Chief Geologist

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Report No. 7

MOUNT CHALMERS COPPER AND GOLD MINE QUEENSLAND

By

N. H. FISHER and H. B. OWEN

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Issued Under The Authority Of Senator the Hon. W. H. Spooner, M.M.,
Minister For National Development

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LIST OF REPORTS

1. Preliminary Report on the Geophysical Survey of the Collie Coal-Basin - N.G. Chamberlain, 1948.

2. Observations on the Stratigraphy and Palaeontology of Devonian, Western Portion of Kimberley Division, Western Australia - Curt Teichert, 1949.

3. Preliminary Report on Geology and Coal Resources of Oaklands - Coorabin Coalfield, New South Wales - E. K. Sturmfels, 1950.

4. Geology of the Nerrima Dome, Kimberley Division, Western Australia - D. J. Guppy, J. O. Cuthbert and A. W. Lindner, 1950.

5. Observations of Terrestrial Magnetism at Heard, Kerguelen and Macquarie Islands, 1947 - 1948. (Carried out in co-operation with the Australian National Research Expedition, 1947 - 1948)—N. G. Chamberlain, 1952.

6. Geology of New Occidental, New Cobar and Chesney Mines, Cobar, New South Wales - C. J. Sullivan, 1951.

7. Mount Chalmers Copper and Gold Mine, Queensland - N. H. Fisher and H. B. Owen, 1952.

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Department Of National Development

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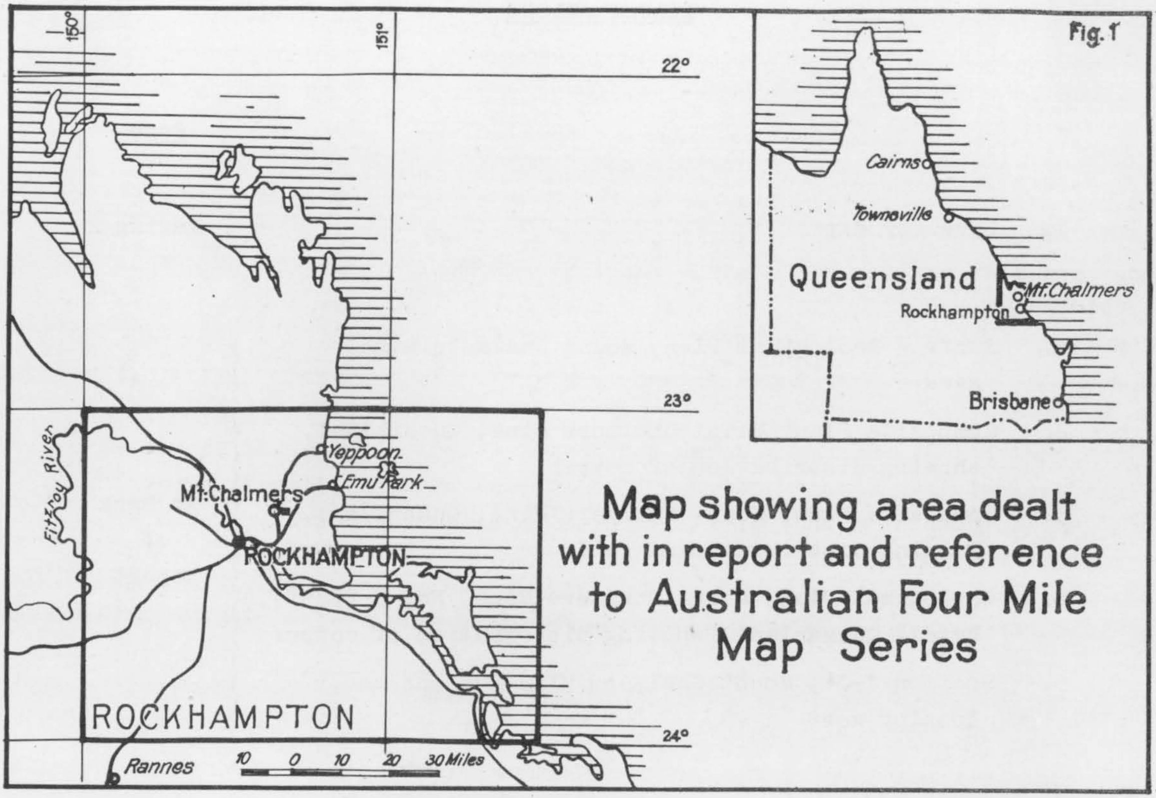

Map showing area dealt with in report and reference to Australian Four Mile Map Series

SUMMARY

The Mount Chalmers mine has produced, mainly during 1908-1914, 428,000 tons of ore, from which more than 10,000 tons of copper and 51,000 ounces of gold have been extracted. The country rock is andesitic breccia which has been intruded first by hornblende andesites, then subjected to strong regional shearing, then intruded by quartz porphyries, mostly flat-lying, copper-gold mineralization then occurred, and finally post-mineral olivine-dolerite dykes were intruded. The orebody is the upper and most heavily mineralized part of a huge mass of silicified and mineralized rock, believed to be formed by metasomatic replacement of the andesitic breccias. The lode is roughly oval in cross-section at right-angles to the long axis, which is inclined gently to the north. Maximum dimensions of the ore zone are: horizontal width 400 feet, thickness 150 feet, and the length down the dip over which it has been worked is 700 feet. The lode contains little or no copper above water level, approximately 100 feet from the surface, and down the dip the grade - particularly the gold content - decreases rapidly below No. 3 level. Average grade of the ore is from 2 to 3 per cent. copper, and 2 to 3 dwt of gold per ton. Higher-grade ore occurs mainly near the andesite hangingwall, underneath the flat andesite sill known as the "schist dyke", which splits the orebody between Nos. 2 and 3 levels, and in the more shattered area between the strong faults along which the olivine-dolerite dykes have been intruded. The pyritic ores, found mostly near the hangingwall, consist mainly of fine-grained pyrite and chalcopyrite. These ores grade into siliceous ores with decreasing amount of pyrite and on No. 3 level the ore consists of high-grade bands and veins of copper sulphides separated by barren patches of country rock.

Ore reserves are considered to be about 400,000 tons, containing approximately 2.75 per cent. copper and 2.25 dwt of gold per ton, plus 70,000 tons or more of oxidized ore near the surface, carrying perhaps 2 to 3 dwt of gold per ton.

INTRODUCTION

The property was examined during the period 18th to 28th December 1943. The accessible underground workings were mapped and the surface geology in the immediate mine area was surveyed in detail by plane table. Plans of the mine originally prepared by the Great Fitzroy Gold and Copper Mines Limited, on a scale of 30 feet to one inch, were available for underground work; also assay plans and sections showing the values in the various rises and winzes. In the compilation of geological plans, extensive use was made of these old company plans, as well as of the records and assays carried out by Mount Morgan Limited during 1942-43.

The plans originally prepared to accompany this report include a detailed geological map of the surface on a scale of 100 feet to one inch; two plans each of the Nos. 1, 2 and 3 levels showing the copper and the gold distribution respectively; two plan projections of the orebody showing the distribution of copper and gold; four cross-sections along the lines laid out by Mount Morgan Limited and known by them as Cross-sections Nos. 4, 6, 8, 10; four cross-sections at right-angles to the foregoing, along the lines referred to by Mount Morgan Limited as Longitudinal Sections A, C, E and G; one through cross-section parallel to the long axis of the orebody; and one identical section showing gold distribution (all the other sections refer to copper). All underground plans and sections are on a scale of 50 feet to one inch.

This report was previously given a limited distribution as Bulletin No. 12 (Geological Series No. 3) and this original report may be consulted at the Queensland State Geological Survey Offices at Brisbane and Rockhampton, at the Canberra and Melbourne offices of the Bureau of Mineral Resources, Geology and Geophysics, and at the office of Mount Morgan Limited, Mount Morgan. All the plans listed above are bound with the original report. With this report only the surface plan, the composite plans showing copper and gold distribution, the plan of No. 2 level, and a cross-section parallel to the long axis of the orebody are reproduced.

SITUATION AND ACCESS

The Mount Chalmers mine is situated in the Parish of Cawarral, County of Livingstone, Queensland. It is 12 miles north-east of Rockhampton and ½ mile east of the Mount Chalmers railway station, which is 18 miles from Rockhampton on the Yeppoon branch line. A spur line was constructed in 1943 from the station to the mine.

PREVIOUS REPORTS

Reports published by the Queensland Mines Department on the Mount Chalmers mine are: Publication No. 216 of the Queensland Geological Survey, "The Great Fitzroy Copper and Gold Mine", by B. Dunstan (1907), and a report on the Mount Chalmers Ore Reserves by J.H. Reid (1938). In addition, unpublished reports by W.J. Loring, J. Malcolm McLaren, A.M. Antoine, O.M.Wallace, J.H. Reid and M.A. Mawby have been available for perusal, as well as the

General Manager's reports for the years 1908 to 1914, and the progress reports by Mount Morgan Limited during 1942-43.

Dunstan's report was written before most of the development had taken place and many of his conclusions regarding the structure of the orebody have been invalidated by more recently available information and by detailed surface mapping. W.J. Loring's special report in 1910 dealt mainly with treatment problems, but included a re-estimate of ore reserves, previous figures being written down by about 30 per cent. In 1914, McLaren prepared a geological report on the mine, with a map of the surface, and some use has been made of his report as the whole of the workings were then accessible.

In March 1939, J.H. Reid of the Queensland Geological Survey having previously, with the assistance of J.E. Ridgway, carried out detailed mapping of an area of 250 acres surrounding the lode outcrop, submitted a report on the property. The underground workings at that time were full of water and not available for examination, and the report was based largely on the results of the surface mapping and on earlier reports on the property, and also on the results of diamond drilling that had been carried out in 1937 and 1938. This report has not been published, but it was made available by the Queensland Mines Department and proved exceedingly helpful in the interpretation of the surface geology and its relation to the underground workings.

HISTORY AND PRODUCTION

The Mount Chalmers area was apparently discovered to be auriferous about 1860 and small quantities of ore were treated for gold. In 1898, dense copper-gold sulphide ore was struck at a depth of 50 feet near the North shaft, but no important production was obtained until 1907 by which time the property had passed into the possession of the Great Fitzroy Gold and Copper Mines Limited. From 1908 to 1914, the mine was worked on a large scale for a total production of nearly 400,000 tons of ore. The pyritic ores were smelted direct and the siliceous ores were concentrated by flotation before smelting. By 1908, recoveries had reached 84 per cent. for copper and 78 per cent. for gold. The mine was closed in April 1914 and no further ore was produced until 1935 when a local syndicate obtained crushings from the workings off the adit level for a gold return of as much as 10 dwt per ton, averaging, according to Queensland Mines Department records, 6 dwt per ton. This syndicate developed into Mount Chalmers Mining and Development Limited which, with assistance from the State Mines Department, carried out a diamond drilling campaign during 1937 and 1938.

TABLE 1. PRODUCTION, MOUNT CHAMLERS MINE

Year	Ore tons	Copper tons	Av. Cu content of ore (recovered) per cent.	Gold oz.	Av. Au content of ore (recovered) dwt/ton	Silver oz.
1891	895	(?)		70		(?)
1892	451	(?)		64		(?)
1896-99	432	(5 p.c. copper ore - Dunstan, 1907)				
1899	20	2		4		36
1900	300	10		(?)		875
1901	250	8		83		145
1905	26	3¼		(?)		(?)
1906	1,400	(for 226 tons concentrates)				
1907	8,700	(not treated during 1907)*				
1908	27,536	839ø	2.31	4,785ø	2.64	12,302
1909	45,566	1,274	2.80	7,086	3.11	42,168
1910	59,365	1,593	2.68	8,124	2.74	36,996
1911	68,407	1,836	2.68	8,953	2.62	33,380
1912	66,145	1,345	2.03	6,690	2.02	21,923
1913	102,028	2,246	2.20	11,188	2.19	26,833
1914	25,716	590	2.29	2,381	1.85	6,369
1935	854			284	6.65	
1936	340			68	4.00	
March 1942 - Nov. 1943	19,599	313	1.60	1,242	1.27	
Total:	428,030	10,059		51,022		181,027

* Smelter blown in February 1908.

ø These figures are based on the assumption that output for 1908 is obtained from the ore mined during 1907 and 1908.

Seven holes were drilled, but only two of these were so placed that they tested the extension down the dip of the orebody and even these penetrated only the eastern half of the ore-bearing zone. In 1941, consequent upon the urgent need for increased copper supplies, steps were taken by the Commonwealth Government to re-open the mine to full-scale production. Mount Morgan Limited acted as managers and provided technical supervision. The mine was dewatered and production began in March 1942. The ore was railed to Mount Morgan for treatment. Later, a branch line from Mount Chalmers station was constructed to the mine but, because of labour shortage, production had not reached the point where operations might have become profitable and, because of this and the fact that the copper supply position had eased, the mine was closed in November 1943, before the loading system and branch railway could be put into operation. The ore treated during this latest period totalled 20,000 tons for a return of 313 tons of copper and 1,242 ounces of gold.

Table 1 is taken from a report to the Queensland Mines Department written in 1939 by J.H. Reid, District Geologist, and has been brought up to date to cover recent operations. The returns prior to 1908 are evidently not complete.

The production figures from 1907 to 1914 indicate a recoverable metal content in the ore of 2.4 per cent. copper, 2.4 dwt of gold and 9 dwt of silver per ton.

WORKINGS AND PLANT

There are two vertical shafts: the North shaft and the South shaft. The South shaft is the main working shaft and was equipped during the 1942-43 period of operation with headframe, steam hoist, coarse gyratory crusher, elevator and loading bins to deliver to the spur railway line. Additional plant included a steam-driven generator, office and store building, change houses and manager's residence. The North shaft was equipped with an exhaust fan.

Datum for the levels is the collar of the North shaft which is 45 feet above the level of the South shaft. The three main levels are No. 1 or 150-foot level, No. 2 at 225 feet, and No. 3 at 300 feet. There is also an adit on the level of the collar of the main working shaft, driven north under the outcrop to the north shaft; a No. 4 or 400-foot level; an intermediate level, half-way between Nos. 3 and 4; and various other sub-levels. The intermediate and No. 4 levels were not accessible at the time of inspection because ore extraction during 1942-1943 had been confined to the workings above No. 3 level, and pumping below this level had not been maintained.

Most of the old workings on the other levels were also inaccessible because of caving.

GENERAL GEOLOGY

The geology of the area is complex. A sequence of interbedded volcanics and sediments has been intruded successively by hornblende andesite, quartz porphyry, and by olivine-dolerite dykes. Only the area adjacent to the workings is shown on Plate 1, but the adjacent area, especially on the western side, is included in a map prepared by J.H. Reid and J.E. Ridgway of the Queensland Geological Survey. The volcanic succession consists, from west to east, of rhyolites, andesites and breccias. The breccias, which predominate in the mine area, embrace a considerable range of rock-types including fine-grained tuffs, andesite breccias of fairly fine, uniform texture, breccias with a similar groundmass but containing shale fragments as much as 2 or 3 inches in diameter, and breccias composed essentially or mainly of fragments of shale. The different types grade into one another, but in places the line of demarcation is definite enough to map. The strike of these beds is usually north-north-west, although it swings to north or north-north-east in the northern part of the area. The dip is apparently steep - usually to the east at 70 degrees or more - but this dip is the dip of the schistosity or shearing only, and it is not definitely established that the beds also dip steeply. In the few places in the mine where original bedding could be identified with certainty, it was nearly flat or at a low angle.

Greenish fine-grained igneous rocks that are intrusive into the breccias have been determined as hornblende andesite. In many places this andesite is seen to be flatly disposed, as in some of the glory holes and in the drill holes and shafts. The barren band in the mine between No. 2 and No. 3 levels, known as the "schist dyke", appears to be a sill of andesite. The hornblende andesite occupies much of the area east, west and south of the lode outcrop and forms a definite hangingwall to the orebody in the south-east glory hole. In some places weathering is more advanced than in others and this, combined with the extensive shearing to which the rocks had been subjected, had imparted to the andesites a somewhat schistose appearance. At many places in the mine, talcose minerals have been developed within these sheared andesites. Their intrusive relations are obvious in numerous places.

Intruding the hornblende andesites, as well as the earlier breccias, are bodies of quartz porphyry. All evidence available from drill cores and surface workings suggests that these porphyries lie very flat. The mineralization apparently post-dated the intrusion of the porphyries, as they are observed in many places to carry patches and veinlets of quartz containing pyrite and chalcopyrite. On the other hand, the porphyries do not exhibit the intense shearing that is the most prominent characteristic of the breccias and hornblende andesites, although they are sheared to some extent in places. It seems likely that their intrusion took place towards the end of the period of deformation which induced the north-north-west, steeply-dipping schistosity in the volcanics and earlier intrusives. Of later occurrence than the quartz porphyries and later also than the mineralization, is a series of steeply-dipping narrow dykes determined as olivine dolerite. These dykes traverse the orebodies in a north-north-westerly direction and have been intruded along strong pre-existing faults.

ECONOMIC GEOLOGY

General

The Mount Chalmers lode is situated within a huge mass of silicified and mineralized rock, which has been so altered that it is usually impossible to tell from which of the outcrop formations it has been derived. The more highly-mineralized portion which forms the lode grades off into this poorly-mineralized silicified material without, as a rule, any definite boundaries. In places the limits of economic values locally coincide with faults, dykes or changes in rock formation, but close control of stoping by assay values is usually necessary. The hangingwall of the lode is better defined than any of the other limits and in some places is quite a sharp contact, as in the open-cut on the north side of the main lode outcrop and on No. 2 level.

In cross-section, the lode is a lenticular formation with its long axis inclined gently towards the north-north-east (Plate 5). The maximum thickness is about 150 feet and the length down the dip over which it has been worked is nearly 700 feet. Copper values do not persist to the surface, but come in at about 100 feet vertical depth. In cross-section at right angles to the elongation, and also in plan (Plate 4), the lode is roughly elliptical. A study of the distribution of the ore on the levels shows that the better copper values are in bands aligned in a north-north-west direction, parallel to the strike of the breccias on the surface. In section also, the ore zones bear some relation to the steep dip of the schistosity, although the dip of the orebody as a whole is flat. The lode can be regarded as striking north-north-west, dipping to the north-east and pitching strongly to the north (Plates 2 and 3).

Type of Mineralization

During the operations of the Great Fitzroy Gold and Copper Mines Limited, the ore was classified as siliceous or pyritic according to whether the amount of insolubles was greater or less than 38 per cent. The pyritic ores appear to have been confined to the hangingwall section of the orebody, but the analyses show a gradation, with increasing silica content, to the extremely siliceous ore of No. 3 level, with insoluble content 70 per cent. The lode material is the result of metasomatic replacement of the country rock, with intense silicification accompanied by pyrite and chalcopyrite mineralization, chloritization, sericitization, etc. In the heavily pyritic sections, replacement has produced a mass of fine-grained pyrite with chalcopyrite disseminated through it. In the semi-pyritic ores the amount of pyrite is less, although the copper content may remain fairly constant. Barite is abundant in the gangue. The ore on the part of No. 3 level that was accessible is completely different in character and consists of bands or veinlets of chalcopyrite and pyrite with, in places, bornite, quartz and witherite. These are separated by barren silicified rock which contains no lode-mineral except a little fine-grained pyrite. Some bands of sulphides may be several feet wide. The smaller veinlets are generally richer. These streaks of ore are usually parallel to the shearing, with steep dip and north-north-west strike. A less important set is nearly horizontal. Coincidence or otherwise of sampling channels with the planes of these bands or veinlets may give rise to wide anomalies in assay results. On No. 3 level, small quartz veins carrying a little copper were observed to cut across the main set of ore veins, and they, in turn, are cut by tiny quartz veinlets. Other minerals identified by mineragraphic examinations are tetrahedrite, sphalerite, galena, jamesonite and gold.

Between Nos. 2 and 3 levels, the hangingwall half of the orebody is split by a sill-like flat body of greenish, slightly-mineralized rock which appears to be identical with the earlier hornblende andesites on the surface. This contains little or no copper and was referred to by the Great Fitzroy Gold and Copper Mines Limited as the "schist dyke" (Plate 5). In Winze 265'N., it is partly replaced by barite. Although it does not appear to persist right through the orebody, it marks the bottom of the pyritic ores, and even those ores classed as siliceous on and above No. 2 level are different in type from the highly siliceous, veined ore of No. 3 level. The hangingwall of the ore, down to No. 2 level at least, is fairly well-defined but, laterally and towards the footwall, the economic ore grades into very silicified rock containing a little pyrite. Specimens from the orebody and from the adjacent mineralized country rock were sent to Dr. F.L. Stillwell for mineragraphic examination and the results of his investigations are included in this report as Appendix 1, to which reference should be made for details of the occurrence of the minerals in the ore.

From the surface to a depth of about 100 feet, the lode contains no copper although the gold content on the adit level and in rises to the surface is the same as in the deeper levels. Most of the ore above No. 1 level consists of sulphides contained in dense red jasper and, at a horizon about 50 feet above the level, the sulphides disappear from the lode, leaving red jasper, practically barren of copper but still carrying gold. This horizon corresponds to the level at which the water was found to lie when the mine was allowed to fill, suggesting that the lode above this level probably contained copper originally, but that it has been thoroughly leached out. The outcrop shows evidence that it was formerly strongly mineralized and there is no obvious geological reason why the original copper mineralization should not have persisted to the present surface. On the other hand, leached derivatives of chalcopyrite and pyrite are absent from the upper portion of the lode except to a limited extent near the hangingwall in the adit level workings, and the orebody exhibits few signs of secondary copper enrichment. This latter condition might be explained by the fact that the general movement of ground water at the outcrop would be downhill towards the south and west, the opposite direction to the flat dip of the lode, and the copper carried away in solution would not be available for reprecipitation within the orebody. The mineragraphic evidence suggests that the low copper content of the near-surface section of the lode was a primary condition (Appendix 1).

Ore Values

Although a few high figures are recorded, the average value of the ore in the mine is fairly constant - 2 to 4 per cent. copper and 2 to 4 dwt of gold per ton. The percentage figure for copper is, on the whole, approximately equal to or slightly higher than, the number of pennyweights of gold per ton. On the upper levels, the gold content tends to be relatively higher than the copper, but it decreases much more rapidly than the copper in the lower levels. In the ore produced in 1914 (Table 2), for example, the figure for pennyweights of gold per ton in the ore above No. 1 level was more than double the copper percentage, between Nos. 1 and 2 levels slightly more, between Nos. 2 and 3 slightly less, and below No. 3 very much less. Table 1 shows a steady decrease in the recovered values of copper and gold from 1909 to 1914, although it is probable that percentage recoveries actually improved during this period. This is obviously due to the working out in the earlier years of the higher-grade ore above Nos. 1 and 2 levels.

W.J. Loring estimated ore reserves in July 1910 at 656,833 tons, averaging 2.98 per cent. copper and 2.57 dwt of gold per ton. Values recovered by Great Fitzroy Gold and Copper Mines from 1911 to 1914 averaged

2.29 per cent. copper and 2.23 dwt of gold per ton. These figures show that, allowing for mill and smelter losses, the calculated grade of the ore was fairly well maintained, the copper output being a little low and the gold a little high.

During 1942-43, when the ore was being treated at the Mount Morgan plant - which, of course, was not specially designed for the treatment of Mount Chalmers ore - recovered values averaged only 1.60 per cent. copper and 1.27 dwt of gold per ton. Recoveries were:-

<u>Flotation</u>	Copper 87.2 per cent.	Gold 54.6 per cent.
<u>Smelter</u>	Copper 94.6 per cent.	Gold 96.7 per cent.
<u>Over all</u>	Copper 82.5 per cent.	Gold 52.8 per cent.

The grade of this ore calculated from mine sampling is 2.62 per cent. copper and 2.16 dwt of gold per ton; from sampling presumably at Mount Morgan mill, 2.40 per cent. copper and 1.93 dwt of gold per ton. These figures are lower than the average quoted for reserves (Messrs. Bewick Moreing's estimate, 1914), but allowance must be made for the fact that most of the stoping was confined to the outskirts of the orebody, particularly on No. 3 level, where re-entry to the main body of the old stopes was not effected.

Table 2 sets out most of the relevant available information about the ore values.

<u>Ore Controls</u>

The ore zone pitches as a whole to the north-north-east (Plate 2). Individual lenses of ore strike north-north-west. As far as could be ascertained, the ore and the low-grade mineralized and silicified material adjacent to it are confined to rocks of the breccia type. In the most southerly glory hole, a sharp wall is seen where hornblende andesite lies adjacent to the hangingwall of the lode, and the andesite of the "schist dyke" within the lode is barren or poorly mineralized. The quartz porphyry is considered to be sufficiently distinctive to be recognizable in the mine even if it were mineralized, and in addition it has not been subjected to the shearing that is obviously a necessary condition for ore formation. The shearing, and apparently the bedding of the breccia, strike north-north-west, corresponding exactly to the long axes of the zones of good ore, so it is likely that differential replacement of more favourable breccia types, probably the fine andesite breccia, has been responsible for this arrangement of the values.

The flat pitch to the north is probably a reflection of the general attitude of the intrusive hornblende andesite and porphyries (Plate 5).

TABLE 2. ORE VALUES, BASED ON MINE SAMPLING

Level	Ore tons	Copper per cent.	Gold dwt	Iron per cent.	Insol. per cent.
Ore Reserves, W.J. Loring's Report, July 1910.					
Pyritic Ore					
1 to 2	30,570	2.54	2.54	18.7	36.2
2 to 3	61,350	2.3	2.1	17.0	38.0
Total Pyritic Ore	91,920	2.38	2.25	17.6	37.4
Siliceous Ore					
Above 1	50,717	2.79	3.0	15.8	54.1
1 to 2	186,841	3.31	3.7	14.3	57.7
2 to 3	325,355	3.0	2.25	9.0	70.0
Total Siliceous Ore	562,913	3.08	2.62	11.3	64.5
Sum pyritic and siliceous ores					
Above 1	50,717	2.79	3.0	15.8	54.1
1 to 2	217,411	3.20	3.08	14.9	54.6
2 to 3	386,705	2.88	2.23	10.3	64.8
Grand Total:	654,833	2.98	2.57	12.2	60.6
Ore Extraction, General Manager's Report 31/5/1914.					
Above 1	1,066	2.83	6.32		
1 to 2	20,764	3.08	3.41		
2 to 3	30,249	2.81	2.69		
Intermediate to 3	12,558	2.55	1.66		
4 to Intermediate	17,028	2.23	1.30		
Total:	81,665	2.70	2.46		
Ore Reserves, 1914, Messrs Bewick Moreing's Report at close of Operations.					
Above 1	35,307	2.65	2.58	16.7	55.0
1 to 2	107,399	2.93	2.53	14.2	57.2
2 to 3	237,669	2.56	2.10	10.6	67.0
Intermediate to 3	62,034	3.09	2.31	10.0	70.0
Total:	442,409	2.73	2.27	11.9	64.1
Production, 1942-43					
Above 1	8,881	1.7	4.1		
1 to 2	4,874	2.66	1.48		
2 to 3	5,592	1.33	2.46		
Development Clean-ups, etc.	653	2.0	2.10		
Total:	20,000	2.62	2.16		

The intense shearing that is the dominant structure of all pre-porphyry rocks is obviously of regional origin, as the hornblende andesites and the other andesites and other rocks on either side of the mineralized area have also been affected by it. Successive intrusions of andesite and quartz porphyry have intensified the shearing within the breccias of the ore zone. Sections drawn through the lode show that the best ore lies immediately below the hangingwall, underneath the "schist dyke", and in the shattered area between and adjacent to the olivine-dolerite dykes and their attendant faults. The intrusive sills appear to have acted as limiting upper horizons for the ascending ore-bearing solutions. The localization of the ore then seems to be due to a combination of these factors:

(1) It is confined to rocks of the breccia type, with differential replacement probably affecting the ore distribution;

(2) The hangingwall lies underneath, and more or less parallel to, flat-lying bodies of hornblende andesite and porphyry;

(3) The regional shearing, combined with local shearing due to intrusions of andesite and porphyry into the breccia, has localized the favourable ore horizons;

(4) The quartz porphyries and the mineralizing solutions probably had a common origin.

No evidence could be found of a central shear plane conformable with the pitch of the orebody, or even of faulting dipping in that direction. Numerous faults were mapped in the workings and the majority strike north-north-west, parallel to the shearing, and dip steeply to the west, although the dips may range from vertical or steeply east to as low as 45 degrees to the west. Slickensides usually pitch steeply north. Other faults strike in different directions - from north-north-west to west-south-west, west-north-west strike being particularly common. The dip of these is generally steep to the south or west, although in some cases dips of 45 degrees were observed. Nearly all the faults are pre-ore and in many cases they were observed to have had some effect on ore deposition. Zones of better-grade ore follow the faults, usually on the hangingwall side. The narrow olivine-dolerite dykes cut steeply through the orebody from near the hangingwall on No. 1 level to the footwall on No. 3. They are quite unmineralized and have no effect on the distribution of ore, except that they have been intruded along strong pre-existing fault zones, and any coincidence of dykes with ore boundaries is entirely due to the relations of these pre-mineral faults with the ore. There is a strong suggestion that the faults along which the dykes were intruded have dropped down, by perhaps as much as 100 feet, the country to the north-east of the dykes.

All the available evidence suggests that the intensity of mineralization, particularly with regard to the gold content of the ore, dies out down the dip of the orebody. The grade of the ore on No. 4 level is poor and, between Nos. 4 and 3 levels, the rises mostly penetrated low-grade ore or comparatively narrow streaks of better ore. The flat portion above the "schist dyke" becomes poorer towards the north-east and lenses out. The main orebody below the "dyke" is mainly fairly good ore down to No. 3 level, but this ore apparently does not extend far vertically below No. 3. Down the dip to the north-north-east the grade appears to diminish and the richer ore to lens out. Diamond drill holes Nos. 6 and 7 penetrated the eastern half of the extension of the orebody. From No. 7, the more easterly hole, no assay returns above 0.15 per cent. copper and 0.3 dwt of gold per ton were obtained. No. 6 passed through 60 feet of mineralized material carrying 1.5 per cent. copper and 0.2 dwt of gold per ton, in the correct position for the extension of the lode (Section J-J', Plate 5), and another 30 feet of similar grade 130 feet lower. Although results obtained from these drill holes are not conclusive because the main orebody may lie west of the holes, the values revealed are not encouraging, particularly the figures for the gold content.

Plate 2 gives a general picture in plan of the orebody as a copper lode. All ore containing more than 1 per cent. copper has been plotted by multiplying its copper content by its vertical thickness, and the copper/feet contours thus obtained are superimposed on a composite outline plan of the levels. The principal mineralized zone is seen to lie near the "front" or south-west limit of the orebody, with a lesser concentration corresponding to the principal mineralization below the "schist dyke". It is significant that all contours except the zero line close completely, suggesting that the prospect of finding further ore to the north-east is not encouraging.

Gold Distribution

Comparison of the distribution of the gold on Nos. 1, 2 and 3 levels with the copper distribution shows that, although the general outlines of the main ore zones on each level are similar, there are wide local differences between the copper and gold contents. In section these differences are even more marked, the principal ones being -

(1) The gold persists up to the adit level and probably to the surface, whereas no copper is found above water level;

(2) Down the dip the gold content diminishes much more rapidly than the copper, and only very low assay values were obtained in the most northerly rises and in No. 6 drill hole;

(3) Gold content drops sharply below No. 3 level, particularly in the south-eastern section of the orebody.

The gold contour plan (Plate 3) when compared with the corresponding copper plan (Plate 2) reveals differences similar to those demonstrated by the sections. The general outlines of the contours in the main section of the orebody are very similar, but the southern limit on Plate 3 is not so abrupt because it carries through to the surface; the lesser concentration in the region of Section-line H-H' on the copper plan is absent from the gold plan; and the gold values disappear so completely to the north that a complete closure is obtained on the zero contour line of the gold plan.

Table 2 sets out the average gold content of the ore on the various levels under different headings and all these figures show a decrease with increasing depth. Particularly high returns have been obtained from some of the semi-oxidized ore above No. 1 level and from the workings below the adit level, and it is probable that local secondary enrichment has been mainly responsible for these occurrences.

Principal Features of Underground Workings

Adit Level. The adit level is driven underneath the outcrop at the same elevation as the collar of the South shaft and 45 feet below the collar of the North shaft.

It passes through intensely silicified quartzite or jasper which, as far as the North shaft, averages 1.5 dwt of gold per ton but does not contain any copper. Near the shaft the back of the drives consists of softer limonitic material. Just west of the North shaft, for sixty feet south and fifty feet north-east, is a definite wall to the quartzite, which dips west and north-west at 60 to 70 degrees. Outside this wall is shaly material which probably belongs to the breccia group. Immediately north of the shaft some stoping has been done to a depth of 50 feet and apparently the ore mined in 1935 and 1936 (Table 1), which returned nearly 6 dwt per ton, came from these workings. Individual assays up to 36 dwt of gold per ton are recorded from this section.

The main drive on this level passes through several faults, some of which appear to be quite strong. These strike north-west to west-south-west and dip south-westerly or south at 35 to 85 degrees.

No. 1 Level. This level is connected to the North shaft only. Most of the southern half of the level was accessible, the remainder being closed off by caving. During 1942-43, two stopes were worked above the level. Stopes C3 and 4, 70 to 190 feet west of the North shaft, between Rises 25'S. and 75'S., were carried to 52 feet above the level, at which height the copper content was rapidly diminishing. Square-set stope No. 1, adjacent to stopes C3 and 4, and just west of Rise 25'S., had reached 35 feet above the level. Production from these two stopes was:-

C3-4	5484 tons assaying 1.46 per cent. copper, 4.1 dwt of gold.
Square-set No. 1.	3397 tons assaying 2.1 per cent. copper, 4.1 dwt of gold.

The country rock on the level is mostly very quartzitic and jaspery but, along the south-east drive, it is a brecciated rock largely replaced by fine-grained silica and probably corresponding to the andesitic breccia exposed at the surface. Steeply-dipping faults follow this drive for much of its length and a band of ore associated with the faults has been stoped overhead to a height of 30 or 40 feet.

<u>No. 2 Level</u> (Plate 4). The higher-grade ore on No. 2 level occurs in two main zones, one near the footwall of the orebody, the other towards the hangingwall. The andesite sill forming the "schist dyke" comes up to the level immediately north-east of the second high-grade zone of ore, and north-east of this the hangingwall lies very flat. This section has been worked by an open stope above the level to the flat hangingwall, and by an underhand stope for a depth of 15 feet or so to extract part of the ore below the level down to the "schist dyke". Above the level, the hangingwall boundary of the ore is fairly well defined.

Operations between Nos. 1 and 2 levels during 1942-43 were confined to two stopes in the footwall section. Production from the upper stope, known as the 29' Floor, 50 feet above the level, amounted to:-

North-west section near North shaft:	1279 tons, 2.16 per cent. copper, 0.8 dwt of gold;
Central section:	1950 tons, 3.5 per cent. copper, 1.4 dwt of gold;
South-east section, east of Rise 40'S:	348 tons, 4.73 per cent. copper, 5.6 dwt of gold.

From the lower stope B-C5, on the north-east side of the upper stope and 20 feet lower, production was 1,089 tons, 1.37 per cent. copper, and 1.3 dwt of gold. In addition 208 tons, 1.08 per cent. copper and 5 dwt of gold were produced from an intermediate level at a depth of 206 feet, on the west side of the North shaft.

The main cross-cut from the North shaft and the long west cross-cut 105'N., pass through sheared quartzitic rocks containing a little fine pyrite and, in places, signs of copper mineralization. These rocks are probably silicified andesitic breccias. In the open stope in the eastern portion of the level, the country rock consists of silicified and pyritized shale in which the bedding can be definitely recognized. It dips at a very small angle to the east and north and is puckered into gentle folds. Farther along the level, near Winze 320' N., the hangingwall country is exposed and consists of slightly silicified sheared talcose material - with no well-defined dip - which may be sheared hornblende andesite.

No. 3 Level. The only portions of No. 3 level that were accessible were the Main cross-cut as far as Winze 270' N., and the workings south-east of this drive. Assay values in these workings tend to be erratic, as previously mentioned, because high-grade streaks and veinlets of ore are separated by barren silicified rock. The ore dimensions are considerably greater than on the other levels and conform to a roughly oval outline, 400 feet long in a north-west direction by 250 feet across. North-west of the Main cross-cut, a considerable amount of stoping has been done from the level upwards, but it is not known to what height this has been carried. In the north-eastern half, this ore would finish against the "schist dyke" at heights of more than 25 feet above the level. Horizontal holes were drilled on the level by Mount Morgan Limited to delimit the ore areas south-east of the Main cross-cut.

Extraction by Mount Morgan Limited is as follows:-

Locality	Ore tons	Copper per cent.	Gold dwt
Stope D6, off Rise 121'N., up to "schist dyke".	2,680	3.12	2.2
Stope E7 on No. 3 level, off North drive 167'E.	486	1.46	0.5
Stope E5 on No. 3 level, off South drive 220'E.	1,149	1.84	0.7
Stope F6 on No. 3 level, off West cross-cut 130'N.	653	2.0	2.1

The drive connecting the South and North shafts traverses quartzitic rock similar to that on No. 2 level, probably a silicified breccia. In the Main cross-cut past the North shaft more signs of bedding are apparent and, in the south-east workings, the country rock is apparently a fine-grained silicified shale, which strikes north-west to north-north-west and dips steeply west. These directions of strike and dip refer only to the shearing or cleavage of the rocks, as bedding was not definitely identified.

No. 4 and Intermediate Levels. These levels could not be examined as they had been allowed to partly fill with water. No ore was extracted below No. 3 level during the 1942-43 operations. Information about ore values on these levels is sketchy because apparently there is no assay plan similar to those for the main levels above. The extent of the levels is shown on Plates 2 and 3. The No. 4 level was developed from an interior shaft, Winze 270'N. The value of the ore on this horizon seems to have been disappointing, being nearly everywhere below 2 per cent. copper. In the General Manager's report of 31st May, 1914, it is recorded that 17,028 tons mined from No. 4 level contained 2.23 per cent. copper and 1.30 dwt of gold. This presumably came mainly from stopes above the level. In the same report, 12,558 tons are recorded from the intermediate level, assaying 2.55 per cent. copper and 1.66 dwt of gold.

DIAMOND DRILLING

Mount Morgan Limited, during 1942-1943, carried out underground diamond drilling to test and prospect for ore at various horizons. In all, 21 holes were drilled - Nos. 1 to 7 on No. 3 level; Nos. 8 to 14 from B5, 6 and 7 stopes, 24 to 34 feet below No. 1 level; Nos. 15 to 19 from C3-4 stope, 25 feet above No. 1 level; and Nos. 20 to 21 on No. 2 level. All these holes were horizontal except Nos. 20 and 21 which were put down vertically from the No. 2 level. The results of this diamond drilling have been taken into consideration in the preparation of the accompanying plans and sections.

Of the drilling carried out from the surface with Queensland Government assistance in 1937-1938, holes Nos. 1 to 5 (Plate 1) were designed to prospect the western extension of the quartzitic outcrop. These did not strike any ore. Nos. 6 (Section J-J', Plate 5) and 7, which were intended to test the lode down the dip, passed through low-grade ore only. Both these holes lie in the eastern half of the lode and it is possible that, if the westerly swing of the orebody indicated by the relative positions of the ore on the No. 3, the Intermediate and the No. 4 levels continued to the north, these holes may have missed the main ore-bearing zone and penetrated only its eastern edge. To settle conclusively the question as to whether the orebody does persist to the north, three additional vertical holes from the surface would be required, on the same line as Nos. 6 and 7, but at intervals of 100 feet successively farther west.

ORE RESERVES

The ore reserve figures adopted for working purposes were based on the assumption that the estimate issued in 1914 by Messrs. Bewick Moreing, General Managers for Great Fitzroy Gold and Copper Mines Limited, was correct. These figures are included in Table 2. The total estimated reserves were 442,409 tons, assaying 2.73 per cent. copper and 2.27 dwt of gold per ton. The amount mined during 1942-43 - 20,000 tons - makes no appreciable difference to these reserves. The mine is insufficiently opened up for any reliable check estimate of the above figures to be made as, with one or two exceptions, it cannot be determined (a) to what height above the level the old stopes were carried or (b) the amount in backs remaining above them. The old stope drives have practically all collapsed and the preparation of most of the old stopes for production again would be difficult and costly.

It is not known whether the above reserve figure is based on W.J. Loring's estimate in 1910 of 654,837 tons, 2.98 per cent. copper and 2.57 dwt of gold, less the amount mined since, plus any additional proved reserves (e.g. below No. 3 level), or whether it is based on an entirely new calculation of reserves still available at the close of the Great Fitzroy Gold and Copper Mines Company's operations. In any case, it is likely that a substantial deduction would have to be made from the above reserves to allow for ore that is left in pillars or that for other reasons cannot be extracted.

J.H. Reid (1938) "deduced that, to the Company's 1914 estimate of 442,500 tons of 2.27 dwt gold and 2.73 per cent. copper reserves above the 300-foot level, there should be added 120,000 tons lying between the 45-foot (adit) and 225-foot levels (between co-ordinates 100'S. and 100'N) carrying up to 16 dwt gold, 2 dwt silver and 2.2 per cent. copper". He also mentioned estimates made by the Company in 1909 of probable ore between the Nos. 2 and 3 levels of 250,000 tons assaying 3 per cent. copper and 1.5 dwt of gold in the northern, eastern and southern extension of the orebody at Nos. 2 and 3 levels. Reid considered that this ore had not been included by the Company in its later estimates of reserves.

Much more information on the mine is available to the writers than Reid had at his disposal in 1938 and the following conclusions have been reached with regard to the possible additional ore referred to above. The plans on which the Great Fitzroy Gold and Copper Mines Company's estimates were based, when compared with the plans at the conclusion of operations in 1942-43 show that, apart from the ore below No. 3 level, there have been no important additions to reserves which still remain unmined. Diamond drilling by Mount Morgan Limited has helped to delimit possible extensions of ore on No. 3 level south-east of the Main cross-cut, and work on Nos. 2 and 3 levels subsequent to the original estimate by Messrs Bewick Moreing Limited in June 1909 referred to by J.H. Reid, of 250,000 tons probable ore assaying 3 per cent. copper and 1.5 dwt of gold, has disproved the possibility of such extensions, so that this amount can almost certainly be eliminated. It is highly probable that this possible ore was considered by Messrs Bewick Moreing in their estimate in 1914. Any ore proved by development since the original estimate would naturally be included in their revised estimate and the remainder discarded, so there is no justification for including in the present reserves ore from an estimate in 1909. It is relevant that 2,912 tons of ore mined during the recent operations on No. 3 level south-east of the Main cross-cut averaged only 1.84 per cent. copper and 0.54 dwt of gold.

With regard to Reid's estimate of 120,000 tons between the 45-foot and 225-foot levels, work done by Mount Morgan Limited has added some new information on the possibility of the existence of this ore. From square-set stope No. 1 above No. 1 level in this section, 3,397 tons of ore assaying 2.1 per cent. copper and 4.1 dwt of gold were produced, corresponding closely with that in the cross-cut on the level shown on Reid's section. A drive north of this cross-cut, near Rise 25'S., however, and horizontal diamond drill holes from the stope 25 feet above the level showed copper values mostly below 1.2 per cent., and erratic but generally low gold assay figures, especially towards the hangingwall. On No. 2 level a continuation of the drive north-east of Rise 20'S. passed through 40 feet of low-grade ore, averaging just under 1 per cent. copper and 0.8 dwt of gold per ton. A stope above this section produced 1,089 tons of ore assaying 1.37 per cent. copper and 1.3 dwt of gold, and diamond drilling parallel to the stope on the north-west side proved values averaging only 0.98 per cent. copper and 1.1 dwt of gold. From these figures it appears that most of the ore in this section is lower in grade than the minimum that has been acceptable for working in the past and little of it - except perhaps part of the ore above No. 1 level - could be included as reserves except under the most favourable metal prices. Mr Reid in his later report (unpublished) calculated 700,000 tons of 2.5 dwt gold ore in the oxidized portion of the orebody above the horizon where the copper values cease. Information is limited in this section but this tonnage figure is probably conservative. Rise 75'S., on the hangingwall of the lode, averages 2.7 dwt of gold per ton over the last 80 feet to the surface, above the limit of economic copper values. Available sampling results indicate an average value of just under 2 dwt per ton on the adit level. Pockets of higher-grade ore have been shown to exist near the hangingwall of the lode north of the North shaft, particularly at 30 to 40 feet below the adit level.

From present knowledge, the ore reserve position may be summarized by saying that the "proved" ore is probably about 400,000 tons, averaging about 2.75 per cent. copper and 2.25 dwt of gold per ton, the extraction of which would be very difficult; that there is possibly more than 70,000 tons of low-grade gold ore near the surface, containing perhaps 2 to 3 dwt of gold per ton; that prospects of further ore outside the above reserves are poor but that to settle this question definitely three additional drill holes from the surface at intervals of 100 feet west of No. 6 drill hole (Plate 1) would be necessary.

ACKNOWLEDGMENTS

We take this opportunity of acknowledging our appreciation of the very useful information and assistance given by Mr E.A. Foote, Mine Manager for Mount Morgan Limited at Mount Chalmers, and of expressing our sincere thanks to Mr and Mrs Foote for their hospitality. We should also like to record our indebtedness to Mount Morgan Limited for providing plans and assay information and for their ready co-operation at all times, and to the Queensland Mines Department, in particular to Mr J.H. Reid, District Geologist stationed at Rockhampton, for making available the information at their disposal.

CANBERRA. 2nd January 1952.

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APPENDIX 1

ROCKS AND ORES FROM MOUNT CHALMERS, QUEENSLAND*

by F.L. Stillwell.

Twelve specimens of rocks and ores from the Mt. Chalmers Copper and Gold Mine, Queensland, have been submitted for examination by the Mineral Resources Survey, Canberra. The average ore carries about 2½ per cent. copper and 2.5 dwt of gold per ton.

COUNTRY ROCK

No. 9 - Country rock from the No. 3 level.
No. 10 - Country rock from the south-east drive, No. 1 level.
No. 11 - Silicified outcrop west of orebody.
No. 12 - Surface specimen, 120 feet south-east of South shaft.

The least altered rocks are Nos. 11 and 12, which can be recognized in thin sections as types of andesite. No. 11 contains numerous phenocrysts of felspar which are absent in No. 12, and they may come from different lava flows. Nos. 9 and 10 are siliceous rocks in which ghosts of altered phenocrysts can be distinguished in a mass of fine-grained silica, and it is probable that they represent andesites entirely replaced by silica.

Specimen No. 11 is an andesite in which the ferromagnesian minerals are thoroughly altered, but which contains numerous stumpy prismatic phenocrysts of plagioclase set in a fine-grained felspathic groundmass. The felspar phenocrysts are about 1.0 x 0.2 mm, and show fine lamellar twinning with an extinction angle of 5-10° in the symmetrical zone, indicating that they consist of andesine (Ab_{70}). The original ferromagnesian minerals are altered to chlorite, epidote, zoisite and quartz. The groundmass consists of fine-grained, interlocking felspathic material with a little chlorite and quartz. The groundmass felspar is untwinned, biaxial and is either orthoclase or albite. An occasional zircon and a little leucoxene are present.

Specimen No. 12 is a highly altered, fine-grained hornblende andesite. It is greenish both in the hand specimen and in thin section. It consists of a mass of fine laths of andesine, with almost straight extinction, associated with ragged prisms of colourless tremolite, derived from hornblende, and some chlorite. Numerous small cloudy areas and grains are dispersed through the rock and consist largely of epidote or zoisite, and in places well-formed crystals of either epidote or zoisite project from the larger areas. Occasional relic phenocrysts of hornblende are represented by ragged wisps of colourless tremolite in areas consisting largely of chlorite, epidote and

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* Mineragraphic Investigations of the Council for Scientific and Industrial Research, Report No. 307, 28th March 1944.

zoisite. A little secondary quartz is present.

Specimen No. 9 is somewhat schistose in the hand specimen. A thin section reveals a brecciated appearance due to the presence of rock fragments with a rather cloudy appearance and a greater abundance of sericite than the surrounding siliceous cement. The rock fragments were originally porphyritic, and the original felspar phenocrysts are represented by mosaics of quartz often with the shape of a felspar crystal. Mosaics of quartz and associated iron ore probably represent replaced phenocrysts of a ferromagnesian mineral. Most of the iron ore is pyrite, but particles of leucoxene have persisted. The matrix between the rock fragments consists of finely crystalline quartz with lesser amounts of sericite. The form of the original felspar phenocrysts is similar to that in No. 11 and the original rock may have been an andesite which has been fractured and sheared. It may also have been an andesite breccia.

Specimen No. 10 is a massive siliceous rock in which the outlines of numerous altered phenocrysts can be recognized in a groundmass consisting essentially of very fine-grained quartz and a little sericite. The phenocrysts have been wholly replaced by quartz and chlorite. The outline of some of these replaced crystals, together with an excess of chlorite over quartz, suggests that they were originally ferromagnesian minerals. Others consisting wholly of quartz suggest the shape of felspar phenocrysts. Ghosts of minute felspar laths can sometimes be seen in the fine-grained cloudy groundmass. A little barite sometimes accompanies the secondary quartz.

The relic structures in the rock indicate that its original nature was similar to the andesites, and it may be regarded as a silicified andesite.

SPECIMENS OF ORE

The specimens of ore include (1) ore from above No. 1 level, (2) ore from No. 1 and No. 2 levels, and (3) ore from No. 3 level.

Ore from above No. 1 Level.

No. 3 - Pyritic jaspery ore from stope above No. 1 level.
No. 7 - Pyritic jaspery ore, 50 feet above No. 1 level.
No. 8 - Ore material from the adit level.

Specimens No. 3 and No. 7 appear in the hand specimen as jasper invaded by veins and veinlets of sulphides and quartz. In a thin section of No. 7, the jasper is found to consist of fine-grained interlocking grains of quartz with disseminated fine particles of red iron oxide which is sometimes segregated into ragged patches. Many of the fine particles of hematite are enclosed within the finest quartz crystals, and the deposition of this hematite must be regarded as contemporaneous with the deposition of silica. Some of the larger patches of hematite suggest traces of crystal form and may have been derived from the iron of replaced ferromagnesian minerals or magnetite. In places, the iron oxide granules follow irregular lines around areas of clear fine-grained quartz, giving a pattern suggestive of colloform banding. Some of these clear areas are vein-like and consist of coarser-grained quartz than is found elsewhere in the rock; others show faint colloform banding. Occasionally, this suggestion of banding is emphasized by the presence of interleaved concentric films of green chlorite. Barite occurs as occasional small irregular areas in parts of the thin section, and isolated grains of pyrite occur throughout the rock.

Polished sections of No. 3 and No. 7 show that the sulphide veins and areas consist essentially of pyrite with varying amounts of chalcopyrite, a little sphalerite and still less galena. In addition there are occasional grains of magnetite, sometimes partly or completely altered to hematite.

In No. 3, the pyrite, which occurs in well-formed cubes where not attacked by later sulphides, is largely replaced by chalcopyrite. Much of the pyrite is extremely fine-grained, and the average width of a crystal is about 0.03 mm, whereas the smallest crystals are 0.001 mm across. These small crystals are closely packed into areas up to 3 mm across. Chalcopyrite has invaded such areas along the grain boundaries, giving rise to an intimate mixture of the two sulphides. In the hand specimen, the areas of disseminated chalcopyrite are 2 to 3 cm across. A small amount of sphalerite accompanies the chalcopyrite. It is distinctly greyer than the occasional magnetite crystals that are present. Sometimes a minute amount of tetrahedrite is present with the sphalerite and is distinguished from occasional areas of hematite that are present in the pyrite by its isotropic character and greenish-grey colour. The hematite is distinctly anisotropic and bluish-grey.

No. 7 appears to contain no chalcopyrite. Instead, it contains rather more sphalerite than No. 3 and, in addition, a small amount of galena. A little magnetite and hematite are also present.

Ore from the adit level, No. 8, includes two types. One consists of jasper, while the other has a limonitic skin of somewhat similar colour to the jasper and consists of quartzy ore with some disseminated pyrite. In thin section, the jasper closely resembles No. 7 but contains much more barite, the barite constituting perhaps one-third of the rock. It also contains inclusions of chloritic schist up to 3 mm long with disseminated oxidized crystals of pyrite that preserve their idiomorphic outline. These chloritic inclusions closely resemble those found in ore specimen No. 1, where there is evidence that the original rock was an andesite.

The quartzy ore consists of dark areas with very fine disseminated sulphides surrounded and veined by white quartz. A thin section discloses that the dark areas consist of fine-grained quartz studded with numerous fine particles of pyrite, yet containing some areas of clear quartz with an outline and disposition suggestive of replaced phenocrysts of felspar in andesite. The white areas surrounding the fine-grained quartz with disseminated sulphides consist mostly of clear, coarser-grained quartz with, in places, remnants of corroded crystals of barite. A polished section shows that the bulk of the opaque sulphides consists of pyrite and many of the particles are less than 0.020 mm wide. Others consist of covellite derived from chalcopyrite or sphalerite. Some of the small areas of covellite contain a small residual core of chalcopyrite. Others contain a core of sphalerite and in some of the larger areas of sphalerite the replacement is only sufficient to produce a marginal rim of covellite around sphalerite. The alteration of pyrite to covellite is not noticeable. This development of covellite is clear evidence of normal enrichment in copper by downward surface waters but, even so, the amount of copper in the ore specimen is very small.

It seems highly probable that the jasper represents andesite that has been more or less completely replaced by silica, some of which may have been deposited in the colloidal state. Either the colloidal silica has since recrystallized or the bulk of the rock formed as fine-grained quartz. Since the jasper is intersected by fresh unaltered sulphides, its formation cannot be related to present surface weathering, and probably belongs to the silicification of the andesites which preceded ore deposition.

Ore from No. 1 and No. 2 Levels.

No. 4 - Ore from No. 1 level
No. 5 - Ore from No. 2 level
No. 6 - Ore from No. 2 level.

These three specimens are closely similar in character. They contain an abundance of barite, which constitutes the bulk of the gangue and is accompanied by a small amount of muscovite and still less quartz. The sulphides are distributed throughout the gangue, with a suggestion of schistose arrangement. The barite is biaxial, positive with a small optic axial angle, a high refractive index, but a low birefringence (which distinguishes it from witherite) and gives a positive flame test for barium. The individual crystals are generally small, although a few range up to 1.0 by 0.2 mm. They show a strong tendency towards parallel arrangement of their long axes. Occasionally they form radiating clusters about 2 to 3 mm in diameter. The crystals show well-developed cleavage, commonly in two directions at right angles.

The sulphide minerals present in the three specimens occur in variable proportions. No. 4 contains chiefly pyrite, with only a little chalcopyrite, but a relative abundance of sphalerite and tetrahedrite, and more galena than was seen in the other ore specimens. The tetrahedrite is greenish-grey and is closely associated with the sphalerite and especially the galena. It may form minute areas about 0.005 by 0.005 mm to 0.010 by 0.010 mm in the interstices of the pyrite crystals. The galena occurs in similar situations, but is not as abundant as the tetrahedrite, nor does it form such large areas. The pyrite in this specimen occurs chiefly as separate crystals, which may range in width from 0.005 to 0.10 mm. Most of the crystals lie between 0.03 and 0.06 mm. The sphalerite forms areas up to 0.3 by 0.3 mm and in places is the chief sulphide.

No. 5 contains considerably more chalcopyrite than No. 4 and tetrahedrite is absent, but sphalerite and galena are both present in small amounts.

No. 6 contains rather more sphalerite than No. 5., to which it is otherwise similar.

Ore from No. 3 Level.

No. 1 - Siliceous ore from No. 3 level
No. 2 - Calcitic ore from No. 3 level.

Specimen No. 1 consists of sulphides and quartz replacing fragments of altered andesitic rock. One angular rock fragment 3 mm across is ramified with fine quartz veins and contains apparent quartz pseudomorphs after felspar phenocrysts in a base of chlorite and silica. Other fragments are essentially chlorite with disseminated pyrite. Coarser grains of pyrite sometimes enclose flakes of chlorite. The matrix in which they occur consists of fine-grained interlocking quartz with patches of coarse vein quartz, sometimes with comb structure, with occasional particles of barite.

The sulphides in No. 1 consist of chalcopyrite and pyrite, with lesser amounts of sphalerite and a lead-antimony sulphide which is referred to as jamesonite, and, in one section, traces of covellite. They occur in the interstices between quartz crystals and sometimes form extensive areas. Pyrite occurs in crystals of various sizes, many of which are minute, and is extensively replaced by irregular areas of chalcopyrite. Where the replacement is advanced, the chalcopyrite contains minute inclusions of pyrite and, where it is not so far advanced, extremely thin stringers of chalcopyrite extend along the boundary planes of adjacent pyrite crystals, so that a complete freeing of the two minerals would be impossible. Owing to the fine-grained character of much of the pyrite, some of the pyrite areas present a frayed appearance where the chalcopyrite has penetrated along the many minute grain boundaries.

Jamesonite occurs as a number of small areas, generally associated with chalcopyrite, sometimes isolated in quartz, but independent of sphalerite. Its colour is similar to that of galena, from which it is distinguished by its strong anisotropism. Nitric acid generally turns it brown and rapidly blackens it, but with some grains the action is delayed and a slow effervescence can be observed. Hydrochloric acid, KCN and $HgCl_2$ and KOH are negative, but $FeCl_3$ generally stains the surface slowly, turning it a mottled brown. Strong microchemical tests for lead and antimony were obtained by leaching the grains with HNO_3 and testing the drops of solution so obtained. The mineral is thus proved to be one of the series of lead-antimony sulphides which are difficult to distinguish positively without a chemical analysis.

In one section, chalcopyrite and occasionally jamesonite and pyrite are intersected by narrow veins, seldom more than 0.002 mm wide, of secondary covellite. This represents the only trace of secondary copper enrichment observed in the specimens from below the adit level.

A single grain of gold, 0.020 by 0.008 mm, was observed in the quartz.

Specimen No. 2, the so-called calcitic ore, consists of large areas of almost massive chalcopyrite, with a gangue of white quartz. Occasional coarse crystals of witherite accompany the quartz. In one polished section, the chalcopyrite forms a wide area enclosing numerous more or less corroded inclusions of pyrite, some of minute size, and a little sphalerite. In another section, numerous small areas of sulphides are dispersed through quartz. Some of these areas consist of pyrite, others of chalcopyrite, and many consist of pyrite more or less replaced by chalcopyrite.

Conclusions.

With regard to the specific information asked for, it can be stated:-

1. The relation between the chalcopyrite and pyrite is one of replacement and intimate mixture. A portion of both minerals occurs in the other in such minute grains as to make a complete liberation of the two impossible by crushing.

2. The gold, as far as can be determined, is not evenly distributed throughout the ore. The only piece of gold observed occurred free in quartz. The possibility is that the gold occurs irregularly in relatively coarse grains, and that quartz is commonly the host mineral.

3. The paucity of copper within 100 feet of the surface is probably a primary feature of the orebody. Secondary copper enrichment is present in a normal way in ore at the adit level, but the total copper present is very small

notwithstanding the fact that it has been more than doubled by secondary enrichment. This signifies either that the amount of copper leached from the weathered and eroded part of the lode was very small or that structural conditions prevailed to prevent the percolation of surface waters from the outcrop down the course of the lode. The small amount of copper in the ore at the adit level and its complete absence in a specimen (No. 7) of sulphide ore above No. 1 level are evidence that the first cause was operative. The presence of secondary enrichment in the ore at the adit indicates that the second cause is not wholly sufficient. There is nothing to indicate a secondary silicification of the ore by descending surface waters but much to suggest a primary replacement of andesites by siliceous solutions at an early stage of mineralization.

4. The specimens submitted suggest that the replaced country rocks consisted of at least two types of andesites. No rocks comparable with rhyolite or dolerite have been observed. Two specimens (No. 1 and No. 11) indicate that the orebody may occur in a belt of fractured andesite.

APPENDIX 2

LIST OF PLANS THAT WERE PREPARED TO ACCOMPANY THE ORIGINAL REPORT
(Only those marked * are reproduced with this report)

Plate		Title	Scale
1	*	Surface Geological Plan	1" = 100'
2		Geological Plan No. 1 (150') level, showing distribution of copper	1" = 50'
3	*	Geological Plan No. 2 (225') level, showing distribution of copper	1" = 50'
4		Geological Plan No. 3 (300') level, showing distribution of copper	1" = 50'
5	*	Composite Plan, showing distribution of copper	1" = 50'
6		Geological Plan No. 1 level, showing distribution of gold	1" = 50'
7		Geological Plan No. 2 level, showing distribution of gold	1" = 50'
8		Geological Plan No. 3 level, showing distribution of gold	1" = 50'
9	*	Composite Plan, showing distribution of gold	1" = 50'
10		Section A-A'	1" = 50'
11		Section B-B'	1" = 50'
12		Section C-C'	1" = 50'
13		Section D-D'	1" = 50'
14		Section E-E'	1" = 50'
15		Section F-F'	1" = 50'
16		Section G-G'	1" = 50'
17		Section H-H'	1" = 50'
18	*	Section J-J'	1" = 50'
19		Section J-J', showing distribution of gold	1" = 50'

Plate 1

SURFACE GEOLOGICAL PLAN
MT. CHALMERS MINE AREA
PH. CAWARRAL - CO. LIVINGSTONE, QUEENSLAND

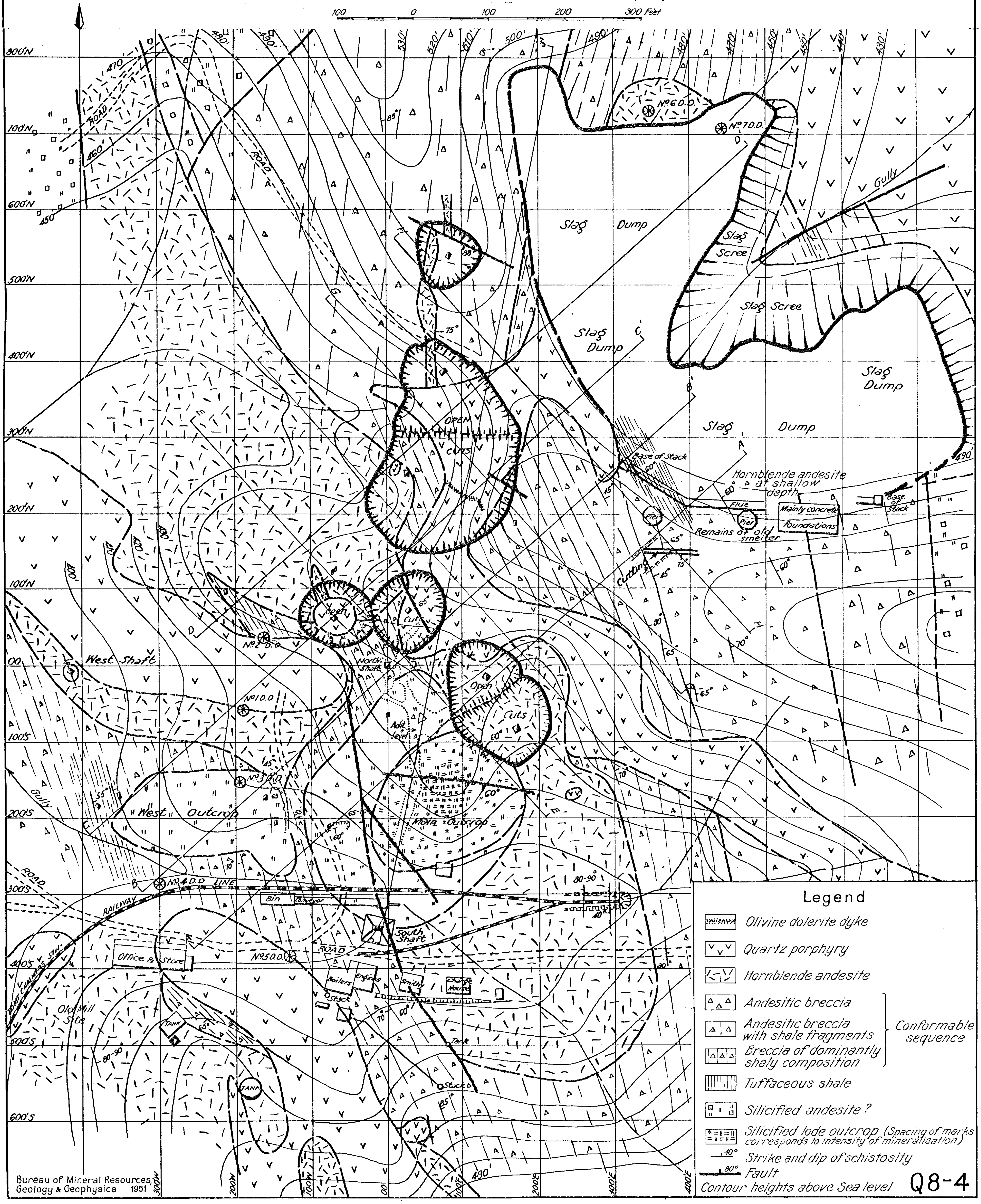
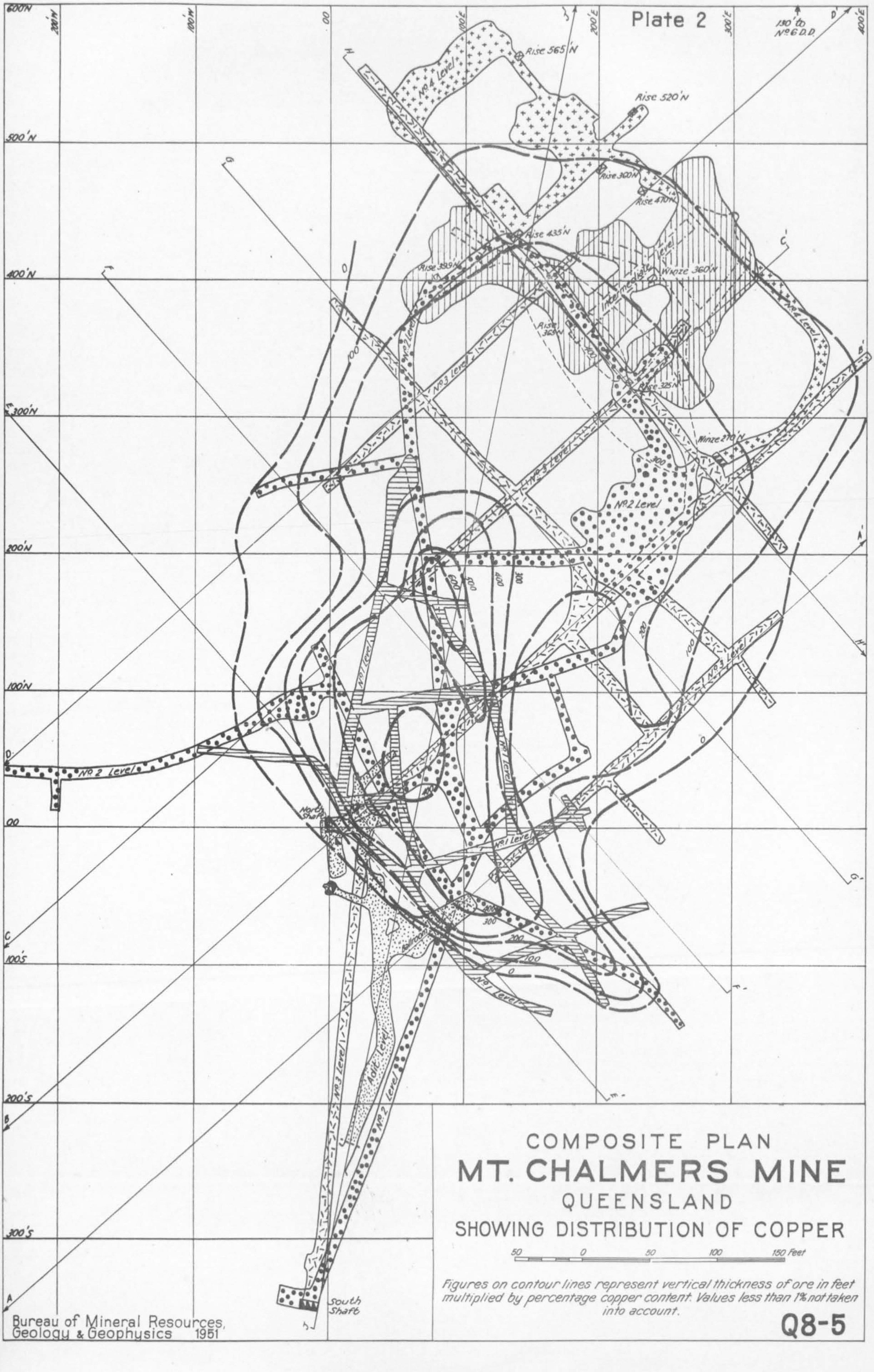


Plate 2



COMPOSITE PLAN

MT. CHALMERS MINE

QUEENSLAND

SHOWING DISTRIBUTION OF COPPER

50 0 50 100 150 Feet

Figures on contour lines represent vertical thickness of ore in feet multiplied by percentage copper content. Values less than 1% not taken into account.

Bureau of Mineral Resources, Geology & Geophysics 1951

Q8-5

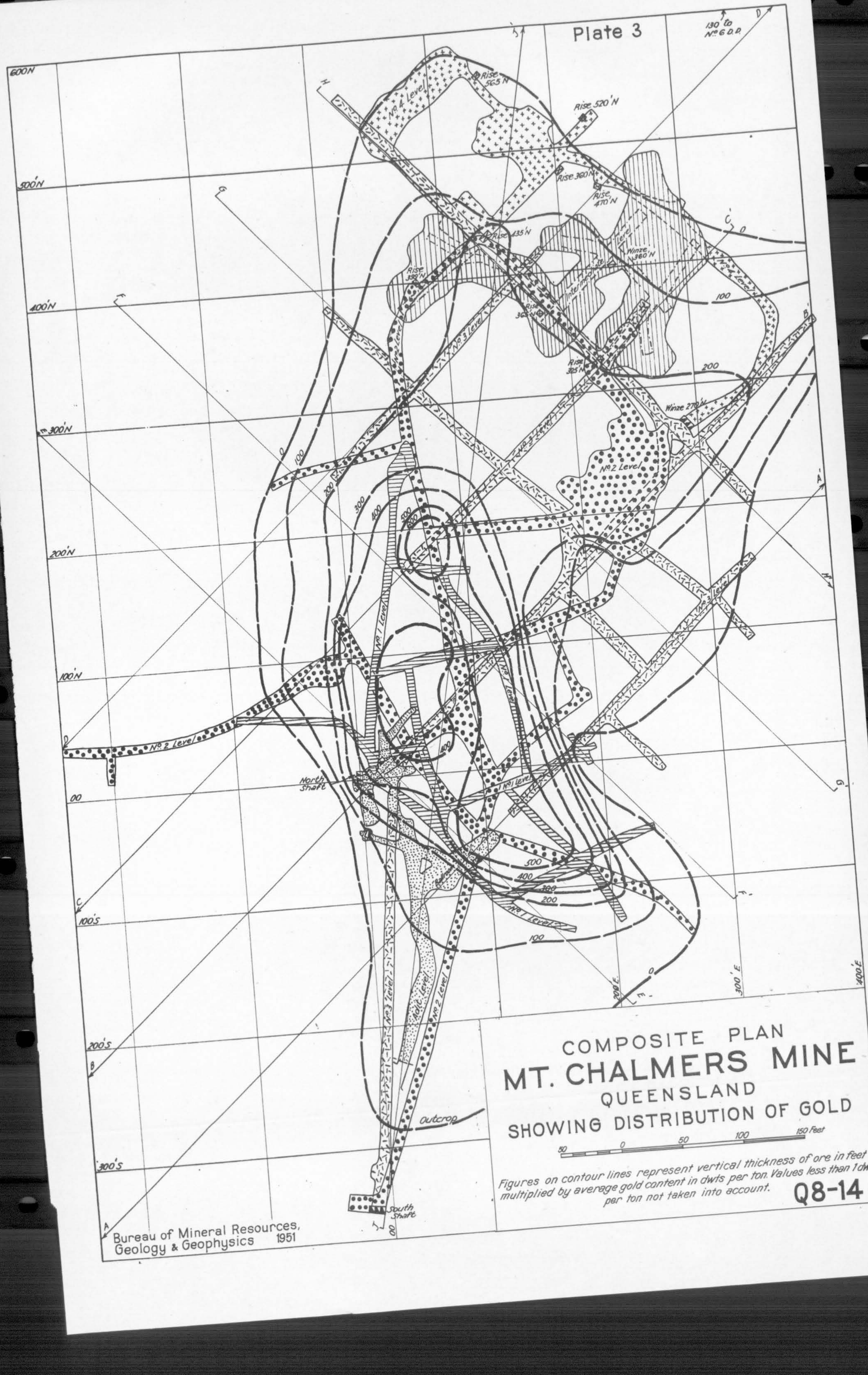
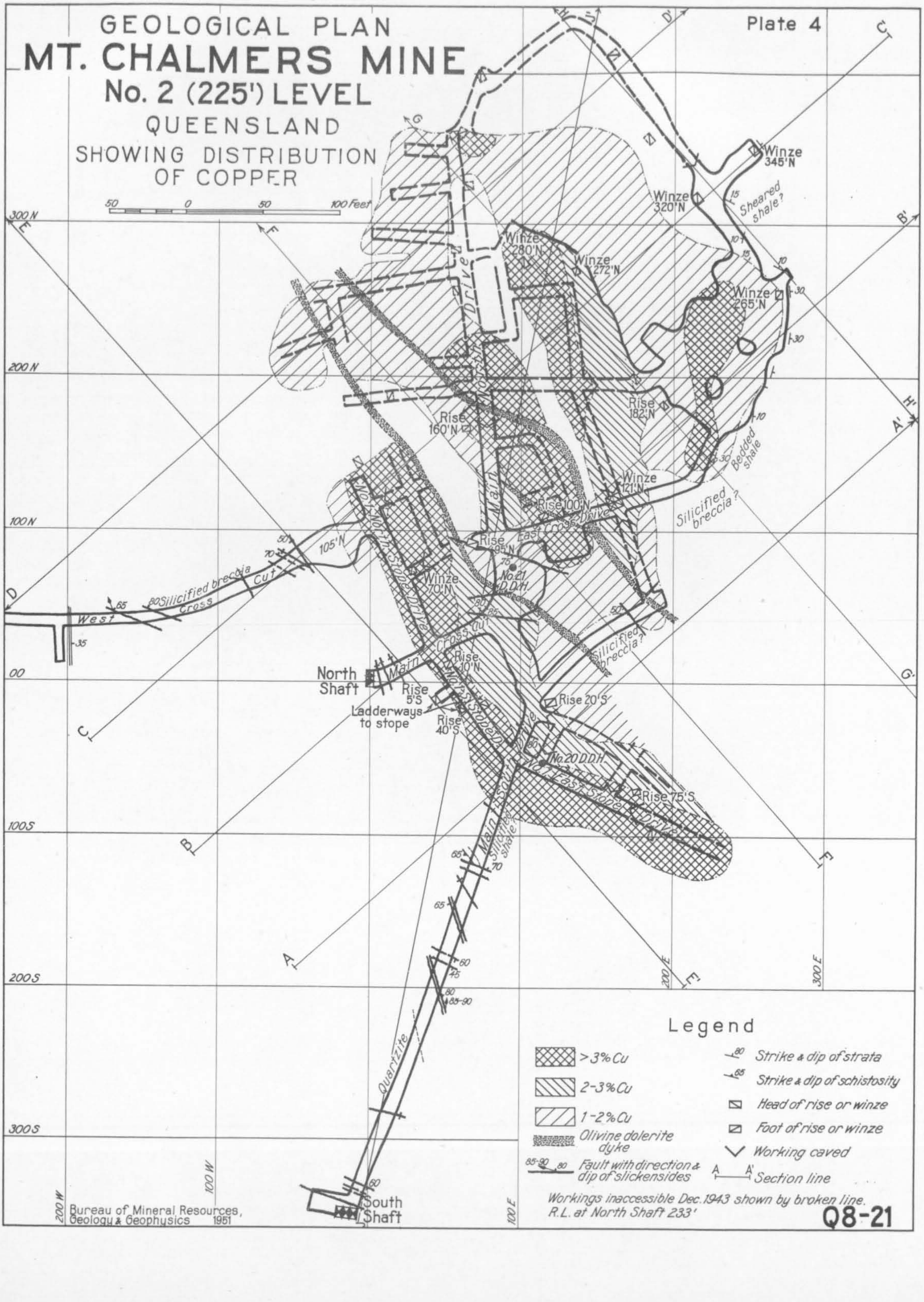
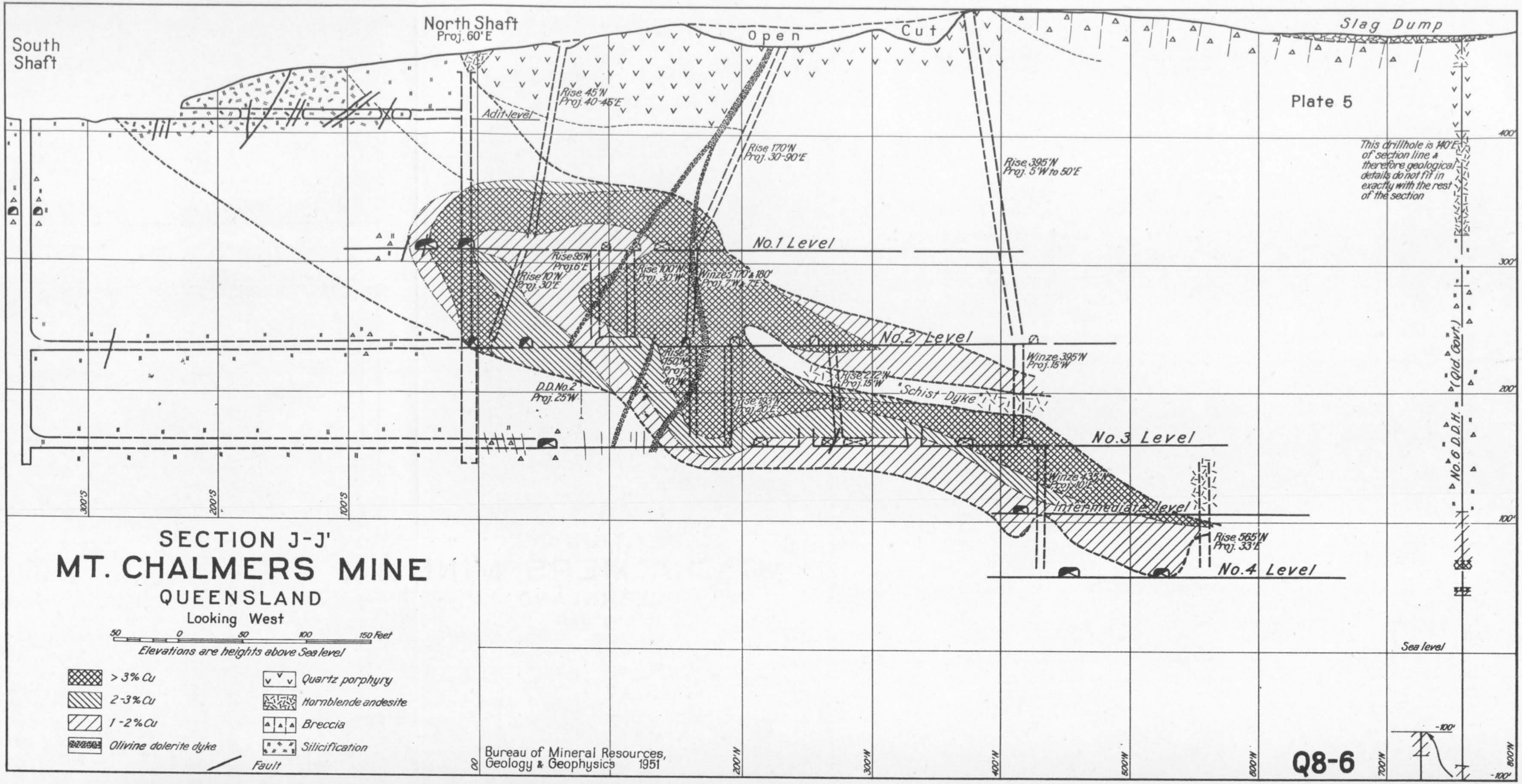


Plate 3
COMPOSITE PLAN
MT. CHALMERS MINE
QUEENSLAND
SHOWING DISTRIBUTION OF GOLD
50 0 50 100 150 Feet
Figures on contour lines represent vertical thickness of ore in feet multiplied by average gold content in dwts per ton. Values less than 1 dwt per ton not taken into account.
Q8-14
Bureau of Mineral Resources, Geology & Geophysics 1951
600'N
500'N
400'N
300'N
200'N
100'N
00
100'S
200'S
300'S
200'E
300'E
400'E
130' to No. 6 D.D.
Rise 565'N
Rise 520'N
Rise 360'N
Rise 470'N
Rise 435'N
Rise 350'N
Rise 362'N
Rise 305'N
Winze 360'N
Winze 270'N
No. 4 Level
No. 3 Level
No. 2 Level
No. 1 Level
Intermediate Level
North Shaft
South Shaft
Outcrop


GEOLOGICAL PLAN
MT. CHALMERS MINE
No. 2 (225') LEVEL
QUEENSLAND
SHOWING DISTRIBUTION OF COPPER
Plate 4
50 0 50 100 Feet
North Shaft
South Shaft
Legend
>3% Cu
2-3% Cu
1-2% Cu
Olivine dolerite dyke
Fault with direction & dip of slickensides
Strike & dip of strata
Strike & dip of schistosity
Head of rise or winze
Foot of rise or winze
Working caved
Section line
Workings inaccessible Dec. 1943 shown by broken line.
R.L. at North Shaft 233'
Bureau of Mineral Resources, Geology & Geophysics 1951
Q8-21



South Shaft
North Shaft
Proj. 60' E
Open Cut
Slag Dump
Plate 5
Adit level
Rise 45'N
Proj. 40-45'E
Rise 170'N
Proj. 30-90'E
Rise 395'N
Proj. 5'W to 50'E
This drillhole is 140'E of section line & therefore geological details do not fit in exactly with the rest of the section
No.1 Level
No.2 Level
No.3 Level
Intermediate level
No.4 Level
Rise 95'N
Proj. 6'E
Rise 10'N
Proj. 30'E
Rise 100'N
Proj. 30'W
Winzes 170' & 180'
Rise 150'N
Proj. 40'W
D.D. No.2
Proj. 25'W
Rise 272'N
Proj. 15'W
Schist Dyke
Winze 395'N
Proj. 15'W
Winze 435'N
Proj. 10'E
Rise 565'N
Proj. 33'E
No. 6 D.D.H. (Old Govt.)
400'
300'
200'
100'
Sea level
-100'
300'S
200'S
100'S
00
200'N
300'N
400'N
500'N
600'N
700'N
800'N
SECTION J-J'
MT. CHALMERS MINE
QUEENSLAND
Looking West
50 0 50 100 150 Feet
Elevations are heights above Sea level
> 3% Cu
2-3% Cu
1-2% Cu
Olivine dolerite dyke
Quartz porphyry
Hornblende andesite
Breccia
Silicification
Fault
Bureau of Mineral Resources, Geology & Geophysics 1951
Q8-6