron gossan.

The vein has been worked by means of a shaft, which was reputedly 60 feet deep but is now almost completely filled with mullock, and by shallow excavations which show little in the way of a well defined structure.

Dumped reject material shows stainings of blue and green carbonates on broken schist and quartz. Some of the joints and planes of schistosity in the wall rocks also carry some copper stains.

Production

Table 17

Period of Production	No. of Lease	Registered Name	Copper Ore	Copper Content	Value
1911	M.L. 185	Marble Bar Copper Lode	Long Tons 11.0 Cupreous Ore	Long Tons 1.64	£A 90
1955	P.A. 2474	W. Bulloch and F. C. Johnston	Long Tons 56.42	5.41	\$40.32
Total to the end of 1960			67.42	6.05	930.32

Assays

Simpson (1952, p. 155) states—

“A valuable surface deposit of copper was reported in 1909 to be located a few miles south of Marble Bar but, up to the end of 1917, only 11 tons of copper ore, yielding 1.64 tons of metallic copper, has been recorded from this district. A sample of ore from this deposit, obtained on M.C. 185, contained malachite and assayed:—Cu, 58.61 per cent.; Au, 3 dwt. 6 gr. per ton; Ag, 64 ozs. 2 dwt. 16 gr. per ton.”

Remarks

Despite its initial good showing (as reported by early investigators), the little development has shown that this deposit is not significant economically.

THE LIONEL DEPOSITS

Introduction

Copper was first produced from P.A. 733L near Lionel in 1954. The P.A. was later converted to M.C. 122L and, up to the end of 1960, this ground had produced 115 tons of ore.

The deposit may be reached by travelling 51 miles southward from Marble Bar along the Nullagine Road, and thence 4.5 miles south-easterly along the track to Lionel. The Mineral Claim straddles the track, which passes between two small open-cuts.

The country is rugged and hilly and dissected by many small drainage channels.

Approximate geographical co-ordinates are :—

Latitude 21° 06' S.

Longitude 120° 37' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph, 98/300.
2. Lands Department 10-Mile Topographic Series Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are available from the Lands Department.

Geological Information

The copper mineralisation occurs in fine to medium-grained hornblende rocks of the Warrawoona System. The rock itself is texturally massive in the vicinity of the deposit but is well fractured and presents a blocky appearance in fresh outcrop. Four open-cuts, each running at approximately 120 degrees, and arranged in echelon along the bearing of 75 degrees, appear as if they may be on separate quartz veins. The veins are covered by siliceous and limonitic box-work gossan, and stone from the cuts carries green and blue carbonates of copper, with some chrysocolla. Chalcopyrite was also seen in some stone from the shafts near the eastern end of the claim. The veins also carry a considerable quantity of calcite.

The workings collectively are approximately 1,000 feet long, the deepest being the two at the eastern end, which are about 600 feet apart. The western-most of these two is 60 feet long and is 36 feet deep at the eastern end. The vein exposed at the ends of the cut is up to three feet wide, and dips to the north at 45 degrees. Two shafts have been sunk in the eastern-most workings to a depth of approximately 40 feet on the underlay to the north. The primary chalcopyrite was encountered here.

Quartz outcrops, west and east of the workings, show, in places, some copper staining, but the open-cuts appear to cover the major part of the occurrence.

Production

Table 18

Period of Production	No. of Lease	Registered Name	Cupreous Ore Produced	Copper Content Units	Grade % Cu.	Value
			Long Tons			£A
1954	P.A. 733L	M. E. Tsakolos	38.32	801.75	20.92	1,414.31
1955	P.A. 733L	M. E. Tsakolos	14.58	316.08	21.68	563.98
1956	M.C. 112L	J. C. & G. M. Baker	39.00	645.43	16.55	1,335.23
1956	M.C. 112L	J. C. & G. M. Baker	*22.71	406.82	17.91	1,091.00
Total to the end of 1960			114.61	2,170.08	18.93	4,404.52

* This parcel was sent to Japan ; ore included 51.20 fine ounces of silver valued at £18.65, and 0.93 fine ounces of gold valued at £14.00.

Remarks

In view of the occurrence of chalcopyrite at the depth of approximately 40 feet, it is considered that the carbonate ore is definitely limited, and the nature of the oxidised ore indicates that the primary ore will be low grade.

THE YANDICOOGINA DEPOSITS

Introduction

Copper has been known to occur in this locality since 1907, but the only recorded production is over the years 1951-1960 and amounts to 34.26 tons of copper and cupreous ore.

The deposit may be reached by travelling for 38 miles south-eastwards from Marble Bar by formed roads and graded tracks via Mt. Edgar Homestead. Most of the approach from Marble Bar is over sand-covered granite country, but the deposits are located on the northern slopes of a low range of hills near the intrusive contact of the granite pluton with Archaean meta-sedimentary schists. Approximate geographical co-ordinates are :—

Latitude . . . 21° 15' S.
Longitude . . . 120° 10' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 109/300.
2. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are available from the Lands Department.

Geological Information

The rocks which contain these copper occurrences consist of metasedimentary sandstones, quartzites and argillaceous rocks, schistose in places, and forming a peripheral border to the granitic pluton. They have been granitised and partially assimilated on the north-western side. They strike generally north-east, dipping south-east, in the area under consideration, and appear to conformably underlie Warrawoona basaltic lavas which are in part submarine, and include tuffs and breccias.

The few scattered workings in the area are on M.Cs. 625 and 626, within one mile of where massive granite crops out to the north. These consist of a series of shallow open cuts (maximum depth 24 feet) and pot holes over a length of about 600 feet. The largest of these exposes zones of mineralised sheeted thin veins and impregnated country rock up to 3 feet in width conformable with the bedding, striking 65 degrees and dipping at 60 degrees to the south-south-east. Elsewhere, these appear to expand into massive lenses of quartz which, in outcrop, measure up to 12 feet across.

Between the workings, and further north-east and south-west, irregularly developed brownish boxwork iron gossan with copper stainings, shows the line of the mineralisation.

It appears that some country rock replacement has occurred, and the walls are ill-defined.

The principal copper mineral identified was malachite, with a little chrysocolla and cuprite. Some lead is present (anglesite and cerussite). Also zinc is reported to be present in the form of hemimorphite (Montgomery, 1907, p. 86). Calcite and barytes are present in the gangue.

Overall, this line of mineralisation can be traced discontinuously, either by copper stainings or gossanous material in quartz, over a distance of two miles, but the "showings" are not strong on the surface, and the workings are very limited.

Barren quartz veins, generally running with the country, are quite common in the area.

Production

Table 19

Period of Production	No. of Lease	Registered Name	Copper Ore	Copper Content	Value
1951	M.C. 232	Roger, D. C.	Long Tons 5.80	Long Tons 0.92	£A 77.00

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Average Assay per cent. Copper	Units Copper	Value
1960	P.A. 2614	Henderson, J. M.	Long Tons 28.46	13.84	393.95	£A 747.70

Assays and Mineralogy

Simpson (1952) gives the following information on ore and specimens from this locality, collected on a visit by Montgomery (1907):—

" the metallic minerals were intimately mixed, and comprised malachite and a little chrysocolla, anglesite with some cerussite, and lastly hemimorphite.

Five samples from the St. Patrick M.L. 137 and an adjacent prospecting area were found to contain :

	1	2	3	4	5
Zinc, per cent.	16.33	8.37	6.93	5.52	4.45
Lead, per cent.	0.39	5.55	1.66	2.79	3.85
Copper, per cent.	14.61	6.40	17.20	5.33	6.68
Silver, oz. per ton	23.17	12.07	20.93	4.69	2.34
Gold, dwt. per ton	0.70	0.70	0.54	0.70	0.70

All the zinc in these samples appeared to be present as hemimorphite”

“ the copper exists as malachite with a little cuprite and chrysocolla. The principal gangue minerals are quartz, limonite, calcite, and barytes in varying proportions. A sample taken from 7 tons of ore assayed :— Cu, 18.23 per cent. ; Pb, 0.76 per cent. ; Ag., 22 oz. 12 dwt. 6 gr. per ton ; Au, 1 dwt. 6 gr. per ton. A sample from Doherty’s M.L. contained quartz, calcite, malachite, cuprite, cerussite, smithsonite and limonite. It assayed :— Cu, 12.81 per cent. ; Pb, 2.57 per cent. ; Ag, 21 oz. 2 dwt. 12 gr. per ton ; Au, 13 gr. per ton.”

Remarks

It seems that this line of mineralisation has been inadequately prospected. Although the surface indications are not strong, they nevertheless extend over a considerable distance, and it is likely that, in host rocks such as these, significant secondary enrichment could have taken place beyond the depth (24 feet) of the deepest workings.

THE NORTH SHAW DEPOSITS

Introduction

The North Shaw centre has been primarily a gold producer. The first recorded copper production was in 1907 when 7.77 tons were taken from the Roy Hill Copper Mine. Over the years 1955 to 1959, 4.98 tons of cupreous ore were produced from three P.As.

General references to the geology of North Shaw may be found in Maitland (1908, p. 246) and Finucane (1938).

The North Shaw mining centre is located about 40 miles south-west from Marble Bar, on the eastern side of the Shaw River between Callina and Coolyia Creeks. The author reached the area by travelling northwards from Spear Hill via the abandoned Pilga Station Homestead, across some 9 miles of sand-covered granite country and 4 miles of Archaean rocks which includes a granitised border.

Approximate geographical co-ordinates are :—

Latitude	21° 15' S.
Longitude	119° 15' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 109/300.
2. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Geological Information

The area which contains this centre consists mainly of massive amphibolitic greenstones. In rare instances, the greenstone is schistose and has been subject to carbonatisation.

There are various places where quartz reefs crop out, trending generally about 25 degrees and 285 degrees. The width of the veins ranges from 6 inches up to 2 feet. These are, in the main, poorly mineralised quartz-gold-copper veins in which the main process has been filling-in with little replacement of country rock. Secondary enrichment at favoured places along the veins has caused localised ore concentrations.

Production

Table 20
COPPER ORE

Period of Production	No. of Lease	Registered Name	Copper Ore Produced	Copper Content	Value
1907	M.L. 147	Roy Hills Copper Mine	Long Tons 7.77	Long Tons 1.90	£A 190.00

CUPREOUS ORE

Period of Production	No. of Lease	Registered Name	Cupreous Ore Produced	Average Assay per cent. Copper	Units Copper	Value
1955	P.A. 2492	Doughty, R. G.	Long Tons 1.24	14.20	17.57	£A 35.15
1956	P.A. 2506	Doughty, J. J.	1.57	17.40	27.29	55.91
1959	P.A. 2585	Doughty, R. G.	2.17	15.80	34.28	63.30
Total to end of 1960			4.98	....	79.14	154.36

Remarks

These are mesothermal quartz-gold-copper veins of low primary grade. Secondary copper enrichment is limited and spasmodic.

THE NORTH POLE DEPOSIT, M.C. 209

Introduction

Cupreous ore was produced from this mineral claim during the years 1955-56 amounting to 285 tons of 23 per cent. copper. There were a few tons of fair grade ore at grass at the time of the author's visit in September, 1961, but the deposit was not being worked at that time.

General and particular references to copper occurrences at North Pole may be found in the following:—Maitland (1908, p. 38), Blatchford (1912, p. 28) and Finucane (1936).

The deposit may be reached by turning westwards off the Marble Bar-Copper Hills road, about 1 mile south of the Comet Gold Mine, and thence travelling north-westwards for about

30 miles by a graded track which, in places, passes through some very rugged country. The mineral claim is located approximately one-half mile south of the North Pole Well. The total distance from Marble Bar by this route is about 40 miles. Approximate geographical co-ordinates are :—

Latitude 21° 5' S.

Longitude 119° 20' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 109/300.
2. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West, Australia 1957.

Aerial Photos and photo-mosaics are available from the Lands Department.

Geological Information

The deposit occurs within one mile of the northern periphery of a granitic mass, measuring about 11 miles by 6 miles, which is intrusive into Warrawoona lavas, and also an inter-bedded sequence of jaspilites and argillites. These latter conformably overlie the lavas and are the host rocks for the copper mineralisation on M.C. 209.

A shaft has been sunk in a gully near the point of an angle formed by two jaspilite bodies, one of which trends 200 degrees and the other 320 degrees away from the shaft. This may be an anticlinal nose plunging eastwards, the continuity of which, at the apex, is broken by an eastward trending water-course. Copper-bearing quartz intrusives have penetrated along the lines of the jaspilites. Copper carbonates, in places 4 feet wide, can be seen in the quartz vein bearing 320 degrees, for a distance of about 1,000 feet from the shaft. Similar mineralisation bearing 200 degrees can be seen for a distance of about 200 feet up the ridge. There is a small open cut in the side of the hill about 30 feet west of the shaft, showing some disseminated copper mineralisation in thin quartz veins.

The shaft, at the time of the author's visit in August, 1961, was filled with water to within about 40 feet of the collar. Just above this level there are two drives on an easterly dipping copper-bearing vein, the general strike of which appears to be about 340 degrees. The quartz vein—about 5 feet thick—and the sedimentary wall rocks carry secondary copper mineralisation.

Drives have been cut for about 30 feet northwards and 24 feet southwards from the shaft, and these have been stoped up to a height of about 18 feet. Rises extend up for about 20 feet and 18 feet. The outline of the excavation is very irregular.

Copper mineralisation in the shaft and drives occurs in bunches and small seams and consists principally of malachite, with cuprite, some chalcocite and chalcopyrite at the deepest levels.

Table 21

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Average Assay Copper per cent.	Copper Units	Value
1955-1956	M.C. 209	Breen's Copper Syndicate	Long Tons 284·99	23·44	3,466·20	£A 6,268·09

Remarks

It seems that this deposit has not been adequately tested. The occurrences of copper in the veins striking 320 degrees and 200 degrees from the shaft should be checked at depth in various places, particularly where the iron gossan is well developed, by costeans, or better, by pits.

Generally, the area holds promise of further copper deposits since it is in close proximity to a small granitic batholith, and the sedimentary strata make suitable host rocks.

THE MT. FRANCISCO DEPOSIT. P.A. 2529

Introduction

A small quantity of cupreous ore was raised from P.A. 2529, approximately 40 chains south of Mt. Francisco, during 1957.

Mt. Francisco is located 17 miles south-south-west of the old tin mining centre of Wodgina in the Pilbara Goldfield. The distance to Port Hedland via Wodgina is 89 miles. Approximate geographical co-ordinates are :—

Latitude 21° 22' S.

Longitude 118° 34' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 110/300.
2. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are available from the Lands Department.

Geological Information

No holdings were being worked in this Area at the time of the author's visit in 1961, and the prospecting area could not be located. The following information therefore concerns only the general geology of the area in which the occurrence lies.

Mt. Francisco is the highest prominence in an isolated range of hills composed of folded and metamorphosed Warrawoona pillow lavas and sediments. These rocks occur as a remnant in a granitic complex intruded by pegmatite and quartz veins carrying, in places, economic concentrations of tin, beryl and tantalite-columbite.

The greenstone rocks themselves have been intruded by granitic, pegmatitic and quartz dykes and veins, and at various times leases have been held for beryl, emerald, copper and lead.

The nearest locality to which the author could find official reference to copper mineralisation is West Wodgina, 10 miles north of Mt. Francisco. Simpson (1952, p. 416) writes—"A small quartz-galena lode in granite on Lewis and Houston's P.A. 616 at West Wodgina, carries strings and bunches of chalcocite, malachite and brilliant green chrysocolla. The chalcocite is mostly in dull, black, minutely granular masses transversed by veinlets of malachite."

It is a fair possibility that the occurrence on P.A. 2529 carried a similar mineral association.

Production

Table 22

Period of Production	No. of Lease	Registered Name	Cupreous Ore Produced	Copper Content Units	Average Assay per cent. Copper	Value
1957	P.A. 2529	Coffin, P.	Long Tons 4·17	17·67	4·23	£A 8·20

Remarks

This holding has not been worked since 1957, when 4·17 tons were taken out. The environment does not impress the author as being particularly favourable for economic concentrations of copper mineralisation.

THE WOODSTOCK STATION DEPOSIT, G.M.L. 1141

Introduction

Copper production from this area is from one lease only, G.M.L. 1141, from which 9 tons of cupreous ore were produced in 1958. The occurrence of copper in this general locality has been known since 1907 when Montgomery (1907, p. 62) reported seeing some copper ore, mostly green carbonate of copper, obtained from the hills about 4 miles from Woodstock Station Homestead.

G.M.L. 1141 is located 4·25 miles almost due east of Woodstock Homestead, which is 104 miles by road south of Port Hedland, on the northern bank of Coorong Creek and 3 miles west of Dead Bullock Well. The country rock is granite and granite-gneiss and the holding is 3 miles south-west of the granite contact with metamorphosed sediments and volcanic rocks of the Warrawoona Series. Approximate geographical co-ordinates are:—

Latitude 21° 35' S.
Longitude 118° 58' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 109/300.
2. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Geological Information

The copper occurs in quartz intrusive into a remnant basic lens in the granite-gneiss, which at this place strikes almost north.

A pit, some 10 feet deep, and several scattered shallow pot-holes, extend over a distance of about 2 chains along the strike, and expose weak copper carbonate mineralisation up to a maximum width, in places, of 3 feet. Occasional mineralisation has taken place along a joint system striking north-north-west and has extended the mineralisation in some places into the country rock.

Production

Table 23

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Average Assay per cent. Copper	Units Copper	Value
1958	G.M.L. 1141	Todd, J., and Stein, L. C.	Long Tons 8.95	8.12	72.67	£A 105.40

Remarks

This occurrence appears to be of little significance as a potential copper producer.

THE PILGANGOORA DEPOSIT, M.C. 439

Introduction

A small quantity of cupreous ore was raised from this locality in 1956. The deposit consists of a copper-bearing quartz vein in metamorphosed basic lavas of the Warrawoona Series.

The area is reached by proceeding southwards from Port Hedland along the Woodstock road for 56 miles, and thence 10 miles easterly by graded tracks across sand-covered granitic terrain to the western slopes of the greenstone hills. Approximate geographical co-ordinates are :—

Latitude 21° 10' S.

Longitude 118° 15' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 109/300.
2. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Geological Information

The copper occurs, along with some gold, in quartz veins, which occupy fractures and shears in a belt of metamorphosed volcanic rocks which are about 4 miles in width, lying between

the two major granitic masses of Tabba Tabba and Lalla Rookh. This belt of rocks wedges out into ortho-gneiss and granite about 8 miles to the north.

The quartz veins vary in length and width, and carry a variable amount of copper mineralisation in outcrop, generally low grade, consisting mainly of carbonate stainings with malachite the principal mineral.

On M.C. 439, which was worked in 1956, a shallow open cut about 23 feet long and up to 8 feet deep has exposed a quartz vein which attains a maximum width of 3 feet and strikes almost north. The dip is close to vertical.

The vein crops out over about 4 chains on the surface and carries, in places, traces of limonite gossan. Copper mineralisation is generally weak.

Production

Table 24

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Average Assay per cent. Copper	Units Copper	Value
1956	M.C. 439	Native Welfare Department	Long Tons 10·64	7·50	79·83	£A 97·75

Remarks

Copper mineralisation on M.C. 439, as seen in the outcrop and in the shallow workings, is weak and disseminated. This deposit seems to be of little economic significance at the present time.

THE BOODARRIE STATION DEPOSIT, P.A. 2508

Introduction

In 1956, 1·2 tons of cupreous ore were raised from P.A. 2508 on Boodarrie Station in the Port Hedland area. The area is 29 miles by road south of Port Hedland along the Abydos road, and the prospecting area is located 12 chains east of the road, one mile north of the southern boundary of Boodarrie Station. Approximate geographical co-ordinates are:—

Latitude 20° 38' S.

Longitude 118° 42' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 110/300.
2. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are available from the Lands Department.

Geological Information

Copper mineralisation occurs in quartz veins in fractured granite and granite gneiss over a maximum width of about 16 feet, extending on a bearing of 346 degrees for a distance of

about 150 feet. The workings consist of a line of irregular shallow pits (maximum depth 12 feet) following generally the strike of the quartz veins, but there are also cuttings at about 90 degrees to this where mineralisation has followed cross-fractures.

Mineralisation, which is weak and disseminated, is in the form of malachite, with a little azurite.

Production

Table 25

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Average Assay per cent. Copper	Units Copper	Value
1956	P.A. 2508	Drew and Party	Long Tons 1·20	5·90	7·08	£A 10·13

Remarks

Copper mineralisation is weak and disseminated and the exposures offer little prospect of this holding becoming a significant producer of copper ore.

OTHER LOCALITIES IN THE PILBARA GOLDFIELD WHICH HAVE PRODUCED COPPER

The following deposits were not visited by the author and there is practically no reference to them in the published literature. Production from each of them amounts to only a few tons, and they appear of little significance.

McPhee's Creek, M.L. 14L (Nullagine District)

The following statement is from Riches (1912)—

“A small parcel of copper was sent from Doherty and Spinney's lease at MCPhee's Creek to Mount Kembla for treatment, and I understand that after paying £29 for cartage, shipping charges, etc., the net proceeds amounted to £48.

The Government Statistician's records show that, in the year 1911, 5 tons of copper ore with a copper content of 2·22 tons were sold from the “Tambina,” M.L. 14L.

Middle Creek, P.A. 687L (Nullagine District)

In 1951, 7·50 tons of copper ore, with a copper content of 0·4 tons, were sold from this prospecting area.

Marble Bar, P.A. 263

This holding was located approximately 1·5 miles south-east of Marble Bar. It was held in the names of Cox and McDonald and, in 1911, 4·75 tons of ore with a copper content of 0·48 tons was raised.

This deposit has not been worked since then.

Braeside

Finucane (1938) has described some cupriferous quartz veins occurring in basic lavas at Braeside about 80 miles east of Marble

Bar (Lat. $21^{\circ} 10' S.$, Long. $121^{\circ} 0' E.$). The lavas, which are tentatively assigned to the Nullagine System, are overlain by a considerable thickness of various sediments. The veins also contain silver, lead, and vanadium in small quantities. Finucane took copper samples from three of the four localities as follows:

1. Late M.L. 37, Ragged Hills Group. Cuprite and carbonates occur over a length of 60 feet. Two pits, 50 feet apart, were sampled and returned assays of 7.37 per cent. copper over 36 inches and 22.52 per cent. over 60 inches. These samples also gave 0.72 and 0.19 ozs. of silver per ton respectively.
2. Two miles south-west of Camel Hump a vein 170 feet long and averaging 48 inches in width strikes 318 degrees, and dips north-east at 70 degrees. Two samples collected over widths of 60 inches and 42 inches yielded 5.44 per cent. and 0.31 per cent. of copper, and 0.07 and 0.19 ozs. of silver per ton respectively. Neither contained any lead.
3. Two miles south of Barramine Station where a formation consisting of small veins of quartz in amygdaloidal lava, averages 12 to 18 inches in width, strikes 333 degrees and dips north-east at 50 degrees. Malachite occurs in the formation, and to a lesser extent in the enclosing lava. No samples were taken.
4. Two and a half miles south of Barramine Station. A formation striking 155 degrees, contains malachite and cuprite. A sample was taken over 60 inches, it gave 11.63 per cent. copper, 0.07 ozs. of silver per ton, and no lead.

THE MT. MCLARTY AND TURRAMUNDA DEPOSITS

Introduction

Copper deposits have been known in the Mt. McLarty area for at least 40 years but until recently they have been considered uneconomic. In 1958 and 1960 a total of 69.47 tons of cupreous ore averaging 22.2 per cent. Cu. was produced.

The deposits include M.C. 374L, known as the Blowhole prospect, about 3 miles east of Mt. McLarty, and others in the vicinity of Turramunda Rock Hole, about 15 miles further south. Two of these deposits were being worked in 1961. Approximate geographical co-ordinates for Mt. McLarty are:—

Latitude $22^{\circ} 23' S.$
Longitude $120^{\circ} 50' E.$

Reference may be made to the following maps:—

1. Lands Department 10-Mile Topographic Series, Sheet 14—De Grey.
2. West. Australia Geol. Survey 4-Mile Geological Series. Balfour Downs Sheet (in press).

Geological Information

The deposits occur in dolomite which is overlain by a conformable sequence of gently folded conglomerate, sandstone, mudstone, "chert breccia," tuff, and interbedded volcanics and associated agglomerates. These are classified as belonging to the Nullagine System, and they unconformably overlie a similar

succession which has suffered a somewhat higher degree of metamorphism. The host dolomite does not appear to exceed about 100 feet in thickness.

M.C. 374L is located about 3 miles east of Mt. McLarty. Copper mineralisation in the form of carbonates, oxides, and silicate is found in patchy seams and bunches, controlled by joints and minor shears. Ore has been recovered from shallow pits scattered over about 25 acres, and concentrated by hand picking.

There is a sink hole on this lease, stated to be over 150 feet deep and to contain a patch of copper mineralisation at about 90 feet.

Possible lateral extension of the mineralisation is masked by the overlying "chert breccia."

Three other deposits are known on a south-east line between 0.5 mile south of Kooraplain Well and 4 miles south-east of Turramunda Rock Hole. The occurrences are similar to that described above, but so far as the few shallow excavations show, are even less extensive.

Production

Table 26
CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Value
1958	M.C. 363L	Kalgoorlie Goldfields Petroleum N.L.	Long Tons 23.48	21.67	£A 1,176.00
1960	P.A. 803L	Napier, G. A.	11.92	21.77	599.25
1960	P.A. 794L (later M.C. 374L)	Clark, J.	34.07	22.76	1,848.70
Totals	.....	.....	69.47	22.20	3,623.95

Remarks

Other copper deposits are known to occur in this general area, for example, east of Mt. McLarty near the derelict vermin fence, north and south of Enacheddong Creek. The source of the copper mineralisation is not known at present; it may be associated with hidden intrusives, or derived from the overlying volcanic rocks. Its association with dolomite is interesting but to date none of the known deposits appear to have much potential.

FUTURE EXPLORATION IN THE PILBARA GOLDFIELD

Principal host rocks for copper-ore bodies which have yielded production in the Pilbara Field are metamorphosed sedimentary and igneous rocks of the Warrawoona System. The metasediments include jaspilites, quartz schists and micaceous sericitic and calcareous schists displaying various degrees of metamorphism, but practically all dipping at steeper angles than 45 degrees and more usually close to vertical. The igneous rocks include pillow lavas, serpentinous rocks and quartz and quartz felspar porphyries, actinolite chlorite schists, and carbonated schists.

Some copper mineralisation occurs in soft shales and sandstones of the Mosquito Creek System in the Middle Creek area south of Blue Spec. These are also steeply dipping but unconformably overlies the Warrawoona rocks.

In the vicinity of Mt. McLarty and Saddleback Hill, disseminated secondary mineralisation with local concentration in fractured zones occurs in almost horizontal, calcareous, Nullagine rocks. The source of this copper may have been adjacent Nullagine basic lavas.

Apart from the worked deposits there are numerous other localities in the Pilbara Field at which Copper minerals have been recorded (Simpson, 1952). None of these, however, has been considered to be sufficiently promising at the surface to encourage prospecting.

Excepting Copper Hills G.M.L. 314L, which was drilled to a vertical depth of approximately 510 feet below the outcrop, and "South Copper Hills" M.C. 47L, which was drilled to a vertical depth of 350 feet, no deposit has been worked or prospected below a depth of 70 feet. Most of the deposits have been worked by prospectors who have been forced, by excessive distances from treatment plants, to discard ore averaging less than about 15 per cent. copper.

Consequently, the majority of deposits have been gouged at the surface for rich carbonate ores, and were abandoned when these were depleted, or at least depleted as far as indicated by the work done.

Because of the intensive exploration of the Pilbara Field by prospectors and geologists since the beginning of the century, it seems pretty safe to assume that no large concentration of copper ore exists anywhere on the surface in this area.

Future exploration, therefore, would necessarily seem to depend upon detailed study by mapping and sampling of possible extensions of known deposits and prospecting below the surface by drilling. Programmes involving physiographic, structural and geo-chemical techniques, involving the expenditure of considerable amounts of time and money, are required.

The author suggests that the following areas might be worthy of more detailed investigation in the above sense—Copper Hills, particularly at or near the junction of the "Copper Hills Porphyry" with the older underlying rocks; North Pole within 2 or 3 miles of the perimeter of the intrusive granitic batholith; and Yandicogina, north-eastwards in a zone about 2 miles wide extending into the Warrawoona rocks from the edge of the intrusive granite.

THE WEST PILBARA GOLDFIELD DEPOSITS

SUMMARY

The principal copper producer in the West Pilbara Goldfield has been the Whim Creek (or Whim Well) Mine which, since 1899, has yielded almost 86,000 tons of copper and cupreous ore worth over £714,000. Mineralisation here occurs in flatly dipping fractured and sheared felsite and metasediment in a lode type of formation which, in places, has been worked up to 30 feet width, but overall averages about 18 feet. There is some doubt as to the age of the host rocks but it seems fairly certain that they are pre-Nullagine and probably should be included in the upper part of the Mosquito Creek System.

At Mons Cupri about 3 miles south of Whim Creek, mineralisation occurs in highly fractured tuffaceous and metasedimentary rock of the same age. There is no defined lode or zones of ore, and the enrichment appears to be due to secondary concentration of a low primary copper content in disseminated pyrite and arsenopyrite.

Concordant quartz veins in steeply dipping metasediments of the Mosquito Creek System have been mined at Egina, Croydon, Yannery, and Whundo. At the two latter places there are a number of thin parallel veins in a zone up to 200 feet wide. The grade of metamorphism of these sediments, principally argillaceous types, is generally a little higher than at Whim Creek.

In the extreme south-eastern part of the Field, at Womunna, a few tons of ore have been raised from localised concentrations of oxidised ore in drag folded sediments which may be of the same age as the Whim Creek deposits.

In the vicinity of Roebourne four groups of copper deposits have been worked in the past. Mineralisation occurs in fractured and sheared dolerite and gabbroidal rocks of Warrawoona age. Some of the steeply dipping quartz veins carry significant gold and silver (especially in the Carlow Castle and Fortune Groups), and some cobalt and nickel.

Practically all of the ore produced from these places has been from the oxidised zone, principally in the form of malachite, with azurite, cuprite, chrysocolla, chalcocite and bornite in sub-ordinate amounts.

The following table summarises the types of deposits in the Field.

Table 27
TYPES OF DEPOSITS IN THE WEST PILBARA GOLDFIELD

Locality	Tenement	Ore Produced		Remarks
		Copper Ore	Cupreous Ore	
Whim Creek (or Whim Well)	Loc. 71	Long Tons 75,213·25	Long Tons 10,684·23	Lode formation, averaging about 18 ft. width and dipping at about 25 degrees in slates and felsite; apparently concordant. Pyrite and chalcopyrite at depth. Contains some gold, silver, and cobalt.
Mons Cupri	Various	2,321·00	....	Disseminated mineralisation in fractured tuffaceous and metasedimentary rock. Pyrite and arsenopyrite with small copper content at depth.
Egina	M.Ls. 3, 91 M.C. 86	542·00	28·59	Steeply dipping concordant quartz vein in metasediment.
Croydon	Various	604·00	99·42	Steeply dipping concordant quartz veins in metasediment. Contains significant amount of zinc near water table.
Roebourne	Various	2,482·71	25·53	Steeply dipping quartz fissure veins in sheared fractured doleritic and gabbroidal rocks. Some gold, silver, nickel and cobalt.
Yannery and Whundo	Various	1,886·42	2,532·74	Steeply dipping parallel concordant quartz veins over zone up to 200 ft. wide in metasediments. Some gold and silver.
Womunna	M.Ls. 243, 245	13·32	5·87	Disseminated mineralisation in drag folded metasediments. Bedded (?).

Table 28
 COPPER AND CUPREOUS ORE PRODUCTION IN THE
 WEST PILBARA GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
Previous to 1899	7,018·00	1,085·57	55,270
1899	2,555·00	441·75	29,478
1900	1,605·00	224·57	12,139
1901	1,162·00	223·90	15,891
1902-1906	.....	.....	.....
1907	3,365·00	726·47	63,548
1908	1,486·00	306·28	17,691
1909	7,135·50	1,041·52	62,447
1910	8,479·80	1,080·61	64,861
1911	9,082·02	1,203·17	69,140
1912	12,284·02	1,483·21	104,289
1913	12,621·73	1,170·02	76,878
1914	7,764·18	638·59	40,607
1915	314·75	55·30	3,546
1916	948·87	166·69	16,116
1917	783·61	128·34	13,406
1918	1,844·19	289·40	28,961
1919	1,030·78	185·66	15,807
1920	1,700·50	313·72	32,059
1921	1,055·00	273·48	18,955
1922	164·00	36·50	2,481
1923	221·00	50·00	3,500
1924	79·00	16·50	1,012
1925-1927	.....	.....	.....
1928	45·00	6·25	400
1929-1952	.....	.....	.....
1953	13·32	3·41	674
1954-1956	.....	.....	.....
1957	381·75	48·87	8,967
1958	6·75	1·22	210
1959-1960	.....	.....	.....
Total	83,147·27	11,201·00	758,333

Average Weighted Assay=11·2%

Cupreous Ore and Concentrates

Year	Ore	Average Assay per cent. Copper	Value
	Long Tons		£A
1949	133·98	8·88	1,843·75
1950	821·40	7·53	6,160·12
1951	898·21	10·31	10,470·91
1952	1,001·90	8·23	7,570·81
1953	672·22	9·42	6,850·58
1954	3,080·16	6·31	17,228·34
1955	3,327·36	6·35	23,981·37
1956	2,331·23	5·07	18,417·89
1957	629·86	4·77	5,379·55
1958	225·25	11·93	4,984·70
1959	263·71	10·82	5,141·10
1960	1·85	11·80	63·85
Total	13,387·13	6·89	108,092·97

THE WHIM CREEK AND MONS CUPRI DEPOSITS

Introduction

A Western Australian syndicate worked the Whim Well mine in 1889 and 1890, but there is no official record of the copper produced. Messrs. J. and W. Bateman exported 724 tons of ore containing 30 per cent. copper during the years 1891 and 1893 but the low market price of copper at that time and the high working costs in a remote area forced them to discontinue production.

In 1896 Prell and Co. of Melbourne took over the Mine and commenced mining operations in 1898. By the end of 1901 the property had produced 9,097 tons of ore worth £84,987.

The property was not worked during 1901 to 1906 but in that year Whim Well Copper Mines Ltd., took over the property and production commenced in 1907 and was steadily increased until in 1913 a peak of 12,000 tons was reached.

Production slumped during the war years but continued until 1919 when Pilbara Copper Field Ltd. took over the property. In 1921, the Assistant State Mining Engineer, T. Blatchford, reported favourably on a proposed scheme to pump water from pools in the Balla Balla Creek to be used in a leaching process for Whim Well ore. In 1927, R. C. Wilson, then Assistant State Mining Engineer, also reported favourably on the prospects of a leaching plant, but the scheme was not implemented.

There is no further record of production from the Whim Creek centre until 1949, when operations were again commenced on the Freehold Property Location 71 and by the end of 1958, 10,684·23 tons of cupreous ore and concentrates had been produced for fertilizer purposes.

Temporary Reserve 1844H was granted in August, 1960, to Depuch Shipping and Mining Co. Ltd. Depuch Ltd. made contact with copper interests in Japan in 1960, whose mining investigators later de-watered and examined the mine. Published preliminary estimates of reserves were 350,000 tons in sight, with a possible further 1,000,000 tons of ore averaging about 3·4 per cent. copper.

These figures include reserves at the Mons Cupri Mine (situated about 3 miles to the south-south-west of Whim Well), the history of which may be summarized as follows.

Mr. J. S. Hicks was granted the Mons Cupri Mining property in 1897. Balla Balla Mines Ltd. acquired the Leases, and by 1904 had expended the sum of £21,000 in the erection of plant and development. Smelting of the ore was attempted locally but the cost of fluxing—the flux was selected from local calcrete deposits—was high because of excessive silica content and this method of extraction was considered unprofitable. In 1904 the Company was reconstructed under the name of New Balla Balla Copper Mines Ltd., but no ore was shipped. The Whim Well Copper Mines Ltd. acquired the property in 1907, and carried out a considerable amount of development and shipped up to 1917, 282 tons of ore, producing 33.75 tons of copper valued at £2,979. The property was later leased by the Pilbara Copper Fields Ltd., and then, as stated above, was subsequently taken over by Depuch Ltd.

The lode at Whim Creek was drilled by the Commonwealth Government in 1942, under the supervision of an officer of the Geological Survey of Western Australia, and in 1952 the area was investigated by North Broken Hill Ltd. Some of the results of these investigations are given later.

The copper mines at Whim Creek occur in a succession of slates and sandstones with interbedded acid felsitic flows, tuffs, and volcanic agglomerates.

Reference to the geology and mining at Whim Creek and Balla Balla may be found in the following: Woodward (1888, 1890, 1911); Maitland (1904, 1918); Maitland and Montgomery (1924); Montgomery (1907, 1908); Simpson (1907); Blatchford (1913); Cullingworth (1914); Blatchford (1921); Wilson (1927); Finucane and Sullivan (1939).

Some other information included here has been collated from information gained from unpublished reports by officers of the Geological Survey, and the State Mining Engineer's Branch, and by North Broken Hill Ltd., and Cumming Smith and Mt. Lyell of Perth.

The Whim Creek Deposits are located in the West Pilbara Goldfield, 53 miles by road easterly from Roebourne on the Great Northern Highway, and 13 miles by track south of the small port of Balla Balla which, however, has not been used by an overseas vessel since 1947.

Port Sampson, 12 miles north of Roebourne, is at present the main sea port for the district. There is a regular air service from Perth to Roebourne during the dry season and an air strip at Whim Creek which is unused at the present time (1961). Approximate geographical co-ordinates are:—

Latitude 20° 50' S.
Longitude 117° 48' E.

Reference may be made to the following maps:

1. Lands Department Lithograph No. 110/300.
2. Lands Department Line Compilation, 1 inch — 1 mile.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Geological Information

The rocks in the vicinity of the mines consist predominantly of sedimentary types such as sandstones, grits, and slates, with interbedded felsitic lavas, tuffs, and volcanic agglomerates. These appear to be a continuation of the belt of rocks which hold the Croydon copper deposits and which have been stated to be probably older Precambrian sediments belonging to the Mosquito Creek System. In the Whim Creek area, however, the rocks do not appear to have been so highly disturbed and, in fact, rather strongly resemble Nullagine Rocks. Blatchford (1921) states:—"From the lithological structure there appears to be no doubt that they do not belong to the Mosquito Creek Series and are more likely to belong to the Nullagine or an intermediate series." Finucane and Sullivan (1932) state:—"There is considerable evidence in support of this view (Blatchford's) but some of the slates immediately north of the Whim Well Mine resemble similar rocks in the Mosquito Creek Series at other localities."

The Whim Well Mine—The Whim Well lode occurs in slates which exhibit various degrees of weathering and are strongly sheared and impregnated with copper solutions. The lode which is arcuate shaped in outcrop with the convex side to the south, appears to conform with the bedding of the country rocks, which, in the mineralised area, have suffered local deformation so that they dip north-north-east at about 25 degrees. A number of well-defined high angle shears, with apparently little displacement, cross the mine workings. Some of these can be traced on the surface for a considerable distance. These shears are pre-mineralisation and appear to have controlled the enrichment in places.

The outcrop of the lode can be traced for a total length of about 2,700 feet, and it dips at about 25 degrees to the north-north-east. The stope widths range up to a maximum of 40 feet, but the average is probably about 12 feet. A maximum width of 60 feet of copper mineralisation was found in a drill hole which made a penetration in the sulphide zone.

The lode partly consists of a soft, white, laminated, micaceous and chloritic slate which is an alteration product of the country rock, and partly of a felsite-like rock containing secondary silica, and quartz veins with limonite and mica. The walls are indistinct due to the unconfined circulation of copper solutions.

The chief copper-bearing minerals are chalcocite and malachite, with subordinate amounts of native copper, cuprite, chrysocolla and azurite. Lead sulphates and carbonates and traces of cobalt have also been detected.

There appear to be three ore shoots, of which the central one has, to date, proved to be the most important. This shoot has been mined over a strike length of approximately 500 feet, and for a down-dip distance of about 650 feet.

The western shoot as mined at the various levels ranges in length from 200 to 300 feet. It has been mined for a down-dip distance of about 200 feet. The eastern shoot is smaller and of less consequence, to date, than the other two, being more siliceous and of generally lower tenor. An adit 150 feet long into this eastern shoot did not encounter any ore of satisfactory grade-

The zone of oxidation in the ore body is fairly extensive because of the flat dip of the ore body and the nature of the enclosing rocks, and there may be extensions of ore beyond present indicated lateral limits. The lode has been worked by open cuts and stopes, leaving irregularly-spaced pillars, mostly of low grade, resulting in a rather unsystematic development.

Access to stopes was by a series of adits. The country rock stands well and few falls have been recorded in the ore body itself, most of these being as a result of crumbling of an overlying ironstone layer. Very little timbering was necessary, which is rather fortunate since mining timber is scarce locally.

The Mons Cupri Mine—Mons Cupri Mine is situated about 3 miles to the south-south-east of Whim Well. The copper mineralisation occurs in cracks and fissures in tuffaceous and arenaceous country rock. The ore consists of irregular concentrations of chrysocolla, azurite, malachite, and a little cuprite. Mineralisation is ill defined and discontinuous. Pyrite and arsenopyrite can be observed at some places in the adits.

Workings consist of numerous open cuts, costeans and pits, and two main levels, one being a tunnel at 75 feet and the other an adit 150 feet below the crest of the hill. The upper level is 600 feet in length and goes through the hill from north to south, while the adit is 480 feet in length and has been driven in from the northern side of the hill. There are other adits and shafts into the hill at various places. The copper occurrences are sporadic and of low grade.

Drilling—The information on drilling at Whim Creek which is given below has been taken from various sources, the acknowledgments for which are given at the head of each section.

All of these bore holes are located with reference to the old Main Shaft (Finucane and Sullivan, 1939, plate 2). This Main Shaft is located 427 feet on a bearing of 147 degrees from the south-east corner peg of M.L. 132.

Partly from Finucane and Sullivan (1939).

The following is the mine record of the bore cores as taken from Blatchford's "Report on the Whim Well and Mons Cupri Copper Mines" (1921) :—

No. 1 Bore—Position 288 feet bearing 4 degrees from Main Shaft. Reduced level at collar 91.17. Dip vertical, depth 352 feet. Footage showing copper values 243 feet–307 feet. Sulphides showed freely in cores from 243 feet–299 feet. Four samples sent to L. Parry of London gave the following results :—

	Gold	Silver	Copper	Sulphur	Iron
	grs.	dwt.	%	%	%
1	14	1.63	0.2	27.0	35
2	Trace	0.33	0.2	17.5	30
3	Trace	0.13	0.15	12.1	24
4	Trace	0.84	7.6	18.0	24

There was no mine record kept of what the above samples represented, but it is clear that there was a large body of heavy pyritic ore carrying a little copper, and that one sample carried copper of payable grade.

No. 2 Bore—Position 335 feet bearing 310 degrees from Main Shaft. Dip vertical. Reduced level at collar 105 feet. Total depth 209 feet. Footage showing copper values 127 feet—187 feet.

SAMPLES SENT TO L. PARRY, LONDON

	Depth	Gold	Silver	Copper	Lead	Zinc
	ft.	dwt.	dwt.	%	%	%
1	145—150	0·5	2·0	2·4	<i>Nil</i>	<i>Nil</i>
2	154—159	Trace	14·0	6·5	4·5	10·9
3	160—166	Trace	1·5	1·4	<i>Nil</i>	1·8
4	166—171	Trace	3·0	1·0	<i>Nil</i>	<i>Nil</i>
5	175—177	Trace	3·0	1·6	<i>Nil</i>	<i>Nil</i>
6	178—184	Trace	1·5	2·4	<i>Nil</i>	<i>Nil</i>
7	186—187	Trace	3·5	5·5	<i>Nil</i>	<i>Nil</i>

No. 3 Bore—Position 554 feet bearing 304 degrees from Main Shaft. Reduced level at collar 119·43 feet, dip vertical, depth 232 feet. Footage showing values 165 feet to 205 feet—40 feet.

SAMPLES SUBMITTED TO L. PARRY, LONDON

Depth	Silver	Gold	Lead	Copper	Zinc	FeS ₂
feet	dwt.	dwt.	%	%	%	
165—169	0·5	<i>Nil</i>	0·5	1·2	5·8	65
170—174	0·6	<i>Nil</i>	Trace	<i>Nil</i>	5·2	53
*183—186	0·8	<i>Nil</i>	<i>Nil</i>	3·6	3·2	58
197—199	0·06	<i>Nil</i>	<i>Nil</i>	7·7	1·7	24

* Appears to contain a little antimony.

No. 4 Bore—Position 265 feet bearing 60 degrees from Main Shaft. Reduced level 93·70 feet dip vertical, total depth 324 feet. Footage containing values 158 feet to 280 feet.

SAMPLED BY L. PARRY, LONDON

Depth	Silver	Gold	Copper	Lead	Zinc
feet	dwt.	dwt.	%	%	%
242—245	Trace	Trace	0·15	<i>Nil</i>	<i>Nil</i>
247—249	<i>Nil</i>	<i>Nil</i>	0·9	<i>Nil</i>	<i>Nil</i>
251—253	<i>Nil</i>	<i>Nil</i>	1·0	<i>Nil</i>	<i>Nil</i>
254—256	<i>Nil</i>	<i>Nil</i>	3·1	<i>Nil</i>	<i>Nil</i>
158—160	Insoluble	Iron	Sulphur	Copper	
	41·35	15·4	21·5		
160—162	56·8	14·57	10·8	not given and no notes made.	
162—165	24·7	25·54	24·5		

DETAILED ASSAYS OF BORE No. 4

Depth	Copper	Depth	Copper
feet	%	feet	%
158—160	Trace	212—214	0·61
160—162	1·30	214—218	0·90
162—164	1·30	218—222	0·56
164—166	0·57	222—226	Trace
166—168	1·24	226—230	0·77
168—170	Trace	230—234	<i>Nil</i>
170—172	0·90	234—238	Trace
174—176	1·56	238—242	<i>Nil</i>
176—178	Trace	242—246	0·87
178—180	1·52	246—250	1·30
180—182	2·15	250—254	Trace
182—184	3·34	254—258	0·52
184—186	2·57	258—262	0·78
186—188	0·66	262—266	1·60
188—190	1·59	266—270	0·73
190—194	0·56	270—274	0·78
194—198	Trace	274—276	0·63
198—202	0·72	276—280	0·84
202—206	0·56	280—284	Trace
206—212	0·58	284—288	<i>Nil</i>
		288—292	<i>Nil</i>

No. 5 Bore—Position 483 feet bearing 63 degrees from Main Shaft. Reduced level 89·93 feet, vertical depth 346 feet, dip vertical. Footage containing values 249 feet to 280 feet.

SAMPLES BY L. PARRY, LONDON

Depth	Gold	Silver	Copper	Lead	Zinc	Iron	Silica	Pyrites
feet	grs.	dwts.	%	%	%	%	%	%
249—253	3·5	4·8	0·13	0·5	3·6	31·9	25·5	68·5
257½—261	3·5	4·8	0·73	0·9	1·8	11·3	67·7	24·0
261—263	<i>Nil</i>	<i>Nil</i>	0·43	<i>Nil</i>	1·4	3·4	79·75	7·5

Pyrites per cent. calculated from iron contents only approximate. General sample from 249 feet to 280 feet; insoluble 66·75%, sulphur 8·66%, iron 8·16%.

No. 6 Bore—Position 520 feet bearing 37 degrees from Main Shaft. Reduced level at collar 88·97 feet, dip vertical, total depth 412 feet. 234 feet to 400 feet assayed *Nil*.

General sample: insoluble 63·59%, sulphur 1·70%.

No. 7 Bore—Position 189 feet bearing 34 degrees from Main Shaft. Reduced level 96·02 feet, dip vertical, total depth 322 feet. Footage showing values 122 feet (94 feet to 216 feet). General average: 4·78% copper, 9·95% iron, 14·71% sulphur, 53·54% insoluble. Ninety-four feet to 142 feet average over 48 feet: 9·4% copper.

DETAILS OF No. 7 BORE

Depth	Copper	Depth	Copper
feet	%	feet	%
94—96	18·23	162—164	0·48
96—98	18·33	164—166	1·45
98—100	12·36	166—170	0·37
100—102	11·27	170—172	0·92
102—104	9·57	172—174	0·58
104—106	5·45	174—176	0·38
106—108	4·46	176—178	0·37
108—110	4·12	178—180	0·63
110—114	8·03	180—182	0·53
114—118	13·64	182—184	Trace
122—126	5·18	184—186	0·67
126—128	2·57	186—188	Trace
128—130	3·39	188—190	Trace
130—132	12·27	190—192	0·68
132—134	13·51	192—194	1·11
134—136	14·61	194—198	0·42
136—138	21·23	198—200	0·63
138—140	9·60	200—202	0·74
140—142	3·91	202—204	1·96
142—144	2·30	204—206	0·95
144—146	1·84	206—208	0·42
146—148	1·98	208—210	0·68
148—150	0·87	210—213	0·21
150—152	2·52	213—216	0·26
152—154	2·34	216—224	<i>Nil</i>
154—156	3·05	224—234	Trace
156—158	2·32	234—258	<i>Nil</i>
158—160	1·40	258—286	<i>Nil</i>
160—162	0·58	286—322	<i>Nil</i>

Assays were done at the Government Chemical Laboratories, and the following information is taken from Departmental records.

Diamond Drill Hole and Co-ordinates	Footage	Assay Width	Cu.	Au.	Fe.	S.
No. 12, R.L. 63'*, 258' bearing 44° from Main Shaft, Azimuth, S77°W. Depressed 52°.	137 —138	ft. 1·0	% 9·55	grs. Nil	} 26·81	} 32·81
	138 —139	1·0	1·91	5		
	139 —142	3·0	7·40	6		
No. 13, R.L. 81'. 306' bearing 54° from Main Shaft, Azimuth S25°E. Depressed 60°	158 —160	2·0	0·47	Nil	} 21·26	} 5·04
	166 —170·5	4·5	0·03	Nil		
	172·5—174	1·5	0·03	Nil		
	178·5—181·5	3·0	0·43	Nil		
	183 —184	1·0	3·90	Nil		
	185 —189	4·0	0·49	Nil		
	192·8—193·8	1·0	0·64	Nil		
No. 14, R.L. 106'. 252' bearing 356° from Main Shaft, Azimuth S10°W. Depressed 70°.	188·5—190·5	2·0	0·22	Nil	} 12·48	} 4·89
	190·5—193	2·5	0·01	Nil		
	240 —242	2·0	0·01	Nil		
No. 15, R.L. 92'. 332' bearing 329° from Main Shaft, Azimuth S10°W. Depressed 60°	114 —116	2·0	0·88	Nil	} 10·80	} 1·39
	147 —149	2·0	0·19	Nil		
	157·5—160·5	3·0	0·03	Nil		
	167 —171	4·0	0·03	Nil		
	181 —186	5·0	0·19	Nil		
	192 —195	3·0	0·68	Nil		
	234 —236	2·0	0·95	Nil		
	251·5—254·5	3·0	0·65	Nil		
No. 16, R.L. 108'. 417' bearing 316° from Main Shaft, Azimuth S10°E. Depressed 60°.	150 —158	8·0	2·70	Nil	} 33·47	} 28·02
	168·5—170	1·5	0·25	Nil		
	175·5—177·5	2·0	0·41	Nil		
	177·5—180·0	2·5	0·12	Nil		
	237·5—239	1·5	1·14	Nil		
No. 17, R.L. 116'. 537' bearing 307° from Main Shaft, Azimuth S10°W. Depressed 60°.	93 — 96	3·0	0·13	Nil	} 6·77	} 4·01
	160·5—163·5	3·0	0·11	Nil		
	166·5—168·9	2·2	0·06	Nil		
	171 —176	5·0	0·10	Nil		
	176 —180·5	4·5	0·14	Nil		
No. 18, R.L. 83'. 265' bearing 46° from Main Shaft, Azimuth S46°W. Depressed 60°.	141·2—142·7	1·5	0·16	Nil	} 6·01	} 3·78
	144 —146	2·0	3·76	Nil		
	146 —150	4·0	0·74	Trace		
	150 —151·5	1·5	0·20	Trace		
	151·5—153	1·5	0·35	Nil		
	153 —158	5·0	1·78	Trace		
	158 —161	3·0	9·38	Nil		
	161 —165	4·0	4·32	Trace		
	225·5—227	1·5	0·40	Nil		

* Datum for Relative Level (R.L.) 100 feet on S.W. peg of M.L. 70.

Complete analysis of a sample of sulphide ore from D.D. No. 18. This is a representative sample selected from the core between depths 144 feet to 165 feet.

	Per cent.
SiO ₂	37·41
Al ₂ O ₃	5·37
FeO*	14·19
MnO	0·27
MgO	3·10
CaO	0·06

	Per cent.
Na ₂ O	0·07
K ₂ O	0·20
H ₂ O—	0·03
H ₂ O+	2·08
TiO ₂	0·27
CO ₂	6·32
P ₂ O ₅	0·18
SO ₃	0·05
S	13·02
As	0·03
Fe	10·08
Pb	0·76
Cu	2·97
Zn	2·44
Ni	<i>Nil</i>
Co	0·26
C	0·52
Ag	trace
Au	<i>Nil</i>
Total	99·68

* FeO calculated from excess Fe after combination of Fe, Pb, Cu, Zn, Co with S and As.

From December, 1952, to February, 1953, a diamond drilling programme involving eight holes was carried out by North Broken Hill Ltd. The report stated that considerable difficulty was experienced during the drilling because of the oxidised nature of the ground and as a result core recovery was poor, and the rate of drilling slow. All drilling was located well above the secondary chalcocite zone.

This information is taken from a field report written in 1952, and made available to the Mines Department by North Broken Hill Ltd.

Drillhole No. 1 (361' bearing 84° from Main Shaft) was sited to determine the downward extent of the oxidised ore, but at 119 feet entered the ore horizon which, at this point, consisted of primary sulphides, predominantly pyrite, with minor amounts of chalcopyrite. Completed at 143 feet.

Sample Depth 119 ft.—123 ft., 0·19 per cent. Cu.
 123 ft.—129 ft., *Nil* Cu.
 129 ft.—134 ft., *Nil* Cu.
 134 ft.—136 ft., *Nil* Cu.
 136 ft.—137 ft., 0·03 per cent. Cu.
 137 ft.—139 ft., 0·05 per cent. Cu.

Bulk assay of the six samples for combined gold and silver resulted in 0·15 oz. per ton.

Drillhole No. 2 (293' bearing 107° from Main Shaft) was sited 150 feet S.30° W. of No. 1. It intersected carbonate ore from 84-100 feet, and 106·8-113·8 feet after passing through ironstone gossan from 72-80 feet, the average grade for the 23 feet being 4·6 per cent. copper. Completed at 128 feet.

Sample Depth		Core Recovery	Assay Copper	Co.	Ag.	Au.
From	To					
feet	feet	feet	%	%	ounces	ounces
72	80 (ironstone)	<i>Nil</i>	.....	.....	.....	.....
80	84	0·75	0·5	} <i>Nil</i>	0·85	<i>Nil</i>
84	89	0·75	2·7			
89	94	0·25	7·0			
94	96	0·67	5·7			
96	97·5	0·5	4·6			
97·5	100	0·67	2·5	} <i>Nil</i>	Trace	<i>Nil</i>
100	106·8 (slate) .....	.....	.....	
106·8	108·8	1·5	3·5			
108·8	113·8	1·25	5·4			
Sludge samples.				} <i>Nil</i>	Trace	<i>Nil</i>
89	94 .....	.....	2·7			
94	99 .....	.....	1·9			
Average grade.						
84	100	16 feet at 4·6 per cent.				
106·8	113·8	7 feet at 4·8 per cent.				

Drillhole No. 3 (453' bearing 110° from Main Shaft) was drilled 150 feet S.60° E. of No. 2 and intersected carbonate ore from 50 feet down to 70 feet, the hole being completed at 86 feet. The average grade for the 20 feet being 8·5 per cent. copper.

Sample Depth		Core Recovery	Assay Copper
From	To		
feet	feet	feet	%
50	50·17	0·17	2·2
50·17	53	0·5	0·9
53	54	0·08	0·6
54	56	0·08	1·7
56	58	<i>Nil</i>	.....
58	60	0·17	4·45
60	62	0·17	1·35
62	62·75	0·08	35·15
62·75	63·25	0·25	2·75
63·25	66	2·0	29·2
66	70	0·17	11·05
Average grade.			
50	70	20 feet at 8·5 per cent.	
54	70	16 feet at 10·4 per cent.	

Drillhole No. 5 (565' bearing 288° from Main Shaft) was sited to test the western extension of the ore body. Gossanous material was intersected from 68 to 71 feet and mineralised felsite persisted to 89 feet. Total depth was 131 feet.

The indications were that mineralisation was less intense in this area and marked the possible western limits.

Sample Depth		Core Recovery	Assay Copper	Co.	Ag.	Au.
From	To					
feet	feet	feet	%	} Nil	ounces	ounces
71	71-67	1-17	4-3			
71-67	73-75	2-5	1-7			
73-75	74-75	1-0	7-2			
74-75	80	1-0	2-8			
80	87-33	1-5	1-1			
87-33	89	1-5	1-8			
Average grade.						
71	80	9 feet at 3-1 per cent.				
71	89	18 feet at 2-1 per cent.				

Drillhole No. 6 (635' bearing 103° from Main Shaft) was drilled some 300 feet S.60° E. of No. 1. Although the felsite persisted, mineralisation was very weak, only an occasional fleck of malachite being visible. The thickness of the felsite intersected in this hole (24-67 feet) suggests that it is within the drag on the Eastern Fault.

The core of this hole was not sampled for assay.

Drillhole No. 7 (310' bearing 124° from Main Shaft) was drilled 350 feet S.30° W. of No. 1 and indicated the limit of mineralisation in this direction. The felsite had thinned to 10 feet and the grade was less than 1 per cent. Completed at 56 feet.

Sample Depth		Core Recovery	Assay Copper	Co.	Ag.	Au.
From	To					
feet	feet	feet	%	} Nil	ounces	ounces
31	33	1-17	0-9			
33	36	2-5	0-5			
36	41	3-0	0-4			
Sludge Sample.						
31	36	0-7 per cent. copper.				
Average grade.						
31	36	10 feet at 0-5 per cent.				

Drillhole No. 8 (525' bearing 278° from Main Shaft) was located to establish the continuity of the ore-body between the central workings and the western workings. Drilling conditions were extremely bad and core recovery at a minimum, there being virtually no core recovered from 96-146 feet, being in strongly

kaolinised felsite. From 146-151 feet, 5 inches of core were recovered consisting of almost pure malachite. From 151-201 feet only fragments of broken felsite were recovered. The hole was abandoned at 201 feet because of caving behind the barrel.

Sample Depth		Core Recovery	Assay Copper	Co.	Ag.	Au.
From	To					
feet 96	feet 146	feet 0.42	% (kaolinised felsite)	%	ounces	ounces
146	151	0.42	48.2	Nil	4.92	0.08

Some azurite and malachite at 188 feet. Hole abandoned at 201 feet due to bad caving conditions.

Representatives of the Rasa Trading Co. Ltd. of Japan, who are at present investigating the Whim Creek Mine for its possibilities as an open-cut project, have commenced a drilling programme, the results of which are not yet available (October, 1961).

Production

Table 29
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Treated	Copper Content	Value
			Long Tons	Long Tons	£A
Previous to		<i>Whim Creek Mine</i>			
1899	Loc. 71	Whim Well Copper Mines	6,638.00	955.70	49,785
1899	Loc. 71	Whim Well Copper Mines	1,405.00	343.00	20,196
1901	Loc. 71	Whim Well Copper Mines	1,054.00	210.80	15,006
1907	Loc. 71	Whim Well Copper Mines	2,224.00	507.58	43,790
1908	Loc. 71	Whim Well Copper Mines	1,414.00	292.81	16,926
1909	Loc. 71	Whim Well Copper Mines	7,007.00	1,016.40	61,226
1910	Loc. 71	Whim Well Copper Mines	8,345.13	1,059.81	63,608
1911	Loc. 71	Whim Well Copper Mines	8,933.90	1,179.14	67,803
1912	Loc. 71	Whim Well Copper Mines	12,068.50	1,451.32	102,148
1913	Loc. 71	Whim Well Copper Mines	12,272.00	1,092.90	71,569
1914	Loc. 71	Whim Well Copper Mines	7,736.00	633.90	40,275
1915	Loc. 71	Whim Well Copper Mines	275.02	47.44	2,975
1916	Loc. 71	Whim Well Copper Mines	401.90	62.91	6,344
1917	Loc. 71	Whim Well Copper Mines	411.30	69.60	7,268
1918	Loc. 71	Whim Well Copper Mines	1,765.50	273.28	27,328
1919	Loc. 71	Whim Well Copper Mines	611.50	107.30	8,245
1920	Loc. 71	Pilbara Copper Fields Ltd.	330.00	59.00	5,900
1921	Loc. 71	Pilbara Copper Fields Ltd.	893.50	160.53	15,783
1922	Loc. 71	Pilbara Copper Fields Ltd.	963.00	251.78	17,420
1923	Loc. 71	Pilbara Copper Fields Ltd.	164.00	36.50	2,481
1924	Loc. 71	Pilbara Copper Fields Ltd.	79.00	16.50	1,012
Total to the end of 1960			75,213.25	9,918.20	650,588
Average weighted assay = 13.2%.					
		<i>Mons Cupri Mine</i>			
Previous to					
1899	M.L. 10	Rushalls Lease	20.00	3.00	150
1899	M.L. 33	Stranger Copper Mine	10.00	2.50	100
1899-1901	M.Ls. 5, 12	Balla Balla Copper Mines Ltd.	1,640.00	201.07	9,499
1899	M.L. 12	Mons Cupri	369.00	47.97	2,537
1911-1917	M.L. 34	Whim Well Copper Mines Ltd.	282.50	33.75	2,979
Total to the end of 1960			2,321.00	288.29	15,265
Average weighted assay = 12.4%.					

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay Copper	Value
		<i>Whim Creek Mine</i>	Long Tons	%	£A
1949-1954	Loc. 71	Whim Creek	5,548·19	6·60	31,913·75
1955	Loc. 71	Walters, J.	2,511·71	5·75	14,253·00
1956	Loc. 71	Walters, J.	2,028·16	4·18	13,538·00
1957	Loc. 71	Walters, J.	554·39	3·79	3,702·00
1958	Loc. 71	Walters, J.	41·78	3·50	279·00
Total to the end of 1960			10,684·23	5·6	63,685·75

Mineralogy

Details of the mineralogy and assays of the Whim Creek ores are included in the description of the drilling results. The following additional information by Simpson (1952, p. 163) is of further interest.

“In the upper levels most of the ore occurs as malachite. In the richer parts of the lode chalcocite is found in considerable quantities, associated with certain amounts of copper silicate and occasional black and red oxides. Chalcocite, occurring both in veins and comparatively large masses, is usually surrounded by the green carbonate. It is also characteristic of the irregular cracks, rather than the planes of sedimentation in which the bulk of the malachite has been formed. Some specimens of malachite are pseudomorphs after azurite, others being finely acicular crystals developed in a vugh of ironstone.”

Reserves

The Geological Survey has made no recent estimates of quantity and grade at the Whim Creek and Mons Cupri Mines. The latest estimate made by a private organisation is 350,000 tons in sight with a possible further 1,000,000 tons averaging 3·4 per cent. Cu.

Remarks

There is quite evidently a large quantity of low grade copper ore at the Whim Creek and Mons Cupri Mines, most of which lies within reasonable open cut depths. The economics of exploitation of these reserves appear to depend partly upon the installation of an efficient treatment plant in the vicinity which can economically beneficiate the ore to a sufficiently high grade for shipping purposes.

THE EGINA DEPOSITS

Introduction

The first copper mining operations commenced at Egina in 1897, and the mine was worked intermittently by the Balla Balla Copper Mines Ltd. until 1900. Further production was recorded in 1907.

During 1955, consequent upon the increased demand for ore for fertilizer purposes, a small tonnage was gathered by scavenging at the surface.

The deposit occurs in pre-Nullagine metasediments which in the mine vicinity strike generally north-east and dip north-west at 75 degrees or more. Copper occurs mainly as malachite in a quartz matrix.

In the early days, the ore which was fairly high grade was carted the distance of about 40 miles to the Mons Cupri Lease for treatment at the small water jacket blast furnace erected there.

Information on the Egina Deposit and the surrounding country may be found in the following :—Simpson (1906), Maitland (1909), Woodward (1911), Maitland (1919), Sullivan (1939).

The centre is located approximately 74 miles east-south-east of Roebourne, and about 34 miles from Whim Creek on the road to the Hong Kong mining centre. The distance to Pt. Sampson, the present nearest working port, is 94 miles by graded road via Whim Creek. Geographical co-ordinates are as follows :—

Latitude 21° 0' S.

Longitude 118° 15' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 110/300.
2. Lands Department 10-Mile Topographic Series, Sheet 13—Onslow.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Geological Information

The rocks in the vicinity of the mine are a metamorphosed sedimentary succession of schists and slates, with some jaspilitic horizons, and are considered to belong to the Mosquito Creek System of pre-Nullagine rocks. The degree of metamorphism is variable, in some places garnetiferous schists can be observed. Concordant and discordant quartz veins intrude these beds.

Copper mineralisation occurs in a quartz vein intruded alongside a jaspilite bed which carries small drag folds plunging steeply to the south-south-west. The width of copper mineralisation ranges from 5 to 15 feet. It strikes 60 degrees east of north and dips to the north-west at about 80 degrees.

The main workings extend over a length of about 200 feet on the southern side of a low hill of argillaceous slates, about 1.5 miles west of Egina Hill.

Most of the ore has been won from above the 30 foot level. A lower level has been driven at a depth of 50 feet (Sullivan, 1939).

Three shafts were sunk on the south-eastern side of the main line of mineralisation. These were evidently sunk at an early stage of the operations since the jaspilite body and the top part of the workings in the open cut suggest that the dip is to the south-east.

Production

Table 30
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Assay Value	Value
Previous to 1899			Long Tons	Long Tons	%	£A
1899	M.L. 3	Egina Copper Mine	260·0	65·0	25·00	} 6,571
1899	M.L. 3	Egina Copper Mine	208·0	24·93	12·00	
1900	M.L. 3	Egina Copper Mine	62·0	12·90	20·80	
1907	M.L. 91	Egina Copper Mine	12·0	1·20	10·00		72
Total to the end of 1960			542·0	104·03	19·19	6,643

Average weighted assay = 19·2%.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay Copper per cent.	Units Copper	Value
1955	M.C. 86	Neale, J.	Long Tons 28·59	% 11·68	334·07	£A 592·74

Assays

Systematic sampling of the old workings by Sullivan (1939) revealed no payable ore. Of twenty-one samples taken for assay, results were less than 1 per cent., six between 1 and 2 per cent., six between 2 and 3 per cent., three between 4 and 5 per cent., and only two above 5 per cent.—the latter results being 9·05 per cent. across 33 inches and 15·12 per cent. across 30 inches.

The ore consisted mainly of massive botryoidal malachite in a quartz matrix. Chalcopyrite ore was encountered below 50 feet.

Remarks

This is apparently a small vein which carried bunches of good ore in the oxidised zone, but values in the lower levels discouraged further development.

THE CROYDON DEPOSITS

Introduction

Copper was first discovered at Croydon in 1898, and the bulk of the production from this centre was recorded during the years 1899 to 1909 from the Croydon Copper Mine, and the Evelyn Copper Mine. No production was recorded from 1909 to 1952, but from 1952 onwards a small tonnage has been produced for the fertilizer market.

The deposits occur in older Precambrian (Mosquito Creek) metasediments in the water shed of the Sherlock River, about 18 miles almost due south of the Whim Creek Copper Mining Centre. The western edge of a large intrusive granitic mass crops out about 3 miles to the east.

The sediments consist of phyllites, slates, quartzites and schists with minor interbedded and transgressive acid and basic rocks. The regional strike is north-easterly, and the dips are close to vertical. These are the host rocks, at various places in the West Pilbara Goldfield, for gold, copper, lead, silver, zinc and antimony mineralisation. Approximate geographical coordinates of Croydon are :—

Latitude 21° 10' S.

Longitude 117° 50' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph No. 110/300.
2. Lands Department 10-Mile Map Series, Onslow Sheet.
3. Geological Sketch Map of Western Australia, Geol. Survey West, Australia, 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Geological Information

Reference to the geology and ore deposits at Croydon may be found in the following : Simpson and Gibson (1907) ; Montgomery (1907) ; Woodward (1909, 1911), and Simpson (1952).

As stated above, the Croydon deposits occur in Mosquito Creek System metasediments in close proximity (3 miles at the surface) to massive intrusive granite. The rocks in the vicinity of the workings consist of vertically disposed, foliated sedimentary and basic igneous schists which have in places reached the andalusite stage of metamorphism. Some beds of quartzite also occur, and all of these rocks are covered in places by surficial ferruginous and travertinous cements.

The Evelyn Copper Mine, M.L. 31 (previously the Croydon Copper Mine)—The workings here consist of a number of isolated shafts, shallow trenches and costeans scattered intermittently along the outcrop of a siliceous intrusion which strikes north-east and south-west over an exposed distance of about 800 feet, and dips vertically with the country. The body is variable in thickness, attaining a width of 16 feet in places. At the surface it consists of an oxide of iron, with clayey material, and with bunches and veins of oxides, carbonates, silicates, and sulphide of copper in laminated metasediment.

The ore deposit was worked principally near the south-western end where the deepest shaft was sunk on a shoot of ore 36 feet long and 16 feet wide at the surface, whilst at a depth of 45 feet it was recorded as being 45 feet long and 8 feet wide, plunging in a north-easterly direction. At the 65 feet level, it was said to be 65 feet in length and 6 feet in thickness.

Below the depth of 50 feet a large quantity of water entered the workings, and from about the same depth the percentage of secondary sulphides increased until, at the maximum depth of 85 feet, the ore consisted primarily of chalcopyrite, marcasite and sphalerite, the amount of zinc in fact becoming so great that further work was said to be unprofitable and the mine was abandoned in 1909.

Woodward (1911, p. 91) states "The large quantity of zinc at this bottom level reduced the value of the ore so considerably that it did not pay working expenses. It is a pity, however, that the work was discontinued at the point at which the secondary concentration of zinc had apparently taken place, for it is

quite possible that this zone would have been passed through in a few feet when the permanent value of the ore would have been determined."

The Quamby (late M.L. 103) and *Kopje* (late M.L. 105)—These Leases are located approximately 1.5 miles north-east of the Evelyn Mine, and are situated on a copper-bearing quartz vein, about 2 to 3 feet in width, from which 15 tons of 27 per cent. oxidised ore was raised in 1907. In 1952, 43.89 tons of ore were recovered from the same ground (P.A. 234) and sold for fertilizer manufacture. No production has been recorded from the *Kopje* Lease. The host rocks here are similar to those further south, and the quartz vein which dips vertically, can be traced discontinuously by gossan and quartz exposures for about 6 chains. Surface copper mineralisation is weak.

Production

Table 31
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Copper Ore	Copper Content	Assay Value	Value
Previous to 1899			Long Tons	Long Tons	%	£A
1899	M.L. 26	Croydon Copper Mine	15.00	3.60	24.00	} 595
1899	M.L. 26	Croydon Copper Mine	25.00	5.00	20.00	
1899	M.L. 28	Evelyn Copper Mine	134.00	17.90	13.36	
1900	M.L. 31	Evelyn Copper Mine	319.00	59.90	18.77	} 6,463
1907	M.L. 31	Evelyn Copper Mine	24.00	5.00	20.83	
1908	M.L. 31	Australasia, Ltd.	42.00	8.10	19.28	
1909	M.L. 31	Australasia, Ltd.	30.00	5.80	19.23	
1907	M.L. 103	Quamby	15.00	4.05	27.00	275
Total to the end of 1960			604.00	109.35	....	7,333

Average weighted assay = 18.9%.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Assay Copper	Value
1952	P.A. 23 (late M.L. 26)	Lee, T.	Long Tons 47.82	% 7.06	£A 337.74
1952	P.A. 234 (late M.L. 103)	Lee, T.	43.89	6.83	299.77
1959	P.A. 257	Watkins, D. C.	7.71	9.34	132.70
Total to the end of 1960			99.42	23.23	770.21

Assays and Mineralogy

According to Simpson (1952) the minerals present in the ore from M.L. 31 were chrysocolla, malachite, cuprite, tile ore, chalcocite, calcite in thick crusts and veins, quartz, and limonite, together with small quantities of chalcopyrite, blende and smithsonite. An assay showed that the ore contained Cu, 15.79 per cent.; Au, trace; Ag, 4 ozs. 15 dwts. 3 grns. per ton.

These results were determined by the Government Mineralogist from samples taken by Montgomery (1907, p. 47). Grab samples from similar oxidised material taken from a cut 15 feet deep gave the following results:—

	Per cent.
Moisture at 100°C.	3·86
Silica, SiO ₂	19·45
Alumina, Al ₂ O ₃	3·08
Magnesia, MgO	1·89
Lime, CaO	7·04
Iron, Fe	20·51
Zinc, Zn	1·73
Copper, Cu	15·18
Sulphur, S	0·36
Oxygen, Carbonic acid, etc.	26·90
	100·00

Remarks

This line of mineralisation, lying concordantly in steeply dipping metasedimentary rocks, has been shown to contain at least one ore-shoot which yielded over 620 tons of about 18 per cent. grade before being abandoned just below the water level. Despite the line of six shafts it would seem that this deposit has been inadequately tested when one takes into consideration its initial good showing, the environment, and its proximity to Whim Creek and Mons Cupri.

THE ROEBOURNE DEPOSITS

Introduction

The Roebourne centre includes what may be conveniently regarded as four areas of copper bearing bodies. These may be called the Carlow Castle Group (which has recorded the most production), the Fortune Group, the Weerianna Group, and the Good Luck Group.

The centre of this mining activity was earlier regarded as Glenroebourne, located approximately 6 miles west of Roebourne, which is 13 miles south by bitumen road from Pt. Samson.

Several copper mines were worked in the early seventies of the last century at Glenroebourne. 3,000 tons of ore yielding 585 tons of metallic copper were recorded as being raised up to the end of 1918. However, it seems very likely that not all of the copper ore produced has been officially recorded (Woodward, 1910, p. 102).

The rocks of the general area consist of a series of ferruginous quartzites, banded quartzites, sandstones and fine grained basic and acid lavas which are included with the Warrawoona System. The general strike is 65 degrees and the dips are steep to the south-east. Dolerite, gabbros and granitic rocks intrude the Warrawoona rock in places. Approximate geographical co-ordinates for Glenroebourne:—

Latitude 20° 45' S.
Longitude 117° 3' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 111/300.
2. Lands Department Line Compilation 1 mile sheets: Roebourne F 50: 3: 8, and Dampier F 50: 2: 2 and 7.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

The Carlow Castle Group—Included in this Group are the mines known previously as the Carlow Castle (late M.Ls. 14, 42, 65, 167, 183 and others), Quod Est or Q.E. (late M.Ls. 150, 167), Wait-a-While (late M.L. 135), and the Federation Copper Mine (late M.L. 42). Many of these leases were held at different times, covering generally the same, or almost the same, ground (Woodward, 1910, Plate IV).

The workings of this Group are situated in doleritic greenstone which is highly sheared in the vicinity of the veins. These lie in a broad valley trending about east and west, and flanked on the northern and southern sides by ridges of banded quartzite. The veins occur along the northern slopes of the valley. They have been worked for both gold and copper.

There are six lines of mineralisation, striking and dipping in different directions, in the form of quartz—chalcopyrite—gold fissure veins. Four of these have received little attention because of low grade and short length of outcrop.

A vein in the north-western portion of late M.L. 65 constituted the main ore body. It strikes north and south, and dips to the east at about 60 degrees, and was developed over a length of about 200 feet at the 70 feet level. It averages just over 3 feet in width. The standing water level is at about 70 feet.

The ore at the Carlow Castle consists of basic schist filled and impregnated with cuprite, malachite, iron oxides, and quartz, and at the lower levels, chalcocite and chalcopyrite. Occurrences of native copper were not uncommon.

Since 1950 a small quantity of cupreous ore for fertilizer purposes has been obtained from this mine by picking the dumps and accessible workings.

The underground operations have been confined principally to the so-called Underlay, Ladder, and Whip Shafts (Finucane and others, 1939, p. 5). Some good ore has been broken from short north and south drives at the 30 feet level of the Underlay Shaft.

The northern or Q.E. section of the ore body was initially taken out as G.M.L. 150 for gold and copper, some of the ore being mined only for gold, and the remainder primarily for copper but from which gold and silver were also recovered. Cobalt and nickel also occur in this ore. (See under Assays below).

The Underlay Shaft apparently followed a southerly plunging pipe of ore down to 80 feet. At 20 feet down this shaft short drives have been driven to the south and north, the northern drive breaking through into the old stope at 14 feet.

The so-called No. 7 "Lode," lies a little to the south-east of the main vein, and it strikes north-easterly and dips at about 75 degrees to the south-east. This vein can be followed over

a length of some 330 feet and has been tested by a series of shafts and trenches which expose carbonate mineralisation in iron stained quartz. The deepest shaft was 80 feet.

No. 2 "Lode" about 700 feet east of the main vein, was worked as the "Wait-a-While" Mine (late M.L. 135). This vein strikes northerly and dips easterly at about 65 degrees. Ore was raised from a number of shafts and open cuts along portion of the outcrop over a distance of about 8 chains. The vein averaged about 4 feet in width and contained iron oxides, copper oxides, malachite, and native copper in quartz.

The No. 3 "Lode" at the north-east corner of the Lease (M.L. 65) crops out in a north-westerly direction over a distance of about 4 chains. It dips steeply to the south-west. Several shafts of various depths have been sunk upon it. Woodward (1911) stated that the "lode" appeared to be small, and of generally low grade, with some rich bunches and wall concentration. Below the water level, in the sulphide zone, nickel and cobalt occur.

The remaining four veins on these leases are of little importance.

The Fortune Group—Included in this Group are the Leases which were held at Glenderry (M.L. 49), Fortune (M.L. 64), Good Fortune (M.Ls. 145, 146 and 174), Good Hope (M.L. 175), Fortune No. 1 and No. 2 (M.Ls. 181, 182); each of these Leases at different times covering portions of two parallel veins. The two veins, called the Western and Eastern "Lodes," strike about north-easterly, and dip steeply to the north-west.

The Fortune Group lies approximately 1.5 miles south of the Carlow Castle, in an alluvial flat through which protrudes low hills and mounds of gabbroidal lavas of age comparable with the Warrawoona System. Copper and gold bearing quartz veins form the ore bodies of this Group, filling shears in the coarse-grained lavas.

Workings on the Eastern "Lode," which averages about 5 feet in width but in places bulges out to 40 feet, extend over a length of 700 feet, the deepest shaft being about 70 feet near the south-western end of the vein. Stopping has been restricted to about 4 feet on the southern wall.

The Western "Lode" has been traced over a length of 500 feet, and averages about 8 feet in width. The deepest shaft on this vein reached water level (70 feet), and the workings contain one section which has been open stoped.

Both veins were evidently of low grade, although high assay results were obtained from some picked ore.

The Weerianna Group—In 1907 a group of leases were taken up in the Weerianna locality by the Roebourne Copper and Gold Mines of W.A., N.L., a Melbourne Company which also owned the Carlow Castle at Glenroebourne. These included the Lilly Blanche Copper Mine (late M.Ls. 77, 187), Ena Reward (M.L. 118), and Ena Extended (M.L. 73).

The bulk of the production came from the Lilly Blanche Mine during 1907 when some thirty men were employed, both gold and copper ore being produced. A small production was also recorded from the same ground during 1915-1916. The mine locality is at present held as P.A. 247.

The Lilly Blanche is situated within the Weerianna Group approximately 2 miles west-north-west of Roebourne in the Mt. Welcome Range. The mine site may be reached by taking the track branching off the Roebourne-Onslow Road which passes through the abandoned State Battery site.

Copper mineralisation occurs in a shear line in a belt of fine grained basic lava (schistose in places) which has been partially intruded by dolerite, gabbro and granite. The rocks strike in a north-easterly direction and dip at angles close to vertical.

Surface indications of the copper mineralisation are weak, and can in most places be detected only by copper stains in quartz and the sparse iron gossan. The deposit has been opened up by two shafts to a depth of 40 feet. When followed down from the surface the width of copper impregnation increased, showing at first some very fair oxide of copper, which at depth gave way to chalcopyrite.

A shoot of ore about 76 feet in length was exposed to a depth of 40 feet from the surface. The walls were well defined and the vein was 3 to 4 feet wide.

The central portion of the deposit was later open-cut and the lateral extensions stopped to within 10 to 15 feet of the surface. The water level was about 43 feet below the surface.

The ground was covered in 1957 by P.A. 247, but no production has been recorded since then.

About 15 chains south and south-east of the Lilly Blanche, a group of seven small copper lodes were worked in a small way on what is known as the Ena Leases. One of the copper bearing veins strikes N.50° E., dips almost vertically, and ranges in width up to a maximum of 3 feet.

It has been open-cut down to a depth of 10 feet over a length of about 30 feet. The vein outcrop consists of rubbly iron-stained quartz and, as at the Lilly Blanche, it occurs in sheared basic lava.

A little to the north-east of these workings are two other veins lying close together. They strike about N.20° E., and appear on the surface as ferruginous oxide and carbonate of copper in a quartz matrix.

On the east side of these two there is a vein cropping out over 3 chains striking N.10° E. Towards the northern end of this outcrop a shaft was sunk 30 feet in low grade ore. Montgomery (1907) states that the shaft was inaccessible at the time of his visit but he was informed that there were three feet of good ore on the bottom of the shaft. Cuttings into the outcrop south of the shaft showed copper-stained rubbly quartz, from which a small amount of fairly good oxide could be obtained.

Good Luck Group—This Group lies between the Carlow Castle and the Fortune Groups. The principal workings were the Good Luck (M.L. 184), and the Azurite (M.L. 129). Others included in this Group are the White Australia (M.L. 114), Asteroid (M.L. 98), and Kensington (M.L. 106).

The Good Luck workings have been referred to in some earlier reports as Brown and North's Mine. These are also located in gabbroidal rocks, the western end approaching close to the contact with a finer grained doleritic type rock.

The vein strikes N.80° W., and dips at about 85 degrees to the south. Where exposed at the surface it averages about 18 inches in width, but at the 70 feet level it widens out to about 42 inches. The walls of the vein are smooth and well defined.

At the surface, copper mineralisation consisted of oxides and carbonates, which at depth gave way to chalcocite and chalcopyrite. Marcasite was also reported.

Details of analyses are given in the assay section below.

The Azurite workings (M.L. 129) are on an east-west trending vein which dips steeply to the north. The host rock is a gabbro, and the channel is narrow with the ore occurring in the form of thin shoots. The deposit was opened up by means of a vertical shaft, 36 feet deep, and a shallow open cut along the vein westwards of the shaft for a distance of 50 feet.

About 15 chains south of the Azurite is a parallel vein which, though narrow, persists over a considerable length of outcrop. It has been worked to only about 15 feet.

The White Australia workings (M.L. 114) on an east-west vein are of a minor nature, and the ore is of low grade.

Production

Table 32
COPPER ORE AND CONCENTRATES
Carlow Castle Group

Period of Production	No. of Lease	Registered Name	Ore Treated	Copper Content	Value
To end of			Long Tons	Long Tons	£A
1899	M.L. 14	Carlow Castle Copper Mine	133·00	30·27	1,991
1900	M.L. 42	Federation Copper Mine	26·00	6·24	468
1907	M.L. 65	Carlow Castle	6·00	1·00	100
1907	M.L. 65	Roebourne Copper and Gold Mines (W.A.) Ltd.	81·00	19·88	1,415
1909-1913	G.M.L. 150	Q. E.	319·84	37·91	*2,330
1910-1911	M.L. 135	Wait-a-While	36·05	9·87	601
1912-1913	M.L. 143	Carlow Castle	59·28	9·50	662
1914	M.L. 167	Quod Est	22·43	3·49	256
1916	M.L. 143	Carlow Castle	69·00	7·80	780
1917-1928	M.Ls. 167, 183	Roebourne Copper Mines			
1957	M.C. 88	Roebourne Copper Mines	167·45	24·75	†2,255
		Carlow Castle Copper Mine	104·58	10·24	‡1,648·05
Total to end of 1960			1,024·63	160·95	12,506·05

Average weighted assay = 15·8%.

* Also 451·71 fine ounces of gold and 233·06 fine ounces of silver from 113·86 tons of gold ore from 1909-1912, and also 111·09 fine ounces of gold from unrecorded quantity of copper ore during 1912-1913.

† Also 21·12 fine ounces of gold from copper ore.

‡ Also contained 56·96 fine ounces of gold, and 19·82 fine ounces of silver valued at £889·00 and £8·05 respectively.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Average Assay Copper	Value
1956	M.C. 88	Carlow Castle Copper Mine	Long Tons 15·58	% 8·27	£A 186·92
1957	M.C. 88	Carlow Castle Copper Mine	9·95	7·87	96·00
Total to the end of 1960			25·53	8·1	282·92

Table 33
COPPER ORE AND CONCENTRATES
Fortune Group

Period of Production	No. of Lease	Registered Name	Ore Treated	Copper Content	Average Assay Copper	Value
			Long Tons	Long Tons	%	£A
1901	M.L. 49	Glenderry	22·00	4·50	20·45	287
1908-1910	M.L. 64	Fortune	51·07	11·68	22·87	690
1912-1913	M.Ls. 145, 146	Good Fortune	219·15	44·75	20·41	2,988
1916-1917	M.Ls. 174, 175	Good Fortune	63·40	9·58	.....	1,011
1918-1919	M.L. 174	Good Fortune	56·77	8·58	.....	904
Total to the end of 1960			412·39	79·09	.....	5,880

Average weighted assay = 19·1%.

Table 34
COPPER ORE AND CONCENTRATES
Weerianna Group

Period of Production	No. of Lease	Registered Name	Ore Treated	Copper Content	Average Assay Copper	Value
			Long Tons	Long Tons	%	£A
1907	M.L. 77	Lilly Blanche	997·00	186·99	.....	17,541
1907	M.L. 73	Ena Extended	6·50	0·77	.....	55
1908	M.L. 118	Ena Reward	20·00	2·87	.....	150
1915-1916	M.L. 178	Lilly Blanche	16·98	2·97	.....	272
Total to the end of 1960			1,040·48	193·60	.....	18,018

Average weighted assay = 18·6%.

Table 35
COPPER ORE AND CONCENTRATES
Good Luck Group

Period of Production	No. of Lease	Registered Name	Ore Treated	Copper Content	Average Assay Copper	Value
1917-1918	M.L. 184	Good Luck	Long Tons 5·21	Long Tons 1·01	% 19·3	£A 111

Assays and Mineralogy

Carlow Castle Group—Referring to the Carlow Castle (M.L. 65), Finucane et.al. (1939) states:—

“Sampling results from the 70 feet level were as follows. In a branch drive on the northern end of the reef, three samples cut within a length of 20 feet gave an average of 6·10 dwt. of gold and 8·88 per cent. copper over an average width of 31·3 inches. Three samples cut across the face of the stope at the northern end of the main drive averaged 7·70 dwt. of gold and 4·06 per cent. copper across a total

width of 186 inches. A fourth sample cut on the brow of the main drive at the southern end of the stope assayed 5·37 dwt. of gold and 6·69 per cent. copper across 24 inches. A run of 12 samples cut at 10 feet intervals in the back of the main drive from the southern end of the 70 feet level to a point 20 feet north of the Ladder Shaft, a total length of 112 feet, gave an average of 1·99 dwt. of gold and 5·04 per cent. of copper across an average width of 34·36 inches. The average of the nineteen samples at the 70 feet level was 4·23 dwt. of gold per ton and 5·36 per cent. of copper across an average width of 42·9 inches."

A trial parcel of Carlow Castle ore was forwarded in 1957 to the Kalgoorlie School of Mines (by Messrs. Hedley, Coat and King who held the Lease at that time). Part of the report made on this ore reads as follows :—

"*Mineralogy and Assays of Ore*—The copper minerals identified were covellite and chalcocite (sulphides), malachite and azurite (carbonates), and native copper; the proportion of native copper was very small. The ore assayed 4·52 per cent. copper.

The cobalt minerals identified were the arsenide cobaltite, the arsenate erythrite and cobaltiferous calcite. The ore assayed 0·84 per cent. cobalt.

The ore contained some free gold which appeared pale probably due to the presence of silver. The ore assayed gold 3·30 dwts./short ton, silver 9·00 dwts./short ton.

A small proportion of pyrite was seen in the ore."

The average content of 21 ore samples taken in the Carlow Castle Mine in 1938 by the North Australian Survey and assayed at the School of Mines, Kalgoorlie, was :—Copper, 5·34 per cent.; Cobalt, 1·18 per cent.; Nickel, trace; Arsenic, 1·21 per cent.; Sulphur, 2·47 per cent.; Gold, 3·56 dwts. per ton.

The Fortune Group—An analysis of a sample taken by Montgomery (1907, p. 15) from heaps of picked ore gave the following analysis :—

	Per cent.
Moisture	1·30
Silica	29·09
Alumina	0·64
Magnesia	0·69
Lime	Trace
Iron	25·12
Nickel	·23
Copper	18·15
Lead	Trace
Sulphur	1·27
Oxygen, carbonic acid, etc.	23·51
	100·00

Equal on the dry ore to—

Copper	18·39 per cent.
Silver	5 ozs. 0 dwts. 8 grs. per ton.
Gold	2 dwts. 13 grs. per ton.

The Weerianna Group—Simpson (1952) states that the copper at Weerianna is found in reefs of iron stained quartz, containing cuprite, malachite, chalcopyrite, and some iron pyrites. Other than the grade of ore indicated in the production table, no assay data is available.

Remarks

The most recently worked mine in the Roebourne centre is the Carlow Castle (105 tons produced in 1957). Good grade ore has been produced in the past, an appreciable amount of it with a significant gold content. The local (W.A.) market is only for fertilizer grade ore at present. To take advantage of potentially valuable accessory minerals it will probably be necessary to achieve a high degree of concentration prior to shipping overseas.

Some of the veins appear as if they could still produce small quantities of oxidised ore of a grade which could provide a satisfactory return to prospectors by picking at rich near-surface concentrations.

Any worth-while development, however, must depend upon the satisfactory testing of these deposits below water level.

THE YANNERY AND WHUNDO DEPOSITS

Introduction

Copper in this locality was first reported in 1912, production commencing in 1913 when the property was known as the Yannery Hill Copper Mine, M.L. 144. In 1915 the adjacent land was taken up as M.Ls. 179 and 180, called the Whundo Leases (originally the Trouble Copper Mine) and intermittent production followed until the collapse of the copper market in 1921.

Production re-commenced in 1955, the Leases then being held as Yannery Hill M.L. 259, Whundo M.L. 260, and Whundo West M.L. 261. The Whundo Leases were later flooded during heavy seasonal rains and part of the old workings collapsed, which caused them to be abandoned.

Up to the end of 1960 a total of 4,419 tons of copper and cupreous ore had been produced from these Leases.

Information on these deposits may be found in Blatchford (1913) and Simpson (1952).

Yannery is located 25 miles south-south-west of Roebourne and may be reached by a track branching off to the south from the Roebourne-Chiraton Road at a point 16 miles from Roebourne, the total road distance being 33 miles. The track passes through the Whundo Leases which are located about 1 mile to the south-west of the Yannery Hill Mine. Approximate geographical co-ordinates are:—

Latitude	21° 10' S.
Longitude	116° 15' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph No. 111/300.
2. Lands Department 10-Mile Topographic Series, Onslow Sheet.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Geological Information

The Yannery Hill Copper Mine—The copper occurs in a quartz vein intrusive into metamorphosed pre-Nullagine sediments which are capped in places by almost horizontal sandstones and cherty rocks of the Nullagine System. The mineralisation appears to be concordant with the older sediments.

The ore body was first exposed on the north-western side of a gully which cut through an escarpment standing some 200 feet above the level of the Whundo workings to the south-west. The ore has been open cut and stoped westwards into the hill over a distance of about 90 yards. The stopes, which were inaccessible at the time of the author's visit, are at least 30 feet deep and up to 30 feet wide in places. The average width of the copper mineralisation, however, seems to range between 2 and 7 feet. Copper minerals identified were malachite, cuprite and chrysocolla.

Blatchford (1912, p. 85) stated that "there appear to be nine lodes running parallel to one another in a belt some 200 to 300 feet wide. The surface of the ground is so broken, however, that it is impossible to say at present whether these outcrops represent separate veins or the broken portions of one or two main cupreous lodes." Subsequent workings were not developed across the above width but only in the shoots on one main line of mineralisation.

The two main stopes, in fairly soft argillaceous sediments, strike about 280 degrees and dip at about 40 degrees to the north-east. Two shafts (inaccessible Sept., 1961) have been sunk on the down-dip side towards the western end of the workings.

At the western end, and near the top of the hill, the line of mineralisation disappears beneath the flat-lying Nullagine sandstones.

About 1 mile north-west and 1.5 miles south-south-west of the workings, on the plain, conspicuous rounded masses of doleritic rock crop out through the pre-Nullagine sediment.

The Whundo Workings—These are located about 1 mile south-eastwards of the Yannery Workings on a fairly flat plain consisting of eroded pre-Nullagine sediments some 200 feet lower than the hills to the east.

The host rocks are similar to those at Yannery, consisting of metamorphosed argillaceous and jaspilitic sediments, strongly drag folded in places.

The workings, consisting of open cuts, shafts, costeans and pits, extend over a total length of about 640 yards on the general bearing of 255 degrees with many localised variations due to drag. The copper mineralisation occurs in quartz veins concordantly intrusive into the bedding, dipping northwards at about 50 degrees, over a zone about 200 feet in width. Part of this area is mantled by soil.

The bulk of the production was obtained from the workings towards the eastern end where a 90 feet and a 60 feet deep shaft are located. Some 40 feet south-east of the 90 feet shaft is a partly collapsed open-cut about 70 feet in length, 15 feet wide and up to 10 feet deep (1961). Drag folds suggest that the ore shoots should have a plunge to the north-north-west of approximately 40 degrees.

The western workings were not so deep and now appear as a line of collapsed holes and shafts.

On M.L. 261 (Whundo West) the workings lie on a well exposed ironstone gossan, from 6 to 30 feet in width, probably an extension of that on M.L. 260.

Further to the west again, the old workings consist of two shallow small open cuts, and several trenches and holes, the deepest of which is collapsed and filled in to a depth of 12 feet. They are orientated in a north-west direction and dip with the country.

The ironstone gossan at the western end can be traced over a distance of about 500 feet, and carries carbonate of copper, mainly malachite.

Production

Table 36
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Units of Copper	Value
1911	M.L. 138	Trouble Copper Mine	Long Tons 23·21	Long Tons 6·22	....	£A 343
1915-1918	M.Ls. 179, 180	Whundo Leases	386·20	82·25	....	8,046
1920	M.L. 192	Whundo	213·00	38·34	....	4,260
1920	M.L. 193	Whundo West	113·00	20·34	....	2,260
1913-1920	M.L. 144	Yannery Hill Copper Mine	469·25	113·81	....	9,961
1920-1921	M.Ls. 144, 192, 193	Yannery & Whundo Copper Mining Co. Ltd.	404·50	87·14	....	8,116
1957	M.L. 259	Yannery Hill Copper Mine	270·51	} 38·81 {	} 3,759·04 {	7,062·50
1958	M.L. 259	Yannery Hill Copper Mine	6·75				121·67	210·00
Total to the end of 1960			1,886·42	386·91	....	40,258·5

Average weighted assay = 20·5%.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay Copper	Units Copper	Value
1951-1954	M.L. 259	Yannery Hill	Long Tons 717·35	% 13·77	....	£A 12,352·87
1953-1954	M.L. 260	Whundo	244·75	13·72	....	4,905·38
1955-1959	M.L. 259	Yannery Hill Copper Mine	776·10	11·39	8,839·15	14,567·85
1955-1959	M.L. 260	Whundo Copper Syndicate	794·54	8·63	6,856·38	10,560·25
Total to the end of 1960			2,532·74	11·0	....	42,386·35

Assays

Simpson (1952, p. 165) gives the following information:—
“The following analyses were made of samples from five separate lodes (at Yannery Hill) containing malachite, limonite, quartz, with cuprite and chrysocolla in the last three:—

No.	Copper	Lead	Silver per ton			Gold per ton
	%	%	ozs.	dwts.	grns.	grns.
1	33·02	<i>Nil</i>	1	0	3	Trace
2	44·82	<i>Nil</i>	0	14	10	13
3	29·02	<i>Nil</i>	0	15	11	13
4	30·66	Trace	0	17	10	26
5	32·28	Trace	0	3	6	26

No nickel or cobalt was found in any of these samples.”

Remarks

Copper occurs in concordant mesothermal quartz veins in pre-Nullagine metasedimentary (mainly argillaceous) beds at both Yannery and Whundo, which are only about 1 mile apart but on different stratigraphic horizons.

The water table at Whundo is probably shallow (perhaps 60 feet) but at Yannery, because of its elevation, it must be considerably more. Neither of these deposits have been tested below the water level, and not even to this depth across the known width of copper mineralisation. It seems to the author that this area is worthy of more detailed investigation.

THE WONMUNNA DEPOSITS

Introduction

In 1951 three Mineral Leases were pegged at Wonmunna in the south-eastern part of the West Pilbara Goldfield. The number of Leases was subsequently increased to fifteen, but the original partnership was dissolved and only five Leases totalling 30 acres were still current in 1961.

Wonmunna is located about 120 miles north-westwards of the turn-off near the No. 38 well on the Meekatharra-Nullagine Road. The distance from the No. 38 well to the rail head at Meekatharra is 200 miles by the Great Northern Highway. The rail distance from Meekatharra to Geraldton, the nearest port, is 336 miles. Access is by graded road via Bulloo Downs and Prairie Downs Homesteads. The deposit is 38 miles northwards by track from Prairie Downs. Approximate geographical co-ordinates are:—

Latitude 23° 15' S.
Longitude 119° 15' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 91/300.
2. Lands Department 10-Mile Topographic Series, Nabberu Sheet.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Geological Information

The copper mineralisation occurs in weakly metamorphosed undulating sedimentary beds of Precambrian age. The sequence includes interbedded calcareous shales, shaley-siltstones, cherts and sandstones. In the vicinity of the deposit a number of small synclinal and anticlinal keels and crests can be seen, with the plunge varying from east to west. The area is also drag folded to some extent so that the overall attitude of the beds is hard to determine but it is thought that dips are generally less than 45 degrees.

Bedded (?) doleritic intrusives are exposed in places but not, as far as the author could see, in the immediate vicinity of the copper occurrences.

Some hills in the vicinity have rounded profiles, whilst the ones at a higher elevation are flat topped and covered by a lateritised zone. This area forms portion of the southern edge of the Hamersley-Ophthalmia Plateau, a description of which is given by Talbot (1920).

The workings consist of two small open cuts, the largest one, near a loading ramp, is about 10 feet deep at the western end, about 10 feet wide and 24 feet long. On the face at the western end a small drag fold in sandy shale contains copper mineralisation in the form of malachite, some azurite, a little chrysocolla and cuprite, with iron oxide stain. This is mainly confined to a band about 18 inches wide but there are some thin seams of malachite along fractures in the adjoining rock. The grade of the material exposed is low.

Weakly developed iron stone gossan can be traced on the surface for about 50 yards eastwards from the cut.

At about 200 yards bearing 260 degrees from the loading ramp is another small open cut. This is L-shaped, each arm being about 10 feet in length, 4 feet wide, and 4 to 5 feet deep. This exposes a small drag fold in banded shale weakly mineralised with azurite, malachite and cuprite in blebs and thin veins. It is on practically the same line as the mineralisation in the bigger open cut but there are no surface indications of copper between the two places.

Generally the copper mineralisation is weak and disseminated. It appears to be a bedded deposit of very low primary grade which has been concentrated in small localised structurally favourable positions.

Production

Table 37
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Copper Ore Treated	Copper Content	Value
1953	M.Ls. 243, 245	Dunnet and Party Womunna Leases	Long Tons 13.32	Long Tons 3.41	£A 674

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Average Assay per cent. Copper	Value
1953	M.Ls. 243, 245	Dunnet and Party Womunna Leases	Long Tons 5.87	23.75	£A 315

Remarks

There are unofficial reports of high copper values in samples from this area. The two small, obviously hand picked, parcels sold, averaged 25-27 per cent. copper.

The copper mineralisation seen by the author, however, was weak and scattered. The isolated location, poor access roads, and long rail distance to port all seriously reduce any margin of profit which might be hoped for by a prospector working these deposits.

Economically this deposit seems to be of little significance.

FUTURE EXPLORATION IN THE WEST PILBARA GOLDFIELD

The Whim Creek deposits are currently being investigated by diamond drilling, mapping, mining development, and sampling. It is generally accepted that the grade of ore will be low, about 3 per cent. copper might be expected, and it will be necessary to prove large reserves which can be economically concentrated locally. The same consideration must be given to Mons Cupri. Both of these places must be evaluated as open-cut prospects at the present time.

Other worked deposits in sedimentary strata occur at Egina and Croydon, 30 and 20 miles respectively from Whim Creek, but lying one on each side, east and west, of a tongue of intrusive granite which extends on the surface from northwards of Whim Creek to about 12 miles south of Croydon. These are pre-Nullagine metasediments as at Whim Creek, but are presumed to be somewhat lower in the succession. Mineralisation occurs in steeply dipping narrow epigenetic mesothermal quartz veins intruded along the sedimentary bedding planes.

Similar veins occur at Yannery and Whundo, but at these places the veins occur over a zone which in places is up to 200 feet wide. The host rocks here are overlain unconformably by unmineralised Nullagine sediments.

Of these four later deposits, it seems that Yannery and Whundo, which are just over a mile apart and collectively have yielded about six times as much ore as either Egina or Croydon, are worthy of more detailed investigation than they have had in the past. It must be expected, however, that the primary sulphides would be met with at little more than 100 feet beneath the surface.

The copper bearing quartz veins in greenstone rocks in the vicinity of Roebourne should probably still yield small parcels of picked ore to prospectors, but the area does not seem to have the same possibilities as the localities discussed above.

THE ASHBURTON GOLDFIELD DEPOSITS

SUMMARY

Mines Department production records show that since 1908 the Ashburton Goldfield has yielded 382.66 tons of copper ore with an average assay of 27 per cent., and 121.3 tons of cupreous ore, for fertilizer purposes, assaying 13.24 per cent. It seems likely, however, that not all of the early production has been officially recorded since the extent of some of the older workings, though limited, is in excess of that required to produce the listed tonnage, and also because there are reports of extra tonnages having been shipped out. The total may be closer to 600 tons.

With the exception of disseminated mineralisation in fractured epidiorite at Blacks Copper Mine, all of the deposits are narrow epigenetic mesothermal quartz-copper vein intrusives into metamorphosed argillaceous and arenaceous sediments of the Mosquito Creek System. Many of them are concordant and a few are in the form of lode formations. They probably all carry gold and silver, and at least at Uaroo, also lead.

They have all been worked only for enriched supergene ore, usually in the form of malachite, but also cuprite, azurite, chrysocolla, and chalcocite, with atacamite (Uaroo) and brochantite (Stockyard Creek). None of the deposits have been worked beyond a depth of 90 feet.

Prospecting has been restricted to surface examinations and sampling, with shaft and pit sinking and costeaning in the vicinity of the richest surface exposures.

The following Table summarises the types of deposits in the Field.

Table 38
TYPES OF DEPOSITS IN THE ASHBURTON GOLDFIELD

Deposit		Ore Produced		Remarks
Locality	Tenement	Copper Ore	Cupreous Ore	
Uaroo	Various	Long Tons 27·84	Long Tons 2·0	Narrow steeply dipping quartz veins in metasediments. Some gold, silver and lead.
Westons	Various	Not recorded		Narrow steeply dipping quartz veins in metasediments over a zone about 400 feet wide, but main mineralisation over 40 feet. Some lode type formation. Some gold and silver.
Victoria	M.Ls. 88, 148	146·00	31·75	Narrow steeply dipping quartz vein in metasediments.
Red Hill	Various	Not recorded		Narrow discordant steeply dipping quartz veins, enriched where they intersect dolerite. Some gold, silver and lead.
Cane River	M.L. 62	175·50	....	Concordant (?) steeply dipping quartz lode in phyllite and schist. Some silver, lead and gold.
Ashburton Downs	P.As. 264, 265, 323	20·05	21·66	Narrow concordant and discordant quartz veins in flatly dipping thinly bedded arenaceous and argillaceous sediments.
Ashburton Downs	P.A. 263	3·65	....	Thin steeply dipping quartz vein in metasediments.
Blacks Copper Mine	....	Not recorded		Disseminated mineralisation in fractured epidiorite.

Table 39
COPPER AND CUPREOUS ORE PRODUCTION IN THE
ASHBURTON GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1908	188.00	36.79	2,311
1909	10.75	4.31	259
1910-1914 .....	.....	.....	.....
1915	146.00	55.24	3,744
1916	2.61	0.27	27
1917	3.71	0.52	67
1918-1938 .....	.....	.....	.....
1939	2.00	0.59	23
1940-1948 .....	.....	.....	.....
1949	1.30	0.19	13
1950 .....	.....	.....	.....
1951	23.70	4.08	493
1952-1956 .....	.....	.....	.....
1957	4.59	1.46	326
1958-1960 .....	.....	.....	.....
Total	382.66	103.45	7,263

Average weighted assay = 27.0%.

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Copper	Value
	Long Tons			£A
1951	39.66	448.15	11.3	493.92
1952	1.75	21.26	12.15	30.63
1953	9.79	91.43	9.34	114.30
1954 .....	.....	.....	.....	.....
1955	12.70	103.23	7.40	141.25
1956	2.0	27.72	13.86	52.66
1957-1959 .....	.....	.....	.....	.....
1960	54.15	914.08	16.88	1,947.00
Total	122.05	1,605.87	13.24	2,779.76

THE UAROO, WESTONS, AND VICTORIA DEPOSITS

Introduction

The first recorded production of copper from the Uaroo centre, which includes the Westons Area and the Victoria locality, some 9 miles north of Westons, is for 1908, and from

this time up to the end of 1960, Mines Department records show that 173.84 tons of 36.7 per cent. copper ore, and 75.38 tons of 14.5 per cent. cupreous ore have been produced.

Uaroo lies 80 miles south-east of Onslow just west of Rous Creek, a tributary of the Ashburton River, in a belt of Mosquito Creek Precambrian metasediments which have been mineralised by copper, silver, and lead bearing concordant and discordant quartz veins. The mineralisation at Uaroo, as far as is known, extends over about 6 miles from the Elsie Helen Mine (M.L. 159) on the north, to the Silver King Mine (late M.Ls. 43, 49) on the south.

Westons is located about 13 miles slightly south of west from Uaroo Homestead, the Euro Leases are 7 miles north of Westons, and the Victoria Leases are about 3.5 miles north of these.

Some of the information given in this report has been taken from the following references: Maitland (1909), Maitland (1919), Talbot (1926), Finucane and Sullivan (1939), Simpson (1952).

The Uaroo locality is 30 miles eastwards by graded dirt track from Barradale Crossing on the North West Coastal Highway. Barradale Crossing is 91 miles south of the port of Onslow. An alternative route to Onslow is via a graded road and track which runs north-north-westwards from Uaroo Homestead, and along the southern bank of the Ashburton River, the distance being 104 miles. The jetty at Onslow was severely damaged during a cyclone early in 1961 and cargo from ship to shore is handled by lighter at present (Oct., 1961). Approximate geographical co-ordinates are as follows:—

Latitude 22° 45' S.

Longitude 115° 20' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 94/300.
2. Lands Department 10-Mile Topographic Series, Onslow, Sheet 13.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Geological Information

The ore bearing area is occupied by a series of metamorphosed sedimentary rocks, consisting of slates, phyllites, sandstones, quartzites, grits and conglomerates which are strongly folded into a series of fairly tight undulations, the axis of which, and the bedding, strike generally north-north-west to north-west, dipping easterly and westerly at generally steep angles. They are considered to belong to the Mosquito Creek System of pre-Nullagine sediments.

These rocks are intruded at various places by thin irregular quartz veins, mostly—but not always—conformable to the strike of the beds carrying copper, gold, silver and lead. All of the copper production has been in the form of oxidised ore from shallow depths.

The Uaroo Group—The Silver King lead deposit lies about 1.5 miles north-west of Uaroo Homestead. The Uaroo Group of copper mines lies about 4 miles north-north-west of this on the same line of interbedded metamorphosed argillaceous and

siliceous sediments. This line lies about 3 miles distant from the western boundary of a large intrusive granitic mass. A small dolerite dyke occurs to the north of the Silver King Mine.

The Uaroo Group of Leases includes the Pedan (late M.L. 60), the Pedan South (late M.L. 61) and the Phoenix (late M.L. 52). The Dark Horse (late M.L. 32) was located about 1.5 miles south of the Phoenix.

The host rocks here are phyllite and slaty argillaceous rocks, which are garnetiferous in places, and banded quartzites. These have been faulted and fractured, and in places are intruded by large irregular barren quartz masses, and thinner more regular mineralised siliceous veins. Some post mineralisation faulting appears to have occurred.

The workings on the old Pedan Lease consist of a shaft about 100 feet deep which is located near a fault from which copper bearing veins strike off to the north and west-north-west (Maitland, 1909). The shaft was sunk on the south-eastern (down-dip) side of the eastern vein and cut the vein (which dips at about 75 degrees) at 6 feet beneath the surface. The vein, as exposed in an open cut just westwards of the shaft, is from 2 to 3 feet thick.

The vein on the western side can be traced in outcrop for about 500 feet, with the indications of copper decreasing westwards. An open cut, 30 feet in length and about 12 feet deep, shows the vein to be about 4 feet in width. The vein has been dragged around to the north-east at the eastern end where it is cut off by the fault.

The main shaft was evidently carried on down through the fault, and according to reports, encountered the vein on the western side at a depth of 85 feet. A westward crosscut at 30 feet also reached the ore-body, which was then driven on for a short distance to the south-west.

The ore consists of malachite, atacamite, chrysocolla, and tile ore, the outcrop being marked by boxwork gossan.

There are several other thin copper bearing veins in the vicinity generally striking with the country, but none has been found rich enough to work.

The Dark Horse (M.L. 32) lies 2.3 miles south-south-west of the Pedan main shaft. The vein has a maximum width of about 2 feet and crops out on a bearing of 153 degrees over about 24 chains, dipping steeply east. It has been tested by two shafts, one 16 feet deep on the outcrop, and the other 48 feet deep on the down-dip side. They penetrate the vein about 30 feet apart along the strike.

The ore consists of blue and green carbonate, and some chalcocite. Copper mineralisation along the vein is variable but generally weak, the two shafts having been sunk on the richest part.

One chain to the east of the deepest shaft a parallel vein about 8 inches in thickness carries copper carbonates over about 3 chains. Some other shallow workings in the vicinity have opened up similar narrow veins showing weak copper mineralisation.

About 2 miles southwards of the Dark Horse Lease a transgressive quartz vein carrying lead, silver and some copper has been worked by an adit, stopes and open cut. This is the old Silver King Lead Mine which was first opened up in 1901.

The vein is a quartz reef, striking approximately north and south and dipping to the east at about 70 degrees. It is about 6 chains in length and varies in width from 15 inches up to 4 feet. Lead occurs as galena, with carbonate and sulphate oxidation products. Silver and copper are accessory.

The adit intersected the vein, which was then driven on at an average depth below the surface of about 60 feet. The reef was stoped to the surface, and underhand stoped below the level over a length of about 75 feet to a depth of 80 feet.

The ore shoot occurs chiefly in an arenaceous bed, and plunges to the north-east at about 65 degrees.

The Walgo Copper Mine (M.L. 81), located 17 miles south-south-west of Uaroo Homestead, was prospected by means of two shafts and open-cuts, about 300 feet apart on a north-south line. The southern open-cut was 100 feet long and 12 feet deep, and the shaft sunk near the middle of this was about 90 feet down. A short drive at the 50 feet level reached 36 feet to the south. The northern open-cut is 20 feet in length and about 10 feet deep. The ore body was stoped upwards from the 30 feet level to the open-cut. The shaft was approximately 30 feet deep.

The ground here is similar to that at the Silver King Mine and the Pedan Lease, and copper mineralisation consists of malachite and cuprite, with iron oxide in a quartz gangue, averaging about 2 feet in width.

The Elsie Helen (M.L. 159) is located on a northwards continuation of the Pedan line of mineralisation and a few tons of ore were raised from here in 1956 and 1957.

The Westons Group—Westons Copper Mine is situated about 13 miles south-west from Uaroo. Copper indications occur in narrow quartz veins intrusive into slates and phyllites, extending intermittently over a zone about 400 feet wide and about 2,000 feet long.

The strongest copper mineralisation, however, in the form of carbonates and oxides with some chalcocite, (Simpson, 1952, p. 162) and a gangue of hematite, titanite, and biotite, appears to be confined to a belt about 40 feet wide (Maitland, 1909, p. 76). It is actually a composite vein, with thin parallel veins enclosing a considerable quantity of phyllite country rock.

The main workings consist of two open cuts about 250 feet apart excavated on a line of mineralisation which strikes about 330 degrees and dips steeply south-west.

The northern open cut is 32 feet long, about 10 feet wide and 15 feet deep, with some trenching on the north side.

The southern open cut is about 120 feet long, about 20 feet wide at the surface but about 6 feet wide at the bottom, and has an average width of 10 feet. Two shafts have been sunk in the floor of this cut. The main shaft according to Maitland (1933, p. 77) reached a vertical depth of 90 feet, without disclosing any ore of importance. Water level was at about 80 feet below the surface.

Another shaft about 35 feet to the south was sunk to about 37 feet, at which level a drive connected with the northern shaft.

East-west crosscuts 7 feet long, were cut from the northern shaft at 35 feet below the outcrop. These showed 6 feet of quartz formation, but a sample taken by Finucane and Sullivan over a width of 5.5 feet assayed only 0.42 per cent. copper and contained no gold.

The Euro Leases were situated about 7 miles north of Westons. The nature of the mineralisation is similar and extends over a length of about 1,300 feet in a zone up to 50 feet wide. Workings consist of a 50 feet shaft and numerous small excavations which disclosed low grade copper mineralisation in the form of malachite, azurite and chalcocite. Seleniferous Tetradymite (sulpho-telluride of bismuth) also occurs in small quantities.

The Victoria Leases are located about 17 miles north-west of Uaroo, and 9 miles southwards of Globe Hill. Mines Department records show that since 1915 this area has produced 146 tons of copper ore containing 55.24 tons of copper (Cu), and 33.75 tons of cupreous ore assaying 10.76 per cent.

The workings consist of a shaft about 70 feet deep with an open-cut about 60 feet long, on a vein which averages about 4 feet in width at the surface and can be traced in a north-east and south-west direction for some 600 feet.

The open-cut leads to the northern end into a rill stope which runs to near the bottom of the shaft. There are drives at the 20 feet, 40 feet, and 60 feet levels.

The ore, mainly in the form of malachite and azurite in a quartz gangue, averages about 3 feet in thickness in the workings although mineralisation extends up to a width of 11 feet in places.

A prospecting shaft about 20 feet deep has been sunk on the ore body a short distance to the north.

Production

Despite the widespread workings, very little tonnage is recorded as having been produced from the Uaroo Centre. It appears that some ore has been sold without returns being listed. For example, there is no record of production from Westons, but Finucane and Sullivan (1939, p. 7) stated "During 1937, 4.8 tons of hand picked copper ore were shipped from Onslow and several bags of ore were lying near the North Open-cut."

Table 40
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
			Long Tons	Long Tons	£A
1908	M.L. 52	Phoenix	6.50	1.94	114.00
1908	M.L. 60	Pedan	6.00	1.00	71.00
1909	M.L. 81	Walgo Copper Mine	10.75	4.31	259.00
1957	M.L. 159	Elsie Helen Copper Mine	4.59	1.46	325.40
1915	M.L. 88	Victoria Copper Mine	146.00	55.24	2,744.00
Total to the end of 1960			173.84	63.95	3,513.40

Average weighted assay = 46.8%.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Average Assay per cent. Copper	Value
1951	M.L. 148	Victory Copper Mine (late M.L. 88)	Long Tons 30·00	10·65	£A 319·67
1952	M.L. 148	Victory Copper Mine (late M.L. 88)	1·75	6·85	3,577·64
1956	M.L. 159	Kempton Bros. Elsie Helen	2·00	13·86	52·66
Total to the end of 1960			33·75	10·62	3,949·97

Assays and Mineralogy

The Uaroo Group.—Simpson (1952, p. 161) states "In the Long Tom Group the ore consists of atacamite, chrysocolla, malachite, and tile ore. A sample of green carbonate assayed:—Cu, 47·36 per cent.; Pb, 0·10 per cent.; Au, 1 oz. 5 dwts. 19 gr. per ton. The quantity of ore raised to the end of 1917 was 169·25 tons, yielding 62·49 tons of metallic copper."

Malachite is abundant in the copper ores of Uaroo, and also occurs to a slight extent in the lead ores.

Two samples from M.L. 5, assayed :

Copper, per cent.	25·14	5·71
Silver, ozs. per ton	1·63	0·41
Gold, ozs. per ton	trace	nil

Sample 1.—An intimate mixture of fine grained malachite, quartz, and a little limonite.

Sample 2.—Vughy chalcedonic quartz with films of malachite.

ANALYSES OF COPPER ORE

Locality	Nature of Ore	Copper	Lead	Gold	Silver
Uaroo		%	%	ounces per ton	ounces per ton
	Chalcocite, malachite, cuprite	54·96	....	Nil	21·09
	Chalcocite, malachite, cuprite	62·35	....	Nil	39·77
	Cuprite, malachite, chalcocite, chrysocolla	54·11	....	Nil	34·81
	Malachite, cerussite, etc.	29·88	4·9	Trace	29·55
	Malachite, cuprite, iron oxides and quartz	25·14	....	Trace	1·63
	Malachite, cuprite, iron oxides and quartz	5·71	....	Nil	0·41
	Malachite, cuprite, iron oxides and quartz	39·70	....	Nil	Nil
Valentine Copper Mine, 2 miles south of	Malachite, cuprite, iron oxides and quartz	9·21	....	Nil	Trace
	Malachite, cuprite, iron oxides and quartz	6·13	....	8 gr.	1·07

Referring to the old Pedan M.L. 60, Maitland (1909, p. 69) states "In November, 1907, a trial shipment of about five tons of the highest grade ore was raised, carted to Onslow, and shipped to England. According to the figures courteously given to me by Mr. Finch, it appears that the parcel weighed 5 tons, 19 cwts. 2 qrs. 1 lb." This ore assayed 21·63 per cent. copper. The assay on dry ore being:

Copper	....	20·33 per cent.
Silver	....	2 ozs.
Gold	....	0·20 ozs.

The Westons Group.—Three samples aggregating 15·66 feet at the bottom of the northern face of the North open cut, taken by Finucane and Sullivan (1939, p. 7) gave an average assay of 5·83 per cent. of copper with a trace of gold. A sample from a bench in the centre of this cut assayed 4·06 per cent. of copper and a trace of gold over 76 inches, but a sample from the southern face of the cut assayed only 0·40 per cent. of copper and a trace of gold over 56 inches.

At the 35 feet level crosscuts from the northern shaft a sample cut over 5·5 feet in quartz formation assayed only 0·42 per cent. copper and contained no gold.

Three samples cut from the southern shaft returned 0·59 per cent. of copper over 3·0 feet, 0·16 per cent. of copper over 34 inches, and 0·40 per cent. of copper over 48 inches. None of these contained any gold.

The Victoria Group.—The only assay information for this area is from Simpson (1952, p. 162) who states "A specimen from Victoria M.L. 94 (old 88), 9 miles south of Globe Hill, is composed of malachite and cuprite and assayed 40·3 per cent. copper."

Remarks

The copper mineralisation in the Uaroo area is known to occur in localities 15 miles apart in an east-west direction, and 17 miles in a north-south direction. Mineralisation is contained in steeply dipping quartz veins and lodes in metamorphosed argillaceous and siliceous sediments of the Mosquito Creek System.

As well as copper, there is gold, lead and silver mineralisation.

Small parcels of good grade copper ore have been produced in the past by prospectors who have hand picked the ore. From the assays given by Finucane and Sullivan, and from the fact that all of the workings have been abandoned at depths less than 90 feet, it is evident that the bulk of the ore now exposed is low grade.

However, because of the considerable area over which mineralisation occurs in a favourable environment, the author considers that the area is worthy of more detailed investigation using modern methods of prospecting.

THE RED HILL AND CANE RIVER DEPOSITS

The Red Hill Deposits are situated 68 miles south-east of Onslow in the Ashburton Goldfield. The Cane River Deposits are 22 miles south of this.

Official production figures show that the late M.L. 62 ("Cano") in the Cane River locality in 1907 yielded 175·5 tons of ore assaying 19·3 per cent. copper. It appears that some small parcels of ore have been won from the Red Hill ore-bodies, but there are no official records of these.

Mineralisation occurs in metasediments of Mosquito Creek age, which are unconformably overlain by flatly dipping Nullagine rocks.

Some of the following information is taken from Maitland (1909), Jones (1939), and Simpson (1952).

Access to these deposits from Onslow is 48 miles eastwards along the North-West Coastal Highway to Peedamulla Home-

stead, and thence 28 miles further eastwards by graded track to Red Hill Homestead. Station tracks lead north and south to the Red Hill and Cane River Deposits respectively. Approximate geographical co-ordinates of the Red Hill ore-bodies are:—

Latitude 21° 50' S.
Longitude ... 116° 5' E.

Reference may be made to the following maps :

1. Lands Department Lithograph 96/300.
2. Lands Department 10-Mile Topographic Series, Sheet 13, Onslow.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia, 1957.

Aerial photos and photo-mosaics are also available from the Lands Department.

Geological Information

The Red Hill Deposits.—These occur near the western edge of a dissected plateau consisting of siliceous dolomites, sandstones, and shales, resting unconformably on ferruginous quartzites and argillaceous rocks of the Mosquito Creek System. These latter rocks are the host to discordantly intrusive copper bearing quartz veins which strike north-easterly to easterly, and dip vertically. There are also some apparently concordant dolerite intrusives which are pre-mineralisation.

Westwards from the old workings a valley flat extends for a few miles until the eastern edge of the dissected upland, of which Mt. Darnell is a part, is reached.

There are two so-called mines, the northerly one being known as the Red Hill Copper Mine, and the southerly one as the Red Hill South Mine.

The Red Hill reef crops out along an east-west line for just over 1,000 feet, and has a maximum width of about 4 feet.

There are two old shafts, called the No. 1 (on the east) and the No. 2. According to Maitland (1909, p. 92) the No. 1 Shaft was carried down to a depth of 30 feet on the vein which had been opened out to the east and west for a distance of about 13 feet. The quartz was found to contain narrow copper and iron bearing seams. Values varied considerably, secondary mineralisation being concentrated in places into small bunches and kidneys of good ore.

No. 2 Shaft, about 60 feet to the west of No. 1, was sunk to a depth of 25 feet upon a bunch of copper bearing quartz which at the surface was 18 inches thick but gradually petered out. At the foot of the shaft, the quartz vein was 3 feet wide and carried an inch or two of low grade copper in a limonite and quartz gangue.

The shoot of ore on which the No. 1 Shaft was sunk occurs where the quartz vein cuts through a dolerite dyke about 25 feet wide.

The Red Hill South workings are on another quartz vein about 40 chains to the south which crops out over about 3 chains, striking 40 degrees and dipping vertically. As for the northern body, the main enrichment occurs where the vein passes through a band of dolerite.

Jones (1939) states that the shaft on this shoot was 28 feet deep and a drive had been extended some feet northwards. The vein averaged about 12 inches in width and over 5 months in 1937 four tons of 50 per cent. copper ore were mined.

Shallow excavations have been made on other small veins in the vicinity but all mineralisation exposed was of low grade.

The Cane River Deposits.—These are situated about 20 miles south of the Red Hill Deposits, and about 8 miles south of Red Hill Homestead.

The rocks in this vicinity consist mainly of quartz-sericite schists striking north-north-west and dipping at steep angles, and which probably belong to the Mosquito Creek System. These are unconformably overlain in places by flatly dipping siliceous dolomites of Nullagine age. Workings in this area are known as the Cane River, Rundle's Hill and Locke's Mines.

The Cane River Leases were pegged over flat ground on a quartz lode which crops out over 1,350 feet, striking 325 degrees, and dipping to the south-west at about 75 degrees. The lode consists of sheets and interlacing lenses of mineralised quartz enclosing a schistose matrix, which itself in places carries disseminated values. The maximum width of lode formation exposed was about 8 feet, with ore lenses up to about 2 feet 6 inches wide (Maitland, 1909, p. 84).

The ore is generally in the form of a quartz gangue, intersected by minute veins and lenses of copper pyrites and its decomposition products. Malachite was plentiful near the outcrop, and at places tile ore and chalcocite were important. The water table stands at about 40 feet depth.

Several shoots of ore were mined, most ore being extracted from the one at the southern end. At this place a shoot of ore about 140 feet long and about 30 inches wide has been mined to a depth of 42 feet. The so-called Nos. 1 and 2 Shafts, and another old shaft 30 feet north-east of the No. 1, are located on the shoot.

No. 3 Shaft, about 250 feet northerly of No. 1, was sunk to 42 feet on a shoot of ore about 2 feet wide. The ore was stoped to 20 feet. The controlling structure is well defined in the bottom of the shaft, but carries no ore. Several short, shallow excavations have been made between No. 2 and 3 Shafts.

No. 4 Shaft is about 115 feet northerly of No. 3, and reached a depth of 42 feet. At 33 feet the lode was driven on 42 feet northerly, and 40 feet southerly, and stoped to the surface. The width of ore varies from a few inches at the northern end, up to 3 feet at the southern end of the open stope.

No. 5 Shaft, 120 feet northwards of No. 4, is 42 feet deep and at the bottom a northerly drive extends for 14 feet. At this level Maitland (1909) states that a thin vein of good ore was exposed underfoot on the hanging wall of the lode.

Several pits and shafts have been sunk on the lode northwards of the No. 5 Shaft over a distance of about 550 feet. Mineralisation exposed in this section is of low grade.

The Rundle's Hill Deposits.—These are situated about 1.75 miles south-east from the Cane River Leases. Malachite, cuprite and chalcopyrite occur in a vertically dipping quartz vein which averages about 3 feet in thickness and can be traced over a distance of 1,350 feet along a line bearing 300 degrees. At the southern end the vein is intrusive into flatly dipping siliceous dolomitic rocks of apparently Nullagine age, which seem to overlie the steeply dipping phyllites and schists which are the host rocks at the Cane River Leases.

Near the south-eastern end of the vein, on the northern slope of Rundle's Hill, a shaft has been sunk to a depth of 18 feet. The vein here is about 3·5 inches wide and carries some malachite and chalcopyrite. Shallow excavations to the north-west of the shaft show a little copper in thin disseminated veinlets.

Other Deposits in the Vicinity—At a few other places a little excavation work has been done on showings of copper. These include Locke's "Mine", 3·5 miles north-west from the Cane River Mine. According to Maitland (1909) copper mineralisation occurs here in a quartz reef striking north-easterly at about right angles to the general strike of country rock, which is soft, fissile phyllite. A shaft reached a depth of about 28 feet, at which level a drive extends 14 feet to the north-east, the exposed mineralisation being about 12 inches wide.

The Big Blow is situated about 30 chains westwards from Locke's Mine. The name is derived from a large lenticular vein of quartz 7 to 8 feet in width which is one of a number of parallel veins carrying a few small lenses of copper ore. A few shallow holes have been dug on these.

Beechworth's, and Niven's, copper shows, situated northwards of the Red Hill Deposits consist of low grade copper mineralisation in quartz veins (Maitland, 1909). Beechworth's yielded a few tons of handpicked ore averaging about 30 per cent. Neither of these seem very promising.

Production

As stated, the only recorded production is from M.L. 62, one of the Cane River Leases. Maitland (1909) states that the ground covering the Cane River Copper Mine was first applied for in 1899. Twelve tons of good grade ore were sent to South Australia but heavy transport charges left the owners no profit. Altogether 44 tons of ore were raised during these early operations but the metallic copper yield is not known and the figure is not included in production statistics.

Jones (1939) states that 4 tons of 50 per cent. copper ore were mined from the Red Hill South Mine in 1937.

Table 41
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Copper Ore	Copper Content	Value
1907	M.L. 62	"Cano"	Long Tons 175·50	Long Tons 33·85	£A 2,126·00

Average Assay = 19·3%.

Assays

Some assays of Red Hill Copper Ores are given by Simpson (1952, p. 160) :

	Copper	Lead	Gold	Silver
	%	%	ounces per ton	ounces per ton
Malachite, cuprite, quartz	24·90	....	Trace	2·45
Malachite, cuprite, quartz	18·68	....	Trace	Trace
Malachite, cuprite, quartz	17·20	....	<i>Nil</i>	<i>Nil</i>
Malachite, cuprite, quartz	46·24	....	<i>Nil</i>	<i>Nil</i>
Malachite, cuprite, quartz	35·76	....	<i>Nil</i>	<i>Nil</i>
Malachite, cuprite, quartz	3·80	40·6	0·04	1·05

Referring to the northern Red Hill workings Maitland (1909) states: "The lode is a quartz reef containing narrow veins of ores of copper and iron, and in some cases secondary silica; a typical sample of this class of ore (7898) assayed in the Survey Laboratory 4.74 per cent. of copper. A much more ferruginous type of oxidised ore (7897) returned 28.15 per cent. of copper, whilst an average sample of the limonitic ore (7900) returned 14.54 per cent. of copper and 28.35 per cent. of iron."

For the Cane River Leases, Jones (1939) referring to the No. 2 Shaft, states that a composite sample from the Shaft and in the back of a 10 feet stope to the south-east, at a depth of 20 feet, assayed 7.11 per cent. copper for an average width of 18 inches.

A sample taken over 40 inches of quartz formation in the 18 feet shaft at Rundle's Hill assayed 1.66 per cent. copper. Four samples taken from pits along the north-western portion of the reef assayed from 1.60 to 3.46 per cent. copper.

Remarks

Despite the generally low grade mineralisation revealed at the limits of earlier workings, it cannot be assumed that the deposits are worked out. This applies particularly to the Cane River Lode. The reserves of carbonate ore, however, must be limited, and future development would depend on the successful testing of the primary ore beneath the water table by drilling along the length of the lode.

THE ASHBURTON DOWNS DEPOSITS

Introduction

Several tenements for copper are located in the Ashburton River Valley, within 12 miles east and west of Ashburton Downs Homestead. Since 1951 and up to the end of 1960, 23.7 tons of copper assaying 19.3 per cent. copper, and 21.66 tons of cupreous ore assaying 13.75 per cent. have been produced.

The deposits are copper bearing quartz veins intrusive into metamorphosed pre-Nullagine argillaceous and arenaceous sediments.

Information on the general geology of the area has been given by Maitland (1909), and Talbot (1926).

Ashburton Downs Homestead is about 200 miles by earth road south-easterly from Onslow, about 0.5 mile south of the Ashburton River. However, ore produced in 1960 has been road-hauled to Meekatharra rail-head, a distance of 350 miles, and then rail-freighted to Perth. Approximate geographical co-ordinates are:—

Latitude 23° 23' S.
Longitude 117° 2' E.

Reference may be made to the following maps:—

1. Lands Department Lithographs 92 and 93/300.
2. Lands Department 10-Mile Topographic Series, Sheet 10—Carnarvon.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Geological Information

Listed production has come from leases located south-east and south-south-east of the Homestead. These are in a thinly bedded sequence of argillaceous and arenaceous sediments to which Maitland (1909, p. 51 *et seq.*) gave the name Ashburton Beds. These probably belong to the Mosquito Creek System. They crop out in a large area of the Ashburton Valley, but are unconformably overlain to the north and south by Nullagine sediments and lavas.

They strike about west-north-west, and westwards and southwards of the Homestead they are highly inclined and show many small and large drag folds.

P.As. 264, 265 and 323 are located about 12 miles east-south-east of the Homestead, and about 5 miles northwards of Prismoid Hill.

In this area the sediments have been invaded by copper bearing quartz veins, which may be traced by discontinuous exposures on the south western sides of low rounded hills over a distance of about 2 miles in an easterly direction.

Both almost horizontal, and near vertical veins can be seen, the former being extensions from the feeder channels along the layering of the sedimentary beds, which in this locality dip to the north-east (with local undulations) at generally 30 degrees.

Due to the undulating nature of the beds and to the hilly terrain it is difficult to assess the continuity of any individual quartz lens, but it seems likely that a number of lenses of limited areal extent exist over a vertical zone of unknown thickness.

Workings at the time of the author's visit (September 1960) consisted of two areas of bulldozed ground, one near the western and one near the eastern end of the line of exposure, and a shallow pit near the western end. In the pit malachite and chalcocite, with a little chalcopyrite in a quartz gangue liberally stained with iron oxide, is exposed over a vertical thickness of about 3 feet. This is overlain by 4 to 5 feet of leached argillaceous rock (slaty in places). About 20 feet higher up the hill, across the crest, the original iron gossan was bulldozed off to a depth of about 4 feet revealing a layer of copper ore up to 3 feet thick in places, but generally of a patchy nature.

Some of the steeply dipping feeder veins can be seen to carry copper mineralisation in places. Crystals of barite were observed in one or two veins.

P.A. 263 is located near the junction of Secret Creek with Wandarray Creek about 2 miles south-east of Mt. Blair, in the same sequence of rocks as the deposits discussed above.

This deposit was not seen by the author but reports indicate that copper mineralisation occurs in a steeply dipping east-west quartz vein which was worked by an open cut 3 feet wide, 30 feet long, and 9 feet deep in the centre. A thin parallel vein about 15 feet to the south shows some copper carbonates on the surface.

A total of 3.65 tons of 42.2 per cent. copper ore were produced from here in 1961, but the deposit has not been worked since.

At about 7 miles south-westwards of the Homestead copper mineralisation in a quartz vein can be traced discontinuously over a distance of about 1 mile in an east-west direction. The vein crops out mostly near the crests on the northern slopes of a series of hills trending east-west, in which thin-bedded ferruginous sandstones and argillaceous rocks dip at steep angles to the south. There is some drag folding.

The vein, which is up to 4 feet wide dips south with the bedding. In one place supergene enrichment has disseminated copper in a patch up to 30 feet wide.

There were no excavations on this deposit at the time of the author's visit, but it was subsequently taken up as M.Cs. 25 and 26, surrounded by Temporary Reserve 2306, and some production was made during 1961.

At about 1.75 miles to the south-west of this deposit, on the eastern side of Stockyard Creek, a hill rises to a height of about 300 feet above the Creek. Along its crest, on an east-west line, a quartz vein crops out over a distance of about 5 chains, and carries fair copper mineralisation in places. A small excavation about 7 feet deep exposes malachite and chalcocite enrichment over about 4 feet in width.

An adit driven into the hill for about 60 feet from the south-west side, about 150 feet below the crest, showed only faint traces of carbonate and no defined vein.

Other copper bearing veins are reported to occur on the eastern slopes of Mt. Blair, and also about 1 mile south-east of the Homestead but none of these has been found rich enough to mine.

Production

Table 42
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Average Assay per cent. Copper	Value
1951	P.A. 263	Maloney, J., and Simmonds, G. W. J.	Long Tons 3.65	Long Tons 1.54	....	£A 229.85
1951	P.As. 264, 265	Iverson, A. E.	20.05	2.54	....	263.00
Total to the end of 1960			23.70	4.08	19.3	492.85

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Units of Copper	Average Assay per cent. Copper	Value
1951	P.A. 264	Iverson, A. E.	Long Tons 9.66	130.31	13.49	£A 174.25
1960	P.A. 323	Devenish, G., and Cumming, C.	12.00	167.65	13.97	320.95
Total to the end of 1960			21.66	297.96	13.75	495.20

Remarks

Copper mineralisation is known to occur over a belt of sedimentary country about 20 miles long in an east-west direction and 10 miles wide, in the vicinity of Ashburton Downs Homestead. The copper occurs in thin quartz veins which are usually, but not always, concordantly intrusive into the sedimentary beds.

In the western part the sediments dip steeply to the south and are very much dissected by water courses forming hills up to about 300 feet high. The veins are thin, about 3 or 4 feet average width, with generally weak gossan development.

In the eastern part the veins are generally about the same thickness, but dip flatly in the sediments. There is a chance therefore that significant supergene enrichment could occur over a considerable area at a reasonably shallow depth.

OTHER DEPOSITS IN THE ASHBURTON GOLDFIELD

The following deposits were not visited by the author, and these notes have been collated from reports by Maitland (1909), Talbot (1926), Jones (1939) and Departmental files.

Blacks Copper " Mine "

This deposit is located about 6 miles north-east of Wyloo Station, approximately 120 miles south-east of Onslow, in an epidiorite member of the Mosquito Creek System. Disseminated copper mineralisation (principally malachite) has been introduced by interlacing quartz veinlets intrusive into the shattered greenstone. Talbot (1926, p. 40) stated after an examination of the old workings and the hill on which they occur, that the mine was valueless, and would become valuable only if it were possible to treat low grade ore on the spot.

It appears that a few tons of ore were raised, but there is no official record.

The Yarraloola Deposits

These are located 3 miles south-east of Yarraloola Station Homestead, on the northern bank of the Robe River.

According to Jones (1939, p. 13) the lode consists of a quartz formation containing malachite and chalcopyrite in quartz-sericite schists. The lode strikes at 20 degrees, dips to the north-west at 80 degrees, and crops out over a length of 950 feet, passing under detritus and alluvium to the south-west. It has a faulted cut-off at its north-eastern end.

The main vein and some other parallel ones in the vicinity have been tested by shallow pits and an open cut. Jones concluded it was probable that small tonnages of high grade copper ore might be exposed if the old workings were cleaned out.

About 14 miles south-west of Yarraloola a shaft has been sunk on a quartz reef showing traces of copper ore. The vein crops out over 700 feet along a bearing of 335 degrees and dips north-easterly at about 70 degrees. Other veins in the vicinity also show some low grade copper mineralisation.

FUTURE EXPLORATION IN THE ASHBURTON GOLDFIELD

Prospecting for copper in the Ashburton Goldfield has followed the typical pattern in Western Australia, that is, surface exploration by prospectors mainly, followed by surface sampling in mineralised areas, and shallow excavations, which have not exceeded 100 feet depth, along the line of the deposit.

Most of the deposits are narrow bodies, generally less than 6 feet in width, and rich shoots of oxidised ore have been worked out at less than 100 feet. At some places, for example Westons and Ashburton Downs, thin parallel bedded veins extend over a zone and it seems likely that the reason for this is the incompetency of the sedimentary host rocks as well as the distance from the mineralising source.

That the source rock was sufficiently rich in copper solutions to form, under suitable conditions, a large deposit of economic grade, seems evident from the widespread low grade mineralisation. The locating of an economic deposit of any appreciable

size may therefore depend upon accurately resolving the structure and lithology, and sub-surface exploration by drilling or geophysical methods.

Present indications may not be regarded as sufficient to encourage the spending of the considerable amounts of money and time involved in such programmes. As a preliminary step, however, the drilling at depth of such deposits as the Cane River Lode and the near-horizontal veins east of Ashburton Downs might be well worth while.

THE GASCOYNE GOLDFIELD DEPOSITS

SUMMARY

Only two copper deposits have been worked in the Gascoyne Goldfield. These have produced a total of 14.08 tons of copper ore and cupreous ore since the first production in 1953.

At both localities the host rocks are pre-Nullagine metamorphosed sedimentary rocks. The Mangaroon deposit occurs in the same belt of rocks as Westons and Maroo but about 80 miles to the south. At Mangaroon copper occurs in association with lead and gold.

Table 43
COPPER AND CUPREOUS ORE PRODUCTION IN THE
GASCOYNE GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1953	4.04	0.82	101.05
1954-60	<i>Nil</i>	....	....
Total	4.04	0.82	101.05

Average assay = 20.29 per cent.

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Copper	Value
	Long Tons			£A
1953	7.94	77.40	9.75	116.10
1954-1957	<i>Nil</i>	....	....	....
1958	2.10	13.96	6.65	16.05
1959-1960	<i>Nil</i>	....	....	....
Total	10.04	91.36	9.10	132.15

THE MANGAROOON STATION DEPOSIT

Introduction

This deposit was not visited during this survey, and the following information has been taken from various sources including Departmental files.

Mangaroon Station Homestead is located on a tributary of the Lyons River. By road it is 177 miles from Onslow, and 217 miles from Carnarvon. Mineral Claim 4H is located about 9 miles east of the Homestead, on the western side of Murlee Creek, about 4 miles northwards of its junction with the Lyons River. Approximate geographical co-ordinates are :—

Latitude 23° 55' S.
Longitude 115° 45' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 78/300.
2. Lands Department 10-Mile Topographic Series, Sheet 10, Carnarvon.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Broad reference to the general geology may be found in Survey Bulletin 85 (Talbot 1926).

General Information

As previously stated this deposit occurs in metamorphosed pre-Nullagine sedimentary rocks. Copper occurs in a quartz vein which also carries gold and lead. The gold and lead content may be more important than the copper. A crushing of lead ore (galena) put through the Northampton State Battery in January 1955, yielded 2 oz. 17 dwt. of gold. Only the course gold was recovered.

As can be seen from the following table the only copper production was in 1958.

Production

Table 44
CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1958	M.C. 4	McDonald, A.	Long Tons 2.10	6.65	13.96	£A 16.05

Remarks

This deposit appears to be small and of little significance as far as copper production is concerned.

THE DALGETY DOWNS DEPOSIT

Introduction

This deposit has not been seen by the author. The following information has been taken from various sources, including Departmental files.

Dalgety Downs Homestead is located about 17 miles east-south-east of Mt. Dalgety, near the centre of the base of a north-erly pointing triangle formed by the course of the Gascoyne River. The road distance to Carnarvon, the nearest port, is 185 miles, and to the railway at Mullewa it is 264 miles. Prospecting Area 936H is located about 4 miles south-west of the Homestead.

Approximate geographical co-ordinates are:—

Latitude 25° 10' S.

Longitude 115° 45' E.

Reference may be made to the Lands Department Lithograph 73/300, and to the map references given for the Mangaroon Deposit.

General Information

No detailed information is available regarding the geology of the deposit on Prospecting Area 936H, which has produced a total of only 12 tons of copper ore.

On his general geological map Talbot (1920) includes the area in the sedimentary sequence which is now regarded as equivalent to the pre-Nullagine Mosquito Creek System.

Johnson (1950) has mapped an extensive area of "gneiss" to within 5 miles of the locality on its eastern side. Johnson defines the gneiss as "Mainly granitised greenstones or sediments. Includes frequent small ungranitised patches of greenstone or sediments. May include some granite or sandplain."

The general area has been known for some time to be copper bearing. Simpson (1952, p. 166) states: "Malachite has been found at Dalgety Downs, 3.5 miles west 30 degrees north of trig. station K.25. The rock in which the copper occurs belongs to the Gascoyne Series and is composed of quartzites, schists, and limestones, which have been intruded by numerous acid dykes, many of which contain a considerable amount of tourmaline. Copper was most abundant in a very granular quartz rock, in which the copper had been deposited round and not within the quartz grains. This undoubtedly points to secondary deposition probably resulting from the decomposition of pyrites which contained traces of copper."

Production

Table 45
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1953	P.A. 936H	Richards, H. R.	Long Tons 4.04	Long Tons 0.82	£A 101.05

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1953	P.A. 936H	Richards, H. R.	Long Tons 7·94	9·75	77·40	£A 116·10

Remarks

As far as is known this deposit has little chance of being developed into an economic mine.

FUTURE EXPLORATION

The geology of this Goldfield, as far as the copper producing potential is concerned, is inadequately known. The most that can be said is that copper mineralisation has taken place in a sequence of metasedimentary rocks which are favourable host rocks elsewhere. At Mangaroon the copper is associated with gold and lead.

The Field may be worthy of more detailed investigation, particularly in the vicinity of Mangaroon and northwards of this.

THE PEAK HILL GOLDFIELD DEPOSITS

SUMMARY

Most of the worked copper deposits in the Peak Hill Goldfield consist of lenticular, copper-bearing quartz veins intrusive into Precambrian metasediments. These host rocks are, in most localities, considered to be probably equivalent to the Mosquito Creek System. At Jimblebar the host rocks may belong to the Archaean Older-Greenstone sequence.

The most important of these deposits, as far as the past production and future prospects are concerned, are those in the vicinity of Thaduna, Igarari, and Kumarina. These are all in sedimentary areas with extensive soil cover, which makes attempts to define extensions or repetitions of the ore bodies very difficult. These areas should lend themselves well to geochemical and geophysical prospecting techniques.

The Jimblebar deposit consists of disseminated low grade copper mineralisation over a fairly extensive surface area in metamorphosed rocks which in this locality are predominantly sedimentary, but contain some basic igneous developments.

Practically all of the production has come from above or near the water table, which is generally between 50 and 100 feet in the present workings. The ore minerals have been green and blue carbonates, with some oxides and secondary sulphides.

Accessory gold, silver, and lead is known to occur in places.

The following table summarises the types of deposits in this Goldfield.

Table 46
TYPES OF DEPOSITS IN THE PEAK HILL GOLDFIELD

Deposit		Ore Produced		Remarks
Locality	Tenement	Copper Ore	Cupreous Ore	
Jimble Bar	M.C. 91P	Long Tons	Long Tons 32·08	Disseminated low grade mineralisation in fractured schistose Archaean sediments.
Ilgarari	Various	639·6	623·58	Narrow zone of steeply dipping discordant quartz veins in Precambrian metasediments.
Kumarina	Various	467·44	1,332·68	Steeply dipping discordant narrow quartz veins in interbedded schistose sedimentary and basic igneous rocks. Accessory gold and silver.
Thaduna	Principally M.L. 68P, with various others	126·25	20,882·26	Lode type disseminated mineralisation in a near vertical dipping graphitic (and occasionally siliceous) ore body, discordantly intrusive into Precambrian metasediments.
Horseshoe and Mulgal	Various	12·20	91·15	Steeply dipping narrow quartz veins in metasediments.

Table 47
COPPER AND CUPREOUS ORE PRODUCTION IN THE
PEAK HILL GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1914	112·70	47·24	2,409
1915	237·58	102·41	7,618
1916	250·93	73·31	8,268
1917	287·84	85·93	9,683
1918	76·28	25·49	2,480
1919	14·39	4·54	353
1920	35·39	14·39	1,401
1921-1939	.....	.....	.....
1940	14·99	2·09	152
1941	.....	.....	.....
1942	13·25	1·63	268
1943-1948	.....	.....	.....
1949	8·19	3·73	498
1950-1955	.....	.....	.....
1956	79·08	26·72	8,444
1957	96·16	31·07	7,365
1958	68·49	9·90	949
1959-1960	.....	.....	.....
Total	1,295·27	428·45	49,888

Average weighted assay = 33·0%.

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Copper	Value
	Long Tons			£A
1944	80·00	992·80	12·41	547·00
1945	257·00	3,000·67	11·67	1,974·00
1946	72·00	630·00	8·75	447·00
1947	508·00	4,167·92	9·20	3,103·00
1948	258·65	2,940·50	11·36	2,204·00
1949	113·00	1,225·96	10·58	929·00
1950	93·90	2,102·89	22·28	2,303·85
1951	22·00	550·00	25·00	660·00
1952	229·04	4,079·13	17·81	7,079·98
1953	163·30	1,116·97	6·84	1,140·00
1954	328·57	3,274·83	9·96	5,914·66
1955	1,797·85	17,775·51	9·89	30,058·58
1956	2,443·12	22,305·25	9·13	37,838·79
1957	1,464·37	13,192·72	9·01	20,352·10
1958	4,624·54	34,893·33	7·55	51,874·55
1959	6,178·47	49,425·20	7·99	73,923·30
1960	4,258·94	33,018·34	7·75	51,888·70
Total	22,901·75	194,692·02	8·50	292,238·51

THE JIMBLEBAR DEPOSIT

Introduction

Jimblebar is situated about 283 miles by road north of Meekatharra, which is the railhead for that area. In 1959, 32 tons of cupreous ore assaying 7·27 per cent. copper was produced from M.C. 91P.

Access is via the Great Northern Highway to the No. 43 Well, 32 miles northwards of Mundiwindi, and thence about 12 miles by track westwards through the abandoned Jimblebar State Battery site. Jimblebar was the centre for gold produced in the area from 1919 to 1935.

Approximate geographical co-ordinates are:

Latitude 23° 28' S.

Longitude 120° 07' E.

Reference may be made to the following maps :

1. Lands Department Lithograph.
2. Lands Department 10-Mile Topographic Series, Sheet 11—Nabberu.
3. Geological Sketch Map of Western Australia. Geol. Survey West. Australia, 1957.

This deposit was not examined by the author and the following information has been collated mainly from a report by Sofoulis (1956), and Departmental files. References to the general geology have been made by Talbot (1920) and Finucane (1939).

Geological Information

The deposit occurs in a hill comprised of metamorphosed steeply dipping sandstone, quartzite and shale which strike north-easterly, and dip south-easterly at about 70 degrees. Apparently conformable bands of schistose basic rocks (probably sills) are included with the sediments. Granite crops out about 1 mile to the south of the hill, which lies in a fork of the headwaters of the northwards flowing Copper Creek (Finucane, 1939, Plate 1, Sheet 1). The host rocks are older than the granite, and probably are a predominantly sedimentary development of the Archaean Greenstones. They are garnetiferous in places.

Copper mineralisation can be seen along the hill over a length of about 1,500 feet, and a width of up to 150 feet. Sofoulis (1956) states that "The schists vary in colour from green-black-brown and grey, and carry frequent stainings, encrustations, veinlets, disseminations, leachings and coatings of the various copper mineral forms. Copper minerals recognised include malachite, cuprite, tenorite, chalcocite, 'peacock' bornite and chalcopyrite."

Joints, fractures, shears, and bedding planes carry some oxidised copper minerals, and patches of both massive and box-work iron gossan occur on the surface in places.

Numerous quartz veinlets carrying some copper occur along these partings.

A 30-foot adit was driven into the hill on the northern side about 220 feet north-east of its highest point. It shows only traces of copper. Other work consists of scattered pits and trenches across and around the hill.

Drilling

Two holes were diamond drilled into the deposit in 1957. These were drilled from the one site, on the south-eastern side of the hill, located 350 feet plan distance, bearing 137 degrees from the portal of the adit on the north-western side of the hill. Hole A1 was drilled on an azimuth of 346 degrees, and Hole B1 on an azimuth of 317 degrees. Both were depressed 45 degrees.

Complete details of the drill holes such as the core logs, assay results, and final depths are not available at the Survey, but it is understood that the core showed only low grade mineralisation.

Production

Table 48
CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Average Assay per cent. Copper	Units Copper	Value
1959	M.C. 91P	Copper Knob Pty. Ltd.	Long Tons 32·08	7·27	233·42	£A 318·40

No production in 1960.

Remarks

It appears that further exploratory work on this deposit is not justified at present.

THE ILGARARI DEPOSITS (INCLUDING BULLA DOWNS)

Introduction

This centre is about 100 miles north-east of Peak Hill in the Peak Hill Goldfield. The first discovery of copper in the vicinity of Ilgarari was made in 1913 and the Area received a good deal of attention from prospectors. The surface ore was rich, consisting of oxides, carbonates, and silicates, and it was hand picked and the resultant material carted by camel teams to the railhead at Meekatharra.

Access to Ilgarari is 178 miles north-east of Meekatharra along the Great Northern Highway, and thence 15 miles via the Ilgarari Homestead Road.

Approximate geographical co-ordinates are:—

Latitude 24° 23' S.
Longitude 119° 35' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 80/300.
2. Lands Department 10-Mile Topographic Series, Sheet 11, Nabberu.
3. Geological Sketch Map of Western Australia. Geol. Survey, West. Australia 1957.

Aerial photographs are available from the Lands Department. Reference to the geology and deposits of the Ilgarari Centre may be found in reports by Talbot (1920), Talbot (1926), Matheson (1940), and Simpson (1952).

Geological Information

The host rocks of the Ilgarari copper deposits have been considered to belong to the Nullagine (Upper Proterozoic) system (Talbot, 1914 and Matheson, 1940). The present writer however thinks that they belong to pre-Nullagine sedimentation.

The workings are situated on a featureless alluvium-covered flat, with sparse mulga vegetation. The few outcrops consist of quartz and iron-stone caps along the lines of mineralisation. The gossans are weakly developed but occur, in a zone up to 50 yards wide, over a length of about 100 chains. The distribution of the veins is shown by Talbot (1914, Plate XVIII).

The sediments as seen in the workings are finely banded flatly dipping shales. These are faulted over a zone striking 65 degrees, and the fault lines are intruded in places by copper-bearing quartz veins up to almost 4 feet in thickness which dip steeply to the south-east. There is some drag on the sediments near the north end of the northern open cut showing that the eastern block has moved downwards.

The exposed ore bodies consist of a gangue of cellular quartz, kaolin and limonite, impregnated by copper minerals. The main ore minerals are malachite and chalcocite, in small bunches, lenses and seams. Associated with these, and also in places in the country rock, are chrysocolla, azurite, cuprite and tenorite.

The bulk of the production has come from the old "Sons of Gwalia" Lease, later 64P, near the centre of the line of outcrop. The ore body has been opened up on the lease at frequent intervals over a distance of about 1,000 feet by a series of narrow open stopes and shafts down to the water level at a depth of about 35 feet. The vein ranged from 1 foot to 3 feet 9 inches in thickness, and carried small irregular shoots of oxidised ore. The workings do not extend into the primary sulphide ore.

Other workings on the line of mineralisation are similar to those on the Gwalia Lease but are not so extensive.

The "Butcher Bird" Lease, late M.L. 41P, is located about 30 chains east of the 109 mile peg on the old Peak Hill-Nullagine telegraph line, that is about 9.5 miles south-south-east of the Ilgarari leases. It is situated on a soil covered flat and the ore body crops out as a poorly developed thin band of siliceous iron-stone gossan. It strikes at about 65 degrees, parallel to the Ilgarari veins, and dips vertically in shaley argillaceous sediments in which, as far as can be seen, the bedding is close to horizontal.

Near the centre of the old lease a shoot of ore about 100 feet long and 3 feet wide has been worked to a depth of 20 feet. About 200 feet south-westwards of this another shoot of ore was worked over a length of 20 feet and a width of 3 feet, to about 20 feet.

Fairly large dumps of rejected material show that considerable hand picking was necessary. This material carries some malachite, azurite, chrysocolla, and chalcocite in a gangue of quartz, kaolin and limonite.

Several copper bodies have been prospected in the vicinity of Bulla Downs Homestead, which is 23 miles almost due north of Ilgarari Homestead. Seventy-eight tons of ore were produced from the late M.L. 36P in 1915-1916, but these workings could not be located and identified.

At a place about 7 miles east-north-east of the Homestead a small copper-bearing vein strikes almost east-west and dips northerly at about 75 degrees. It has been opened up by four shafts over a length of about 180 feet, and carries malachite, chrysocolla and copper oxides over an average width of 2 feet. The workings extend to a depth of 25 feet.

A limonite gossan about 20 feet wide and 10 chains in length, striking at 60 degrees, occurs some 12 chains east-south-east of the above workings. There are no surface indications of copper mineralisation although it occurs in the same host rock, that is, interbedded sandstones and shales of variable dip, as the deposit to the west.

The "Hard to Find", M.L. 46P, lived up to its name and could not be located by the writer. It produced 2 tons of copper ore in 1917.

Production

Table 49
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1914	M.Ls. 10P, 11P	Sons of Gwalia South Leases	Long Tons 2.87	Long Tons 1.04	£A 68.00
1914-20	M.L. 9P	Sons of Gwalia	458.49	169.89	15,680.00
1915-16	M.L. 36P	Bulla Downs	78.61	20.42	1,977.00
1916-18	M.L. 41P	Butcher Bird	36.80	8.33	949.00
1917	M.L. 46P	Hard to Find	2.00	0.81	81.00
1917-18	M.L. 35P	Burra Copper Mines Ltd.	25.84	8.85	943.00
1940	P.A. 615P	Owen, E. L.	7.49	1.00	81.00
1940	P.A. 713P	Reid, R.	7.50	1.09	70.80
Total to the end of 1960			639.60	211.43	19,849.00

Average weighted assay = 33.0%.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1948	L.T.T. 1P/48	Edwards, M.	Long Tons 177.00	12.00	2,124.00	£A 1,593.00
1948-49	M.C. 27P	Oma, E. C.	95.45	11.61	1,118.30	839.00
1950	M.C. 37P	Edwards, M. R., Hilditch, A. S.	32.00	22.00	704.00	640.00
1952	M.C. 35P	Edwards, M.	15.65	7.40	115.81	130.68
1954	M.C. 60P	Edwards, M.	45.82	11.82	541.81	760.35
1955-56	M.C. 64P	North End G.M. Syndicate	211.55	9.38	1,984.48	3,271.95
1956	P.A. 854P	Edwards, R. W.	37.66	11.32	426.15	830.55
1959	L.T.T. 1P/58	Smith, R. J.	8.45	7.95	67.18	104.00
Total to the end of 1960			623.58	11.3	7,081.73	8,169.53

Assays and Mineralogy

The following mineral determinations were made by the Government Chemical Laboratory on a suite of specimens collected by Matheson (1941). The present writer has abbreviated the description in places.

Registered No.	Lab. No.	Locality	Determination	Remarks
2/2057	8280	Dump of S.W. shaft. Truman's Show. 13 miles N.N.E. of Ilgarari	Chalcocite with disseminated malachite and crust of chrysocolla	Rich ore.
.....	8281	From outcrop S.E. of workings — 7 miles E.N.E. of Bulla Downs Homestead	Copper, nil	Limonic gossan.
2/2043	8282	Sons of Gwalia Lease, Ilgarari	Azurite, cuprite and malachite	Rejected vein material.
.....	8283	Same as 8281	Copper, nil	Limonic gossan.
2/2058	8284	5 chains S.E. of Truman's Show	Sericitised felspar	Cellular quartz with white mineral.
.....	8285	Same as 8281	Copper, nil	Limonic gossan.
2/2059	8287	From Sons of Gwalia Lease Ilgarari	Chrysocolla, chalcocite, malachite, temerite	Vein material.
2/2044	8288	Same as 8287	Chalcocite, malachite, and chrysocolla	Vein material.
2/2049	8292	Dump of most S.W. Shaft M.L. 41P Ilgarari	Limonite, malachite, quartz, opal chrysocolla	Rejected vein material.
.....	8293	From N.E. workings on M.L. 35P, Ilgarari	Finely crystalline gypsum with a little quartz, psilomelane, limonite, calcite and kaolin	The gypsum has probably been formed by alteration of calcite in lode channel.
2/2062	8294	S.W. Shaft Truman's Show	Chrysocolla, cuprite, malachite	Vein material.

The 639.60 tons of copper ore produced from these deposits gave an average assay of 33 per cent., and the 623.58 tons of cupreous ore averaged 11.3 per cent.

Remarks

The above deposits occur in a succession of argillaceous and arenaceous sediments which are metamorphosed generally to a low grade and which vary in dip from horizontal to almost vertical. These have been correlated with the Nullagine System by

various geologists, but the present writer is inclined to favour a pre-Nullagine classification.

The copper mineralisation occurs in generally discordant, steeply dipping, narrow quartz veins. Outcrops are poor and the topography is flat to undulating with a fairly widespread soil cover. Geochemical methods would be the best prospecting technique in this area.

THE KUMARINA DEPOSITS

Introduction

Copper discoveries were made at Kumarina (previously known as Humphrie's Find and Wonyulganna) in 1913. This locality is 24 miles south of Ilgarari, and 160 miles northwards of the railhead at Meekatharra. Access is via the Great Northern Highway to a point about 20 miles northwards of the crossing over the northern branch of the Gascoyne River, and thence westwards for 5 miles by graded track.

At the time of the author's visit, a crushing and screening plant was in operation at the locality, operated by Mr. T. L. Parkinson, treating small parcels of ore from Balfour Downs and Red Hill.

Approximate geographical co-ordinates are:—

Latitude 24° 43' S.

Longitude 119° 32' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 80/300.
2. Lands Department 10-Mile Topographic Series, Sheet 11, Nabberu.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

The following published reports contain general and particular references to the Kumarina Deposits: Talbot (1914, 1920, 1926), Matheson (1941), and Simpson (1952).

Geological Information

The line of copper mineralisation at Kumarina occurs in low-lying almost flat ground, bounded, about two miles to the north of the workings, by the southern edge of the Collier Range which is composed of beds of sandstone and shale which dip at generally low angles to the north.

At about 20 chains south-westwards of M.C. 34P (late Wonyulganna M.L. 3P), there is a low laterite capped hill of decomposed schistose greenstone near which the main line of mineralisation appears to terminate.

The ore body is a quartz vein (or veins) striking north-east and dipping steeply northwards, and attains a width of 30 feet in places (M.C. 34P). At its north-eastern end it disappears beneath an alluvium cover on low, scrub covered ground. It appears to be discordantly intrusive into a series of fairly thinly bedded

metamorphosed sandstones and shales, and weathered schistose greenstone. However the vein outcrop and gossan is irregular and spasmodic through soil and detritus, therefore, and also partly due to the high degree of weathering, the structural relationship of the intrusive and its host is difficult to determine.

The workings extend over about 32 chains as a series of shafts, pits, and open cuts, the deepest of which (on M.C. 63P) has reached a depth of 160 feet, and has been opened up over a length of about 650 feet at the surface. Most of the older workings, however, are above the water level which occurs at about 50 feet.

The vein at 160 feet depth on M.C. 63P is 2 feet wide, but at the surface in one place it has been worked to a maximum width of 15 feet. The form of the mineralisation on this lease is typical of the Group, and consists in the upper levels of malachite, azurite, chrysocolla, copper oxides and chalcocite. Primary sulphide, and some bornite, increases with depth. Pyrite also occurs in the deeper levels.

Production

Table 50
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1914-15	M.L.s. 29P, 30P, 31P	Two Sisters Leases	Long Tons 64.04	Long Tons 30.93	£A 1,466.00
1914-15	M.L. 32P	Resurgam	25.88	8.94	587.00
1916-17	M.L. 31P	Two Sisters North	115.76	31.40	3,594.00
1917-20	M.L.s. 37P, 38P	Sonia and Diana Leases	135.04	47.26	4,807.00
1949	M.C. 34P	White, A. F.	8.19	3.73	498.25
1956-57	M.C. 43P	Parkinson, L. T.	118.53	51.07	14,517.82
1958-60	<i>Nil</i>				
Total to the end of 1960			467.44	173.33	25,466.07

Average weighted assay = 37.0%.

CUPREOUS ORE

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1948	L.T.T. 5P/48	Broun, W. H.	Long Tons 46.20	10.0	462.00	£A 345.00
1949	L.T.T. 1P/49	Wright, E. A.	53.00	8.72	462.16	356.00
1950-51	M.C. 34P	White, A. F.	77.50	24.27	1,880.89	2,255.85
1952-59	M.C. 43P	Parkinson, T. L.	383.55	27.00	10,356.32	27,839.68
1954	M.C. 59P	Parkinson, T. L.	60.00	21.00	1,260.00	3,330.00
1955	P.A. 850P	Parkinson, T. L.	20.95	14.00	293.30	786.80
1955-60	M.C. 63P	Parkinson, T. L.	691.48	17.09	11,818.26	30,498.95
Total to the end of 1960			1,332.68	19.9	26,532.93	65,412.28

Assays and Mineralogy

The following mineral determinations were made by the Government Chemical Laboratory on a suite of specimens collected by Matheson (1941) :

Registered No.	Lab. No.	Locality	Determination	Remarks
....	8286	From dump of most southerly shaft late M.L. 7P (now 63P)	Principally fibrous gypsum with a little calcite and a trace of kaolin and limonite	The gypsum has probably been formed by alteration of calcite in lode channel.
....	8289	Dump of Main Shaft M.L. 37P (old Sonia Lease)	Chalcopyrite, limonite, quartz, aragonite, malachite	Probably represents primary sulphide ore.
2/2060	8290	Same as 8289	Limonite, chalcopyrite, malachite	Rejected vein material.
2/2061	8291	From shaft dump M.L. 3P (now part 34P)	Quartz, malachite, chalcocite, chrysocolla	Rejected vein material.

Two specimens from the Kumarina Leases gave the following results :—

1. Malachite with a little azurite, chrysocolla and quartz—Cu, 36.02 per cent. ; Au, nil ; Ag, 3 dwt. 11gr. per ton.
2. Liver ore in dark red finely granular masses, from the Seward M.L. 3P (now partly M.C. 34P), Cu, 43.31 per cent. ; S, 1.80 per cent. ; CO₂, 11.52 per cent. ; Fe₂O₃, 23.39 per cent. ; this is equivalent to malachite 58 per cent. ; chalcocite, 9 per cent. ; cuprite, 3.5 per cent. ; limonite, 26 per cent. ; gangue, 3.5 per cent.

Remarks

At Kumarina a discordantly intrusive, narrow quartz vein or veins, carries copper mineralisation with minor accessory silver and probably also gold over a strike length of about 32 chains. The water table occurs at about 50 feet, but significantly, secondary sulphide (chalcocite) occurs down to a depth of 160 feet. The area is generally mantled with soil and talus, and possibly younger bedded formations, and the gossan and outcrop on the known ore body is not well developed. It is possible that obscured deposits in the vicinity might be detected by geochemical or geophysical methods of prospecting.

THE THADUNA DEPOSITS (INCLUDING NABBERU)

Introduction

The copper deposits at Thaduna (also sometimes called Nabberu or Nabberoo) were discovered in 1941, and the first recorded production is for 1942. Copper mineralisation is known to extend intermittently over a zone about 6 miles in length in a north-south direction, the workable parts of which have been covered by various tenements, many of which have covered the same, or partly the same, ground.

Up to the end of 1960, 126 tons of approximately 13 per cent. copper ore, and 20,822 tons of 7.67 per cent. cupreous ore have

been produced from this "belt", mainly from the ground now held as M.L. 68P (The Thaduna Copper Mine), and M.C. 65P which is about 2 miles to the south of the former.

The deposits are located 125 miles by road north-eastwards of Meekatharra railhead, on Neds Creek Sheep Station, about 12 miles south of Thaduna Hill (Trig. R.40). Approximate geographical co-ordinates are :—

Latitude 25° 32' S.

Longitude 119° 41' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 71/300.
2. Lands Department 10-Mile Topographic Series, Sheet 11, Nabberu.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

The general geology of the area is discussed briefly by Talbot (1920, p. 65).

Geological Information

The deposits occur in a flat, rather featureless area covered generally by a loamy soil, and broken in only a few places by low lateritic breakaways. As shown on the State Geological Sketch Map (which is based on regional mapping by Talbot) the deposits lie just inside a greenstone belt a couple of miles south of its contact with a granitic mass of which Thaduna Hill is a part.

Talbot, however, emphasised the difficulty of identifying the true nature of the rock succession underlying the alluvial cover. Exposures in mining excavations indicate that at least the northern part of the belt is a sedimentary succession. The rocks may in fact be an extension of the sedimentary belt shown on the Sketch Map occurring eastwards and south-eastwards of the granitic mass.

The country rocks are a succession of mudstone, shale, siltstone (greywacke ?) and fine grained sandstone, which as far as can be ascertained from the weathered exposures, strike about 220 degrees, and dip at 80 degrees to the south-east.

The ore bodies strike about 320 degrees and are almost vertical. Mineralisation is in the form of disseminated azurite, malachite, and cuprite in a carbonaceous (graphitic) and quartz gangue which reaches a maximum thickness of about 30 feet. The presence of the carbonaceous material suggests a syngenetic origin, but the structure is apparently transgressive and its occurrence in the shear may perhaps be explained by the mobilisation of carbonaceous sedimentary material by the intrusive granite.

The main workings on 68P (Thaduna Copper Mine) consist of two open cuts, the bigger one on the east reaching a maximum depth of about 90 feet at the southern end. It is about 600 feet long and from 25 to 30 feet in width. About 33 feet west of this, near its centre, a parallel body from 4 to 5 feet in width has been stoped to the surface and driven on, and partly overhead stoped to the north, over a length of about 200 feet.

A shaft has been sunk from the centre of the main open cut and at the 125 feet level (from the bottom of the open cut) a cross-cut has been driven westwards to the western body. The workings here attain a maximum depth of 200 feet, and at the southern end, the body has been stoped between the 200 and 125 feet levels. Northwards of the crosscut, a raise is being extended upwards to the floor of the western open-cut.

The eastern and western workings are separated by a lens of country rock ; but the two ore bodies appear to coalesce to the south beyond the limit of the open cut.

The line of mineralisation has been tested southwards by twenty-one costeans 50 feet apart over a length of about 1,450 feet. This line also includes three smaller open cuts and three shallow shafts. Northwards of the main cut it has been tested by five costeans over about 440 feet.

Three diamond drill holes were drilled in 1952 to test the lode at depth. Hole No. 2 drifted off course and was abandoned without penetrating the lode. Holes 1 and 3 made intersections about 200 feet apart at vertical depths of 270 feet and 500 feet respectively. Hole No. 3, the most northerly one, is 550 feet south of the main open cut. The country rock consists of shale, mudstone, and tuff, and the lode, 16 feet wide in No. 1 and 12 feet wide in No. 3, consists of carbonaceous shale and quartz. Assay results are given below.

About 2 miles south of M.L. 68P, workings known as Ricci's Copper Mine (M.C. 65P, covering or partly covering ground at various times previously known as P.As. 769P, 772P, 784P, 804P, and M.C. 23P) consist of a series of shafts and open cuts extending over about 360 feet. Copper-bearing quartz can be traced on the surface beyond the workings over a distance of half a mile.

In the workings, mineralisation is seen to occur in a graphite-bearing quartz formation in the form of green and blue carbonates, with some oxide and chalcocite. The ore body is vertical and strikes at 345 degrees. The workings are from 2 to 8 feet wide, and the main shaft has reached a depth of about 50 feet.

M.C. 94P (previously P.As. 877P, 863P and 883P) is located on an area of flat ground 2.5 miles north-west of M.L. 68P. To the end of 1960, 100 tons of cupreous ore had been produced from a shallow shaft and open cut on this property.

Costeaning has disclosed copper mineralisation in a quartz vein over a length of about 20 chains, with an average surface width of 9 feet.

Table 51
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1942 1956-58	P.A. 753P M.C. 65P	Kalinowsky, J. E. Bettineschi and Ricci	Long Tons	Long Tons	£A
			1.05	0.15	120.00
			125.20	16.62	2,240.50
Total to the end of 1960			126.25	16.77	2,360.50

Average weighted assay = 13.3%.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
			Long Tons			£A
1944-45	P.A. 769P	Walsh, E. A.	298.75	12.13	3,624.36	2,273.00
1945	P.A. 772P	Morrisey, H. J.	38.25	9.65	369.11	248.00
1946	P.A. 784P	Walsh, E. A.	72.00	8.75	630.00	447.00
1947	M.C. 23P	Wright, E. A.	101.00	7.82	789.82	587.00
1947	P.A. 804P	Wright, E. A.	407.00	8.30	3,378.10	2,516.00
1952-53	M.L. 66P	Walsh, E.	292.92	8.25	2,417.93	2,631.35
1954	P.A. 842P	Jessop, E.	222.75	6.61	1,473.02	1,824.31
1955-60	M.C. 65P	Ricci, A.	1,169.26	8.46	9,887.38	14,584.84
1955-60	M.L. 68P	Thaduna Copper Mining Coy.	18,118.57	7.53	136,476.52	190,564.29
1959	P.A. 877P	Rooney, J. P.	80.42	7.98	642.92	921.90
1960	P.A. 883P	Rooney, J. P.	21.34	6.45	137.65	182.50
Total to the end of 1960			20,822.26	7.67	159,826.81	216,780.19

Assays and Mineralogy

To the end of 1960 the following grades of ore have been won from the three producing centres:—

The Thaduna Copper Mine (now M.L. 68P); 18,118 tons of cupreous ore assaying 7.53 per cent. copper.

Ricci's Mine (now M.L. 65P); 2,309 tons of cupreous ore assaying 8.7 per cent. copper, and 126 tons of copper ore assaying 13.3 per cent. copper.

Rooney's Mine (now M.C. 94P), 101 tons of cupreous ore assaying 7.6 per cent. copper.

The principal copper minerals have been malachite and azurite, with some cuprite and chalcocite. The gangue consists essentially of quartz and graphite, with bleached and partially bleached country rock.

On M.L. 68P two inclined surface diamond drill holes which intersected the ore body gave the following results.

D.D.H. No. 1:—Vertical depth of intersection—270 feet. The core recovery in ore was very poor therefore no assays were attempted. The sludge assayed 2.9 per cent. copper over a horizontal width of 16 feet.

D.D.H. No. 2:—Vertical depth of intersection—500 feet. The core assayed 1.28 per cent. over 19 feet, and the sludge assayed 1.20 per cent. over 21 feet. The horizontal width of the lode in this intersection was 12 feet.

Reserves

The Thaduna Copper Mining Company estimated in November 1961 that they had reserves of 200,000 tons of 4 per cent. copper suitable for fertilizer purposes.

Estimates of reserves on other leases are not available.

Remarks

This is a well mineralised area and the ore-bearing structures are strong. Although the grade of mineralisation (as known) is low for such a remote locality, it is expected that the ore could be economically upgraded by flotation to about 20 per cent. before despatch.

The author is favourably impressed by this Area and detailed geological, geochemical, and geophysical investigation of the country surrounding the known deposits is recommended.

THE HORSESHOE AND MULGAL DEPOSITS

Introduction

In 1942, 12·2 tons of copper ore were raised from Prospecting Area 761P, about 8 miles east of Horseshoe, and in 1956, 10·53 tons of cupreous ore were raised from Prospecting Area 856P, about 49 miles north-north-west of Horseshoe. Neither of these has been worked since.

A third deposit, about 15 miles north-east of Horseshoe has been worked intermittently for cupreous ore since 1950. The ground has been held by different persons at times but the latest was Prospecting Area 872P. Previously it was 817P, 835P and 852P. To the end of 1960, this deposit had yielded 80·62 tons of cupreous ore. The last production was in 1959.

These deposits are copper-bearing quartz intrusives of limited size in Precambrian metasediments of the Mosquito Creek System.

Horseshoe is located 90 miles north of Meekatharra. Its approximate geographical co-ordinates are:—

Latitude 25° 27' S.
Longitude 118° 34' E.

Reference may be made to the following maps:—

1. Lands Department Lithographs 72/300 and 79/300.
2. Lands Department 10-Mile Topographic Series, Sheets 10 and 11.
3. Geological Sketch Map of Western Australia. Geol. Survey West. Australia 1957.

Reference to the general geology of the Area is given in Geological Survey Bulletin 48 (Woodward, 1912).

Geological Information

The host rocks consist essentially of steeply dipping, folded, arenaceous, argillaceous, and siliceous sediments with minor interbedded "greenstone" developments. The assemblage is intruded in places by siliceous gold, copper, and lead bearing veins.

The worked copper deposits consist of narrow, lenticular steeply dipping quartz veins of low grade.

With the exception of the country in the vicinity of the Horseshoe manganese deposits, the area has not been subject to detailed geological examination.

Production

Table 52
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1942	P.A. 761P	Pegler and Pegler, H.	Long Tons 12·20	Long Tons 1·48	£A 148·00

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
			Long Tons			£A
1950	P.A. 817P	Edwards, R. W.	6.40	10.62	68.00	68.00
1952	P.A. 835P	Rumble, P. R.	16.77	13.10	219.74	200.80
1955	P.A. 852P	Rumble, P. R.	44.88	7.64	342.81	477.31
1956	P.A. 856P	Cooper and Lester	10.53	20.70	217.87	475.00
	P.A. 852P	Collis, D. J.	3.15	6.55	20.63	25.00
1959	P.A. 872P	Rumble, R. W.	9.42	15.72	148.08	312.00
1960	<i>Nil</i>					
Total to the end of 1960			91.15	11.15	1,017.13	1,558.11

FUTURE EXPLORATION

The known economic copper deposits in the Peak Hill Goldfield occur in metamorphosed sequences of Precambrian rocks which are predominantly sedimentary, but also include minor developments of igneous rocks.

Insufficient work has been done on the field relationships of the host rocks at the time of writing (December, 1961) to permit an irrevocable age classification to be made. Tentatively they are assigned to pre-Nullagine time, and may be the equivalent of the Mosquito Creek System which is well developed in the Pilbara.

All of the deposits are considered to be epigenetic, and genetically related to nearby intrusive granitic masses.

The three principal centres of production are Thaduna, Kumarina and Ilgarari. The country in the vicinity of these deposits is generally flat with a considerable soil cover and few significant outcrops. The depth to the water table probably averages about 60 or 70 feet.

The writer considers that these areas are worthy of more detailed investigation, particularly by geochemical and geophysical techniques, with drilling to follow on promising prospects.

THE MURCHISON GOLDFIELD DEPOSITS

SUMMARY

Copper deposits in the Murchison Goldfield have produced 1,053 tons of copper ore with an average copper content of 13.6 per cent., and 2,094 tons of cupreous ore averaging 7.12 per cent. This production has come mainly from the old Gabanintha gold mining centre, much of it being obtained by reworking mines which were initially gold producers.

Most of the deposits in the Field are in the form of copper-bearing quartz veins intrusive into basic or ultrabasic Archaean greenstones.

The following table summarises the types of deposits:—

Table 53
TYPES OF DEPOSITS IN THE MURCHISON GOLDFIELD

Locality	Tenement	Ore Produced		Remarks
		Copper Ore	Cupreous Ore	
Holden's Find	Various	Long Tons 6.72	Long Tons	Thin low grade cupriferous quartz vein in Archaean basic igneous rocks.
Yaloginda	Various	24.76	35.85	Irregular mineralisation in sheared Archaean amphibolite.
Mt. Mulcahy	P.As. 3514, 3518, and 3651	....	23.40	Thin quartz vein in Archaean basic lavas.
Gabanintha	Various	932.15	1,967.21	Copper-gold-quartz veins in basic and ultrabasic Archaean greenstones.
Mt. Eelya	P.A. 3519	....	6.06	Quartz vein in Archaean meta-sediments.
Day Dawn	Various	55.56	48.23	Quartz veins in basic Archaean rocks. Primarily worked for gold.

Table 54
COPPER AND CUPREOUS ORE PRODUCTION IN THE
MURCHISON GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1900	5.15	1.95	91
1901	10.50	1.20	76
1902-05	....	....	....
1906	133.50	39.60	2,816
1907	31.71	3.52	274
1908	....	....	....
1909	608.00	44.00	2,823
1910-13	....	....	....
1914	23.39	5.26	329
1915	33.70	6.55	492
1916	....	....	....
1917	82.92	18.67	2,164
1918	78.34	15.45	1,794
1919	16.81	3.49	377
1920-43	....	....	....
1944	18.00	1.28	54
1945-54	....	....	....
1955	11.59	3.07	887
1956-60	....	....	....
Total	1,053.61	144.04	12,157

Average weighted assay = 13.6% Cu.

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Copper	Value
	Long Tons			£A
1953	25·54	303·22	11·87	461·00
1954	286·15	2,047·25	7·15	2,652·88
1955	801·84	5,420·23	6·80	7,372·28
1956	524·93	3,366·23	6·41	4,589·34
1957	.....	.....	.....	.....
1958	85·80	957·14	11·15	1,768·10
1959	152·10	1,182·40	7·77	1,807·60
1960	218·00	1,627·50	7·47	2,302·40
Total	2,004·36	14,903·97	7·12	20,953·60

THE HOLDEN'S FIND DEPOSIT

Introduction

A copper deposit has been mined at Cashburns, about 4·5 miles south-east of Holden's Find, some 45 miles north of Meekatharra. The deposit was worked in 1917, a total production of 6·72 tons of copper ore averaging 16·5 per cent. copper being recorded.

The ore occurs as a cupriferous quartz vein in fine-to-medium-grained basic igneous rocks, which are assigned to the Archaean Greenstone complex.

The deposit is about 51 miles by road from Meekatharra. The Great Northern Highway is followed for 41 miles to the Peak Hill road turn-off, thence about 9 miles north-westwards and westwards by graded roads and bush tracks.

Approximate geographical co-ordinates are as follows:—

Latitude 26° 0' S.
Longitude 118° 37' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 59/300.
2. Lands Department 10-Mile Topographic Series, Sheets 10 and 11.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia, 1957.

Aerial photographs and photomosaics are available from the Lands Department.

Information on the general geology, and of the copper occurrence is given in reports by Clarke (1914), and Hobson (1940).

Geological Information

This deposit was examined by Matheson in 1940 and Hobson quotes from his report as follows, "The copper lode is situated at Cashburn's Find, which is about 4·5 miles south-east of Holden's Find, and 0·75 miles east of the 65 mile peg on the Meekatharra-Peak Hill telegraph line. Mining of the lode was carried out in 1917, and M.L. 17N, embracing portions of G.M.Ls. 1292N and 1273N, was applied for but not surveyed.

The lode consists of a copper-stained, limonitic quartz reef, which strikes N.40° E. and dips vertically, and which has been mined over a width of three feet and a length of 16 feet, to 20 feet from the surface. Hand picking of the ore was apparently resorted to, and malachite, chrysocolla, and a little azurite were noted in the dumps. Copper sulphides and pyrite appear to be entirely absent however. The country rocks in which the lode occurs, are fine to medium-grained bouldery greenstones. Auriferous quartz veins have also been mined at Cashburn's Find, but there appears to be no connection between these ore bodies and the cupriferous lode."

Production

Table 55

Period of Production	No. of Lease	Registered Name	Copper Ore Produced	Copper Content	Value
1917	Sundry	.....	Long Tons 6.72	Long Tons 1.11	£A 111.00

Average assay = 16.5% Cu.

Remarks

There are no indications of the ore body persisting much beyond the limits of the shoot already mined. The deposit appears to be of little economic importance.

THE YALOGINDA DEPOSITS

Introduction

These copper deposits are located near Mt. Gibbs, about 14 miles south-west of Meekatharra. The first recorded production is in 1917, and up to the end of 1960, 24.76 tons of copper ore had been produced, and since 1953, 35.85 tons averaging 7.6 per cent. copper have been produced for fertilizer purposes.

The host rock is a fine-grained sheared amphibolite greenstone and the copper ore occurs essentially as malachite with some azurite and cuprite in kaolinised rock threaded with thin quartz veins.

The copper workings are situated about 4 miles south-west of Yaloginda, and 13 chains south of the old Chunder Loo South G.M.L. 1102. They may be reached by turning to the south-west off the Meekatharra-Cue road just north of the 471 mile peg, 4.6 miles south of the Meekatharra Road Board Office.

Approximate geographical co-ordinates are :—

Latitude 26° 45' S.
Longitude 118° 20' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 59/300.
2. Lands Department 10-Mile Topographic Series, Sheet 7, Geraldton.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are also available from the Lands Department.

Some of the following information is taken from reports by Clarke (1916), Hobson (1940) and Simpson (1952).

Geological Information

These copper deposits occur to the south-south-west of the old Chunder Loo gold mine in finely foliated and fractured horn-blendic rocks. Granitic rocks (the Yellow Granite of Clarke, 1916, p. 215), crops out about one mile to the west of the Chunder Loo. The granite is foliated near its intrusive contact with the greenstones, and in places coarse and fine pegmatitic varieties are developed.

At the time of Hobson's inspection in 1940, the workings consisted of two old shafts, about 30 feet deep, with an open cut measuring approximately 15 feet by 10 feet between them. In those portions of the open-cut (which was partly filled at the time) still available for inspection, malachite and minor quantities of azurite were scattered irregularly in small bunches and seams in a white kaolinitic rock, which was also seamed with thin quartz veins. Small blebs of limonite occur in the ore body but there is no suggestion of a limonitic gossan.

The rich portion of the ore body was evidently of limited extent, and its outcrop could not be traced much beyond the shafts. Production since 1941 (about 48 tons of ore) has consisted of re-picking the dumps and working the richer pockets at shallow depth.

About 9 tons of cupreous ore were produced in 1955 from a small deposit located about 1.2 miles due west of the abandoned Yaloginda townsite. This is also a quartz vein intrusive into Archaean basic igneous rocks.

Production

Table 56
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Value
			Long Tons	Long Tons	£A
1917	Sundry Claims	.....	6.76	1.41	150.00
1944	P.A. 2986N	Walsh, E., and Ricci, A.	18.00	1.28	54.18
1955-60	<i>Nil</i>				
Total to the end of 1960			24.76	2.69	204.18

Average assay = 10.8% Cu.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Average Assay per cent. Copper	Copper Units	Value
			Long Tons			£A
1955	P.A. 3383N	Jeffreys, E. G.	8.95	5.16	43.60	55.11
1955	P.A. 3351N	Jeffreys and Reynolds	20.15	6.64	136.15	154.70
1956	P.A. 3385N	Jeffreys, E. G. and K. E.	6.39	9.30	59.42	96.00
1957-60	<i>Nil</i>					
Total to the end of 1960			35.85	6.06	179.75	305.81

Assays

The only assay information available is from Simpson (1952) who wrote, "Specimens from a place one half mile south of the Chunder Loo Goldmine assayed:—Cu, 37.38 per cent.; Au, 8 dwt. 17 gr. per ton; Ag, 2 oz. 10 dwt. 11 gr. per ton."

Remarks

These copper deposits appear to be small and of little significance.

THE MT. MULCAHY DEPOSITS

Introduction

Two Prospecting Areas were worked for copper in this locality in 1954 and 1955. The total recorded production amounts to only 16.55 tons of cupreous ore assaying about 8 per cent. Cu. Prospecting Areas 3518 and 3514 cover partly the same ground which was held as Mining Leases 66 and 75 in 1918 and 1920 respectively.

These are located about 30 miles north-north-west of Cue, on the western slopes of a series of greenstone ranges some 8 miles south of the Wilgie Mia ochre deposits.

Access is for 32 miles north-westwards from Cue along the Berrengarra road to the Glen Homestead, and thence about 3 miles eastwards by station tracks.

Approximate geographical co-ordinates are:—

Latitude 27° 2' S.
Longitude 117° 42' E.

Reference may be made to the following maps:—

1. Lands Department Lithograph 54/300.
2. Lands Department 10-Mile Topographic Series, Sheet 7, Geraldton.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

A description of these deposits is given by Hobson (1940).

Geological Information

The copper-bearing structures occur in somewhat graphitic, schistose basic lavas of the "Older Greenstones" and strike about 300 degrees with a steep dip to the north. The country rocks also include some massive amphibolites, and some bands of metamorphosed basic sediments.

On M.L. 66 there are two shafts about 160 feet apart, which were reported to have been originally sunk to water level at about 30 to 35 feet, and the ore body was up to 5 feet wide. At the time no production had been recorded but Hobson in 1940, stated that he was informed that two tons of ore were sent to Port Kembla, and that returns showed this ore to contain 14 per cent. copper.

The outcrop of the ore shoots have not been traced on the surface away from the shafts despite a number of shallow costeans having been dug across the line of strike. The two shafts may be on different shoots of ore. Quartz veins, carrying no ore, occur in the vicinity.

The production recorded during 1954 and 1955 was evidently taken from the western shaft which was still fitted with a hand windlass and ladder at the time of the writer's visit in 1961.

The ore as seen in the dumps and in the vicinity of the shafts consists of malachite and azurite impregnating hornblende schists. About 16 feet south of the western shaft a mass of limonite a few square yards in extent occurs on the surface and has been exposed by a pit about 4 feet deep. It contains very little copper staining.

In the vicinity of the workings the country is soil and rubble covered, while further west it is an alluvial flat. To the east can be seen outcrops of slightly schistose basic lavas and medium grained amphibolites.

Production

Table 57
CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Average Assay Copper per cent.	Copper Units	Value
			Long Tons			£A
1954	P.A. 3514	McCarthy and Stone	9.54	9.05	86.33	125.27
1955	P.A. 3518	Anderson and McCarthy	7.01	6.80	47.67	57.20
1960	P.A. 3651	Seivuright, K.	6.85	6.10	41.78	50.50
Total to the end of 1960			23.40	7.5	175.78	232.97

Remarks

There are no surface indications to suggest that this deposit is of much economic significance.

THE GABANINTHA DEPOSITS

Introduction

The cupriferous deposits of the Gabanintha Centre occur in the vicinity of the abandoned townsite, which is 22 miles east of Nannine, a railway siding on the Meekatharra-Geraldton railway. Quartz reefs in greenstone have been worked for both gold and copper, the first recorded production being in 1906. Up to the end of 1960 a total of 966.57 tons of copper ore has been recorded with an averaged copper content of 13.6 per cent., and 1,769.67 tons of cupreous ore with an average copper content of approximately 8.8 per cent.

Approximate geographical co-ordinates are:—

Latitude 26° 55' S.

Longitude 118° 38' E.

Reference may be made to the following maps:—

1. Lands Department Lithographs 466/80 and 59/300.
2. Lands Department 10-Mile Topographic Series, Sheets 7 and 8.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Reports on the geology of this centre have been made by Gibson (1904), Montgomery (1906), Simpson and Gibson (1907), Montgomery (1909), Maitland (1919), Hobson (1940) and Simpson (1952).

Aerial photographs and photo-mosaics are available from the Lands Department.

Geological Information

The workings, for description, may be divided into two groups: the gold and copper workings in the immediate vicinity of the townsite (the Mountain View Group), and the principally-copper workings some 3.5 miles to the south-east (the Lady Alma Group). Both of these occur in fine- to medium-grained basic volcanics and intrusives (amphibolites) of the "Older Greenstones" which are generally schistose in the vicinity of the ore bodies, and in granite near the intrusive contact with the greenstones. The ore bodies in the granite, however, are low grade and have not been developed to the same extent as the others.

The granite has intruded the greenstones as large masses and dykes. The main granite mass crops out half a mile east of the townsite, and the western boundary follows roughly a north-south line, but numerous small intrusions penetrate the greenstone close to the mass. The granite, in the main, is massive and free from schistose structures, the main body being generally a coarse-grained pinkish variety consisting essentially of quartz and feldspar (orthoclase) with accessory hornblende, biotite, magnetite and apatite.

The copper occurs in quartz veins occupying fracture zones approximately parallel to the granite-greenstone contact. The gold-copper workings in the vicinity of the abandoned townsite include the leases known as the Mountain View, Leviathan, Unexpected, Grafton and Tumblegum. These were worked primarily for gold in earlier years, however, since 1953 the Tumblegum Lease has produced about 243 tons of cupreous ore for fertilizer purposes, some of this being produced from the treatment of old tailings.

The Tumblegum Reef is one of the most extensive occurring at Gabanintha. It crops out for about 1 mile, dips vertically, and consists of veins and bunches of copper-bearing quartz in a fractured zone in the greenstones, the latter rock itself carrying gold and copper in places. The vein is 3 to 8 feet wide.

Gibson (1904) stated that a lot of work had been done, mainly towards the southern end of the reef, down to a depth of 130 feet and that a good supply of fresh water was struck at 60 feet. The work done was principally the sinking of shafts, and driving at the 70 feet level. Work done recently has been in driving, stoping and trimming of pillars. In September 1954, a licence to treat the old tailings on the Tumblegum (G.M.L. 1925) Lease was granted to Mr. G. Motter, who has since produced a considerable quantity of concentrate for fertilizer purposes (see production table).

The Mountain View Leases are located approximately one mile north-north-west of the main Tumblegum workings, and about one half mile north of the abandoned townsite. The ore bodies consist of copper and gold bearing quartz and greenstone rock in a zone between 2 to 4 feet wide. Near the main shaft (on the old G.M.L. 379), which was about 240 feet deep, the reef bifurcates, a branch striking off to the south-east.

A reef parallel to this branch was worked on the old Golden Hope (G.M.L. 461) adjoining the Mountain View on the north-west side. The ore bodies were worked by shafts, drives at the 40, 80 and 150 feet levels, and by stoping.

The reefs consist of a mixture of quartz and highly foliated greenstone, and are very broken and irregular (Gibson 1904).—The quartz occurs for the most part in bunches, some of which are of considerable extent, while others extend only a few feet. These bunches generally are richer in their gold contents than the lode matter (foliated greenstone). Both the quartz and the lode matter carry a high percentage of blue and green carbonates of copper, the lode matter being in places, particularly rich, with some pockets of ore being obtained averaging over 30 per cent. copper.

The country consists of fine-grained greenstone, and is commencing to get hard and settled in the bottom workings. Water level is 80 feet, the supply being fresh but limited in quantity ”.

Maitland (1919) stated that at a depth of 240 feet the belt of fractured country rock was found to be enclosed between two main walls, about 40 feet apart, and to be traversed by indistinct bands of schistose lode stuff containing more or less quartz, and a good deal of copper pyrites.

What may be regarded as the Lady Alma Group is situated approximately 3.5 miles south-east of Gabanintha, and includes recent holdings for copper such as M.Cs. 9, 10, 15 and 20, G.M.L. 1990, and P.As. 3507 and 3459. Some of these cover old holdings such as M.L. 4 and G.M.L. 340. Montgomery (1909, p. 30) states that a good deal of work was done in the Lady Alma Mine (M.L. 4) over the previous three years and that a reveratory smelting furnace had been erected but because of the fuel supply difficulties and other problems, smelting had proved less profitable than mere concentration by hand picking. The slag dump from this furnace can still be seen at the edge of the loading ramp.

At the northern end of these workings a main shaft has been sunk to a depth of 120 feet. The water level was encountered at 92 feet. Montgomery states that there was a crosscut at this level which showed the lode formation to be 25 feet wide from wall to wall, but that the included material “ is mostly jumbled broken country rock with veins and bunches of quartz in the spaces between the blocks of country. Some good copper glance (chalcocite) ore was obtained above this level, and in driving on the lode at it there was some very good sooty black sulphide of copper, with quartz carrying a little chalcopyrite. The shoot, however, was short and pitched rapidly southward. In the lowest workings there was still some very good ore, but the shoot seemed to be only a few feet in length ”.

There are two copper bearing veins in the Lady Alma Group (these are shown by Gibson, 1904, Plate VI, as being in north-south echelon and striking north-west and south-east). Ore from the main, or eastern vein contains cuprite, limonite, bornite, malachite, quartz and dolomite, with a little mica and chalcocite. An analysis of this ore is shown below. The outcrop of

the vein as shown near the southern shaft proved to be a strong body of brown iron ore (gossan) from beneath which some fair copper ore has been raised.

Hobson stated that during his inspection in 1941 material in the ore paddock near the northern shaft contained green and blue carbonates of copper associated with limonite and quartz.

At the southern workings there was a deep shaft, a shallow shaft, an irregular hole and two shallow trenches. The copper minerals can be seen to occur as narrow streaks or small patches irregularly distributed throughout the country rock. Hobson further stated that at neither the northern nor southern workings was the outcrop of the ore body of any great extent.

Little work has been done on the remaining leases. These are on a low rise of ultrabasic rocks, with minor quantities of medium to coarse grained amphibolites or epidiorites. On M.L. 6, a shaft 60 feet deep and a shallow hole at one side of the shaft shows some stoping striking N. 60° W. and having a width of about 4 feet. The stoping did not seem to be very extensive, as there is no other shaft in the vicinity. Workings near the northern boundary of the lease consist of two shafts and a shallow trench approximately 90 feet long and 4 to 5 feet wide. The strike of the trench is N.5° E.

Other workings on adjoining leases consist of a series of shallow trenches and irregular holes striking north-west. The dumps from these showed malachite and azurite in fractures in ultrabasic rocks.

Almost all ore produced prior to 1941 came from late G.M.L. 340, later M.L. 9. The ore body on this lease seems to be fairly small.

Production

Table 58
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
			Long Tons	Long Tons	£A
		MOUNTAIN VIEW GROUP			
1906	G.M.Ls. 379N, 504N, 505N	Mountain View Leases	127·00	38·10	2,681·00
1914-15	G.M.L. 1175N	Unexpected	42·22	8·32	606·00
1917-18	G.M.L. 1360N	Leviathan	53·50	11·20	1,201·00
1918-19	G.M.L. 1408N	Grafton	83·34	16·72	1,935·00
1920-60	<i>Nil</i>				
Total to the end of 1960			306·06	74·34	6,423·00
Average assay = 24·2% Cu.					
		LADY ALMA GROUP			
1906	M.L. 4N	Lady Alma ...	6·50	1·50	135·00
1909	M.L. 4N	Lady Alma ...	608·00	44·00	2,823·00
1955	M.C. 9N	Rinaldi, L. V. ...	11·59	3·07	866·00
1956-60	<i>Nil</i>				
Total to the end of 1960			626·09	48·57	3,824·00
Average assay = 7·7% Cu.					

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Average Assay per cent. Copper	Copper Units	Value
			Long Tons			£A
		MOUNTAIN VIEW GROUP				
1953	P.A. 3277N	Ball, R. A.	25.54	11.87	303.22	461.00
1954	G.M.L. 1943N	Terrel, J. H.	11.81	7.18	84.78	110.20
1954	P.A. 3342N	Young, J. F.	10.14	7.44	75.44	100.08
1955	G.M.L. 1725N	Lauritsen, O. M.	5.71	5.10	29.13	32.03
		"NEW BREW"				
1955	P.A. 3343N (M.L. 20N)	Motter, G., "Tumblegum"	153.14	7.15	1,095.93	1,315.60
1955	L.T.T. 1289H (G.M.L. 1925N)	Motter, G.	238.56	5.74	1,370.20	1,759.80
1956	L.T.T. 1289H	Motter, G.	129.83	4.50	584.94	761.43
1956-60	G.M.L. 1990N	Tumblegum	329.98	7.10	2,342.67	3,303.45
1958-59	P.A. 3459N	Alac, M.	119.98	10.61	1,273.20	2,285.30
1959	P.A. 3485N	Yaksich, A.	24.42	9.37	229.05	375.55
1960	Nil					
Total to the end of 1960			1,029.11	76.06	7,388.56	10,502.44

Average assay = 7.1% Cu.

LADY ALMA GROUP

1954-55	P.A. 3324 now M.L. 9N	Rinaldi, L. V.	596.36	7.21	4,298.93	6,010.21
1956	P.A. 3385N	Jeffreys, E. G. and K. E.	6.39	9.30	59.48	96.00
1956	M.C. 9N	Rinaldi, L. V.	55.81	5.21	290.78	279.08
1956	M.C. 10N	Rinaldi, D.	215.13	6.96	1,498.91	2,032.83
1959-60	P.A. 3507N	Grylls, West, Vi- cins and Facer Cawse, L. W., and Rixon, R. D.	39.47	5.89	232.57	257.20
1959-60	M.C. 15N		24.94	11.05	275.56	494.00
Total at the end of 1960			938.10	45.62	6,656.23	9,169.32

Average assay = 7.1% Cu.

Assays and Mineralogy

A grab sample taken by Montgomery from bags of ore from the northern workings of the Lady Alma Group, was analysed in the Survey Laboratory and gave the following results:—

	Per cent.
Moisture	1.23
Copper	28.64
Lead	0.06
Bismuth	Nil
Iron	22.60
Zinc	Nil
Nickel	0.11
Alumina	2.20
Lime	1.01
Magnesia	6.50
Silica	6.02

	Per cent.
Carbonic anhydride	10.89
Combined water	5.25
Sulphur	3.40
Oxygen (by difference)	12.09
	100.00

In addition gold at the grade of 2 dwt. 11 gr. per ton, and silver at 5 oz. 25 gr. per ton were recorded.

Remarks

The ore bodies in the Mountain View Group were worked in the first instance primarily for gold but contained some copper. Those of the Lady Alma Group are notable for the amount of limonite associated with the copper carbonates near the surface. It seems likely that these Gabanintha deposits could still yield an appreciable quantity of copper-bearing material.

THE MT. EELYA DEPOSIT

Introduction

In 1955, 6 tons of cupreous ore assaying 5 per cent. copper was recorded as being produced from a Prospecting Area located approximately 17 miles east-north-east of Cue.

The Prospecting Area is located about 2.5 miles north-west of Mt. Eelya, and can be reached by proceeding for 19 miles north-eastwards from Cue along the Taincrow Homestead Road, and thence for about 4 miles southerly by station tracks.

Approximate geographical co-ordinates are as follows :—

Latitude 27° 25' S.
Longitude 118° 10' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 54/300.
2. Lands Department 10-Mile Topographic Series, Geraldton Sheet.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Geological Information

The rocks in which this deposit occurs are granitised and partially granitised acid sediments, containing in places acid and basic intrusions. The degree of granitisation decreases southwards until the old gold mining centre of Eelya is reached. According to Woodward (1914) "... a low ridge composed of basic schists strikes in a north-easterly direction and it is upon its western face—that a number of leases scattered over a distance of ten miles have been worked." "... At the north end of this belt, near a remarkable pinnacle-shaped quartz blow called Eelya Hill, are two abandoned leases which were known as Eelya Reward and Eelya North; here a very flat reef was worked to a shallow depth only, but which yielded some very rich stone." At these leases, according to the writer's own observations, the general strike of the auriferous quartz body, which follows an arcuate line in outcrop and appears to be controlled by local folding, is to the north-west and dips to the south at between 50 and 75 degrees.

The production from P.A. 3519 was from a shallow pit sunk on a poorly exposed quartz vein striking almost east-west with the schistosity of the metasedimentary country rock. Some slight blue and green copper carbonate mineralisation was seen. The ore bearing body is small and appears of little consequence.

Production

Table 59
CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Treated	Average Assay Copper	Units Copper	Value
1955	P.A. 3519	Canestrini, P.	Tons 6.06	5.05	30.58	£A 15.30

Remarks

There is nothing to suggest that there are sizeable copper reserves in the vicinity.

THE DAY DAWN DEPOSITS

Introduction

Day Dawn is located about three miles south-west of Cue on the Meekatharra-Geraldton Railway. It is principally a gold mining centre and since 1900 has produced only 111.12 tons of copper ore with a calculated average grade of 14.6 per cent., and 48.23 tons of cupreous ore for fertilizer purposes at a calculated grade of about 9.6 per cent.

Reference may be made to the following maps:—

1. Lands Department Lithograph 200/80.
2. Lands Department 10-Mile Topographic Series, Geraldton Sheet.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Approximate geographical co-ordinates are:—

Latitude 27° 25' S.
Longitude 117° 55' E.

Geological Information

The rocks of this area belong to the Archaean greenstone complex, consisting essentially of basic volcanic rocks which exhibit various degrees of metamorphism and are highly folded in a north and south direction, the whole being intruded by numerous acid porphyritic dykes which are probably offshoots from the granitic rocks lying to the westward.

According to Woodward (1907) all the lodes in this area are the normal quartz reef type presenting the usual characteristics of zonal enrichment, which may occur as either a well defined shoot following the folds in the plane of the fissure, or as patches of great richness but of limited extent near the surface. The water level is generally at about 100 feet.

G.M.L. 14D (Croesus) was abandoned at the time of Hobson's inspection. He wrote that west of the main line of workings on this lease there are two shallow shafts approximately 60 feet apart, with a partly filled small open cut lying between them. The strike of the open cut is N. 30° W., dip 70° W., and the average width is about 2 feet. The ore body was evidently a quartz reef

containing malachite and some limonite. Minor quantities of malachite could also be seen in the hanging wall rocks. Only very minor quantities of malachite could be seen in the dumps.

On M.L.s. 1D and 2D, according to Hobson, the ore body consisted of a quartz reef having a probable length of about 100 feet, and a width of between 3 and 4 feet. The workings consisted of an underlay shaft, open cuts and also a vertical shaft which intersected the ore body at depth. Woodward (1907) described the ore body as "containing small bunches and strings of green and blue carbonate of copper". The body strikes north-west and dips south-west. P.A. 65D occupied the same ground, and some of the ore crushed during 1906 was obtained by re-dressing the spoil heaps.

Between M.L. 2 and the late Rubicon (G.M.L. 138) workings were two parallel ore bodies striking N. 20° W. with a steep westerly dip. From the exposures seen in 1941, Hobson judged the ore bodies to be between 60 and 100 feet long, and to have a maximum width of from 3 to 4 feet. It appears that a shaft was sunk on the ore body to a depth of about 70 feet, but the copper ore, which was mainly chalcocite, was obtained from near the shaft at about 20 feet below the surface.

Hobson inspected the dumps of the old Rubicon workings but did not find any copper minerals. Woodward records that 300 feet north of the cross-cut from the vertical shaft at the No. 7 level, a bunch of copper pyrites was cut. This may be the locality from which the copper recorded in the production table came.

Production

Table 60
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Treated	Copper Content	Value
1900-01	M.L. 2D	San Diego Copper Mine ...	Tons 15·65	Tons 3·15	£A 167·00
1907	G.M.L. 14D	Murchison Associated Gold Mines Ltd.	6·50	1·02	84·00
1907	P.A. 65D	Canning, G. C.	25·21	2·50	190·00
1914	G.M.L. 138D	Rubicon	4·80	1·00	54·00
1914	Sundry Claims	.....	3·40	0·43	27·00
1915-60	<i>Nil</i>	.....		
Total to the end of 1960			55·56	8·10	522·00

Average assay = 14·57% Cu.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Average Assay per cent.	Units Copper	Value
1954	P.A. 1046D	McCarthy, R., and Harrop, H. B.	Long Tons 10·42	4·15	43·24	£A 61·83
1955	P.A. 1046D	Gorman, W. N.	5·20	14·23	74·00	148·00
1955	P.A. 1055D	Goddard, J. M.	4·58	11·25	51·50	79·83
1956	P.A. 1064D	Gorman, W. N., and Lee, C.	28·03	10·85	304·33	532·10
1957-60	<i>Nil</i>	.....			
Total to the end of 1960			48·23	9·80	473·07	821·76

Remarks

The production from this centre has been in the past as a by-product of gold mining, and recently by picking old dumps, and from small surface workings. The area has been well prospected and the possibility of anything other than small copper ore bodies being found near the surface seems remote.

FUTURE EXPLORATION

With the exception of those at Gabanintha the known deposits in the Murchison Goldfield have been workable, and then only in a small way, because of secondary enrichment at, or just below, the outcrop.

Prospectors should pay attention to the margins of the greenstone belts, within one or two miles of the contact with the granite. A poor showing in outcrop does not necessarily mean that the deposits will not be workable.

THE NORTHAMPTON MINERAL FIELD DEPOSITS

SUMMARY

The Northampton Mineral Field consists of an extensive belt of country stretching north and south on both sides of the Geraldton-Carnarvon Highway. The town of Northampton lies in the southern half of the Field 31 miles north of the port of Geraldton.

Copper is known to have been raised from about the year 1850 although official production figures commenced in 1899. From this year to the end of 1960, 24,057 long tons have been produced averaging about 7.63 per cent. Cu.

The main copper producing area extends from the Gelirah Mine, 17 miles south of Northampton, to the Geraldine Mine on the Murchison River 38 miles north of Northampton. This Field has also been the chief source of supply of lead ore in the State, its total value amounting to almost £A4.5 million. In some instances lead and copper ore have occurred in the same ore body, and have been worked from the one mine.

The productive deposits are, in general, grouped around two localities, namely, Northampton in the south, and Galena in the north.

The host rocks of the area consist of various types of garnetiferous gneiss, probably formed by widespread granitisation of Archaean sediments. This rock has been intensely fractured and sheared along zones extending north-east and south-west. Many of these zones have been intruded by dolerite dykes varying in thickness up to about 180 feet. These generally dip at high angles to the west, and it is common to see in their vicinity gradations from "normal" granite-gneiss into a pegmatitic facies.

Copper and lead bearing bodies are frequently found in close association with these dykes, but this relationship is considered to be structural rather than genetic.

The deposits in this Field have not been examined by the author. The following information, which because of the large number of deposits and the scope of this Bulletin is presented in summarised form, has been drawn from reports by the following investigators: Woodward (1895), Maitland (1903), Montgomery (1908), Wilson (1926) and Berliat (1952). In addition,

the author has had access to a number of unpublished reports written by J. Sofoulis of the Geological Survey following his examination of the copper deposits in 1957. A. J. Noldart and W. R. Jones, also of the Geological Survey, have supplied some valuable information following their regional mapping of the area in 1961.

Production

Table 61
COPPER AND CUPREOUS ORE PRODUCTION IN THE
NORTHAMPTON MINERAL FIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1899*	98·00	24·50	1,715
1900 ....	.....	.....	.....
1901	38·50	11·55	277
1902-1921 ....	.....	.....	.....
1922†	998·66	208·75	13,435
1923	9,626·29	883·21	59,143
1924	10,672·00	554·19	34,955
1925	2,469·72	138·49	8,952
1926-1928 ....	.....	.....	.....
1929	116·00	12·11	974
1930-1939 ....	.....	.....	.....
1940	7·08	0·61	46
1941-1956 ....	.....	.....	.....
1957	9·44	1·41	201·40
1958-1960 ....	.....	.....	.....
Total‡	24,035·69	1,834·82	119,698·15

Average Assay = 7·6% Cu.

* Production between 1899-1901 also included 490 fine ounces of silver valued at £55 10s.

† Production between 1922-1925 also contained 91·51 fine ounces of gold, and 20,718·76 fine ounces of silver.

‡ It is known that between 1850 and 1899 a considerable tonnage of ore from the Northampton copper mines was exported to Europe, but the tonnages and grades have not been recorded. It is estimated that the additional unrecorded total may be about 9,000 tons.

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Copper	Value
1955	Long Tons 21·79	151·69	6·96	£A 185·55

THE GERALDINE COPPER MINE (MINERAL LEASES 10 AND 11)

These were located about 1 mile north of the Murchison River, and the old workings can be seen from the Carnarvon Road. The ore body strikes north-east, and it dips to the north-west at about 70 degrees. There were several other leases in the vicinity, some being worked for lead and some for copper.

The main mine workings are on late M.L. 11 (previously M.L. 73—Mitchell's Four-Mile Pool). Vertical shafts were sunk to 108 feet, 140 feet, and 32 feet, and an inclined shaft sunk to the 113-foot level. At the 60 feet level the vein was driven for 100 feet and crosscutting showed mineralisation over a maximum of 20 feet consisting of veins, 6 to 12 inches thick, carrying black sulphide of copper, with native copper in places in the joint planes. At the 108-foot level the vein was driven on for 174 feet, and crosscuts showed mineralisation over a maximum of 30 feet. From the bottom of the 140-foot shaft, a diagonal drive had been extended 30 feet into the ore body.

Wilson (1926, p. 19) states that ore from the 140-foot level consisted of copper glance with some galena and blende.

Production from the Geraldine Copper Mines (M.L.s 10 and 11) for the period 1899-1901 is recorded as being 136.5 long tons assaying 26.4 per cent. Cu.

THE MARTINS SPRING COPPER MINE

These workings are situated on Location 312, 5 miles north-west of Northampton Townsite.

There are two collapsed shafts, 45 feet apart, originally 50 feet and 42 feet deep. At 42 feet in one of these shafts a cross-cut was extended for 30 feet, and there was a connecting drive.

Ore from these workings was stated to contain lead, and as much as 50 ounces per ton of silver (Maitland, 1903).

About 10 chains south of these workings is a shaft collapsed in to a depth of about 15 feet. Some lead ore was evidently recovered here although dump material shows copper staining.

THE YANGANOOKA COPPER MINE

These old mine workings are located about 3 miles north of Northampton adjacent to the main road on freehold Blocks Nos. 32 and 314 (Maitland, 1903).

There are two parallel ore bodies on this property, striking north-east and dipping at steep angles to the north-west. The main workings consist of several shafts (the deepest 180 feet) and levels situated on the western lode. Maitland states that the mine had not been worked for 35 years, but records showed that dressed ore ranged from 17 to 34 per cent. and the 458 tons sent away realised £5,880.

THE WHEAL BETA COPPER MINE

These workings are located approximately 2 miles north-north-west of Northampton. There are two groups, one on Location 44, the other approximately 30 chains to the south-west on Location 9753.

The north-eastern workings are on the eastern side of a hill formed by a dolerite dyke. There are three old shafts covering

a length of 120 feet on a copper-bearing shear about 1-2 feet wide which dips at steep angles to the north-west. The middle shaft is about 60 feet deep.

On Location 9753 the lode has been traced along the surface by a line of shallow costeans, trenches and shafts over about 900 feet. The shafts have fallen in, the deepest one now standing at 15 feet. The ore body here is about 18 inches wide, with a similar strike and dip.

THE UNARING COPPER MINE

The Unaring (or Unarino) workings are situated within the Northampton townsite on the southern part of Location 325, about 1 mile south-west of the Railway Station.

Shallow shafts and costeans trace the line of mineralisation over about 200 feet in a north-north-easterly direction. It dips steeply to the east. Two shafts, 60 feet apart, were originally 46 feet and 58 feet deep, the latter one having crosscuts 15 feet west and 8 feet east at the bottom.

The dumps show some copper carbonates with granite-gneiss, pegmatite and dolerite rubble.

THE WHEAL ALPHA COPPER MINE

The Wheal Alpha (late M.L. 9) is located 1.5 miles east of Northampton townsite. The old workings consist of six partially collapsed shafts and a few shallow excavations over about 300 feet, reaching a maximum depth of 60 feet. The standing water table is at about 15 feet.

The ore body dips to the west at about 70 degrees and consists of copper carbonates in a kaolinised schistose matrix. Some sulphides show in the dumps, and also some pegmatitic material.

THE WANERENOOKA COPPER MINE

The Wanerenooka workings are located within the townsite of Northampton on Location 27, which is about three quarters of a mile north-north-west of the Railway Station.

Ore was discovered here, and production commenced in 1842, which makes it one of the oldest copper mines in Australia. The mine was worked consistently for twelve years after discovery, and then intermittently by various companies until 1903. The ground was taken out as M.L. 60PP in 1956, then later 64PP, and M.L. 71PP. In 1957 a small tonnage was produced under the name of the Roger Malray Copper Mine.

The mineralised shear which comprises the Wanerenooka lode strikes north-easterly and dips to the north-west at 75 degrees. The granitic-gneiss country rock contains numerous ptygmatic fold structures in close proximity to the ore body. The mine was dewatered in 1957 (and subsequently) and various examinations made in the light of current market potentialities. So far sufficient finance for further development has not been made available.

The mine was initially developed from a three compartment shaft, sited about 48 feet west of the outcrop, which reached a depth of 240 feet. Five other lesser shafts were sunk on the property.

Levels were developed at depths of 80 feet, 140 feet, and 180 feet, and workings extend over a horizontal distance of about 400 feet. The thickness of the ore body is stated to be 27 feet at the 80-foot level, 30 feet at the 140-foot level, and 39 feet at the 180-foot level. Provis (in Maitland, 1903, p. 23) states that that best makes of one, averaging 1 foot in thickness, were on the hanging and foot walls which were smooth and well defined. Accordingly the workings consist mainly of drives and stopes along the walls, with crosscuts in places, and some winzes.

Most of the driving is to the north-east which suggests that the ore-shoot plunges in that direction.

Sofoulis (unpublished report, 1957) considered that the average grade of ore in the mine was from 1-2 per cent. Cu, and that the production of copper ore would have been of the order of 2,000 tons.

THE VICTORIA NORTH, AND VICTORIA, COPPER MINES

These leases (variously M.L.s. 23, 38, 84, 85, 86 and 111) covered mostly the same ground and were located near the western boundary of Location 14181, the present Show-ground and Race-course reserve at Northampton.

The old workings follow a north-south line over a length of about 800 feet. Two shafts, 80 feet apart, were sunk at the northern end of this line, the deeper of these was said to be 70 feet. These are now partly collapsed and hold water to within about 15 feet of the surface.

The ore body was apparently vertical and near the surface consisted of a ferruginous and siliceous kaolinised schist containing green and blue carbonates with some oxides. In the deeper workings there was a good deal of iron pyrites.

THE WHEAL MARGARET COPPER MINE

Several leases were held on the Wheal Margaret copper "lode", including M.L. 12, the Wheal Margaret, M.L. 25, the Wheal Margaret South, and M.L. 18, the Wheal Margaret North. These leases were located within Northampton townsite, about 1 mile south-east of Wanerenooka Hill.

The main workings are on the Wheal Margaret lease where five shafts extend in a north-easterly direction over a distance of 270 feet. The workings reached a depth of 180 feet on the underlay, which was about 75 degrees to the east. A shoot of ore was stoped from the main two-compartment shaft over a length of 200 feet, the width of the "lode" varying from 7 inches to 2 feet.

The ore consisted of green and blue carbonates near the surface and sulphides at depth, in a kaolinised matrix probably representing fault gouge. Some pegmatitic material was found in a shallow hole at the northern end of these workings.

In 1902 the Mines Department drilled a hole to intersect the Wheal Margaret "lode" at depth. The hole was sited 257 feet east of the outcrop, between the Main and No. 2 shafts, and drilled at a depressed angle of 59 degrees in the direction north 38 degrees west, to a total depth of 651 feet. It is considered that the ore channel was intersected at about 400 feet borehole depth but mineralisation was negligible.

The Wheal Margaret South, on Locations 281 and 267, had a shaft 40 feet deep with a 25-foot drive at the bottom and a line of shallow costeams and trenches extending to the south-west. The water level in the old shafts now stands at about 25 feet.

The ore body which is from 2 to 4 feet wide, dips to the east at about 75 degrees.

THE YANKEE CROSSING COPPER MINE

These old workings are located 1.5 miles south-easterly of Northampton townsite on Location 5695, just to the east of the Gwalla property. A small but rich shoot was worked to a depth of 40 feet, at the north end on a vertical shear.

The water table stands at about 15 feet in a series of shallow workings trending north-east.

THE GWALLA COPPER MINE

This mine is three quarters of a mile south of Northampton on Location 315. There are two parallel ore bodies which strike north-east and dip south-east at steep angles; the most work was done on the eastern one on which several shafts had been sunk, the deepest of which was 198 feet on the underlay (180 feet vertical). According to Montgomery (1908), drives and stopes on the 108-foot level extended over about 650 feet. At 594 feet north-east from the deep shaft (the more northerly of the two mentioned) a 6- by 4-foot shaft was sunk in 1907 to 104 feet. There were short drives from the bottom. Ore in this shaft was reported as poor and siliceous.

Oxley, (in Montgomery, 1908) referring to the most southerly shoot, states that the lode averaged 4 to 12 feet in width, but that in the face and backs of the drives along the hanging wall from the main shaft, there were strong makes of bornite ore about 9 inches wide, with small seams of black oxide occurring across the footwall.

Montgomery said that dump material, as well as some that he saw bagged for shipment, was of low grade. He saw no bornite but only occasional pieces of tarnished chalcopyrite and sooty coatings of black ore. The workings were flooded at the time of his visit.

Maitland (1903) stated that during the period 1863-1868, 902 tons of ore valued at £16,573 were raised.

THE WHEAL FORTUNE COPPER MINE

This mine is situated 3 miles west of Northampton on Location 436 on the same shear as the Wheal Fortune Extended Lead Mine. The shear trends north-east and dips steeply to the south-east. The two mines are about 400 yards apart.

The Wheal Fortune, which lies to the south-west, produced both copper and lead between 1862 and 1868. Maitland (1903) estimated its production as 2,475 tons of lead ore and 985 tons of copper ore.

The workings extend for about 700 feet along the strike, and reach a maximum depth of 300 feet. It is stated that ore in the shallower levels was copper ore, but a cross-structure carrying lead ore was encountered at depth and this was then mined.

In plan the copper shoot appears on the south, and it is possible that there are two separate southerly plunging ore bodies.

THE NARRA TARRA LEAD AND COPPER MINE (LOC. 833)

This mine is located about 13 miles south-east of Northampton near Protheroe townsite, approximately 3.5 miles south-west of Nabawa.

There are three distinct lines of mineralisation striking in a north-east direction, the main workings being in the "west lode" which dips steeply east. The principal economic minerals comprised ores of lead, but Wilson (1926, p. 24) stated, "A curious feature about the main lode, which also applies to the east lode to some extent, is that at the south end of the mine, the galena gives out quite suddenly, and its place is taken by copper pyrites, the southern portion of the lode having been mined for its copper content. In the case of the east lode, however, quite a quantity of the lead ore contains copper also. My specimens seemed to indicate that the copper pyrites had been deposited subsequently to the galena. The feature of the middle lode was the presence of some good specimens of pyromorphite at the north end workings."

According to the plan and section shown in Wilson's report the main workings (drives and stopes) extended over about 930 feet and to a depth of 550 feet. There are 5 shafts and three ore passes. Two open cuts covered a length of about 300 feet, and reached a maximum depth of 45 feet. On the same section an almost vertical fault is shown between the sections worked for copper and lead.

Under "General Remarks" Wilson makes the following comments: "Main Lode—It will be noted that the main lode workings have produced 113,992 tons of lead ore containing 12,053 tons of concentrates valued at £349,490 11s., and in addition 24,833 tons of copper ore containing 1,682 tons of copper and 36,837 oz. of silver valued at £116,285 2s. 3d. A glance at the Longitudinal Section will show, however, that most of the ore above the 550 feet level has been stoped out, leaving very little ore in reserve. Furthermore, the values obtained at the 550 feet level were not sufficiently encouraging in the opinion of the management to warrant the further sinking of the shaft to open up another level . . ." "Middle Lode: There are two lots of old workings on this lode which are about half a mile apart. On general appearance, the lode at the north end where the pyromorphite outcrops, appears the more encouraging, and a prospecting shaft to test its value under this outcrop seems justified." "Eastern Lode: About 1,900 feet to the south-east of the Main Lode on Location 119 the eastern lode is now being developed. This was worked in the early days of the Field, and was then known as the Narra Tarra Copper Mine. Like the middle lode it can be traced for about half a mile, and the workings are also confined to either end of it."

The "lode" was worked at the southern end for copper, southwards of the main vertical shaft. The ore was oxidised to at least 102 feet.

The production given by Wilson is at variance with the official figures. Over the period 1922-25 Location 833 is credited with producing 23,766.67 long tons of ore containing a copper content of 1,784.64 tons of metallic copper. In 1929 production from the Narra Tarra mine on the same location is recorded as 116.0 tons of ore containing 12.11 tons of metallic copper. This was probably the biggest single producer of copper ore on the Field.

THE GELIRAH LEAD AND COPPER MINE

This mine is located on Freehold Block No. 328 which lies just on the eastern side of the old railway line about 12 miles north of Geraldton. There are two parallel ore bodies, the more easterly of which crops out over a distance of 300 yards along which several shafts have been sunk to a maximum depth of 120 feet. It is said that a large quantity of ore was raised from here (Maitland, 1903).

The western ore body has been opened by a series of shafts over a distance of 200 yards, and was found to contain good lead ore in places, associated with zinc blende and iron pyrites.

This mine was worked prior to 1860, and re-opened for a short period in 1872.

THE WHITE PEAK COPPER MINE

This mine is situated on Freehold Block No. 4, between the old railway line and the main road 9 miles north of Geraldton (Maitland, 1903). A rich shoot was said to have been worked, but nothing has been done since 1858 and the workings have collapsed.

OTHER PROPERTIES THAT HAVE PRODUCED COPPER

These include the Ouraka (M.L. 94), Hennings (M.L. 95), Tambarra, and Gibsons (M.L. 30). These are all in the same group, eastward and south-eastward of the Geraldine Copper Mine. The workings are shallow and they have each produced only a few tons of ore.

FUTURE EXPLORATION

The majority of the ore shoots, both of lead and copper, occur along the north-easterly striking shear structures and brecciated zones, which dip steeply either to the east or west. Mineralisation of minor importance has been found along a fracture system, the components of which strike to the north-west. These evidently exert some structural control on the ore occurrences in the north-easterly shears. The discontinuation of ore at the bottom of the deeper workings appears to be due to structural reasons.

Surface indications of ore-bodies have included pegmatitisation and silicification along brecciated zones. In places there has been a fair development of iron gossan with carbonate staining.

Practically all of the copper ore so far mined has been composed of oxidised or secondary minerals lying above, or adjacent to, the water table. There is no adequate information on the grade of the primary ore beneath worked shoots, but it appears that future copper mining in this Field will depend upon the detection and development of such ore bodies of satisfactory grade. The best place to look for these initially would be below worked-out mines, applying the results of structural analysis and then testing by drilling.

Such a project would be long range and beyond the capabilities of the small operator, who will necessarily have to confine himself to surface prospecting in areas which contain some or all of the indications listed above.

THE YALGOO GOLDFIELD DEPOSITS

SUMMARY

Copper has been produced from seven centres in the Yalgoo Goldfield, the earliest recorded production being in 1906. However, the total amounts to only 725 tons, about two-thirds of which has been mined from M.C. 14 at Warriedar since 1957.

All of the ore bodies are copper-bearing quartz veins in metamorphosed Archaean basic igneous rocks or Archaean metasediments. Most of them are known to carry some gold and silver. Little work has been done below the water table level.

The following table summarises the types of deposits in the Yalgoo Goldfield :—

Table 62
TYPES OF DEPOSITS IN THE YALGOO GOLDFIELD

Locality	Tenement	Ore Produced		Remarks
		Copper Ore	Cupreous Ore	
Twin Peaks	Various	Long Tons 33·00	Long Tons 54·49	Narrow steeply dipping quartz veins in Archaean basic rocks.
Wadgingarra	M.L. 6 P.A. 2510	13·91 ....	.... 2·80	Steeply dipping quartz veins in Archaean rocks. Low grade. Also some economic gold and silver.
Bunnawarra	P.A. 2565 ....	....	5·73	Steeply dipping quartz vein in Archaean basic rocks.
Warriedar	M.C. 14 ....	....	569·24	Quartz vein in fractured doleritic Archaean rocks.
Field's Find	P.A. 2363	30·45	....	do. do. do.
Lang's Find	P.A. 2537	9·35	....	do. do. do.
Mt. Gibson	Various	4·99	....	Quartz veins in Archaean metasediments.

Table 63
COPPER AND CUPREOUS ORE PRODUCTION IN THE
YALGOO GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1906	27·41	3·25	284
1907	10·00	2·00	130
1908	9·50	1·49	97
1909-1914 ....	....	....	....
1915	4·99	1·10	95
1916-1944 ....	....	....	....
1945	30·45	4·07	205
1946-1956 ....	....	....	....
1957	9·35	1·26	193
1958-1960 ....	....	....	....
Total	91·70	13·17	1,004

Average weighted assay = 14·36%.

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Copper	Value
	Long Tons			£A
1949	7·00	72·73	10·39	48·00
1950 ....	.....	.....	.....	.....
1951	40·00	136·00	3·40	240·00
1952-1954 .....	.....	.....	.....	.....
1955	10·29	80·35	7·80	101·86
1956-1957 .....	.....	.....	.....	.....
1958	43·09	393·40	9·13	636·70
1959	112·56	1,232·09	10·94	2,220·95
1960	419·78	4,252·10	10·13	7,415·20
Total	632·72	6,166·67	9·75	10,662·71

THE TWIN PEAKS DEPOSITS

Introduction

The first recorded production of copper from this centre was in 1906. To the end of 1960 the total production of copper and cupreous ore had amounted to 84 tons averaging about 16 per cent. Cu.

The workings were abandoned at the time of the author's visit in 1961.

The deposits are located north-eastwards of Twin Peaks Homestead, the workings on M.C. 25 (pegged in May, 1961), being about 0·5 mile bearing 70 degrees from the Trig. Station. The road distance to the railway at Mullewa is about 70 miles. Approximate geographical co-ordinates are :—

Latitude 27° 20' S.

Longitude 116° 0' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 55/300.
2. Lands Department 10-Mile Topographic Series, Sheet 7—Geraldton.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Aerial photographs and photo-mosaics are available from the Lands and Surveys Department.

Geological Information

The general geology of the area is shown on Plate 1 of Bulletin 106 (Johnson, 1950). The deposits are located near the southern end of a narrow lens of "basic lavas with intrusive basic and acid rocks, pyroclastics and minor quantities of sedimentary rocks." To the north-east the "greenstone" rocks are surrounded by intrusive granite, while southwards and westwards the "basement" rock is obscured by Recent alluvium.

The country rock in the vicinity of M.C. 25 consists of schistose and fractured basic igneous rock which rises at the southern end into two prominent peaks. Fractured quartz-felspar-porphry was observed on the eastern side of the vein. Copper

mineralisation occurs in a narrow silicified zone along a fault line which strikes about 30 degrees east of north and dips to the east at about 80 degrees.

As seen in the various excavations the silicified zone appears to be a composite sheeted intrusion averaging about 3 feet in width. The workings, which were not examined at depth, consist of two shafts, one 80 feet and the other 24 feet deep, two open cuts and a line of pot holes and shallow pits. An old bin containing some ore still stands near the 80 feet shaft.

Copper mineralisation, which is not pronounced, is in the form of blue and green carbonates, and possibly chrysocolla. The main concentrations appear to be on the footwall.

The vein can be traced for about 60 feet north-eastwards from the main shaft before it lenses out. South-westwards a little copper staining in a poorly developed gossan has been exposed by shallow excavations over some 400 feet.

About 6 chains westwards of the main ore body, near its southern end, two shafts have been sunk, on poor showings of carbonate in spongy iron gossan. The shafts are about 90 feet apart and are now almost filled in.

The Ringing Bell Copper "Lode" described by Maitland (1919) is apparently the same as the one seen by the author. However, no Mines Department records could be found showing its position with respect to the ground described above.

Production

Table 64

COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1906	P.A. 105H	Tibbets, W. H.	Long Tons 13·50	Long Tons 2·27	£A 193·00
1907-08	P.A. 155*	Summers, S. D.	19·50	3·49	227·00
1909-60	<i>Nil</i>				
Total to the end of 1960			33·00†	5·76	420·00

* Stated to be 1·5 miles south of the Ringing Bell (Maitland, 1919).

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1949	M.C. 7	Dower, H. J., and Party	Long Tons 7·00	10·39	72·73	£A 48·00
1951-55	M.C. 7	Twin Peaks Copper Industries Ltd.	47·49	3·89	184·67	292·76
1959-60	<i>Nil</i>					
Total to the end of 1960			54·49	14·28	257·40	340·76

† Maitland (1919, p. 14) reports that 8 tons of ore were raised from the Ringing Bell Copper Lode about 1917.

Remarks

These deposits are narrow copper-bearing siliceous intrusions (adopting a sheeted lode-like formation in places) into fault lines in metamorphosed Archaean basic igneous rocks.

They have been low-grade from the surface, and do not appear to be of much importance.

THE WADINGARRA DEPOSIT

The first production from this centre was in 1906. Until the end of 1960 only 16·71 tons of copper ore and cupreous ore, assaying about 4·7 per cent. Cu, has been recorded.

Wadgingarra is situated 7·5 miles east of Yalgoo (the nearest township with the usual facilities). The copper deposits are about 5 miles north of Wadgingarra Railway Siding.

Approximate geographical co-ordinates are :—

Latitude 28° 28' S.

Longitude 116° 45' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 40/300.
2. Lands Department 10-Mile Topographic Series, Sheet 7, Geraldton.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

General Information

Production in this area has been recorded for Mineral Lease 6, the Olive Queen, and Prospecting Area 2510, a short distance to the north-east. Gold has been produced from this area and the presence of copper in the gold ores has, at times, made the treatment difficult.

The main workings on the Olive Queen consists of two shafts on a well defined quartz reef which strikes about north-south and dips vertically. The northern shaft has been sunk below water level which is at about 105 feet, and the southern shaft is 38 feet deep.

Very small quantities of copper carbonates could be seen in the quartz outcrop, and in a small dump of reject material near the northern shaft. Some pyrite shows in the dump material and a poor development of limonitic gossan follows the line of the reef.

Several chains to the north-east on lower ground are some shallow pits, and what look like small dumps of dry blown material.

The host rocks are poorly exposed, being covered by laterite or sand in many places, but appear to be metamorphosed, Archaean basic igneous rocks.

Production

Table 65
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1906	M.L. 6	Olive Queen	Long Tons 13·91	Long Tons 0·98	£A 91·00

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1955	P.A. 2510	Johansen, J.	Long Tons 2·80	11·30	31·68	£A 49·10

Remarks

These deposits appear to have little chance of being developed further.

THE BUNNAWARRA DEPOSIT

A few tons of cupreous ore were produced from a copper-bearing quartz reef located 7·5 miles west of Bunnawarra Homestead, in 1960. The host rocks are Archaean basic igneous lavas and low grade mineralisation has occurred along an east-west fault line.

Surface copper indications are confined to occasional showings of carbonates in poorly developed limonitic cap and quartz.

The ore came from a shallow open cut a few yards long.

Production

Table 66
CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1960	P.A. 2565	Todd and Hodder	Long Tons 5·73	8·90	50·95	£A 81·50

Remarks

This deposit is small and of little consequence.

THE WARRIEDAR DEPOSIT

Production of cupreous ore for fertilizer purposes commenced from M.C. 14 near Warriedar in 1958. Up to the end of 1960, 232 tons assaying 10·53 per cent. Cu had been produced.

The Mineral Claim is located in the southern part of the Yalgoo Goldfield on Warriedar Station property. When traveling from Perth, the best access is along the Great Northern Highway via Miling and Wubin to the 236-Mile peg, thence 20·8 miles by graded tracks to the Homestead, thence 6·5 miles by graded track via the abandoned Long's Find to the Mine.

Distance to rail is 74 miles south-eastwards to Perenjori via the old mining centre of Rothsay. This road has recently (1961) been improved.

Approximate geographical co-ordinates are :—

Latitude 29° 10' S.
Longitude 117° 5' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph No. 41/300.
2. Lands Department 10-Mile Topographic Series, Sheet 4, Perth.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Geological Information

There are a number of rounded prominences in the vicinity of M.C. 14, one of which is Mt. Warriedar about 1 mile to the south-west, rising to about 530 feet above the general level of the plain country further south. Mt. Warriedar forms the southern end of a long range which with few breaks extends north-north-west almost to Yalgoo.

The country rocks are two basic igneous types, one of which is less metamorphosed and appears to be intrusive into the older. The younger is the host rock on M.C. 14.

The nearest known outcrop of granitic rock is an intrusive mass of acid type, a few miles to the south. Feldtmann (1921) regards this Mulgine Granite as an acid marginal facies of the more normal granite to the south. Molybdenite has been reported in the vicinity of Mulgine.

M.C. 14 lies approximately 2 miles north 65 degrees east of Warriedar Trig. in a greenstone development on the eastern side of a belt of Archaean metasediments.

The copper on M.C. 14 occurs in a quartz vein in a strongly fractured, though texturally massive, fine-grained basaltic dolerite. The vein, which ranges in width from 1 foot to 4 feet, strikes 25 degrees west of north, and dips at angles from 35 to 40 degrees to the south-west. It crops out poorly, indicated only by a few scattered quartz boulders, on the northern flank of a low rise comprised of blocky doleritic rubble and reddish brown decomposition products, and can be traced on the surface with any degree of certainty for only about 5 chains.

About 100 yards south-west of the mine shaft, scattered outcroppings of copper-bearing quartz can be seen. These appear to occur in two, or more, narrow veins striking about 235 degrees.

The vein has been worked down-dip to about 140 feet, and drives and stopes extend over about 90 feet. The vein shows an overall increase in thickness from about 1 foot at the north-western end to about 4 feet at the other.

The workings are within the oxidised zone and the ore minerals are azurite, malachite, chrysocolla, some chalcocite, and also the rather rare pseudomalachite. Gangue minerals include quartz, with limonite, calcite, and chalcedony. There is some gold and silver. Near the surface copper mineralisation tends to be disseminated throughout the gangue and also in the weathered material in the walls, whereas in the deeper parts of the workings it is more usually concentrated in seams or kidneys throughout the quartz.

Production

Table 67
CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Value
1958	M.C. 14	O'Callaghan and Howlett ...	Long Tons 43·09	9·13	£A 637·70
1959	M.C. 14	O'Callaghan and Howlett ...	112·10	11·10	2,220·95
1960	M.C. 14	O'Callaghan and Howlett ...	414·05	10·15	7,333·70
Total to the end of 1960			569·24	10·26	10,192·35

Remarks

The observable structure on M.C. 14 is not extensive, and also it seems likely that primary ore of lower grade will be met just below the present workings. It is doubtful if it will develop into a big producer but should have a useful life in a small way. Other copper-bearing reefs in the vicinity should be investigated.

OTHER DEPOSITS IN THE YALGOO GOLDFIELD

Introduction

Small quantities of copper ore have been reported raised from Field's Find (1945), Lang's Find (1957) and Mt. Gibson (1915). None of these deposits showed much promise and although they have received attention from prospectors at various times since, no further work has been done.

These deposits were not visited by the author but they are known to be formed by copper-bearing quartz veins in Archaean rocks.

Production

Table 68
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore		Value
			Long Tons	Long Tons	£A
1945	P.A. 2363	Malone, M. P. (Field's Find)	30.45	4.07	205.16
1957	P.A. 2537	Deveson, R. E. (Long's Find)	9.35	1.26	193.20
1915	Sundry Claims	Mt. Gibson	4.99	1.10	95.00

Remarks

As far as is known these deposits are of little economic significance.

FUTURE PROSPECTING

Copper deposits have been worked over a wide area in the Yalgoo Goldfield but, with the exception of Warriedar which has been producing only since 1958, less than 50 tons has been raised from each locality.

The surface expression of the Warriedar deposit was not outstanding and it is possible that other comparable ore bodies have been overlooked because of insignificant outcrops.

No particular area can be recommended however. The most that can be said is that the majority of known deposits in this Field occur in the Greenstone belts shown on the State Geological Map.

THE EAST MURCHISON GOLDFIELD DEPOSITS

SUMMARY

Recorded production of copper ore for the East Murchison Goldfield is 649.73 tons assaying 14.97 per cent. Cu, and 4,629.61 tons of cupreous ore assaying 10.55 per cent. Cu. The bulk of this production has come from the three widely-separated centres Barrambi, near the common boundary of the Murchison and East Murchison Fields, Kathleen, and Lawlers.

All these deposits are short shoots in auriferous quartz veins; at Barrambi the quartz is intrusive into Archaean meta-

sediments, and at the other two, quartz is intrusive into fine- and coarse-grained Archaean epidiorite. They are all located near the edge of old gold mining centres. Practically no work has been done below the water table.

The following table lists the various centres and summarises the types of deposits at each.

Table 69
TYPES OF DEPOSIT IN THE EAST MURCHISON GOLDFIELD

Locality	Tenement	Ore Produced*		Remarks
		Copper Ore	Cupreous Ore	
Barrambi	P.A. 1895B, M.C. 2B	Long Tons 109·91	Long Tons 1,264·10	Narrow steeply dipping quartz veins in metasediment. Some gold and silver.
Kathleen	Various	280·98	1,846·90	Fairly narrow steeply dipping quartz veins containing short ore shoots in fine to coarse grained epidiorite. Contains gold and silver.
Sir Samuel	Various P.As....	10·74	133·24	Cupriferous gold quartz veins in fine grained epidiorite.
Agnew and Law- lers	Various	248·10	1,415·99	Cupriferous gold quartz veins in medium and fine grained epidiorite

* Up to the end of 1960, but known to be incomplete in some cases.

Table 70
COPPER AND CUPREOUS ORE PRODUCTION IN THE
EAST MURCHISON GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1908	6·77	1·32	69
1908-14 ....	.....	.....	.....
1915	10·93	2·03	147
1916	63·42	11·22	1,311
1917	75·00	11·70	1,532
1918	82·44	12·15	1,314
1919-37 ....	.....	.....	.....
1938 ....	.....	3·02	161
1939-41 ....	.....	.....	.....
1942	9·43	1·52	152
1943	0·40	0·33	33
1944	26·80	3·01	183
1945	9·12	1·70	159
1946-55 ....	.....	.....	.....
1956	100·59	11·02	2,131
1957	264·83	38·28	6,906
1958-60 ....	.....	.....	.....
Total	649·73	97·30*	14,089

Average weighted assay = 14·97% Cu.

* Does not include 3·37 tons of metallic copper produced by Wiluna Gold Mines during 1938-44.

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Copper	Value
	Long Tons			£A
1951	268·93	2,742·34	10·19	3,079·46
1952	340·05	4,571·57	13·44	5,495·72
1953	892·10	7,567·29	8·48	10,043·47
1954	553·04	7,882·89	14·25	12,671·49
1955	695·58	8,269·42	11·89	14,083·62
1956	411·43	4,228·48	10·37	7,261·07
1957	575·54	6,149·21	10·68	10,504·25
1958	737·79	6,208·66	8·41	9,161·15
1959	155·15	1,224·01	7·89	1,745·10
1960 ....	....	....	....	....
Total	4,629·61	48,843·87	10·55	74,045·33

THE BARRAMBI DEPOSIT

Introduction

This deposit is located just inside the western boundary of the Goldfield about 14 miles south-east of the old gold mining centre of Errols.

It was first worked in 1944 as P.A. 1895B, and later the same ground was covered by mineral claims 2B and 3B. Up to the end of 1960 a total of 1,374 tons of cupreous and copper ore had been produced. The deposit is 85 miles south-east of Meekatharra railhead, about 5 chains west of Barrambi Station Homestead. Approximate geographical co-ordinates are :—

Latitude 27° 30' S.

Longitude 119° 10' E.

Reference may be made to the following maps :—

1. Lands Department Lithograph 53/300.
2. Lands Department 10-Mile Topographic Series, Sheet 8, Wiluna

Geological Information

The deposit occurs near the southern end of a belt of chloritic schists (greenstone) and acid metasediments which contain auriferous veins in places. The belt is up to 2 miles wide and is surrounded by granite and partially granitised older rocks. Mineralisation is in quartz veins intrusive into clayey metasediments. The workings are in the centre of a soil-covered flat and outcrops are represented only by floaters. Water level stands at 120 feet.

The ore body is a sheeted quartz vein, 3 to 4 feet wide, which trends north and south and dips steeply to the east. The main shoot about 40 feet long, has been worked by two shafts to 100 feet and an open cut about 25 feet deep between these. The workings are in a partially collapsed state due to flooding by rain water.

About 170 yards north of the open cut there is a shaft about 40 feet deep. The dump from this shows no copper. About 60 yards south of the cut the dump from another shallower shaft shows azurite, malachite and a little cuprite in quartz.

Crystalline gypsum is very common in the workings and dumps.

Production

Table 71
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1944 1956-57	P.A. 1895B M.C. 2B	C. H. King Rinaldi and Motter	Long Tons	Long Tons	£A
			19·50	2·00	117·00
			*90·41	16·27	2,871·45
Total to the end of 1960			109·91	18·27	2,988·45

Average weighted assay = 20·2%.

* Also contained 4·37 fine ounces gold and 216·73 fine ounces of silver.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1956-59	M.C. 2B	Rinaldi, Motter and Motter	Long Tons 1,264·10	9·20	11,628·73	£A 8,359·47

Remarks

This and other copper bearing quartz veins in the vicinity might yield further small parcels of picked ore to prospectors.

THE KATHLEEN DEPOSITS

Introduction

There are two groups of copper workings in the vicinity of Kathleen. The first, within one mile westwards of the townsite, contains the oldest workings with production records dating back to 1908. The other group of more recently discovered deposits lies 3 miles north of the townsite.

The total production of copper ore up to the end of 1960 amounts to 272 tons assaying approximately 12 per cent. Cu. Cupreous ore production totals 1,816 tons assaying 11 per cent. Cu. Approximate geographical co-ordinates are:—

Latitude 27° 30' S.
Longitude 120° 30' E.

Reference may be made to the following maps:—

1. Mines Department Lithograph L103, 1 inch equals 20 chains.
2. Lands Department 10-Mile Topographic Series, Sheet 8, Wiluna.
3. Geological Sketch Map of Western Australia, Geol. Survey West. Australia 1957.

Geological Information

Descriptions of the principal older workings near the townsite are given by Montgomery (1909) and some of the following information is taken from his report.

East of the townsite the principal rock types are granitic in composition and several gold deposits have been worked there. Westwards of the townsite country rock is fine- to coarse-grained epidiorite and copper is the principal economic mineral, with accessory gold and silver. This belt of greenstone country extends through to the Sir Samuel centre, 9 miles to the south. In the vicinity of the copper mines the country trends north-west. The ore bodies follow this trend and dip steeply to the south-west. They are generally small and siliceous, occupying shear zones sometimes in close association with small doleritic intrusives. There are also numerous parallel acid dykes which are not mineralised.

Gossans are only weakly developed but the ore bodies are fairly easy to follow on the higher ground because of good out-crop conditions.

The Workings near the Townsite.—The old Kathleen (M.L. 17) and Cobar Copper King (M.L. 15) leases adjoin, lying a few chains west of the western boundary of the residential area. P.A. 1426, held in 1951-52, covered the principal workings on these two old leases.

The Kathleen workings, at the northern end, consist of a 60-foot shaft (now partly filled in), and another shaft which is now only 6 feet deep. The siliceous ore body is about 2 feet wide, and dips steeply west. The old dumps show some copper carbonates, oxides, and a little chalcopyrite and pyrite. Crystalline gypsum is common.

The northernmost excavation on the main ore body consists of a 30-foot shaft, located about 90 feet south-west of the 60-foot shaft mentioned above. The ore body extends more or less continuously for about 400 feet on a bearing of 155 degrees, most of it lying in M.L. 15. The workings include an open stope about 20 feet long and 18 feet deep, which underlays to the west at about 55 degrees. An underlay shaft extends for some depth past the stope. The ore body is similar to that described above.

At about 200 feet east of the southern end of this line is another underlay shaft, at least 40 feet deep, surrounded by a fair sized dump, the material in which shows conspicuous carbonate staining, some crystalline malachite and azurite, and a little copper oxide. Other excavations further south include three underlay shafts to a maximum depth of about 30 feet, a 24-foot long open stope, and several shallower excavations.

Along this line the ore body consists of a solid vein, 2 to 4 feet in width, with occasional, parallel, thin-sheeted veins intruded in the wall rock over a total width of 6 feet. Mineralisation is weakest at the southern end. Thin basic and acid dykes occupy other parallel shears in the medium grained basaltic country rock.

Another line of workings, including the old Shepherd (M.L. 12) and the Copper King (M.L. 14) lies about 30 chains further west. Other leases held on this strip include M.Cs. 5, 13 and 11, M.L. 25, and P.As. 1424, 1427, 1436 and 1446.

The principal workings occur near the centre of the line of leases on two parallel ore bodies which trend at 340 degrees and dip westwards at about 50 degrees. The easterly ore body has been worked over a distance of 160 feet on the south, and over about the same length some 10 chains further north.

At the southern end, on late M.C. 11, there are two shafts, the northern one being underlain to the west and at least 30 feet deep. Twenty-seven feet south of this there is an open stope, 33 feet long, which appears to have been on a short shoot which plunges to the south, and which was cut by a vertical shaft about 30 feet beyond the southern end of the cut.

The dumps around the two shafts contain traces of carbonates, chrysocolla, copper oxides and pyrite in a hornblende gangue. There is very little quartz. The ore body, which averages about 2 feet in width, occupies a twisting shear in coarse grained epidiorite. It is altered to hornblende schist in places.

The northern workings include what was apparently the old Shepherd lease main shaft, stated to have been 100 feet deep (Montgomery, 1909). There are two other shallower shafts and two pot holes on this line. These disclose a siliceous ore body about 2 feet wide, the main shoot of which extends over about only 40 feet. Mineralisation in the outcrop is weak, and there are only a few patches of spongy brown iron-oxide.

About 200 yards further west the second ore body has been worked mainly by a 40 feet open stope, about 30 feet deep, and a shaft which underlays at about 75 degrees from the bottom of this. Other workings, which extend north and south over a total length of about 500 feet, include shallow shafts, pot holes and costeans.

The open stope ranges from 7 to 10 feet in width and was obviously on the main shoot, elsewhere the ore body is about 3 feet wide. At the south end two shallow pot holes have been sunk on a rather solid quartz vein but these do not show anything of interest.

From about 300 to 440 feet northwards of the open cut there is a scattered group of shallow workings which include two shafts, a couple of pot holes and an east-west trench about 195 feet long. The trench, which is on the northern side, shows only weak mineralisation on the line of the main ore body.

P.A. 1472 covers a small ore body about 20 chains westwards of this line. The shoot has been worked by an open stope about 30 feet long and three feet wide, and an underlay shaft from the centre of this, which reached a depth of 60 feet. A drive at the 15-foot level extends for 27 feet south and connects with a small open cut 12 feet long.

The ore body trends 325 degrees and dips westwards at 80 degrees. It occupies a shear in coarse-grained hornblende rock and appears to be petering out in the workings at the south end.

The Workings 3 Miles North of the Townsite.—These consist of four prospecting areas in about one square mile. The country consists of similar rock as that to the south. P.As. 1478 and 1486 are adjoining on the eastern side of the area amongst a range of low greenstone hills. Production has come mainly from P.A. 1486 where an open cut about 24 feet long and 20 feet deep has been sunk on an ore body which averages 2 feet in width and trends 350 degrees with a steep westerly dip. Two underlay shafts extend for some depth past the bottom of the open cut.

P.A. 1487 is located on an alluvial flat to the south-west of the hilly country on which P.A. 1486 is located. The deposit is worked from a shaft about 40 feet deep with a drive at the bottom level. These deposits appear to be of limited size.

Production

Table 72
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1908	M.L. 12	"The Shepherd"	Long Tons	Long Tons	£A
1945	P.A. 1329	Jessop, E.	6.77	1.32	69.00
1956-57	M.C. 13	Delich, T.	9.12	1.70	158.72
1957	P.As. 1486, 1487	Ainsworth, R. J., and Woosmam, H. G.	*220.43	29.02	5,684.60
1958-60	<i>Nil</i>		†44.66	3.14	301.25
Total to the end of 1960			280.98	35.18	6,213.57

Average weighted assay = 12.5% Cu.

* Also contained 12.81 fine ozs. gold, and 893.45 fine ozs. silver.

† Also contained 4.18 fine ozs. gold, and 66.15 fine ozs. silver.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1951	P.A. 1424	Rooney, J. P., and Hinde, R. M.	Long Tons			£A
1951	P.A. 1427	Poletti, A., and Party	31.01	9.89	306.64	307.78
1951-52	P.A. 1426	Alac, M.	257.45	14.13	3,637.56	4,465.89
1952	P.A. 1432	Flannigan, P.	8.00	6.00	48.00	48.00
1952	P.A. 1440	Jones and Campbell	27.35	7.91	216.37	216.37
1952	P.A. 1446	Moriarty and Crombie	20.15	10.92	220.17	280.50
1952-55	M.C. 5	Poletti, A.	347.52	9.19	3,194.44	3,696.63
1953	P.A. 1446	Crombie, K. B.	5.35	13.60	72.76	109.14
1955	M.C. 11	Alac, M.	619.36	12.43	7,701.69	13,139.65
1955	P.A. 1478	Coe, C.	17.76	3.57	63.56	23.83
1955	P.A. 1476	Grgich, G.	9.22	10.00	92.24	140.00
1956	M.C. 11	Alac, M.	68.18	6.43	438.44	550.96
1956	P.A. 1472	Glucina, D.	63.66	11.12	708.24	1,262.31
1956	P.A. 1475	Howarth, C. A.	30.62	10.85	332.19	575.68
1956-57	M.C. 13	Delich, T.	190.26	11.99	2,280.67	4,221.20
1957	P.As. 1486, 1487	Ainsworth, R. J., and Woosmam, H. G.	60.04	8.72	523.36	699.75
1958-60	<i>Nil</i>					
Total to the end of 1960			1,846.90	11.15	20,603.57	30,581.52

Assays and Mineralogy

The average grade of copper and cupreous ore produced from this area is about 12 per cent. Cu. Copper minerals include malachite, azurite, chrysocolla, and oxides, and near the water table enriched sulphides such as bornite, chalcocite and covellite. Primary ore contains pyrite and chalcopyrite. The principal gangue mineral is quartz. Gold and silver have been recovered from some of the copper ore.

Remarks

The individual shoots of ore are limited in extent, but are remarkably consistent in type and attitude. The shears containing the ore bodies are rather more sinuous than usual and because of this it is probable that additional undiscovered shoots occur in the vicinity of the old workings. To date, however, all ore bodies have been too small and of too low grade to permit mining below the water table.

THE SIR SAMUEL DEPOSITS

Three small copper shows have been worked near Sir Samuel townsite, which is about 9 miles south of Kathleen. The total production of the area up to the end of 1960 is 10·74 tons of copper ore, and 133·24 tons of cupreous ore assaying 9·14 per cent Cu.

The deposits are on almost the same north-south line. P.A. 1492 the most southerly one, being only about 10 chains east of the townsite boundary. P.As. 1475 and 1489 are in the same belt of fine-grained basaltic greenstone, just over 2 miles to the north.

Mining in the vicinity has been chiefly for gold, although most of the gold ore bodies opened up have contained copper, often in considerable quantities (Gibson, 1907).

The ore bodies are gold-chalcopyrite-pyrite quartz veins intrusive into north-south shear zones in the fine-grained greenstone. They are up to 8 feet wide but probably average 3 feet, and dip at variable but steep angles to the west. They can be worked for copper only in the few places where considerable secondary enrichment has occurred.

Production

Table 73
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1942-43	L.T.T. 87H	Westralian Tailings Treatment Ltd.	Long Tons 0·82	Long Tons 0·71	£A 63·0
1957	P.A. 1491	Sawyer, H. A.	9·92	0·87	180·0
1958-60	<i>Nil</i>				
Total to the end of 1960			10·74	1·58	243·0

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1951	P.A. 1438	Howarth, C. A.	Long Tons 18·00	7·67	138·15	£A 151·96
1955	P.A. 1475	Howarth, C. A.	10·15	9·70	98·46	152·53
1955	P.A. 1470	Howarth, C. A.	19·98	7·48	149·45	383·08
1956	P.A. 1475	Howarth, C. A.	30·62	10·85	332·19	575·68
1957	P.A. 1489	Howarth, C. A.	17·61	10·10	178·00	299·35
1957-58	P.A. 1491	Sawyer, H. A.	36·88	8·74	322·37	479·80
1959-60	<i>Nil</i>					
Total to the end of 1960			133·24	9·14	1,218·62	2,042·40

THE AGNEW AND LAWLERS DEPOSITS

Agnew is located 25 miles south of Sir Samuel, and Lawlers is 6 miles further south. Copper production has come from leases 2 miles south of Agnew, and from 2 miles west and 1.5 miles south-west of Lawlers.

Production, commencing in 1915 and up to the end of 1960, has amounted to 248 tons, and cupreous ore has amounted to 1,416 tons averaging about 11 per cent. Cu.

Most of this production has come from the Bower leases (Gibson, 1907, p. 23) and vicinity, the most northerly of the groups.

These deposits occur as two fairly large quartz reefs cropping out across the eastern and northern slopes of a low hill of fairly coarse-grained doleritic greenstone, which is schistose in places. The two reefs are parallel and lie 2 to 3 chains apart. They trend along lines between bearings 300 and 340 degrees, and dip at angles ranging from 50 to 60 degrees to the north-east. The north-easterly one is up to 12 feet thick at the surface, and the other one up to 6 feet thick.

The veins were worked originally for gold by underlay shafts and open cuts, being known as the Bower Leases. In 1917-18 the Bungarra lease (M.L. 29) yielded 157 tons of copper ore.

Part of this ground was later worked as P.As. 1281, 1448, and 1493, and M.C. 10, and the bulk of the total production sold as cupreous ore.

There was very little copper showing in the dumps at the time of the author's inspection and no signs of present work. Visible copper consisted of malachite and azurite.

About 56 chains to the east a shaft has been sunk to about 50 feet on a ferruginous quartz reef in fine-grained greenstone. It appears that some driving and stoping was carried out, and the vein material in the fair-sized dump shows copper carbonates and oxides, with iron oxides in quartz. The structure is not well defined and the vein cannot be traced far beyond the shaft.

There are numerous other quartz veins in the vicinity but so far these have been found to be unprofitable to work.

P.As. 1323 and 1457, 2 miles west of Lawlers townsite have produced 116 tons of copper and cupreous ore. The deposit here consists of a 3-foot wide ferruginous quartz vein which has been traced over 60 yards in highly weathered basic rock on a loam flat. The workings consist of two shafts, each 30 feet deep, near the northern end, which are connected by a stope from the bottom, and shallow open cuts to the south. Observable ore minerals are malachite, azurite, and tile ore in spongy brown iron oxides and quartz.

The vein strikes at 185 degrees and is practically vertical. It does not appear to extend far beyond the present workings.

A few tons of cupreous ore have been recovered from a quartz vein intrusive into schistose greenstone 1.5 miles south-west of Lawlers. This deposit (P.A. 1429) is surrounded by old gold workings. It appears of little significance.

Production

Table 74
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1915-16	Sundry Claims	.....	Long Tons 74·35	Long Tons 13·25	£A 1,458·00
1917-18	M.L. 29	Bungarra	157·44	23·85	2,837·00
1942	P.A. 1281	Vistarini, H.	9·01	1·14	122·00
1944	P.A. 1323	Carter, V. E.	7·30	0·96	31·00
1945-60	<i>Nil</i>				
Total to the end of 1960			248·10	38·30	4,448·00

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Average Assay per cent. Copper	Copper Units	Value
1952	P.A. 1429	Coe, C.	Long Tons 34·95	10·76	376·10	£A 424·55
1953	P.A. 1457	Jasper, M.	108·87	8·69	946·66	1,184·00
1953-54	M.C. 10	Alac, M.	1,123·61	11·57	13,004·02	19,806·02
1957-58	P.A. 1493	Delich, J.	148·56	9·41	1,398·36	2,223·05
1959-60	<i>Nil</i>					
Total to the end of 1960			1,415·99	11·11	15,723·14	23,637·62

FUTURE EXPLORATION

The deposits so far worked in this Goldfield have all consisted of short shoots in the oxidised zone, the grade becoming unprofitable near and below the water table.

Mining for copper in the future, apart from some picking around the old known deposits, seems to depend upon the locating of sub-surface ore bodies. The present knowledge is insufficient to enable positive suggestions about where these may be found. Past experience does not suggest that the area is particularly favourable for economic copper mineralisation on any appreciable scale.

THE MT. MARGARET GOLDFIELD DEPOSITS

SUMMARY

Copper production commenced from three centres towards the south-western side of the Mt. Margaret Goldfield in 1899. By the end of 1960, 47,880 tons of copper ore containing 4,455 tons of Cu had been produced, most of it during the years 1899 to 1908. From 1950 to the end of 1960, 381 tons of cupreous ore assaying 6·72 per cent. Cu were sold.

Gold was found in association with the copper, and at Murrin Murrin and Eulaminna the principal mines were worked for pyritic ore when the copper fell below workable grade at depth.

The deposits occur as siliceous ore bodies occupying shear zones in Precambrian metasediments, or at the contact of these with basic lavas. They are generally conformable with the country strike. The water table varies in depth from 90 to 120

feet, and the copper ore became unpayable under the existing conditions at a maximum depth of 250 feet.

Table 75
COPPER AND CUPREOUS ORE PRODUCTION IN THE
MT. MARGARET GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1899	273·00	67·64	4,338
1900	4,539·00	402·90	30,718
1901	7,660·00	575·30	40,738
1902	1,954·00	124·50	6,852
1903	18,965·00	790·50	45,557
1904	500·00	20·00	900
1905	60·00	14·70	674
1906	4,361·05	574·67	21,934
1907	5,144·37	1,213·70	58,914
1908	4,404·10	668·38	20,221
1909-49	.....	.....	.....
1950	.....	0·84*	107
1951	.....	0·33†	50
1952-56	.....	.....	.....
1957	19·92	1·84	404
1958-60	.....	.....	.....
Total	47,880·44	4,455·30	231,407

Average weighted assay = 9·35% Cu.

* From 2·84 tons matte.

† From 1·30 tons matte.

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Copper	Value
	Long Tons			£A
1950	9·21	84·64	9·19	63·80
1951-53	28·90	273·31	9·45	292·74
1954	72·86	536·57	10·00	659·62
1955	145·00	742·41	5·12	652·50
1956	69·67	533·97	7·95	752·88
1957	9·60	96·19	10·02	163·40
1958	.....	.....	.....	.....
1959	20·66	135·98	6·58	178·40
1960	25·54	159·18	6·23	182·95
Total	381·44	2,562·25	6·72	2,946·29

THE EULAMINNA DEPOSITS

Introduction

The old mining centre of Eulamina, also previously known as Anaconda, is situated 180 road miles north of Kalgoorlie via the gold mining centre of Leonora. This latter place is now a rail-head, 541 miles from Perth. The main workings are located a few chains south and south-east of the derelict Eulamina railway siding.

Woodward (1908, p. 76) reports that mineral leases were first worked at the Anaconda in 1899, and ore recovered was treated in both water jacket and two reveratory blast furnaces on the leases. However, after 1917, the production was mainly of pyritic ore which was railed to Bassendean near Perth and used for production of agricultural fertilizer. The copper content of this ore was not recorded.

Accounts of the history and mining development of the centre are given by Woodward (1908) and Clarke (1925). The underground workings were not accessible during the author's visit in March, 1962, therefore this information is taken from these reports.

Geographical co-ordinates for Eulamina are :—

Latitude 28° 57' S.
Longitude 121° 45' E.

Reference may be made to the following maps :—

1. Geological Map Scale 1 inch equals 40 chains, Plate 3, Bull. 103 (Hobson and Miles, 1950).
2. Mines Department Lithograph L31, 1 inch equals 40 chains.
3. Lands Department 10-Mile Topographic Series, Sheet 5, Kalgoorlie.

Geological Information

The principal workings at Eulamina (the Anaconda mine, previously the Mt. Malcolm Copper Mine—M.L. 10) are on late M.L. 20F. Mineralisation occurs along a contact between pillow lavas on the east, and metasediments on the west. Both of these are of Archaean age. Specimens of wall rocks taken from the 201-foot level and below were tentatively identified in the laboratory as greatly weathered andesitic rocks (Clarke, 1925).

There are three irregularly shaped major ore bodies trending from north-east to north and dipping to the east at angles ranging between 50 and 60 degrees. These extend over a distance of about 1300 feet, each one being about 300 feet long and having an average width of about 10 feet.

The workings reached a depth of 307 feet on the southern shoot. This ore was said (Woodward, 1908) to have carried 15 to 25 per cent. Cu down to 192 feet, while below this down to 250 feet the Cu content ranged from 1 to 10 per cent. Below 250 feet the body was worked for pyritic ore.

Mineralisation down to 130 feet was mainly in the form of malachite and azurite with iron oxides in a siliceous matrix. This zone carried some gold and silver. Between 130 and 192 feet the ore carried a high percentage of iron and chalcodony with chrysocolla, cuprite and native copper.

Below 190 feet to 250 feet ore minerals were chiefly bornite, chalcocite, and pyrite, with sphalerite occurring at about 200 feet. Below 250 feet mineralisation was mainly in the form of decomposed pyrite, pyrite, and powdery chalcocite. Some cobalt (asbolite) occurs in this ore.

The ore body has been open cut to about 60 feet and at the time of the author's visit some copper ore was being recovered from old workings at the south end of the cut.

Ore recovered from the middle shoot consisted of massive chalcocite and iron pyrites with smaller quantities of cuprite and native copper in chalcodony and iron oxides. These workings also reached a depth of 307 feet.

In the southern part of the northern workings the ore was low grade to a depth of 100 feet below which to 142 feet it averaged 30 to 35 per cent. Cu (Clarke, 1925). The high grade ore contained chalcocite and pyrite. In the top zone small quantities of cuprite, native copper, and chrysocolla in siliceous iron oxide and chalcodony occurred. The demarcation between the leached material and the enriched ore was quite distinct. Towards the northern end of this shoot the surface ore was quite rich and has been open cut down to a depth of about 65 feet.

This cut terminates at the northern end against a transverse fault, movement along which seems to have been north block east. Northwards of this fault there is no well defined ore body, the mineralisation having spread out into thin lenses in the metasediment. It appears that the transverse fault was pre-ore.

The longitudinal section of the workings shown on Plate 4 of Bulletin 84 suggests that the various shoots may have had a fairly steep plunge to the south. Water level varies from 90 feet at the southern end to 120 feet at the north.

Clarke stated that he found no indication of other lines of lode in the vicinity. He added, however, that two shafts had been sunk and a little surface work done on a mineralised fissure line, striking about north-east and dipping east at about 60 degrees on M.L. 40C some two miles south of the Anaconda mine.

Production

Table 76
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1899-1902	M.L. 10C (later 4F)	Mt. Malcolm Copper Mine (later Murrin Copper Mines)	Long Tons 13,516·60	Long Tons 1,001·98	£A 70,754·00
1903-04	M.Cs. 6C, 10C (later 6F, 4F)	Murrin Copper Mines Ltd.	19,465·00*	810·50	46,457·00
1905	<i>Nil</i>	.....	.....	.....	.....
1906	M.Ls. 4F, 5F	Mt. Malcolm Copper Mine	3,839·00	418·00	17,065·00
1906-08	M.Ls. 4F, 5F, 11F, 12F	West Australian Copper Co. Ltd.	9,794·05	1,976·08	80,199·00
1909-49	<i>Nil</i>	.....	.....	.....	.....
1950-51	P.A. 1599F	Philiphoff, M.	*	1·17	157·40
1952-56	<i>Nil</i>	.....	.....	.....	.....
1957	M.C. 5F (previously M.L. 20F in part)	Grgich, G.	19·82	1·84	404·00
1958-60	<i>Nil</i>	.....	.....	.....	.....
Total to the end of 1960			46,643·97	4,209·57	215,036·40

Average weighted assay = 9·0% Cu.

* Includes some tonnage from the Murrin Murrin centre.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Average Assay per cent. Copper	Units Copper	Value
1951-53	P.A. 1599F	Philiphoff, M.	Long Tons 28-90	9-45	273-31	£A 292-74
1954	M.L. 24F	Bradley, J.	60-02	6-80	408-14	466-97
1955-56	P.A. 1645F	Le Feuvre	145-00	5-12	742-41	652-50
	now M.L. 24F					
1956	M.C. 5F	Grgich, G.	20-84	5-87	122-47	130-85
1957-58	NH	.....	.....	.....	.....	.....
1959	M.L. 25F	Anaconda Copper Mine	20-66	6-58	135-98	178-40
1960	P.A. 1661F	Marion, J. S.	25-54	6-23	159-18	182-95
Total to the end of 1960			310-96	5-92	1,841-49	1,904-41

Assays and Mineralogy

Overall grade of the copper ore produced from this centre was 9.35 per cent. Cu. Cupreous ore has averaged 5.92 per cent. Cu. The oxidised copper minerals were malachite and azurite, with some cuprite, chrysocolla and native copper. Ore in this zone also carried some gold and silver. Sulphide ore minerals consisted of chalcocite, bornite and chalcopyrite. Cobalt occurred in small quantities as asbolite.

Remarks

The fact that this ore body gave little obvious surface indication should be noted. Other jaspery and spongy iron gossans on this line, particularly if at the contact of the pillow lavas and metasediments, should be worth testing.

THE MURRIN MURRIN DEPOSITS

Introduction

These are located about 4 miles north-north-east of Eulammina, near the abandoned townsite of Murrin Murrin. As may be seen from the production tables most of the tonnage was produced during the years 1899 to 1907.

There is very little information available about these old workings, which are not inaccessible at depth. Reference may be made to the maps mentioned for the Eulammina deposits.

Geological Information

These deposits occur in an area which carries a fairly extensive soil cover over metasediments, adjacent to outcrops of basic intrusives (see plate 3, Bull. 103). The ore bodies are chalcopyrite bearing quartz veins dipping at various angles and trending generally north to north-east. The centre has also produced important quantities of gold, silver, and pyrite.

The main ore body (on late M.L. 6C) was worked by a line of 11 shafts, the deepest reaching 114 feet by the year 1909. At this level 130 feet of driving was carried out, and an internal shaft taken down another 25 feet. There is a suggestion that the ore shoots plunged at about 60 degrees to the south.

The grade was reported to be about 2 per cent. Cu. in the bottom levels. Between 1911 and 1922, 12,360 tons of pyritic ore was raised from M.L. 18F.

Sulphide ore began at 80 feet depth and in patches was very rich in zinc blende (Clarke, 1925, p. 84).

Since 1950 a small amount of oxidised copper ore has been produced from in and around these old workings.

Production

Table 77
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value
1899-1901	M.L. 6C (late 6F)	Butte City Copper Mine (later Murrin Copper Mines)	Long Tons 910·00	Long Tons 168·36	£A 11,892·00
1905-07	M.L. 6F (previously 6C and 48C)	Murrin Murrin Nangaroo Lease	291·97	62·33	3,707·00
1907	G.M.L. 207F	Bound to Win	8·12	3·55	156·00
1907	M.L. 13F	Trafalgar	15·20	6·10	267·00
1908	M.L. 18F (previously 6F and 6C)	Nangaroo	6·80	3·00	160·00
Total to the end of 1960			1,232·09	243·34	16,182·00

Average assay = 19·7% Cu.

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Average Assay per cent. Copper	Copper Units	Value
1950	P.A. 1613F	Cable, D.	Long Tons 9·21	9·19	84·64	£A 63·80
1954	M.C. 2F	Cable, D.	12·84	10·00	128·43	192·65
1956	P.A. 1649F	Fanette Cox and Bernarde	6·75	5·30	35·78	30·38
1956	P.A. 1650F	Grey, A.	42·08	8·93	375·72	591·65
1957	P.A. 1650F	Grey, A.	9·60	10·02	96·19	163·40
Total to the end of 1960			80·48	8·9	720·76	1,041·88

Remarks

There is very little information available about the geology of this centre, and the abandoned old main workings are inaccessible. Production of cupreous ore has come mainly from patches of ore left at shallow depth between the older workings.

THE RIO TINTO CENTRE DEPOSITS

These old workings are located 2·5 miles slightly west of north from the Eulaminna (see Plate 3, Bull. 103). Some ore was produced from workings on W.R. 136C, but details of production are not recorded.

The ore occurs in quartz veins in metamorphosed interbedded sediments and lavas. These deposits were worked in the early years of the century, at the same time as the Eulammina deposits. The centre is currently (early 1962) receiving attention from prospectors.

FUTURE EXPLORATION

Copper has been produced from three centres embracing only a small area of the Mt. Margaret Goldfield. These centres, Murrin Murrin, Eulammina, and the Rio Tinto locality are located on the western flanks of a south plunging syncline (Hobson, 1951, Plate 1). The syncline is invaded by granite with a confined granitisation front, about 8 miles south-east of Eulammina.

Similar rocks in a comparable position elsewhere in the Field might be considered potentially prospective. The failure to locate workable copper deposits in the past, despite widespread and fairly continuous prospecting activity, may in part be due to the fairly complete leaching of the outcrops which is evidently a feature of this area.

THE NORTH COOLGARDIE GOLDFIELD

No copper deposit of any significance has yet been found in this Goldfield. The total recorded production up to the end of 1960 amounts to only 6.12 tons.

Copper ore has been raised in small parcels from one or two leases in the Goongarrie district (Simpson and Gibson, 1907). The deposits occur in metamorphosed Archaean basic igneous rocks and consist of north trending gold and copper bearing quartz veins, usually of limited size.

One such deposit occurs on the old Providence Lease (M.L. 13Z). Several shafts and shallow cuts have been sunk on the vein, the copper ore of which consisted mainly of malachite in ironstone and quartz. The vein is from 6 to 18 inches wide and is vertical.

There are numerous old gold workings in this area and a few of these show a little malachite and azurite in the dumps.

Production records, which are probably incomplete, show that in 1906, 4.70 tons of ore containing 0.42 tons of Cu valued at £33 were raised from this Lease. In 1907 1.42 tons of ore carrying 0.40 tons of Cu valued at £18 were raised from an unregistered prospecting area in this vicinity.

THE BROAD ARROW GOLDFIELD

A small quantity of copper has been produced from the old Lady Bountiful and Mt. Pleasant gold mining centres. These are situated 17 miles west-south-west and 11 miles south-west respectively of Broad Arrow townsite.

THE LADY BOUNTIFUL DEPOSIT

This deposit has been covered by P.As. 4779W and 4920W at different times. It is 70 chains north-west of Water Reserve 14354. Production in 1953 and 1955 amounted to 29.05 tons of cupreous ore assaying 10.1 per cent. Cu. Unspecified Crown lands in this vicinity yielded a further 5.54 tons assaying 3.9 per cent. Cu in 1956.

The prospecting areas covered part of a belt of slaty meta-sediments, 8 chains wide, trending about 300 degrees. These are in contact with fine-grained doleritic greenstone on the west, and coarse-grained quartz dolerite greenstone on the east. Copper mineralisation occurs in a transgressive quartz vein towards the western side of the metasedimentary strip. The vein dips steeply to the south.

There is a shaft about 30 feet deep underlying about 80 degrees to the south. Malachite, cuprite and chrysocolla with iron-oxides can be seen in a 2 feet wide quartz vein in the shaft. There are numerous pot holes in the vicinity which testify to the prospectors' attempts to find an extension to the shoot.

THE MOUNT PLEASANT DEPOSIT

Prospecting Area 5240W, covering the same ground as late M.L. 7W, lies 30 chains north-east of Mt. Pleasant Residential Reserve 4074. In 1960, 51.79 tons of cupreous ore assaying 7.79 per cent. Cu were raised from this property.

The workings, some of which were undoubtedly made for gold, include a shaft at least 45 feet deep, underlying at 80 degrees to the east, an open stope about 90 feet long which is now partly filled in, and a 45 feet shaft at the southern end. A couple of chains beyond this are two shallow costeans which disclose a little quartz with no significant mineralisation.

Country rock is a light coloured metasediment which trends 10 degrees east of north.

Some azurite, malachite and tile ore was seen in the dumps, and carbonate stains occur outside the workings in the weak gossan. The ore body as seen in the workings is a banded-quartz vein up to 3 feet in width. There is little exposure beyond the workings and it seems to be small and of little importance.

THE EAST COOLGARDIE GOLDFIELD

THE BOORARA DEPOSIT

Production up to the end of 1960 from this Goldfield has amounted to only 79.67 tons of ore, practically all of which has come from two adjoining leases in the Corsair gold mining group, about 7 miles east of Kalgoorlie.

The surrounding country consists mainly of various types of metasediments including some jaspilitic horizons. The regional strike is about 300 degrees and dips are close to vertical. The vicinity of the copper deposit has been well prospected and contains numerous old gold workings, very few of the dumps from which show any signs of copper mineralisation.

On M.L. 100 and P.A. 4940 copper occurs in a quartz vein about 2 feet thick in clayey metasediment. The ore body does not crop out well and cannot be traced far on the surface. The main shaft which is now collapsed and inaccessible, was said to have been 180 feet deep. The ore body was evidently worked mainly for gold and there is now very little copper bearing material remaining in the dumps.

The area is not considered to be particularly favourable for economic copper mineralisation.

THE YILGARN GOLDFIELD

Production statistics show that 81 tons of copper and cupreous ore have been produced from two areas in this Goldfield. A deposit described as being 11 miles south-west of the

old gold mining centre of Marda, covered by M.L. 37, yielded 16 tons of copper ore assaying 5 per cent. Cu in 1942. This deposit could not be found by the author.

The balance of the production came from two prospecting areas about 60 chains apart at the old gold mining centre of Carterton, 2 miles east of Water Reserve 13313. P.A. 6603, the northernmost of the two, yielded 38.37 tons of cupreous ore assaying 4.5 per cent. Cu in 1950. P.A. 6791 yielded 26.6 tons of cupreous ore assaying 6.05 per cent. Cu in 1956.

Both of these deposits occur in hilly country composed of fine-grained doleritic lavas. Copper mineralisation can be seen in narrow quartz veins striking about east-west and dipping vertically, which have been worked by shallow shafts and pits.

The principal economic mineral in this area is gold. Copper mineralisation seen to date is limited and of low grade.

THE DUNDAS GOLDFIELD

Copper production has been recorded from only one place in the Dundas Goldfield. In 1953, 12.69 tons of cupreous ore assaying 8.36 per cent. Cu worth £116.74 were raised from P.A. 2253. This is located 100 chains west of Rungine, a siding on the Coolgardie-Esperance railway, about 8 miles north of Norseman.

Copper mineralisation occurs in a sheeted quartz vein, 2 to 3 feet wide, which trends 10 degrees east of north and dips vertically in coarse-grained amphibolite. The hilly country is well timbered and rock exposures are good.

The deposit has been worked by means of a shaft 14 feet deep on the north, a pit 5 feet deep 12 feet further south, and a trench 5 feet deep and 27 feet long 72 feet further south.

Copper minerals exposed are carbonates and oxides. The grade is low and the deposit does not appear to be important economically.

THE PHILLIPS RIVER GOLDFIELD DEPOSITS

SUMMARY

The principal copper deposits in the Phillips River Goldfield extend in a belt from about 1 mile westwards of Ravens-thorpe townsite to about 3 miles northward, and thence about 13 miles south-eastwards to the vicinity of the deserted township of Kundip. Hopetoun, 30 miles away on the south coast, is the nearest coastal town, but the harbour has not been used for many years even by coastal freighters. Newdegate, the nearest railhead, is 84 miles to the north-west.

Total copper ore production for the Field from 1920 up to the end of 1960, is 106,182 tons with an average assay of 10.24 per cent. Cu valued at £1,085,776. The cupreous ore production, which dates only from 1950, totals 866.36 tons with an average assay of 12.13 per cent. Cu valued at £27,716.

Production has come from copper-gold-silver ore bodies which, at the grade considered workable in the past, have mostly been small and erratic. It is now known however that the Elverdton-Desmond shear carries copper mineralisation assaying about 1.5 per cent. Cu over a length of at least 2,200 feet, and an average width of 39 feet. Drill hole intersections have been made at depths varying between 180 and 660 feet. However

a borehole intersection at 1,150 feet vertical depth passed through more than 20 feet of strong lode formation which assayed 1.7 per cent. Cu.

The ore bodies are believed to be epigenetic, hypothermal, quartz-copper-gold replacement deposits. They are, to a certain extent, conformable in strike and dip with the host rocks, occupying shears at rock type contacts, and occasionally shear and fracture zones in massive basic igneous rocks.

The host rocks in general are metasediments which in some places are partially granitised, and interbedded basic igneous rocks. These are classified as Archaean Greenstone by Sofoulis (1958, p. 97) who also states that "the amygdaloidal lava beds have been the most susceptible horizons, whilst recorded production from agglomeratic and metasedimentary Greenstones has been of a minor nature only". The present writer however considers that the metasediments have had more influence on ore deposition. The Elverdton ore body is transgressive through acid to ultrabasic rocks over part of its length north of the main shaft, whilst to the south of this it is confined to an acid metasedimentary bed.

Rocks of the Greenstone system are overlain by metasediments of the Whitestone system and these also have been mineralised in places.

The belt of deposits follows the boundary of a granitised core for about 11 miles on the north-eastern side and for about 4 miles on the north-western side. According to Ellis (1953) there is a strong suggestion that the best of the small copper deposits occurred along the north-eastern boundary, and that the best of the small gold deposits were in greenstone country on the north-western side of the core.

Mineral association is mainly quartz-gold, and quartz-gold-chalcopyrite, with minor pyrite and pyrrhotite. Quartz is present in all ore bodies, and most of them carry copper minerals such as azurite, malachite, covellite, and chalcopyrite. Oxidation extends to 200 feet in places but occasionally sulphides occur to within 30 feet of the surface.

The deepest workings are on the Elverdton and Cattlin ore bodies to about 500 feet vertical depth. It was found that gold values diminished with depth, probably mainly because of secondary enrichment. The gold was associated with siliceous ore, rather than with copper sulphide. All smelted products contained some silver. Lenses and pods of basic material are present in the ore bodies in some places and these appear to have been introduced at the same time as the ore.

The predominantly gold prospects tend to pass into low grade copper deposits in the deeper parts of the workings. Much of the copper ore contained little quartz which became even less plentiful at depth.

Recovery of gold was effected by amalgamation and cyanidation. A few of the ores were free milling but below water level the copper content of most bodies caused difficulty with the cyanidation process. Some of the tailings dumps have been re-treated over the past few years.

A Government smelter produced blister copper from copper ores in the early days of the Field. Currently ore produced from the Ravensthorpe Copper Mines leases are being concentrated by acid treatment and flotation. A detailed description of the earlier metallurgical treatment of the copper ores has been given by McKeown (1917).

TABLE 78

TABULATION OF SOME MINING LEASES—PHILLIPS RIVER GOLDFIELD

RAVENSTHORPE CENTRE

Lease		Ore Body			Host Rock	Rock Types in Workings	Minerals in Workings	Rock Types on Lease	Remarks
No.	Name	Nature	Strike	Dip					
M.L. 13	Cousin's Glory	Ferruginous quartz veins	N 50° E	Vertical	Sheared greenstones and sheared hornblende	Sheared basic lavas, mica schists, diorites, sheared hornblende	Some copper traces, quartz - primary and secondary garnet	Basic lavas, hornblende, diorite mica schists	Includes southernmost shafts of G.M.L. 87. Other shafts south end of lease. Four fairly deep shafts, not accessible.
M.L. 14	Sunrise	Quartz - biotite veins in fault zone	N 30° E	10°-25° E	Basic granitised lavas	Basic granitised lavas	Quartz, dark green biotite	Basic lavas, granitised lavas, granite, quartz-gabbro	Several shallow prospecting shafts and one underlay shaft on quartz-biotite veins. Veins—1in. thick mica.
M.L. 15	Mt. Cattlin	Lease now covered by G.M.L. 215 and G.M.Ls. 223 to 227.							
M.L. 16	Marion Martin	Shafts dumps, bubbly quartz and cupriferous quartz veins	N 80° E N 70° E N 60° E	Vertical Vertical N 75°	Sheared basic lavas and greenstone schists	Basic lavas, greenstone schists, granite, diorite, dolerite, garnetiferous greenstone schists	Quartz (massive and sugary), azurite, malachite, cuprite traces, iron gossans, pyrite in sugary quartz, garnets. Some chalcopyrite and blue magnetite on central dumps. Ochre	Diorite dykes, granite, basic lavas, greenstone schists	Copper not prevalent on dumps of W. shafts but much stronger on N. and E. dumps. Area cut by N.N.W. trending diorite dykes. One lode can be seen to have formed along zone of metamorphism of greenstone schists by igneous dykes. Garnets predominate in N. and E. workings. Area intruded by granite tongues.
M.L. 26	Ellendale ....	.....	N 40° E	N 75°	Basic greenstone lavas	Basic greenstone lavas, pegmatite	Quartz, magnetite, traces of copper and manganese stains	Basic lavas, pegmatite, diorite dyke	Veins cut at N. end by pegmatite. Diorite dyke across S.W. corner trending N.S.

M.L. 27	Lady Janet	Ferruginous quartz veins with copper	....	....	Sheared basic lavas	Sheared basic lavas, pegmatite, diorite, porphyry	Quartz, tourmaline, azurite, malachite, mica, feldspar	Basic lavas, agglomerates, diorite, porphyry	Shafts inaccessible. Workings on series of parallel to sub-parallel shears. General trend N. 60° E. in lava bands in agglomerates. Copper increasing to N.E.
M.L. 28	Golden Crown	Quartz veins	....	....	Sheared basic lavas	Basic lavas	Traces of copper staining. Iron gossan	Basic lavas, diorite, pegmatite, porphyry	Two shafts in basic lavas in agglomerates, not accessible.
M.L. 30	Glasgow	Rubby quartz veins	....	....	....	Basic lavas, granite, pegmatite	Mica, quartz, copper stains, garnet	Basic lavas, pegmatite and diorite dykes	Granitic material on dump from deeper levels. Not accessible.
M.L. 40	Maori Girl	No workings.							S.W. corner basic lavas, remainder agglomerate	Diorite dyke trending N. 20° W. through lavas.
M.L. 45	Maori Win	....	....	....	....	Garnetiferous basic lavas	Garnets, quartz, amphibolite	Basic lavas, some garnetiferous amphibolite. Granite to S.E. with pegmatite	Pegmatite veins S.E. and S.W. corners. Granite boundary cuts S.E. corner of lease. Workings collapsed, not accessible.
M.L. 48	Lone Hand	....	....	....	Garnetiferous basic lavas	Garnetiferous lavas, pegmatite, altered lavas from greenstone	Quartz, garnets, mica	Granite with small tongue of lavas to N.	Shaft sunk on granite boundary in lavas. Not accessible.
M.L. 56	Early Morn	Ferruginous quartz veins	N 10° E	Vertical	Sheared basic lavas	Sheared basic lavas	Quartz, tourmaline, traces of copper stains	Basic lavas, agglomerates	Two shafts not accessible. Workings in lava band in agglomerate horizon.	
M.L. 58	Gaulus	No workings.							Basic lavas, pegmatite and diorite dykes	Dykes trending N.N.W.
M.L. 65	Chief	No workings.							Agglomerate N. section, remainder basic lavas	Pegmatite dyke through agglomerate. Some small diorite dykes.
M.L. 72	Kandahar South	No workings.							Basic lavas	

TABLE 78—continued
TABULATION OF SOME MINING LEASES—PHILLIPS RIVER GOLDFIELD—continued
RAVENSTHORPE CENTRE—continued

Lease		Ore Body			Host Rock	Rock Types in Workings	Minerals in Workings	Rock Types on Lease	Remarks
No.	Name	Nature	Strike	Dip					
M.L. 74	Lady Jessie	Quartz-tourmaline veins	....	....	Sheared basic lavas	Basic lavas and pegmatite	Quartz, tourmaline, agglomerate, pegmatite, traces of copper staining, garnet	Basic lavas, pegmatite, diorite, agglomerate	Shaft and small open cut with pegmatite. Not accessible.
M.L. 78	I.X.L.	Ferruginous quartz veins	....	....	Sheared basic lavas	Basic lavas, diorites	Quartz, copper staining	Basic lavas, diorite	Several shallow prospecting shafts. Not accessible. General trend N. 30° E.
M.L. 110	Grimsby	Quartz veins ....	....	....	Sheared basic lavas	Basic lavas	Traces of copper on joint planes, limonite	Basic lavas, diorite	Three small shafts. Not accessible.
M.L. 114	Surprise	Cupriferous quartz and greenstone schist veins	N 70° E N 80° E N 80° E	Vertical Vertical N 35°	Basic lavas and greenstone schists	Basic lavas, granite, dolerite, diorite, greenstone schists	Quartz, azurite, malachite, cuprite ochre, iron gossans, pyrite, chalcocite, mica, traces of garnets	Basic lavas, greenstone schists, granite, diorite dykes, dolerite	Main shaft has been repaired and mine opened. New lease for copper taken out on N. section. Copper lodes appear to be in series of sub-parallel veins on schist-granite contacts.
M.L. 211	Divided	Small costeans only	....	....	Basic lavas	Basic lavas, granite	Quartz, azurite staining	Diorite dykes, granite, basic lavas	
M.L. 214	Enterprise	No workings.							
M.L. 219 = M.L. 189 = M.L. 46	Mt. Cattlin West Puzzle Zealandia	Part included in western section of G.M.Ls. 225 and 226. Workings S.W. corner. Quartz veins	N 75° W	S 70°	Mica schists	Basic lavas and garnetiferous lavas	Garnet, mica, quartz, traces of copper, manganese	Basic lavas, granite tongue into working area. Diorite dyke	Workings in centre included in G.M.L. 226. Diorite dykes trending N. 20° W.

M.L. 223 = M.L. 166	Optimist Turn of the Tide	.....	.....	.....	Garnetiferous lavas	Garnetiferous lavas	Quartz, garnet, malachite and azurite stains. Hematite gossans	Granite W. and E. sections of lease, remainder basic lavas with horn- blendite dyke	Basic lavas bounded on E., S. and W. by gran- ite. Hornblende dyke, trending N.N.W., cut- ting all other forma- tions. Not accessible.
M.L. 322	Ireland's Own	Basic lavas with quartz veins	....	....	Basic lavas	Basic lavas, fresh and granitised, granite, diorite	Traces of copper staining, biotite	Basic lavas, gran- ite, granitised lavas	Several shallow shafts. Not accessible.
M.L. 393 = M.L. 320 = M.L. 115	Sunset Sunset Sunset	Cupriferous quartz, greenstone veins	....	....	Basic lavas and greenstone schists	Basic lavas, gran- ite, diorite, green- stone schists	Quartz, azurite, malachite, cup- rite, iron gossans, pyrite, chalcop- pyrite, traces of garnet, molyb- denum	Basic lavas, gran- ite, diorite and dolerite dykes, greenstone schists	Area including two shafts, W. section, now in new Mineral Lease. Two shafts only not acces- sible.
G.M.L. 2	Albavale	Ferruginous quartz veins with copper	N 70° E	Vertical N 70°	Sheared greenstone schists	Sheared greenstone schists, fine- grained lavas, di- orite, agglomerate	Quartz, tourmaline, bornite, pyrite, chalcopyrite with azurite and mal- achite	Basic fine-grained lavas, hornblende, diorite, porphyry, agglomerates	Workings on series of parallel shear zones, in fine-grained lava and greenstone schist bands, in agglomerate. General trend N. 60° E.	
G.M.L. 4	Maori Chief	Shattered green- stone. Quartz veins	N 20° E N 45° E	N 65° Vertical	Garnetiferous basic lavas and green- stone schists	Garnetiferous lavas, greenstone schists, diorite	Quartz, magnesite traces	Granite tongues on S.E., remainder basic lavas	Diorite dykes trending N.W.	
G.M.L. 13	Marion	Quartz - tourmaline veins	....	....	Sheared basic lavas	Basic lavas, ag- glomerates	Quartz, tourmaline	Basic lavas, diorite, porphyry, ag- glomerates	Two small shafts not accessible.
G.M.L. 17	Grafter	Massive quartz veins	N 25° E	Vertical	Basic greenstone lavas	Basic lavas, peg- matite	Garnets, quartz, mica	Basic lavas with N.W. trending di- orite dyke. Small pegmatite dykes	Working in poor con- dition generally.	
G.M.L. 22	Maori King	No workings.							N.-W. section basic lavas. S. section hornblende gran- ite. E.-N.-E., granite	Diorite dykes trending N. 40° W. through lavas and granite.
G.M.L. 24	Empire	Ferruginous quartz veins	....	....	Fine-grained lavas	Fine-grained lavas	Quartz, copper staining	Fine-grained lavas, diorite, quartz- gabbro	Workings small, not ac- cessible.

TABLE 78—continued
TABULATION OF SOME MINING LEASES—PHILLIPS RIVER GOLDFIELD—continued
RAVENSTHORPE CENTRE—continued

Lease		Ore Body			Host Rock	Rock Types in Workings	Minerals in Workings	Rock Types on Lease	Remarks
No.	Name	Nature	Strike	Dip					
G.M.L. 32	Agnes	Ferruginous quartz veins	N 30° E	Vertical	Sheared fine-grained basic lavas	Sheared fine-grained basic lavas. Sheared agglomerates	Traces copper staining, primary and secondary quartz. Some garnets	Basic lavas, sheared agglomerates, porphyry	Four main shafts not accessible. Line of workings on shear zone. General trend N. 30° E. Working in lava band in agglomerates.
G.M.L. 45	Floater Proprietary	Quartz veins	N 20° E	....	Amygdaloidal basic lavas	Basic lavas	Garnets, quartz	Basic lavas. Agglomerates to N.	Only small shallow workings, mainly costeans.
G.M.L. 54	Plantagenet South	No workings.						Basic lavas and small pegmatite dykes	
G.M.L. 60 = G.M.L. 51	Sirdar Two Bobs	....	N 25° W N 30° W	S 80° S 70°	Greenstone schists and lavas	Garnetiferous lavas, greenstone schists and lavas	Quartz, azurite, malachite	Basic lavas	No copper present on eastern shaft dumps but strong traces on western dumps. Not accessible for most part.
G.M.L. 62	Plantagenet North	No workings.						Basic lavas, pegmatite dykes	
G.M.L. 63	Golden Link	Quartz veins in sheared fine-grained lavas	N 5° W	E 80°	Sheared fine-grained basic lavas	Fine-grained basic lavas, hornblende diorite	Traces of copper staining	Basic lavas, agglomerates, hornblende diorite	Four shafts on series of parallel shear zones. General trend N. 10° W. Not accessible.
G.M.L. 68	Danger	Ferruginous quartz veins	....	....	Sheared basic lavas	Sheared basic lavas, hornblende diorite	Pyrite, marcasite, secondary quartz, iron gossans	Basic lavas	One main shaft, two subsidiary shafts. Workings not accessible.
G.M.L. 76 = G.M.L. 50	Planet Plantagenet	Massive quartz reefs and rubbly quartz veins	N-S N 20° E	E 65°	Basic greenstone lavas	Basic lavas, pegmatite	Garnet, quartz, mica	Basic lavas and small pegmatite dykes	Workings mainly inaccessible and collapsed.

G.M.L. 87	Pole	Ferruginous quartz veins	N 30° E N 20° E	Vertical E 80°	Sheared basic lavas	Sheared basic lavas, hornblende diorite, granitised basic lavas, greenstone schists	Primary and secondary quartz, pyrite, marcasite, copper stains, iron gossans, magnesite, garnets	Basic lavas, diorite, hornblende, granitised lavas, greenstone schists	Several fairly deep shafts collapsed. Lode workings on series of parallel to sub-parallel shears. General strike N. 20-25° E., dip vertical to E. 80°. Workings not accessible.	
G.M.L. 153	Maori Queen		N 25° E	N 70°	Garnetiferous greenstone lavas	Garnetiferous lavas, pegmatite	Quartz, magnesite, faint copper staining, garnets, mica	S.W. section hornblende granite, remainder basic lavas	Not accessible.	
G.M.L. 160	Revival	Pebble band 3ft. wide	N 40° E	N 85°	Loose unconsolidated pebbles	Pebbles	Quartz, traces of azurite	Agglomerates to N., remainder basic lavas	Lode appears to be an old creek bed or ravine, dipping almost vertical and filled with unconsolidated pebbles and soil.	
G.M.L. 161	Parramatta	No workings.							Agglomerates entirely	
G.M.L. 169	Kooyaura Main Lode		N 45° E	Vertical		Basic lavas	Garnets, quartz, tourmaline		Workings small and collapsed. Not accessible.	
G.M.L. 215	Mt. Cattlin	Cupriferous quartz veins	N 80° E N 75° E	N 85° N 50°	Sheared basic lavas	Sheared basic lavas, amphibolite-hornblende rock, granite, diorite, garnetiferous lavas, mica schists	Quartz, azurite, malachite, pyrite, chalcopyrite, garnets, marcasite, magnesite, cryso-colla, mica, cuprite	Basic lavas, granite, quartz-gabbro dyke on N.E. corner. Diorite, mica schists, garnetiferous lavas	This lease includes Mt. Cattlin Mine. Plans and Longitudinal - Sections available. Workings now in poor repair and almost inaccessible. Includes part of M.L. 15.	
G.M.L. 218	Garland	No workings.							Basic lavas	
G.M.L. 219	Airzone	Quartz reef	N 20° W	S 50°	Basic lavas	Basic lavas	Quartz, hornblende, tourmaline	Basic lavas, diorite dykes	Heavily penetrated by massive quartz reefs. Workings collapsed, not accessible.	
G.M.L. 223	Mt. Cattlin No. 1	No workings.							Basic lavas with quartz - gabbro, hornblende and diorite dykes	Hornblende diorite and hornblende dykes N. 20° W. Quartz-gabbro dyke E.W. trend across others. Includes part of M.L. 15.

TABLE 78—continued
TABULATION OF SOME MINING LEASES—PHILLIPS RIVER GOLDFIELD—continued
RAVENSTHORPE CENTRE—continued

Lease		Ore Body			Host Rock	Rock Types in Workings	Minerals in Workings	Rock Types on Lease	Remarks
No.	Name	Nature	Strike	Dip					
G.M.L. 224	Mt. Cattlin No. 2	.....	....	....	.....	Basic lavas and quartz-gabbro	.....	Basic lavas, granite, quartz-gabbro and diorite dykes, vesicular lavas	Shaft on edge of quartz-gabbro dyke. Granite tongue and diorites trending N. 20° W. One shaft not accessible. Includes part of M.L. 15.
G.M.L. 225	Mt. Cattlin No. 3	Manganiferous quartz veins	....	....	Basic lavas	Basic lavas	Garnets, traces of manganese staining, quartz	Basic lavas, hornblende diorite dykes	Shaft S. boundary. Not accessible. One shaft only. Includes part of M.L. 15.
G.M.L. 226	Mt. Cattlin No. 4	Cupriferous quartz magnesite vein	N 60° W	S 70°	Basic lavas	Basic lavas	Quartz, magnesite, garnet, azurite, malachite, mica	Basic lavas, granite to S.W. and S.E., hornblendite, diorite	Workings in N.W. corner, only partly accessible. Granite in N. trending tongues with workings at tip. Includes part of M.L. 15.
G.M.L. 227	Mt. Cattlin No. 5				No workings.			Granite southern half, remainder basic lavas	N.W. covered by loam, etc. Diorites dykes trending N.N.W. through all other rocks. Includes part of M.L. 15.
G.M.L. 228	Mt. Cattlin No. 6	Cupriferous quartz veins	....	....	Sheared basic lavas and garnetiferous lavas	Sheared basic lavas and garnetiferous lavas	Azurite, cuprite, malachite, pyrite, garnets, quartz, mica	Basic lavas on W. side, remainder granite with N.N.W. trending diorite dykes. Quartz - gabbro dyke trending E.W. across centre	Lode formation on same line of shear as on G.M.L. 215 to west. Workings inaccessible. Quartz-gabbro dyke cutting through all others.

G.M.L. 229	Mt. Cattlin No. 7				No workings.			Basic lavas, S.W. corner, remainder granite	Hornblende diorite dyke N.S. in N.E. corner.
G.M.L. 234	Bullrush ....	....	....	....	Basic lavas	Basic lavas	Garnet, quartz, magnetite, traces of copper	Basic lavas with N.W. trending di- orite dyke	Not accessible.
G.M.L. 236	Airzone West	Costeans in quartz reef	N 25° W	Vertical	Basic lavas	Basic lavas	Quartz, hornblende	Basic lavas, some granitised. Small diorite dyke	

McMAHON CENTRE

M.L. 195	Mt. Benson Extended	Pyritic quartz veins	N 50° W	S 70°	Sheared and granit- ised greenstones	Sheared green- stones, granite, granitised lavas, massive green- stones	Traces of second- ary copper, pyrite	Sheared and mas- sive greenstones, granite, granit- ised lavas, ag- glomerates	Moderate workings, not accessible. Three shafts.
M.L. 204	New Moon	Pyritic quartz veins	....	....	Sheared greenstones	Sheared green- stones, granite, diorite	Traces of second- ary copper, iron- stone, pyrite	Sheared green- stones, granite, diorite	Workings fairly extensive, not accessible. Three shafts.
M.L. 205	Ballarat	Pyritic quartz veins	....	....	Massive sheared greenstones	Massive sheared greenstones, gran- ite	Pyrite, marcasite, traces of second- ary copper, garnets	Greenstones, dior- ite, granite, ag- glomerates	Workings large, not ac- cessible. Five shafts.
M.L. 295	Common- wealth	Ferruginous quartz veins	....	....	Micaceous green- stones	Micaceous green- stones, sheared lavas	Traces of second- ary copper	Diorite, green- stone schists, ag- glomerates	Small workings, not ac- cessible.
M.L. 300	Birthday	Ferruginous quartz veins	N 5° W	S 80°	Sheared greenstones and lavas	Sheared green- stones, basic lavas	Traces of copper, quartz, garnets, N. end, crysocol- la, malachite, azurite	Agglomerates, basic lavas, gran- ite	Workings extensive, not accessible. Northern workings show garnets in places. Shafts scat- tered over lease.
= M.L. 215	Birthday	N. end, cupriferous quartz veins	N 80° W	S 85°					
M.L. 311	Last Chance North	Ferruginous quartz vein	N 40° W	S 80°	Weathered lavas...	....	Quartz	Weathered lavas, greenstone schists, agglomerates	Small workings, not ac- cessible. Several shafts.
M.L. 326	Last Chance Proprietary	Plain and cupri- ferous quartz veins	N 10° W N 20° W N-S	S 70° S 80° W 70°	Sheared greenstones	Greenstone schists, agglomerates, lavas, granitised lavas	Crysocolla azurite, malachite, mag- nesite, manga- nese traces	Greenstone schists, basic lavas, ag- glomerates, gran- ite	Workings extensive, not accessible. Water level 70ft. Five shafts.

TABLE 78—*continued*TABULATION OF SOME MINING LEASES—PHILLIPS RIVER GOLDFIELD—*continued*McMAHON CENTRE—*continued*

Lease		Ore Body			Host Rock	Rock Types in Workings	Minerals in Workings	Rock Types on Lease	Remarks
No.	Name	Nature	Strike	Dip					
M.L. 351	Mt. Benson East	Ferruginous and cupriferous quartz veins	N 65° W	S 80°	Sheared greenstones	Mica schists, greenstones	Traces of azurite, malachite, cuprite, pyrite, garnets	Diorite, greenstone schists, mica schists, granite, agglomerates	Workings small, not accessible.
M.L. 394	Last Chance	Quartz veins in shear zone	N 80° W	Vertical	Sheared greenstones and mica schists	Greenstones, mica schists	Traces of azurite, malachite, cuprite, chalcopyrite, magnesite, garnets, quartz	Basic lavas, agglomerates, mica schists, granite	Workings extensive, not accessible. Several shafts in sheared lava bands in agglomerates.
M.L. 397	Benson	Ferruginous and cupriferous quartz shear zones. Pyritic quartz reefs	N 50° E N 70° E N 80° E N 80° E	N 70° Vertical Vertical S 70°	Sheared greenstones	Sheared greenstones, granite, basic lavas	Azurite, malachite, magnetite, pyrite, chalcopyrite, cuprite, garnets	Sheared greenstones, diorite, granite, agglomerates, basic lavas	Workings very extensive, not accessible. Water level 90 ft. Ten shafts.

ELVERDTON-DESMOND CENTRE

Lease		Ore Body			Host Rock	Rock Types in Workings	Minerals in Workings	Rock Types on Lease	Remarks
No.	Name	Nature	Strike	Dip					
M.L. 87	Welcome Stranger	Ferruginous, cupriferous quartz stringers in sheared lavas	N-S N 10° W	W 80° Vertical	Sheared fine-grained blocky lavas and greenstone schists	Sheared greenstones, fine-grained lavas, granite material, granitised lavas	Quartz, azurite, malachite, cuprite, crysocolla, iron gossans	Granite, sheared basic lavas, fine-grained lavas, diorites, granitised lavas	Workings now in M.L. 186 and M.L. 232. Not accessible but workings appear to be in a series of parallel to sub-parallel shears 50 yds. to 150 yds. apart, echelon N.W.

M.L. 139	Elverdton Welcome Stranger	Cupriferous quartz veins in sheared lavas	N-S	Vertical	Sheared greenstone schists	Granitic material, greenstone schists	Malachite, azurite, quartz, cuprite, limonite gossans	Granite, diorite, granitised basic lavas, greenstone schists	Lode along fault zone on granite greenstone junc- tion 3ft. wide.
M.L. 220	Grand Slam	Not accessible	N 10° E	W 80°	Sheared greenstone lavas	Sheared green- stones, granitised basic lavas, gran- itic material	Quartz, azurite, malachite, pyrite	Granite, granitised basic lavas, sheared basic lavas	Workings 3ft. wide, fairly deep, apparently along fault zone. Not acces- sible.
M.L. 399	Star of Des- mond	Cupriferous quartz veins in sheared greenstones	N 30° W	N 70°	Sheared greenstone mica schists	Granitised basic lavas, greenstone schists, granitic material	Quartz, azurite, malachite, gar- nets, crysocholla, cuprite, magnes- ite, pyrite, limon- ite gossans	Granite, diorite, granitised basic lavas, greenstone schists, quartz- gabbro	Workings fairly deep, not fully accessible. Lode appears to be on junc- tion of greenstone dyke and granitised lavas and junction of greenstone schists and granitic ma- terial.
M.L. 407	Elverdton....	.....	.....	.....	.....	Sheared greenstones and diorites, granite, granit- ised lavas, fine- grained lavas	Malachite, azurite, pyrite, chalc- opyrite, cuprite, quartz	Granite, diorite, granitised basic lavas, greenstone schists	See Plan and Sections of Elverdton Mine. Not now accessible in most of workings.
M.L. 408	Desmond	Quartz stringers and cupriferous stringers in sheared green- stone schists	N-S N 10° E N 10° W N-S	Vertical Vertical E 70° E 80°	Sheared greenstone schists, granitised lavas	Sheared greenstone schists, granitic material, granit- ised lavas, fine- grained lavas, granitised green- stone schists	Malachite, azurite, cuprite, crysochol- la, chalcantinite, m a n g a n e s e staining, quartz, magnetite, limon- ite gossans, pyrite, chalcopyrite, mica, tourmaline	Granite, diorite, granitised basic lavas, fine-grained lavas	Lode along shear zone varying from N. 10° W. to N. 10° E., dipping vertical to E. 75°. Gen- eral trend N.S. N. end is series of parallel shear zones echeloned to N.W. Few of workings acces- sible. Plans and Sec- tions available. Area covered by P.A.

TABLE 78—continued
TABULATION OF SOME MINING LEASES—PHILLIPS RIVER GOLDFIELD—continued

KUNDIP CENTRE

Lease		Ore Body			Host Rock	Rock Types in Workings		Minerals in Workings		Rock Types on Lease	Remarks
No.	Name	Nature	Strike	Dip							
M.L. 52	Harbour View	For Eastern Half of lease see under M.C. 17 and G.M.L. 258.									
		Ferruginous quartz veins with occasional tourmaline	N 70° E	S 70°	Weathered lavas	basic	Weathered lavas	basic	Quartz, azurite, and malachite staining, chlorite	Weathered basic lavas with some dioritic dykes trend N. 75° W.	Eastern half of lease now under M.C. 17. Western workings trend N. 80° E. with southerly dip of approx. 70°. Workings further N. trend N. 50° W. dip. Southerly approx. 70°.
M.L. 60	Red, White, and Blue Union Jack	Lease now divided into G.M.L. 136, G.M.L. 137, and G.M.L. 138									
M.L. 68		Quartz, tourmaline vein	N-S	E 65°	Weathered lavas	basic	Weathered lavas	basic	Quartz, tourmaline	S.E. corner in Barren Series conglomerate. Remainder basic lavas. Small outcrop Barren conglomerate and tertiary conglomerate in centre of lease	Large lease enclosing G.M.L. 132, G.M.L. 120, and M.L. 392. No workings outside abovementioned leases, except one shaft in N.E. corner. Two outcrops quartz, tourmaline veins towards N. boundary. N.W. corner covered by Barren Series conglomerate rubble with basic lavas beneath.
M.L. 71	Pemberley	No workings.								Weathered basic lavas with capping Barren rubble to S.W.	No workings on lease. Large lease covering area between M.L. 68 (Part M.L. 60) and M.L. 370.
M.L. 94	Harbour View Extended	No workings.								Weathered basic lavas with some dioritic dykes, trend N. 70° W.	Triangular lease between M.L. 71, M.L. 60, and G.M.L. 258.

M.L. 216	Harbour View South	See under M.L. 366.				Small area N. section weathered basic lavas. Remainder to South Barren Series quartzite, sandstone and conglomerate	Only workings are on N. end. Two shafts in M.L. 366. Lease includes whole of M.L. 366.		
M.L. 366	Harbour View South	Ferruginous quartz vein, cupriferous with depth	....	....	Weathered greenstone and vesicular lavas	Weathered greenstones, vesicular and other basic lavas	Quartz, azurite, chalcantinite, pyrite, chalcocopyrite, cuprite on dumps	Weathered basic lavas on N. portion, Mt. Barren Series, sandstones, quartzites and conglomerate on rest	Only two vertical shafts on lease neither accessible. N. section of lease mainly covered with soil, etc.
M.L. 370	North Harbour View	Rubbly ferruginous quartz veins, becoming cupriferous with depth	N 30° E	S 45°	Weathered greenstone lavas	Weathered greenstones and other basic lavas, mica schists	Quartz, azurite, malachite, cuprite, chalcocopyrite, white mica in places in schists	Weathered greenstone, lavas, vesicular lavas, and other basic lavas	Workings in series of vertical shafts and underlay stopes in general N. 40° E. line. Shafts mainly in poor condition, some partly accessible to 50ft. Depth 20ft.-60ft.
M.L. 392	Scotland	Rubbly ferruginous ironstone quartz veins, and flat dipping ironstone bed	N 35° W N 10° E N 20° E	N 30° S 45° S 50°	Weathered basic lavas and laterite	Weathered basic lavas and laterite	Quartz and traces malachite on shaft dumps. Iron ore massive in costean	Weathered basic lavas and laterite over most part of lease, with Barren Series pebbles on S.E. edge	Shafts on N. and N.E. sides of lease and on W. corner. Small open-cut for ironstones in centre of lease. Ironstone lode 3ft. thick, glassy appearance. High iron rate. Shafts in poor condition.
G.M.L. 65	Gem	Series quartz veins becoming ferruginous with depth along shear zones	Main N 65° E N 55° E	.... S 45° S 25°	Whitish kadinitic weathered lavas, with fresher weathered lavas to S.W. corner at depth	Weathered lavas and altered lavas at depth	Quartz, gossans, tourmaline, traces azurite and malachite at depth	Q/fe's to N.E. corner, remainder basic lavas with thin laterite capping	Workings in two areas, centre and S.W. Centre area accessible but poor to 60ft. S.W. workings interconnected with workings of G.M.L. 250 and accessible, but in poor condition throughout. Veins along shear planes.

TABLE 78—continued
TABULATION OF SOME MINING LEASES—PHILLIPS RIVER GOLDFIELD—continued

KUNDIP CENTRE—continued

Lease		Ore Body			Host Rock	Rock Types in Workings	Minerals in Workings	Rock Types on Lease	Remarks	
No.	Name	Nature	Strike	Dip						
G.M.L. 79	Gem Extended				No workings.			Weathered basic lavas and laterite capping	Lease includes G.M.L. 200 and has one shaft in Lease 200. No data available.	
G.M.L. 102	Groper				No workings.			Weathered lavas in S.W. corner. Remainder Q/fe's	No workings on lease majority of which is in Q/fe belt to east.	
G.M.L. 111	Harbour Lights				No workings.			Weathered basic lavas with laterite capping	No shafts on lease originally, one shaft now under G.M.L. 268 in S.E. corner.	
G.M.L. 120	Try Again...	Ferruginous rubbly quartz veins	N 60° E	S 40°	Sheared and weathered basic lavas	Weathered basic lavas	Quartz and traces copper staining (carbonates)	Weathered lavas with thin laterite cap	Series of vertical shafts in centre of lease some 15ft.-60ft. deep, mainly in poor condition.	
G.M.L. 136	Western Flag	Ferruginous quartz veins. Strongly cupriferous with depth	N 80° E	S 70°	Weathered greenstone lavas	Weathered greenstone and other lavas	Quartz, azurite, malachite, cuprite, chalcopyrite, pyrite	Mt. Barron series on S.W. corner of lease. Remainder basic greenstone and vesicular lavas	Lode is continuation of Flag lease lode and is mined in a series of shafts both vertical and underlay. Workings partly accessible and in poor condition.	
G.M.L. 139	South Flag				No workings.			Weathered lavas on N.E. corner of lease, overlain by Mt. Barron series to south	No work carried out on lease.	
G.M.L. 200	Gem Consolidated North				No workings.		Weathered basic lavas	Quartz	Weathered basic lavas. Laterite capping in part	One shaft only on lease, not accessible — 40ft. depth.

G.M.L. 202 = G.M.L. 147 = G.M.L. 179	Fairplay Fairplay Fairplay Ex- tended				See under G.M.L. 262 and G.M.L. 263.				G.M.L. 147 and G.M.L. 179 combined to form G.M.L. 202. Lease covered by G.M.Ls. 262 and 263.
G.M.L. 249 = G.M.L. 151	Gem Con- solidated Gem Con- solidated	Ferruginous quartz veins, cupriferous with depth	....	....	Apparently junction of basic lavas and altered quartzitic lavas	Greenstone lavas and other weath- ered basic lavas, with quartzitic and granitised lavas	Quartz, gossans, marcasite, pyrite, chalcopyrite, cup- rite, azurite, mal- achite	Weathered basic lavas with small outcrop of dior- itic lavas on S.E. corner. Thin lat- erite cap	Workings in N.E. corner, interconnected with G.M.L. 65 and G.M.L. 250 but flooded below 125ft. level. Main shaft good condition but workings mainly poor on upper levels. Beryl mine on S. boundary of lease not accessible. Plans available for Beryl mine.
G.M.L. 250 = G.M.L. 74 = G.M.L. 67	Two Boys... Two Boys... Hill End	Ferruginous quartz veins, becoming cupriferous with depth	Main N 25° E Sub- sidiary N 45° W	.... N 40° S 40°	Basic lavas appears to be junction of lavas and altered lavas, also some greenstone lavas present	Weathered lavas and altered lavas at depth, quartz- itic in nature. Some greenstone lavas present. Also some granit- ised lavas	Quartz, marcasite, pyrite, chalcopy- rite, iron, gos- sans, cuprite, azurite, malach- ite, chalcantinite, tourmaline	Weathered basic lavas mainly with Q/fe's on S.E. corner and small outcrop diorite rock on S.W. cor- ner. Thin cap- ping of laterite over most of lease	Workings all in N.W. corner. Two main shafts and numerous small sub- sidiary shafts surround- ing. Workings inter- connected with G.M.L. 65 and G.M.L. 249. Main workings not ac- cessible. Subsidiary workings poor condi- tion.
G.M.L. 252 = G.M.L. 137 (Portion of M.L. 60)	Flag Flag	Ferruginous and cupriferous quartz veins, becoming more cupriferous with depth, along sheer zones	Main N 75° E Sub- sidiary N 40° E N 30° W	.... S 45° S 40° N 50°	Weathered green- stone and other lavas. Appears to be on junction of two in observed workings	Weathered basic greenstone and other lavas. Fresh lavas and altered lavas on Flag mine dump	Quartz, cuprite, azurite, malach- ite, tourmaline, marcasite, pyrite, chalcopyrite	Weathered green- stone and other lavas. Traces lat- erite capping. Quartzite pebbles on south section of lease from Mt. Barren series to S.	Mine workings not ac- cessible and partly flooded. Other workings run in a N. 80° E. line from the western boundary of lease 3 chains N. of Flag mine. Further small workings in greenstones on boundary of G.M.L. 252 and G.M.L. 253 to N. of Flag mine.

TABLE 78—continued
TABULATION OF SOME MINING LEASES—PHILLIPS RIVER GOLDFIELD—continued

KUNDIP CENTRE—continued

Lease		Ore Body			Host Rock	Rock Types in Workings	Minerals in Workings	Rock Types on Lease	Remarks
No.	Name	Nature	Strike	Dip					
G.M.L. 253 = G.M.L. 138	Eastern Flag Eastern Flag	Ferruginous quartz veins, becoming cupriferous with depth, along shear zones	Main N 75° W N 50° W Sub- sidiary	.... S 60° N 40° S 50°	Weathered greenstone and other lavas	Weathered greenstone and other lavas	Quartz, malachite, azurite, chalcocopyrite, chalcantinite, traces cuprite and pyrite	Weathered lavas....	Workings small on boundary G.M.L. 252 to N. with faulting evident. Other workings on centre W. of lease as semi-open cuts put down on parallel shear zones. St. N. 75° W. dipping S. 65°.
G.M.L. 258 = G.M.L. 256 = G.M.L. 254 M.C. 17	Harbour View Harbour View Harbour View	Cupriferous quartz veins with iron gossans	Main N 20° E N 30° E Sub- sidiary N 70° E N 50° W	.... S 30°- 65° S 60° S 70° S 75°	Predominantly weathered greenstone lavas, with other lavas to N.W.	Predominantly greenstone lavas, vesicular and other lavas present	Quartz, azurite, malachite, cuprite, chalcantinite, some white mica, possibly some cobalt minerals (see assays)	Weathered greenstones, vesicular lavas, some agglomerates on western boundary and occasional dioritic dykes, trending N. 60° W.	Workings extend northwards from main shafts, along shear plane in a series of shafts and deep open cuts into M.L. 370. Some smaller workings in N.W. corner. Main workings not accessible, others in poor condition.
G.M.L. 260 = G.M.L. 257 = G.M.L. 251 = G.M.L. 156	Gem South Gem Consolidated South Gem Consolidated South Gem Consolidated South	Ferruginous quartz veins	N 80° W N 65° W	S 40° S 65°	Weathered basic lavas and vesicular basic lavas	Weathered vesicular and other basic lavas	Quartz, iron gossans, manganese staining, azurite, malachite, chalcocopyrite, chlorite	Weathered basic lavas with small outcrop of fresh dioritic lava on S.E. corner. Thin laterite capping over most of lease	Workings are to centre south of the lease, and are in fair condition and for most part accessible. Workings 100ft. depth and stoped throughout on vein 4ft. wide.

G.M.L. 261	Gem Re- stored	Ferruginous quartz veins cupriferous with depth along shear zones	See G.M.L. 266 for N.W. section Eastern mine N 45° W	S 50°	Weathered basic lavas	Mainly basic lavas with some small shallow workings in Q/fe's to S.W.	Quartz, iron, azurite, malachite, cuprite, chalcopyrite, pyrite, chalcantinite	Banded ironstones to N.E.—E. corner and west corner. Remainder basic lavas. Thin cap laterite over most of lease	See G.M.L. 266 for N.W. section of lease. Eastern shaft and mine, poor condition and only partly accessible. Depth 160ft. but not as extensively worked as Gem Restored mine. All lodes on and parallel to shear zones and/or faults.
G.M.L. 262 (Includes G.M.L. 263)	Beryl West	Quartz veins ferruginous and cupriferous with depth	....	....	Weathered basic lavas	See G.M. L. 263.		Weathered basic lavas with laterite capping	Lease includes G.M.L. 263 and 3-4 small shafts and workings N. and W. of G.M.L. 263. Later workings only fair condition.
G.M.L. 263	Hillsborough (includes Fairplay mine)	Ferruginous quartz veins becoming cupriferous with depth	N 60° E	S 70°	Weathered basic lavas and fresh basaltic lavas at depth	Weathered basic lavas and fresh basaltic lavas at depth	Quartz, tourmaline, pyrite, chalcopyrite, cuprite, azurite, malachite	Weathered basic lavas with laterite capping	This lease includes Hillsborough and Fairplay mines, and several subsidiary shafts. Mines are mostly accessible but flooded at depth. Plans for mine are available.
G.M.L. 266	Gem Re- stored	Ferruginous quartz veins along shear planes, becoming cupriferous with depth	Main N 60° W Subsidiary N 30° E	S 45° N 70°	Weathered basic lavas	Weathered basic lavas, and mica schists	Quartz, iron gossans, azurite, malachite, cuprite, chalcopyrite, crysocolite, pyrite, chalcantinite?	Banded ironstones, to N.E. and N. and S.W. Remainder basic lavas. Thin cap laterite over most	Workings include Gem Restored mine and 3-4 subsidiary shafts—30ft. deep. Mine workings in good condition, flooded below 210ft. Oxidised zone down to approximately 160ft., then got start at sulphides. All lode on and parallel to shear zones.
G.M.L. 268	Sea View	Ferruginous quartz veins	....	....	Weathered basic lavas	Weathered basic lavas	Quartz, iron gossans, traces secondary copper	Weathered basic lavas with thin laterite capping	Two shafts only sunk—40ft., no lode yet encountered. Lease not surveyed.

Table 79
COPPER AND CUPREOUS ORE PRODUCTION IN THE
PHILLIPS RIVER GOLDFIELD TO THE END OF 1960

Copper Ore and Concentrates

Year	Ore	Copper Content	Value
	Long Tons	Long Tons	£A
1900	34·00	10·19	725
1901	1,089·14	198·51	12,918
1902	308·25	23·36	1,238
1903	1,561·33	214·59	10,984
1904	3,468·89	485·02	24,280
1905	2,329·04	307·66	15,592
1906	2,885·00	287·24	25,270
1907	10,414·57	658·73	57,273
1908	2,015·71	182·51	9,233
1909	7,330·70	532·99	29,815
1910	25,871·65	1,685·03	96,745
1911	13,563·68	853·91	46,862
1912	1,318·38	218·61	15,815
1913	806·95	140·82	9,737
1914	4,841·15	613·23	37,524
1915	3,681·03	426·48	24,093
1916	5,428·08	482·76	48,618
1917	5,255·57	540·79	66,868
1918	2,901·66	373·61	42,978
1919	215·02	52·76	4,993
1920	217·27	44·30	4,125
1921	95·34	17·59	1,207
1922	31·84	3·52	217
1923	26·01	8·44	541
1924	3·69	·66	44
1925-28	.....	.....	.....
1929	33·18	5·75	420
1930-37	.....	.....	.....
1938	.....	3·39	185
1939	.....	.....	.....
1940	13·80	2·70	159
1941	6·10	1·25	105
1942	9·40	2·85	241
1943	.....	.....	.....
1944	1·21	1·30	130
1945	.....	.....	.....
1946	74·00	1·10	105
1947-48	.....	.....	.....
1949	40·00	·91	119
1950	48·00	·57	76
1951	4·83	1·09	138
1952	5·00	·46	94
1953-55	.....	.....	.....
1956	6·46	2·95	770
1957	558·83	92·51	13,189
1958	1,726·71	408·23	53,265
1959	4,408·75	1,093·25	230,078
1960	3,552·13	905·96	199,007
Total prior to 1961	106,182·35	10,887·58	1,085,776

Cupreous Ore and Concentrates

Year	Ore	Units Copper	Average Assay per cent. Cu.	Value
	Tons			£A
1950	6·97	168·88	24·23	206·15
1951	55·70	586·18	10·52	1,035·40
1952	64·00	571·92	8·94	1,322·34
1953	72·00	604·80	8·40	1,406·19
1954	84·82	863·50	10·18	2,046·62
1955	52·50	460·20	8·77	1,146·37
1956	32·48	579·39	17·84	1,258·95
1957	99·39	1,224·76	12·32	3,913·35
1958	211·17	3,034·71	14·37	8,337·00
1959	64·43	985·10	15·29	2,904·05
1960	122·90	1,428·41	11·62	4,140·50
Total	866·36	10,507·85	12·13	27,716·92

THE CATTLIN GROUP

The mines in this Group lie to the north-west and north of Ravensthorpe, close to the township boundary. The main workings are situated in Locations 34, 35, 124, 126, 127 and 161, and mining reserve 21276. Reference may be made to Mines Department Lithograph L105, and Lands Department Lithograph 420/80. A geological map is included in Bulletin 110.

THE CATTLIN MINE

The ore body strikes east-north-east and dips northwards at 85 degrees. Primary mineralisation is chalcopyrite in quartz, and there is a good deal of associated pyrrhotite. The gangue contains a considerable amount of hornblendic material.

The latest description of the workings was given by Montgomery (1910). At this time levels had been developed at 65, 100, 200, 300, 400, and 500 feet, the ground above the 100-foot level being practically stoped out. The ore body, where worked, was usually 5 to 10 feet thick, but in places was as much as 15 feet. There were two main shoots of ore exposed in the workings. Between these shoots the lode channel was difficult to follow in the country rock. The shear may have been partly transgressive since Montgomery states that the country rock in the lower levels (identified as intermediate between camp-tonite and kersantite) was nothing like the garnetiferous schists seen on the surface. Drive lengths for the various levels varied between 400 and 800 feet, but these were probably extended before the workings were abandoned in 1920.

Primary sulphides were encountered at about 54 feet without any appreciable secondary enrichment being reported. In detail the copper and gold values varied considerably, but overall the gold values above the 200-foot level averaged about 5 dwts. per ton, while at the 500-foot level the average was about 4 dwts.

The mine was said to make about 120,000 gallons of salt water a day, mostly between the 300 and 400 foot levels.

Some work was done on smaller parallel ore bodies to the north and to the south-east. One of the latter (on the Adante Lease, 207) was worked mainly for gold.

Total production, from 1900 to 1920, amounted to 24,513 tons of ore yielding 1,291 tons of metallic copper valued at £93,138.

THE MAORI QUEEN

This ore body consists of a chalcopyrite-bearing quartz reef, occurring near the nose of the main granite mass, very close to its contact with basic lavas. The strike is north-east and the dip at the surface is about 75 degrees to the north-west, but below about 70 feet it increased to almost vertical. The vein is cut by a quartz-diorite dyke which strikes north-west and dips to the south. The ore body varied in width from 1 to 4 feet.

On the south side of the dyke and down to water level at about 80 feet, the ore body has been stoped over a length of 160 feet, the first 40 feet being high grade. This later section was stoped down to the 200-foot level at which depth it proved too poor to work further.

North of the dyke, a stope 70 feet long was worked down to 70 feet, the northern 20 feet then being stoped down to 100 feet on a southerly pitching shoot.

Only 13.73 tons of copper ore yielding 0.18 tons of metallic copper are recorded from these workings (G.M.Ls. 1,119 and 153).

Other Workings

Most of the other workings in this Group produced mainly gold, with only a small copper production.

These consist of the Floater Mine (G.M.Ls. 43 and 82), a string of workings on a north-easterly shear some 35 chains north-west of the Maori Queen, and workings on another parallel shear about 18 chains north-west of these.

Summary

The principal production in this Group has come from the old Cattlin workings. Most mineralisation is associated with strong shearing, the principal structures being orientated parallel to the boundary of the intrusive granite. Some other shears are developed almost at right angles to these, but the ore bodies located in them have not been very important. Granitic and basic dykes are often closely associated with the ore bodies.

THE ELVERDTON GROUP

This important group of workings is located about 7 miles south-east of Ravensthorpe along the Hopetoun Road. The ore bodies were worked principally for copper, the biggest copper producer in the Field—the Elverdton Mine—being located here. Most of the tonnage was obtained between 1900 and 1920. Since 1953, however, there has been a revival of mining on the Elverdton, and in 1960 production of copper ore from this mine was 3,552 tons. The principal production has come from the Elverdton (M.L. 95), Mt. Desmond (M.L. 109), Desmond (M.L. 208), P.L.P. (M.L. 199), and currently M.C. 35 and 36.

The workings in this area occur in interbedded sediments and basic igneous rocks of the Greenstone System on the north-eastern side of the Ravensthorpe granitic pluton.

Reference may be made to Mines Department Lithograph L105, and Lands Department Lithograph 420/80. A geological map is included in Bulletin 110.

The Elverdton Mine

The mineralised Elverdton shear trends north and south, and dips steeply to the east. It is conformable with the country over most of its length, but towards the northern end it swings around to the north-north-west and is transgressive. Prior to 1953 drive lengths reached a maximum of 1,070 feet on the 249-foot level. The lowest level was at 498 feet where there was 375 feet of driving. On a mine section reproduced in Bulletin 110, the maximum stope length is 370 feet above No. 3 level.

The ore was oxidised down to about 87 feet and consisted of ferruginous copper carbonate in a siliceous gangue. Workings above this level extended over about 680 feet, part of these extending on to the South Elverdton, late M.L. 168. Below 87 feet the ore was reported to consist of copper and iron pyrites in a siliceous gangue, with lenses of basic material.

Information given by Mr. R. Haynes of Ravensthorpe Copper Mines (Geol. Surv. File 24/1928) is to the effect that as at December 1959 the drives had been extended by 200 feet south on the No. 1 level, the first 100 feet averaging 2.5 per cent. Cu, and the second 100 feet 4.9 per cent. Cu. The No. 2 level had been extended 200 feet, the ore averaging 5 per cent. Cu. The average widths of ore on both levels was 9 feet.

By diamond drilling, the zone of mineralisation has been shown to extend over 2,200 feet in length and up to 39 feet in width, and to extend down to at least 1,150 feet vertical depth (a borehole penetration at this depth gave 26 feet of 1.7 per cent. Cu). Within this block there is discontinuity of ore in places, caused by restricted zones of compression. Movement on the shear was east block south with a horizontal displacement not greater than 100 feet.

South of the Elverdton shaft the shear is confined to a particular bed in the granitised sediments, and north of the shaft it is transgressive at an acute angle through bedded acid and basic rocks. Post-ore faulting, if present, is of a minor nature although there are numerous thin tension gashes in the ore, many of them filled with basic greenstone material.

Some slight radio-activity was detected in the northern end of the Elverdton working in 1954, but it is considered to be not economic. A report on this is given in Bulletin 110.

The mine was said to have made 90,000 gallons of salty water per day and when abandoned it flooded to about 120 feet below the surface.

The production from this mine is given as follows :—

Table 80
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value	Gold	Silver
1901-06	M.L. 95	Elverdton	Long Tons 2,946.02	Long Tons 401.43	£A 22,657.0	Fine ozs. 9.63	Fine ozs.
1907-15	....	P.R. Gold and Copper Co.	30,704.23	2,192.34	124,822.0	2,569.38	6,537.35
1915-20	M.L. 95	Elverdton	7,418.57	675.84	67,229.0	519.69	.....
1953-60	M.Cs. 35, 36, 59, 74 M.L. 419	Ravensthorpe Copper Mines N.L.	10,217.27	2,491.62	493,505.1	3,604.91	17,285.60
Total to the end of 1960			41,287.09	5,761.23	708,213.1	6,713.61	23,822.95

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Average Assay per cent. Copper	Value
1953-55	P.A. 785	Wehr, H.	Long Tons 65·00	8·30	£A 1,291·80
1953-58	M.L. 411	Wehr Bros. (transferred to Ravensthorpe Copper Mines N.L., July, 1958)	216·44	9·33	5,239·34
1958-60	M.Cs. 35, 36, 59, 74, M.L. 419	Ravensthorpe Copper Mines N.L.	134·75	15·59	5,688·35
Total to the end of 1960			416·19	11·18	12,219·49

The Desmond Mine

The ore body on this mine is similar to that on the Elverdton and is actually a northward continuation of the same shear zone. The two main shafts are about 32 chains apart. A shoot of ore about 125 feet long and 5 feet wide was stoped from levels at 45, 96, and 196 feet. Drives on the 196-foot level reached 245 feet to the north of the main shaft and 600 feet to the south. The main shaft reached a depth of 250 feet. Stoping sections are reproduced in Bulletin 110. The width of the mineralised zone was stated to vary from 20 feet at the south end to 60 feet at the north end where it was of lower grade and consisted of cupriferous greenstone, often schistose.

The production for this mine is given as follows :—

Table 81
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore	Copper Content	Value	Gold	Silver
1901-05	M.L. 109	Mt. Desmond	Long Tons 814·21	Long Tons 30·77	£A 1,640	Fine ozs 38·37	Fine ozs.
1906-14	M.L. 109	Mt. Desmond, Phillips River Gold and Copper Co.	1,762·22	216·76	18,128	22·19	180·06
1911-15	M.L. 208	Phillips River Gold and Copper Co.	1,234·05	215·74	14,956	219·59	14·55
1915-20	M.L. 208	.....	1,392·85	164·82	16,093	155·38	.....
1904-10	M.L. 199	P.L.P.	208·66	33·69	2,277	13·69	7·41
1914	M.L. 199	P.L.P., Phillips River Gold and Copper Co. Ltd.	17·56	1·88	121	3·14	.....
Total to the end of 1960			4,814·21	663·66	82,115	452·36	202·02

THE MT. McMAHON GROUP

This group embraces a number of old mines centred about 3·5 miles east-north-east of Ravensthorpe. Most of the old mining leases fall within Location 384, and the remainder on Locations 123, 129, 130 and 268, and just northwards of 384. Reference may be made to Mines Department Lithograph L105, and to Lands Department Lithograph 420/80. The ore bodies are located in a belt of metasediments, partly granitised sediments and lavas between the granitic pluton on the south-west and the

jaspilitic sedimentary succession of the Ravensthorpe Range on the north-east. The country strike is north-west and south-east. A geological map is published with Bulletin 110.

Most of the workings are inaccessible due to flooding and partial collapse since they were abandoned about 1915. The following information is summarised from earlier reports.

The Mt. Benson Mine

Sofoulis (1958) comments, "The lode appears to have been in the nature of a series of shears en echelon, consisting of quartzose material in a cupriferaous, sheared, greenstone matrix, becoming less quartzose with depth. Width of the lode on the surface has varied from 2-6 feet and appears to have averaged 3 feet in deeper levels. That the sulphide zone is not restricted to the water table is evidenced by the occurrence of sulphides in the vicinity of the 35 feet level. Some smaller gold-bearing sugary, pyritic veins were seen in small workings on the lease, but these were not of any great extent. Mine sections show the ore "shoots" to be short and inconsistent, with an apparent westerly plunge. Assay plans show the bottom level to be generally barren. Minerals identified in dumps and in shallow workings were blue and green carbonates of copper, traces of oxides of copper, and considerable amounts of pyrite in patches. Some chalcopyrite is present below 30 feet".

The main work appears to have been done in two places approximately 1 mile north-west of Recreation Reserve 9526. A main shaft in the westernmost workings was sunk to a depth of 167 feet and a winze reached a depth of 187 feet from a drive to the west, and drives were extended over a length of about 310 feet. Crosscuts were extended 130 feet to the north, and 70 feet to the south, probably in an attempt to cut parallel lodes.

Another main shaft was sunk to 157 feet on the eastern workings and a considerable amount of driving and cross-cutting was done there. Mineralisation intersected in drives from crosscuts suggest the presence of parallel ore bodies. More details are given by Montgomery (1903).

The production for this mine is given as follows:—

Table 82
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Value	Gold	Silver
1900-03	M.L. 10, 143	Kingston	Long Tons 11-00	Long Tons 3-15	£A 256	Fine ozs. 4-71	Fine ozs. 5-00
1903-06	M.L. 175	Mt. Benson	605-19	73-64	3,702	287-88	.....
1906-13	M.L. 175	Mt. Benson, Phillips River Gold and Copper Co. Ltd.	1,142-40	80-21	5,692	458-77	199-83
1913-16	M.L. 175	Mt. Benson	16-95	.....	.....	28-95	.....
1916-19	M.L. 363	Mt. Benson	376-33	20-44	.....	115-76	.....
Total to the end of 1960			2,151-87	177-44	.....	896-07	204-83

In 1956, 17-45 tons of cupreous ore assaying 12-52 per cent. Cu was produced from M.C. 38, and in 1958 and 1959, 102-5 tons of cupreous ore assaying 8-46 per cent. Cu was produced from M.L. 413.

The Mary Mine

These workings are inaccessible and the last available report was written by Montgomery in 1903, about 10 years before production ceased. This mine is situated about 50 chains north-north-west of Reserve 9526.

At the time of Montgomery's visit, workings had been taken down to water level (79 feet). The ore body was 4 to 5 feet wide at the bottom of the shaft striking almost east-west, and dipping steeply north. Above 25 feet it consisted of carbonate minerals, earthy copper oxides, and ferruginous quartz. Below the 25 feet level the ore consisted of chalcopyrite coated with covellite in a siliceous gangue.

A second vein, striking about 10 degrees north-westwards of the former and dipping steeply to the south, was being developed at the time of Montgomery's visit, and later this was developed into the major producer. This vein, which was about 4 feet wide and extended over a length of about 400 feet, carried oxides of iron and copper, and carbonates of copper in a quartz gangue. It was opened up by four shafts.

According to Sofoulis (1958) there are smaller parallel veins at other parts of the lease. Most of them lie in sheared garnet zones in greenstone country rock, the shears being slightly transgressive to the boundary of the intrusive granite. Numerous small granitic intrusives are present in the area.

Recorded production for the Mary Mine (M.C. 7) over the period 1901-1913 amounts to 844.62 tons of ore containing 120.53 tons of metallic copper valued at £6,245. The ore also contained 20.15 fine ounces of gold and 42.35 fine ounces of silver.

The Last Chance Mine

This mine is located about 20 chains north-north-east of Recreation Reserve 9526. The property has been held as M.Ls. 116 and 361, and lately as M.L. 394. The workings have been flooded and are inaccessible, the information given here being taken from Montgomery's reports, and Woodward (1909).

The ore body strikes north-north-west and dips steeply to the south, occupying one of a series of parallel shears. It was from 3 to 4 feet wide.

A shaft was sunk to 120 feet and an external shaft from a short drive at 100 feet reached a depth of 130 feet. About 400 feet of driving was carried out in the 60-foot level and most of the production of the mine came from stopping above this level to the surface.

Country rock is a micaceous schist, garnetiferous in places. Water level was at about 65 feet, and the ore in the face of a drive at the 60-foot level consisted of oxides and carbonates of copper in a gangue of brown iron ore. Below 60 feet good chalcopyrite ore was found in places in seams up to 18 inches thick. Traces of nickel and cobalt were reported in 1903. Production figures are as follows:—

Table 83
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Value	Gold	Silver
1901-13	M.L. 116	Last Chance	Long Tons 1,134.48	Long Tons 181.72	£A 11,030	Fine ozs. 25.82	Fine ozs. 46.57
1916-18	M.L. 361	Last Chance	77.29	8.80	.....	4.49	.....

CUPREOUS ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Cupreous Ore	Average Assay per cent. Copper	Copper Units	Value
1958-59	M.L. 413	Wehr, H., and Party	Long Tons 102·50	8·46	867·09	£A 2,463·76

The Ballarat (Emily Hale) Mine

These workings are located about 30 chains west-north-west of the Last Chance. The ground has been held as M.Ls. 124, 205, 131 and M.C. 28.

The ore channel here lies in a belt of partially granitised basic lavas within 5 chains of the boundary of the intrusive granite on the west. The ore body strikes north-south, and dips to the west at 45 degrees near the surface. At 40 feet the dip increased to almost vertical, but resumed the 45 degree angle at about 60 feet. Water level was at about 60 feet, below which the oxides and carbonate of copper gave way to chalcopyrite in a quartz gangue. The width averaged about 3 feet.

The deepest workings are reported to have been at 110 feet, with 90 feet of driving to the north and 70 feet to the south at this level. Stopping was carried out above the 65 feet level with drives 100 feet to the north and 90 feet to the south. A short crosscut west from the 110-foot south drive intersected a small lens of ore striking north-west and dipping to the south.

Production figures are as follows:—

Table 84
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Value	Gold	Silver
1903-06	M.L. 124	Emily Hale	Long Tons 132·27	Long Tons 21·43	£A 1,192	Fine ozs.	Fine ozs.
1906-09	M.L. 205	Ballarat	199·70	21·70	1,876	2·84	....
	Total	....	331·97	43·33	3,068	2·84	....

Last Chance Proprietary Mine

These workings lie about midway between the Last Chance and the Ballarat Mines. A shaft was sunk to a depth of 125 feet, and from this level an internal shaft was taken down to 215 feet on a southerly plunging ore body. At the surface, the vein, which averages about 3 feet in width, strikes north-south, but at depth it trends north-north-west. Most of the production came from oxidised ore above the 65 feet level. Below this zone the ore consisted of quartz, chalcopyrite and marcasite, with some covellite.

Production is as follows :—

Table 85
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Value
1901-04	M.L. 120	Last Chance Proprietary	Long Tons 34·87	Long Tons 4·53	£A 252·00
1904-07	M.L. 200	Last Chance Proprietary	238·07	27·47	2,257·00
Total ....	.....	.....	272·94	32·00	2,509·00

The Kilmore (New Moon) Mine

These workings are situated 15 chains south-west of the Ballarat Mine. The mine was originally known as the Kilmore (M.L. 119), and later as the New Moon (M.L. 204). Country rock is a hybrid hornblende granite, the vein occurring near the contact of intrusive granite and a basic remnant. The trend of the ore body is north-north-east and the dip steep to the north-west. It was up to 13 feet wide, consisting of small, rich, ferruginous veins of oxides and carbonates of copper in a sheared basic matrix.

The workings are reported to have reached 40 feet and, in the deepest parts, sulphides occurred in veins up to 15 inches thick.

This mine produced 66 tons of ore yielding 12 tons of metallic copper worth £1,150. Some 70 fine ounces of gold were recovered.

The Mt. Benson Extended Mine

These old workings are located on the western side of the Mt. Benson Mine. There are three shafts, the dumps from which all show some rocks of granitic composition. The ore bodies are quartz veins carrying pyrite and chalcopyrite. The strike of the main vein is north-west and the dip is steep to the south-west.

These workings produced 66 tons of ore containing 12 tons of metallic copper valued at £693.

The Birthday Mine (M.C. 300)

The workings on this Lease consist of two groups of shafts near the northern and southern boundaries. The ore bodies strike about 80 degrees west of north in the northern part, and about 15 degrees west of north on the south. Mineralisation is in the form of cupriferous quartz veins in sheared greenstone. There are no production records of these workings.

The Commonwealth Mine (M.L. 295)

This lease lies on the north side of the Ballarat workings. The ground was originally known as the Federal (M.L. 131), and as the Contest (M.Ls. 191, 196). The ore body, which is a cupriferous quartz vein in sheared greenstone, strikes north-west, and where worked was about 3 feet wide.

Metallic copper valued at £285 was obtained from this ground.

Other workings in this Group are small and of little consequence.

The Kundip Group

The abandoned Kundip township is situated 13 miles south-east of Ravensthorpe on the Hopetoun Road. The group of old mines covers about 3 square miles. The centre of this area lies approximately 1.5 miles easterly from the township, on the western slopes of the southern end of the Ravensthorpe Range.

Reference may be made to Mines Department Lithograph L105, Lands Department Lithograph 421/80, and to the geological map (Plate 12) by A. J. Noldart in Bulletin 110. Blatchford (1900), Woodward (1909), and Montgomery (1903, 1910, and 1914) have written reports on the area.

Copper has been accessory to gold in this group. These minerals occur in quartz veins, and in lode formation in shears, copper mineralisation being more important in the latter. Primary sulphides which occur both above and below the water table include pyrite, marcasite and chalcopyrite. No pronounced zones of secondary enrichment are known, and mining records suggest that generally mineralisation becomes weaker at depth.

The Kundip rocks are a southerly extension of the Archaean metasedimentary and basic igneous complexes of the Elverdton area. Mineralisation occurs mainly in shear patterns. The major mines are all located on strong lateral shears trending north-north-east and east-north-east. At the surface granite crops out about 1 mile west of the workings, but diamond drilling has shown that it underlies the workings of the group at relatively shallow depth.

The most intensive mining activity was between the years 1901 to 1909, then it gradually declined up to 1928. Some of the mines were re-worked during the period 1935 to 1948, but since that time only a little surface prospecting has been carried out. The biggest producers have been the Flag, Harbour View, Gem, Gem Consolidated, Two Boys, and the Hillsborough-Fairplay. The following information is taken mainly from the reports mentioned above.

The Flag Mine

The ground embracing these workings has been held at various times as M.Ls. 50, 60, 136, 137, 138 and 139. These are approximately 1 mile east-north-east of Kundip townsite. The available information does not include details of development after 1910.

The main ore body near the centre of old M.L. 60, was opened up over a distance of about 1,100 feet by a line of shafts and costeans, extending generally east-west. There are two others in this vicinity. The maximum depth reached was 300 feet in the main shaft on the main ore body which was stated to range in width from 1.5 to 12 feet, but averaged about 4 feet near the surface. It dips at about 50 degrees to the south and strikes approximately east-west. The ore body was not payable over the full length of 1,100 feet, the ore being mined from a series of shoots. A considerable amount of crosscutting and driving was

carried out, particularly in the oxidised ore above the water table at 102 feet. Those portions of the ore bodies above this level were either highly ferruginous and carried good copper mineralisation, or else were more siliceous when the gold values were usually higher.

The average gold assay in the main workings was 1 oz. 15 dwt. per ton; and picked parcels of copper ore ranged from 8.8 to 11 per cent. Cu.

Water intake was 60,000 gallons per day at the 200-foot level with a salt content of 1.5 per cent. There are a few other lodes of lesser importance on these leases. Production figures are as follows:—

Table 86
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Value	Gold	Silver
1901-06	M.L. 60	Red, White and Blue Flag Gold and Copper Mining Co. Ltd.	Long Tons	Long Tons	£A	Fine ozs.	Fine ozs.
1906-07	M.L. 60		1,487.22	54.95	3,741	1,167.32	107.29
1907-10	M.Ls. 136, 137, 138, 139	Flag Gold and Copper Mining Co. Ltd.	9,223.63	149.08	8,718	4,729.53	1,078.38
1912-19	M.Ls. 136, 137, 138	Flag Gold and Copper Mining Co. Ltd.	3,570.65	39.38	3,743	3,033.74	....
Total	.....	.....	15,298.79	249.23	16,529	9,539.28	1,185.67

The Harbour View Mine

The Harbour View leases lie on the north-western side of the Flag workings. This was the first mine worked in the Kundip group, most production being recorded for the years 1900 to 1923, with a small quantity of gold ore being raised in 1940 to 1941. Reports of development have not been made since 1914, therefore details of development up to 1923 are not known.

The mine was developed in three sections known as the North, Central, and South workings. The deepest mining was at a depth of 170 feet on the South section, which contained two shoots of ore.

Workings on the North section reached a depth of 110 feet. There are three shafts on the Central section, the deepest reaching 50 feet.

The ore body was up to 20 feet wide on the 140 feet level, but only up to 14 feet wide at the surface. Payable ore was mainly confined to the footwall in a series of thin veins extending over a width of up to 6 feet.

Strike of the workings is north-north-east with a dip of about 65 degrees to the west. Plunges of 60 to 70 degrees to the south are suggested by the mine plans.

Water level varied from 110 feet in the north section to 140 feet in the South section. Ore above water level consisted of ferruginous quartz veins carrying carbonates of copper with fine to coarse gold. There was no pronounced zone of secondary enrichment although signs of leaching were noted near the surface. Below water level the ore was less ferruginous.

Production figures are as follows :—

Table 87
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Value	Gold	Silver
1900-05	M.Ls. 52, 59	Harbour View	Long Tons 4,223·61	Long Ton 76·80	£A 4,524	Fine ozs. 1,940·72	Fine ozs. 61·41
1905-07	M.Ls. 52, 54	Ravensthorpe G.M. Syndicate N.L.	1,256·56	24·36	2,382	433·94	164·98
1907-13	M.Ls. 52, 94	Harbour View Leases	3,911·77	64·66	3,642	2,227·62	1·88
1913-23	M.Ls. 52, 94	Harbour View Gold and Copper Co. Ltd.	2,812·82	90·14	8,236	1,836·05	360·11
1940-41	G.M.L. 258	Harbour View	519·00	.....	.....	105·59	.....
Total	.....	.....	12,723·76	255·96	17,784	6,543·92	588·38

The Gem, Two Boys, and Gem Consolidated Mines

Noldart (in Sofoulis 1958) stated that the principal workings of each of these three mines are on the same main ore body, and that the workings were inter-connected before the year 1914, after which there is no available information.

These leases are located about 1·7 miles north-north-east of Kundip township. According to the geological map in Bulletin 110 (Plate 12), the host rock is part of the greenstone complex. This is overlain by the Whitestone metasedimentary succession which outcrops a few chains to the east.

The ore body worked in these three mines has a strike between west and west-north-west, with a dip to the north in places and to the south in others, with an anticlinal effect, the axis being along the strike (Noldart in Sofoulis, 1958). The values were generally low until a depth of 40 to 70 feet was reached (the Gem Consolidated mine was the deepest with a bottom level at 250 feet vertical depth). The ore channel is cut in several places by diorite dykes, and frequently dislocated by small faults, and was lost to the east against a longer fault. Ore in the upper levels contained clean free gold in a ferruginous and quartzose gangue, but at and below water level copper became more important in the form of carbonates, oxides, and sulphides (including covellite). Some massive pyrite carrying low copper and good gold values was encountered below water level. The

ore appears to have formed along the contact of a granitic intrusive. Ore extracted from these workings returned approximately 22,380 fine ounces of gold. Production figures for the various leases are as follows :—

Table 88
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Value	Gold	Silver
THE GEM MINE							
			Long Tons	Long Tons	£A	Fine ozs.	Fine ozs
1903	G.M.L. 57	Gem	8·00	.....	.....	24·30	.....
1904-06	G.M.L. 65	Gem	687·50	.....	.....	613·34	.....
1907-13	G.M.Ls. 65, 79	Gem	8,238·35	.....	.....	3,546·35	.....
1914-29	G.M.L. 148	Gem	4,250·13	22·40	2,393	3,374·33	.....
	Total	.....	13,183·98	22·40	2,393	7,558·32	.....
THE TWO BOYS							
1904-05	G.M.L. 67	Hill End	37·00	.....	.....	23·53	.....
1905-27	G.M.L. 74	Two Boys	11,282·71	28·30	3,249	8,369·34	.....
1927-28	G.M.L. 203	Two Boys	234·00	.....	.....	125·04	.....
	Total	.....	11,553·71	28·30	3,249	8,517·91	.....
THE GEM CONSOLIDATED (Beryl)							
1909-10	G.M.L. 151	Gem Consolidated	777·50	.....	.....	616·30	.....
1911-21	G.M.Ls. 151, 156	Gem Consolidated	6,411·76	76·75	8,327	5,090·35	.....
1939-48	G.M.Ls. 249, 260	Beryl Gold Mines Lid.	2,654·00	.....	.....	2,375·87	.....
	Total	.....	9,795·26	76·75	8,327	8,682·52	.....

The Hillsborough Mine

This mine, in which the most recent work was in 1955, includes the old Fairplay and Hillsborough workings. Recent work was confined to the latter. These adjoin the Gem leases on the south and south-west.

The Fairplay workings consist of a main vertical shaft, with levels at 155 feet and 193 feet, which reached a vertical depth of 295 feet. The ore body strikes east-west and underlays steeply to the south.

The Hillsborough mine consists of a main shaft and several smaller shafts with levels at 119 feet and 165 feet. The strike of the ore body in this section is north 65 degrees east with a dip about 50 degrees to the south.

Production is as follows :—

Table 89
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Value	Gold Ore	Gold
			Long Tons	Long Tons	£A	Long Tons	Fine ozs.
1906-24	G.M.L. 98	Hillsborough	692·84*	57·65	4,746	3,295·51*	6,018·84
1909-22	G.M.Ls. 147, 179	Fairplay	130·09*	131·30	11,975	4,860·72*	8,678·54
1929	G.M.L. 202	Fairplay ....	....	....	....	110·00	51·79
1941-42	G.M.L. 262	Beryl West ....	....	....	....	90·00	18·90
1948-55	G.M.L. 263	Hillsborough ....	....	....	....	258·00	59·09
Total	....	....	822·93*	188·95	16,721	8,614·23*	14,833·82

* These figures are incomplete.

THE HAMERSLEY RIVER DEPOSIT

Introduction

A small tonnage of copper ore was produced in 1915 from late Mineral Lease 97H, 23 miles south-south-west of Ravensthorpe. Where the track from Ravensthorpe crosses the derelict overland telegraph line it branches into three, and the deposit is about 2·5 miles further on along the centre track, lying on the eastern side of the Hamersley River at the northern end of a number of small manganese deposits. Approximate geographical co-ordinates are :—

Latitude 33° 50' S.

Longitude 120° 0' E.

Reference may be made to the following maps :—

1. Regional Geological Map of the Ravensthorpe District, Plate 6, Sheet 2, Bulletin 110 (Sofoulis, 1958).
2. Lands Department 10-Mile Topographical Series, Sheet 2, Esperance.

References to the deposit, and to the general geology have been made by Montgomery (1914), Gray and Gleeson (1949), and Sofoulis (1958).

Geological Information

The host rocks for the copper and manganese mineralisation are a succession of jaspilitic metasediments which are an extension of those forming the Ravensthorpe Range.

These include various types of schists, with dolomites and jaspilites. According to Sofoulis (1958, p. 203) a granitic tongue from the Ravensthorpe pluton has introduced minor copper-silver-lead mineralisation into these metasediments near the Hamersley River. The regional strike of these rocks is east-north-east. These Archaean rocks are overlain in many places by Proterozoic and Miocene sediments.

According to Montgomery (1914) workings on late M.L. 97H consist of a shaft 38 feet deep, and several trenches. Copper occurs in a number of small quartz veins carrying malachite

and oxides of copper and iron. Silky schist and fine grained sandstone carrying nodules of azurite and thin veins of malachite are exposed in the excavations.

A crosscut (depth not given) extends 18 feet eastwards from the shaft and exposes a number of small copper-bearing veins but no defined lode. The mineralisation as seen in the workings was probably the result of secondary deposition.

Production

The only officially recorded production is for 1915 when 2.03 tons of ore with a copper content of 0.28 tons Cu. worth £16.00 were sold.

Assays and Mineralogy

A rough sample of cupriferous schist assayed: Copper, 7.90 per cent.; Gold, none; Silver 6 dwts., 22 grs. per ton. Other specimens assayed showed up to 17 grs. per ton of gold.

One of the richer looking pieces of cupriferous schist was found to contain a little atacamite (oxychloride of copper), as well as light and dark blue azurite and green malachite.

In the hills west of Hamersley Gorge some quartz veins carry a little chalcopyrite and galena. Erythrite (cobalt bloom), cobaltite (CoAsS), siderite, sphalerite, tetrahedrite and stibiconite are also reported from this area (Montgomery, 1941, p. 23).

Remarks

Low grade copper-silver-lead mineralisation is known to occur in this area, but so far no worthwhile deposit has been found. The area may be worth more attention, particularly since calcareous rocks occur in the intruded sequence.

THE WEST RIVER DEPOSITS

These are located on the north and south banks of the West River 7 miles slightly west of north from McCulloch's workings. Official production figures are not available but Simpson and Gibson (1907) report that 14.5 tons of copper ore valued at £189 was raised from sundry claims prior to 1907. Judging by the extent of the workings the total is in excess of this.

The country rock is partly granitised metasediment including dolomite which strikes generally north-west. Copper occurs in steeply dipping quartz veins about two feet thick following north-west and north-south trend lines. There are also one or two cross veins. Seams and bunches of amphibole, possibly riebeckite or arfvedsonite, were noticed in and around the quartz veins. Water was standing at 43 feet in the shafts at the time of the author's visit in April 1962. Most of the workings were inaccessible at this time.

A description of the old workings is given in Simpson and Gibson (1907, p. 44). The deepest workings were on the old Copper King lease where driving was carried out on a vein 2.5 feet wide at 150 feet.

It seems likely that there are other comparable copper deposits in this area. The country between the West River and McCulloch's deposits should be prospected. The gossans at these places are only poorly developed.

FUTURE EXPLORATION

Certain prospecting recommendations are included in Survey Bulletin 110 which gives the results of a two-year (1951-52) regional and economic survey of the Phillips River Goldfield.

General recommendations in this publication include the opinion that copper-gold deposits are most likely to be found in the belt of "greenstone" rocks within about one mile of the contact of these rocks with the "magmatic granite body". "Greenstone belts" east of the Ravensthorpe Range are considered to be unprospective.

The Whitestone metasedimentary rocks between Mt. McMahon and Kundip are considered to be likely host rocks, particularly in areas where the beds are closer to horizontal than vertical. With reference to the Greenstones and an echelon shear zones developed in these, it is stated that ". the procedure of lateral prospecting both on the surface and underground from the known ore bodies is strongly recommended. Strike extensions of the known mineralised lines are also strongly recommended." These and other ideas are more fully explained on pages 141 to 144 of Bulletin 110.

THE DEPOSITS OUTSIDE PROCLAIMED GOLDFIELDS

THE ARRINO-YANDANOOKA DEPOSITS

Copper has been produced from various localities in the vicinity of Arrino and Yandanooka, two small centres with railway sidings on the Perth-Mingenew railway line. Arrino is 175 miles north of Perth, and Yandanooka is 10 miles further north. At most of the worked deposits the copper occurs in sedimentary rocks, and some of these places are very close to the sedimentary contact with Archaean granitic-gneiss. Early investigators considered that the granitic rocks were intrusive into the sediments, and that the deposits were hydrothermal in origin. Recent workers (McWhae, et al. 1958, p. 14) have shown that the granitic rocks are overlain by a group of sediments (the Yandanooka Group) consisting of five formations of sandstone, siltstone and conglomerate. The age of these rocks is considered to be between late Precambrian and Silurian. Three of these formations contain volcanic debris, and it is thought that the copper has been concentrated in places by the action of meteoric waters.

The proximity of the old workings (in the basal sandstone of the Yandanooka Group) to the granitic complex, and the presence of quartz veins in this, may have misled the early investigators. One of these quartz veins, at about 1.5 miles south south-east of Mount Muggawa, is cupriferous, but the majority evidently are not.

The Arrino Copper Mines (Late M.Ls. 3 and 4)

These old workings are located about 18 chains south-west of the railway siding at Arrino. The ground has also been held as Mining Leases 12 and 38, and has been called at various times The Cyprus Copper Mine, Cheyne's, and Money Mia (Campbell 1903, p. 13). There are three old shafts adjacent to a shallow water course which runs through the north-western corner of late M.L. 4.

Campbell (1910) states that the first trial shaft was sunk on the south side of the water course to a depth of 20 feet in 1868. Several tons of ore were said to have been raised. A main shaft, located in the water course, was sunk to 80 feet but did not cut the ore body and appears to have reached gneiss. Several years later a new shaft was sunk south of the old workings, but although 40 tons of good ore were said to have been raised, the workings were abandoned.

The ore body was reported as striking at 155 degrees, dipping steeply to the west, and consisting of veins and bunches of green carbonate in sandstone.

No reference to M.Ls. 5 or 7 has been found.

The officially recorded production is as follows :—

Table 90
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Copper Ore	Copper Content	Value
1899	M.Ls. 3, 4	Arrino Copper Mines	Long Tons 25·00	Long Tons 6·25	£A 300·00
1899	M.L. 7	Lady Bertha Copper Mine	3·00	0·45	27·00
1899	M.L. 5	Wheal Dodd Copper Mine	10·00	1·25	80·00
Total to the end of 1960			38·00	7·95	407·00

Baxter's Copper Mine (Location 342)

These workings are situated about 5 miles south of Arrino Siding, and were surrounded by M.Ls. 16, 17, 18 and 20. Campbell (1910) states that copper was discovered here in 1903, and that 19 leases were originally applied for but that most of these were soon abandoned.

Two shafts were sunk in the north-western corner of Location 342 in sandstone, about 5 chains east of the granite outcrop. The two shafts were sunk to about 60 feet, and an open cut adjoins the northern one. Later another shaft was sunk, at about 82 feet to the south-east, to a depth of 41 feet. It had a cross-cut at the bottom. A bunch of black sulphide was encountered in the "lode", the bearing of which was 150 degrees, and the underlay 60 degrees to the west.

Later work was confined to shallow open-cutting along a stockwork of veins a few chains south-west of the 41 feet shaft. It is reported that about 600 tons of ore were raised and sent away from here before 1906 by the Arrino Proprietary Copper Mining Company, but there are no official records of this. The only recorded production is for 1953, when 32 tons of cupreous ore averaging 8·06 per cent. Cu was raised from Location 342.

The Mt. Muggawa Deposits

Mt. Muggawa is situated 6 miles north of Arrino Siding on the western side of the Mingenew railway line.

Campbell reported that the principal workings here were in a "quartzose lode" outcropping in gneiss and mica schist about 1·5 miles south-east of the Mount, and trending 30 degrees

west of north. Prior to 1870 five underlay shafts and one vertical one were sunk. The width of the ore body is about 2.5 feet, and it dips to the east at a steep angle.

Several shafts were sunk between Mt. Muggawa and Mt. Misery, about 1.5 miles further north, but no worthwhile deposit was found. Seven and a half tons of ore with a copper content of 1.2 tons are recorded as having been raised from freehold property in 1908. This production came from a small deposit in chocolate tuff, in the north-western corner of Location 4441. Campbell reports that at the time of his visit in August, 1907, a 52-foot shaft had been sunk on a formation 2.5 feet wide, striking north-south, and dipping westerly at 70 degrees. This formation carried veins of ore, some of which were black sulphide of copper. A sample taken by Gibson, Survey Geologist assayed 33.16 per cent. Copper, 21 grs. per ton gold, and 16 dwts. 7 grs. per ton silver.

Other showings of copper mineralisation have been reported from about 2 miles east-north-east of Yandanooka (or 1.5 miles north of Granite Hill); from 4 miles north of this in the south-west corner of Location 1965; at Mt. Scratch in Location 358 where a shaft sunk in tuff showed green malachite and particles of native copper; and in the vicinity of the north-east corner of Location M328 and for some distance to the north.

The production from sundry claims in the Arrino-Yandanooka area is recorded as 126.05 tons of ore assaying 14.6 per cent. Cu, in 1908.

Future Exploration

With the exception perhaps of the deposit located about 1 mile to the south-south-west of Mt. Muggawa, it is fairly certain that these concentrations of copper have been due to the action of meteoric waters on a very low grade copper content in the volcanic debris in the overlying sedimentary formations. It seems unlikely that worthwhile deposits will be found anywhere in this area.

THE JERRAMUNGUP DEPOSIT

This ground was originally held as the Netty Copper Mine (M.L. 59H) which yielded some production about the year 1907. A Licence to Treat Tailings was taken out on this ground in 1955 (L.T.T. 1309H), and it was held as a Mineral Claim in 1956 (M.C. 534H).

The deposit is located about 2 miles north-east of the Jerramungup Homestead. Reference may be made to the Lands Department Lithograph 419/80. This deposit was not examined by the author and the following information has been taken from a report by Mr. A. Oliver on Geological Survey File 172/20 written in 1920.

The country rocks consist of granitic-gneiss, with some remnants of slate, quartzite and basic igneous rock. The ore body, which trends in an east-west direction, had been worked by means of a shallow open-cut, from 12 to 15 feet deep, and two shafts about 20 feet apart which were originally about 80 feet deep. The width of the mineralised zone is not given, but it must have been fairly wide since it is stated that there were a number of north-south crosscuts leading off from the open-cut. The shafts were connected at the bottom by a drive. It is reported that altogether a good deal of cross-cutting and driving had been done.

It is estimated that about 200 tons of copper ore were taken from this deposit prior to 1920, but there is no official record of this. Simpson (1952) states that specimens of country rock, impregnated with malachite, were obtained from Anderson's Reward Claim. The malachite appeared as stringers or minute crystals on fracture faces. An assay of one specimen gave:— Copper, 37·41 per cent.; gold, trace. Production from this ground is as follows:—

Table 91
COPPER ORE AND CONCENTRATES

Period of Production	No. of Lease	Registered Name	Ore Produced	Copper Content	Average Assay per cent. Copper	Value
			Long Tons Copper Ore	Long Tons		£A
1907	M.L. 59H	Netty Copper Mine	3·08	1·26	40·90	40·00
			Cupreous Ore			
1955	L.T.T. 1309H	O'Sullivan, J. J.	17·85	....	7·53	193·20
1956	M.C. 534H	Hlich, J. P., and Barnham, I. L.	1·19	....	10·95	22·00
Total to the end of 1960			22·12	....	....	255·20

THE WARBURTON RANGE DEPOSITS

A small tonnage of ore has been produced from several small deposits on the Warburton Range Native Mission Reserve in the Eastern Division, about 440 road miles eastwards of the Leonora railhead.

Mineralisation occurs in Nullagine volcanics which strike west-north-west and dip at about 25 degrees southwards. There are eight deposits over about 13 miles in an east-south-east line. They appear to be a combination of primary veins, concentration by solution and precipitation, and copper bearing amygdales in lava. It is considered (Timony, 1961) that a small quantity of easily won ore can be recovered but that the prospect of large scale mining development is remote.

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J. H. LORD
Government Geologist

GEOLOGICAL SKETCH MAP OF WESTERN AUSTRALIA

Centres of Copper Ore Production Shown Thus ○ ROEBOURNE

Scale 80 Miles to 1 Inch



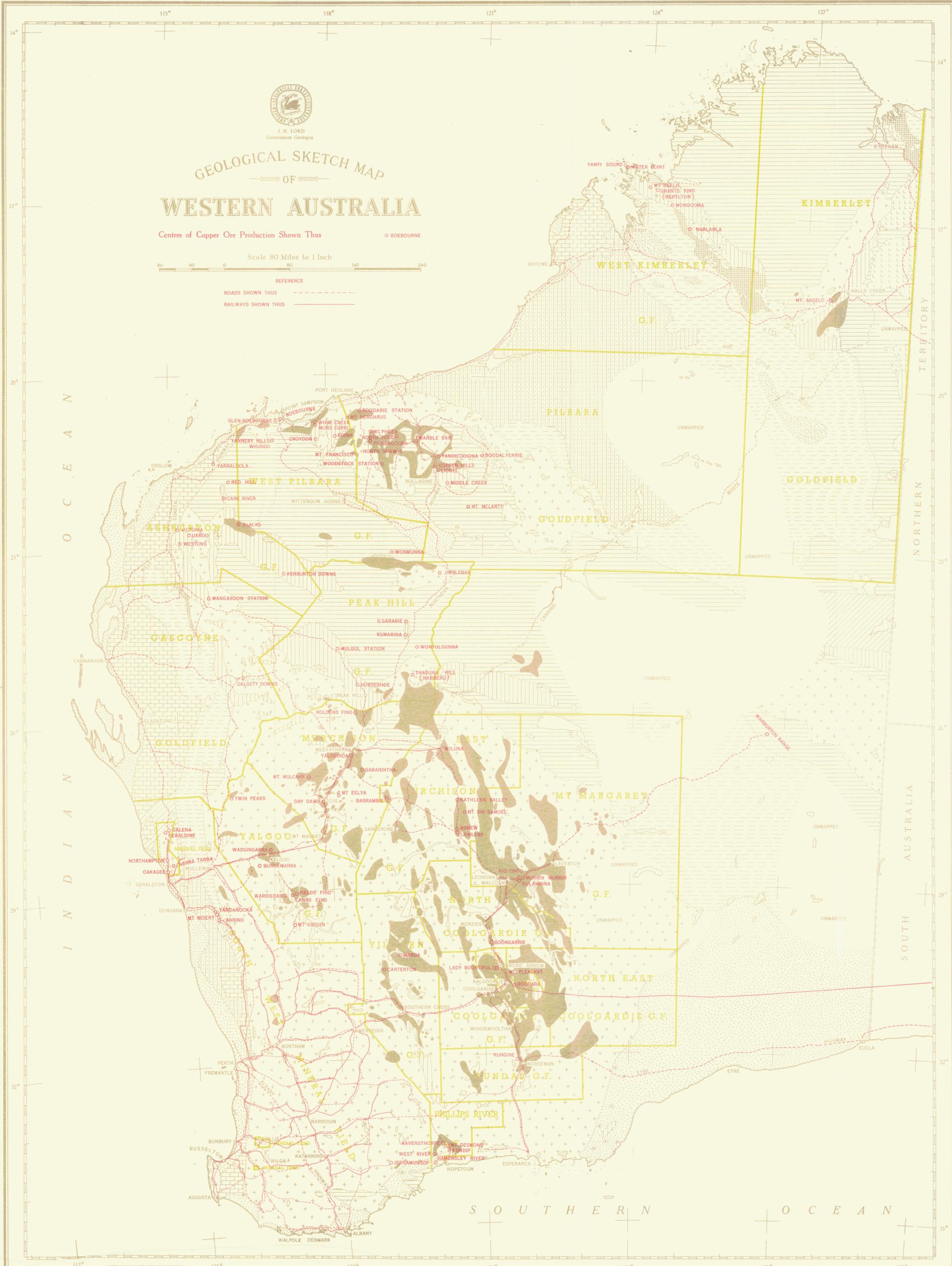
REFERENCE

ROADS SHOWN THUS

RAILWAYS SHOWN THUS

O C E A N I A N I D I A N

NORTHERN TERRITORY SOUTH AUSTRALIA



112° 115° 118° 121° 124° 127° 130° RECTANGULAR POLYCONIC PROJECTION LONGITUDE EAST FROM GREENWICH

