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WESTERN AUSTRALIA.

DEPARTMENT OF MINES

REPORT

OF THE

GOVERNMENT GEOLOGIST

FOR THE

YEAR 1943

PERTH :

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Annual Progress Report of the Geological Survey of Western Australia for the Year ended 31st December, 1943.

The Under Secretary for Mines.

I have the honour to submit for the information of the Honourable the Minister for Mines, my report on the operations of the Geological Survey for the year 1943.

STAFF.

Mr. H. A. Ellis returned to duty with the Geological Survey on the 20th September, having been placed on the reserve of officers from the second A.I.F. Mr. Ellis was on military duty for over three years, having enlisted on 14th August, 1940.

The professional staff at the end of the year consisted of the following officers:—

Government Geologist—F. G. Forman, B.Sc.

Geologists—H. A. Ellis, B.Sc., A.O.S.M.; R. A. Hobson, B.Sc. (Hons.); R. S. Matheson, B.Sc.; K. R. Miles, D.Sc., F.G.S.

On the 29th March, Mr. G. B. Everard commenced duty as semi-technical assistant. His duties include the registration and proper keeping of the rock and mineral collection, the keeping of the rock and mineral indices up to date, the cutting of rock sections for petrological examinations, the handling of specimens to and from the collection for the use of the professional officers, and the care of the technical library. No assistance had been available for work of this nature since the transfer to another Department of Mr. Outtrim in 1940, and the present appointment has helped considerably to save the time of professional officers, and add to the efficiency of their work.

The office work continues to be conducted by a typist, a junior clerk and a messenger.

ACTIVITIES OF PROFESSIONAL STAFF.

F. G. Forman, B.Sc., Government Geologist.

At the beginning of the year, I was engaged with a representative of the British Phosphate Commission, Mr. J. C. Dulfer, on a survey of the phosphate deposits of the Abrolhos Islands, west of Geraldton. This work was commenced on the 15th December, 1942, and was completed on the 14th January, 1943. From the 5th to 26th February, I accompanied Mr. Dulfer on a survey of the phosphate deposits of the Recherche Archipelago, near Esperance, and from the 11th to 17th March, I accompanied him on an inspection of the reputed phosphate deposits near the mouth of the Murchison River.

I was engaged on office work almost continuously for the months of April to July. During this period, I made six brief visits to Greenbushes in connection with tantalite prospecting and mining operations.

From the 30th August to the 22nd September, I was in the field, investigating water supply problems for the Army. Another short trip to assist the Army in a water supply problem was made on the 7th October.

From the 26th to 31st October, I made a visit to the Blue Spec Gold-Antimony Mine, east of Nullagine in the Pilbara district, to advise on the water supply at that centre.

From the 8th to 18th November, I accompanied Mr. Hobson to the Mount Margaret Goldfield in order to review the field work carried out by Mr. Hobson and suspended owing to war conditions late in 1941.

H. A. Ellis, B.Sc., A.O.S.M.

Mr. Ellis returned to duty at the Geological Survey on the 20th September, and before the end of the month, made an inspection trip to Greenbushes connected with tantalite development on M.C. 1.

During October, Mr. Ellis investigated the occurrence of lithium-bearing minerals in the Coolgardie-Londonderry district. Field work occupied his time from the 7th to 31st October, during which period he also investigated the occurrence of tale and soapstone at Mount Monger.

During November, Mr. Ellis was occupied in preparing reports on his field work during October and in inspection work on the columbite-tin lode on M.C. 9 at Greenbushes. Mr. Ellis also assembled information on the graphite deposits at Donnelly River, Kendenup, Munglinup River and Young River, and towards the end of the month commenced field work on these deposits.

Mr. Ellis was in the field until 21st December, examining the graphite occurrences mentioned above, vermiculite deposits at the Young River, and an occurrence of spodumene near Ravensthorpe.

R. A. Hobson, B.Sc. (Hons.).

Mr. Hobson was in Head Office continually from January to April. During this period he prepared reports on the work done by him at Greenbushes during 1942, and completed his maps of that area. During this period, Mr. Hobson also completed reports on the sampling of lakes for alunite near Baladjie and Mount Palmer, and also prepared final estimates of the quantity and quality of iron ore likely to be available from the Koolyanobbing iron ore deposits.

During May, Mr. Hobson was engaged at Greenbushes on the examination of an area in the vicinity of Dredging Claim 95 and Mineral Claim 48, and also in carrying out a preliminary sampling of sundry areas throughout the Greenbushes Tinfield. He returned to Head Office on the 24th July, and was then engaged until early in October preparing reports and maps dealing with his work at Greenbushes.

In November, Mr. Hobson accompanied me on a review of field work carried out by him during 1941 in the Mount Margaret Goldfield.

From the 6th to 17th December, Mr. Hobson made an examination of the Ora Banda Amalgamated Gold Mine at Grant's Patch.

Throughout the year, Mr. Hobson attended to routine office duties during my absences on field inspections.

R. S. Matheson, B.Sc.

In January, Mr. Matheson investigated the tungsten deposits at Callie Soak and the molybdenite deposits at Mount Mulgine in connection with applications for financial assistance. Whilst in the Callie Soak area Mr. Matheson made brief visits to Poona, Coodardy Tin Leases and the Big Bell Gold Mine.

During the early part of February, Mr. Matheson was absent from work on sick leave.

From the 18th February to 7th April, he was engaged on the compilation of a bulletin describing the mica deposits of Western Australia. From the 8th

April to 15th May, Mr. Matheson was engaged in the mapping and sampling of phosphate deposits in the Dandaragan district. His work on the Mica Bulletin was completed towards the end of May.

In June and July, Mr. Matheson was at Head Office, completing reports on work carried out by him at Greenbushes during 1942, and assisting the preparation of the Annual Progress Report for 1941 and 1942. During this period he also accompanied a representative of the British Phosphate Commission on a tour of inspection of the Dandaragan phosphate deposits.

During August, Mr. Matheson was engaged at Head Office in the compilation of general information to be included in the forthcoming bulletin dealing with the mining groups of the North Yilgarn Goldfield. He also organised a card index system for the recording of mineral prices and specifications which has proved of distinct value to the work of the branch.

In September, Mr. Matheson accompanied Dr. H. G. Raggatt, Commonwealth Geological Adviser on inspection trips to the Dandaragan phosphate deposits and the anthophyllite asbestos deposits at Bindi Bindi.

Mr. Matheson made another trip to Dandaragan in October with representatives of the British Phosphate Commission.

Early in November, Mr. Matheson made preparations for the mining of a trial parcel of phosphate nodules from Cook's deposit at Dandaragan. He supervised the obtaining of this material which occupied his time from the 16th November to 7th December.

The remainder of the year was occupied by Mr. Matheson in compiling a report on the work done by him at Dandaragan and on a visit to the Cresco Fertiliser Works where the trial parcel from Dandaragan was being treated.

K. R. Miles, D.Sc., F.G.S.

During the early part of January, Dr. Miles was engaged in logging and taking representative samples of bore core obtained during the drilling of the ore body of the Whim Well Copper Mine, Whim Creek, by the Commonwealth Copper and Bauxite Commission in 1942. On the conclusion of this work he commenced the preparation of a bulletin on the tantalite deposits of Western Australia.

On 2nd March, Dr. Miles left Perth to make an inspection and assess the possibilities of the scheelite deposits at Coolgardie (Londonderry), Higginsville, Comet Vale and Westonia. He took with him the Department's Mineralight Ultra Violet Ray Lamp which proved of considerable assistance to the men operating these deposits. Whilst in the district he investigated a deposit of lepidolite at Tantalite Hill, Londonderry.

After returning to Perth on 18th March he was engaged at Headquarters until early in June on various duties, including the preparation of a report on the scheelite deposits, notes and plans for the tantalite bulletin and a report on the petrography of rocks from the Greenbushes Tinfield.

From 9th to 16th June, Dr. Miles was engaged in sampling the salt lakes of the Campion district in connection with the proposed alumina treatment plant. After completion of his reports he was engaged until the end of July on petrological work—in connection with rocks from Greenbushes, the Mt. Margaret Goldfield and the South Coast.

From 5th August to 1st September he was engaged in a survey of the moulding sand deposits in the metropolitan area, in company with Mr. H. A. Stephens of the Council for Scientific and Industrial Research. During the course of this work the bentonitic clay deposits of Marchagee were examined and sampled.

From September until the end of the year, Dr. Miles was engaged at Head Office on multifarious duties, including completion of the tantalite bulletin, preparation of a report on the moulding sands investigation, and various departmental reports on microscopic

mineralogy and petrology, including during October a report on the constitution of phosphate nodules from Dandaragan.

Reports based on the year's field work are published herewith, with some exceptions, as follow:—

A number of reports prepared by Messrs. Hobson and Matheson describing the work on the Greenbushes Tinfield are not published because of their length and the fact that they will be included in a comprehensive bulletin dealing with the Greenbushes Tinfield, which is now in course of preparation.

Various reports dealing with phosphate deposits are also withheld pending the compilation of a report covering all the phosphate deposits of the State.

Other reports not published were prepared for purely departmental information or for the Department of the Army.

I wish to record my appreciation of the loyal work of all members of the staff throughout the year.

F. G. FORMAN,
Government Geologist.

ALLUVIAL TANTALITE, MINERAL CLAIM 1— GREENBUSHES.

By F. G. Forman, B.Sc.

On the 14th and 15th of May I made an inspection of mining operations on M.C. 1, Greenbushes, where Messrs. Collett and Freeman are recovering alluvial tantalite from an area covered by the road reserve.

High grade lode tantalite has been obtained in the past from a short but rich shoot of ore on M.C. 1 about 60 feet from the western side of the main Greenbushes-Bridgetown road. Alluvial tantalite shed from the lode has also been worked on either side of the road reserve, but alluvial ground within the reserve has, until now, been left intact. The recent urgent request from Professor Greenwood for the supply of high grade tantalite resulted in an offer from Collett and Freeman, who hold M.C. 1 on tribute from Tantalite, Ltd., to mine the alluvial ground beneath the road reserve, and this operation is now in progress.

Mining operations consist of working out the alluvial material in drives supported by timber beneath the road surface. The alluvial wash varies from two to three feet in thickness and lies on an uneven surface; the bottom of the wash at the S.E. corner of the block of ground being at a depth of about 12 feet whilst the wash at the present N.W. corner of the workings has risen to such a shallow depth as to necessitate the breaking of the road surface to enable the wash to be removed. Alluvium has been exposed in the direction of the length of the road for a distance of 60 feet without the full width of the gutter being found.

At the time of inspection about one-third of the available ground had been worked for a recovery of 11 cwt. of tantalite lumps weighing from a few ounces up to 24½ lb. Many lumps of between two to 10 lb. weight have been recovered and make up a very large proportion of the total. There is every indication that when the block of ground is worked out a total of well over one ton of high grade tantalite will be recovered.

The lump tantalite so far obtained was hand picked from the wash and arrangements are being made for the fine material to be sluiced. No information is available regarding the grade of the fine wash.

The lump tantalite so far recovered has not yet been assayed. Judging, however, from the results of earlier working of the alluvial on either side of the main road a Ta₂O₅ content of 66 per cent. or over is confidently expected.

Judging by the large size of tantalite lumps and their extremely angular shape it seems clear that the lode from which they were shed must be very close to where they are now found. It is also obvious that portion of the tantalite being recovered was derived

from the short, rich shoot, 60 feet west of the road mentioned earlier in this report, but the contour of the bottom of the present alluvial workings suggests the likelihood of some of the tantalite coming from a yet undiscovered shoot to the north of the known one. In view of the present urgent demand for high grade tantalite, I recommend that prospecting operations to try and locate a possible new shoot be carried out. The likely area was pointed out during the present inspection to both Mr. J. H. Collett and his manager, Mr. H. Paterson. The provision of £200 for this prospecting should be made immediately in order that the work may be done while the present operations are in progress. On completion of the present programme the men now being employed will be moved to other urgent operations on M.C. 6 and the Vulcan Tin Mine, M.C. 4.

WATER SUPPLY AT THE BLUE SPEC GOLD-ANTIMONY MINE, NULLAGINE, PILBARA DIVISION.

By F. G. Forman. B.Sc.

A visit was made to the Blue Spec Mine between the 20th and 23rd October to investigate the possibility of obtaining additional water supplies at this mine. Mr. J. L. Dillon, manager of the Blue Spec Mine extended to me every courtesy and provided transport facilities between Marble Bar and the mine and during the actual investigation.

The Blue Spec Mine is located in hilly country, which is made up of steeply dipping and tightly folded slates, quartzites and grits of the Pre-Cambrian Mosquito Creek Series.

These rocks have an extremely low inherent porosity, and underground water supplies are, therefore, dependent on water which fills joints, faults and shears traversing them. As a general rule these features are impossible to detect by a surface examination and therefore, the obtaining of an adequate water supply in any one well or bore is largely a matter of chance. The workings at the 300ft. level of the Blue Spec Mine are in dense slaty rock and although the rocks are well jointed and sheared the workings are practically dry. On the other hand the domestic supply well, situated about 1,000 yards south-east of the mine, is in rock made up of alternate layers of slates and grits, which are well jointed, and from which a small supply of 1,500 gallons per day is at present being obtained.

Existing Bores and Wells.

Middle Creek, along the western bank of which all the existing water supplies are located, flows across a wide flat occupying a break in the east-west trending hills lying to the south of the mine. The country rocks underlying this flat have a strike parallel to the general trend of the hills and dip steeply towards the south at angles of from 70° to 90°.

The existing bores and wells indicate that water supplies of the order of 1,500 gallons per day are all that can be expected from any one source. Details of the various supplies are as follows:—

No. 1 Bore is about two miles from the mine, is 243 feet deep and is said to yield 1,500 gallons per day of brackish water.

No. 2 Bore, known as Lister Bore, is situated one mile south of the mine, has a depth of 226 feet and a water level at 186 feet. This bore is said to yield 1,500 gallons per day. After standing, the bore can be pumped at the rate of 120 gallons per hour, but the supply rapidly falls off to the above steady amount.

No. 3 Bore is at present in progress. It is situated about 100 yards west of the No. 2 Bore and is at present 251 feet deep with no water.

An abandoned bore a few hundred yards east of No. 1 Bore is 182 feet deep and is stated by Mr. Peterson to be capable of yielding 80 gallons per hour. It is reported that this bore was abandoned because of the crookedness of the hole.

An abandoned dry bore 120 feet deep is situated about 100 yards north of No. 2 Bore. This bore was abandoned when the contractors struck country, which in their opinion, was too hard to drill.

The domestic supply well is situated about 1,000 yards south-east of the mine. It is 194 feet deep and has a 40 feet crosscut at the bottom. The supply from this well is reported to be 1,500 gallons per day, the water level being at 140 feet. Mr. Peterson who had charge of the sinking of the well, reports that the water supply is derived from numerous small seepages which come in through narrow joints and contact planes between the rock types.

All the above sources are connected by pipe line to the main service tank at the Blue Spec Mine. The estimated total supply per day being 4,500 gallons.

Middle Creek Government Well is situated close to the western bank of Middle Creek about two miles south of the mine. The supply is said by Mr. Dillon to be very small.

Recommendations.

To obtain the additional supplies required to bring the present supply of 4,500 gallons per day up to 20,000 gallons per day, the total quantity estimated by Mr. Dillon would require the sinking of probably seven or eight additional bores. There can be no guarantee that every bore would obtain a supply and where difficulty is experienced in striking water each bore should be continued to at least 300 feet before abandonment. With a contract price of 30s. per foot, the price paid for previous bores, it will be seen that a boring programme, if successful, would cost at least £2,100 leaving out of consideration the cost of additional pumping equipment.

It is recommended that a first effort to augment supplies should be made by additional crosscutting in the domestic well. A further 100 feet of crosscutting in either direction across the strike of the country should give an added yield equivalent to that obtainable from at least two new bores, and there is also an excellent chance of opening up more open country, which would yield considerably greater supplies. One hundred feet of 6 x 4 crosscut should not cost more than £800, and in addition to exploring the possibility of obtaining a really heavy supply of water it would, combined with the existing 40ft. crosscut, provide a storage capacity of 20,000 gallons.

Further useful exploratory work could be carried out very cheaply by crosscutting with a diamond drill from the bottom of the new main shaft at the mine. The best direction of this work would be to the north in order to test the country under the flat to the north of the mine. This I understand has already been proposed by Mr. Carroll.

A suggestion mentioned to me by Mr. Dillon, to develop a water supply by pumping from sand soaks in the Nullagine River near the junction of Five Mile Creek and distant about six miles from the mine, should be considered only as a last resort on the score of expense. Before being seriously considered it would be essential to test the permanency of the soak supplies by heavy pumping tests at the end of the dry season.

A SPODUMENE DEPOSIT, RAVENSTHORPE, W.A.

(Approx. Lat. 33° 35' S., Approx. Long. 120° 02' E.)

By H. A. Ellis, B.Sc., A.O.S.M.

Locality.

The spodumene occurs as a constituent of a pegmatite dyke outcropping in the bed and western bank of one of the tributaries of the headwaters of Cattlin Creek, about four chains east from a point on the Ravensthorpe-Newdegate road, 1.3 miles north of the Ravensthorpe Post Office. The strongest development of spodumene is in the creek bed approximately 10 chains S.E. from the N.W. corner of Water Reserve 17.

Ravensthorpe is approximately 30 miles by road from the disused small vessel port of Hopetoun on the south coast, and 81 miles by road from the railhead at Newdegate (306 miles by rail from Perth).

The deposit was inspected on December 16th, 1943.

Geology.

Medium to coarse grained blocky amphibolites outcropping strongly in the east bank of the creek have been intruded by a medium grained pegmatite dyke striking N.W. and about four chains wide where it junctions at the S.E. end with the blocky amphibolites in the creek bed. More or less horizontally disposed tongues of pegmatite from three feet to $\frac{1}{2}$ inch thick can be seen intruding the amphibolites on the eastern bank in a series of nearly horizontal master joints. Occasionally the S.E. contact of the dyke can be observed dipping at from 90° to 15° and occasionally flatter to the east.

The Spodumene Occurrence.

Fresh apple-green coloured spodumene crystals varying in size from 18 inches x 6 inches x 4 inches maximum dimensions, down to crystals $\frac{1}{4}$ inch maximum dimension, occur in the extremely fresh pegmatite in patches of varying density of spodumene concentration and with no particular orientation. Some patches of dyke contain up to 20 per cent. by volume (estimated of spodumene, others up to 10 per cent., while considerable areas of exposed pegmatite contain no visible spodumene. The best patch seen would be about one sq. chain in area containing about 20 per cent. by volume of spodumene.

The spodumene bearing portion of the dyke considered of possible economic importance is the strip approximately four chains wide at the eastern end, and about two chains long (N.W. along the strike) in the creek bed and on the western bank.

The pegmatite over this area consists principally of quartz, albite feldspar, muscovite mica and spodumene with beryl, columbite and black tourmaline as very minor accessory minerals. A pink tourmaline is reported to occur here; specimens were seen in the possession of local inhabitants but none was observed in the pegmatite.

It was reported locally to the writer that concentrates obtained from material broken from an outcrop of this dyke further to the N.W. from the spodumene deposit, were examined by the Government Mineralogist and contained cassiterite, columbite, lepidolite mica and amblygonite.

A remarkable feature of the pegmatite is its freshness, consequently rendering mining operations costly right from the surface. The even grain size—more like a very coarse grained granite than pegmatite—is also noteworthy when compared with the usual large scale crystalline development found in most pegmatites carrying minerals of economic importance.

The deposit was not being worked at the time of inspection (December 16th, 1943) but showed signs of having been recently lightly attacked, as evidenced by several wide, shallow excavations and benchings in the vicinity of which there remained possibly $\frac{3}{4}$ ton of ore.

Estimate of Tonnage.

It is considered desirable to present some estimate of the quantity of spodumene likely to be contained in that portion of the dyke in which spodumene can be seen to be present in the outcrop.

The estimate which follows is influenced by the following factors:—

- (a) The irregular and unpredictable manner of occurrence of accessory minerals in a pegmatite dyke.
- (b) Complete lack of any mining development.
- (c) The possibility that the spodumene bearing portion of the dyke may be underlain at no great depth by amphibolite, as suggested by the flatly lying pegmatite intrusions into the amphibolite in the eastern bank of the creek. On account of this possibility a vertical extent of 10 feet only has been assumed in the following computation.

- (d) Impracticability without mechanical aid of trench sampling the wide, fresh pegmatite, hence a visual estimate only of the volume of spodumene in the pegmatite was possible.

Area over which pegmatite carries spodumene	= 264 x 132 sq. ft.
Depth to which pegmatite is assumed to carry spodumene.	= 10 feet.
Volume of spodumene bearing pegmatite	... = 348,480 c. ft.
Using conversion factor of 15 c. ft. per ton	= 23,232 tons.
then Tonnage of spodumene bearing pegmatite.	
Estimated percentage by volume of spodumene in above volume of pegmatite.	= 10 per cent.
Volume of spodumene in pegmatite	... = 34,848 c. ft.
Weight of spodumene in pegmatite using S.G. of spodumene as 3.1.	$\frac{34,848 \times 62\frac{1}{2}}{2240} \times 3.1$
	= 3014 tons.

Thus 23,232 tons of spodumene-bearing pegmatite are estimated to contain 3,014 tons of spodumene based on the above assumptions.

Quality of the Spodumene.

A representative sample of the spodumene crystals was collected over the area on which the above computations are based, and has been analysed at the Government Chemical Laboratory with the following results:—

Lithia (Li_2O) = 6.20%. Lab. No. 9383.

General Remarks.

It is essential that the factors quoted in the estimate of tonnage be given due consideration when reviewing the economic possibilities of this deposit. The hardness of the pegmatite and the frequent intimate intergrowth of quartz and feldspar with some of the spodumene are not favourable to successful hand picking of the broken ore. The relative high S.G. of spodumene (3.13-3.20) suggests concentration of a crushed ore as being likely to be successful if prices and production costs are favourable to the exploitation of this deposit.

THE YOUNG RIVER VERMICULITE DEPOSITS. YOUNG RIVER, EUCLA DIVISION, W.A.

Approx. Lat. $33^\circ 32'$ S., Approx. Long. $121^\circ 00'$ E.

By H. A. Ellis, Geological Survey of W.A.

Locality.

These deposits are situated on the eastern bank of the Young River, approximately 64 miles east of Ravensthorpe by road via Dunn's and Munglinup, in approximate latitude $33^\circ 32'$ south, and approximate longitude $121^\circ 00'$ east. Esperance, the nearest shipping port on the south coast, is 76 miles distant in a general east-south-easterly direction by a moderately good sand plain road.

In the early stages of development the deposits were somewhat difficult of access, but recent road improvements have considerably reduced these difficulties. The easiest approach to the deposits is by the Ravensthorpe-Esperance road, turning north off this road at a point 9.4 miles west of the Young River Crossing—the turn off being some 59 miles from Esperance and approximately 60 miles from Ravensthorpe.

The deposits were first inspected by the writer in June, 1940, and again in December, 1943.

History.

The deposits were found towards the end of 1939 by prospector G. Halbert of Ravensthorpe, who first detected the vermiculite flakes in the soil of mounds built by ants on the soil-covered slopes of the low hills forming the eastern bank of the Young River in this locality. A considerable amount of prospecting in the nature of costeens and shallow shafts was done in early 1940, and by June of that year two deposits of potential economic value were opened up in a small way. Much difficulty was encountered at this time in securing an assured market for the vermiculite, and even to-day (January, 1944), the supply exceeds the demand. The deposits are embodied in Mineral Claims Nos. 204H and 205H each of 24 acres and are being worked by a Perth firm, The Perth Modelling Works.

Physiography.

This part of W.A. is characterised by extensive areas of broadly undulating sand-plain country devoid of large trees, except along the river courses, and covered for the most part with low scrub and mallee. The surface is mostly sandy, with either a clayey or gravelly sub-soil close to the surface. The south trending drainage channels, such as the Oldfield and Young Rivers, are entrenched to depths varying from a few feet up to 50 feet in places in the bottom of very broad valleys (up to 5 miles wide in places) and are, for the most part of the year, a chain of widely separated pools or rock-holes of saline water. The actual stream beds follow a meandering course in the wide valleys, the soil banks occasionally being replaced by rock. The vermiculite locality on the Young River is characterised by a small extent of moderately hilly country adjoining the eastern bank of the river, the more resistant basic rocks of the hills forming the actual banks in places. These hills carry a moderately dense growth of medium sized timber—mostly Yate, of considerable value as mining timber.

Geology.

No systematic geological surveys have as yet been carried out in this part of the State, and only observations made at widely spaced intervals can be quoted in this account of the geology of the area.

Shortly after passing eastwards through the easily recognised "Greenstone Belt" of Ravensthorpe, sand plain country is encountered, and topography and vegetation change rapidly from the sharply dissected, timbered, hilly country of the gold and copper belt, to the broadly undulating, scrub-covered sand plain, with occasional low rounded hills to the south and wide shallow valleys. Infrequent outcrops seen on the road consist of quartz mica schist with numerous thin beds of actinolite and anthophyllite schist alternating rapidly with the mica schist. These beds have a regional strike of approximately east and west and dip at from 50° to 90° to the south. They have been intruded by granite, quartz reefs, and basic rocks, the latter giving rise to useful magnesite deposits in the vicinity of Bandalup Creek.

Still further east, after passing from high level sand plain country just east of No. 1 Rabbit Proof Fence down a very marked topographic slope, and into a large expanse of lower lying sand plain country, occasional bands of gneissic country outcrop, particularly in the vicinity of the Oldfield, Munglinup and Young Rivers. Here the rocks are markedly gneissic with biotite and hornblende, and occasionally garnet, the predominant minerals after quartz and felspar. The strike now is predominantly in the north-east quadrant, with dips more moderate, between 30° and 55° to the south-east.

The relation these rocks bear to the "Greenstone Series" at Ravensthorpe, or the metamorphic sedimentary beds of the Stirling Range, is as yet unknown. On the Munglinup River they contain well defined zones of graphitic schist carrying flake graphite in payable quantities, and on the Young River in the vicinity of the vermiculite deposits, where there are some good exposures, they can be seen to be intruded by basic rocks forming an actinolite—anthophyllite—hornblende complex.

Here, the country rock is mainly biotite gneiss with interbedded hornblende granulite, which is sometimes gneissic and sometimes massive. The regional strike is north-south with a prevailing dip of from 40° to 50° to the east, and both the gneisses and intrusive basic rocks have been intruded by muscovite bearing granite, tourmaline-bearing pegmatite dykes, and quartz reefs.

In the absence of definite proof as to age, the schistose and gneissic series is presumed to be of pre-Cambrian age, and from its general appearance in the field to be formed mainly from metamorphosed sediments.

The Vermiculite Deposits.

Vermiculite is a name given to a group of micaceous minerals, all hydrated silicates, considered to be alteration products, chiefly of the micas. When heated they

lose their water of composition, and in so doing swell up or exfoliate to varying degrees. It is this property of exfoliation which gives them their commercial value as insulating material against heat and sound, and according to the degree of exfoliation and the strength of the exfoliated material, the value of the product varies. Some types change colour on heating, and when the finely divided material is used as a pigment or filler in paints, the nature and intensity of the colour are of importance.

Considerable doubt exists as to the mode of origin of the vermiculites, and the writer collected representative material in 1940 with the object of having some chemical investigations made which would throw some light on the mode of origin of these deposits. Unfortunately, the demands of war activities on the available Departmental Chemical Staff have prevented this investigation being carried out.

Field evidence gathered during the examination of these deposits does not support the conception that vermiculite is simply a weathered form of say biotite or phlogopite mica, etc., but that it is a mineral formed under deep-seated hydrothermal metamorphic conditions. This conception is supported by available evidence noted in the examination of a number of other minor occurrences of the mineral in the south-west part of the State carried out by the writer in early 1940.

The evidence favouring a deep-seated origin may be summarised as follows, the characteristic associations being common to deposits some hundreds of miles apart in latitude and longitude:—

- (1) The host rock is invariably a highly sheared basic igneous rock consisting of hornblende, actinolite, anthophyllite and usually tale, in varying proportions.
- (2) In every case there is evidence of granitic or pegmatitic intrusive rocks in the immediate vicinity of the deposits.
- (3) The vermiculite invariably occurs in obvious shears in the basic rock, and is itself frequently intersected by shear planes and often highly foliated.
- (4) In every case the biotite or other micas in the highly weathered adjoining granite and gneiss are not of the vermiculite group.

The occurrence of a dark green vermiculite in the heart of fresh microcline felspar boulders from a pegmatite dyke outcropping near the southern end of the Young River deposits is interesting, in so far that this vermiculite could not possibly have had access to atmospheric weathering agencies, being completely surrounded by over 9 inches of remarkably fresh felspar.

The above information concerning the mode of origin of vermiculite has an important economic significance, as the writer is of the opinion that, contrary to a somewhat general geological belief, vermiculite deposits are not confined to the zone of weathering, but continue to depths limited only by the continuity of the host rock and the deformation structures primarily responsible for the formation of the mineral.

The Young River vermiculite zone which has been developed commercially, lies towards the western margin of a complex of basic rocks comprising mainly massive hornblendites with actinolite, anthophyllite and tale bearing facies, which are intrusive into interbedded hornblende granulite and biotite gneiss, striking approximately N. and S. and dipping at from 30° to 55° to the east. The zone is approximately four miles long by about ½ mile in width, is moderately hilly, and carries a medium growth of eucalypts and scrub.

The basic intrusive rocks, frequently massive and coarse-grained, have been sheared in directions mostly confined to the N.W. and S.E. quadrants, the shears dipping sometimes steeply to the north and sometimes steeply to the south, and controlling the occurrence of the vermiculite. The basic intrusive rocks and the gneissic series have been invaded by granite and pegmatite.

Numerous separate vermiculite prospects of varying grain size, colour and exfoliation value have been opened up over a distance of about 1,800 feet along the belt and over a width of approximately 800 feet, in the west-central section of the belt. They all occur in sheer planes of varying length and attitude, none exceeding 100 feet long—the majority being much less than this—in the weathered basic intrusive hornblende or actinolite-anthophyllite rock.

To date, the demand for the mineral has resulted in the opening up of the two best prospects only, the northern deposit, situated some 1,200 feet north of Halbert's camp, and the southern deposit, located about 450 feet S.S.W. from the camp, both on the eastern bank of the river.

The Northern Deposit.

This deposit is situated on the crest of a flat-topped ridge approximately 1,200 feet north of Halbert's camp, and 400 feet N.E. from the northern end of the N.-S. stretch of the river immediately west of the camp.

The vermiculite occurs in a complex intersecting shear pattern in granular hornblende and granular actinolite rock, the principal directions of shearing being N. 15° W. dip E. at 75°; and N. 60° W. dip both N.E. and S.W. at from 60° to 80°; forming wedge shaped masses of vermiculite and "horses" of hornblende. The shear pattern frequently forms lozenge shaped masses resulting in two hanging walls, making mining operations somewhat difficult.

The deposit has been worked over a total length of 75 feet, (following the shears) down to a maximum vertical depth of 45 feet and over a maximum width of 12 feet. The vermiculite lens was 2ft. 6in. wide at the bottom of the deepest workings (December 11th, 1943) and was narrowing in from a width of 12 feet some 20 feet higher up. The lenses appeared to have pinched out at the S.E. end of the workings, but the N.W. face still showed up to 12 feet of vermiculite near the surface.

The gradual conversion of the hornblende into masses of interlocking dark green scaly vermiculite is amply demonstrated in the residual "horses" of hornblende, and in the wall rocks.

There is a strong outcrop of a pegmatite dyke carrying tourmaline and muscovite mica immediately west of this deposit, and the hornblendites in the vicinity contain numerous octahedra and tabular crystals of magnetite.

Similar shaped magnetite crystals with an indicator zone of reddish iron oxide distributed in the surrounding vermiculite occur in the heart of the vermiculite lenses in the deposit being worked.

The vermiculite is strongly foliated in places, the maximum size of the scales noticed being about 1½ inches by one inch, with by far the largest proportion of the scales under ¼ inch maximum dimensions, forming a compact interlocking mass, easily mined, though liable to form dangerous ground. To date this deposit has produced 420 tons, some of which has been used in Perth and some shipped to the Eastern States.

The following information relative to the treatment of the vermiculite has been supplied by the Managing Director, Perth Modelling Works:—

Weight of ore before exfoliating = 80 lb. per cubic foot.

Weight of ore after exfoliating = 6.8 lb. per cubic foot.

Normally, before exfoliating, the vermiculite is dressed to two sizes, viz.,

(a) —3 + 8 mesh.

(b) —8 + 40 mesh.

These two sizes, when exfoliated, have been found most suitable for the various uses for which the expanded vermiculite is required.

The Southern Deposit.

This was the first deposit worked, and provided the initial bulk parcels of ore on which commercial tests were carried out in an endeavour to establish the value of the deposits.

It is situated on the east bank of a small tributary of the river some 450 feet S.S.E. from Halbert's camp, and about 150 feet S.E. from the southern end of the N.-S. stretch of the river immediately west of Halbert's camp.

It is of a similar nature to the northern deposit, occurring in a shear pattern in a green actinolite rock with "horses" of hornblende and actinolite in the vermiculite. The shear pattern has a general strike of N. 65° W. and dips at about 60° to the N.E. The deposit has been worked as an open cut for some 20 feet long by 15 feet wide, by 18 feet deep on the underlay, and although the shears with the accompanying vermiculites have narrowed in considerably at the south-eastern end of the cut, a good face of ore is exposed in the north-western end and in the bottom of the cut.

The following information, relative to the treatment of the vermiculite from this deposit, has been supplied by the managing director of the Perth Modelling Works:—

Weight of ore before exfoliating = 80 lbs. per cub. ft.

Weight of ore after exfoliating = 8-10 lbs. per cub. ft.

As in the case of the Northern deposit, this vermiculite is dressed to two sizes before exfoliating, viz:—

(a) —3 + 8 mesh.

(b) —8 + 40 mesh.

Production and Ore Reserves.

The following production figures were supplied by the owner of the deposits, and represent very closely the quantities sold up to the end of 1943.

Northern Deposit	420 tons (approx.)
Southern Deposit	150 tons "
Total	570 tons "

Several small parcels mined for experimental purposes in the early stages of the development of the deposits are not included in the above tonnages.

It is not practicable to compute the ore-reserves available in the two deposits already being worked, on account of insufficient exposures and the extremely irregular manner of occurrence of the mineral in the complex shear patterns in which it occurs.

With a knowledge of the manner of occurrence and from an inspection of the workings as they appeared in December, 1943, and taking into account the quantities already mined from the two deposits the following guess as to remaining ore is made:—

Northern Deposit	300 tons.
Southern Deposit	150 tons.

These guesses are made with respect to ore down to the level of the deepest part of the workings: 45 feet in the Northern deposit and 18 feet in the Southern deposit.

Other Vermiculite Prospects.

Some 18 other vermiculite prospects have been opened up in very shallow shafts or small costeans over an area approximately 1,800 feet long by 800 feet wide.

In many of these the vermiculite is of good expanding quality, but in none of them were the initial dimensions as promising as those of the Northern and Southern deposits, and they have consequently not been opened up to any extent.

The demand for the mineral is not sufficiently strong at present to warrant the further prospecting of these occurrences. One of these deposits, situated about 250 feet S.E. of the Southern deposit, is of interest in that at a depth of about 18 feet the shear carrying the vermiculite bottomed on pegmatite, the felspar of which is a glassy form of albite-oligoclase, resembling petalite in

hand specimens. Several outcrops of pegmatite in the vicinity of some of the other deposits also carry this glassy felspar.

In the absence of any development work on these occurrences, it is not possible to form any estimate of the quantities of vermiculite likely to be obtained from them.

General Remarks.

The Young River vermiculite deposits constitute the best yet found in this State, and with only the two best of the surface prospects yet partially developed, have been able to meet current market demands.

The future development of the deposits depends entirely on the market demand and although at the present time (January, 1944) it is possible to offer only a guess at the ore reserves (450 tons), the potentialities of the area over which vermiculite has been found have not been even partially explored in depth in any instance, and in only two instances has there been any moderate scale surface development.

Attempts to develop in depth any vermiculite deposit would be largely an experiment in the light of our present knowledge of the mode of origin of the mineral, but the writer has confidence that they will live in depth, providing the host rock persists and the shears continue, both factors of strong geological probability.

THE YOUNG RIVER GRAPHITE DEPOSIT, YOUNG RIVER, EUCLA DIVISION, W.A.

(Approx. Lat. 30° 32' S., Approx. Long. 121° 00' E.).

By H. A. Ellis, B.Sc., A.O.S.M.

Locality.

This deposit is situated on the eastern side of the Young River, approximately 64 miles east of Ravens-thorpe by road via Dunns' and Munglinup, in approx. Lat. 30° 32' S., and approx. Long. 121° 00' E. Esperance, the nearest shipping port on the south coast, is 76 miles distant in a general east-south-easterly direction by a moderately good sand plain road.

The deposit is held under P.A. 813H, and is distant about 60 chains south from Halbert's Camp on the vermiculite deposits. The deposit was inspected on December 11, 1943.

Geology.

The graphite occurs in a graphitic schist band interbedded with biotite and hornblende gneisses, and outcrops in one place on flat to undulating scrub-covered country in which outcrops are scarce. The same type of country rock is associated with the vermiculite deposits to the north, and the Munglinup River graphite deposits some 12 miles to the south-west.

A band of graphitic schist had been opened up to a depth of six feet in a wide costean which showed a true width of 10 feet of high grade flake graphite ore with no true hanging-wall encountered. The strike of the beds is N. 45° W. dipping at from 60° to 35° to the N.E. in a curving dip. The footwall is decomposed yellowish coloured biotite gneiss, similar in all respects to the country rock at the Munglinup graphite deposits.

The bed outcrops for 20 feet to the N.W. and can be traced by floaters for a distance of 15 chains to the S.E. Only one opening has been made in the deposit, and on this account no bulk samples were taken.

By comparison with similar sized openings on the Munglinup graphite deposits in which the graphite forms from 20 to 25% by weight of the original ore, it can be stated with confidence that the material from this single opening on the Young River graphite is of similar grade.

Dr. Miles, of this branch, examined specimens of the ore microscopically, and found it to consist of flake graphite and oligoclase felspar with a very small fraction of red rutile fragments.

The ore is moderately hard where exposed, and gives bright surfaces of flake graphite and fresh to kaolinised

oligoclase felspar of striking appearance when broken. Small scale, but intense foliation can be detected in hand specimens, and the graphite is presumed to have been formed by the metamorphism of original carbonaceous shale of sedimentary origin.

General Remarks.

In the present stage of development the deposit is obviously a very good graphite prospect only, and no estimate can be made of ore reserves. Only a very small proportion of fine flake graphite can be detected in hand specimens, the bulk of the graphite presenting a bright glistening flaky appearance.

If the market demand is sufficient, then this deposit, which is held in conjunction with the Munglinup River deposits, some 12 miles to the S.W. by the Perth Modelling Works, Perth, would certainly warrant vigorous development.

THE KENDENUP GRAPHITE DEPOSITS, W.A.

Approx. Lat. 34° 32' S., Approx Long. 117° 37' E.

By H. A. Ellis, B.Sc., A.O.S.M.

Locality.

These deposits are situated 2.2 miles S., 20° W. air-line from the Kendenup Railway Siding (on the Perth-Albany Railway) at a distance of seven chains N. 15° W. from the S.E. corner of Plantagenet Loc. 167. (See Lands Dept. Litho. 445/80.)

Kendenup Railway Siding is 289 miles from Perth and 51 miles from Albany, the nearest port.

The deposits were inspected on December 4th, 1943.

Geology.

At the time of inspection (December 4th, 1943) the deposits were not being developed, and all of the original openings had fallen in; the deepest remaining excavation being four feet only. The workings had been used as a rubbish dump and no information at all about the manner of occurrence of the graphite could be obtained. The adjoining country is broadly undulating with no rock outcrops. Occasional boulders of quartzite and schist found in adjoining cleared land suggest the presence of metamorphic rocks below the soil mantle.

A description of the area and the deposits is contained in G.S.W.A. Bulletin No. 74, pp. 94-99, from which the information about the graphite deposits given below is digested.

The Graphite Deposits.

At a vertical depth of 50 feet a graphite-bearing formation, trending a little north of west and south of east, and presumably dipping vertically, or nearly so, was prospected by tunnelling for a length of 75 feet and a width of 25 feet. Five samples taken from various parts of the drives gave returns of 36.58 per cent., 80.54 per cent., 46.24 per cent., 18.22 per cent., 26.86 per cent., and 12.10 per cent. of graphite in the flake form.

No information is available concerning the widths over which these samples were cut, and no bulk sample of a mineable portion of the ore appears to have been taken.

It is stated in the report that considerable quantities of ore containing 60 per cent. of graphite could be obtained by hand-picking ore broken in the course of development work.

Water and Mining Timber.

The Kalgan River is merely a wide, flat valley in this locality and does not carry water. Ground water sufficient for treatment purposes would probably be found in normal mining operations to 100 feet.

Some mining timber exists on Location 456 nearby but is not plentiful, most of the adjoining country being cleared and cultivated for orchards and mixed farming.

Ore Reserves.

It is impossible to make any estimate of ore reserves on the existing information.

Quality of the Graphite.

No material representative of the mineable portion of the deposit could be obtained, hence no information other than that quoted above with reference to samples can be given.

General Remarks.

Despite the absence of information giving a lead to the widths over which the sample values quoted above were obtained, the deposit can be considered a very good prospect. Available information shows that this deposit contains flake graphite in seams of unstated width in proportions varying from 12.10 per cent. up to 30.54 per cent. This latter value is admitted as having come from a picked sample, i.e., from a specimen.

The graphite ore from this locality could no doubt be successfully concentrated by oil-flotation processes, and if suitable markets can be obtained for the products then the deposit is well worth prospecting.

The author of the report quoted in Bulletin 74 considered the deposits of sedimentary origin, a view supported by the writer.

The development of the prospect should be entirely dependent on the market demand, since from available information insufficient is known about the quality and quantity of ore available from this resource to consider the erection of a treatment plant.

TALC AND SOAPSTONE DEPOSITS.

Mt. Monger—37.5 Miles S.E. of Kalgoorlie, W.A.
By H. A. Ellis, B.Sc., A.O.S.M.

Locality.

Mt. Monger is a gold-mining centre situated some 37 miles S.E. of Kalgoorlie by a good road. It is noted for the wide distribution there of serpentinous rocks and, for W.A., the unusual occurrences of gold in certain talc bearing types of this rock.

The Talc and Soapstone Occurrences.

Definitions:

Talc, in this report, is the name used for the pure or nearly pure hydrous magnesium silicate in all its forms of crystallinity, possessing the standard characteristic properties of this mineral.

Soapstone is the name used for the massive type of partially altered basic and ultrabasic rocks containing varying proportions of fine scaly or granular talc in intimate crystalline intergrowth with residual partially altered ferromagnesian minerals of the parent rock. It is essentially a hydrothermal alteration product of some basic or ultrabasic rock type, and at Mt. Monger, appears to be closely associated with serpentine.

General Distribution.

The distribution of the serpentinous rocks at Mt. Monger is shown in G.S.W.A. Bull. No. 90 on Plates I. and II.

In October, 1943, the writer made a general reconnaissance of the district with the object of determining the relation of the talc and soapstone occurrences to the serpentine rocks mapped by Clarke and described in G.S.W.A. Bull. No. 90, with the following results:—

- (1) What is known locally as the "Talc Belt" is confined to the south-western margin of the serpentine belt which extends in a general south-easterly direction towards Mt. Monger Trig. Station from a point approximately one mile west of Crendon's Homestead. (See Plate II., G.S.W.A. Bull. No. 90.)
- (2) The portion of this belt in which talc and soapstone are best developed is confined to that portion of it which has a sheared porphyry-serpentine contact on the south-western side, notably in the section which lies from 2½ miles to 4 miles S.E. of Crendon's Homestead, taking in "McCahon's Great Hope" and the old "Lass O'Gowrie" leases.

- (3) The best locality at present known for talc and soapstone occurrences of commercial grade is the "Loganberry" Lease, G.M.L. 5961E, pegged to include most of the ground in the original "Lass O'Gowrie" G.M.L. 4803.

The "Loganberry" Lease—G.M.L. 5961E.

This lease is situated about four miles along the track S.E. from Crendon's Homestead in the direction of Mt. Monger Trig. Station. This is the only lease on which commercial grades of soapstone are so far known to occur, and from which small quantities have been mined and sent to Perth.

The ground pegged in this lease takes in most of that previously covered in the old "Lass O'Gowrie" G.M.L. 4803 which was worked for gold in soapstone and serpentine matrix in the early stage of the development of the Mt. Monger field. The talc and soapstone occurrences form part of the actual auriferous shears in the serpentine, and have been mined as either footwall or hanging wall rocks in the normal course of mining, or more frequently as the actual matrix of the gold. In fact, many hundreds of tons of good grade foliated soapstone have no doubt been crushed as gold ore in the course of mining operations on this lease.

SOAPSTONE PRODUCTION TO OCTOBER 31st, 1943.

Quantity.	Nature of Product.	Prices.
19 tons	"Spalls," capable of cutting 12 in. x 12 in. x 6 in. blocks in Perth. (A massive tremolite-talc rock.)	£4 per ton on rail 7 miles west of lease.
3½ tons	"Spalls," capable of cutting 6 in. x 6 in. x 6 in. blocks in Perth. (A massive tremolite-talc rock.)	£2 10s. per ton on rails 7 miles west of lease.
11½ tons	"Spalls," as above, but of inferior quality	£1 17s. 6d. per ton on rails 7 miles west of lease.
54 tons	"Lump Talc"—suitable for grinding. (This is a foliated soapstone containing a high proportion of talc.)	£1 17s. 6d. per ton on rails 7 miles west of lease.
7 tons	"Lump Talc"—suitable for grinding. (This was a product containing more talc than the 54 ton consignments.)	£3 per ton on rails 7 miles west of lease.

Quality.

No details of the heat resisting properties of the massive soapstones are yet available, but the material from this lease is reported to be of a better quality than that from the Glen Lynn quarry near Bridgetown, the soapstone from which was in demand commercially. The "Loganberry" soapstone certainly has more talc and less unaltered original mineral in its composition than that from Glen Lynn judged by the appearance and feel of the raw material.

The "lump talc" (foliated-soapstone containing a large proportion of talc) grinds to a shade off white in colour and is suitable for all purposes for which French chalk is used. It will be noted that no pure talc suitable for toilet powders, etc., has yet been produced from this lease. (See description below for the occurrence of this mineral.)

The Deposits.

The deposits are not developed, having been worked of necessity in the search for gold. Most of the shafts were inaccessible at the time of inspection (October, 1943) through lack of ladders, but the general description which follows gives a picture of what is at present known concerning these deposits.

In the north-western portion of the lease and embracing the sheared porphyry-serpentine contact, a series of shafts up to 100 feet vertical depth, shallow costeans and trenches, arranged in no definite alignment, have been sunk either on gold shoots in the soapstone-serpentine or with the object of cutting them on the pitch-steep to the south on this field. The main trend of the auriferous

shears is N.-W. with dips of from 30 to 60 degrees to the south-west, though some dip east at the same angles. Occasionally this series of shears is cut by east-west shears dipping from 30° to 60° to the south in which the gold shoots pitch steeply to the west.

Soapstone of various grades, types of which have already been marketed, constitute the rock type containing the gold in many instances, and form the walls of the foliated soapstone shears.

The occurrences are lenticular in shape, pitch steeply to the south, and are invariably foliated on a small or large scale; the higher the proportion of talc in the soapstone the more intense the foliation. The degree of foliation has a distinct bearing on the commercial value of the soapstone when "block" soapstone is under consideration.

What is at present (October, 1943) known about the dimensions of the lenses may be summarised as follows:—

The coarse and medium grained talc-tremolite rock sold so far as potential blocks to cut 12in. x 12in. x 6in. and 6in. x 6in. x 6in., outcrop in one place only. It has been cut in workings from the surface to 100 feet vertical depth. The maximum width so far seen is about two feet and the longest exposure in a drive, 20 feet, with the soapstone still in the face. This class of soapstone usually forms the hanging wall or footwall of an auriferous soapstone shear containing higher grade foliated soapstone.

The material sold as "lump talc" has been encountered over the same vertical depth as the block soapstone varieties, and like the latter is in lenticular masses up to eight feet wide in places, pitching steeply to the south. The maximum length exposed in driving is 18 feet, with the foliated soapstone still in the face but obviously getting narrower. It is in this material that many of the gold shoots occur; in one instance associated with small concentrations of high grade honey coloured and pale green coloured scheelite as bunches and stringers in good quality foliated soapstone. Up to 60 lbs. of scheelite was obtained in one such patch recently (October, 1943).

Talc of high grade, grinding white, in both the scaly and foliated massive forms occurs mainly in the more intensely foliated parts of the higher grade "lump talc" lenses in workings down to 100 feet. It is present in minor amount only, as veins up to 1½ inches thick and irregular shaped masses weighing a few pounds only. No doubt it could be obtained in small but payable quantities by hand picking methods if the main occurrences of potential block soapstone and "lump talc" were being exploited.

Remarks.

Considerable quantities of talc-tremolite rock and high grade soapstone suitable for grinding are available from this lease.

As a potential source of soapstone suitable for the cutting of blocks say 12in. x 12in. x 6in., the deposits have limitations imposed by the relative narrowness of this type of material so far exposed (2ft.) and by the fact that the rocks are foliated to a greater or less extent, a physical defect prominently revealed under heat tests.

Several grades of soapstone consisting of obviously different proportions of talc and tremolite are available, and may prove to be of commercial value when ground.

An added attraction to any development work done on this lease with a view to the production of the various grades of soapstone available, is the fact that the talc and soapstone occurrences are intimately associated with gold and scheelite occurrences, and consequently that work done in developing the talc is automatically systematic prospecting for gold and scheelite.

THE MUNGLINUP GRAPHITE DEPOSITS.

P.A. 802H. Munglinup River, Eucla Division, W.A.
Approx. Lat. 33° 40' S., Approx. Long. 120° 51' E.

By H. A. Ellis, B.Sc., A.O.S.M.

Locality.

These deposits are situated about ¼ of a mile east from the eastern bank of the Munglinup River at a point approximately four miles north (upstream) from the Kavensthorpe-Esperance road crossing of the Munglinup River in approximate Lat. 33° 40' S., and approximate Long. 120° 51' E. The distance to the port of Esperance is approximately 72 miles by a moderately good sand-plain road, and the distance to the nearest practicable small vessel loading point—the mouth and estuary of the Oldfield River, is about 16 miles air line. There is no constructed road to this latter point. The deposits were inspected in December, 1943.

Geology.

The graphite deposits form portion of a zone of graphite schist which appears to be part of a series of metamorphic rocks consisting now largely of granular hornblende gneiss and garnetiferous hornblende gneiss, with a regional strike of N.-E. and S.-W. and a prevailing dip of about 40° to 45° to the S.E. Field evidence favours the conception that the rocks were all of original sedimentary origin, and that the graphite-bearing seams consist of overlapping lenses of original carbonaceous sediments now altered to graphitic schists of varying degree of graphite content.

The rocks are nearly everywhere highly weathered, with the zone of weathering extending to a vertical depth of at least 50 feet as exposed in the deepest accessible workings.

Evidence exists in the rocks of the surrounding country, notably at the Young River, that these gneisses have been intruded by basic igneous rocks, and that both the gneisses and basic igneous rocks have been intruded by granite and pegmatite dykes.

The gneissic series has not been correlated by field work with any of the known goldfields series, and is presumed in this report to be of Pre-Cambrian age.

The Graphite Deposits.

The graphitic schist zone outcrops in places on undulating scrub-covered country, and is characterised by grey soil with graphitic flakes, magnesite boulders (possibly derived from an original dolomitic content in the altered sediments), and occasional outcrops of graphite-bearing rock of a grey colour. The graphite-bearing zone is bounded by granular hornblende gneiss and garnetiferous gneiss, and also carries thin bands or lenses of these rocks within its borders.

On P.A. 802H the zone was traced in a north-easterly direction for 1200 feet from the most south-westerly outcrops, its extension to the south-west being obscured by flat, soil and scrub-covered country. No doubt the zone continues below this obscuring mantle.

The average outcrop width of the zone over 1200 feet is 109 feet, giving an average true width of 70 feet, allowing for an average dip of 40° to the south-east. Four hundred feet north-east from the most southerly workings the zone has an outcrop width of 300 feet, with a true width of 210 feet, and contains at least four defined graphite concentrations in the nature of seams dipping concordantly with the country rock. These seams are respectively 10 feet, 10 feet, 4½ feet, (bottom not exposed) and 12 feet true width, and contain up to 25 per cent. of flake graphite. (The minus 200 mesh graphite from these seams is in a flake form.)

Three hundred feet south from the above series a graphitic seam seven feet true width, of high graphite content, and continuous with one of the higher of the seams in the zone, has been opened up near its outcrop, and also at a vertical depth of 50 feet in a cross cut driven from a vertical shaft sunk at a distance of 103 feet in the direction of the dip.

The seams are exposed in two separate places at a depth of 50 feet, and the graphite content of the ore-bodies has continued to be consistent with that seen in outcrop portions of the seams.

The potentialities of the zone have not been nearly fully explored yet, particularly with respect to the central portion.

Ore Reserves.

Approximately 27,000 tons of graphite ore could be obtained from an inclined depth of 100 feet down the dip from the seams already sufficiently exposed to warrant a provisional estimate being made, not taking into account the continuation of the ore-bodies to the north-east and south-west beyond the present limits of exploration.

Quality of Ore.

Representative samples of the graphite ore collected during the investigation have not yet undergone treatment, but results of investigations carried out by the Kalgoorlie School of Mines on material collected from the same sample cuts at an earlier date, though not yet in a finalised condition, show that material from the upper seams contains from 23 to 25 per cent. by weight of marketable graphite products distributed by grades as follows:—

Mesh.	Percentage by weight of original ore.	Carbon Content.
+ 80	3-4%	99-6%
— 80 + 200	8%	97%
— 200	12-13%	82%

It is difficult to detect any material difference in the appearance of the ore in the various seams as regards graphite content, and as far as the eye can perceive the majority of the ore exposed and included in the ore-reserve estimate will be found to be of the same high standard as that shown above.

Water and Mining Timber.

Some brackish springs situated about $\frac{1}{4}$ mile west of the deposits show promise of being able to supply the water necessary for a treatment plant. As yet they are untested as to quality and capacity, but prospects of obtaining useful supplies on development are good, providing the mineral content of the water does not interfere with the properties of the graphite flake after using it in a flotation plant.

Ample mining timber (Yate) is available from a spot about one mile from the deposits.

General Remarks.

The deposits are sufficiently developed to enable the production of graphite ore to be commenced immediately if required. Sufficient experimental work has been done on the ore at the Kalgoorlie School of Mines to enable a flow-sheet to be designed for the successful treatment of the ore, mining conditions are good—a thick, moderately soft ore body suitably disposed for cheap mining—and a high quality graphite is obtainable as a final product. All that is required now is a suitable market for the various grades of graphite which this deposit is capable of supplying, but judging by the fact that this deposit—possessing as it does such strong potentialities as a producer of high grade graphite—is still undeveloped, one is forced to the conclusion that West Australian graphite has not been required up to the present juncture.

RECENT DEVELOPMENTS ON A COLUMBITE AND CASSITERITE LODE M.C. 9, GREENBUSHES, W.A.

By H. A. Ellis, B.Sc., A.O.S.M.

Locality.

M.C. 9 is situated on the eastern side of Bunbury Gully, approximately one mile S.E. of Greenbushes Post Office, along the Greenbushes-Bridgetown road.

History.

At a distance of 270 feet on a true bearing of 50° from the north-eastern corner of W.R. 289, several shallow shafts had been sunk many years ago in decomposed pegmatitic lode material carrying cassiterite and columbite. In October, 1943, owing to the existing strong demand for tantalum-bearing minerals, some attention was given to this area, and the work described below was commenced. An inspection of the area was made on November 20th, 1943.

The Columbite and Cassiterite Lode.

Approximately 25ft. S.W. from the old excavations made in part of the pisolitic laterite capping of the lode formation many years ago, a vertical shaft 35 feet deep has been sunk in typical schistose pegmatite lode formation striking N. 25° W. and dipping S.W. at about 40°. With the exception of the first seven feet which consisted of pisolitic laterite, the shaft is entirely in lode formation, and no definite footwall was exposed in the bottom of the shaft at the time of inspection.

The lode has been driven on for 15 feet to the S.E., and 11 feet to the N.W. from the bottom of the shaft, and at a distance of 27 feet N.W. from the 35ft. shaft another vertical shaft was being sunk and was down 23 feet at the time of inspection (November 20th, 1943). The lode material is typical crumbly, free treating ore common in the shallow workings of all of the weathered pegmatitic lode formations of the Greenbushes field. Exactly similar material was hydraulically sluiced in the Vulcan Cut in Westralian Gully and consisted of quartz, mica, feldspar, tourmaline, and irregular concentrations of finely disseminated cassiterite and tantalite or columbite intimately mixed with the pegmatite constituents. The lode formation is strongly schistose, with several prominent bands of mineral-bearing schistose pegmatite.

Values are distributed in varying proportion throughout the depth of the shaft, and the present workings have been made in material averaging approximately 1.7 lbs. of clean mixed concentrates to the cubic yard. The concentrates from samples taken over regular intervals during the sinking of the shaft contained from 25 per cent. to 40 per cent. by weight of columbite and from 40 per cent. to 55 per cent. by weight of cassiterite. The columbite present in the samples contained approximately 49 per cent. of Ta_2O_5 and 34 per cent. of Nb_2O_5 as determined by specific gravity assays.

The true width of the lode material penetrated by the 35ft. shaft is about 27 feet, and until a bulk parcel of this type of lode matter has been treated, no satisfactory value per cubic yard can be arrived at.

Remarks.

The lode formation at present exposed (November 20th, 1943) can be considered an excellent prospect containing mixed cassiterite and columbite in payable quantities. Only a very small portion of lode has been prospected, and obviously much more prospecting work is necessary before any idea of the extent and value of the lode can be arrived at.

The width of the lode in one place can be determined by cross-cutting from the bottom of the present 35ft. shaft after doing sufficient driving to stow the material from the cross cut.

The continuation of the lode on the surface can be sought along the strike in a series of costeans.

Until this prospecting work is done no consideration need be given to the erection of a plant designed to treat large quantities of this lode material.

LITHIUM BEARING MINERALS IN THE COOLGARDIE-LONDONDERRY DISTRICTS, W.A.

(Coolgardie Lat. 31°00' S. approx, Long. 121°12' E. approx.)

By H. A. Ellis, B.Sc. A.O.S.M.

Summary.

An investigation of the field occurrence of lithium-bearing minerals known to occur in the Coolgardie-Londonderry district was undertaken by the writer in October, 1943.

The minerals and localities investigated were as follows:—

Mineral.	Locality.
Lepidolite mica	Grosmont
Petalite	Tantalite Hill
Amblygonite }	Londonderry
Spodumene }	Mercer's Find

Enquiries made amongst local mining people and old prospectors failed to discover any other localities where these minerals were known to occur in the district.

The occurrences of amblygonite and spodumene were found to be of mineralogical interest only, and lepidolite mica exists in quantities too small to permit of commercial exploitation.

Petalite, a lithium aluminium silicate containing when pure, practically the same amount of Li_2O as

lepidolite mica, was found to occur in considerable quantity in the main felspar quarry, Londonderry.

The conclusion is reached that the petalite from this source is the only lithium-bearing mineral in the district examined offering prospects as a commercial source of lithia salts.

SUMMARY OF APPROXIMATE QUANTITIES AND QUALITIES OF LITHIUM-BEARING ORES—
COOLGARDIE-LONDONDERRY DISTRICTS—W.A.

Mineral and Nature of Ore.	Locality.	Ore at Grass (approx. only).	Ore in Sight (approx. only).	Possible Ore (approx. only).	Weight of lithia bearing mineral in ore (approx. only).	Li_2O content (approx. only).	Total.
<i>Lepidolite mica</i> in pegmatite dyke	Grosmont	tons. 3,600	tons. nil	tons. 34,200	tons. 197 nil 1,862	tons. 12 nil 111	123
<i>Lepidolite mica</i> lenses massive, scaly in pegmatite dyke, capable of being selectively mined	Tantalite Hill, Londonderry	nil	nil	450	450	17	17
<i>Petalite</i> masses in pegmatite, capable of being selectively mined	Felspar Quarry, Londonderry	1,040	1,000	37,400	1,040 1,000 37,400	41.6 40.0 1,496.0	1577.6
<i>Amblygonite</i> lenses in pegmatite dyke	Mercer's Find, 3 miles N., 30° W., from Ubini	2 cwt.	nil	nil	2 cwt.	not assessed	
<i>Spodumene</i> crystals in pegmatite dyke	Mercer's Find, 3 miles N., 30° W., from Ubini	nil	nil	nil	nil	nil	

LEPIDOLITE MICA.

Locality—Grosmont.

Grosmont is an abandoned gold-mining locality situated 10 miles by road S.W. of Coolgardie. On some flat ground about 12 chains N. 30° W. from the old open cut gold workings on the N.W. slope of Grosmont Hill—on the crest of which is an old battery site—M.C. 3 has been pegged to take in several pegmatite dyke outcrops on which work was carried out many years ago.

About five chains slightly west of north from the S.W. corner of M.C. 3 lies the southern end of an open cut made in a pegmatite dyke in the early days of mining in this locality. The cut is at present some 210 feet long by 15 feet wide by 12 feet deep, the sides having collapsed to a considerable extent, particularly on the western wall, the debris filling the bottom of the cut.

As far as can be ascertained from the present collapsed state of the workings, the pegmatite dyke is concordantly intrusive into medium to fine grained amphibolite schist, was about 12 feet thick, striking N. 15° W., dipping from 80° to 85° to the west, and was mined to a vertical depth of perhaps 20 feet.

Pegmatite shows in the north face of the cut, but the outcrop disappears under an alluvial flat. It does not outcrop on higher ground some six chains along the strike to the north. The south face of the cut is in decomposed amphibolite schist and shows the south end of the dyke dipping at a steep angle to the south into the schists.

The dyke is composed mainly of microcline felspar and quartz with lepidolite mica as a minor constituent.

A rough estimate of the percentage by volume of the main constituents is:—

Felspar	..	..	..	50%
Quartz	..	..	..	45%
Lepidolite mica	..	..	..	5%

Biotite mica, beryl and topaz occur as accessory minerals, not in commercial quantities, and the felspar and quartz are not present in large masses. Felspar could be saved, no doubt, in any flotation process designed to treat the pegmatite dyke as a lithium ore.

The lepidolite mica is not confined to any particular part of the dyke and occurs in the following forms:—

- (a) Books; largest seen approximately 5in x 2in.—pale violet in colour—books down to ¼in. square nearly all pierced by quartz crystals.
- (b) Scaly-granular; as violet coloured masses of small dimensions—up to 3 lb. weight—found in dumps.
- (c) Grey-massive; as small concentrations—½ lb. weight—found in dumps.
- (d) Violet-massive; similar to grey-massive and as stringers through quartz and felspar up to 1½in. thick.
- (e) Foliated-crenulated-violet; scales up to ¾in. diameter—found in dumps.
- (f) Scaly-violet; up to ¼in. scales; gelatinous looking in columns—in irregular shaped concentrations—found in dumps.

A green felspar occurs in small concentrations, noticeably near topaz occurrences; while fine, compact, crystalline, unimineral concentrations of grey tourmaline occur between the contact of the pegmatite and amphibolite schist and occasionally as veins up to two inches thick in the country rock, particularly at the southern end of the dyke.

Estimates of Tonnage and Quality.

The following items are of importance in assessing the value of these estimates:—

- (1) Exact width of dyke and depth to which mined not ascertainable—estimate of width and depth mined is probably too generous.
- (2) Estimate of percentage by volume of lepidolite in the dyke is generous in absence of exact measurements.
- (3) Assumption is made that dyke maintains its outcrop dimensions and mineral content to a depth equal to the length of the outcrop.

Factors Used.

- (1) S.G. of Lepidolite taken as 2.8.
- (2) Based on estimated percentage by volume of constituents of peg. dyke, namely, felspar 50 per cent., quartz 45 per cent., lepidolite mica 5 per cent., 14 cubic feet of peg. dyke weigh 2,240 lb.

Volume of tonnage conversion factor = 14.

Ore at Grass.

The tonnage of broken pegmatite in the dumps containing an estimated volume of five per cent. of lepidolite is determined as follows:—

$$\begin{aligned}\text{Volume of cut} &= 210 \times 12 \times 20 \text{ cubic feet.} \\ &= 550,400 \text{ cubic feet.} \\ \text{Tonnage} &= \frac{550,400}{14} \text{ tons.} \\ &= 3,600 \text{ tons.}\end{aligned}$$

Weight of Lepidolite Mica in Ore at Grass (Dump).

$$\begin{aligned}\text{Volume of lepidolite mica in dumps} &= \frac{5}{100} \times \frac{550,400}{1} \text{ cubic feet.} \\ &= 2,520 \text{ cubic feet.}\end{aligned}$$

Weight of Lepidolite Mica in dumps.

$$\begin{aligned}&= 2,520 \times 62.5 \times 2.8 \text{ lb.} \\ &= 197 \text{ tons.}\end{aligned}$$

Tonnage of lepidolite mica per vertical foot

$$\begin{aligned}&= \frac{197}{20} = 9.8 \text{ tons.}\end{aligned}$$

Possible Ore.

Length of known outcrop = 210 feet. Assuming the pegmatite dyke maintains its dimensions and mineral content to a depth equal to the known outcrop length, then the possible ore below the bottom of the open cut is—

$$\begin{aligned}190 \times 12 \times 210 \text{ tons—containing 5 per cent. by} \\ \text{volume of lepidolite mica.} \\ &= \frac{190 \times 12 \times 210}{14} \text{ tons.} \\ &= 34,200 \text{ tons.}\end{aligned}$$

Weight of Lepidolite Mica in Possible Ore.

$$\begin{aligned}&= 190 \times 9.8 \text{ tons} = \text{depth} \times \text{tonnage per vertical foot.} \\ &= 1,862 \text{ tons.}\end{aligned}$$

Resume of Tonnages.

From the above figures it will be seen that approximately 3,600 tons of lepidolite bearing pegmatite (Lithium ore) has already been mined and is lying in the dumps on M.C. 3 Grosmont. This ore is estimated to contain 197 tons of lepidolite mica.

Possible ore to a depth of 210 feet is 34,200 tons of lepidolite bearing pegmatite carrying 1,862 tons of lepidolite mica.

Proved + Possible Lepidolite Mica = 2,059 tons.

Quality.—A bulk sample from the dumps was collected, but at this stage of the investigation has not been submitted for analysis.

A sample of lepidolite mica from this dyke was analysed by the Government Chemical Laboratory many years ago, the results appearing at p. 19, G.S.W.A. Bull. No. 53. The Li_2O content in the sample analysed was 5.97 per cent.

Total tonnage of proved plus possible lepidolite mica available from the pegmatite dyke would contain—

$$\begin{aligned}&5.97\% \text{ of } 2,059 \text{ tons of } \text{Li}_2\text{O} \\ &= 122.9 \text{ tons}\end{aligned}$$

assuming that all of the lepidolite mica was of the same grade as the sample analysed and reported on in Bull. 53.

Other Pegmatite Occurrences at Grosmont.

About three chains east from the southern end of the main open-cut on M.C. 3, a series of pot holes has been sunk on a pegmatite dyke located from floaters over a length of about three chains along the N.-S. strike. At

the northern end, a 20ft. shaft has been sunk in the decomposed amphibolite schist on the footwall of the dyke which here dips 80° to the west, and is about eight feet thick. This dyke contains all of the lepidolite mica types seen in the dumps of the main open-cut, but in a very much smaller proportion.

The dyke may be worth prospecting for higher concentrations of lepidolite mica if the deposit in the main cut was being developed as a source of lepidolite mica.

About five chains S.W. from the south end of the main cut on M.C. 3, a quartz reef containing a concentration of felspar outcrops, and has been opened up to a depth of three feet. Lepidolite mica shows in the dump, but the occurrence is small and of no economic importance.

Locality: Tantalite Hill.

Tantalite Hill is in the Londonderry district where an unsuccessful attempt was made to treat eluvial and pegmatitic material for its columbite and tantalite content. It is situated three miles S.W. (air line) from Londonderry railway siding.

Some small lenses of massive scaly lepidolite mica in a pegmatite dyke were located near the S.E. corner of M.L. 86. These have already been reported on by Dr. Miles of the Geological Survey (File G.S. 28/1943).

A generous estimate of the tonnage available from this deposit is 450 tons of massive scaly lepidolite containing 3.87 per cent. of Li_2O . The writer made an extensive search of the Tantalite Hills area in an endeavour to locate further lepidolite occurrences of value, but without success.

Remarks.

It cannot be too strongly stressed that pegmatite dykes are notorious for their irregular behaviour with respect to both mineral content and dimensions. Consequently, any estimates of tonnage of ore available from a pegmatite dyke, made under the circumstances as outlined above in this report, need to be confirmed by a prospecting campaign before placing any firm value on the deposit.

A successful treatment process for the extraction of the lepidolite mica from the pegmatite dyke is also a factor to be considered in valuing these deposits.

PETALITE.

Locality: Felspar Quarry, Londonderry.

This quarry is situated 4.4 miles by road S.W. from Londonderry Railway Siding, the latter being 10 miles S.S.W. from Coolgardie and 366 miles by rail from Perth. It is 13 miles by a good road from Coolgardie to the quarry.

The quarry has been developed as a source of microcline felspar and has been opened up to a maximum depth of about 70 feet on the western side, and to an average depth of about 50 feet over an area roughly oval in shape about 400 feet long by 270 feet wide (October, 1943).

Approximately 100,000 tons of pegmatite dyke material have been excavated for a return of 23,500 tons of felspar up to August 31st, 1943.

Approximately 80,000 tons of waste products comprising mostly impure felspar, quartz, petalite and its decomposition products have been removed to the dump.

Petalite occurs in masses in the quarry capable of being selectively mined, in large scale pegmatite formation along with microcline felspar and quartz. Some of the petalite masses exposed in the quarry (October, 1943) would contain up to 15 tons of unaltered petalite, and others, whose full dimensions cannot be judged, contain considerably more.

The main concentration of petalite occurs in the western part of the quarry, but it has occurred to a greater or less extent throughout the workings with the exception of the present (October, 1943) north face of the quarry.

Estimates of Tonnage and Quality.

Approximate composition of pegmatite by volume:—

Felspar (all types)	.. ..	Approx. 35%
Petalite + alteration products likely to contain lithium	.. ..	25%
"Hornstone," an albite-chalcedony rock probably completely replacing petalite	.. ..	15%
Quartz	.. ..	25%

Volume to tonnage conversion factor = 15 approx.

Ore at Grass.—Dumped separately (Oct. 1943) approx. 40 tons.

Clean petalite distributed through 80,000 tons of main dump (5% of Vol. of petalite + alteration products). Possibly 1,000 tons.

Ore in sight.—Clean petalite in sight in the quarry (October, 1943). Possibly 1,000 tons.

Possible Ore.

An area of approximately 200 feet by 140 feet on the western side of the quarry where petalite is prominently exposed at present (October, 1943) and using a very conservative figure of 10 per cent. by volume of clean petalite, may give 187 tons of petalite per vertical foot.

Possible ore to a depth of 200 feet below present level of quarry on western side, presuming the volume of petalite to remain constant = 37,400 tons.

Quality.

A bulk sample of clean petalite has been obtained and submitted to the Government Chemical Laboratory for analysis.

Bulk samples of large exposures of the altered petalite have also been submitted. Results of these analyses will not be available for some time yet.

In the absence of results of representative samples, the analyses of the above two types of material given by Dr. Simpson in his description of the petalite occurrence at this quarry in *The Journal of the Royal Society of W.A.* Vol. XXIV (1937-38) at page 120 may be taken as a guide to the possible economic value of the products as Lithium ores.

The unaltered petalite quoted in this report contains from 3.72% to 4.13% of Li_2O , while the alteration products contain from nil to a maximum of 1.11% of Li_2O .

On account of the low Li_2O content of the altered petalite, estimates of the quantities of this material available in the quarry have not been submitted. The average Li_2O content of the clean petalite available from this quarry may be in the vicinity of 4%.*

Li_2O content of ore at grass (Oct. 1943):

+Ore in sight (Oct. 1943):
= 4% of 2,040 tons = 81 tons.

Li_2O content of

Possible ore:
= 4% of 37,400 tons = 1,496 tons.

Remarks.

The same observations concerning dimensions and mineral occurrences in pegmatite dykes as were made in connection with the Grosmont Lepidolite deposits apply here.

* A chip sample of 30 tons at grass analysed by the Government Chemical Laboratory contained 4.2% Li_2O .

AMBLYGONITE.

Locality—Mercer's Find.

The locality referred to as Mercer's Find at which amblygonite is reported to have occurred in a pegmatite dyke is situated three miles N 30° W. (air line) from Ubini Siding, on the Perth-Kalgoorlie railway. A track leaves the main telegraph line about five chains S.W. from the 12 mile soak (on the telegraph line about 2½ miles due north of Ubini Siding) and proceeds in a general westerly direction for two miles to the old workings.

The amblygonite occurred under circumstances as described by Blatchford at pp. 17-18, G.S.W.A., Bull. 53. The workings have now all collapsed, but a dump of about 2 cwt. of broken amblygonite was found nearby. The composite quartz reef and pegmatite concentrations were carefully examined over the length of the outcrop without locating any further occurrences of amblygonite.

This occurrence has no economic value.

SPODUMENE.

Locality—Mercer's Find.

The reported occurrence of spodumene is of mineralogical interest only—careful search along the outcrop of the composite quartz reef and pegmatite concentrations revealing no trace of this mineral.

NOTES ON THE FELSPAR QUARRY, LONDONDERRY.

By H. A. Ellis, B.Sc., A.O.S.M.

Inspected October, 1943, by H. A. Ellis in connection with lithium-bearing minerals, Coolgardie Londonderry District. A few points of geological interest came to the writer's notice during this inspection and are set out below:—

From the present state of the workings it would appear that the pegmatite dyke trends in a direction of N. 70° E. approximately, and that the width so far exposed, say at the western edge of the present workings, is in the vicinity of 450 feet.

The northern boundary of the dyke is clearly exposed in the existing northern face of the quarry where it can be seen dipping to the north at an angle of approximately 30° under the fine and medium grained greenstone of the rising country to the north. The limits of the dyke could not be determined in any other direction. An estimate of the approximate composition of the dyke by volume is as follows:—

Quartz	....	Approximately	25%
Felspar	....	"	35%
Petalite plus decomposed products	..	"	25%
"Hornstone" (albite, chalcedony replacement of petalite)	....	"	15%

Biotite mica, garnet, lepidolite mica, beryl, apatite, columbite occur as very minor accessory minerals.

A sketch plan showing the dimensions of the quarry as at October, 1943, is attached (file 64/18).

Production Figures to the end of August, 1943.

Clear microcline felspar	....	23,500 tons
Mullock	....	80,000 tons

Summary of Felspar Production from September, 1936, to 31st August, 1943.

Tonnage felspar produced	....	23,500 tons
Mullock	....	80,000 tons

Yearly Output of Felspar.

1936—2,187 tons	1940—3,478 tons
1937—2,630 "	1941—4,114 "
1938—3,028 "	1942—3,399 "
1939—3,271 "	1943—1,293 " To 31st August.

Average Tonnage Felspar Produced Monthly.

1936—182 tons	1940—290 tons
1937—220 "	1941—340 "
1938—255 "	1942—280 "
1939—273 "	1943—108 " To 31st August.

Output of Mullock—September, 1936, to August, 1943.

1936—6,000 tons	1940—17,000 tons
1937—10,000 ..	1941—12,750 ..
1938—12,000 ..	1942—4,014 ..
1939—14,000 ..	1943—3,828 ..

Average Tonnage Mullock taken out Monthly.

1936—500 tons	1940—1,400 tons
1937—830 tons	1941—1,000 ..
1938—1,000 ..	1942—350 ..
1939—1,160 ..	1943—320 ..

Average Number of Men Employed.

1936—8	1940—13
1937—8	1941—14
1938—10	1942—6
1939—15	1943—5

Beryl.

Approximately five tons of beryl had been obtained to date. (See Beryl file.)

Masses of Felspar.

The manager of the quarry informed the writer that one mass of felspar occurring near the eastern end of the present quarry outline contained 1,500 tons of felspar practically free of any impurities. At the present time clear microcline felspar is being mined from the eastern and western parts of the quarry at the rate of approximately 63 tons per week—manpower shortage considerably hampering rate of production.

Future Prospects.

The dyke would appear to have excellent prospects in depth, and in a direction of N. 70° E., towards the smaller albite felspar quarry.

The northern face of the quarry, which shows a capping of greenstone, shows to a marked degree a strong "reaction border" of some 40 feet in thickness, as a result of assimilation of the invaded greenstone.

NOTES ON ORA BANDA AMALGAMATED MINES, N.L., G.M.Ls. 1962W, 1966W, 1967W, 1970W, 2111W, 2119W, 2120W, GRANT'S PATCH, BROAD ARROW GOLDFIELD.

By R. A. Hobson, B.Sc., Hons.

SUMMARY.

The workings controlled by Ora Banda Amalgamated Mines, N.L., are located at Grant's Patch, which is 27 miles north-west of Kalgoorlie. The Company commenced operations in 1936 and, since that date to October, 1943, has produced 52,553.88 fine ounces of gold. The total recorded production from the ground held by the Company is 65,359.95 fine ounces of gold. The workings are divided into two sections and there are two main haulage shafts, 15 chains apart. Ore is carted approximately a quarter mile to the mill.

All ore bodies have formed in narrow shear zones. The country rock is a porphyrite—known locally as "cat" rock, which in the vicinity of the shear zones is quite schistose.

In the workings off Nicholson's No. 1 Main Shaft the ore bodies have formed in shear zones, having the following general strikes: 62°–77°, 87°–90°, 96°–98°, 111°–128°. The principal ore body, which has been worked from the surface to No. 6 level, has a maximum stope length above No. 6 level of 320 feet and an average width of 4–5 feet. Its dip is vertical. Except at the west ends of Nos. 5 and 6 levels, where it has a general strike of from 96°–98°, it has formed in a shear zone striking at 111°–128° and dipping vertically. In the upper levels there has been appreciable production from ore bodies formed in other shear zones.

Only one winze has been sunk below No. 6 level and it is reported that the ore body did not extend below 30 feet in this winze. The winze was full of water at the time of inspection. The reported average values in this winze are 15 dwts. over 36in. There is no geological reason for not testing the ore body by other winzes below No. 6 level.

Water is pumped from the workings off Nicholson's No. 1 Main Shaft at the rate of 32,000 gallons per day.

The principal ore body in the workings off Mackenzie's No. 1 Main Shaft has been worked from the surface to No. 7 level (V.D. 710ft.) and has been practically completely stoped above No. 6 level. It has a maximum stope length of 520 feet above No. 4 level and an average width of 4–5 feet. The ore body has formed in a number of intersecting shear zones, which have the following general strikes: 68°–74°, 85°–90°, 97°–100°, 104°–118°. It will be noticed that these strikes correspond with the strikes of the shear zones in the workings off Nicholson's No. 1 Main Shaft, but it will be seen from Figures 1 and 2 that the dips do not correspond. The pitch of the ore body is vertical and is controlled by the pitch of the intersections of the shears.

The values at No. 7 level—average 5 dwts. over 48 inches—are reported to be lower than can be profitably worked by the company and it is reported that the values have been decreasing with increasing depth in these workings. No geological reason is apparent why the ore body should not be tested below No. 7 level.

These workings are practically dry and about one hour's pumping each morning is all that is necessary.

It is evident that development has lagged behind and very little ore is immediately available for breaking.

INTRODUCTION.

Grant's Patch is located 27 miles north-west of Kalgoorlie. It is connected by formed road to Broad Arrow (14 miles) and to Ora Banda (eight miles) and by telephone to Coolgardie. From production figures it appears that the first find at Grant's Patch was made in 1932.

Ora Banda Amalgamated Mines, N.L., commenced operations in 1936. Prior to 1936 a certain amount of work had been done on the same ground by Ora Banda Mines, N.L. (G.M.Ls. 1962W, 1970W) and also by prospectors (G.M.Ls. 1966W, 1967W and Prospecting Areas). In 1936 the workings were inspected by Forman¹. Since Forman's inspection an appreciable amount of work has been done. Nicholson's No. 1 Main Shaft has been deepened from 370 feet to 582 feet. Numbers 3 and 4 levels off this shaft have been extended and numbers 5 and 6 levels have been driven. Almost all the known ore above these levels has been stoped. A new shaft—Mackenzie's No. 1 Main Shaft—has been sunk 730 feet. Numbers 2 and 3 levels off this shaft have been extended, and numbers 4, 5, 6 and 7 levels have been driven. Practically all the known ore above number 6 level has been stoped.

The object of the present examination was to ascertain the existing conditions at these workings and more especially at the lower levels. No samples were taken by the writer, who had no assistant and no facilities for sampling. All information regarding values was supplied by the mine manager.

The total recorded production from the ground now held by Ora Banda Amalgamated Mines is given in Table I. It will be seen from this table that of a total of 65,359.95 fine ounces of gold produced from 1932 to 1943 (October), 52,553.88 fine ounces were produced by Ora Banda Amalgamated Mines N.L. since 1936. The only production not included in this table, which is taken from Mines Department official figures, is that from Prospecting Areas in existence prior to the now existing leases. The table shows that the maximum production of gold was in 1938, when 8,699.86 fine ounces of gold were produced from 18,730 tons of ore milled. The maximum tonnage of ore milled was in 1941 when 24,065 tons of ore were milled for 6,649 fine ounces of gold. The table also shows that the average grade of the ore milled by the existing company has decreased each year.

The mill is situated approximately ¼ mile west of Nicholson's No. 1 Main Shaft, which is about 15 chains west of Mackenzie's No. 1 Main Shaft. From these two main haulage shafts ore is carted to the mill by motor truck. The mill was so placed to avoid any possible contamination of a Government dam situated some two

¹ Forman, F. G., The Ora Banda Amalgamated Gold Mine, Grant's Patch, Broad Arrow Goldfield, *Ann. Prog. Rept. Geol. Survey for 1936*, p. 5.

TABLE 1.

Production from G.M.Ls. 1962w, 1966w, 1970w, 1967w, 2111w, 2112w, 2119w, 2120w, for the Period 1932 to 1943 (Oct.)

Registered Name of Company or Lease.	Lease Number.	Period.	Alluvial.	Dollied and Specimens.	Ore Treated.	Gold Therefrom.	Total Gold.	Grade dwts. per Ton.	Silver.
			fine ozs.	fine ozs.	Tons (2,240 lbs.)	fine ozs.	fine ozs.	Tons (2,240 lbs.)	fine ozs.
Lady Rosina	1962w ...	1932	...	...	155.0	214.96	214.96	27.7	...
		1933	...	...	602.0	1,555.72	1,555.72	51.7	...
Carnbe	1966w ...	1933	...	...	422.0	456.84	456.84	21.6	...
Lady Rosina Extended...	1970w ...	1933	...	...	121.5	234.69	234.69	38.6	...
Mackenzie's Find ...	1967w ...	1933	...	...	337.0	354.90	354.90	21.1	...
		1934	...	...	289.0	116.72	116.72	8.1	...
Ora Banda Mines, N.L. ...	1962w, 1970w	1934	...	...	219.0	423.32	423.32	38.7	...
		1935	...	...	8,278.0	5,050.38	5,050.38	12.2	...
		1936	...	...	2,001.0	1,132.54	1,132.54	11.3	...
Ora Banda Amalgamated Mines, N.L.	1962w, 1970w 1966w, 1967w 2111w, 2112w 2119w, 2120w	1936	...	...	13,193.0	7,284.42	7,284.42	11.0	...
		1937	...	...	16,495.0	8,308.73	8,308.73	10.1	...
		1938	...	...	18,730.0	8,699.86	8,699.86	9.3	175.00
		1939	...	...	18,955.0	8,019.87	8,019.87	8.5	...
		1940	...	...	23,775.0	8,330.00	8,330.00	7.0	...
		1941	...	...	24,065.0	6,649.00	6,649.00	5.5	...
		1942	...	...	20,745.0	5,262.00	5,262.00	5.1	...
		1943 (to Oct.)	...	...	13,150.0	3,266.00	3,266.00	5.0	...
			...	...	161,532.5	65,359.95	65,359.95	8.1	175.00

miles south-south-west of the workings. At the mill the ore is first of all put through a cracker and then through a ten-head battery. From the battery it goes through a classifier, then a ball mill to a cyanide plant. Some of the gold is recovered at the battery by means of cloths and the remainder by zinc boxes. The residues are estimated to contain just over 1 dwt. gold per ton.

The writer wishes to thank the mine manager, Mr. Kingdon, for assistance and information given during the course of his examination and also the underground manager, Mr. Kittelty, for information regarding the workings, especially those off Mackenzie's No. 1 Main Shaft.

GENERAL DESCRIPTION OF THE WORKINGS AND ORE BODIES.

As can be seen from the plan,* the workings are divided into two sections and there are two main haulage shafts—Nicholson's No. 1 Main Shaft and Mackenzie's No. 1 Main Shaft. In addition to the main workings, some shallow prospecting work, off other shafts, has been done, but this prospecting work was inaccessible to the writer. Some of these shallow workings were inspected by Forman in 1936². All ore bodies consist of lenticular quartz veins and stringers in narrow shear zones. Quite a number of shear zones are developed having varying strikes and dips and more will be said of these in a later section of this report. The ore bodies are not confined to any one set of shears. Although the two main shafts are only 15 chains apart and the country rock is the same throughout all the workings, there are quite striking differences between the workings off each of these shafts. It will be convenient to describe the workings off each shaft separately.

Nicholson's No. 1 Main Shaft Workings.

Two main ore bodies—designated by Forman as the East Lode and the West Lode—have been worked.

The East Lode has been worked from the surface to No. 6 level (V.D. 557 feet). From the surface to No. 5 level its general dip is vertical, but between 5 and 6 levels it has a general northerly dip of about 70°-75°. To No. 4 level the ore body is developed in a shear zone, or zones having a vertical dip and a strike varying from 111°-128°. In the Nos. 5 and 6 levels the eastern

portion of the ore body is developed in the same shear zone, but the western portion is developed in a shear zone having a general strike of from 96°-99° and a northerly dip. The shoot has a maximum stope length of 320 feet above No. 6 level and is reported to have been stoped over an average width of from four to five feet. The pitch is westwards at an average angle of approximately 55°.

At the time of inspection ore was being broken from above No. 5 level (60W-100W) and it is anticipated by the management that some ore could be obtained from above No. 2 level (270E-330E and 380E-440E). A leading stope has been taken from both of these places above No. 2 level, but no work was in progress there at the time of inspection. It is reported that some good ore was encountered in a winze to No. 2 level from a small level off a shallow shaft at 480E and 232S. Insufficient work has been done to make a reliable estimate of the ore likely to be available at each of these places, but no great quantity is anticipated.

The stope above No. 6 level is reported to have averaged 10-12 dwts. The average reported values on No. 6 level are shown on the plan. It will be seen that these averaged 12 dwts. over a width of 48 inches and a length of 230 feet in the central portion of the level. Values at either end of the level are lower. The only work done below No. 6 level is a winze at 120W, which is reported to have followed the ore body down for 30 feet on the underlay. The average values are reported to have been 15 dwts. over 36 inches. The ore body is reported to have ended at 30 feet, but only a small amount of exploratory work has been done below that depth. This winze was full of water at the time of inspection. No other winzes have been sunk from the No. 6 level.

Forman's West Lode consists of three separate shoots developed in two sets of shear zones striking from 62°-77° and 87°-90° respectively. The dip is to the north. The main work has been done on an ore body striking from 87°-90° and dipping north. This has been followed down to just above No. 3 level, where it is intersected by a vertical shear as illustrated by Forman³. Very little work has been done on this ore body since 1936. This shoot has a maximum stope length of 140 feet above No. 2 level, and is reported to have had an average width of five feet.

² Forman, F. G., Op. Cit.
^{*} Plan not published.

³ Forman, F. G., Op. Cit.

TABLE II.
Diamond Drilling Results.

Bore No.	Elevation or Depression.	Workings.	Level.	Assay Results.														
				ft.	ins.	ft.	ins.	ozs.	dwt.	grs.	ft.	ins.	ft.	ins.	ozs.	dwt.	grs.	
1	Horz	Mackenzie's No. 1 Main Shaft	3	187	0	—	189	0	0	0	19	191	0	—	193	0	0	
				189	0	—	191	0	0	2	9	193	0	—	195	0	0	
2	+ 60°....	do. do.	4	2	0	—	4	0	0	0	9	41	0	—	43	0	0	
				10	0	—	12	0	0	1	9	43	0	—	45	3	0	
				17	9	—	19	9	0	14	9	45	3	—	47	0	0	
				32	0	—	35	0	0	2	9+	53	0	—	55	0	0	
				35	0	—	37	0	0	1	19	55	0	—	57	0	0	
												57	0	—	59	0	0	
												59	0	—	61	0	0	
												61	0	—	63	0	0	
												65	0	—	67	0	0	
												67	0	—	69	0	0	
												69	0	—	71	9	0	
												71	9	—	74	0	0	
3	Horz	do. do.	4	2	0	—	4	0	0	0	14	183	0	—	185	0	0	
				4	0	—	6	0	0	4	0	191	0	—	193	0	0	
				6	0	—	8	0	0	1	14							
				103	0	—	105	0	0	0	9							
				165	0	—	167	0	0	2	0							
4	+ 44° 14'	do. do.	4	4	0	—	6	0	0	1	19	59	0	—	61	0	0	
				8	0	—	10	0	0	0	9	61	0	—	63	0	0	
				12	0	—	14	0	0	3	5	63	0	—	65	0	0	
				14	0	—	16	0	0	0	9	67	0	—	69	0	0	
				16	0	—	18	7	0	4	14	73	9	—	76	0	0	
				18	7	—	21	0	0	2	19							
				31	0	—	33	0	0	2	0							
				38	9	—	41	0	0	1	14							
				41	0	—	43	0	0	2	19							
5	Horz	do. do.	4	2	0	—	4	0	0	1	5	12	0	—	14	0	0	
				4	0	—	6	0	0	2	9	16	0	—	18	0	0	
				6	0	—	8	0	0	3	19							
6	do.	do. do.	4	54	0	—	56	0	0	2	19							
7	do.	do. do.	4	0	0	—	4	3	0	1	5							
				4	3	—	6	0	0	1	9							
8	do.	do. do.	4	All assays trace.														
9	do.	do. do.	3	147	0	—	149	0	0	2	14	187	0	—	194	7	0	
				170	0	—	172	5	0	0	14+	187	0	—	189	10	0	
				172	5	—	174	11	0	1	19+	189	10	—	194	7	0	
				174	11	—	177	2	0	0	9+	194	7	—	197	11	0	
				181	8	—	182	0	0	0	19							
				182	0	—	184	0	0	0	9							
10	do.	do. do.	3	155	0	—	157	0	0	4	7							
				202	0	—	204	0	0	3	14							
11	do.	do. do.	4	6	0	—	8	0	0	2	9							
				8	0	—	10	0	0	1	14							
				36	0	—	39	0	0	0	14							
				39	0	—	41	0	0	6	0							
				41	0	—	43	0	0	5	19							
				43	0	—	45	0	0	2	19							
12	do.	do. do.	4	130	0	—	132	0	0	4	19							
13	do.	do. do.	3	All assays trace.														
14	do.	do. do.	?	Hole abandoned at 37' 6" and position not fixed.														
15	do.	do. do.	3	74	0	—	76	0	0	3	5							
				76	0	—	78	0	0	2	14							
				88	0	—	90	0	0	1	9							
				90	0	—	92	0	0	2	19							
				92	0	—	95	0	0	2	0							
				95	0	—	97	0	0	9	7							
16	do.	do. do.	3	52	5	—	60	10	0	1	14							
				68	0	—	70	0	0	2	0							
				79	0	—	81	0	0	2	14							
				81	0	—	94	6	0	1	19							
				97	0	—	101	4	0	0	9+							
				101	4	—	106	6	0	0	9+							
				106	6	—	111	3	0	0	9+							
				111	3	—	115	8	0	0	14+							
17	do.	Nicholson's No. 1 Main Shaft	4	240	8	—	242	8	0	11	14							
18	do.	do. do.	4	125	0	—	127	0	0	1	5							
19	do.	do. do.	4	All assays trace.														
20	do.	do. do.	4	All assays trace.														
21	do.	do. do.	3	0	0	—	5	6	{	1	8	12	1	—	15	0	0	
										9	5	15	0	—	19	11	0	
				5	6	—	8	0	0	2	9							
22	do.	do. do.	3	94	7	—	97	10	0	1	5							
23	do.	do. do.	3	All assays trace.														
24	—60° 42'	do. do.	5	66	0	—	69	0	0	2	0	72	0	—	74	0	{	
																	0	
																	10	
																	8	
																	0	
25	—56° 18'	do. do.	5	95	0	—	97	0	0	1	19						0	

TABLE II—continued.
Diamond Drilling Results—continued.

Bore No.	Elevation or Depression.	Workings.	Level.	Assay Results.															
				ft.	ins.	ft.	ins.	ozs.	dwts.	grs.	ft.	ins.	ft.	ins.	ozs.	dwts.	grs.		
26	— 74°	Nicholson's No. 1 Main Shaft	5	82	0	—	84	0	0	3	14	101	0	—	103	0	0	7	19
				84	0	—	86	0	0	2	19	103	0	—	105	0	0	1	0
				88	0	—	90	0	0	15	0	115	0	—	117	0	0	6	0†
				90	0	—	92	0	{	0	6	0							
				99	0	—	101	0		0	5	5							
27	— 55°	do. do.	5	All assays trace.															
28	Horz	do. do.	3	All assays trace.															
29	do.	do. do.	3	All assays trace.															
30	do.	do. do.	3	All assays trace.															
31	— 55°	do. do.	5	78	0	—	83	0	0	3	9								
				78	0	—	83	0	0	0	14‡								
32	— 37°	do. do.	5	41	0	—	43	0	0	4	0								
33	— 33°	Mackenzie's No. 1 Main Shaft	5	93	0	—	95	0	0	12	19								
				95	0	—	97	0	0	0	9								
				119	0	—	121	0	0	4	19								
34	— 40°	do. do.	5	All assays trace.															
35	— 40°	do. do.	5	120	0	—	122	0	0	1	0								
				122	0	—	124	0	0	2	0								
36	— 54°	do. do.	5	119	0	—	121	0	0	3	0	153	0	—	155	0	0	3	5
				121	0	—	123	0	0	1	5	155	0	—	157	0	0	1	9
				123	0	—	125	0	0	1	9	157	0	—	159	0	0	1	9
37	Horz	do. do.	5	24	0	—	26	0	0	2	0								
38	do.	do. do.	5	All assays trace.															
39	do.	do. do.	5	2	0	—	4	0	0	1	5								

NOTE.—(1) Assays marked thus (†) are sludge assays.

(2) Assay results supplied by Ora Banda Amalgamated Mines, N.L.

Ore is being broken at the present time from below No. 2 level (100W-180W). It is anticipated by the management that some ore might be obtained from selected places above No. 1 level between 100E and 100W, but no development work has been done. It is not anticipated that the quantity of ore obtained would be very great.

The workings off Nicholson's No. 1 Main Shaft are estimated to make 32,000 gallons of water per day mainly from the west ends of Nos. 5 and 6 levels. A very heavy flow of water was encountered in a drill hole in the west face of No. 5 level. The flow was too great for the mine pumps and the hole was plugged.

Mackenzie's No. 1 Main Shaft Workings.

The principal ore body has been worked from the surface down to No. 7 level (V.D. 710 feet). It has a variable strike and dip and has formed in a number of intersecting sheers, of which more will be said in a later section of this report. It has a maximum stope length above No. 4 level of 520 feet and is reported to have had an average width of from four to five feet. The pitch is vertical. The ore body has been practically stoped out from the surface to No. 6 level and no ore was being obtained from above No. 6 level at the time of inspection. The reported average values at No. 6 level are shown on the plan. It will be seen that in that section of No. 6 level, which has been stoped, the average value is reported to have been 6½ dwts. over 48 inches. Beyond the east end of the main stope at this level the average value is reported to be only 4 dwts. over 48 inches.

The values at No. 7 level and also in the winze from No. 6 level are reported to have averaged 5 dwts. over 48 inches. A leading stope has been taken off at this level and the broken ore was being hauled at the time of inspection. Ore could be seen in the west face, but the east face was inaccessible because of broken ore. It is reported that the east face is still in ore. No further work is contemplated at this level and no winzes have been sunk below this level.

At No. 2 level a parallel ore body has been stoped off a drive, which is approximately 40 feet south of Mackenzie's No. 2 Shaft. The stope has a maximum

height of 50 feet. It is considered possible by the management that there may still be some ore above this stope but no development work has been done. A winze, No. 1 west winze, was sunk in ore for 30 feet below the level and it is estimated by the management that 1,100 tons of 7 dwts. ore probably exists below this level.

A parallel ore body north of the main ore body has been tested at three levels, Nos. 1, 2 and 4. In all drives the average values are reported to have been about 2 dwts. over the full width of the drive.

The workings off Mackenzie's No. 1 Main Shaft are practically dry—about one hour's pumping each morning is all that is necessary.

DIAMOND DRILLING.

During 1940 thirty-nine bores were drilled—23 from the workings off Mackenzie's No. 1 Main Shaft and 16 from the workings off Nicholson's No. 1 Main Shaft. These bores are shown on the plan. The whole of the cores were assayed, generally in two feet lengths, and the results of this work were made available to the writer. All results greater than a trace are recorded in Table 11. The assay results for horizontal bores are shown on the plan, but those for depressed or elevated bores are not shown.

A number of depressed bores were drilled from Nos. 5 levels in both lots of workings and some good values recorded. Subsequently Nos. 6 levels were driven, but otherwise very little development work followed the diamond drilling. The values obtained were generally low and patchy, there being no continuity of ore bodies suggested by adjacent drill holes.

GENERAL GEOLOGY.

Under this heading it is proposed to discuss the country rock and also the various shear zones in which the ore bodies have formed.

Country Rock.

The workings occur in a soil covered area and no outcrops were seen in their vicinity. Underground the country is seen to be a porphyrite, with felspar phenocrysts, up to one inch in diameter, set in a fine grained

matrix. The degree of abundance of those phenocrysts varies considerably and often in a face they are seen to occur in patches. Over appreciable areas of the face they are absent. Away from the ore channels the rock is massive and shows a blocky jointing. In the vicinity of the ore channels it is strongly sheared and very fine grained. Sulphides are often seen in the walls of the drives and examination of thin sections shows the presence of carbonates. In the vicinity of the ore channels occasional remains of felspar phenocrysts are seen (2/2826) and there is a grading from the heavily sheared rock to the porphyrite. The porphyrite is known locally as the "cat" rock or "native cat" rock.

A number of specimens were brought back and have been examined in thin section by the writer's colleague, Dr. K. R. Miles, who comments as follows:—

"Specimens examined included types of "cat rock" forming the country rock of the principal lodes at Grant's Patch, together with specimens of schist from the lode channel itself. The "cat rock" specimens were marked B1, B2, B3-B6a, B6b, B10 (registered numbers 2/2817-2/2823, B10 discarded). This is a markedly porphyritic rock containing phenocrysts of felspar—mostly cloudy from alteration but where sufficiently fresh, determined as labradorite ($Ab_{45}An_{55}$)—set in a cloudy altered ground mass ranging from very fine to medium-fine-grained and consisting essentially of felspar, a chloritised ferromagnesian mineral and epidote, carbonate, pyrite, etc. Several specimens viz., 2/2817, 2/2819, 2/2820 showed a suggestion of flow orientation in the ground mass minerals. This rock is classified as a porphyrite or porphyritic andesite, an intermediate basic rock of igneous origin which may have been either a sill or a flow. The ground mass of one medium-fine-grained specimen (2/2818) shows affinities with dolerite.

The rocks from the ore channel viz., B8, B9, B11-14 (registered numbers 2/2825-2/2829, B8 discarded) are for the most part sheared and heavily altered and replaced by carbonates and sulphides. Relict structures are sufficient to identify these as having been derived from the porphyrite (or andesite) "cat rock" as a result of dynamic metamorphism (shearing) and later hydrothermal alteration.

Porphyrite (andesite) and its sheared products constitute all except one of the specimens examined, the odd one (2/2824) being a medium grained amphibolised dolerite (dolerite amphibolite), a hypabyssal intrusive possibly representing a more basic facies of the same magma from which the porphyrite was derived."

Specimen 2/2824—a dolerite amphibolite—comes from the south face of a crosscut opposite to Nicholson's No. 1 Main shaft at No. 5 level. (Co-ordinates 60S, 15E.) Underground this rock appeared to be more sheared as the lode channel was approached and no boundary between the dolerite amphibolite and the porphyrite was seen. This is a point which should be checked as opportunity offers. It should be noted that the ground mass of one other specimen (2/2818) showed affinities with a dolerite.

At two places in the workings off Mackenzie's No. 1 Main Shaft—south faces Nos. 2 and 6 level plats—pillow lava was seen. At No. 6 level the pillows were well developed and were seen to be finer grained at their margins than in their centres. The centres of pillows showed well developed felspar phenocrysts, while at the margin the phenocrysts were small and inconspicuous. Two specimens were collected (2/2819, 2/2820)—one from the centre and one from the margin of a pillow—and both were found in thin section to be fine grained porphyrites (or andesites?) similar in every way to the other specimens of porphyrite collected. It is concluded therefore that the porphyrite is a flow rather than a sill.

Shear Systems.

(a) *Nicholson's No. 1 Main Shaft Workings.*—An analysis of the strikes of various ore bodies suggests that there are at least five sets of shears having strikes and dips as indicated in Figure 1. This diagram has been generalised from a larger one on which the general strikes of the various ore bodies were

plotted. The principal production has been from an ore body formed in that set of shears having a general strike of from 111° - 128° , but there has also been appreciable production from ore bodies having the following general strikes:— 87° - 90° , 96° - 98° and 62° - 77° . All workable ore bodies have been stoped and the levels timbered and it is not now possible to see the points at which the shears appear to have junctioned. Consequently it cannot be positively stated that at all places where there is a change in the general strike of the level that the ore body has formed in a new shear, but it would appear probable that it has. Good evidence for this is to be seen at No. 4 level off Mackenzie's No. 1 Main Shaft, of which more will be said in the next section of this report.

It has been suggested that there are two sets of shears having the following strikes 87° - 90° , 96° - 98° , but it is possible that these belong to one system of shearing having a strike varying from 87° - 98° . If this is so then that portion of the ore body at the western ends of Nos. 5 and 6 levels has formed in the same set of shears as the ore bodies at Nos. 1 and 2 levels (40W-40E and 20W-50E respectively).

The pitch of main ore body is to the west and appears to be controlled by the pitch of the intersection of the shears.

(b) *Mackenzie's No. 1 Main Shaft Workings.*—Figure 2 is a shear system diagram for these workings compiled in the same manner as Figure 1. It will be noticed that while there is general correspondence of the strikes of the shears in both lots of workings there are noticeable differences in the dips, e.g., in the workings off Nicholson's shaft those shears having a strike of from 111° - 128° have a vertical dip, while in the workings off Mackenzie's Shaft those shears having a strike of from 104° - 108° generally have a northerly dip, although there are some with a vertical dip.

In these workings the existence of parallel shears can be well seen at Nos. 2 and 4 levels. At No. 4 level opposite to the main shaft the ore is seen to continue beyond the end of the stope for a short distance along a shear having a strike of 71° , although the main portion of the ore has been diverted to a shear having a general strike of 104° . A similar set of conditions is seen in the drive to the west of this point.

The pitch of the ore body is vertical and is controlled by the pitch of the intersection of the shears. Below No. 3 level the ore body has formed in shears having a general vertical dip and consequently has a vertical pitch. The pitch of the intersection of two shears is dependent upon the dip of each of the shears. At No. 2 level the main ore body has formed in parallel shears all belonging to the one system.

CONCLUSION.

Because of wartime conditions development work has lagged behind ore breaking and the reserves of ore, which can be immediately worked, amount to only a few hundred tons.

The values—5 dwts. per ton—at No. 7 level, off Mackenzie's No. 1 Main Shaft are reported to be lower than can be profitably worked by the Company. The values in these workings are reported to have been decreasing with increasing depth. In the past ore from these workings has been mixed with high grade ore from the workings off Nicholson's No. 1 Main Shaft, but at the present time very little high grade ore is available and consequently the 5 dwt. ore is not being worked. No winzes have been sunk below No. 7 level. There is no geological reason for supposing that the conditions below this level are different from those above it.

The values at No. 6 level off Nicholson's No. 1 Main Shaft and the stope above it were very satisfactory—those in the stope being reported to have averaged 10-12 dwts. over 4-5 feet. Only one winze has been sunk below this level. This winze is reported to have been in good values—15 dwts.—for 30 feet. There is no geological reason for not testing the ore body by other winzes, below No. 6 level.

THE TUNGSTEN DEPOSITS ON M.Cs. 24 AND 25, CALLIE SOAK, MURCHISON G.F.

By R. S. Matheson, B.Sc.

GENERAL INFORMATION.

As a result of an application for financial assistance from the Mines Department a brief examination of these deposits was carried out on the 16th and 17th January, 1943.

The deposits are situated in the vicinity of Callie Soak, about 25 miles north-west of Cue and about 3¼ miles west of Telegootherra Trig. The deposits are about 11 miles north-west by road from the Big Bell Mine.

Some notes on tungsten deposits from the Callie Soak area are already contained in Bulletin 57* and the Mining Handbook.

According to the official production statistics 8.41 tons wolfram valued at £1,148 were recovered from 238.64 tons of ore, obtained from the area during the period 1910 to 1916. Calculations based on the price during the period of production, which was about 46s. per unit for 65 per cent. ore, shows that there is an error in the statistics, and they should read 8.41 tons of WO₃, not 8.41 tons of wolfram. Allowing for this correction it will be seen that the ore produced from this area, which was no doubt hand picked, averaged 3.52 per cent. WO₃.

GEOLOGY.

The area is composed mainly of porphyritic granite, which is intruded by a series of quartz and pegmatite veins. A few lenses of quartz-biotite rock, which may possibly be recrystallised remnants of pre-existing sediments, are also present. The complex is presumably of Pre-Cambrian age.

The principal tungsten mineral is wolframite (ferberite variety), but scheelite occurs, and is fairly abundant in two places. The tungsten minerals are everywhere associated with fractured, translucent, somewhat ironstained, quartz veins, and the quartz-biotite rock is frequently their host rock. Wolframite is not confined to the quartz, but also occurs in the quartz-biotite rock in proximity to quartz veinlets.

Cassiterite does not appear to be associated with the wolframite at this locality, but hematite pseudomorphs after magnetite are fairly common.

The soil in proximity to the lodes contains detrital wolframite, and is reported to be sufficiently rich, in a few places, to warrant working.

THE LODES.

The writer was concerned mainly with Martin's Lode and Bald Hill Lode, which are situated on M.Cs. 25 and 24 respectively, but a few smaller lodes occurring in the area were also inspected. The wolframite was readily detected by its marked physical characters but a "Mineralight" lamp was used to assist in the detection of scheelite.

The co-ordinates given below are referred to the plant accompanying Dr. Moss's report.

Martin's Lode (Co-ords. 1390S, 575E).

This is the only lode seen in the district, which has prospects of being worthy of large scale development. The financial assistance applied for is to prospect this lode.

The lode consists of a lens of quartz-biotite rock intruded by quartz veins and veinlets, which strikes N. 50° E. and probably dips vertically. It attains a height of about 15 feet above the general level of the surrounding country, and has a length of 265 feet and an average width of about 65 feet.

The two main quartz veins are barren, but a network of wolframite-bearing quartz veinlets occurs in the lens. The wolframite is not confined to the quartz veinlets, but was noted in the quartz-biotite rock in proximity to

them, in several places. Wolframite is most abundant along the south-eastern side of the lode, but it is also present on the north-western side. A small amount of scheelite, occurring in quartz, was detected by the "Mineralight" near the south-west end of lode, on the north-west side of the two well defined quartz veins. The reported occurrence of detrital wolframite on all sides of the lode supports the view that it has been mineralised erratically as a whole.

The existing workings consist of four shallow trenches; three on the south-eastern side of the lode and one on the north-western side. The trenches are short, and the longest extends only about half-way across the width of the lode.

The assay results from samples already taken from the lode give no indication of its average value, and this information can only be obtained by trenching and bulk sampling. A good indication of the economic value could be obtained, however, by bulk sampling the material mined from one trench across the centre of the lode.

Bald Hill Lode.

This lode is situated on a bare granite hill about 90 chains south-west of Martin's Lode.

A pegmatitic quartz vein, which strikes N. 20° W. and probably dips vertically, has been mined here over a length of 40 to 50 feet and to a depth of about 16 feet. The workings could not be examined due to the presence of water which stands at nine feet in the shaft. The vein appears to be about six feet wide and consists of a mixture of laminated quartz, felspar and mica, which is mineralised erratically with wolframite and scheelite. Wolframite frequently occurs as a core in the scheelite.* Most of the production from the Callie Soak areas has come from this deposit.

Detrital wolframite is present in the soil on the north-eastern side of the workings, and a fair amount of scheelite has been overlooked in the dumps.

This deposit has prospects of being quite a good small scale proposition.

Other Lodes.

Although these lodes have little bearing on this report it is advisable to record their presence.

A pegmatitic quartz vein containing wolframite and scheelite, which has prospects similar to the Bald Hill Lode, is situated about 22 chains west of Martin's Lode (at Co-ords. 1440S, 880W). The vein is lenticular, and strikes N. 50° W. and probably dips vertically. It outcrops over a length of 90 feet and has a maximum width of about 10 feet. Mineralisation has apparently been erratic, and the workings consist of a few potholes and one shaft, which has been sunk to a depth of 20 feet on a small fairly rich shoot. A fair amount of scheelite, and wolframite within scheelite, was noted in the dumps near the shaft. Scheelite is not abundant in the walls of the underground workings, and the floor of the workings, which is the most likely place for its occurrence, was covered at the time of inspection. A little molybdenite is scattered through this quartz vein.

Another scheelite and molybdenite bearing quartz vein has been opened up in a shallow trench, the co-ordinates of which are 200S, 820W. The vein is only a few inches wide however, and does not warrant much attention.

Wolframite-bearing quartz veinlets are associated with most of the small lenses of quartz-biotite rock shown on Dr. Moss's plan, but the mineralisation does not appear to have been extensive.

SUMMARY AND CONCLUSIONS.

The tungsten deposits in the Callie Soak area consist of wolframite and scheelite bearing, pegmatitic quartz veins, which are intruded into a complex of porphyritic granite and scattered lenses of quartz-biotite rock. In some deposits wolframite is the most abundant tungsten mineral, while in others scheelite predominates. The wolframite deposits are generally associated with quartz veinlets intruding lenses of quartz-biotite rock, and mineralisation of the host rock as well as the quartz

* Woodward, H. P., G.S.W.A. Bull. No. 57 (1918), pp. 53-54. Maitland, A. G., G.S.W.A. Mining Handbook (1919), Chap. II., Part III., Section 6.

† See specimen No. 2/2578, Geological Survey Collection.

‡ For report and plan refer to Mines Dept. File 1166/42.

* See specimen No. 2/2579, Geological Survey Collection.

was noted in several places. Only very small amounts of scheelite occur in these deposits. The scheelite deposits are associated with quartz veins intruding granite and a fair amount of wolframite is generally present. In these deposits mineralisation appears to have been confined to the quartz.

A few of the deposits warrant prospecting, but only one of them (Martin's Lode) has prospects of being worthy of large scale development. This lode consists of a lens of quartz-biotite rock, about 265 feet long and 65 feet average width, which has been intruded by a network of wolframite-bearing veinlets. Mineralisation has been rather erratic, but there is reason to believe that the WO_3 content of the lens as a whole, or a large part of it, may be sufficient to warrant large scale development.

A fair amount of trenching and bulk sampling would be required to determine the average value of the lode, and this would prove costly, but some indication of the economic value could be obtained by bulk sampling the material mined from one trench across the centre of the lode.

THE MOLYBDENITE DEPOSITS ON P.A.'s. 2323, AND 2324, MT. MULGINE.

Yalgoo Goldfield.

By R. S. Matheson, B.Sc.

General Information.

Mt. Mulgine is situated about seven miles south south-west of Warriedar, and about 55 miles east of the railway at Perenjori.

About 78 tons of Molybdenite ore valued at £865¹ were mined from shallow workings at this centre during the period 1917 to 1922, the price of molybdenite at the time being about £5 per unit for 90 per cent. concentrates. No production has been recorded since 1922, and this has been attributed to low prices. An increasing demand for molybdenite in the last few years has led to renewed interest in the deposits, and the price (at January, 1943) has again risen to £5 per unit. Since 1938 examinations of the deposits have been made by representatives of the Big Bell Mines, Ltd., and the Broken Hill Pty. Co. Ltd., and also by Dr. F. A. Moss, who holds one of the existing prospecting areas.

The writer's inspection was made during the period 13th to 15th January, 1943, as a result of an application² to the Mines Department for financial assistance to prospect the deposits.

Geology.

The writer's investigations were of necessity confined to a small area in the vicinity of the workings, but the general geology has already been described in departmental reports.³

Mt. Mulgine is a rough, isolated hill which attains a height of about 300 feet above the general level of the surrounding country. It is composed mainly of fresh, foliated, microcline-muscovite granite, which is intruded by a network of pegmatitic quartz and pegmatite veins. Narrow dolerite dykes, which have a general north-west strike, intrude this complex. The granite varies from fine to coarse grained, and its foliation planes strike in a north-westerly direction and dip almost vertically.

All the molybdenite occurrences are associated with the pegmatitic quartz veins, which generally strike in a north to north-west direction and dip vertically. The quartz veins are lenticular and vary in width from a stringer to about 12 inches. Although molybdenite is sometimes present in the quartz, it usually occurs as thin seams on the margins of the veins or as scattered flakes and rosette-like forms in the adjacent granitic wall rock. The marginal seams of molybdenite are erratic in occurrence, and the impregnation of the wall rock varies in width from a few inches to about two feet.

Wider zones of mineralisation occur where quartz veins intersect, or are parallel and in close proximity to one another. The molybdenite has been weathered out of the mineralised zones in places to depths up to two feet from the surface, but the nature of the vugs, together with occasional spots of molybdic ochre or residual flakes of molybdenite appear to give a fairly reliable indication of the existence of deposits.

Pyrite is a common constituent in the mineralised zones and fluorite was noted in one or two places, while the occasional presence of scheelite, magnetite, pyrrhotite, and manganese has been recorded. In the mineralised zones the molybdenite is reported to occur in close association with the mica, either interleaved with or completely replacing it.

The Workings.

The 14 trenches and adit referred to in Dr. Moss's report were examined by the writer, but in only five of the trenches and the adit were the prospects sufficiently encouraging for the deposits to warrant detailed examinations. The trenches are situated on the southern slope of Mt. Mulgine and the adit is at the head of a gully on its western side. Descriptions of these workings are given below, and the co-ordinates are referred to Plan No. 3 accompanying Dr. Moss's report.⁴

Trench A. (Co-ords 16—M, Western trench).

This trench strikes N. 13° W., is about 92 feet long, and it has a maximum depth of 12 feet. Mineralisation commences rather suddenly in the trench, about 48 feet from the north-west face, on a joint plane which strikes N. 60° W. and dips 65° N.E. Although the floor of the trench is covered, it seems likely that a molybdenite impregnated zone extended from the joint to the face, the average width being about six feet. The mineralised zone occurs between two quartz veins which are well exposed in the face. The eastern vein has an average width of about 12 inches and can be traced back to the joint, while the western vein only extends about half this distance, and diminishes in width from six inches in the face to a stringer. Quartz veinlets probably intruded the intervening granite, so that conditions were very favourable for mineralisation. No mineralisation appears to have occurred beyond the outer boundaries of the quartz veins.

The results of three samples taken from this trench by the Big Bell Mines Ltd. during the investigation are given below.

Sample.	Sample Width.	%MoS ₂ .
Horizontal sample from N.W. face	4 ft.	1.38
Vertical sample from east wall, 22 ft. from N.W. face	6 ft.	0.42
Horizontal sample edge of shallow hole (so called winze) on N.W. side of joint	6 ft.	1.01

Trench B. (Co-ords 17 to 18—L).

This trench swings from south-west to north, is about 36 feet long, and has a maximum depth of six feet at the north face. A 4 in. quartz vein, which strikes N.-S. and dips very steeply west, can be seen extending from the face into the eastern wall of the trench. The granitic country on both sides of the vein has been impregnated with molybdenite and pyrite, and the mineralised zone is exposed over a length of 20 feet over an average width of three feet. In this trench unweathered lode material is encountered at two inches from the surface. Indications of the mineralised zone were noted in the outcrops to 27 feet beyond the north face, but could be traced for only a few feet south of the trench.

An eight inch pegmatite vein, which strikes N. 65° W. and dips vertically, cuts through the trench near the north face, but its relationship to the quartz vein could not be established.

The north face was sampled over a width of nine feet by the Big Bell Mines Ltd., and it assayed 0.69% MoS₂.

⁴ For report and plan, see Mines File 1038/42.

¹ Maitland A.G., G.S.W.A. Bull. No. 89, p. 70.

² Refer to Mines Dept. File 1038/42.

³ Blatchford, T., Mines Dept. Ann Rept., 1918, pp. 77-78. Maitland A.G., G.S.W.A. Mining Handbook, Chap. II., Part III, Section VII.

see Maitland A.G. File 211/17.

Trench C. (Co-ords 17—M).

This trench strikes N. 15° W., is about 44 feet long, and has a maximum depth of 12 feet at the north-west face. The mineralised zone has an average width of about eight feet six inches, and extends about 38 feet back from the face, where it cuts out rather suddenly. No defined quartz vein was seen in this trench, but there are indications that a network of quartz veinlets occurred. Molybdenite is reported to have been picked up on the strike 50 feet beyond the north-west face, but the lack of surface indications suggests that the mineralised zone is not continuous between these two points.

The assay results of samples collected from this trench by the Big Bell Mines Ltd. are given below:—

Sample.	Sample Width.	%MoS ₂ .
Horizontal sample from N.W. face	5 ft. 9 in.	6.99
Horizontal sample 37 feet from N.W. face	6 ft. 9 in.	1.91

Trench D. (Co-ords 17—N.).

This trench is V shaped, and its apex faces north. The south-eastern branch is 38 feet long, and the south-western branch is 28 feet long. The trench has been excavated to a maximum depth of eight feet from the surface.

Three narrow quartz veins, which strike about N. 15° W. and dip vertically, were intersected in this trench.

In the south-eastern branch a quartz vein, varying from 18 inches to 10 inches wide, is exposed. Molybdenite occurs erratically within the vein and as seams along its walls. There has been practically no mineralisation of the adjacent country. The vein has also been prospected in trenches to the north and south, but the assay results are not encouraging.

Another quartz vein occurs on the north-west wall of the south-west branch, about eight feet west of the vein described above. The vein is about 10 inches wide and mineralisation extends over 18 inches, but the vein is a short lens which cuts out before reaching the south-east wall.

About six feet further west, another quartz vein about six inches wide occurs, and the adjacent country, for a few inches on both sides of it, is impregnated with molybdenite. The maximum width of the mineralised zone is 15 inches.

The assay results of samples collected from this trench by the Big Bell Mines Ltd. are given below:—

Sample.	Sample Width.	%MoS ₂ .
Horizontal sample face of S.E. branch	4 ft.	0.28
Horizontal sample N.W. wall of S.W. branch 3 ft. to 8 ft. from S.W. face ..	5 ft.	0.62
Horizontal sample N.W. wall of S.W. branch 8 ft. to 13 ft. from S.W. face ..	5 ft.	0.31
Horizontal sample S.E. wall of S.W. branch 0 ft. to 3 ft. from S.W. face	3 ft.	0.41

Trench E. (Co-ords 17—O to P).

This trench strikes N. 47° W., is about 22 feet long and has a maximum depth of 10 feet.

A two inch quartz veinlet with a thin seam of molybdenite on its west wall is exposed for a few feet in the floor of this trench. Mineralisation of the wall rock is confined to the eastern side of the veinlet and does not exceed 14 inches in width. In the north-west face the mineralised zone is only about six inches wide and does not extend to the floor.

The assay results of samples collected from this trench by the Big Bell Mines, Ltd. are given below:—

Sample.	Sample Width.	%MoS ₂ .
Horizontal sample from N.W. face	3 ft. 6 in.	0.57
Floor sample	6 in.	High Grade

North-West Adit Workings.

The adit was inaccessible at the time of the writer's inspection, due to the presence of water and foul air. At the surface, however, vugs and occasional flakes of molybdenite were noted in quartz veins for about two chains east of the mouth of the adit.

In the report of the Big Bell Mines Ltd., these workings are described as follows:—

"A trench was cut in the side of the hill to form an open cut 79 feet long, some six to 10 feet wide, and of height from zero to 34 feet. At the floor of the 34ft. face an adit was driven for a distance of 49 feet. Near to and in the mouth of the adit a winze was sunk to a depth of five feet and has formed a soak for water. The total tonnage excavated (all by hand drilling) is in the order of 1,170 tons, of which 690 tons was overburden, and 480 tons of stone carrying some molybdenite. Most of the tonnage lies in dumps near the entrance to the open cut.

The whole of the workings are in granite-carrying small quartz and pegmatitic quartz veins. A dolerite dyke strikes across the open cut close to the mouth of the adit, and maintains a width of about four inches from floor to surface, a distance of over 30 feet."

The following assay results are reported to have been obtained from samples collected during this examination:—

Sample.	Sample Width.	%MoS ₂ .
Horizontal sample from face of adit	3 ft. 9 in.	0.83
Horizontal sample from roof near shallow winze ..	4 ft. 6 in.	1.43

SUMMARY AND CONCLUSIONS.

An inspection of the principal workings at Mt. Mulgine showed that five trenches and the adit contained molybdenite in sufficient quantities to warrant a detailed examination. The molybdenite is associated with quartz veins, and generally occurs as thin seams along their margins or as scattered flakes and rosette-like forms in the adjacent granitic wall rock. Molybdenite is occasionally scattered through the quartz veins themselves. The floors of the trenches and the adit could not be examined, but the observations made were sufficient to show that the marginal seams of molybdenite are erratic in occurrence, and the width of impregnation of the wall rock very variable. Mineralisation has been erratic horizontally, and it is reasonable to expect it to be similar vertically.

The comparison between the quantity of material mined and the production, which is given below, is supporting evidence of erratic mineralisation, and it is obvious that mining at this centre, as a whole, has been carried out at some considerable loss.

The total production from this centre is 78 tons of molybdenite ore valued at £865, and it was obtained during the period 1917 to 1922. If the 1918 price of molybdenite, which was £5 per unit, is assumed to have been obtained for the whole of the production, then the average value of the ore was about 2¼ per cent. MoS₂. The 78 tons of molybdenite ore have been recovered from workings which, according to the Big Bell Mines Ltd., yielded 4,000 tons of rock. Admittedly some of the workings are of a prospecting nature, but the fact can not be overlooked that the marketable ore constituted only about two per cent. of the total amount of material mined at this centre. Making an allowance for dead work and assuming that one per cent. molybdenite ore could be treated profitably on the spot, it is not unreasonable to adopt a recovery value of 20 per cent. for this grade of ore in any large project.

The five trenches and adit in question would yield about 120 tons of material per vertical foot, from which, if the above recovery value of 20 per cent. is accepted, 24 tons of one per cent. molybdenite ore could be recovered. The prospects are, therefore, not encouraging.

In conclusion, the writer is of the opinion that while small parcels of ore averaging about two per cent. MoS_2 may be obtained from these deposits by selective mining, due to erratic mineralisation it is unlikely that sufficient ore of suitable grade could be developed to justify any large scale project.

BENTONITE AT MARCHAGEE, WESTERN AUSTRALIA.

Interim Report.

By K. R. Miles, D.Sc., F.G.S.

In August, 1943, a very brief inspection was made of a clay deposit claimed to contain high grade colloidal clay (bentonite) near Marchagee on the Midland Railway line, some 150 miles north of Perth. The clay deposits occur in several clay pans located about nine miles west of Marchagee Siding. The country in the immediate vicinity of the clay pans is a sand plain covered with low scrub vegetation, and sprinkled with boulders of travertine limestone. Scattered high points on this sand plain are capped by ferruginous gravel.

The principal deposit, located on M.C. 258H on the south-west corner of Victoria Loc. 5866 consists of a long narrow, irregular shaped clay pan, running in the approximate direction N. 35° W. This clay has an average depth of two to three feet and bottoms on sand. It consists of A. Top Clay, 9-10 inches thick—a greyish clay which is claimed to be high grade bentonite grading into B. Middle Clay (transition layer)—of highly gypseous clay (about six inches) which grades downward to C. Bottom Clay, a fawn-brown coloured clay average about 15 inches, very similar in general appearance to the Top Clay but claimed to have very inferior colloidal properties. All three layers, but particularly the top and bottom, are plentifully sprinkled with fragments of travertine.

For purposes of computation the clay deposit can be taken as approximately 25 chains long by one chain wide. Assuming that the average thickness of Top Clay is nine inches then the deposit contains a little over 3,000 tons of high grade bentonite, on a conservative estimate. Should the Bottom Clay on further testing prove to be of commercial importance then, assuming an average thickness of 12 inches of pure material, this would yield a further 4,000 tons of bentonite.

Samples of the different varieties of clay from this deposit have been sent to the laboratories of the C.S.I.R., Melbourne, for further testing in connection with the Foundry Sands Investigation.

Some 12 to 15 chains south-east of M.C. 258H is a small shallow clay pan covering less than a quarter of an acre. At the time of inspection this pan was rather wet but a sample hole revealed a surface layer about 12 inches deep of clean clay underlain by gypseous material. Should this type of material prove to be a useful colloidal clay it is estimated that this deposit may contain a maximum of about 400 tons of bentonite.

M.C. 259H on Victoria Loc. 7308 lies about $1\frac{1}{2}$ miles south-east of M.C. 258H. This contains a clay pan which at the time of inspection was covered with water and could not be sampled. The clay pan covers an area of about $1\frac{1}{2}$ acres or more. It is claimed that the top four inches of clay on this deposit is useless as colloidal clay but that beneath this is a layer, about 12 inches thick, of fair grade bentonite, underlain by a hard layer of ferruginous cement. Assuming that the overall average thickness of workable bentonite is 12 inches in this deposit, it will contain approximately 2,500 tons.

The above are the only known deposits of commercial bentonite in Western Australia, amounting to a possible total of about 10,000 tons of clay whose quality and properties have yet to be checked by thorough testing of plasticity and colloidal properties.

Considerable tracts of country geologically and physiographically similar to that of Marchagee can be found in this and adjacent districts, however, and it is possible that other similar bentonite bearing clay pans will yet be located.

NOTES ON A SALT DEPOSIT NEAR WYALKATCHEM, S.W. DIV.

K. R. Miles, D.Sc., F.G.S.

During his return to Perth from an inspection of salt lakes in the Campion district on June 15th, 1943, the writer took the opportunity of making a brief inspection of a small lake salt deposit approximately nine miles south-south-west of Wyalkatchem townsite. This lake, which is approximately circular, covers an area of about six to seven acres, lies near Bulagen Spring on Reserve \uparrow 21221, about 15 to 20 chains south-east of the south-east corner of Avon Loc. 17135 (Lands litho 33/80).

Portion of this lake is at present leased by a Mr. Duffeld, who is producing salt to fulfil Army contracts. The lake occurs in a shallow depression in yellow sand plain country. At the time of inspection the lake was covered with water to a depth of about 11 inches in the centre. This was stated to be about four inches above the water level of last month, due to recent heavy rains. Little water is said to enter this lake from surface drainage, the increase being largely produced by underground seepage. Measurement of the salt concentration in the water by hygrometer indicated 65 to 70% NaCl at the surface.

At the time of inspection the salt layer being worked was approximately 2-2 $\frac{1}{2}$ inches thick, consisting of clean well crystallised halite overlaying a thin crust (half to one inch thick) of rather dirty salt, beneath which is a zone of gypseous mud. This lower salt layer is the product of crystallisation of an earlier season and it serves to seal off the impure gypsum-bearing brines below. Care is taken not to break this layer and to gather only the clean salt which is continually forming upon its upper surface. By this means Mr. Duffeld claims to be able to obtain a uniformly clean product consistently free from gypsum and other chemical impurities.

Plant on the lease includes a small mill which is run by a truck engine driven by producer gas. Salt stacked on the bank amounts to several hundred tons. It is claimed that two men operating this plant can produce and bag between $1\frac{1}{2}$ and 2 tons of salt per day. Mr. Duffeld considers that with additional plant a steady production of about 1,500 tons per annum could be maintained from this deposit for a number of years. Samples of the crude salt, crude washed salt and the coarsely ground final product, were collected for purposes of departmental reference.

NOTES ON THE SALT LAKES—CAMPION DISTRICT.

By K. R. Miles, D.Sc., F.G.S.

This district is experiencing its wettest season for many years. Very heavy falls were recorded in the early months of this year (1943), and there have been periodic soaking rains throughout the last six months. Most of the lakes are filled with water. It has, furthermore, been reported that the main chain of lakes extending from Yellowdine and Southern Cross northwards through Lakes Seabrook and Koorkoordine, respectively, to Lake Deborah and thence south-westwards through Warra-chuppin, Lake Brown to Hines Hill, Baandee and towards the Avon River south of Beverley, have for a short time been more or less connected by flowing water. No salt was seen in any of the lakes visited during the recent inspection carried out between the 9th and 17th of June, 1943.

South Lake Campion.

The site of an old salt lease, 1564/152, is a small lake lying just west of the Campion-Merredin road, about five miles south of the Alunite works at the new town.

site of Chandler. This lake is in the strip of country connecting the Lake Campion lake series with the eastern end of Lake Brown. (See plan.) It is about 30 chains long by 20 chains wide and was three parts filled with samphire, the remainder being covered with water. The total area available for salt catchment is small. On the eastern side the main road is a long, narrow, curved arm of lake running north and south, about 30 chains wide and probably near a mile long. This was covered with water. No salt was seen hereabouts but seed gypsum was plentiful on the western shore line.

Lake Brown.

Salt is reputed to have been obtained in the past from several portions of Lake Brown, particularly in the south-eastern corner, and towards the centre of the main body of the lake.

The probable site of one old salt lease, 1572/152, in the south-eastern end of the Lake Brown chain, is a small, circular lake about 12 chains east of the road and three-quarters of a mile south of the narrow causeway crossing, which lies some seven miles south-west of Chandler. This lake is about 20 chains in diameter, and at the time of inspection was mostly covered with water to a maximum depth of about $4\frac{1}{2}$ inches. No salt existed on the floor of the lake, which consists of red clay, underlain by whitish clay containing scattered crystals of gypsum. A sample (No. 1) of the water was collected from the centre of this lake.

About a quarter of a mile north of this circular lake is the southern shore of the main arm of Lake Brown east of the causeway. This was covered with water and extended northwards for over a mile, and was about half a mile wide. A sample of water (No. 2) was collected from a point about half a mile south of the causeway and 10 chains east of the western shore. The water here was about $9\frac{1}{2}$ inches deep and the floor of the lake a blue-grey mud.

The main body of Lake Brown itself was seen to be covered with water. Some salt is reputed to have been obtained from somewhere near the central portion of this lake, a mile or more south-east of the main Lake Brown-Nungarin road crossing. No detailed inspection was made of this part of the lake and no water samples collected, owing to its general inaccessibility because of the water logged condition of the surrounding ground.

An isolated pear-shaped stretch of lake lying west of the road and about one to one and a half miles north of the narrow causeway mentioned above is reputed to have been worked for salt in the past. The bulk of this lake appears to be a silted-up samphire-covered flat containing narrow water-filled channels. No salt was seen, but the eastern shores were plentifully sprinkled with seed gypsum. No water samples were taken.

Warrachuppin Lakes.

It is not known if salt has been collected from these in past years. The main lake is about $1\frac{1}{2}$ miles east of Warrachuppin siding and just north of the railway line. It is flanked on the western end by a large granite rock (trig. hill). It was covered with water, a sample of which (No. 4) was taken from about five chains north of the shore where it was 10 inches deep. No salt or gypsum was seen. It is probable that, owing to the heavy run off of fresh rain water from the rock into this lake, the salt concentration may be lower than elsewhere. Other smaller lakes to the south of the railway line were water-filled and showed no signs of salt.

Baladjie.

Inspection of the western end of the Lake Deborah chain at about $1\frac{1}{2}$ miles due north of Baladjie siding showed that the lake was here completely filled with water over its entire expanse. A sample (No. 3) was collected at about 15 chains north of the southern shore where the water was 11-12 inches deep. The floor of the lake consists of fine red mud, underlain at a few inches by a bluish puggy clay containing thin sandy lenses and thickly scattered with flat disc-shaped crystals (often showing penetration twins) of gypsum. No salt was seen.

SCHEELITE DEPOSITS IN THE CENTRAL GOLDFIELDS, WESTERN AUSTRALIA.

By K. R. Miles, D.Sc., F.G.S.

Introduction.

The writer spent the period, March 2nd-18th of this year in a tour of inspection of a number of scheelite and wolframite deposits which are at present being actively investigated in the Central Goldfields District of the State. Localities visited included Coolgardie, Londonderry, Higginsville, Norseman, Comet Vale and Westonia. It had been intended also to inspect a small wolfram show at Ora Banda but the project was abandoned owing to car trouble on the road.

The writer took with him the Mineralight Ultra Violet Ray Lamp recently acquired by the Department. The object of this trip was to inspect and assess the possibilities of each deposit, and with the aid of the Mineralight lamp to assist the operating companies wherever possible in their surface and underground prospecting and mining development.

Owing to the sporadic nature of the scheelite distribution in all occurrences, the first aim has proved very difficult of achievement and it was found possible to gain only a very general idea of the scheelite content of the deposits, in some cases due to inability to obtain sufficient precise measurements with the instruments and in the time available, and in others due to lack of sufficient surface exposures or of underground development.

The assistance provided by the Mineralight lamp was very definite and was fully acknowledged by the managements of the operating companies at all centres visited. In this regard the picture, both visual and mental, provided in a few minutes by the action of the ultra-violet light particularly in underground workings, is such as can seldom be obtained even after the closest examination under ordinary light and the most exhaustive sampling involving many hours of labour. Lamping of surface outcrops and dumps also proved of considerable value, giving as it does a much broader and more complete picture of the distribution of the scheelite on a much larger scale and on a rough quantitative as well as qualitative basis. This was particularly the case at Higginsville and Comet Vale, though it is to be admitted that in both these localities the lamp seldom revealed the presence of scheelite on the surface or in dumps at places where it had not already been detected by dish sampling.

As regards the actual technique of lamping, all surface lamping was carried out at night, the darker the night the greater the effective area of illumination by the ultra-violet rays. It was found that in old dumps well washed by rains scheelite particles down to very minute grains could clearly be distinguished under the lamp, but on newly broken surfaces of old dumps and on new dumps only a small percentage of the scheelite present on the surface—mostly coarse fragments—could be activated by the rays. In examining surface soil overlying supposed lines of lode, and also in shallow pits, trenches and costans it was found necessary to distinguish scheelite fragments from scattered dead leaves of certain shrubs which gave off a slightly fluorescent glow, and from the inherent whiteness of the ubiquitous travertine some of which appears to give a faint phosphorescent afterglow. After a little experience, however, the writer had no difficulty in distinguishing the scheelite under the lamp, the characteristic bluish white glow being very uniform in colour in all deposits investigated. Fresh surfaces of scheelite gave the best illumination, but even highly weathered and hydrated surfaces of scheelite crystals gave a weak fluorescence under strong ultra-violet light.

The underground workings—except for the upper portions of some shafts—were all examined and lamped during day time. It was found essential that all faces to be lamped should be thoroughly washed down—frequently a very difficult procedure in old workings—since not only do the accumulated dust, mud and (frequently) salt, very effectively mask any scheelite which may be present, but scheelite fragments and scheelite dust may often be distributed over barren faces as a result of the firing of a

scheelite-bearing face considerable distances away. Furthermore, the composite machine oils used underground invariably fluoresce fairly strongly, giving a whitish light under the lamp, and it was found necessary to examine insufficiently cleaned faces with great care in order that no small oil spots should be mistaken for scheelite. The strong tendency of scheelite to crush to a fine slime under the impact of explosives was clearly demonstrated on several occasions when partly washed, freshly fired scheelite-bearing faces were found under the lamp to be covered by a fine white fluorescent sludge.

In order to obtain as much experience as possible in quantitative estimations by visual examination of scheelite under ultra-violet rays, the writer carefully inspected and lamped all dumps which had been sampled and assayed for WO_3 , at all centres visited. Conclusions to be drawn from these inspections, however, are subject to modification by a number of variable factors, viz., the degree of superficial concentration on old dumps (both sand dumps and ore dumps) by wind and rain erosion, the average grain size of the ore in the dumps, the possible presence of the sometimes associated tungsten mineral wolframite, which does not fluoresce, and the well known tendency of scheelite to slime, and its ability to self concentrate in sands, etc. However, as a result of his observations the writer was able to obtain a limited amount of useful comparative data upon which to base a quantitative estimate of scheelite during lamping.

The Deposits.

Londonderry.

Whilst in the Coolgardie district the opportunity was taken to inspect and lamp a scheelite prospect held by the Coolgardie Scheelite Syndicate. This is situated about one mile from the old tantalite leases at Tantalite Hill, on a bearing slightly east of north, and about two miles south-west of the old Londonderry townsite.

The find consists of a small prospecting shaft sunk to a depth of about 15-18 feet on a narrow quartz vein in schistose epidiorite-amphibolite country. This shaft is situated on the southern slopes of a low hill in undulating country. The quartz vein is about 18 inches to 2 feet in width and where exposed strikes in the direction north 85° east. About 10 feet east-north-east of the shaft are the outcrops of several thin quartz stringers which run in an approximate north-south direction.

About 12 feet south-west of the prospecting shaft is a shallow pot hole less than 8 feet deep. On the north face of this hole is exposed about 15 inches of quartz together with several stringers 1 inch wide. Underfoot the quartz bulges to about 3 feet wide.

The writer was informed that scheelite had been found in the prospecting shaft. To a depth of about 10 feet this shaft had been opened out to about 8 feet by 6 feet, whilst below this it was much smaller. It was claimed that scheelite could be traced over a length of 5-6 feet having an average width of about 8 inches and a maximum of 1 foot. On lamping it was found that there was practically no trace of scheelite on the north-eastern face of the shaft, whilst scheelite fragments, scattered over one thin seam having a maximum width of about 6 inches could be traced in a mixture of quartz and amphibolite stringers on the south-western face. A thin skin containing a little scheelite was disclosed on the north-western wall. The quartz reef appears to dip steeply to the north-west. No scheelite was visible on the floor of the shaft which was covered with rubble. The scheelite concentration in this shaft seemed disappointingly low, being probably less than .5 per cent. over a workable width of (say) 3 feet for the full length exposed. On lamping, small fragments of scheelite were seen to be sporadically scattered through the adjacent quartz dump, which contained no more than about five tons of broken stone.

There was almost no sign under the lamp of the existence of scheelite in the shallow pit south-east of the prospecting shaft, though it is reported that a few fragments have been obtained from here. A small dab of gold was originally found in this hole. The

lamp also revealed no trace of scheelite associated with the quartz stringers outcropping to the east-north-east of the shaft.

It was claimed that traces of scheelite had been found associated with quartz along a line extending southwards on the surface for more than 3,000 feet. Using the lamp it was found that occasional specks of scheelite, sometimes associated with quartz floaters were to be seen in one or two places, but there was absolutely no sign of the existence of any connected scheelite lode formation, the amphibolite to the south of the find proving for the most part quite barren.

Higginsville.

Geology and Occurrence.—At the time of the writer's inspection mining development operations were being carried on at the Higginsville Scheelite Mine on G.M.L. 5668, by Norseman Gold Mines, N.L. The mine is situated on the crest of a low ridge running approximately north and south, at about $\frac{1}{2}$ mile south-east of the Higginsville railway siding. The country rock hereabouts is medium grained fibrous actinolitic amphibolite having a rude schistosity, in some places merely incipient and superficial and in others distinctly marked, and trending at all angles from about north 10° east to north 10° west.

Surface workings along the alleged main line of scheelite lode extend over a length of about 400 feet in the direction north 20° east from the main shaft at the southern end of the workings through the No. 1 north shaft which is approximately 100 feet north of the main shaft, to the No. 2 north shaft, about 200 feet further north again. The main shaft and No. 1 north shaft are connected by underground workings, and at some 30 feet north of the latter shaft is a narrow open cut leading downwards into a stope, but northwards of this point the workings consist of a series of shallow potholes, trenches and costeans.

At a little less than 50 feet north of the main shaft a quartz reef which branches to the north-east is exposed in an open-cut. This is a fairly well defined vein averaging about one foot wide and is known as the North-East Branch Lode. It strikes at approximately N. 55° E. and is traceable on the surface for 80-90 feet. A shaft sunk on the line of this lode at about 100 feet from its point of branching with the main lode has been called the No. 1 north-east shaft. There are no further surface indications of the branch lode north or north-east of the No. 1 north-east shaft, although the presence of several costeans and pot holes indicates that a search had been made for its continuation.

The surface workings were first lamped. Several old dumps in the northern and central portions of the main line of workings showed the presence of a fair amount of scheelite fragments, confirming dish samples previously panned by the company. Definite traces of scheelite were also proved in several dumps and in the sands on a lease adjoining the scheelite lease to the north. At a point about 200-230 feet north of the main shaft, and on the east-sloping ground just below the "main lode" line of surface workings was found a fair concentration of detrital scheelite mixed with gravel and loam. This material was in all probability shed from the outcrops of pre-existing scheelite from the crest of the rise in this vicinity and it is possible that some more scheelite veins may be found as a result of further surface prospecting hereabouts.

Scheelite was seen *in situ* in several trenches and one open-cut in the main lode line of workings. Its common occurrence was as thin stringers occasionally associated with a little quartz and in other places almost devoid of quartz, in amphibolite schist country. It was noted also that the country rock was frequently very little oxidised or weathered right up to the surface outcrops. From a superficial examination it appeared that the scheelite was very irregularly distributed through the lode channel and was of a distinctly lenticular habit. A few very insignificant traces of scheelite were found with the aid of the lamp in several pot holes sunk south of the main shaft in localities where scheelite was reported to have been found. Lamping of the current ore dump revealed that except for an occasional specimen stone very little more scheelite could be detected under the ultra violet rays than with the naked eye, and that the *apparent* scheelite content of the ore dump was

no greater than that of the adjoining mullock dump. This was undoubtedly due to the fine rock dust masking ore and mullock alike.

The scheelite lode formation in the main lode has been opened up underground and mined at the southern end over a length of about 150 feet. The main shaft has been sunk to a depth of about 100 feet, whilst levels have been driven at approximately 40 feet and 70 feet. A considerable block of ore has been stoped north of the main shaft above the 70-ft. level, between 25 feet and 120 feet north. A further block has been stoped south of the main shaft for about 50 feet, between about 30 feet and 60 feet, vertical depth.

The lode formation is a white quartz reef. Lamping underground revealed that where found the scheelite usually occurs as marginal stringers or bunches moulded on one side against quartz, and on the other against the amphibolite wall rock. Frequently the stringers could be seen completely enclosed in the amphibolite, but scheelite was seldom found embedded in the wider and more solid portions of the quartz reefs. The scheelite was very irregularly distributed, making any estimate of ore reserves very difficult to obtain. The greater part of the lode formation in the northern end of the 70-ft. level appeared to be barren of scheelite. A short length of what appeared to be fair grade scheelite ore (1.5 per cent.?) is probably still available between the main shaft and about 25 feet north, above the 70-ft. level. Although some massive bunchy scheelite is obtained, under the lamp it appears that the mineral is disseminated in fairly thin stringers and flattened fragments. The lode formation as a whole dips almost vertically or at a very steep angle to the east and during lamping it was observed that, if anything, the scheelite stringers favoured the hanging wall rather than the footwall of the formation.

Very little scheelite was seen in the south end of the workings at the bottom level, but overhead over a length of about 15 feet some scheelite ore remains to be stoped. Scheelite stringers very broken and irregular but more or less continuous in formation were traced in the main shaft from 15 feet to 40 feet down on both north and south faces. There was very little sign of scheelite in the bottom sections of the main shaft.

The No. 1 north-east shaft has been sunk to a depth of about 42 feet on a steep underlay to the south-east, and some driving and stoping has been carried out for a short distance south-westward. The lode formation appears to have cut out a short way north-east of the shaft. The No. 1 north-east shaft workings are not connected underground with the main workings. Lamping revealed fair scheelite values on the hanging wall of the No. 1 north-east shaft between about 10 feet and 42 feet (bottom) suggesting the necessity of taking out further stripping cuts and possibly crosscutting into the hanging wall to test the possible width and extent of the scheelite stringers. It was noticeable that where the quartz formation was large and massive, in the No. 1 north-east workings, it was usually found to be barren of scheelite.

From the lamping of the surface and underground workings on this lease it is obvious that appreciable quantities of scheelite do exist and although in a few places good concentrations of coarsely crystalline scheelite have been found, in general its irregular distribution and often widely disseminated state make selective mining to obtain even up to about .8-1 per cent. scheelite in the final ore a matter of considerable difficulty. The present company operating this deposit is endeavouring to maintain an average production of about 50 tons per week of ore containing about .6 per cent. scheelite. In order to carry out any large scale mining for scheelite in the Higginsville district it appears obvious that it would be necessary to perfect a treatment plant capable of successfully concentrating scheelite ore containing at least as low as .01 per cent. scheelite.

Treatment.—Whilst in the district the writer took the opportunity of inspecting the scheelite treatment plant which is located at the Norseman Gold Mines, N.L.s., Norseman Mine at Norseman. The treatment consists of crushing to pass a coarse screen (about one-eighth mesh), the crushed ore then passing direct from the trommels to two Wilfley tables arranged in series. A sample of the residues from the treatment plant was tested under the ultra violet rays. The sample had been sieved

through screens of varying mesh from medium-coarse down to very fine. It was found that scheelite could be clearly distinguished in relatively appreciable quantities in all fractions, indicating a distinct loss in treatment. From a purely megascopic examination the writer estimated that the residue contained in the neighbourhood of .05 per cent. scheelite. It was interesting to note also that, although the quantity of residue contained in each fraction differed slightly, the percentage of scheelite visible in each fraction appeared to be roughly of the same order.

Samples of residues have now been sent to the School of Mines, where it is hoped that with the aid of the Superpanner more quantitative data regarding the scheelite losses from this treatment plant will be obtained.

Comet Vale.

Geology and Occurrence.—The scheelite workings (M.C. 23Z) at Comet Vale are situated on the late G.M.L. 5590Z (5410Z), "King of the Hills," in hilly country immediately west of Lake Goongarrie, and three to three and a half miles east of Comet Vale town-site. The country rock in the vicinity of the lease consists of fairly dense fine grained, usually blocky altered basic lava—now serpentinised basaltic amphibolite which here and there shows a rude schistosity striking nearly east and west. A large white quartz reef has intruded the amphibolites in a composite belt in the central northern portion of the lease. This quartz runs approximately 10° north of due west in a broken line over a length of about 500 feet, and forms the backbone of a sharp ridge which slopes down steeply to the south to a broad gully, and to the north into a short east running gully. The lease is flanked to the north, south-west and south-east by high land. A thin dyke of felspar porphyry intersects the amphibolite-quartz ridge in the centre of the lease, running in an approximate north-south line almost up to the quartz reef where it cuts out abruptly.

The amphibolite in the immediate vicinity of the previously mentioned line of quartz reef, on both its northern and southern sides has been altered to a coarsely crystalline amphibolite (actinolitic) schist. Evidence of movement in the schist along a line of fissuring prior to the intrusion of the quartz can be seen in the presence of small drag folds in the planes of schistosity of the schist lying immediately south of the quartz in several places, and also in the curved and folded legs occasionally emanating from the main quartz body, suggesting intrusion and replacement by the quartz of pre-existing drag folds.

Portions of the composite quartz reef on the eastern half of the ridge have been mined for gold in the past, several adits having been driven into the hill from the east and south-east. The adits extend into stopes, several of which open upwards into open-cuts, and also connect up with a winding drive running a little west of north for about 200 feet.

At about half way along the quartz reef line there is a distinct break of about 50 feet in the reef, the quartz on the western side of this gap apparently having been displaced slightly to the south-westward. The scheelite workings at present being operated are located along a line of schistosity which cuts through the gap in an approximate east-west direction, making an angle of about 25° with the main quartz reef line. These scheelite workings are connected to a long inclined adit, the south adit, running into the hill in the direction of N. 45° E. for a distance of about 110 feet.

As a result of his surface inspections, the writer prepared a rough geological sketch map of the area, fixing the geology and the positions of surface workings by pace and compass traverses. The approximate positions of the underground workings on this map are based on a plan by M. V. Weatherall, kindly loaned the writer by Mr. E. Mundle, of Gold Fields Australian Development, Ltd.

Lamping for scheelite was first carried out over the surface workings. Traces of scheelite seams were seen in several small potholes about 120 feet N.N.W. of the scheelite workings (west shaft) and in a long shallow trench or open-cut extending immediately west of this point. No sign of scheelite was found on the surface between this open-cut and the workings, the slopes here being covered by a thick mantle of quartz boulders and

rubble. Despite the heavy overburden, however, it is probable that did a strong line of scheelite lode connect the present workings with the abovementioned open-cut, some traces at least of scheelite would have been found in the loam on the lower slopes in this vicinity.

About 70 feet further west of the open-cut referred to above, is another trench or open-cut some 20 feet long and eight feet deep on the western slope of the central ridge. Scheelite was reported to have been obtained from this trench in the past. The east and west faces showed about one foot of white quartz, none of which revealed scheelite under the lamp. Traces of scheelite were seen on the northern wall of the trench, however, whilst frequent scheelite specimens were visible in an adjacent small dump of quartz fragments evidently broken out from the trench.

At some 65 feet to the westward and down the slope from the last trench is the mouth of the west adit, which runs at about N. 25° E. into a hill for about 35 feet, where it branches into two forks each extending a further 20 feet. At about 15 feet from the mouth of the adit the lamp revealed a thin seam of scheelite having maximum width of about two inches associated with stringy quartz in amphibolite schist. A few scattered blebs of scheelite were also located near where the adit drive forked. The exposures in this adit gave little promise of yielding workable supplies of scheelite.

At the writer's suggestion two short costeans were dug at intervals in the country between the two scheelite-bearing open-cuts or trenches described above. No trace of scheelite was found in either of these, on lamping, indicating that the scheelite occurrences along this belt are more or less isolated and do not represent portions of a continuous lode formation.

At about 60 to 70 feet due north of the main scheelite workings is a short line of shafts and surface pot hole running in the general direction of N. 60° W. These workings are on what is known as the north lode which is reported to have been worked for scheelite during the last war. The shafts here were inaccessible but the dumps under the lamp revealed an abundance of scheelite fragments.

No trace of scheelite was found during a brief lamping of the broken surface quartz in the eastern half of the composite quartz reef ridge.

Lamping of the underground workings revealed that the scheelite ore is only sparsely distributed through the lode formation in a disappointingly irregular manner. The workings consist of a rather winding west drive running from the foot of the inclined south adit at a vertical depth of about 50 feet, for about 75 feet to meet the west shaft (vertical), and also an east drive running eastward for about 55 feet. The east shaft (vertical) connects with the east drive at about 20 to 25 feet east of the adit. A crosscut has been driven northwards from near the face of the east drive for a distance of 25 feet and opposite this north crosscut is a short crosscut running south to break through into the old gold workings. Scattered thin seams of scheelite nowhere more than about one inch wide were seen in the back of the west drive at its extreme western end near the west shaft, and a few small crystals were noticed on the south wall about 30 feet west of the adit. The remainder of the west drive appeared quite barren of scheelite. The beginning of the east drive also appeared quite barren overhead except for a strip from about 15 feet west of the east shaft to the shaft itself where some scheelite was visible in the backs of a small leading stope. The average grade of ore in this stope is probably less than one per cent. over a width of 15 inches. Eastward of the east shaft the only scheelite seen was one or two small scattered crystals on the south wall. There was no sign of scheelite in the north crosscut which had been driven out in an attempt to intersect the eastern continuation of the old north lode scheelite formation. Scheelite was visible on both the eastern and western faces of the east shaft almost from the surface down to about 40 feet V.D., in discontinuous lines of stringers. The maximum width of scheelite mineralisation in the shaft is about 18 inches, the average about nine inches. A lamping estimate based on observation alone suggests an average grade of little more than one per cent. scheelite in this section.

It was noticed that the scheelite in this mine was seldom associated with quartz bodies of any size. More commonly it occurs in scattered small crystals or thin stringers enclosed in actinolitic schist, though occasionally scheelite fragments are found moulded upon thin quartz stringers. Nowhere was the scheelite seen in bunches or in large crystalline aggregates. In general it must be understood that the development work carried out in the scheelite workings to date has exposed no appreciable tonnage of available scheelite ore but rather to the contrary has revealed that only relatively very limited quantities of workable ore can be expected from this mine.

The writer was informed that during development good scheelite ore was encountered underfoot along the southern side of the east drive from a short distance past the adit to a point about 10 feet east of the east shaft, but the lamp failed to reveal any sign of scheelite in the muddy floor. From the general tenor of the ore elsewhere in this part of the mine, it is doubtful if any better average grade would be obtainable underfoot. However, the possibility of an improved scheelite value at depth should certainly be tested by means of a winze sunk on the lode formation in the east drive.

In passing it may be mentioned here that on the flat low ground forming the north-eastern corner of the lease are the sands and residues dumps from the old scheelite treatment plant operated during the last war. The profiles of several portions of one dump were lamped and it was interesting to note that an appreciable quantity of fine ground scheelite could be seen in roughly banded layers throughout the dump—in places concentrations up to about five per cent. or more.

Treatment.—Mining development operations at Comet Vale have been carried out by Goldfields Australian Development Company Ltd., which was responsible for the sinking of the west and east shaft and for the driving on the east and west drives and the north crosscut. Two parcels of ore obtained during this development work have already been treated at the State Battery, Coolgardie. These two crushings were of 50 tons and about 100 tons respectively. A third crushing of 30 tons had been railed to Coolgardie a few days before the writer's arrival at Comet Vale. The ore for this last crushing was obtained from the small leading stope off the east shaft on the east drive and is probably more representative of the ore to be obtained by selective mining than the first two crushings which were obtained solely from development work. About 150 tons of further development ore remains in dumps on the lease.

The figures for the treatment of the first two parcels only are so far available. The following were supplied through the courtesy of the Superintendent of the State Batteries:—

Parcel.	Weight of Ore.	Weight of Concentrates.	WO ₃ Content (Calculated from Assay).	Per cent. WO ₃ Recovered.
1	tons. 50	lbs. 440	lbs. 168	·15
2	97	266	166	·076
Total ...	147	706	334	·102

From these figures it can be seen that, even allowing for a possibly rather low percentage recovery from the treatment plant at the Coolgardie Battery, the head value of the scheelite ore in these two parcels must have been fairly low—well under 5 per cent. scheelite.

Westonia.

Towards the close of his tour the writer made a brief inspection of the property of Edna May (W.A.) Amalgamated Gold Mines at Westonia. Wolframite is reputed to have occurred in the past in relative abundance through the ore bodies of this mine and the present company has recently been engaged in sampling and testing some of the old sands dumps with the object of deciding on the possibility of re-treating these for recovery of their tungsten content. Sample analyses

had indicated that the two dumps on the western side of the leases contained appreciable quantities of tungsten, and experimental work is at the present time being carried out at the School of Mines, Kalgoorlie, to work out various technical details of a practicable treatment process.

An evening was spent in lamping the various sands dumps on the leases. In general the ultra-violet rays gave very useful confirmation of the sampling results and indicated furthermore that a considerable proportion of the tungsten present in these dumps occurs as scheelite as well as wolframite. The best concentrations of scheelite were seen in the two dumps on the western sides of the leases as mentioned above, whilst a drain running at the foot of the principal dump was found to contain a high concentration of both scheelite and wolframite. Scheelite was usually found to be relatively abundant amongst the coarser residues in the vicinity of the original spillways in many of the old dumps.

The geology of the Edna May mining centre was recently described by Mr. R. S. Matheson.* Briefly, the gold bearing lodes here consist of a complex series of quartz reefs intruded in an elliptical belt forming the contact between greenstone (amphibolite) and a series of granitic replacement gneisses.

A profitable day was spent in lamping various portions of the old and new underground workings. Finely disseminated scheelite was located in a number of places where tungsten ore (originally thought to be principally wolframite) had been known to occur in the past. In the old workings especially, the results of the lamping were of course considerably impaired by the mud and dust covering everything, but some good examples of what is probably the typical occurrence of scheelite in the mine were seen in portions of the new workings on the No. 6 level hanging wall section of the south reef and on the No. 5 level (south reef) in the Central Lease. It was noticeable that the scheelite occurred principally in the wall rock immediately adjoining the quartz reef rather than in the reef itself. The most favourable host rock appeared to be a rather streaky type of quartz biotite gneiss which may be either coarsely or finely banded. The scheelite occurs either in small seamlets or in scattered groups of individual fragments or disseminated tiny grains. Seldom was scheelite seen in any quantity in the blocky reef quartz itself.

Scheelite evidently occurs in many cases associated with and replacing wolframite. On examining individual specimens of apparently massive homogeneous crystalline wolframite, from various localities underground, under the ultra-violet rays it was found that in all specimens the wolframite was in course of replacement, to a varying degree, by granular aggregates of fine crystalline scheelite.

From the underground lamping it was clear not only that the scheelite (and presumably wolframite) was distributed very sporadically through the mine, but that the maximum concentrations of tungsten ore present in any part was far too low to permit of any economic mining for tungsten alone. However, providing a suitably efficient extraction process is obtained, some useful quantities of tungsten ore should be available from the two old sands dumps mentioned above (some 60,000 tons of sands in all). Furthermore, if the company were to carry out its present intention, on the erection of suitable plant, of treating the current run of ore residues before passing them out to the dump, it should be possible to increase the tungsten head value of the ore at little extra cost by judicious mining here and there of some additional selected wall rock.

In this way a small but no doubt useful production of an extremely important and valuable, in fact, essential, war-time mineral could probably be maintained for a considerable time to come.

Conclusions.

As a result of his inspections of the scheelite deposits at Londonderry, Higginsville, Comet Vale and Westonia described in the preceding pages, the writer has drawn the following conclusions:—

- (1) The Londonderry occurrence is more of mineralogical interest than of economic importance, there being no indication in the present exposures that any ore body of workable size exists.
- (2) At Comet Vale development has revealed limited quantities of scheelite sporadically distributed in a rather poorly defined ore body. Although there are no geological reasons why the scheelite should not exist at least in similar grade at depths greater than those so far explored, the possibilities of other than a very small scale of production appear rather remote under existing conditions.
- (3) The Higginsville scheelite mine contains scattered lenses of fairly good grade scheelite and other sections in which disseminated low grade scheelite is available. Development operations so far carried out indicate the customary sporadic distribution of this ore, however, which adds considerably to the difficulties of economical mining. The ore formation appears to continue strongly in depth and further lenses should be met with below the existing bottom level.
- (4) Lamping of the sands dumps and parts of the underground workings of the Edna May Amalgamated Gold Mines, at Westonia, has confirmed sampling results indicating fair concentration of scheelite and wolframite in several of the dumps; and has provided some valuable information regarding the general distribution of scheelite in the ore bodies of the mine itself.
- (5) The remarkable value of the Mineralight lamp in investigations of this nature, and the tremendous advantage of its assistance over the old and laborious "blind stabbing" methods of dish sampling in scheelite mining were clearly demonstrated during the course of this tour.

A LEPIDOLITE DEPOSIT NEAR TANTALITE HILL, LONDONDERRY, COOLGARDIE, G.F.

By K. R. Miles, D.Sc., F.G.S.

During a visit to the district in March, 1943, the writer made a search for a pegmatite dyke thought to contain appreciable quantities of the lithium bearing mica lepidolite in the vicinity of the tantalite leases at Tantalite Hill, south-west of Londonderry. The aim of this search was to investigate the possibilities of the lepidolite deposit as a source of lithium, for which there was reported a keen war-time demand. The pegmatite dyke was duly located within the boundaries of the late M.L. 86, "Tantalite Ridge" (since taken out as M.L. 93), which forms the south-eastern member of a group of mineral leases originally pegged for tantalite, around the site of the original tantalite find known as Mercer's Find and later called Tantalite Hill, which lies some three miles W.S.W. of the old Londonderry railway siding.

Geology and Occurrence.

The country hereabouts consists principally of greenstone—medium-fine and coarser grained amphibolite and amphibolite schists having a general north-south trend and occasionally capped by ferruginous laterite. The country is undulating and moderately well timbered. The pegmatite dyke in question runs in a direction approximately N. 30° E., intruding the greenstone and is probably about 100-200 feet wide, both the eastern and western boundaries being obscured by overlying soil and rubble. The dyke is either rather irregular in composition, containing segregated areas of quartz, lepidolite-bearing feldspar pegmatite and lepidolite lenses, or is a

* Reports on Some Mining Groups in the Yilgarn-Goldfield—Edna May Group. Annual Progress Report Geol. Survey, W.A., 1939, pp. 18-22.

composite one in which masses of white quartz have apparently been later intruded into the original pegmatite-filled fissure. Outcrops over the full length and breadth of the dyke are very irregular and poor, a great proportion of the dyke being hidden under soil and rubble over-burden.

Four lenses of massive scaly lepidolite were located within this pegmatite dyke-zone. The largest lens (No. 1) lies approximately four chains on a bearing N. 60° W. from the south-east corner peg of M.L. 86. This portion of the dyke lies on the northern side of a gentle slope which rises gradually south-westwards to a ridge whose crest is formed by a low outcrop of white quartz. Northwards the ground flattens to a gentle rubble covered slope.

The lepidolite in these lenses consists of masses of interlocking scales averaging .05-.1 inches in diameter. The lenses are irregular bodies, lenticular, and more or less elongated in the main direction of the dyke. Their margins are usually seen to be moulded upon clear white quartz. Their general distribution was fixed by pace and compass traverses as shown on the accompanying sketch plan, plotted on a scale of 40 feet to an inch.

The main lepidolite lens (No. 1) is the most southerly of the group. It measures approximately 33 feet in length, has a maximum width of about 9 feet and tapers out to thin stringers both to the north and the south. No. 2 lens is situated in the line of No. 1 lens about 12 feet further north. It has a maximum length of about 10 feet and average width of not more than 18 inches. Some 20 to 25 feet east of No. 1 lens and running the direction north 50° east is another thin broken lens of massive lepidolite (No. 3) extending over a length of about 16 feet with an average width of about 18 inches. No. 4 lens also rather irregular in width, lies about 55 feet due north of No. 1 lens and runs in the direction north 40° east for about 20 feet. Its average width is probably slightly less than 18 inches.

Tonnage.

Assuming then that lens No. 1 has an average width of about five feet (a generous estimate), then the total area of lepidolite exposed at the surface in the four lenses would amount to approximately 234 square feet. Allowing for the lepidolite ore to weight at the rate of 15 cubic feet/ton, then the tonnage of lepidolite ore available would be approximately 15½ tons per vertical foot. Now it is to be expected by the very nature of the occurrence that these lepidolite bodies will be lenticular in depth as in length. Assuming that they extend to depths equal to their lengths, before lensing out or giving way to further lenses, it would be a generous estimate to concede an average depth of 30 feet for the deposits. Based on a average depth of 30 feet, the total tonnage available from surface indications would then be approximately 450 tons. This may be considered a maximum figure. Loose boulder and rubble of lepidolite scattered over the ground surface might yield a further five or six tons of ore.

Grade.

In order to determine the grade of this lepidolite ore a representative sample of chips from the four lenses were collected by the writer and these were submitted to the Government Mineralogist and Analyst for an analysis of the lithium content. Although the chips appeared to consist almost entirely of interlocking lepidolite flakes, it is probable that the ore contains a certain amount—possibly up to 10 per cent.—of interstitial granular quartz.

The lithium analysis proved the ore to be of low grade, containing only 3.87 per cent. Li_2O . This indicates a fair percentage of impurity in the original ore as pure lepidolite usually contains from 4.5-6.2 per cent. Li_2O . There is at the present time a steady demand for lithium ore, the American price being A16s. 11½d. per long ton unit of contained Li_2O . Buyers have stipulated a minimum grade of six per cent. Li_2O however, which appears to rule out all possibility of utilising the above described lepidolite deposit under existing market conditions.

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