COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

1944/34 B

REPORT ON THE COMMONWEALTH MICA MINE AT YINNIETHARRA, GASCOYNE RIVER, NORTHWEST DIVISION, WESTERN AUSTRALIA.

by

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DEPARTMENT OF SUPPLY AND SHIPPING.

MINERAL RESOURCES SURVEY BRANCH.

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(Plans No. 1129, 1131, 1136, 1145/6/7.)

Page.

ACCOMPANYING PLATES.

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I. INTRODUCTION.

A. General.

The area was visited in company with Mr. R.S. Matheson of the Geological Survey of Western Australia in December, 1942, when eleven pegmatite bodies bearing mica and beryl were examined. The report furnished after that visit (H.B. Owen, "Mica Deposits of Yinnietharra and Bidgemia Stations, Gascoyne River, Western Australia", Mineral Resources Survey Report No.1943/2, Canberra, 20/1/43), gives details of access, topography, climate and vegetation which are not repeated here.

In view of the urgent demand in Australia for "strategic" mica, i.e. mica of quality equivalent to Clear and Commercial-clear, it was recommended that one deposit at Yinnietharra should be opened and prospecting of others carried on simultaneously. As a result of these recommendations, the Deputy Controller of Mineral Production started mining operations on the selected dyke by open-cutting in June, 1943.

Although it was stressed in the abovementioned report that poor exposure of the dyke, on which there were no workings, rendered any estimate of the probable yield of marketable mica speculative, the results actually obtained were far below expectations, and a heavy financial loss on the project was incurred. Consequently, while the question of abandoning the mine was under consideration, a detailed examination of the workings was carried out in June, 1944, again in the company of Mr. Matheson, and the results of this investigation, which was not wholly confined to geological aspects, are embodied in the present report.

The deposit occurs on a low hill at approximate latitude 24° 31' S. and approximate longitude 116° 03' E., 12½ miles northwest from Yinnietharra homestead. A locality map showing salient features of the district is given on Plate 1. Plate 2 is a plan of the dyke and also shows the workings. This mapping was done with compass, tape and clinometer.

B. Geology.

The area is occupied by Archaean rocks consisting of gneissic granite, and biotite gneiss or schist. The regional trend of the schistosity is northwest with few small local deviations from this direction.

The country rock has been invaded by numerous acid dykes which range in size from insignificant veins to dykes and irregular masses over 100 feet wide by 600 feet long. The composition of these pegmatite masses ranges from almost wholly quartz to about equal proportions of quartz and felspar (microcline and albite). Variations in composition within the limits of one dyke are common and are the subject of discussion in a later section of this report.

On the occasion of the visit to the field in 1942, it was noticed that, in general, the dykes occupied two sets of fissures approximately at right angles to each other and respectively concordant with, and normal to, the strike of the schistosity.

The body chosen for development was one of the latter class with its general strike about northeast and dipping to the northwest. This dyke had not previously been exploited and, being unnamed when first seen, was referred to as No.4. As it still lacks a name, the original reference will be used herein.

II. ECONOMIC GEOLOGY.

A. Structure.

Since December, 1942, a large part of the outcrop has been removed by open-cut mining and the following description of surface features relies on notes made in 1942 with additions made in the light of more detailed examination of that part of the surface which now remains.

The course of the outcrop is sinuous (see Plate 2) and the direction of strike ranges from 30° to 70°, the average being 53°. At its southwest extremity, the dyke pinches rapidly and dies out completely. From this point the pegmatite can be traced along the strike in a generally northeast direction for 670 feet where it has an apparent width of 75 feet, but beyond this there is a wide alluvial flat and the dyke does not outcrop. At the northeast end, the footwall cannot be traced with certainty and the dyke may be narrower than it appears to be, or it may be split into branches.

There is mica showing abundantly in certain portions of the outcrop. In the spur extending east from the main body between the Centre and West open-cuts, mica is especially plentiful. Irregular patches of quartz are also noticeable and, near the southwest end of the dyke, quartz veins, striking 145° intersect the main body on the northern side, but do not extend beyond the footwall. This quartz represents a late phase of the igneous activity, but it is not clear whether the quartz originated within the dyke or external to it.

The dyke is a curved body resulting from injection into a sinuous fissure (see Plate 3). Some movement may have taken place after final consolidation of the pegmatite, but if this has occurred any such displacement or distortion has been so slight as to leave no obvious traces.

The main structural feature of the dyke is a pronounced flattening of the dip, which is accompanied by a decrease in width. In the ensuing description, this feature will be referred to as a "roll". This structure is shown in the section of the dyke exposed at the foot of the haulage way of the Centre open-cut and at this point, the footwall swings in a fairly smooth curve from vertical at the surface to horizontal at a depth of 30 feet, and then curves sharply back with a steep reversed dip and again becomes vertical at 44 feet from the surface. The hanging-wall dips in a series of steps and re-entrants. In this section, the dyke is approximately 24 feet wide at the surface, 9 feet wide at a vertical depth of 30 feet and about 23 feet at 40 feet depth. The shorter section in the block diagram (Plate 3), which illustrates this feature, is a few feet west of the face exposed in the workings at the foot of the haulage and slightly oblique to it. The roll pitches about 25° on a bearing of 15° to 20° and emerges at the surface between the Centre and West open-cuts. It is very prominent in the southwestern end of the Centre open-cut where the dyke passed out of the cut at comparatively shallow depths, necessitating the abandonment of open-cutting in this portion of the workings. Farther northeast along the strike, the roll is less distinct and is revealed in the rise from the 84 foot level to the open-cut, but apparently dies out in a short distance east of the underground workings where the dyke has resumed its normal strike and has a steep dip to the north-northwest.

B. Texture.

The terms "granitic" and "pegmatitic" as used in the ensuing description of the texture of the dyke rock require definition. The former term is applied to that part of the dyke rock which is composed of a coarse granular assemblage of quartz and felspar, with or without, muscovite, and which is characterised by a more or less uniform distribution of the minerals in individual crystals or segregations, not exceeding a few inches in diameter and generally smaller. The application of the term "granitic" to such rock is not intended to imply that the rock is not pegmatite. The word "pegmatitic" is used as descriptive of those parts of the dyke rock which have resulted from the replacement of the granitic rock by rock which is characterised by extremely large and unevenly segregated mineral masses, in which individual crystals or segregations of crystals of any one mineral may be measurable in feet.

The texture or internal structure of the dyke rock displays a wide range in grain size, which is believed to depend upon the degree of alteration which the original rock has undergone.

Those portions of the body which possess a comparatively fine granitic fabric including graphic intergrowths of quartz and felspar, probably represent original rock which has undergone little or no alteration of its textural character. This rock consists essentially of microcline and quartz and a little muscovite, with albite replacing microcline to a greater or lesser degree.

The altered zones, which generally occur near the walls, but may form irregular veins in any part of the main body, are characterised by a "giant" texture in which individual crystals of microcline, and muscovite, and masses of quartz, and albite, may possess dimensions of several feet. The passage from the pegmatitic texture to the granitic type is sharp, but the different zones are not generally bounded by definite walls or planes, and there is an irregular penetration of the latter by the former. Tongues of quartz and large crystals of microcline project into, and are nearly surrounded by, rock of the granitic texture.

An attempt has been made to illustrate the relationship between granitic and pegmatitic textures in the sketches on Plates 4(a) and 4(b). These are drawings, approximately to scale, of parts of the dyke exposed in the walls of the various open-cuts. These sketches suffice to show that, in general, the alteration zones are tabular in form and are sub-parallel to the general attidude of the enclosing dyke. Fig. 2 of Plate 4(a), shows that the mica-rich zone can be very irregular in outline, but even here there is a rough conformity with the hangingwall of the main body.

C. Mineralogy.

The following list gives the principal minerals in their order of abundance. The percentages set against them can be regarded as only a rough approximation to the actual proportion of each mineral present in the pegmatite as a whole, that is in the entire dyke rock and not only that portion possessing pegmatitic texture. Wide variations in the mineral composition of the body occur from place to place according to the degree to which the original rock has been replaced.

Mineral		Per Cent.
Quartz	....	40
Microcline	....	35
Plagioclase (Albite)	..	15
Muscovite	....	3
Biotite, Tourmaline, Garnet, Beryl etc.	....	2

Quartz. In what is believed to be representative of the original pegmatite, quartz occurs graphically intergrown with microcline and associated with microcline and muscovite in a rock with a granitic texture. Quartz replacing other minerals takes the form of veins and large irregular glassy masses, but whitish translucent quartz is not uncommon. Such whitish quartz replacing granitic pegmatite in a dyke about 6 miles northwest from No.4 was visibly retained the granular texture of the replaced rock. On weathering, this quartz breaks into gravel of remarkably uniform size. At The Cairn, 1 mile southeast from the mine, quartz which occurs in large masses in a pegmatite, contains whitish streaks and patches suggestive of traces of an earlier texture.

Microcline. This felspar is a common constituent of both original and replaced portions of the dyke. As mentioned above, it is found closely associated with quartz in comparatively fine-grained rock, but no remnants of orthoclase were found.

In other parts of the body, microcline occurs in large euhedral crystals commonly one foot in diameter by 2 feet long; much larger crystals up to about 3 feet by 5 feet are present. These crystals are generally associated with muscovite and often show partial replacement by albite and contain round grains of plagioclase, which are not in optical continuity with the microcline.

Albite. Albite is common and occurs in large masses and in microscopic veinlets, and patches in microcline. Intermediate stages showing replacement in the hand specimen are not uncommon. Further details regarding the felspars are given at the end of this section.

Muscovite. Similarly to quartz, muscovite occurs both as an original mineral and as a later one replacing earlier portions of the rock mass. Crystals and aggregates of muscovite reach large dimensions, single 'books' measure up to 2 feet in diameter by 6 to 9 inches thick. Aggregates of books of this size, and smaller, are closely packed, resulting in large masses of mica almost wholly devoid of any other mineral. Development of the mica crystals in close proximity to each other has led to interpenetration and much mutual distortion of the books. The mica is the ruby variety and is described in detail in a later section.

Only that muscovite which is deposited from later hydrothermal solutions occurs in crystals large enough to yield commercial sheet mica. Aggregates of such mica containing numerous crystals in as many different orientations commonly occur in close association with the large masses of quartz, and usually have the interstitial spaces filled with clear glassy quartz. Less commonly in No.4 dyke mica books occur in felspar, and then are present generally as individual crystals, or smaller segregations than those found in the quartz. Single mica crystals surrounded by a considerable thickness of quartz also occur. In other deposits on Yinnietharra, large segregations of mica may be found in a felspathic matrix.

There is little concerning the distribution of commercial muscovite in the dyke that can be regarded as regular. Its occurrence is predictable only insofar as it is known to be restricted to areas of complete replacement. These zones of replaced rock have been shown to possess a roughly tabular form parallel to the boundaries of the dyke, but this relationship is not always true of other deposits and could not be expected to hold good indefinitely in No. 4 dyke. It is noteworthy that the mica-bearing zone disclosed in No. 2 and the East open-cuts is very much narrower than in the main workings.

Biotite. This mica is comparatively rare and occurs only near the walls of the dyke. It is fairly prominent near the footwall in the west and centre open-cuts. As its occurrence is limited to the proximity of the walls, it appears that this mineral may be derived from the wall rock by absorption of ferro-magnesian minerals.

Tourmaline. Black tourmaline is less common in No. 4 dyke than in many pegmatites elsewhere at Yinnietharra. Small crystals occur near the walls in a few places and in minor amount scattered in granitic pegmatite near a coarse grained replacement vein in the East open-cut. Minute laths and flattened basal plates of tourmaline form deleterious inclusions between the laminae of mica crystals.

Garnet. Reddish-brown common garnet is rare and is found in narrow veins and bands which consist largely of small crystals of the mineral embedded in quartz.

Beryl. Although rare, beryl is found in large pale green crystals in replaced zones in the dyke. It appears to replace quartz and felspar, and, more rarely, muscovite. It is generally associated with the larger masses of quartz, and, in some cases, with the very big microcline crystals, and, in others, adjacent to or penetrating books of muscovite. Crystals with diameters up to 6 to 8 inches have been found during mining operations, and these and smaller ones set aside for sale. Only 600 pounds of beryl were recovered from about 5,000 tons of pegmatite, but all small crystals and fragments would be lost and even some large crystals overlooked. It is unlikely that beryl constitutes more than 0.2 per cent of the rock.

Bismuthinite and columbite both occur in a large pegmatite situated 1 mile south-east from the mine, but neither has been noted in No. 4 dyke.

D. Relationship between Felspars.

Specimens of felspar from various places (some are shown on Plate 4(a)) were subjected to examination and the following observations made. It was thought that microcline might have resulted from alteration of orthoclase in the original dyke rock, but no remnants of the latter mineral were found during microscopic examination of thin sections and cleavage flakes. The microcline contains a number of rounded and corroded grains of plagioclase (oligoclase ?). Such grains are not in optical continuity with the microcline whereas the veinlets and patches of albite usually are. These inclusions of albite are common and are usually very irregular in outline. The veinlets traverse the microcline in all directions. Albite is common on external edges of microcline faces and these replacements range from a thin skin of soda felspar to almost complete replacement.

It appears that plagioclase felspars were introduced in two stages separated by a phase when microcline was deposited.

Notes on the specimens from places marked on Plate 4(a) are given:-

No. 1 (West open-cut). Very white felspar, somewhat weathered and showing multiple twinning in the hand specimen. This felspar is albite approaching oligoclase in composition. It contains a very small amount of microcline and grains of quartz.

No.2 (West open-cut). This specimen was taken from rock with a granitic texture composed of plagioclase, quartz and muscovite. The felspar is albite.

No. 2A. This was a larger crystal of felspar adjacent to the position of No. 2 specimen and was found to be microcline partly replaced by albite along edges of the crystal.

No. 3 and 4. (West open-cut). These two specimens are similar to No. 2A and contain irregular patches and veins of albite enclosed in the microcline.

No. 6 and 7. (East open-cut). Both very similar to No. 2.

No. 8 (East open-cut). This specimen of microcline was taken from a vein of coarse felspar and mica in the west face of the cut. It is partly replaced by albite which occurs in plates up to 2 millimetres thick lying at random orientation.

Other specimens from the dump at the West open-cut and from the main workings were similar to the above and consisted of either microcline or albite.

III. DESCRIPTION OF MUSCOVITE.

A. General.

Most of the books of crude mica as won possess ragged and tangled edges (prism faces) due to interpenetration of adjoining crystals of mica and, less commonly, of masses of quartz, felspar or beryl. Fractures extend deeply into the books from the edges, but generally have a limited range in planes normal to the basal cleavage.

In thin plates, the mica is brownish-pink by transmitted light and distinctly red in places 3 m.m. or more in thickness. The mineral is sufficiently clear to permit objects in daylight to be plainly distinguished when viewed through the mica in packs from 6 to 12 m.m. thick. Some thin sheets show a very few small orange-coloured stains and minute dust-like inclusions just visible to the unaided eye. Small black spots up to 1 m.m. across, and inclusions of foreign minerals of about the same size, occur rarely.

The trimmed block mica resulting from the final processing of this mica is marketed as "Commercial-clear" which is about equivalent to Indian "Good-stained" and slightly better. Further splitting yields very high quality hard ruby mica.

B. Structural Defects.

The structural imperfections in the mica at Yinnietharra are similar to those commonly encountered elsewhere such as fractures, buckles, striations ("fishbone") and tangled areas.

Most, but not all, of the muscovite in No. 4 dyke occurs in segregations formed of many close-packed crystals with random orientation. The crystals or books are tightly wedged against each other and much bending and fracturing of the mica has been cuased at interfaces. Although this damage is mainly confined to the edges of the books, the zone so spoiled may average two or more inches in width, and this means that most crystals with diameter of 6 inches or less are almost worthless, and the effective size of larger crystals is greatly reduced.

Fractures are common in the marginal warped areas of damaged books and may extend beyond the zone of distortion as inconspicuous fine lines. On splitting the mica to thin plates, these cracks show to better advantage and are seen to follow curved and branching paths forming delicate arborescent and wisp-like patterns. As indicated above, the fractures may not have much vertical range with the result that comparatively thin plates of fractured mica may be split from a book and discarded leaving sound material beneath.

Striations, or rulings, in the form of narrow bands of parallel ripples occur in some books, but "fishbone", that is two or more sets of rulings, intersecting at 60° or 120°, were noticed only rarely. Rulings bear a relationship to the crystal axes (generally parallel to, and at 60° and 120° to the optic axial plane) and may be caused by interruptions during the growth of the crystal or subsequent parting on the gliding planes.

"Tangling of the mica", which prevents splitting to films of even thickness, is mainly confined to the marginal areas of the books that are badly buckled.

The structural imperfections of the mica produced from the mine have proved very serious and have been the principal cause of the rejection of 98.9 per cent of crude mica won, (See Tables I and II).

C. Stains and Inclusions of Foreign Minerals.

Although stains in the mica are necessarily inclusions in the strict sense, that term is here used to indicate films of foreign matter which lie between and do not interrupt the laminae of the mica. On the other hand, the word 'inclusion' is used to describe a mineral particle, often a euhedral crystal, which lies across the laminated structure of the mica, or a platy inclusion thick enough to produce noticeable distortion and separation of the laminae.

The mica recovered from No. 4 dyke is free from that heavy staining due to magnetite and hydrated ferric oxide, which takes the form of a lattice of intersecting yellow, red, brown and black streaks and only a few spots and small irregular patches of orange and red stains were observed in all the mica examined. These stains rarely exceed 2 m.m. in diameter, but tend to occur in clusters occupying a total area of 3 sq. c.m. or less. Rarely, larger areas of staining are encountered. These stains may be removed with a minimum loss of mica by splitting.

Black spots consisting of plates of magnetite are also very rare and small. Careful scrutiny of about 1 pound of specimens of block mica trimmed for despatch from the mine revealed only one such spot, although some of this mica had been specially selected as being more stained than the average.

Mineral inclusions, as defined above, while rare, are less uncommon than stains, and constitute a more serious blemish in the sheet mica. For this latter reason, typical examples of different types of inclusions are described in detail and some are illustrated on Plate 5. The comparative rarity of the inclusions is indicated by the fact that it was necessary to select from mica ready for despatch to Melbourne, specimens in which spots and stains were developed to an unusually high degree and thus avoid the tedious search under magnification necessary to find flaws of this type in mica of the average grade.

Two examples of the commonest type of inclusion are shown magnified to about 140 and 280 diameters in Fig. 1a and 1b, Plate 5. This type of inclusion, when about the size of those shown in the figures, which were the largest observed, can be felt with the fingertips as a raised spot, and is visible to the unaided eye as a minute black speck. Under the microscope, it is seen to be a circular or elliptical dark greyish-brown stain surrounded by a fragment of crystalline mineral staining. The centre is occupied by a fragment of crystalline mineral which is partly obscured by the stain. The mineral occupying the centre of such spots has not been identified owing to the small amount available and to the masking of optical properties by the surrounding muscovite (and biotite in some cases). It is worth noting that the largest mineral grain observed in any of these spots measured 0.09 x o.05 m.m. and it is believed that such spots may originate about fragments of minerals belonging to different species. An area of light brown staining with the appearance of biotite intergrown with the muscivite surrounds each spot. Inclusions of similar type were noted in musvovite from the Rex Mine, Northern Territory (Owen, H.B. "Microscopie Examination of Mica from Rex Mine, Northern Territory" Min. Res. Surv. Rept. 1943/43).

Tourmaline crystals occur embedded in the mica as laths measuring from 1 x 0.5 x 0.05 m.m. to needles visible only under magnification. Thin plates showing the basal section have been observed.

Small inclusions of quartz and felspar are rare, but large irregular fragments, and inch across, and tongues and wedges protruding several inches into the books are common near the edges of the larger crystals.

Tapering plates of silica lying between the laminae of the muscovite and exceeding half an inch in thickness at the outer edge were seen in books in situ in the main workings.

Flattened plates of albite up to 3 x 2 m.m. have been noted and a few very much smaller fragments of felspar.

An interesting occurrence of biotite intergrown with muscovite is shown in Fig. 2, Plate 5. To the unaided eye, this inclusion of biotite appears by reflected light as a silvery streak about 0.2 m.m. wide, and by transmitted light as a narrower brown line. Splitting the mica revealed that the line possessed considerable vertical depth and extended almost through the thickness of the book. When magnified, the line is seen to be composed of contiguous, or nearly so, specks of included minerals, mainly biotite. This defect is fairly common in mica from some mines in the Northern Territory where it is known as 'metallic' or 'mineral' streak, and where the included mineral is usually magnetite, but only few examples were noticed at the Commonwealth mine at Yinnietharra - (Metallic streak is more common in the heavily stained mica from The Cairn, Yinnietharra). The streak shown in the accompanying figure differs from others previously examined in that the line of inclusions follows a sharply sinuous course for part of its length.

Small inclusions of air are also present, but staining of the mica due to this cause is generally not sufficiently serious to reduce the quality of the mica any appreciable degree.

D. <u>Size</u>.

The size, or grade of the sheet mica recovered from the mine is dealt with in Section IV of this report in which it is recorded that only 4% of the marketable product was sheet mica, exceeding the size of Grade 4. Sheets of Grade 2 or better (over 15 sq. inches) amounted to less than 1%. The proportion of Grade 6 recovered was unusually low and the result indicates that most of the small mica that could have been recovered was not saved.

IV. ORIGIN OF THE MICA PEGMATITE.

Without an extremely detailed study of the fabric and mineral constitution of the pegmatite, it is not possible to be dogmatic in discussion of its origin. It is apparent, however, that No. 4 dyke displays many of the characteristics described by A.L. Anderson in a paper dealing with mica-bearing pegmatites in the United States, (Anderson, A.L., Genesis of the Mica Pegmatite Deposits of Latah County, Idaho. Econ. Geol. Vol 28, p.41). In that contribution, the writer claims that the coarse-grained portions of the dyke which contain commercial muscovite result from the action of hydrothermal solutions upon the original dyke rock which consisted of graphically intergrown microcline (orthoclase ?) and quartz.

There is at least one major difference between the pegmatite of No. 4 dyke and those described by Anderson. In Idaho, microcline, partly replaced by albite, is found only in those portions of the dyke which possess a granitic texture, while at Yinnietharra (and the Plenty River field, Northern Territory) microcline occurs in the granitic pegmatite and as large crystals in replacement zones. This fact suggests that the later hydrothermal solutions which were responsible for the alteration and replacement of the original granitic pegmatite were very rich in potassium and deposited microcline and muscovite at the expense of the original intergrown microcline and quartz.

In Section II C, it has been stated that specimens of microcline which were sectioned enclose corroded grains of plagioclase, (which is probably oligoclase), and veinlets and patches of albite. It is evident from inspection of the sections that the microcline is later than the enclosed oligoclase (?) which it is replacing, and is, in turn, being replaced by the albite. The albite itself may be of two separate generations; firstly, that which is intergrown in optical continuity with the microcline and, secondly, that which is attacking and replacing the microcline on interfaces and boundaries and bear no constant relationship to the optical orientation to the host mineral.

The results so far obtained suggest that mineralisation took place somewhat in the following stages, but this suggestion is only tentative.

1. Felspars of original rock (granitic assemblage of quartz, orthoclase or microcline, plagioclase and muscovite) replaced by microcline.

2. Deposition of large crystals of microcline and muscovite, with glassy quartz at end of this stage.

3. Stage of albitization in which large crystals of microcline attacked on edges and microcline of stage 1 almost wholly replaced. Further introduction of quartz probable.

4. Introduction of beryl, tourmaline and garnet, but tourmaline may be earlier.

V. DESCRIPTION OF WORKINGS AS AT 26/6/44.

The dyke has been developed by three open-cuts, two of which, No. 1 or Centre open-cut and No. 2 or West open-cut, were operated by inclined haulage ways cuts in the direction of the schistosity of the country rock (see Plate 2). The other, East open-cut, which is the smallest of the three openings, is shallow and advantage has been taken of a low rise where the pegmatite outcrops above the soil of an alluvial flat.

East open-cut. This small quarry is the first working place opened and is about 20 feet wide and follows the hangingwall for 60 feet. Its maximum vertical depth at the face is 10 feet and to gain even this modest depth, it has been necessary to depress the quarry floor below horizontal. Operations were discontinued when approximately 300 tons of dyke rock and 180 tons of country rock had been excavated.

No. 1 or Centre open-cut. A new open-cut was started further up the gentle slope of the low hill on which the dyke outcrops. The site chosen coincided with a sharp swing in the strike of the body and consequently the open-cut became arcuate in plan with the incline extending north-westerly from the apex of the arc. The southern arm of the cut averages 20 feet wide and consists of two benches at 14 feet and 29 feet below surface and 25 and 40 feet long respectively. The walls are vertical. The main branch of the open-cut extends on a bearing of 70° from the foot of the haulage way for 130 feet. The average width is 30 feet at the surface and 8 feet at the floor and the vertical depth is

44 feet. The incline is 145 feet in length from the floor of the cut to natural surface.

The tonnage of dyke rock excavated from the cut is 8,000 long tons and country rock removed, exclusive of that from the incline amounts to about 2,000 tons.

A vertical shaft at a point 35 feet north from the junction of the incline with the wall of the open-cut, has been sunk to 91 feet and a cross-cut bearing 150° extended for 26 feet at the 84 foot level intersects the hangingwall of the dyke at 6 feet and the footwall at 24 feet from the shaft. A rise from the end of the crosscut is connected through to the floor of the open-cut. This rise follows a somewhat spiral course, being vertical for 15 feet above the level, then inclining to the south-west and then to the south-south-east. The footwall appears in the eastern corner of the rise at about 14 feet below the floor of the open-cut, and, at the 84 foot level, the wall crosses the rise diagonally from east to west.

Short drives extend at right angles to the cross-cut; one bearing 240° and 16 feet from the shaft is 10 feet long and reaches the footwall in the southern corner of the face. The other drive starts against the footwall and extends only 6 feet into the dyke on a bearing of 62°.

Where interested by these workings, the two walls of the dyke are parallel and their strike is 80°. The dip of the footwall is very steep and irregular and averages about 85° to the north; the hangingwall is vertical.

No. 2 or West open-cut. This open-cut was started to provide additional working faces which could be worked simultaneously with No. 1 cut, but poor results led to its abandonment at a depth of 18 feet.

The cut is 62 feet long with an average width at the surface of 16 feet. The walls are nearly vertical. Along the north wall of the cut, the hangingwall of the dyke dips at 65° to 70° to the north, but the footwall is steeper and passes through the vertical to a steep reversed dip to the south.

VI. PRODUCTION.

The figures in Table I are derived from records kept at the mine and refer to production from No. 1 open-cut only. Table II is compiled from both mine and shop records. It was noticed that there was not always complete, or even close, agreement between mine and shop, regarding the nett weights of mica consigned to and received in Melbourne, and the figures in Column 3 of the table are those given by the shop.

There does not seem to be any necessity to correlate the figures in the final column of Table I with those in Column 4 of Table II, nor is it possible to do so. Crude mica produced during any given period was not necessarily sorted, trimmed and despatched to Melbourne at the same time, and some mixing of crude mica recovered in different periods was inevitable. It is not possible to indicate with exactness which mica came from the east open-cut, but it is known that Lots 1, 2 and 3, and probably 4 (Table II) were produced before No. 1 open-cut was operating, and that the remainder, except for a small amount from No. 2 open-cut, was derived from the main workings.

TABLE I.

Operations at No. 1 open-cut.

Period	Approx. end of period.	Pegmatite broken Long tons	Crude Mica Recovered lb.	Lb. per ton of rock.	Rough trimmed mica consigned from mine. lb.
	1943				
1	4 Oct.	464	7,350	15.9	595
2	22 Oct.	630	26,904	42.7	1,084
3	31 Oct.	391	14,733	37.7	797
4	19 Nov.	184	9,054	49.2	1,944
5	2 Dec.	626	29,465	47.1	3,209
6	18 Dec.	328	18,382	56.0	2,854[x]
7	1 Feb. '44	324	14,556	44.9	1,381
8	15 Feb.	591	15,264	25.8	1,036
9	1 Mar.	657	13,097	19.9	1,683
10	15 Mar.	668	11,288	16.9	1,076
11	29 Mar.	640	22,984	35.9	1,037
12	10 Apr.	51	9,580	187.8	526
13	25 Apr.	166	4,239	25.5	230[ж]
14	10 May	520	7,694	14.8	282
15	24 May	559	10,640	19.0	428
16	7 June	581	9,591	16.5	261
17	21 June	615	8,352	13.6	252
		7,995	233,173	29.2	18,675

x Rough sickle-trimming started with Consignment No. 11, which was despatched from the mine on 3rd February, 1944.

ж Further improvement in trimming at mine.

TABLE II.

Marketable sheet mica recovered at Departmental cutting shop.

Lot No.	Date Consigned	Nett weight recd. at store lb.	Remarks by mine Superintendent.	Marketable block mica recovered lb.	Value £ s d
	1943				
1	25 Aug.	261	'Oxidised', some clear.	38¾	24. 10. 1
		100(S)		99¼(S)	
2	2 Sep.	374	Mainly scrap	47	27. 18.10
3	11 Sep.	617½		94½	50. 12. 3
4	22 Sep.	628		92	43. 9. 1
5	4 Oct.	1,199		146¼	67. 13. 0
6	22 Oct.	1,205½		160	67. 16. 0
7	31 Oct.	422		45¼	19. 11. 1
8	19 Nov.	958		105	45. 9. 9
9	2 Dec.	1,360	Commercial-clear	99¼	87. 8.11
9a	2 Dec.	90½	Sickle trimmed block	90½	60. 6. 0
10	18 Dec.	5,224	Best mica despatched to date.	250	146. 7. 4
-	- -	14	Trimmed block mica	13½	8. 18. 4
	1944				
11	3 Feb.	1,564	Rough Sickle-trimmed	276	152. 8. 1
		6	Block	6	4. 8. 2
12	17 Feb.	1,627	Rough sickle-trimmed	289½	176. 6. 9
13	3 Mar.	1,054½	Rough sickle-trimmed	198½	111. 6. 8
14	17 Mar.	1,045	Rough sickle-trimmed	184	90. 14. 0
15	31 Mar.	304		51	39. 16. 0
16	27 Apr.	232		46	22. 9. 8
17	12 May	327		140¾	83. 7. 4
18	26 May	424		159	81. 3.11
19	9 June	223		128¼	60. 12. 0
20	23 June	206		113½	53. 16. 9
21	7 July	297		169½	84. 16. 0
		19,663[z]		2,944	1,611. 2. 0[x]

Notes:

Lots 1 to 4 from east open-cut, but No. 4 may have contained some mica from No. 1 open-cut.

Lot 1 contained about 100 lb. of heavily stained mica from the King Mine.

(S) Indicates stained mica not included in total.
x Includes value of about 17,600 lb scrap mica - £110
z Mine records show total mica consigned, excluding stained mica from King Mine, as 19,851 lb.

Table III shows the grades of the mica recovered. After receipt of Lot 11, a new system of grading came into force and it has been necessary to divide the table into two parts showing the results obtained under the two systems. To facilitate comparison, the dimensions of each grade is indicated in both sections of the table.

TABLE III.

Grade	Large sq.ins.	Medium sq.ins.	Strip not less than	Small sq.ins.	Washer sq.ins.	Total
Dimension	60 to 20	20 to 10	5 ins.by 1 ins.	10 to 6	6 to 1½	
Lb	4	35¼	35¾	121	882	1,078
Per cent.	0.4	3.3	3.3.	11.2	81.2	100.0

(b) Lots 11 to 21.x

Grade	1	2	3	4	5	6	Total
Dimension (sq.ins.)	36-24	24-15	15-10	10-6	6-3	3-1½	
Lb.	1½	10¾	66¾	323¼	937	526¾	1,866
Per cent.	0.7		3.6	17.3	50.2	28.2	100.0

x Including 104 lb. from Lots 9 and 10, which was experimentally graded at mine in accordance with new system.

The figures in the above talbe may be summarised to show the proportions of different sizes of sheet mica recovered:-

Exceeding 10 square inches	....	4.0 per cent.
From 10 to 6 " "	....	15.3 " "
From 6 to 1½ " "	....	80.7 " "
		100.0 " "

VII. PREPARATION OF MICA AT THE MINE.

It was not intended that marketable block mica, properly trimmed and graded should be produced at the mine, but that final preparation should be conducted at the Departmental mica cutting shop in Melbourne. Nevertheless, some selection and preparation of the mica at the point of production was necessary and the methods used underwent a series of refinements during the short history of the project.

To guard against possible loss of sound mica, it was considered that all but obviously useless material should be forwarded to Melbourne, but this procedure led to large quantities of very poor mica being despatched, involving an undesirable amount of work in the store, and some improvement in the methods practiced at the mine became necessary.

The changes in procedure are reflected in Table II, but are given again in condensed form below:-

TABLE IV.

Lot No.	Description	Nett weight lb.	Block mica recovered lb.	Per cent. recovered
1 - 10	Thumb-trimmed	12,249	1,078	8.8
11 - 14	Rough sickle-trimmed	5,291	948	17.9
15 - 21	Sickle-trimmed	2,013	808	40.1

During the final stage represented by Lots 15 to 21, the procedure involved in the preparation of mica at the mine was conducted in the following steps.

1. Separation of mica from mullock.
2. Selection of mica for trimming.
3. Rifting and trimming.

1. During trucking of the broken stone, books of crude mica were set aside and later sent to the surface separately. The efficiency of this separation of crude mica depended upon the workmen's willingness to interrupt shovelling and pick out mica by hand. This step was not intended to go beyond separating mica from mullock, but there was a tendency to discriminate against apparently poor mica, and, naturally, much small mica was not picked out. Examination of the mullock dumps showed that a considerable quantity of mica remained mixed with the broken rock, but little of this mica appeared to have commercial value other than for purposes of grinding.

The crude mica from the open-cut was dumped on the ground at places convenient to the cutting shed near the top of the incline and from these dumps was further selected for cutting.

2. This selection was done without systematic rifting of the books and depended on external appearance. In most instances the heap of crude mica was turned over with a shovel and the apparently best mica picked out and thrown into a wheelbarrow for removal to the cutting shed.

Dumps of rejected mica were found to contain many books an inch or more in thickness which had been discarded on account of fractures and blemishes on the outside. Many of such books when split to thicknesses of a quarter of an inch or less were found to contain usuable mica.

3. The cutters combined the operations of rifting and cutting. Badly fractured and buckled areas were cut out, but, in general, striations and inclusions were left. This stage of operations suffered severely from lack of experienced men as owing to frequent changes in personnel, it was not possible to keep the same men at this work long enough for them to become proficient. Nevertheless, the great improvement in technique that was effected under such difficulties has been indicated.

The resulting sickle-trimmed mica was not graded into sizes nor classed according to differences in quality, but despatched in bulk to Melbourne for grading after such further trimming as seemed necessary.

VIII. CONCLUSIONS.

The value of production fell far short of meeting working expenses, and it is unlikely, except under radically different circumstances, that the mine could be operated without loss.

The factors chiefly responsible for the unsuccessful financial outcome of the project were:-

(1) The use of non-selective mining methods.
(2) Natural defects in the mica won.
(3) Waste of mica through inexperience and lack of efficient labour.

To these three statements, it is probable that the following can be added justifiably:-

(4) Unduly high standard of classification of the mica adopted in Melbourne.

With regard to (1), it is apparent that non-selective methods of mining cannot be applied to the production of muscovite without jeopardising the success of the venture. The choice of open-cutting, which necessitated removal of the entire width of dyke rock, at Yinnietharra was dictated by the circumstance of the urgent need for mica which prevailed at the time the project was launched. It was considered that this method would yield the maximum of both mica and information regarding its occurrence in the shortest possible time. When the project was abandoned, underground mining was about to be started and it is possible that the volume of rock to be broken and hauled to the surface would have been so reduced without appreciably diminishing the quantity of crude mica recovered that a decrease in costs might have been effected.

The high incidence of natural defects in the mica mentioned in (2) constituted a serious cause of loss, which more than offset the abundance of mica in the dyke. The loss of mica through this cause is revealed in Section III of this report. Paradoxically the poor recovery of marketable sheet mica is due, in large part, to the high proportion of mica in the dyke with consequent mutual interference between contiguous muscovite crystals. This condition could not be foreseen and is one of the ever-present hazards connected with the winning of mica.

The points raised in (3) have been mentioned in Section VII, which deals with the selection and preparation of mica on the surface at the mine. This stage of operations lacked organisation along the lines usually adopted at mica mines. There was no adequate inspection of the crude mica, and rifting was not carried out as a distinct step of the process. In this way, numerous books were discarded without being rifted into plates sufficiently thin to permit adequate inspection. During June, 1944, and apparently for some time previously, mica was being produced from the open-cut in greater volume than could be handled on the surface. This unbalanced condition would have been rectified with the start of underground mining as labour previously employed in the open-cut would then be available on the surface.

Poor quality of the labour available and frequent changes in personnel afforded additional difficulties in the way of proper selection and preparation of the mica. Rifting and trimming requires some (though not a high degree of) skill, and frequently the men engaged on this work left the mine before acquiring the necessary proficiency. Loss of sheet mica of grade 6 is indicated by the figures in Table IIIb, which reveals that the quantity of grade 6 is little more than half that of grade 5. This is contrary to the results obtained elsewhere, and can be due only to the rejection of sound mica of small sizes.

The application by the Melbourne store of unduly high standards of classification is evidenced by the fact that no stained or spotted sheet mica was recovered. In other words, classification and grading of the mica yielded only commercial-clear quality or grinding scrap, and nothing of intermediate value.

The supply position regarding 'strategic' mica, that is, mica of commercial-clear quality or better, early in 1944, was as follows:-

Grade 6: Large surplus in store.
Grade 5: No immediate shortage and supplies readily available.
Grade 4: Serious shortage.

Later the position deteriorated somewhat and the production of No. 5 Grade from Yinnietharra assumed some importance, but, by the end of May, it became apparent that requirements of the three grades given above could be met without the small contributions from Yinnietharra.

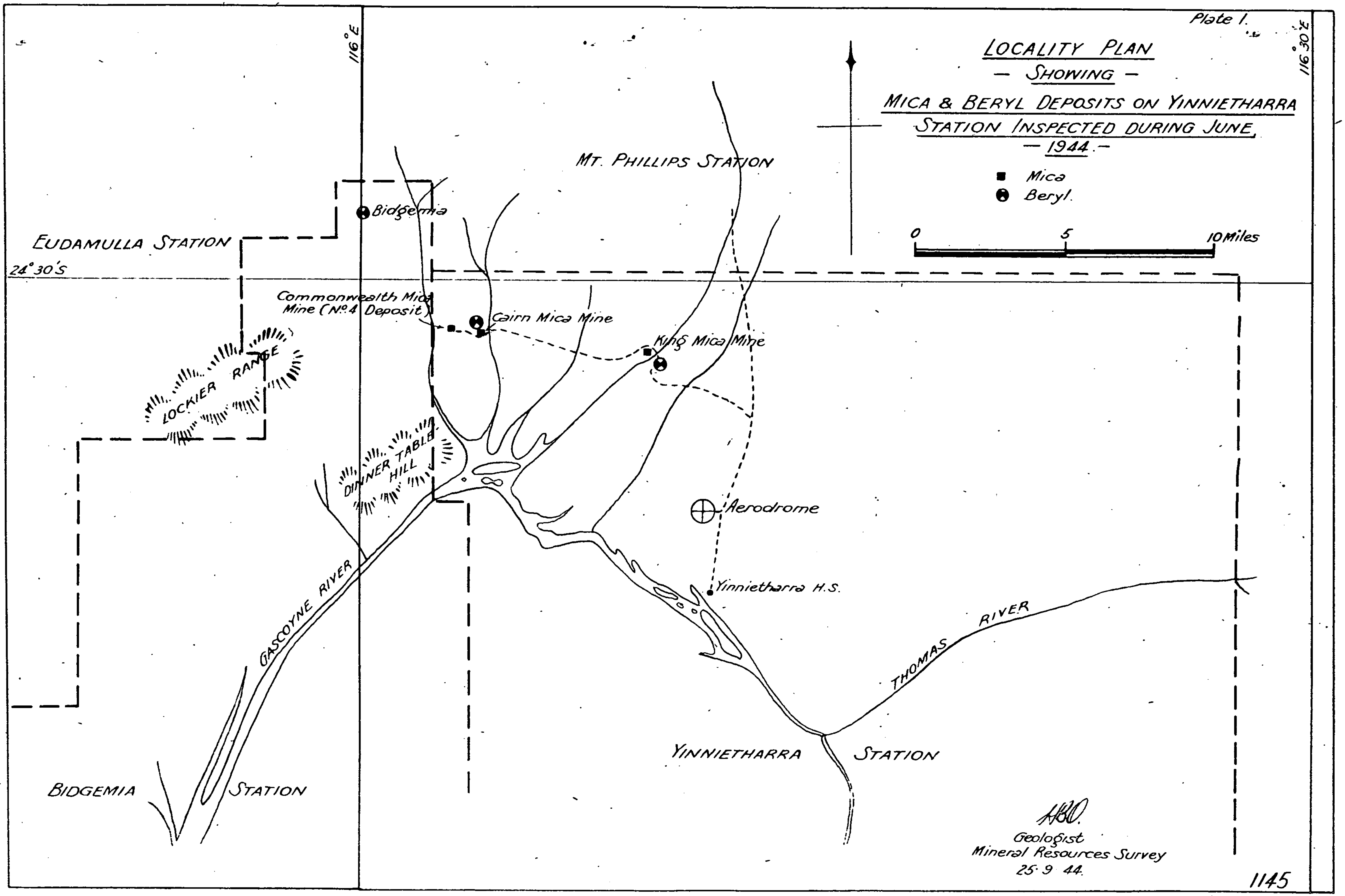
Stained mica was not in short supply at any time since the start of operations and consequently no special effort was made to separate stained sheet mica from the residue left after the selection of strategic mica.

The mine was expected to provide only strategic mica of Grade 5 and upwards and was not credited with all the grade 6 which was, or could have been, produced, or with any of the poorer qualities of sheet mica. It must be admitted, however, that contributions to mine revenue from these sources would not have reduced the loss very materially and the preparation and selection of stained mica at the store would have caused diversion of staff to work on types of mica which were in plentiful supply from other Australian sources.

CANBERRA, A.C.T.
10th October, 1944.

(Sgd) H.B. OWEN,
Geologist.

Plate I.


LOCALITY PLAN
— SHOWING —
MICA & BERYL DEPOSITS ON YINNIETHARRA STATION INSPECTED DURING JUNE, — 1944 —
Mica
Beryl.
0
5
10 Miles
116° E
116° 30' E
24° 30' S
MT. PHILLIPS STATION
EUDAMULLA STATION
Bidgemia
Commonwealth Mica Mine (No. 4 Deposit)
Cairn Mica Mine
King Mica Mine
LOCKIER RANGE
DINNER TABLE HILL
Aerodrome
Yinnietharra H.S.
GASCOYNE RIVER
THOMAS RIVER
YINNIETHARRA STATION
BIDGEMIA STATION
Geologist
Mineral Resources Survey
25·9·44.

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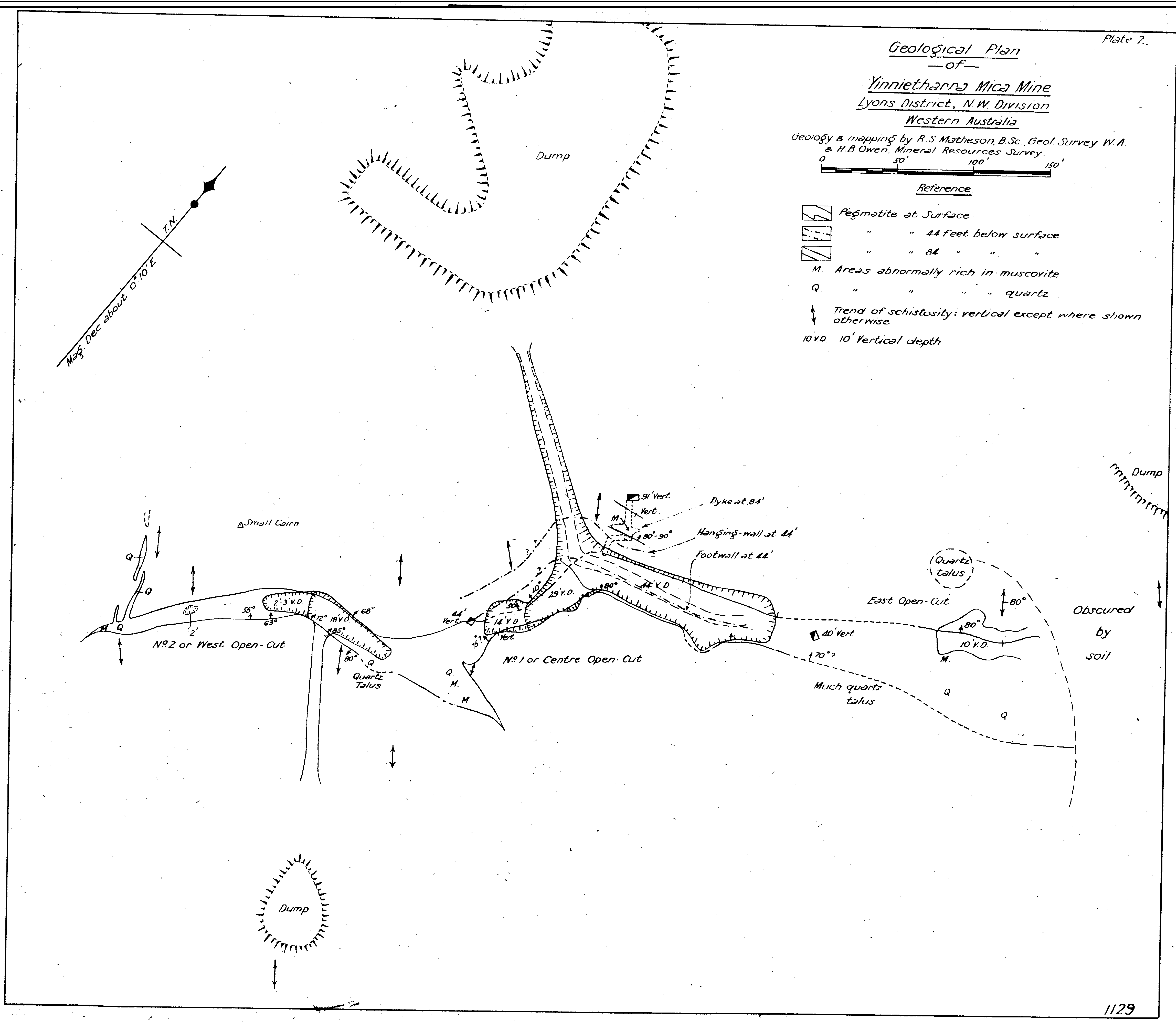


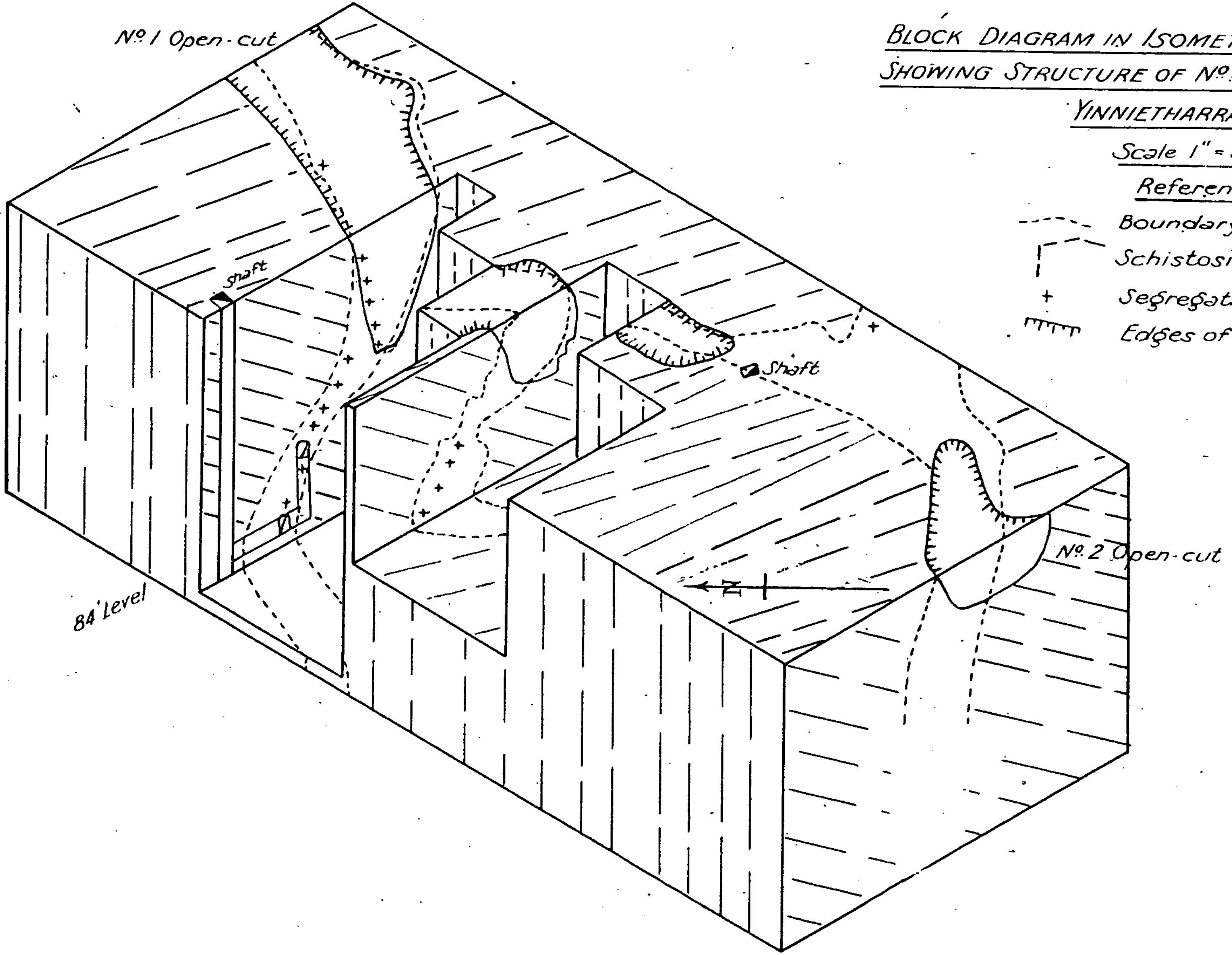
Plate 2.
Geological Plan
—of—
Yinnietharra Mica Mine
Lyons District, N.W. Division
Western Australia
Geology & mapping by R. S. Matheson, B.Sc., Geol. Survey W.A.
& H. B. Owen, Mineral Resources Survey.
0
50'
100'
150'
Reference
Pegmatite at Surface
" " 44 feet below surface
" " 84 " " "
M. Areas abnormally rich in muscovite
Q. " " " " quartz
Trend of schistosity: vertical except where shown otherwise
10'V.D. 10' Vertical depth
T.N.
Mag. Dec about 0°10' E
Dump
Small Cairn
No. 2 or West Open-Cut
No. 1 or Centre Open-Cut
East Open-Cut
Dyke at 84'
Hanging-wall at 44'
Footwall at 44'
91' Vert.
Vert.
80°-90°
44' V.D.
29' V.D.
14' V.D.
2'3' V.D.
18' V.D.
10' V.D.
44' Vert.
40' Vert
Quartz talus
Much quartz talus
Obscured by soil
1129

Plate 3.

BLOCK DIAGRAM IN ISOMETRIC PROJECTION SHOWING STRUCTURE OF No. 4 PEGMATITE DYKE.

YINNIETHARRA, W.A.

Scale 1" = 50'



Reference

- - - Boundary of pegmatite
Schistosity of Country Rock
\+ Segregations of Muscovite
Edges of Open Cut

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Geologist
Mineral Resources Survey
31.8.44

1131

No 2 Open-Cut

Scale 1" = 10 Ft

For Reference see Plate 4

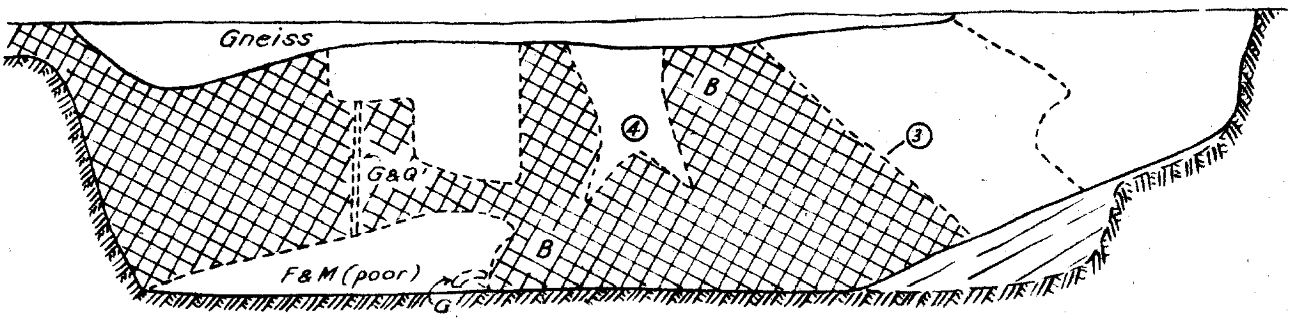

Fig. 1. North Wall

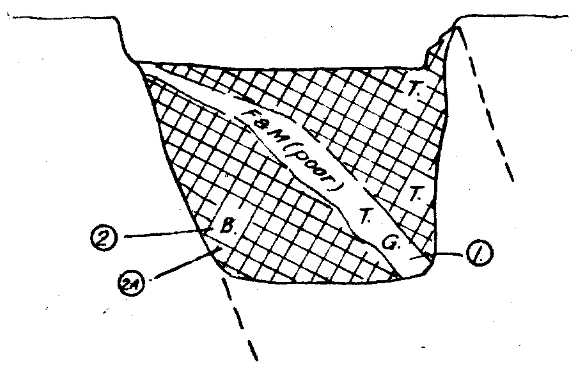

Fig. 2. West Face

East Open-Cut

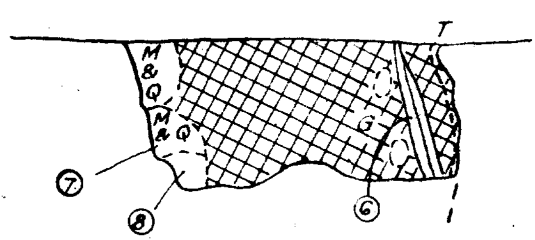

Fig. 3 West Face

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Mineral Resources Survey
27.9.44.

Sketches of Pegmatite Exposed in Open-Cuts at Yinnietharra.

Scale 1" = 10 ft.

No 1 Open-Cut

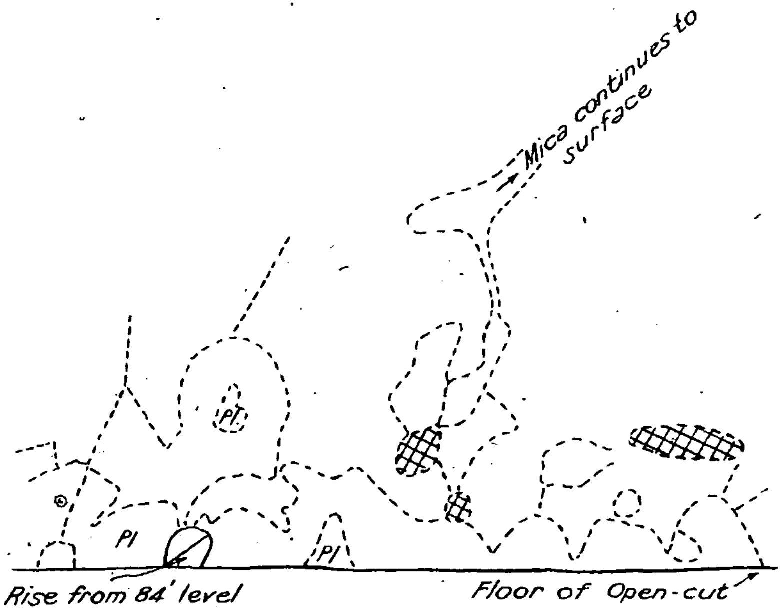

FIG. 1. HANGINGWALL SIDE

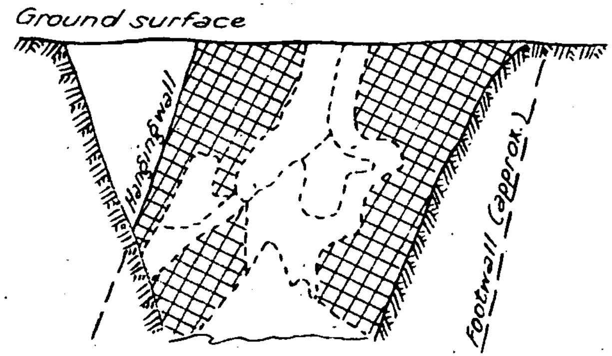

FIG. 2. EAST FACE AT 26·6·44

Reference

- Graphic or granitic pegmatite
- Quartz (Q)
- Microline
- Quartz & Felspar (F)
- Pl. Plagioclase
- Muscovite (M)
- G. Garnet
- B. Biotite
- T. Tourmaline
- ② Specimens described in report

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Mineral Resources Survey
27·9·44.

INCLUSIONS IN MUSCOVITE FROM YINNIETHARRA

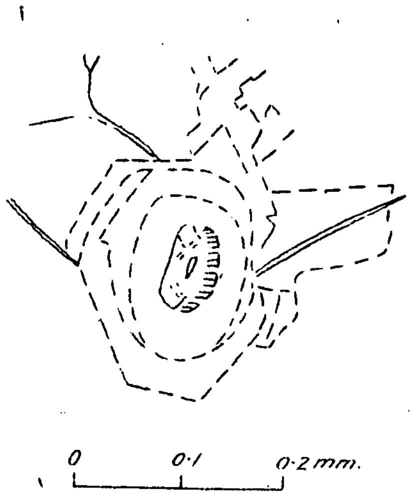


FIG. 1(a).

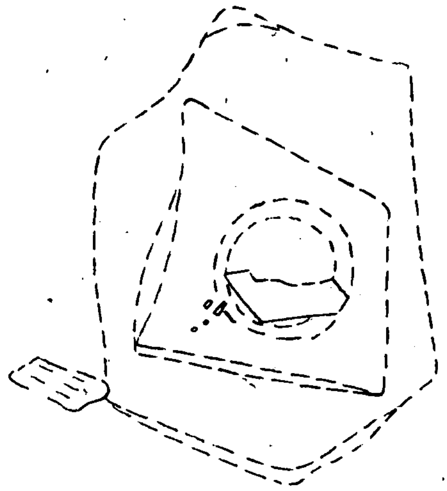
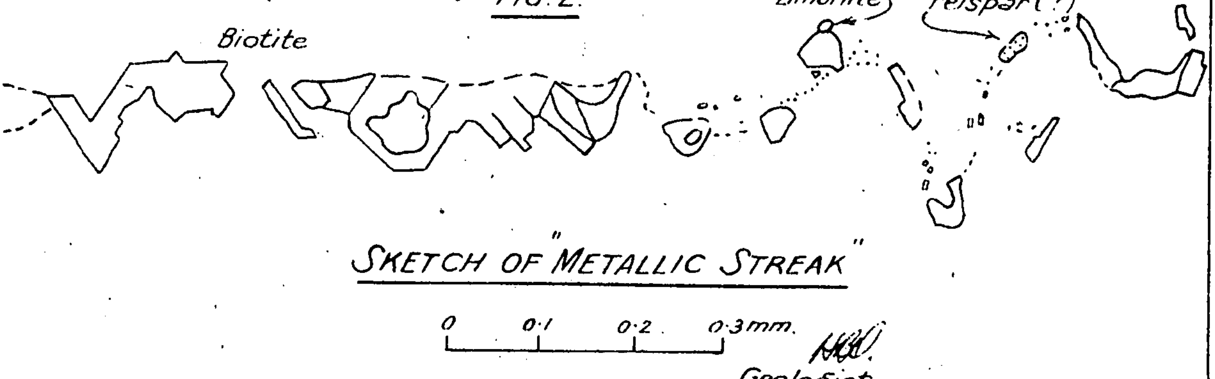


FIG 1(b.)

FIGS 1(a) & 1(b) CAMERA LUCIDA DRAWINGS OF SPOTS

FIG. 2.



SKETCH OF "METALLIC STREAK"

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