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—
WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 82.

THE
MAGNESITE DEPOSITS OF BULONG,
North-East Coolgardie Goldfield.

WITH NOTES ON
THE PREPARATION AND USES OF MAGNESITE,
BY
F. R. FELDTMANN.

*Issued under the Authority of
The Hon. C. A. Hulson, M.L.A., Minister for Mines.*

WITH TWO PLATES AND SEVEN FIGURES.



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1919.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA.

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PREFATORY NOTE.

One of the many effects of the War has been the cessation of the production of Magnesite by the different belligerent nations. and has led to very many inquiries as to (a) the occurrence of local deposits, and (b), if deemed adequate, whether exploitation, etc., would be justified with the view to making Western Australia (and the Commonwealth) industrially independent.

Recognising the fact that the State's store of mineral deposits is a national asset, of which it became necessary to take stock, certain geological investigations into the magnesite-bearing rocks and deposits of Bulong were authorised.

The occurrence of magnesite at Bulong had been known to the Department since 1897, but it was only as a result of the war conditions that any serious attempt at its exploitation was inaugurated.

About two months were devoted by Mr. Feldtmann to work in the field, and as a result of the survey it appears that in their geological relationships the Bulong magnesite deposits conform to similar occurrences of the mineral in other parts of the world. The Bulong magnesite occurs in a serpentine rock in the form of short irregular veins of varying size, which in certain parts are sufficiently numerous to form a stockwork; in addition, there is a surface coating of a magnesite cement, which covers an area of about 15 acres. The analyses of the mineral in the Survey Laboratory show it to be of an excellent grade of commercial magnesite, whilst the field observations demonstrate that there is a considerable quantity of high grade material available in the deposits exposed near Bulong.

The report is illustrated by two geological maps and several photographs.



GOVERNMENT GEOLOGIST.

Geological Survey Office,
Perth, 24th December, 1918.

THE MAGNESITE DEPOSITS OF BULONG.

North-East Coolgardie Goldfield.

With Notes on the Preparation and Uses of Magnesite.

I.—INTRODUCTION.

Attention was first seriously drawn to the magnesite deposits in Western Australia in September, 1913, when application was made for a reserve of 470 acres, for exclusive rights to prospect and mine for magnesite, situated about 7 miles NNW. of Kundip in the Ravensthorpe District, and about 2½ miles NNE. of Desmond township. Magnesite from that district had, however, already been used by the Phillips River Gold and Copper Company, Limited, as a flux in their copper reduction furnaces and for the manufacture of bricks for lining convertors.

Later in the same month application was made for a reserve of 640 acres, situated between the township of Bulong and the western edge of Lake Yindarlgooda in the North-East Coolgardie Goldfield. This reserve (59H) was approved and gazetted in November, 1913.

In December 1913, a reserve for the same purpose, about 4½ miles northeast of Coolgardie, was applied for and approved, but was surrendered after a short trial.

In 1914, bulk samples of the Bulong magnesite were sent by the interested syndicate—the Magnesia Syndicate, Ltd.—to South Australia and Germany. Encouraging reports on these samples being received, a hundred tons of magnesite was raised.

The declaration of war with Germany and Austria making it impossible to obtain supplies of the mineral from Austria, further impetus was given to the working of the Bulong deposits, and the reserve was extended to include 1,000 acres.

In April 1915, the writer was instructed to examine and map the Bulong deposit and proceeded to Bulong in the same month. The survey of the deposits and surrounding country—about 40 square miles in all—was finished in July, 1915.

Owing to lack of assistance in the field, the survey had to be made by prismatic compass, an unsuitable instrument for the work, owing to the great differences in the local magnetic variation at various points. With the instrument used, the local variation was

found to range from about 1° E. to about 54° W. (at Mt. Magnetic), the average variation being about 2° W.

A preliminary report on the results of the survey was published in the Annual Report of the Geological Survey for 1915.

In March 1916, two Mineral Claims 1^Y and 2^Y , of 300 and 150 acres respectively— M^1 . C^m . 1^Y covering a large part of Reserve 59H—were taken up by the Permasite Manufacturing Company, Ltd., which had taken over the interests of the original syndicate.

The district was revisited by the writer in November 1917, to examine the progress made in the working of the deposits, and a report thereon was written for the Annual Report of the Geological Survey for 1917.

The present report contains in addition to the information given in the previous papers—somewhat amplified—notes on the magnesite deposits of other countries—inserted for purposes of comparison—and on the products and uses of magnesite. In the compilation of these notes the works mentioned in the footnotes—in particular Bulletins 355 and 540 of the United States Geological Survey, the Report on the Mineral Resources of the United States for 1913, and Memoir 98 of the Canadian Geological Survey—have been freely used. The writer is indebted to Mr. E. S. Simpson for the revision of this portion of the report, also to Mr. E. de C. Clarke for a general revision of the manuscript. The sections of the Bulong rocks were examined by Mr. R. A. Farquharson, Petrologist to the Survey.

II.—PROPERTIES AND USES OF MAGNESITE.

PROPERTIES OF MAGNESITE.

Theoretical Composition.—Magnesium Carbonate ($MgCO_3$); 47.6 per cent magnesia (MgO), 52.4 per cent carbon dioxide (CO_2). Hardness—3.5 to 4.5. Specific Gravity—3 to 3.12; a cubic foot of solid magnesite weighing about 190 pounds. Colour—dazzling white, but grey or brown when impurities, such as clay, iron oxides, or serpentine, are present in any quantity. Transparent to opaque. Fracture—flat conchoidal, showing a surface like broken porcelain. Weathered surfaces usually have a characteristic hackly outline, or else the appearance of a cauliflower, but are smooth and powdery where frequently subjected to the action of water. Crystallizes in the rhombohedral system, but is more usually massive. Is practically insoluble in cold hydrochloric acid, but readily soluble in the warm acid.

When subjected to high temperatures, magnesite is gradually broken down, proportions of the CO_2 being driven off, according to

Brill,* at certain temperatures between 237°C. and 510°C. , a series of compounds with the general formula of $n\text{MgO} \cdot (n-1)\text{CO}_2$ being formed between 237°C. and $405^{\circ}\text{C.}^{\dagger}$

Two main types of magnesite deposits are found:—

- (a) Replacement deposits of *crystalline* magnesite; the Austro-Hungarian deposits, and those of the Grenville District, Canada, are of this type. The Tumby Bay deposits, South Australia, are also replacement deposits, but the writer has no information as to whether these are crystalline or massive.
- (b) Veins or lenses of *massive* magnesite in serpentine; these include the Grecian, Californian, New Caledonian, and Transvaal deposits and those of many other countries, including most of the Australian States. Veins of crystalline magnesite occur in serpentine at Drammen, Norway, and other places, but this type of occurrence is uncommon.

Hydromagnesite: Of the many natural hydrous carbonates of magnesium, the only one of commercial importance is the basic carbonate hydromagnesite ($3\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 + 3\text{H}_2\text{O}$), the theoretical composition of which is 43.9 per cent magnesia, 36.3 per cent carbon dioxide, with 19.8 per cent combined water. It occurs usually in the amorphous form as a white fine-grained, powdery deposit, and occasionally as small tufted silky crystals. It is found as beds in shallow depressions (as at Atlin, British Columbia) and as veins in serpentine or other magnesia-rich rocks. Unlike magnesite, it gives off abundant water when heated in a closed tube.

PREPARATION, PRODUCTS, AND USES OF MAGNESITE.

Magnesite is marketed and used in three forms—crude, caustic calcined, and dead-burned.

Crude Magnesite. This is merely the mined or quarried mineral after removal of as much of the impurities present as is convenient by hand-picking. It is used for the manufacture of carbon dioxide, magnesia, and the sulphate (Epsom salts) and chloride of magnesium.

Caustic calcined. This is produced by calcining the crude material at temperatures ranging from 800°C. to $1,100^{\circ}\text{C.}$, according to the use to which it is to be put. By this method from 2 to 8 per cent of CO_2 is retained, and the resultant material is mouldable at high pressures, like lime slakes in contact with water, and combines readily with magnesium chloride to form a hard, vitreous cement

*Brill, Otto, Ueber die Dissoziation der Karbonate der Erdalkalien und des Magnesiumkarbonates: Zeltschr. anorg. Chemie, vol. 45, part 3, June, 1905, pp. 277-292.

†The magnesite used in these experiments was specially prepared and purified.

(oxychloride or Sorel cement). Caustic magnesite deteriorates rapidly by absorption of CO_2 and moisture from the atmosphere. A series of experiments carried out by Sen* show the loss of weight of magnesite calcined at various temperatures, and also the gain in weight of the calcined material due to reabsorption of CO_2 and moisture after continued exposure to the atmosphere. The summary of the results is as follows † :—

Temperature of Calcination.	Total loss per cent on heating.	Specific gravity of MgO .	Total gain in weight due to reabsorption of moisture and CO_2 per cent.	Approximate reabsorption of moisture per cent.	Approximate reabsorption of CO_2 per cent.
700°C	50.86	3.327	12.97	7.09	5.82
1,000°C	51.03	3.334	3.86	2.20	1.89
1,200°C	51.19	3.529	1.25	0.86	0.48

Dead-burned Magnesite. Magnesite, when subjected to a white heat (from 1,500° C. to 1,700° C.), loses practically all its CO_2 —less than 1 per cent. being retained—diminishes greatly in bulk, and becomes dense, hard, and practically unmouldable. It is exceedingly refractive and chemically inert. It does not slake with water, but is said to disintegrate in contact with steam.

Dead-burned magnesite is used in the manufacture of fire-proof basic bricks and hearths, converter linings, and other refractory material. Morganroth‡ states that white massive magnesite is less suitable for this purpose than the crystalline variety, as the former “decrepitates or burns to a powder” before all the CO_2 is driven off. He also states that, on account of its content of chemically combined iron, the Austro-Hungarian magnesite is more readily dead-burned and sets more readily than the purer material obtained elsewhere; the same results may, however, be obtained by the addition of iron to the purer massive material. In this connection, it should be noted that analyses of the Bulong magnesite show, on the average, a fairly high iron content.

Calcination of Magnesite. Magnesite is burned in kilns either of the bottle or vertical shaft type, or of the rotary type. At the Veitsch work (Styria), according to Morganroth§—

“It is burned in kilns of the bottle variety. These kilns burn, on the average, 12 to 15 tons in 24 hr. As a rule, producer gas is used as fuel. Within the last few years several plants have installed kilns of the rotary or cement type to burn the magnesite, powdered coal being

* Sen, A. M., Tests on the air slaking of magnesite calcined at various temperatures : Mysore Dept. of Mines and Geology, Records, vol. XV, 1916, part II., pp. 158-163, 1917.

† *Op. cit.*, p. 163.

‡ Morganroth, L. C., The occurrence, preparation and use of magnesite : Am. Inst. Min. Eng. Trans., vol. 48, p. 2352, 1914.

§ *Op. cit.*, p. 2350.

used as fuel. The capacity of these rotary kilns is probably 50 to 60 tons in 24 hr. The magnesite can be burnt as thoroughly in these kilns as in the bottle kilns, but they have one disadvantage, in that a larger percentage of fines is produced.

The magnesite as burned in the bottle kilns is drawn about every 6 hr. It is quenched with water and then passes through a crusher, which reduces it to the size of a walnut or less. It is then screened, being separated into three sizes. From the screens it goes to the picking tables, where the underburned pieces of magnesite, together with any dolomite or quartz, which were too small to be removed at the quarries, are picked out. The largest pieces of magnesite are again crushed and these smaller pieces are re-picked. The magnesite finally is crushed to the size of corn, again picked over, and then put in sacks holding from 150 to 200 lbs. In this shape it is shipped to the user."

"Within recent years an economy has been effected in the picking or sorting of magnesite by the installation of magnetic separators. Magnesite containing iron is readily separated in this manner."

Both types of kilns are used in California.

Manufacture of Carbon Dioxide. Magnesite is less used than formerly in the manufacture of carbon dioxide, as most of the magnesite produced in foreign countries is calcined at the mine for the production of magnesia, no attempt being made to save the CO_2 , as it was found that for the most efficient production of the gas the magnesite had to be calcined at a lower temperature than that best suited for caustic calcination. Moreover, carbon dioxide is more cheaply obtained from limestone and as a by-product from distilleries.

In the manufacture of carbon dioxide from crude magnesite, the ore is roasted with about one-tenth its weight of coke,* the resultant gases being pumped into scrubbers filled with limestone, and washed with water. The gas is then pumped into an absorption tank, where it is absorbed by a sprayed solution of potassium carbonate. The "loaded solution" is pumped back into boilers and raised to a temperature just below the boiling point of water, when it gives up its gas, which is then pumped through cleansing tanks and cooling pipes to a gasometer. It is then liquified by compression and run into steel cylinders. The residual caustic magnesia is sold as a by-product.

Carbon dioxide is also manufactured by directly treating magnesite with crude sulphuric acid.

Magnesium sulphate (Epsom salts). Before the war, most of the Epsom salts used was obtained as a by-product from the potash salt industry in Germany. It is made from magnesite by treatment with sulphuric acid.

In addition to its uses as a medicine, magnesium sulphate is used in warp-sizing for weighting in cotton mills, in the tanning industry to soften certain leathers, and in chemical laboratories.

*Vide Hess, F. L., The magnesite deposits of California: U.S. Geol. Survey Bull. 355, pp. 8-9, 1908.

Magnesium chloride. Formerly largely exported from Germany, where it was obtained as a by-product, magnesium chloride is now produced by treating either crude or calcined magnesite with hydrochloric acid. It is also obtained as a by-product from residual bitters of salt (sodium chloride) refineries. It is said that the magnesium chloride obtained from magnesite is purer than the German salt, which is generally contaminated with potash compounds, but that its manufacture is expensive, and that, being in the form of a solution, it is too bulky and heavy to permit much transportation.

Magnesium chloride is used in the manufacture of the oxy-chloride cement, in the manufacture of "cold water" fire-proof paint, for dressing cotton goods, and in chemical laboratories. It is also used with an alkaline chloride as an electrolyte in the preparation of metallic magnesium.

Small quantities of metallic magnesium are used in shrapnel shells, giving by day a dense white cloud of magnesium oxide, and a dazzling white light by night. The metal is also used in the form of ribbon for photographic purposes. An alloy of about 2 per cent. of magnesium with aluminum (magnalium), which combines lightness with strength and rigidity, is used in the construction of aeroplanes.

Light Magnesium carbonate (*Magnesia levis alba*). This is usually prepared by precipitation from solutions of the sulphate or chloride by sodium carbonate, but it can be manufactured from magnesite or dolomite by calcination and precipitation from solution. It is used for therapeutic purposes, as a toilet preparation, as fire-proof material, and, mixed with asbestos fibres, as a heat insulator for boilers and steam pipes.

Oxychloride or Sorel cement. Finely ground caustic calcined magnesite wet with a solution of magnesium chloride of a certain strength sets as an exceedingly strong, hard vitreous cement. For flooring and similar purposes it is usually mixed with a filler such as wood-flour, sawdust, cork-dust, asbestos, serpentine, or ground quartz, which may constitute from 10 to 40 per cent of the finished cement. It is applied in a plastic state to wood, metal, or concrete, to which it holds firmly; it sets in a few hours. Thus used it is said, when properly mixed and laid, to be superior to any other cement for cleanliness, resilience, immunity from abrasion, lightness, warmth, and the fact that it may be laid thinly (usually to a depth of half an inch) over large surfaces without cracking. It takes colours readily, takes a good polish with oil or wax, and is fire and water-proof. It is not, however, acid-proof nor wholly alkali-proof, and softens with constant immersion in water.

Owing to the difficulty of obtaining raw material of uniform quality and the deterioration of the caustic magnesite before using,

these floors have not always been satisfactory. The cement must be practically free from lime, the presence of which, owing to its greater tendency to absorb carbon dioxide and moisture, causes swelling.

In addition to its use as a flooring, oxychloride cement is used for the manufacture of tiles and artificial marble.

Refractory material. Dead-burned magnesite is used either in the form of bricks or of sand for purposes where highly refractory material is required. As bricks, it is used for lining open-hearth furnaces and converters in the basic steel process, copper converters, electric furnaces, reverberatories, settlers, and furnaces for refining lead. Crushed, it is used for lining the bottoms of open-hearth furnaces, for rotary kiln linings, crucibles, and cupels.

Morganroth* states that the crystalline magnesite was used exclusively for refractory purposes. The purer varieties of magnesite are the more refractory (the fusing point of pure magnesia has been estimated at $1,910^{\circ}$ C.), but require a greater heat in calcining, and in practice magnesia carrying from 3 to 4 per cent SiO_2 , 6 to 8 per cent Fe_2O_3 , and about 4 per cent CaO is generally used. Silica, iron, and alumina lower the fusing point of magnesite, causing it to sinter more readily, iron giving the bricks a brown colour. The presence of lime was formerly said to cause the bricks to disintegrate more readily at high temperatures. Wilson,† however, mentions a brick, in the manufacture of which Grenville magnesite was probably used, having the composition—

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	
10.26	6.67	2.98	8.70	71.75	loss on ignition 0.05

and it has been stated that the most suitable crude magnesia for basic bricks has the composition—

SiO_2	$\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$	CaO	MgO
1.2	13.0	7.3	77.6

Calcined magnesite mixed with 10 to 40 per cent of furnace slag has also given satisfactory results as a lining for open-hearth steel furnaces.‡

Manufacture of Paper. One of the most important uses of magnesite is the manufacture of magnesium bisulphite, which is preferable to either sulphurous acid or calcium bisulphite as a disintegrating agent in the preparation of wood-pulp for the manufacture of paper, on account of its greater stability, its greater solvent action on wood resins, and the fact that its use is not injurious to sizing agents.

* *Op. cit.*, p. 2352.

† Wilson, M. E., magnesite deposits of Grenville District, Argenteuil County, Quebec: Can. Geol. Survey Memoir 98, p. 5, 1917.

‡ Wilson, M. E., *op. cit.*, p. 5.

The wood boiled with the disintegrating agent breaks down into a pulp, which is afterwards rolled into paper.

Other Uses. Other uses of magnesite or its derivatives include the manufacture of sintered magnesite tubing for chemical and electro-metallurgical work; the use of the carbonate of magnesium in tooth-paste, and to prevent scale in boilers used for sulphurous waters; and of the oxide in the manufacture of dynamite and in the rubber industry.

III.—MAGNESITE DEPOSITS OF OTHER COUNTRIES.

Austria-Hungary. Deposits of crystalline magnesite occur in several widely scattered localities along a general NW.-SE. line in Austria and Hungary. In Austria the most extensive deposit occurs at Veitsch (Styria), where it forms the top of an isolated hill. From the top of the hill to the base of the deposit is from 700 to 800 feet.* In northwest Hungary the largest deposits occur between the towns of Jolsva and Nyustya, where the veins range from 150 to 300 feet in width. The Austro-Hungarian magnesite is of a blue-grey or drab colour. It occurs in huge lenticular masses or veins, associated with talc and other minerals, in beds of dolomite. It was probably formed through the replacement of Palæozoic limestone by magnesite deposited from solutions of magnesium bicarbonate, derived from basic intrusives.

The Austro-Hungarian magnesite is used almost exclusively for refractory purposes, as, owing to its iron content, it sinters comparatively readily.

200,947 metric tons of magnesite was exported in 1913.

Greece. The most important deposits are on the west side of the island of Eubœa. The magnesite occurs in veins and lenses in serpentine. Some of the veins are of great size, one 50 feet wide, 75 to 100 feet high, and fully 300 feet long, being recorded. The magnesite is pure white and of very high grade. A large proportion of the magnesite mined is exported crude, a somewhat smaller proportion being exported in the caustic calcined state. It is mainly used in the manufacture of cement.

India. The chief deposits are in the Chalk Hills, near Salem, Madras Presidency. The magnesite occurs as veins in serpentine and other magnesia-rich rocks. The main deposits are said to occur over an area of 10 square miles. Magnesite is also found as veins in ultrabasic rocks at various places in Mysore.

In 1915, 7,450 tons of magnesite, valued at £3,973, was produced in the Salem district. In 1916 the production for India was 17,640

* Morganroth, L. C., *op. cit.*, p. 2348.

tons, valued at £14,065—of this, 17,540 tons was from the Salem district.

Transvaal. A large area of serpentine, thickly veined with magnesite, occurs near Malelane on the Pretoria-Delagoa Bay Railway, near the eastern border of the Transvaal.* Some of the veins attain a width of 4 feet, but the majority are between 2 and 4 inches. Analysis shows the magnesite to be free from lime but to contain a high percentage of silica. The mineral has been chiefly used in the manufacture of oxychloride cement.

United States. The only deposits of magnesite of commercial importance are those of California, where it is found at various localities in the counties of Tulare, Sonoma, Santa Clara, and San Benito. At all these localities it occurs as veins, mostly of small size, in serpentine.

A deposit in Kern County, interbedded with clays and clay shales, is considered to be of sedimentary origin.

With the exception of that of the Sonoma and Kern County deposits, most of which contain a high percentage of silica, the Californian magnesite is of high grade. It is mostly used in the manufacture of paper by the sulphite process.

154,052 short tons of crude magnesite, valued at \$1,311,893, was produced in California in 1916.

Canada. Extensive deposits of crystalline magnesite occur in the Grenville District, Argenteuil County, Quebec, associated with metamorphosed sediments—including crystalline limestone, sillimanite-garnet gneiss, and quartzite—of the Grenville series.† The deposits are of early Pre-Cambrian age, and Wilson‡ considers “that they are of metamorphic origin, and have been formed by the replacement of the limestone member of the Grenville series, through the agency of magnesia-rich solutions.” The ridges on which the magnesite occurs are composed mainly of magnesite, dolomite, serpentine, and diopside.

The magnesite everywhere includes more or less dolomite, averaging from 7 to 10 per cent lime. The deposits are said to be more extensive and more easily worked than those of California.

58,090 tons of magnesite, valued at \$728,275, was produced in the Grenville district in 1917.

Deposits of hydromagnesite, the largest covering nearly 18 acres, occur near Atlin in northern British Columbia. The mineral occurs in superficial beds ranging from 1 to 8 feet in thickness—the average being about 3 feet—and occupying faintly marked de-

* Hall, A. L., The magnesite deposits of Malelane: Union of South Africa Geol. Survey Ann. Rep., 1906, pp. 127-132, 1907.

† Wilson, M. E., *op. cit.*, p. 62.

‡ *Op. cit.*, p. 62.

pressions. Young* estimates the total tonnage of the deposits at 171,100. He considers that the hydromagnesite was deposited on the bottoms of ponds, which have since disappeared.

Deposits, said to be extensive, of magnesite have been found in the Bridge River District, B.C., where the mineral occurs as veins of both the massive and crystalline varieties in serpentinised peridotite of Mesozoic Age.†

IV.—AUSTRALIAN DEPOSITS.

Queensland. Magnesite, said to be chiefly associated with decomposed basalt, occurs in various localities, but only in small quantities.

New South Wales. Magnesite outcrops over an area of 100 acres about $3\frac{1}{2}$ miles northwest of Fifield, Parish of Tout, County Kennedy, in the form of large blocks projecting through red clay.‡ It is thought to have been formed by the weathering of ultrabasic rocks. Analysis of a sample showed it to be of exceptional purity, lime being absent.

9,189½ tons of magnesite, valued at £9,992, was mined in New South Wales in 1917; this included 4,189½ tons from the Fifield district and 5,000 tons from Attunga in the Tamworth Division.

Victoria. Magnesite occurs at Heathcote as veins and nodules along the junction of a serpentinous rock with a fine-grained granitic rock.§ Veins, from 1 to 6 feet thick, occupy the junction line, and the mineral is also found in the decomposed granitic rock to a distance of 16 feet from the junction. The magnesite formed by decomposition of the basic rock has been leached out and redeposited along the junction and in fissures in the decomposed basic rock over a wide area.

189 tons of magnesite, valued at £567, was raised in 1915, and 30 tons, valued at £90, in 1916.

Tasmania. Magnesite has been found in several localities, but so far only in small quantities.

South Australia. Magnesite deposits have been found 5 or 6 miles from the town of Tumby on the Eyre Peninsula. The mineral is found in veins or greatly elongated lenses,|| a large number of these occurring

“along a zone over 20 chains in length and $1\frac{1}{2}$ chains in width. The maximum thickness of the veins is between 4 and 5 feet, and a few of

* Young, G. A., Hydromagnesite deposits of Atlin, B.C.: Can. Geol. Survey Sum. Rep., 1915, pp. 50-61, 1916.

† Drysdale, C. W., Can. Geol. Survey Sum. Rep., 1915, p. 83, and 1916, p. 48.

‡ Jacquet, J. B., Aus. Min. Standard, vol. 38, p. 172, 1917.

§ Dunn, E. J., Victoria Geol. Survey Records, vol. IV., part 1, p. 53, 1917.

|| Ward, L. K., S. Aus., Review of mining operations, No. 20, pp. 30-33, 1914.

them appear to extend continuously for a length of 40 feet."
 "The country rock on the W. side of the carbonated zone at its S. extremity is mica schist and carries veins of bluish and white quartz. The magnesite has probably been formed by the replacement of some magnesium-bearing rock, possibly a magnesian limestone, the replacement having perhaps been effected by emanations from the acid igneous magma which has produced the gneisses and pegmatite dykes of the country immediately to the S.E."

Ward stated that some hundreds of tons could be readily won from the upper portion of the veins, but that no larger estimate could be framed with any pretence to accuracy.

Western Australia. Magnesite has been reported from several localities, besides Bulong, in this State. These include various points northeast of the railway line between Kundip and Ravenshorpe. Coolgardie, Hannan's Lake, Waverley, Menzies, Eulaminna, Comet Vale, Bardoe, Kanowna, Norseman, Munglinup, York, and Golden Valley. The only places where the mineral is known to occur in any quantity are the Ravensthorpe district, Coolgardie, Waverley, and Bulong.

In the Ravensthorpe district magnesite is found on the surface as an alteration product of serpentine.* The reserve applied for in 1913 was situated about 2½ miles NNE. of Desmond township. The Ravensthorpe magnesite has been successfully used by the Phillips River Gold and Copper Company as a flux in their copper reduction furnace and as a lining for the convertors. Analysis shows the magnesite to be of high grade, though containing a somewhat high percentage of lime.

Regarding the Waverley deposit, the State Mining Engineer states†:—

"During excavation of the Government Water Tank, the layer of magnesite above mentioned" (*op cit* p. 6) "was encountered and a good deal of this material is seen thrown out on the spoil embankment round the tank. The bores show that it is somewhat extensive."

The full extent of the deposit has not been determined. Small boulders of magnesite were seen by the writer lying on the greenstones some distance southeast of the Tank.

At Coolgardie, magnesite boulders occur on the basic rocks about 4 miles northeast of the town, in the Camel Farm Reserve.

A vein of magnesite of fair width has recently been worked near Coolgardie. Analysis of a specimen from this vein showed it to be of very high grade, free from lime, but containing a moderate quantity of iron and alumina. The exact locality of the vein has not been ascertained.

At Hannan's Lake the mineral occurs only as a few small and scattered veins in the serpentine forming the low hills near "Ser-

* Woodward, H. P., Geological report upon the gold and copper deposits of the Phillips River Goldfield: W.A. Geol. Survey Bull. 35, p. 39, 1909.

† Montgomery, A., Report on the Waverley or Siberia District: p. 7, 1909.

pentine Bay," about $4\frac{1}{2}$ miles SSE. of Boulder City, and a mile east of Mt. Hunt. The veins are too small and sparsely distributed to be of any commercial value.

The writer was informed by his colleague, Mr. E. de C. Clarke, that magnesite boulders are profusely scattered on the ultrabasic rocks on three areas, two of which are about 4 chains long, about a mile east of Eulaminna Railway Station, in the Mt. Morgans District.

No definite information was available as to the occurrences of the other localities.

V.—GEOLOGY OF THE BULONG AREA. (Plates I. and II.)

GENERAL STATEMENT.

The gold-mining township of Bulong is situated in the North-East Coolgardie Goldfield, about $19\frac{1}{2}$ miles east of Kalgoorlie and $2\frac{1}{2}$ miles west of the western edge of Lake Yindarlgooda—the westernmost, and probably the largest of a chain of dry lakes extending eastward for probably 45 miles. The town lies in a complex of basic and ultrabasic greenstones, the most prominent members of which are serpentines and amphibolised gabbros. In the gold-mining area west of the town, many of the rocks are talcose and highly carbonated. The greenstones extend eastward to the western edge of the lake, and northward beyond Taurus. The various members of the complex are intimately associated, and, as at Kalgoorlie, to the Younger Greenstones* of which they correspond, apparently represent local differentiations of a highly basic magma, intruded as one mass. It was found impossible to separate even the two main varieties on the map. Viewed broadly, the easternmost part of the complex is more highly basic than that west of Bulong and, except for a few small areas of gabbro or amphibolised gabbro, consists wholly of serpentine, with which the magnesite is invariably associated.

Intruding the greenstones west of the magnesite areas are several large porphyrite dykes—the largest being a mile in length—striking north and south. A few small dykes are found in and near the main magnesite area. Porphyrite dykes, apparently of considerable length, also occur west of the town, intimately associated with the Queen Margaret and other lodes.

A number of small porphyrite dykes, almost black in colour, striking east and west, intrude the greenstones close to the magnesite areas. These dykes may belong to a different period of intrusion, but more probably formed part of the same magma as the other dykes and were intruded along lines of weakness complementary to the main north and south lines.

* *Vide* G.S.W.A. Bull. 69, pp. 24 *et seq.*

East of the main greenstone area is a belt of highly sheared rocks of clastic origin, containing numerous ellipsoidal pebbles of porphyrite—but, so far as could be determined, of no other rock—as well as smaller angular and subangular fragments of the same rock. These rocks are best described as pebble breccias. The planes of shearing strike north and south, and dip west at steep but varying angles. The extreme western edge of the lake approximates to the boundary between these rocks and the greenstones. North of the lake, rocks forming part of the same series extend eastward beyond Mt. Tabletop, on the road to Kurnalpi. Immediately south of the westernmost part of the lake, the pebble breccia belt—here probably only a branch of the main belt, which is some miles farther east—is a little more than a mile wide. Two and a half miles farther south it is only three-eighths of a mile wide.

Another area of highly schistose rocks, probably belonging to the same series, underlies the alluvial flat south of the Government Tank. The few exposures of these rocks are too weathered for accurate determination. No pebbles were seen in the rocks, some of which are of slaty appearance; others appeared to resemble the matrix of the pebble breccias. Part of the western boundary of these schists can be mapped with some degree of accuracy, but the eastern boundary is entirely obscured and the full extent of the area occupied by them cannot be ascertained with any certainty.

In the greenstones north and northwest of the town are several comparatively small areas of apparently clastic rocks, some of which resemble the pebble breccias, but contain no pebbles; others the slaty rocks previously mentioned. These smaller areas possibly represent portions of the main belt which have been nipped in during periods of compression.

East of the pebble breccias south of the lake, and forming the Yindarlgooda range of hills, is a second area of greenstones. These are, on the whole, less highly basic than the rocks of the magnesite area and appear to consist of amphibolised gabbro and comparatively fine-grained epidiorite. They extend to the western edge of the lake, east of the Yindarlgooda range. They have been intruded by many small dykes of porphyry or porphyrite, the direction of strike of which is variable, but predominantly ENE. In composition these dykes appear to be somewhat more acid than those intruding the main greenstone area.

THE GREENSTONES.

The rock [$\frac{1}{3-70}$] found at the old battery site, near the north-east corner of M^l. C^m. 1Y, is probably typical of the serpentines of this area. It is a fine-grained dull, dark-greenish rock composed, according to Mr. Farquharson, of plates of unaltered augite poecili-

tically enclosing rounded areas of serpentine, the shape and mode of occurrence of which suggest original olivine; there are also some reddish-brown pleochroic flakes, probably originally hornblende, now largely altered to chlorite. The long range of hills west of the magnesite area is almost entirely composed of similar rock. The rock forming the small range west of the Government Tank, Mt. Stuart, and the hills to the south is more completely serpentinised. According to Mr. Farquharson, the Mt. Stuart rock appears to have been originally more of the Harzburgite type.

The low hills fringing the lake immediately south of W.R. 79 are partly composed of comparatively fresh medium-grained gabbro [$\frac{1}{167}$] consisting of augite, fibrous uralitised augite, and lime-soda felspar partly zoisitised. A very similar rock forms the low range west of the prominent quartz blow three-quarters of a mile south of the southeast corner of M¹. C^m. 1^y. The hills farther south are of the battery type.

The greenstones of the flat west of the main porphyrite dyke are amphibolised gabbros or dolerites. Coarse amphibolised gabbros or dolerites occur west of the town at and near the site of the old Southern Cross battery.

Serpentine forms the greater part of Gumbulgera trig. hill near Taurus, but amphibolised gabbro occupies the southern slopes of the hill.

The talcose carbonated rocks of the gold-mining area west of Bulong have already been mentioned.

THE PORPHYRITES.

The greater part of the large dyke west of the magnesite area consists of fine-grained dark-grey porphyrite [$\frac{1}{168}$] with numerous white phenocrysts of felspar and rare phenocrysts of quartz. It is described by Mr. Farquharson as a zoisitised hornblende-quartz porphyrite—the hornblende is not visible to the naked eye. The rock is very similar to the Kalgoorlie porphyrite. Where seen, the marginal portions of the dyke were finer in grain and more felspathic, the rock being practically an albite porphyrite [$\frac{1}{238}$] containing a few fibrous colourless wisps which probably represent original hornblende. The small dykes to the north consist largely of the felspathic variety.

The black east and west dykes are described as quartz-hornblende porphyrites of dacite affinities [$\frac{1}{73}$]. The black colour is due to a fine blackish dust which occurs associated with the hornblende and in all the felspars.

The small dykes of the Yindarlgoooda range consist of a medium-grained brownish-grey rock, in which black specks of

biotite are visible. It is described as a biotitic quartz porphyry or albite-quartz porphyrite. The relations of these dykes to the hornblende porphyrites could not be determined.

THE PEBBLE BRECCIAS.

A detailed discussion of these rocks is not warranted in an economic report such as the present.

The pebbles all consist of porphyrite—largely chloritised and micacised—resembling that of the large dykes. They range in length from about an inch to more than a foot, and one doubtful pebble measuring 5 feet by 3 feet was seen. All are elongated in a north and south direction, parallel to the planes of shearing. The smaller angular intrusions are also of a general porphyritic character, but some show in section a tendency towards a flow structure. The matrix likewise is composed of porphyritic material.

The rocks were probably basal conglomerates, laid down under water, containing pebbles and finer material resulting from the degradation of a porphyrite. Subsequent volcanic explosions gave rise to the agglomerate structure, and the rocks were later intensely sheared.

Associated with the pebble breccias are areas, of varying size, of a pale porphyritic rock. These may represent portions of the original porphyrite mass, or more probably, as some specimens appear to have a flow structure, and one [T_{527}^1], from the northern end of an island on W.R. 76, contains small vesicles, submarine flows intruded into the conglomerate during the period of volcanic activity.

The apparent sediments south of the Mt. Stuart range are compact, fine-grained creamy or greyish fissile rocks, composed largely of sericite with some quartz. Very similar rocks were seen on the edge of the lake south and southwest of Mt. Tabletop.

VI.—THE MAGNESITE DEPOSITS.

GEOGRAPHY.

The largest area of magnesite-bearing serpentine occupies a basin elongated in a nearly north and south direction, parallel to the lake edge, the northern end of the basin being nearly $2\frac{1}{4}$ miles due east of Bulong. The basin lies between a high, steep ridge rather more than half a mile west of the lake, and a lower and more broken series of hills fringing the lake (Fig. 1) and connected with the main ridge north and south of the basin. The magnesite area extends for about three-quarters of a mile south of the basin, its total length being nearly $2\frac{1}{4}$ miles. It is irregular in width, ranging from about 30 chains at its northern end to about 5 chains near its southern end, averaging about 18 chains. It covers about

350 acres. The southern half of this area is largely obscured by superficial deposits and the boundaries assigned to it on the map are only approximate.

Fig. 1.

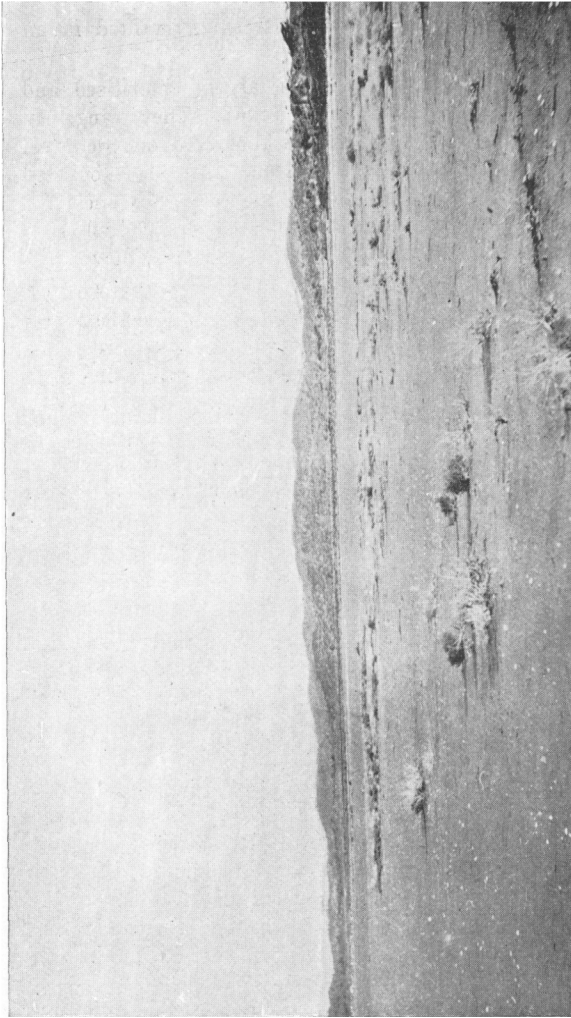


Photo.: F. R. Feldtmann.

Neg. F169.

General view, looking SW., of country surrounding the main magnesite area.

Several smaller areas of magnesite-bearing rock occur, one south and three north of the main area, the northernmost, about three-quarters of a mile north of the main deposit, being the largest. It occupies a basin about half a mile long and more than 30 chains wide at its widest point, and covers an area of about 90 acres.

No magnesite deposits were seen south of those mentioned, other than occasional small boulders, nor is it likely that deposits of any size occur. A few small patches, negligible from an economic point of view, were observed to the north of those mapped, and it is possible that others occur in the vicinity of Taurus.

Small lenses of magnesite were seen in two places in the pebble breccias near the boundary of the serpentine; the magnesite here has evidently been dissolved out of the serpentine by surface waters and redeposited in the elastic rocks.

The ridge west of the main magnesite area rises to a height of about 240 feet above the level of the lake. It forms the southerly extension of a wide and irregular hilly area, scored by deep valleys, which stretches northward to the west of the Taurus group of leases. The ridge runs south for a considerable distance. Opposite the southern end of the basin, three miles southeast of the town, it widens out to a complex of hills; farther south it gradually becomes less defined but rises abruptly at Mt. Magnetic, about five miles southeast of Bulong, to die out a little farther south.

The hilly area north of the ridge is joined about one and a half miles north of the Government Tank by an escarpment running in a southsouthwest direction, about half a mile east of the town. This escarpment faces eastsoutheast and the flat below it gradually falls towards the lake. South of the Government Tank the flat is about 130 feet below the surface level at the Post Office and about 60 feet above the level of the lake. It is drained by a series of watercourses mostly ill-defined which, towards the eastern end of the flat, unite to form a deeply cut creek (Magnesite Creek). The creek runs east to the lake, cutting through the previously mentioned ridge close to the western boundary of M¹. C^m. 1Y. West of the ridge a second creek runs into the first one from the north.

The road from Bulong to the magnesite quarries crosses the escarpment west of Mt. Stuart, thence passes to the north of the mount and runs eastward over the flat to follow Magnesite Creek through the gap in the main ridge to the quarries; thence the road runs on to the old Battery site. This road is good, on the whole, though heavy on the flat in wet weather. Another track farther south runs from the magnesite area through former W.Rs. 89 and 100 and joins the main track south of former M.L. 3Y.

There is no track to the northernmost magnesite area. Probably the best route would be to leave the track to the old battery site south of M.A. 3; thence to pass east of the large quartz blow on former G.M.L. 3212^E and follow a general northerly direction from 10 to 15 chains east of the eastern boundary of M¹. C^m. 2Y, passing about 10 chains east of the northeast corner of the claim; thence to follow a westnorthwest direction and cross the boundary of the magnesite area south of the main creek draining that area.

An alternative route would be to leave the main road to the quarries south of former M.L. 3^Y and run northeast to where a drain to the Government Tank leaves the creek running south to join Magnesite Creek; thence to follow an old cart track running north along the

Fig. 2.

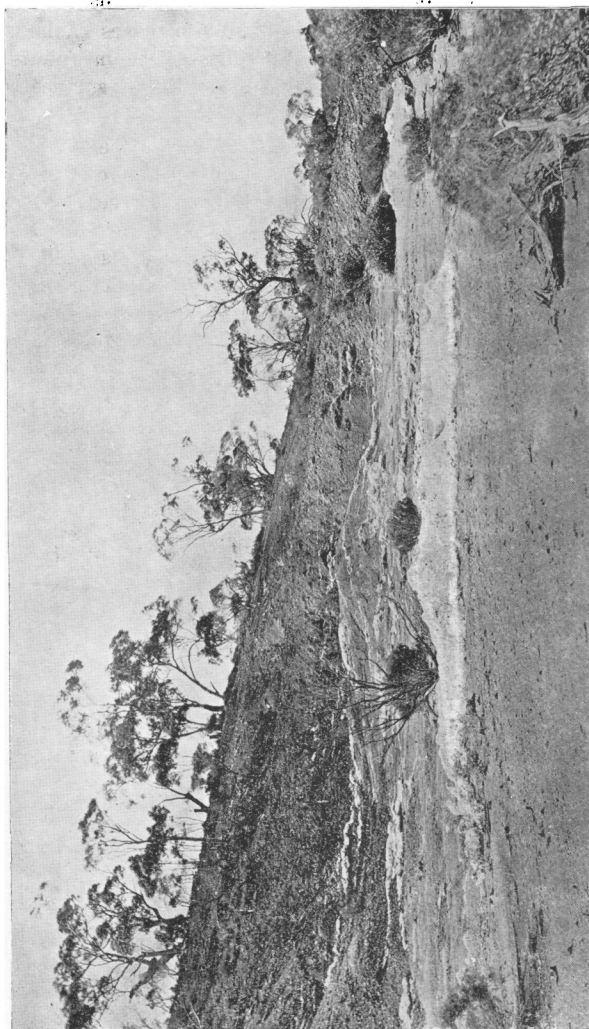


Photo.: F. R. Feldtmann.

Outcrop of large magnesite vein in depression W. of W.R. 79.

Neg. F174.

previously mentioned creek and turn east to follow the western portion of the creek draining the northern area through a gap in the ridge west of that area. This, however, would necessitate a cutting in the gap.

OCCURRENCE.

The magnesite occurs, for the most part, as short irregular veins in the serpentine. In places these veins are so numerous as to form a stockwork. Being less subject to weathering than the

Fig. 3.



Photo.: F. R. Feldtmann.

Neg. F214.
Nearly flat veins of magnesite in E. bank of watercourse, about 4 chains NW. of No. 1 Quarry.

surrounding rock, and of a dazzling white colour, except where stained by iron, they stand out conspicuously above the surface of the ground. The veins are very irregular both in strike and dip.

Some of the larger veins in the small depression west of W.R. 79 (Fig. 2) strike about N. 15° W., and, where exposed, dip fairly steeply westsouthwest; others are almost flat (Fig. 3), but most

Fig. 4.

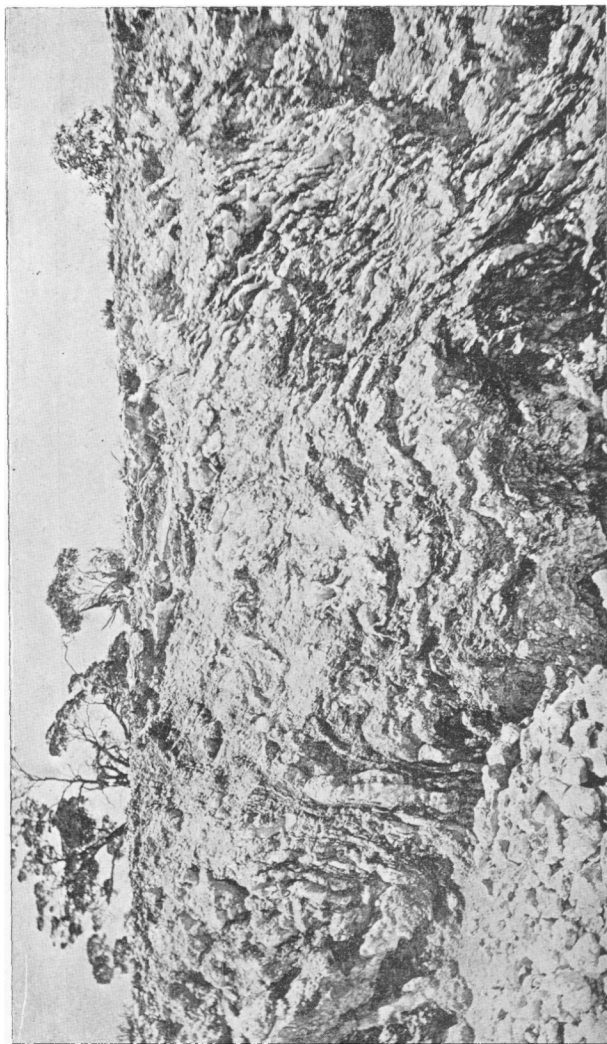


Photo.: F. R. Feldtmann.
 E. face of No. 3 Quarry, near S. end. Showing great number of highly contorted veins of magnesite. Neg. F215.

of the veins are greatly contorted (Fig. 4). Where a number occur together they are usually roughly parallel.

None of the veins approach those of the Grecian and Californian deposits in size, rarely attaining a width of two feet. Most are only a few inches in width, and a number are mere threads.

Where the serpentine is much decomposed, as at the main workings, the veins are exceedingly numerous, in places occupying a greater volume than the enclosing material (*vide* Fig. 4). In

Fig. 5.



Photo.: F. R. Feldtmann.

Neg. P218.

Surface deposit of magnesite, over a foot thick, between No. 2 and No. 3 Quarries.

such places the enclosing rock is soft, enabling the veins to be quarried easily.

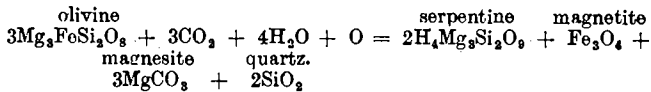
In a few places the magnesite forms a surface deposit. The largest deposit of this type covers a large portion of an area of

about 15 acres, immediately south of Magnesite Creek. The two larger quarries are on the northern edge of this deposit, which in a few places is over a foot thick (Fig. 5). It is probably due, in the first place, to the occurrence of large flat veins of magnesite, the intervening country being covered by material resulting from the degradation of the vein outcrops, which has been recemented through the agency of surface waters. These surface deposits are usually more discoloured than the veins.

As shown by the analyses, the proportion of impurities present in the magnesite varies considerably. The specimen collected by the writer from No. 2 Quarry appeared to be fairly representative of the larger veins. The exact localities of the other specimens analysed have not been ascertained, but it is most probable that they were obtained from the surface deposit near No. 2 Quarry. A few of the veins at the southern end of the main area are of a creamy colour; in others small vughs, thinly lined with chalcedonic silica, are present. On the small hills south of the basin the magnesite at the surface contains much opal. The specimens analysed were comparatively free from lime, and though a fair amount of silica is shown in two of the analyses (one specimen contained small vughs lined with chalcedony), the quantity present in the larger veins probably averages much less. The quantity of iron and alumina present is not great, but it has been found that there is sufficient iron present—some in the form of ferrous carbonate—to discolour the calcined material. The magnesite can, on the whole, however, be regarded as fairly high grade. The purer material can be largely separated by hand-picking.

ORIGIN.

It is possible that some of the magnesite was formed through the alteration of olivine, present in the original peridotites, into serpentine. Assuming the proportion of magnesium to iron present in the olivine as 3 to 1, in the absence of an analysis of the mineral, the change, according to Van Hise,* is represented by the equation:

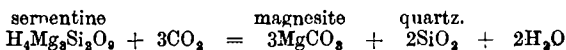


The increase in volume involved in this change is 37.13 per cent., and the pressure set up thereby would tend to form fissures in the rock in which the magnesite would be deposited.

From the much greater number of veins present in the decomposed rock it appears certain that most of the mineral was formed

* Van Hise, C. R., *A treatise on metamorphism*: U.S. Geol. Survey Mon. XLVII., p. 309, 1904.

by the decomposition of the serpentine, the change being represented by the equation *:



The increase in volume caused by this change is 18.84 per cent., and the rock would be further fissured, largely along parallel lines, as there is a distinct parallelism of many of the veins.

In this area some of the silica set free by these changes has taken the form of chalcedony, but a proportion has combined with water to form opal.

A certain amount of magnesite may have been formed by the alteration of the original augite in the rocks, either directly through the alteration of the augite to chlorite, in which change magnesite is sometimes formed, or indirectly, from serpentine derived from the augite.

From the manner of its origin it is probable that the magnesite extends downward as far as the limits of decomposition of the serpentine.

THE WORKINGS.

Two Mineral Claims, Nos. 1^Y and 2^Y, of 300 and 150 acres respectively, are held by the Permasite Manufacturing Company, Limited. M^l. C^m. 1^Y covers the northern half of the largest magnesite area, and includes the best of the deposits. M^l. C^m. 2^Y includes two small areas north of the main area. The second largest deposit, which is not so accessible as the main area, lies immediately north of M^l. C^m. 2^Y and is not covered by any claim. The magnesite in this deposit is largely obscured by detrital material, and the writer was unable to form an estimate as to the relative proportion of veins therein.

The magnesite mined up to the present has been obtained from three quarries in M^l. C^m. 1^Y. No. 1 Quarry (Fig. 6), 300 feet north of Magnesite Creek and a little east of a large watercourse which runs into the creek from the north, was, at the time of the writer's second visit, over 40 feet in length by about 25 in width; it ranged from 10 to 15 feet in depth. The rock in this quarry, though containing a fair number of magnesite veins, was not so thickly veined as that in No. 3 quarry.

The other two quarries are from about 80 to 220 feet south of the creek. No. 3 (Fig. 7)—the largest—being about 1,000 feet southwest of the northeast corner of the claim. This quarry was 140 feet long, by an average width of 26 feet, and was 20 feet deep at the southern end, where the magnesite veins appeared to occupy more than half the total area of the rock (*vide* Fig. 4).

* Van Hise, C. R., *op. cit.* p. 349.

No. 2 Quarry, about 90 feet west of No. 3, was about 55 feet long by 15 feet wide, on the average, and was 12 feet deep at the southern end.

Fig. 6.

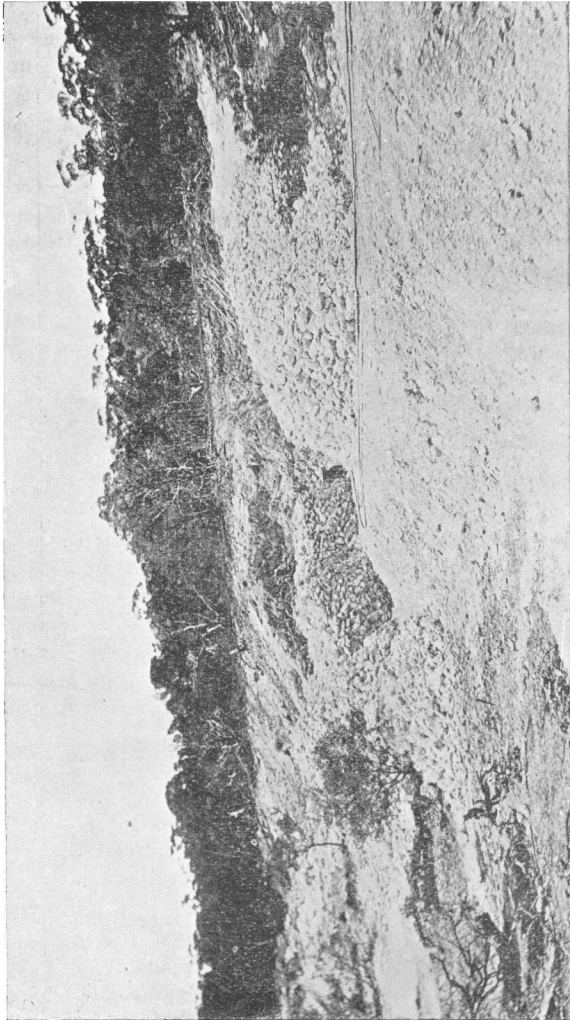


Photo.: F. R. Feldtmann.

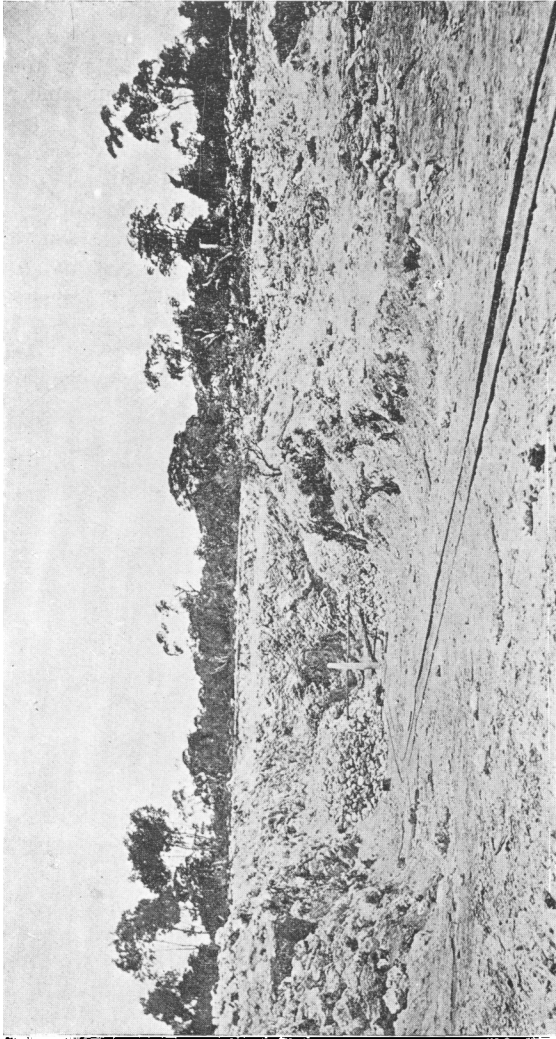
Neg. F219.

No. 1 Quarry and stacks of magnesite from SSW.

In addition, a number of trial holes have been sunk, to depths of about 6 or 7 feet, one group being a little south of No. 2 and No. 3 Quarries, a second group near the southeast boundary of former W.R. 100, and one hole a little west of the west corner of W.R. 79. Veins of magnesite were cut in each, but were more numerous and, on the whole, larger in the northern group of holes.

The deposits were ~~not~~ being regularly worked during the writer's second visit, but parcels were being sent away from time to time, as required.

Fig. 7.



Neg. F220.

No. 3 Quarry from north.

Photo.: F. R. Feldtmann.

PRODUCTION.

According to the estimate of the Company's manager at Bulong, the magnesite "at grass" at the time of the second visit was as follows:—

7 tons of "firsts" bagged and ready for carting.
 496 tons of "firsts" broken and stacked at quarries, and
 70 tons of "seconds" broken and stacked at quarries.
 A total of 688¼ tons of magnesite was quarried and exported in 1915, and 10½ tons in 1916. In 1917, 73 tons left Bulong, of which about 20 tons was treated in Western Australia.

The value of the mineral is estimated at £1 per ton on the ground, the export value being estimated at a trifle under £4 per ton.

VII.—SUMMARY AND CONCLUSIONS.

The country between Bulong and Lake Yindarlgooda consists of a greenstone complex—comprising serpentines and amphibolised gabbros—intruded by dykes of porphyrite. East of the greenstone complex is an extensive area of highly sheared elastic rocks, best described as pebble breccias.

The magnesite occurs as irregular veins, averaging a few inches in width, in the serpentine rocks, being more numerous where the rock is much decomposed. In places the magnesite forms a surface deposit.

The main area of magnesite-bearing serpentine has a length of nearly 2¼ miles; its width ranges from 5 to 30 chains, averaging about 18 chains, the area being about 350 acres. The northernmost area occupies about 90 acres.

Most, at any rate, of the magnesite has been formed by the action of carbonated waters on the serpentine in the zone of weathering.

Analyses show the magnesite to be comparatively free from lime, but to contain, on the average, moderate amounts of silica and iron—some of the iron being probably present in the ferrous form—though in the analyses of the purer specimen, probably representative of many of the larger veins, the proportions of silica and iron present were very small.

Owing to the irregular nature of the deposit, the comparative lack of evidence as to the actual depth to which the veins extend—this being largely governed by the limits of decomposition of the serpentine—and the fact that a large part of the area occupied by the magnesite-bearing rocks is covered by detrital material, any estimate of the quantity of magnesite present is impossible, but without doubt there is a very large tonnage of the mineral carrying well over 90 per cent. of magnesium carbonate, including much containing fully 95 per cent. of magnesium carbonate.

Prospecting for the mineral should, in this locality, be confined to the serpentine areas and more particularly to the decomposed portions of the rock. Where the rock is obscured by detrital material, a growth of ti-tree, usually associated with spinifex, is characteristic of the magnesite country. A capping of siliceous laterite, usually opaline in composition, is common on the low hills in the magnesite areas.

ANALYSES OF MAGNESITE.

1.—WESTERN AUSTRALIA.

	1. Bulong. No. 2 Quarry.	2. Bulong.	3. Bulong.	4. Coolgardie.	5. Waverley.	6. Comet Vale.	7. Bandimup.	8. Kundip.
Magnesia, MgO ...	47·36	44·96	44·31	46·95	47·09	44·96	46·63	46·20
Carbon dioxide, CO ₂ ...	51·69	49·33	47·76	51·23	51·62	48·10	51·13	51·58
Combined water, H ₂ O+ ...	...	0·08	<i>Nil</i>	...	0·16	...	...	<i>Nil</i>
Moisture, H ₂ O — ...	0·15	0·97	1·17	trace	0·12	...	0·99†	...
Silica, SiO ₂ ...	0·12	1·12	4·99*	0·63	0·16	Insol. 5·76	0·28	0·29
Alumina, Al ₂ O ₃ ...	0·16	0·56	0·42	1·04	0·61	1·38	0·19	0·32
Ferric oxide, Fe ₂ O ₃ ...					0·20		...	0·24
Ferrous oxide, FeO ...					...		0·10	...
Lime, CaO ...	<i>Nil</i>	1·06	<i>Nil</i>	<i>Nil</i>	trace	<i>Nil</i>	1·34	1·43
Sodium chloride, NaCl ...	0·53	1·76	1·39	...	...	...	...	...
Potassium chloride, KCl ...	0·01	0·09	0·08	...	...	...	...	...
Magnesium chloride, MgCl ₂ ...	0·08	<i>Nil</i>	0·11	...	...	...	...	...
Sulphur trioxide, SO ₃ ...	trace	0·13	0·15	<i>Nil</i>	0·08	...	...	<i>Nil</i>
Total ...	100·10	100·06	100·38	99·85	100·04	100·20	100·66	100·06

* The specimen contained small vugs lined with chalcidonic silica.

† Moisture and organic matter.

ANALYSES OF MAGNESITE—continued.

II.—OTHER AUSTRALIAN STATES.

	1.	2.	3.
	Victoria. Heathcote.	New South Wales. Fifield.	South Australia. Near Tumby Bay.
MgO ...	48.05	99.01	43.01
CO ₂ ...	51.87		47.46
H ₂ O + ...	0.16		0.34
H ₂ O ...	Insol. siliceous material	Gangue (Sand)	0.26
SiO ₂ ...			5.12
Al ₂ O ₃ ...			2.13
Fe ₂ O ₃ ...			0.46
FeO ...	...	...	0.19
CaO ...	0.07	Nil	0.32
NaCl ...	Cl trace	...	...
Total ...	...	99.97	99.47

1. Victoria, Geol. Survey Records, vol. IV., pt. I., p. 54, 1917.

2. Aus. Min. Standard, vol. 38, p. 172, 1907.

3. S. Aus., Review of mining operations, No. 20, p. 32, 1914.

III.—OTHER COUNTRIES.

	1.	2.	3.	4.	5.	6.	7.	8.
	Austria-Hungary, Jobava.	Greece.	Greece.	Transvaal.	California, Sonoma Co., Red Slide.	California, Santa Clara Co., Alameda Claim.	California, Tulare Co., near Porterville.	Canada, Quebec, Grenville Dis- trict.
MgO ...	44.80	45.45	46.00	45.272	43.42	46.61	45.17	39.25
CO ₂ ...	50.10	51.26	51.51	49.80	48.02	51.52	50.74	49.72*
HO ₂ ...	...	...	...	0.16	...	...	...	...
SiO ₂ ...	0.74	0.90	0.38	2.30	7.67	0.73	2.28	1.60
Al ₂ O ₃ ...	0.30	0.86	0.15	...	0.26	0.14	0.03	1.81
Fe ₂ O ₃ ...	3.27		0.08	0.80	0.29	0.21	0.26	
CaO ...	0.20		1.68	...	0.04	0.40	1.32	
Total ...	99.50	100.00	99.89	98.332	99.76	99.61	99.80	...

1. Fortschritte der Min., Krist., und Pet., vol. 4, p. 32, 1914.

2 & 3. Can. Geol. Survey Memoir 98, p. 10, 1917.

4. Union of South Africa Ann. Rep., 1906, p. 129, 1907.

5. U. S. Geol. Survey Bull. 355, p. 27, 1908.

6. " " " 355, p. 36, 1908.

7. " " " 355, p. 46, 1908.

8. Can. Geol. Survey Memoir 98, p. 38, 1917.

* Loss on ignition.

I N D E X.

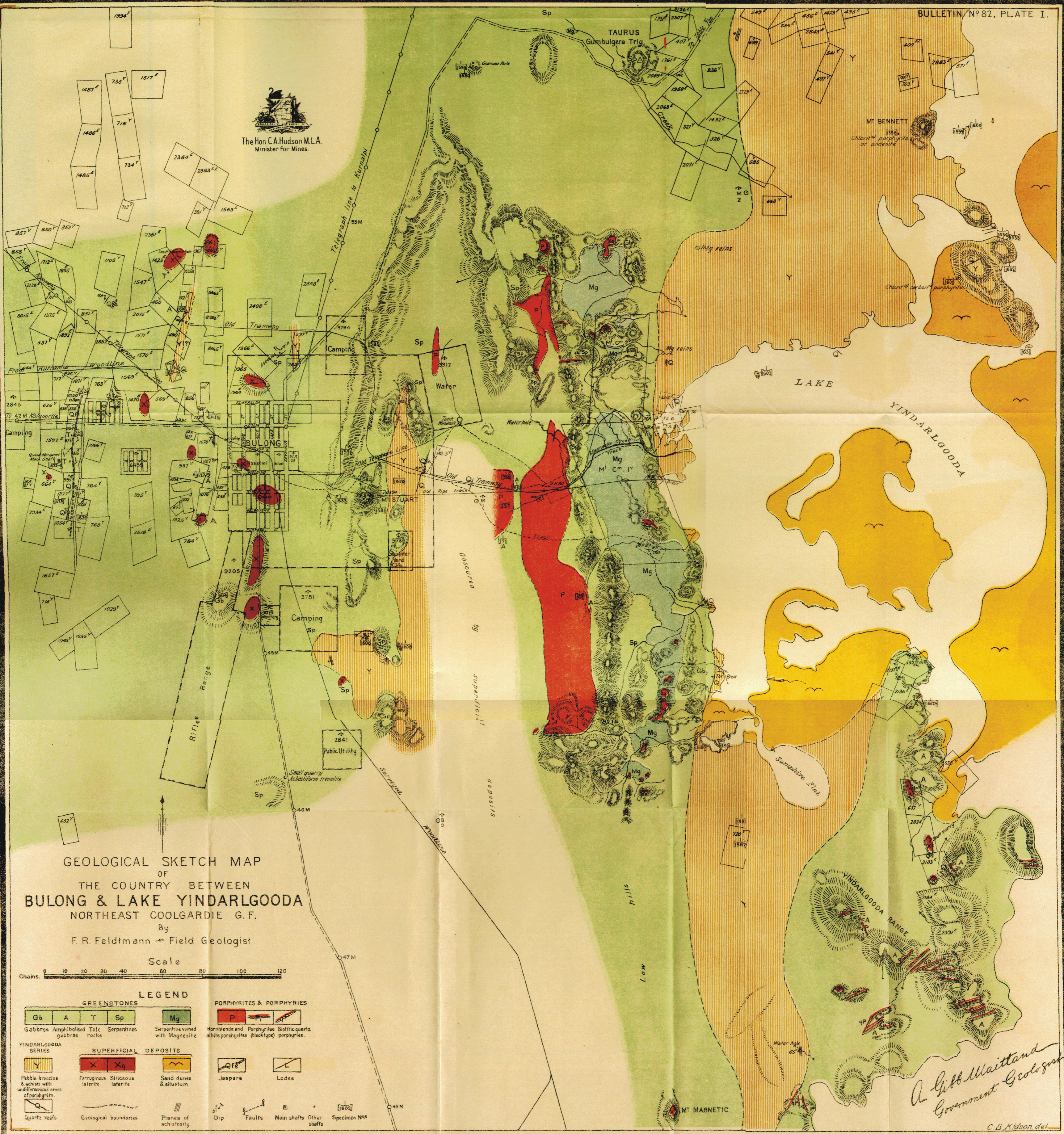
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A. Gibb Maitland
Government Geologist

C.B. Kelson, del.

Chains 0 10 20 30 40 50

PORPHYRYTES



Hornblende & Hornblende porphyritic (black type)



Jaspers

1
[1588]
Specimen Nos

A. Gibb Wattland
Government Geologist