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POSSIBILITIES OF DEVELOPING THE HARTS RANGE MICA BELT

by

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REPORT NO. 1 OF THE MINERAL ECONOMIST.

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POSSIBILITY OF DEVELOPING THE HARTS RANGE MICA BELT

I. INTRODUCTION.

Shortly after I took up the appointment of Mineral Economist, the high quality of the mica from the Harts Range, treated at the Supply and Shipping mica factory in Melbourne, came to my notice. If the area were comparable with the mica fields of India possibilities of developing a useful mica industry in Central Australia seemed to be worth examining. Accordingly, I paid a visit to Harts Range between the 22nd September and 4th October.

In the past, the world's requirements of sheet mica (averaging about 150,000 cwt. pre-war annually) have been largely obtained from India, in three main areas: Bihar, Madras and Rajputana. Bihar has supplied perhaps over 80 per cent. of the world's requirements of better quality sheet mica; certainly more than 90 per cent. of the mica splittings used in the manufacture of micanite throughout the world are obtained from India. During the war, Brazil considerably increased its production of better quality mica and it is not unlikely that this output will continue. Recently, increasing shipments of African mica have been sent to London. Nevertheless, because of the vast reservoir of labour alongside high quality mica mines, the Bihar mica belt, India, is in a strong position for maintaining its past importance, particularly in its output of splittings.

To anticipate, it seems to me that there is a good possibility of developing the Central Australian mica belt, particularly for the increased output of high quality sheet mica and, with the possibility of employing New Guinea and other Island labour, of developing in the Islands a splitting industry from the lower quality smaller size block mica. Whether or not the world can always rely on Indian mica, either in peacetime or wartime, it is difficult to say, but when it is remembered that this mineral is vital in the equipment of aeroplanes, tanks and other instruments of war, its importance for defence purposes is, obviously, paramount - from this point of view alone, it may be urged that Australian deposits should be developed as far as possible. Even as a peacetime industry, its importance to electrical equipment is great.

At the present time, I doubt whether there are as many as 80 miners engaged in mica mining in the Harts Range area. These men are simply gouging the easily mined pockets of mica in the more accessible mica veins, and there is little or no mining in the true sense of the term. The total annual production is of the order of 600 to 1000 cwt. of block mica. This may be compared with the extent of the industry in India where, during the war, something of the order of a quarter of a million people were engaged in the various phases of mica mining, cutting, sorting and splitting, and the total production ranged between about 120,000 and 200,000 cwt. It will be realised, therefore, that when discussing the possible development of the mica industry, one is thinking in

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terms of a considerable body of labour. Right from the outset, it must be appreciated that development of this industry in Australia is dominantly a labour problem.

In judging the possibilities of developing the mica deposits of the Harts Range, the difficulty is the almost complete lack of reliable detailed mining data in the past - production data for the later war years only are available. However, by comparing the degree of areal concentration of the pegmatites, the type of deposits and the quality and sizes of the mica so far produced with those of India, a reasonable picture can be obtained of comparative possibilities. The method of approach throughout this report, therefore, will be comparison of the Harts Range with Indian mica.

II. TRADE TERMS.

As a background to this report, it is advisable to provide some of the definitions which are used in the mica trade:-

Ruby Mica - Mica of a deep ruby colour when in thicknesses of about one-eighth of an inch or more. Below that thickness it is increasingly colourless. Ruby mica is preferred by the electrical industry to mica of other tint and thus generally is higher in price.

Green Mica - Mica of various shades of greenish tint, also colourless in thin films. Brownish, yellow and golden tints are also known.

Mica books - the individual crystals of mica as they occur in the deposits.

Crude mica - mica books as extracted from the mines.

Block mica - mica after it is trimmed and the more serious flaws removed. The thickness varies down to .008 inch, but is normally between one-twentyfifth and one-eighth of an inch. It includes all sizes and all qualities.

Films - cleanings, such as cleavages removed in dressing mica to give the latter a clean surface, and between .001 and .008 inch in thickness.

Condenser films - obtained by splitting high quality block mica of sizes up to No. 4, to a thickness of .001-.008 inch, and used for the manufacture of condensers. Called "condenser splittings" in America. When cut to shape, called condenser plates in England and "condenser films" in America.

Splittings - mica, generally of lower quality, which has been separated along its cleavages into thin laminae approximately .001 inch in thickness (not over .0012 inch).

Splitting quality - usually a stained soft mica which is particularly easily separated into thin cleavage films.

Manufactured mica - mica cut to any particular size or shape.

/Sheet

Sheet Mica - sometimes understood to mean only block mica, but better applied to include also cleanings, condenser films, and splittings to distinguish such higher priced mica from scrap mica, which is generally used in the ground condition.

Built-up mica - products made by cementing splittings into various forms and universally known as micanite.

Electrical mica - a term sometimes used to denote the more heavily stained and spotted block mica, otherwise more or less free from flaws, and which can be used for insulation purposes.

Thumb-trimmed mica - In Canada and the United States the crude mica books from the mine are first trimmed by breaking off the more imperfect pieces with the fingers. The resulting marketable product is known as "thumb-trimmed mica" or sometimes as "cobbed".

Punch Mica - a term used in the United States to denote small sizes, usually of thumb-trimmed as distinct from knife or shear-trimmed, from which washers or other small shapes can be cut, $1\frac{1}{2}$ inches in diameter in the case of stained qualities, and $1\frac{1}{4}$ inches in diameter in the case of clear.

Strained mica - books which have been so badly strained by pressure that they are traversed by innumerable cracks across the cleavage planes.

Ruled mica - mica in which the parting planes or strain lines are in long parallel lines.

Strip mica - in some cases parallel parting planes divide the mica into long narrow strips, an inch or more in width, which are useful for certain purposes.

Buckled mica - mica which is warped or bent, presumably by rock pressure, in the pegmatite veins. Also called "unlevel" when the warping is slight.

Cross grained - crude mica books which are badly flawed by innumerable partings across the basal cleavage.

Fish-tail or Herring-bone - When lines are developed in triangular directions, reminiscent of a fish-tail or herring-bone pattern. Much of this mica can still be split without breaking up.

Hair cracks - in some cases the mica can be split although fine lines remain, known as hair cracks. They are a defect.

Wedge mica - some books may consist of aggregates of wedging crystals to which the name "wedge mica" is applied (also called "A mica" in America).

III. GRADING AND CLASSIFICATION.

Grading:

Crude mica is cut into irregular shapes which are graded according to the area of the largest rectangle which

/can

can be cut from each block. The grading as used in Australia is as follows:-

Grade Number or Name	Area of largest Rectangle contained in Block
	Square inches
Extra-extra Special	Over 100
Extra Special	60 to 100
Special	48 to 60
A1	36 to 48
1	24 to 36
2	15 to 24
3	10 to 15
4	6 to 10
5	3 to 6
6	1.5 to 3

There is no provision for grades smaller than No. 6.

This grading is slightly different from that used in India, where A1 is now known as "Special" and sizes No. $5\frac{1}{2}$ to 7 are introduced.

Classification:

Mica is classified as to quality. The various qualities as used in Australia are as follows:-

Quality	Characteristics.
"Clear"	free from all mineral inclusions and mineral stains, cracks, waves and buckles, but may contain slight "vegetable" stains and air inclusions; hard.
"Commercial-clear"	free from all mineral inclusions and cracks; may contain slight "vegetable" stains and air inclusions, together with a few small red or black spots near the edges of the block; hard, but may be slightly wavy.
"Stained"	free from all mineral inclusions and cracks, but may contain mineral and "vegetable" stains; may be somewhat wavy; hard, but may be softer than the better qualities.
"Spotted"	free from all mineral inclusions and cracks; may contain mineral and "vegetable" stains and spots and may be more wavy and softer than "stained".

(Note: The term "vegetable" is a misnomer. The term "inclusion" has a different significance from that applied to Indian mica).

/This

This may be compared with the Indian classifications as defined by Mr. R. Hart of the Joint Mica Mission and myself during the latter part of the war:-

Quality	Characteristics
Superfine	The mica must be hard and optically flat. It must contain no stains or flaws of any description.
Clear and Slightly Stained	The mica must be hard and substantially flat and free from cracks. The largest rectangle obtainable must be free from mineral inclusions and stains, but may contain small air stains within a small part of the rectangle.
Fair Stained	The mica must be hard and free from cracks, but may be slightly wavy. The largest rectangle obtainable may contain some small air stains, and within a small part of this area may contain small light stains.
Good Stained	The mica must be hard and free from cracks. It may be wavy but not buckled. It may contain air stains throughout, and may contain light stains and heavier stains or mineral spots around the edges.
Stained	The mica may be fairly hard, and may be wavy and slightly but not badly buckled. It should be free from cracks. The mica may contain stains and small mineral inclusions on the edges and heavier stains over a small part of the area.
Heavily Stained	The mica may be slightly buckled. It may contain heavy stains and mineral inclusions over part of the area.
Densely Stained	The mica may be partly buckled, and may contain dense stains and scattered mineral inclusions.
Silver Stained and White	The same as Stained, but air stains may be of such a pervading character as to impart a silvery or white appearance to the whole surface.
Dotted	Quality as for Good Stained but with isolated black dots throughout.

/Densely

Densely Stained and Spotted	As for Densely Stained but with heavy spots and mineral inclusions.
Black Spotted	Hard flat mica with spots and streaks and with mineral inclusions throughout. The spots and streaks not to be generally red in colour.
Red Spotted	As for Black Spotted but the majority of spots and streaks are red.

Note: "Air" stains means, correctly, gas stains or inclusions.

If Australia should find it possible to export mica, shipments would need to be classified on the Indian basis. The two classifications may be roughly compared as follows:-

Australian Type	Equivalent Indian Types
Clear	Clear. Slightly Stained. Fair Stained (in part).
Commercial Clear	Fair Stained (in part). Good Stained. Probably also some stained.
Stained	Stained. Densely Stained. Black Stained.
Spotted	Spotted. Black Spotted.

In the Harts Range there is quite a fair amount of green mica produced which is classified on a similar basis to the ruby mica. In India, the green mica of Madras is classified quite differently from ruby mica, and the Australian equivalent mica may also require to be classified on the same basis if exported.

IV. THE HARTS RANGE MICA BELT.

(a) General.

Accessibility: The Government Depot on the northern side of the Harts Range is about 140 miles by road from Alice Springs, or 100 miles in a straight line north-east.

The nearest Queensland rail-head is at Dajarra, a direct distance of about 300 miles. The nearest coast is on the Gulf of Carpentaria, about 500 miles in a direct line from the Harts Range.

The rail distance from Alice Springs to Port Augusta is about 800 miles and by road to Darwin about 900 miles. To many in Australia, the impression of inaccessibility of Alice Springs is governed by the time taken for the railway journey from Adelaide - $3\frac{1}{2}$ days for a trip which, in most countries, would take less than 24 hours. By contrast, it is only six hours by air.

/From

From the point of view of distances from the seaboard, the Harts Range region is no more inaccessible than many developed regions of the world, and is, indeed, more accessible than many. It is of interest to note that in India mica is sent from Rajputana to Bihar, a distance of over 1000 miles, for further treatment before marketing.

Climate: The climate of the Harts Range area is quite comparable with many other continental regions, such as Rajputana, Arizona and Brazil - it is a delightful climate for six to seven months of the year and dry and hot during the remaining months. The rainfall is of the order of 10 to 12 inches; during recent months there have been heavy rains but, allowing for the improved condition of the country at present, I certainly would not regard it unfavourably as compared with similar regions elsewhere.

Topography: The Harts Range rises to a height of from 3000 to 3700 feet, above the plain to the north, which is at a general level of 1800 to 1900 feet. The Plenty River traverses the plain, running east parallel to the Range some 10 miles to the north. The Range itself is rugged, generally with bare rock faces showing only a small amount of scrub, but the plain country is, in places, relatively thickly timbered - some of the timber is used for mining purposes.

On the plains, it is possible to drive almost anywhere by car, as a rule river beds offering the only difficulty because of their sandy nature. In the hills, many places which were formerly not easily accessible are now readily reached by car.

Water Supply: In the plains a fair water supply is made available by bores. Bores along the Plenty River would yield an adequate supply should one ever be needed by a Settlement in this area.

In the hills a small supply of water is obtained from a few boreholes situated near some of the mines. Water is supplied by truck to some of the mines from the Depot at a cost of 2/6 per 100 gallon.

(b) The Mica Deposits.

Rock Associations: Pegmatites occur in almost any kind of rock, but pegmatites containing commercial sheet muscovite mica occur only associated with certain types of mica schists and mica gneisses. I know of no exceptions to this unique association, although, from a certain looseness of terminology in designating these rocks, there may appear to be exceptions. This report is not the place to enter into a discussion on the origin of mica-bearing pegmatites, but the association of these deposits with a single group of metamorphic rock types is apparently connected with their mode of origin.

Obviously, such a restriction in their occurrence is an aid in prospecting for mica-bearing pegmatites. Any development of this region must, therefore, be accompanied by detailed geological work. A preliminary survey should be made on the scale of 1 inch = 1 mile, followed by a survey of the more favourable areas on the scale of 4 inches = 1 mile, or even larger scales in some localities. The survey of a region such as this can be adequately undertaken only by a geologist with a decided leaning to petrology, and should be taken up as a long-term project - if the belt is developed

a resident geologist would need to be located there permanently.

Geological work would require as a basis, reasonably accurate topographical maps. The existing maps are not sufficiently accurate or detailed for the purpose. An air survey of the belt would be desirable - it is, in fact, imperative if the region is to be developed.

Types of Deposits: There are three main types of mica deposits in the Harts Range and they are similar in every way to mica deposits in other mica regions of the world:-

(i) Fissure Type of Deposit: These have a definite and regular strike, either parallel to or across the enclosing country rock, and usually have quite a regular dip with persistence in depth. They may vary in thickness from a few inches up to 20 or more feet, and in strike length from, say, 100 feet to 1,000 feet or more. Down the dip they may persist for hundreds of feet. The thicker veins generally have a quartz core with pegmatite on either side and the mica normally occurs within the pegmatite, either close to the footwall or to the hanging wall. Formerly miners were under the impression that if mica occurred on the hanging wall it would not be found on the footwall or vice versa. However, recent experience in India has entirely disproved this, and I have no doubt that this experience will be found to hold in the Harts Range belt. Examples: Billy Hughes, Dinkum and Eastern Chief Mines.

(ii) Tongue or Pipe Deposits: Such pegmatites usually have no great strike length, and their width can be almost equal to their length; in depth they are commonly as persistent as the fissure veins. Almost invariably they have a central quartz core and the mica is distributed in the pegmatite around this core, normally close to the walls. Not uncommonly the pegmatite tongue may be ringed by pockets of mica distributed around the walls. The boundaries of such tongues are commonly very irregular, and the layout of mine workings is accordingly not so simple as with the fissure type of vein. It has been my experience that, on the average, the tongue-shaped deposits contain a better quality mica than do the fissure veins. Examples: Ulgarna and Stradiotto's Mines.

(iii) Masses or Spurs: These "massive" pegmatites are very irregular in form; they generally consist of a large central mass with massive quartz core, and from which spurs branch off irregularly into the adjacent country rock. They are irregular in depth as in outcrop. The mica is generally very unevenly distributed in this type of pegmatite, and is commonly in close association with unreplaced masses of mica-schist which are usually found within such pegmatites. Examples: Rex and Yugo Jack's Mines.

/Distribution.

Distribution: The Harts Range belt may be divided into five main zones according to the distribution of the pegmatites. From the western end of the Range, to about 8 miles east of the Depot, there is quite a considerable number of deposits containing mica of various qualities, but on the whole not of very high quality. In the centre of the Range, extending east for a further 15 miles, the Range appears, from present indications, to be more or less barren of mica-bearing pegmatites. Further east again, extending to about 40 miles east of the Depot, there is a zone in which the mica is of good quality, comparable to the best of the mica in the Bihar belt, India. In addition, there are two outlying zones, one to the north-west known as the Undippa area and the other to the north-east known as the Plenty River area, both on the northern side of the Plenty River. The quality of the mica in the Undippa zone varies from deposit to deposit, much of it appears to be of spotted quality, but some very high quality mica was seen in the north-eastern portion of this zone. All of the mica in the Plenty River zone is of very high quality indeed.

Of course, only a few mines are worked at any particular time. During the war years there are records of about 40 mines being worked at various times within the belt, whilst at the present time mica is being obtained from about 25. Most of the production is at present from the zone near the Depot.

Abundance of Pegmatites: Unlike most mineral deposits, mica-bearing pegmatites commonly occur in swarms. I have known as many as four or five separate payable mica-bearing pegmatites within an area of 40 acres in India. Usually it is easy enough to find a pegmatite, generally the difficulty is to determine those which contain payable mica.

It is relevant to give some idea of the abundance of these pegmatites within the Harts Range belt as compared with, say, the Bihar mica belt. The area covered by the Harts Range belt is approximately equal to that of the Bihar belt. In the latter belt, however, there is a remarkable concentration of mica-bearing pegmatites at the western end of the belt within a zone of 50 square miles, known as the Kodarma Reserve Forest. In fact, nearly 50 per cent. of the mica produced in Bihar probably comes from this portion of the belt. In the remainder of the Bihar belt the mica-bearing pegmatites are more widely scattered. So far as one can judge at present, there is no portion of the Harts Range belt which contains a concentration of pegmatites comparable with the 50 square miles of the Kodarma Reserve Forest, but the degree of concentration or areal abundance of pegmatites in the Harts Range belt is certainly comparable with the remainder of the Bihar mica belt. This abundance is also comparable with the degree of concentration of pegmatites in the Rajputana and Madras belts. From my brief visit, I would not regard it as improbable that parts of the Plenty River and Undippa zones may, when prospecting and development bring to light more deposits in the future, show a high degree of concentration of pegmatites.

/Mica.

Mica Content of Pegmatites: Mica mines are not amenable to sampling and assaying as are other mines. Mica miners do not go to the trouble of carefully measuring their excavation work and comparing this with the yield of block mica. As a result, there is no statistical data upon which a reliable estimate can be made of the comparative mica content of the various deposits. It would be impossible now to estimate the total rock which has been excavated in the various mines; also it is doubtful whether the recorded production of mica approaches the actual production. Mr. Owen, geologist of this Bureau, quotes estimates which are equivalent to a yield of .8 per cent. of block mica in the mine rock excavated from the Spotted Tiger Mine, and .13 to .35 per cent. in some other mines. The Spotted Tiger is recognised in the area as a comparatively prolific producer, and the average payable deposit in the belt will yield a considerably lower percentage than .8 per cent.

In India, the total of all qualities and sizes of block mica produced represents 1-1.5 per cent. of the mine rock excavated: but this includes 80 per cent of splitting quality mica which, in Australia, is left on the dumps. Thus, of block mica comparable with that marketed in Australia, the equivalent Indian percentage is about .2-.3 per cent.

These comparisons do not take into account the relative cutting percentages of block from crude, but there is no reason to anticipate that the cutting percentage of Harts Range mica would differ widely from the Indian should Australia also produce splitting qualities. Relative qualities are also ignored in these percentage comparisons, but as the Australian average quality of similar block is higher than the Indian, the comparison would be increasingly in favour of the Australian depcsits.

On the whole, from the above figures, and from the appearance of such mine faces as were examined, which to me seemed to show a similar proportion of mica to the Indian mines, .3 per cent would be a reasonable average for those mines in the Harts Range which are being worked.

Qualities: There are two main types of mica in the Harts Range - ruby mica and green mica. On the whole these two different types occur in separate pegmatites but, occasionally, both have been obtained from the one pegmatite. Some of the mines, e.g. the Spotted Tiger, have been big producers by Australian standards, but the mica is stained and spotted. Other mines like the Billy Hughes yield a clear green mica much of which can be used for many of the purposes of the clear ruby mica. As a rule, producers of green and spotted or heavily stained mica yield a much greater output than do the mines from which only ruby mica is obtained.

Apparently, the proportions of the total output of the belt are approximately 60 per cent. ruby and 40 per cent green. In the clear qualities, the proportion of ruby is much higher, of the order of 90 per cent. ruby against 10 per cent. green. Of commercial clear, the proportion is, perhaps, 60 per cent. ruby and 40 per cent. green, whilst in the stained qualities the proportion of green exceeds that of ruby.

TABLE I.

PERCENTAGES OF SIZES AND QUALITIES

BIHAR AND HARTS RANGE MICA

	BIHAR MICA				AUSTRALIAN MICA 1945/46			
	Clear	Com. Clear	Stain-ed.	Totals	Clear	Com. Clear	Stain-ed	Totals
	%	%	%	%	%	%	%	%
Over Over XX Special	.0063	.0074	.0326	.0463	-	-	-	-
Over XX Special	.0032	.0074	.0379	.0485	-	-	.0813	.0813
XX Special	.0063	.0126	.3388	.3577	.0016		.2184	.2200
X Special	.0295	.0505	.2504	.3304	.0055	.0055	.1692	.1802
Special = A1	.0642	.0926	.3451	.5019	.0202	.0715	.5503	.6420
1	.1873	.3220	2.1023	2.6116	.2855	.4176	1.7491	2.4522
2	.5261	.9586	6.7835	8.2682	.8511	1.4111	4.3650	6.6272
3	.7828	1.4952	11.5710	13.8490	1.5989	3.2809	7.9079	12.7877
4	1.7814	2.7126	33.1169	37.6109	4.0855	7.6852	16.8568	28.6275
5	3.1156	6.8961	-	10.0117	9.7847	18.7893	-	28.5740
6	3.8458	22.5181	-	26.3639	9.0117	10.7952	-	19.8069
TOTALS:	10.3458	35.0731	54.57.85	100.0001	25.6447	42.4563	31.8980	99.9990

On the whole, the Harts Range mica shows a general unlevel character. Nowhere, whilst visiting the mines, did I see any mica which approaches the optically flat although some of it in the Plenty River area was reasonably flat, but since my return to Melbourne I have been shown mica which does approach the optically flat. However, as the production of the belt is so small, I would feel very diffident at comparing this characteristic with the Bihar mica in which, after all, optically flat mica is extremely rare.

In Table I are given percentages of various qualities of Bihar and Harts Range mica. The Bihar list is of the total 1938 production of a single firm in Bihar, approximately 20,000 cwts. This firm's operations were widespread over the Bihar belt, but on the whole its average quality was, if anything, above the average for Bihar. From this production all splitting quality stained block sizes No. 5, 5½ and 6 have been excluded, thus restricting the comparison to block equivalent to that marketed in Australia. All Indian No. 5½ has been included in No. 6. Australian sizes No. A.1 and up have been listed with Special and up respectively. The Australian production data are for the year 1945/46 (which are more representative than those of other years), a total of 545 cwt. (61,037 lb.), but from which all stained block Nos. 5 and 6 have been excluded in order to make the comparison more equitable.

In the Indian qualities, all Superfine, Clear, Slightly Stained and Fair Stained have been included under Clear, notwithstanding that some of the Indian Fair Stained is comparable with Australian Commercial Clear. Under Commercial Clear is included only Good Stained, notwithstanding that some Indian Stained would be equivalent to Commercial Clear. Thus, the table tends to weight the qualities if anything in favour of Indian mica.

The Table clearly shows that the quality of Australian mica is considerably higher than the average Indian mica - 25 per cent. Clear Australian against 10 per cent. Clear Indian ruby, and 42 per cent. Commercial Clear against 35 per cent. Commercial Clear Indian ruby.

These figures are impressive. Of course the Australian figures are for mixed ruby and green mica, but if the ratio of ruby to green is taken as 60 : 40 throughout, the ratios remain unaltered. As it happens, of Australian Clear Mica a very high proportion is ruby, perhaps 90 per cent. and if this were taken into account, the Australian figures would be raised even more favourably as compared with the Indian.

There is, of course, much room for criticism in comparing a production of 547 cwt. with 20,000 cwt. The Australian production figures can be regarded only as a sample when compared with the Indian figures, and may be looked upon in the same manner as a mine sample indicates the probable total yield of a mine.

/Sizes

Sizes: The sizes in the Harts Range belt range up to Over Extra Extra Special, but the amount of special sizes is small. There are no very large sizes such as those of several feet across which have been found from time to time in other countries, but, as the Harts Range belt has only been scratched to date, the possibilities that large books may be found must not be discounted.

In Table I, the various sizes of Australian mica produced in 1945/46 are compared with those from the 1938 Indian production mentioned in the previous section. It will be seen that apart from specials, the Australian sizes are roughly comparable with the Indian. As the main demand, in block, is for Nos. 5, 4 and 3, the mica sizes of the two areas are comparable.

V. BRIEF SUMMARY OF THE INDUSTRY.

(a) Prospecting.

In the hills, prospecting is simply a matter of examining the outcrops of pegmatites for mica - the pegmatites themselves crop out so clearly that they can be seen without difficulty. Most of the mining to date has been little more than prospecting, and has consisted in the removal of the surface mica. Except for about half a dozen mines, once the easily worked surface mica has been removed the mines have been abandoned.

On the plains, where the rocks are largely covered by soil, some of the pegmatites crop out slightly above the general surrounding surface - commonly it is the quartz core which is noticeable, and the vein is opened up along the sides of this in prospecting. There are other pegmatites which do not crop out noticeably, their presence may be indicated by quartz or pegmatite boulders - this is often the case in the Undippa and Plenty River zones. In such soil regions indications of mica-bearing pegmatites may be given by the presence of mica in the soil, brought up perhaps by ants. It is apparent that in both the Undippa and Plenty River areas there is considerable scope for intensive prospecting. Possibly geophysical means can be used in prospecting for pegmatites, but the difficulty would be to detect those containing payable mica. For the present, however, there are plenty of outcropping pegmatites awaiting development without resorting to geophysical prospecting.

If a large company were to undertake mining in the Harts Range mica belt, it should continuously pursue a vigorous prospecting policy. Perhaps the best arrangement would be for it to sub-lease portions of its mining leases to such of the present independent miners who would care to do this work. The period of each of such leases would be for, say, one or two years, and the miner would retain all mica which he found. At the end of the period, the miner would be given a bonus according to the value of the deposits found, and allotted a fresh sub-lease elsewhere.

As indicated earlier in this report, a knowledge of the geology of the area could be of considerable assistance to prospecting, for the delineation of the country

/rocks

rocks will at once restrict the field of search to those rocks in which the pegmatites yield commercial mica.

(b) Mining.

During the war there were several hundred mica mines in active production in India. In Bihar alone the number of underground mines exceeded 200, excluding those worked by open cut. However, in Bihar it might be said that 14 out of some 200 mines supplied 30 per cent. of the total production. The depth of the workings varied down to several hundred feet, one mine in Madras reaching 900 feet. The more important mines are worked systematically on reasonably efficient mining methods, using mechanical equipment. The smaller mines, however, are rarely mechanically equipped and depend largely on hand drilling. About 20 per cent. of the mica in Bihar is obtained from numerous small surface workings.

In Bihar, India, 60 per cent. of the total production is mined by three large firms, each with production ranging between 15,000 cwt. and 40,000 cwt. annually; the remainder of the production is distributed amongst smaller concerns ranging down to individual groups of villagers who may be mining only a few cwts. per annum. One of the largest concerns was an English Company founded as long ago as the 1870's - Chrestien Mining Company. This Company has recently sold out to Indian interests and there are no longer any European mica mining concerns in India.

In Bihar, it is common for a larger mine to be developed to its payable limits in depth and strike. Levels in some cases are as little as 15 ft. apart, in others up to 50 ft. The mine is then stoped out from bottom to top. The development openings generally provide sufficient space to compensate the voids of the broken vein rock, and in stoping only mica is hauled to the surface. Barren portions are, of course, not stoped. In stoping, much of the vein-rock is barred down, drilling and explosives being resorted to as little as possible. In a few of the deeper mines in recent years stoping may proceed in the upper levels whilst development is in progress.

Frequently, in periods of low prices, the stopes may be left untouched awaiting an increase in prices. As one of the medium miners once remarked to me, he regarded his stopes as money in the Bank - with rise in prices he was able to rip out his stopes at a minimum of further cost.

In drilling, short holes are used, 18 inches to 2 feet. In machine holes up to 3 sticks of $\frac{7}{8}$ inch gelignite are used, and one to small hand-drilled holes. Ventilation is generally natural. Lighting is by candle, hurricane lamp or primitive oil lamps, but electric lighting is installed in a few mines. Timbering is rarely necessary except in shafts. Pumping is heavy in some mines. Power is supplied by steam boilers or oil engines.

/Although

Although in Rajputana new mines are being found, the tendency in recent years in Bihar and Madras is to re-open old mines and extend them in depth - new mica-bearing pegmatites are no longer easily found.

In the Harts Range, only about three of the properties now being worked can be regarded as mines in the strict sense of the term. In most cases the miners are merely scratching the surface and are not working at any depth - the deepest mine is only about 100 feet. Commonly, after a small pocket of mica is worked at the surface, instead of developing the vein a miner will transfer his attention to another lease. Although the number of pegmatites opened up must be of the order of 100, the number at present worked is about 25, and new veins are found from time to time - several were being prospected in the Undippa zone during my visit.

Most of the drilling is by hand. The Department of Supply and Shipping rents a total of eight compressors to the more important mines, but as a rule about three of these compressors are under repair, or idle for other reasons. A similar number of Sullivan hoists and rock drills are also hired.

I received the impression that excessive explosive is being used - in some cases there seemed to be undue shattering of the rock and damage to the mica.

The mines are dry and thus free from necessity to pump. I would not be surprised if the mines in the Undippa and Plenty River zones should require some pumping when they are developed at depth.

At the present time, the majority of the miners on the belt spend only a part of their working time in actual mining. Most of them spend at least two-thirds of their working time cutting crude mica before despatch.

(c) Labour.

Most of the men on the belt, totalling about 80, are Italians or Australians of Italian descent. Others include Australians of British origin and immigrants from the United Kingdom and elsewhere. It was of interest to note that some of the Italians were anxious to bring their relatives from Italy to the belt. Some of the miners have their families with them. All work under the most arduous conditions.

Some of the miners work alone, others work as groups of partners and, occasionally, some mines have been worked by small companies. A mine has been sold for as much as £1000, and over £250 has been paid for a partnership. At the present time, the independent miners and partners, with the ruling high prices for mica, are making excellent profits - some, I gather, are now making as much as £1500 a year, and this is free of income tax.

A small company working on the belt has difficulty in obtaining labour, a difficulty which can be readily appreciated after seeing the living standard in this area. A small company cannot provide housing conditions for its employees any better than those of

/independent

independent miners. Labour on wages is also subject to income tax. Individual mica mines are comparatively short-lived. Mica mining, to be permanent and successful, can best be undertaken only by large concerns with considerable capital, capable of controlling 20 to 40 mines together, all in various stages of production and with widespread prospecting operations bringing new mines into existence as old ones are worked out. Such a company could afford to provide housing conditions and amenities suitable to attract labour as in other Australian mining towns.

At present the miners either live in tents, or build rough stone walls roofed by sheet iron. The housing conditions are extremely primitive, and would not be tolerated in any Australian city - indeed, the conditions are no better and, in some cases, not as good as the housing conditions which much Indian mica mining labour enjoys. One can, however, admire the care which the miners and their families take to make the best of these conditions.

It seems to me that there is scope for the design of a small portable house, suitable for the climate, which can be readily erected, dismantled, and transported from site to site. Such houses could be rented by the Government to the miners, just as compressors are rented. It should be remembered that the miners are largely transient and, even if they were permanent, difficulty in obtaining building supplies would render house construction difficult. A portable comfortable house would improve the standard of living for miners in the Territory.

(d) Block Mica.

In India, the crude mica is brought to the factories, rifted to a thickness which is amenable to easy cutting and then the mica is cut by means of a sharp sickle, removing the greater number of flaws such as cracks and severe warps, and some of the more serious stains or spots. This mica is then sorted according to sizes and quality, so that more than 100 various grades and qualities may be produced. After final trimming, practically all of the larger sizes, No. 3 and up, are exported as block. Also practically all the higher quality, Good Stained and up, sizes 4 and down, are exported in block form. Most of the mica of stained and Lower qualities, of sizes 5 to 6 with a certain proportion of 4's and 3's, are sent for splitting.

In Australia some of the miners send the crude mica direct to the Government factory in Melbourne for cutting. Others cut the mica themselves and roughly sort it according to size and quality for despatch to the Government factory. A large proportion of the mica is discarded - that is, all mica of smaller sizes and lower quality which, in India, would be used for the manufacture of splittings. As something of the order of 70 per cent. of the total Indian mica exported is represented by No. 5½ and 6 splittings, the importance of this is apparent.

/As

As none of the miners who cut their mica at the mines weigh their crude, the average cutting percentage (i.e. the percentage of block obtained from crude) is not known. However, at the Melbourne factory, in 1945/46, from 36 tons of crude 15.65 per cent. block was cut; and in 1946/47, 20.66 per cent. block was cut. The cutting percentage this year is expected to be higher.

The cutting percentage in Bihar is about 20-25 per cent. It is futile to compare the cutting percentages of the two countries - in India an enormous amount of small sizes and poor quality crude, which would be left on the dumps in Australia, is cut for splittings.

Naturally, the transport cost on crude mica which is sent to Melbourne, per lb. of block produced, is considerably greater than on block mica despatched from the mines. On the 1946/47 cutting percentage, the transport cost on crude sent to Melbourne is 8.45d. per lb. of block produced, and 1.86d. per lb. on block mica despatched. However, in view of the possibility that a very large amount of the mica trimmings which are left on the dumps at the mines could be used if sent to the Melbourne factory and also because of the fact that by cutting their mica at the mines, the miners are spending more than two-thirds of their time in cutting instead of in mining, it would probably pay all the miners to send their crude mica to Melbourne for cutting. Probably many of the miners feel that by cutting the mica themselves they make more out of it, in quality and sizes, than would labour on wages and bonus.

The amount of mica which can be cut per day depends upon the sizes and quality of the mica. Naturally the larger the size the more the cutter can trim per day; also the better the quality, and the fewer the flaws, the more can be cut. I understand that a good cutter can cut and trim about 15 lb. per day of block mica on the general run of qualities and sizes. mined in the Harts Range area. One man informed me that he has cut up to as much as 50 lb. of block per day from good quality large books. Some of the slower cutters cut as little as 4 lb. particularly if the sizes are small. These figures can be compared with the rate of cutting in India, which varies from 4 to 8 lb. for small sizes and 8 to 12 lb. for large sizes. Apparently, the Australian cutter is a more rapid worker than the Indian, although I doubt whether his standard of cutting would be as good - it may be pointed out that block mica can be very considerably reduced in value by poor cutting. However, in comparing the rates of cutting, it should be remembered that the higher average quality of Australian mica tends to permit a higher rate of cutting.

It is apparent that if one takes an average of 12 lbs. per day for all sizes and qualities of block mica cut from Harts Range crude mica, the cost of cutting will be quite a considerable item in the total cost of block produced. Every 30/- per day earned in wages will add 2/6 to the average cost of the block mica produced.

(e) Splittings.

In India the splitting quality mica is divided into two parts. Practically all splitting quality block of sizes 5½ and up remains in the factories and are split by

/factory

factory labour mainly in the form of what is known as "book-form" splittings; that is, as each block is split the splittings are kept together like the leaves of a book, each splitting being dusted so that it will not adhere to the next one, highly stained splittings being generally removed. As many as 40-50 splittings may form one "book" representing the original block; the "books" are carefully packed for export in 2-5 lb. packets. Occasional splittings are checked for thickness by micrometer. Almost the whole of No. 6 splitting block and a certain amount of $5\frac{1}{2}$ are distributed to contractors who issue the mica to home splitters in the villages where the mica is split as a cottage industry. Normally, perhaps 100,000 people are engaged in this industry in Bihar, attaining to about 170,000 people during the war.

This side of the industry is non-existent in Australia, and splittings are imported from India for the manufacture of micanite.

(f) Condenser Films.

The greater part of the high quality mica of sizes 4 and down is used for the manufacture of condensers. A certain amount of condenser films is made in India (particularly during the war) but each consumer country generally perfers to make its own condenser films from block of the requisite quality imported from India. Some condenser films are split in Australia for the local industries.

(g) Marketing.

In India the larger mica producers are also dealers and exporters, that is, as dealers they purchase mica from smaller producers to enhance output from their own mines and factories and export the final product direct to consumers in Europe and America. There is a large number of smaller dealers who purchase mica in the local bazaars from the small miners and some of these dealers may either export or sell their mica to the larger firms. Quite a considerable amount of business is done through brokers in London and New York, the mica being largely sent on consignment and the brokers charge 2 per cent. commission. These brokers perform a very useful function on behalf of the dealers and the consumers; they hold mica stocks from all producing countries, so that consumers can visit their warehouses, examine samples, and purchase exactly the sizes and qualities which they require from time to time.

It will be appreciated that as there are so many sizes and qualities, a producer may require to hold stocks of certain sizes and qualities for some considerable time before being able to sell them at a suitable price.

In Australia, as a result of the war, all mica is marketed by the Department of Supply and Shipping at a fixed price. Should, however, Australia find it possible to enter into the oversees markets the present marketing set-up would require revision.

(h) Manufactured and Built-up Mica.

The interest of the mica producer may be said to end at the point where his block or splittings are marketed. However, as different qualities and sizes are used for different purposes he has to bear in mind the requirements of industry - he may, in fact, find it possible to adjust his sizes and

/qualities

TABLE II.

COMPARISON OF 1938 AND 1947 STERLING PRICES, BIHAR RUBY BLOCK EX STORE AND AUSTRALIAN PRICES (CONVERTED TO STERLING) RUBY AND GREEN BLOCK (SHILLINGS STERLING PER LB.)

	Indian C.S.S.		Indian F.S.		Aust. Clear	Indian G.S.		Aust. Com. Clear	Indian Stained		Indian H.S.		Aust. Stained	Indian Spotted 50/50 1st	Aust. Spotted
	1938	1947	1938	1947	1947	1938	1947	1947	1938	1947	1938	1947	1947	1947	1947.
O.O.E.E.S.	70/-	190/6	60/-	150/-		55/-	130/-		30/-	88/-	26/-	63/-			
O.E.E.S.	60/-	175/6	50/-	129/-		40/-	100/-		26/-	77/6	21/-	58/-			
E.E.S.	50/-	141/-	40/-	112/6	142/7	35/-	82/6	98/7	22/6	70/-	17/6	53/-	43/2	32/-	37/-
E.S.	40/-	107/-	30/-	75/-	114/5	25/-	68/-	85/5	17/-	57/6	15/-	48/-	37/10	29/3	33/5
S.	30/-	88/6	25/-	60/-	76/7	19/-	53/-	61/7	15/-	50/-	12/-	39/-	33/5	26/-	29/-
1	25/-	75/-	18/6	52/6	61/7	14/-	44/-	47/2	12/-	40/-	9/6	33/-	29/-	22/9	23/10
2	22/6	64/6	14/6	42/-	52/10	9/6	37/-	39/7	8/9	31/-	7/6	24/-	22/-	20/3	17/7
3	16/-	55/6	12/6	36/-	37/10	8/6	30/-	29/-	6/-	24/-	6/3	17/-	14/-	15/3	8/10
4	13/6	48/6	11/-	31/-	27/2	6/-	28/-	19/5	4/-	15/6	3/9	12/6	8/10	8/-	5/2
5	7/6	33/3	4/3	21/-	14/-	3/-	15/-	8/10	2/3	8/6	1/-	6/6	4/5	4/6	3/7
5½	5/9	18/6	3/-	15/6		2/6	10/9		-	7/-	-	3/9		2/7½	
6	2/6	9/3	1/-	7/6	9/7	-/11	5/9	7/-	-	3/6	-	2/6	3/7	1/7½	1/10

TABLE III.

COMPARISON OF AUSTRALIAN PRICES WITH LONDON PRICES OF INDIAN MICA RECALCULATED TO QUALITIES EQUIVALENT TO AUSTRALIAN.

Classification and Grade	1 London price recalculated to Australian qualities	2 Col. 1 plus Duty and Exchange	3 Australian Pool Selling Price	4 Australian Buying Price under P.R.O. 2901
CLEAR				
X Special	105/9	148/-	178/3	162/-
Special	77/6	106/6	143/-	130/-
A1	65/-	91/-	95/9	87/-
1	54/8	76/6	77/-	70/-
2	43/8	61/2	66/-	60/-
3	37/3	52/2	47/3	43/-
4	30/3	42/3	34/-	31/-
5	19/3	27/-	17/6	16/-
6	9/2	12/9	12/-	11/-
COMMERCIAL CLEAR				
X Special	72/9	101/9	123/-	112/-
Special	56/6	79/2	106/9	97/-
A1	46/-	65/4	77/-	70/-
1	38/3	53/7	59/6	54/-
2	30/7	44/-	49/6	45/-
3	25/-	35/-	36/3	33/-
4	19/6	27/4	24/3	22/-
5	11/-	15/2	11/-	10/-
6	5/6	7/8	8/9	8/-
STAINED				
X Special	45/-	63/-	54/-	49/-
Special	38/9	54/4	47/3	43/-
A1	32/8	45/-	41/9	38/-
1	27/9	38/9	36/3	33/-
2	23/3	32/7	27/6	25/-
3	17/9	25/-	17/6	16/-
4	10/3	14/2	11/-	10/-
5	5/6	7/6	5/6	5/-
6	2/9	3/10	4/6	4/-

qualities slightly to suit demand.

The principal use of high quality block mica is as insulation in transformers, armatures, radio tubes and in television. Large amounts are manufactured into condensers, where its dielectric properties are all important. Lower quality block is widely used in heating elements and terminal insulation of heating apparatus such as water heaters, toasters, flat irons etc., and for washers and discs in a large variety of electrical equipment. Even from Stained quality No. 5 block a small amount of condenser films is sometimes split, but this is scarcely a paying proposition on present prices for Stained. Non-electric uses of mica include windows for ovens, stoves and furnaces, lamp shades and chimneys, gas masks, goggles, instrument covers, steam gauges and special compass indicators.

Built-up mica, or micanite, is an industry in itself - the amount of splittings made into micanite exceeds the amount of block used in the electric industry. The splittings are cemented with recognised cementing media, such as shellac or a synthetic resin, and formed into boards, tapes, tubes, rods and various shapes. There has been some development of micanite manufacture in Australia in recent years.

(i) Substitutes.

For various insulation purposes a number of synthetic resins and other plastic products, as well as porcelains and patent ceramic products, are increasingly used, but so far no adequate substitute, possessing all the peculiar properties of mica which make it so suitable for many electrical purposes, has been discovered. Because of the shortage of high quality mica during the war, much research was devoted in America and the United Kingdom to finding a substitute - the final decision reached at the end of the war appeared to be that the best substitute for high quality mica was mica of lower quality.

During the war Germany found a means of producing artificial mica but, I understand, at enormous cost. So far, I have not seen any report of the method used.

(j) Prices.

In Table II prices of mica for 1938 and 1947 are listed. The 1938 prices are those of a well known Indian Company, London Warehouse. The 1947 prices for Indian mica are the "Government" prices; that is, the prices which have been fixed by the British and Indian Governments as the basis of sale of the balance of stocks held by the Joint Mica Mission at the end of the war - private sale prices are lower in a few cases, in other cases higher.

In comparing the 1938 and 1947 prices for Indian mica, it may be pointed out that the qualities are not perhaps quite equivalent. Before the war, each firm had its own standards of qualities. It so happens, however, that the standards of the Company whose prices are listed in Table II were closer to the Joint Mica Mission standards than those of any other Company, and are quite comparable. The table demonstrates the remarkable rise in prices between 1938 and 1947, ranging between 150 per cent. and 650 per cent. according to size and quality.

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The Australian prices listed are ex-Departmental Stores, Melbourne, converted to sterling for purposes of comparison. The Australian Clear is listed with the Indian Ruby Clear (C), Slightly Stained (SS) and Fair Stained (FS) for purposes of comparison. Some of the Indian F.S. would be included in Australian Commercial Clear, but the latter ranges between Indian C.S.S. and F.S. Also Australian No. 6 includes the equivalent of Indian No. 5½.

The Australian prices are for both green and ruby, without distinction. As the overseas prices for green are rather lower than for ruby, it should be expected that, on the whole, the Australian prices should be lower than the Bihar Ruby prices - the disparity should be only slight for Clear, increasing for Commercial Clear and Stained, as the amount of green is least in the Australian Clear and greatest in the Stained.

In order to obtain a more comparable picture, the various Australian qualities were taken to consist of the the following proportions of Indian qualities :

Australian Clear	-	20 per cent. C. & S.S., 20 per cent. F.S., 20 per cent. Ruby A.Q. (Madras), 40 per cent. Green 1st (Madras);
Australian Commercial Clear		25 per cent. G.C., 25 per cent. S., 25 per cent. Ruby B.Q. (Madras) and 25 per cent. Green 2nd (Madras);
Australian Stained	-	25 per cent H.S., 25 per cent. D.S., 25 per cent. Spotted, 25 per cent. B.Q.

Applying the current sterling prices for Indian mica to each of the above percentages, average prices were then calculated for each of the Australian qualities, Clear, Commercial Clear and Stained. These average sterling prices are listed in column 1 of Table 111. Australian No. 6 consists of Nos. 5½ and 6. To get a rough idea of the proportions a box of No. 6 was resorted, giving 37½ per cent. No. 5½, and 62½ per cent. No. 6. These proportions were used in calculating the prices of average Indian Nos. 5½ and 6 equivalent to No. 6 Australian.

In column 2, 25 per cent. exchange and 15 per cent. duty have been added, thus giving a price basis which may be taken as representing approximately the import prices of average Indian qualities and sizes, which would be closely equivalent to the respective Australian qualities and sizes. The Australian selling prices ex Government Pool, Melbourne, are given in column 3 for comparison. Column 4 lists the prices paid to the miners under Prices Regulation Order 2901 of February 1947.

Comparing columns 2 and 3 of Table 111, it is apparent that in Clear mica the Australian price for all sizes below No. 2, except No. 6, are low. In Commercial Clear the Australian prices for Nos. 4 and 5 are low. In Stained, the Australian prices for all sizes except No. 6 are low. In Spotted mica it will be seen from Table 2 that Australian prices for sizes below No. 1 are low.

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The above comparison of present Australian and overseas prices is, perhaps, not entirely relevant to this report, but is given for information. It does suggest that some revision of Australian prices may be made to encourage mining at the moment. A rise in prices of No. 6 in Commercial Clear, Stained and Spotted is not justified - particularly in stained and spotted there is practically no market for No. 6 and stocks are accumulating at the Government Store. I did observe at one mine that the miners, during a slack period, were going over the dump and culling Stained block of this size - a rise in price of No. 6 would only encourage this.

A rise in prices may be open to justifiable criticism. We are here dealing with mixed ruby and green mica, of which the latter has a lower value than the former. The consumer may contend that the price should be determined by the mica of the lowest value - he has to buy mica to suit a particular purpose and either may have to reject portion of a parcel or buy a higher quality in order that he can use the whole. On the other hand, the miner producing green mica is unduly favoured at the expense of the ruby producer. The obvious course is to distinguish ruby from green mica.

There are no figures available of the average London prices of total mica sales either before the war or at present. The average Indian export price of all block mica before the war was about 3/- per lb. sterling, and, at the present time, must be well over 10/- sterling per lb. The average price paid by the Department of Supply and Shipping for all mica purchased from Australian mines during 1945/46 (61,037 lb., £40,665.12.3) was 13/4 per lb. of block or 10/8 sterling - the selling price would be 10 per cent. higher if all the lower size stained qualities could be marketed.

The enormous rise in prices since 1938 is indicated in Table II. It is not expected that the present peak prices will be maintained, in fact there is now a tendency in some lines for a slight fall. Nevertheless, it is most unlikely that prices will ever fall to their pre-war level.

The mica trade has maintained in the past, with some justification, that the electrical industry obtained its mica at a cost far below its real value to that industry. The previous low price has been partly due to the total absence of co-operation amongst Indian producers, coupled with lower labour costs. Labour costs in India have, in recent years, been doubled and trebled without any corresponding increase in efficiency, and India could never afford to return to the old prices.

Table IV showing the present London prices of condenser films and splittings is given to complete the picture.

(k) Costs.

Mining: Before the war, the cost of mining mica in Bihar by one of the large companies was the equivalent of approximately 1/- (Australian) per lb. of block (exportable and splitting) - if only the equivalent higher quality block (i.e. excluding splitting quality) is taken into account as in Australia the equivalent cost is 4/- - 5/- (Australian) per lb.

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TABLE IV.

PRICE OF CONDENSER FILMS AND SPLITTINGS, LONDON, 1947.

SHILLINGS STERLING PER LB.

Grade	Condenser Films		Splittings, Bihar Ruby		
	1st	2nd	Book-packed	Dust Loose	Loose
No. 3	46/6	32/3	24/-		
4	42/-	30/-	21/-	12/-	
5	29/6	21/-	19/6	9/-	
5½	22/6	17/-	13/6	5/-	
6	10/-	8/-	4/9		1/5 -3/-

As mining in the Harts Range belt has been on such a small scale, by independent miners who have largely restricted their work to the surface, it would be impossible to estimate in reliable detail what the mining costs would be for a large company working a number of properties at the one time. For the conditions under which these mica pegmatites would be worked, experienced mining opinion estimates the total mining costs at amounts ranging from a maximum of 30/- to a maximum of 40/- per ton of vein rock, that is respectively 4/6 and 6/- per lb. of block mica assuming the percentage of block mica indicated on page 10 (.3% or 6.7 lb. of block mica per ton of vein rock). However, mica mining is a cheaper operation than underground mining for other minerals which occur in deposits of a similar size; apart from development work, only the mica is required to be brought to the surface and as much as possible of the broken rock is left in the stopes; also drilling and explosives are used at a minimum in stoping. Actual costs might be expected to be nearer the lower figure, but it would be unwise to anticipate this at present.

Should it prove possible later to utilise the lower qualities and smaller sizes now left in the dumps for splittings, then the costs will be correspondingly reduced.

The figures quoted are nothing more than an indication that mining costs in the Harts Range are likely to be of the same order as mining costs in India. Notwithstanding the lower wages of Indian mining labour this is not paradoxical, but is in keeping with general mining experience of costs as between Eastern and Western countries - low wages in the East are compensated by low efficiency.

Freight: Present freights are as follow:-

	Crude	Block
Harts Range Depot to Alice Springs (140 miles)	£4.10. 0	£4.10. 0
Rail, Alice Springs to Melbourne (1446 miles)	11. 4.10	12.16. 6
Per ton	£15.14.10	£17. 6. 6
Per lb.	1.69d.	1.86d.

Taking the cutting percentage as 20 per cent. the freight on mica transported as crude is 8.45d. per lb. of block, against 1.86d. per lb. when shipped as block.

The trucking charge Harts Range to Alice Springs comes out at 7.7d. per ton mile, which is higher than the 6d. per ton mile generally charged by the Works and Housing Department in the Territory.

The rail freight, Alice Springs to Melbourne, includes break-of-gauge handling at Port Pirie and Mile End.

Cutting and Other Charges. In India the cost of cutting varies widely, according to the sizes, but in terms of Australian currency the average would probably be of the order of about 3d. - 4d. per lb.

/At

At the Melbourne factory cutting costs range between 1/4 - 2/6 per lb., the average being 1/10d. The cutters are paid the award rate, £5.19.6, plus a bonus of 6d. per lb. of block cut.

In addition to cutting, there are of course other charges, such as sorting, packing, and overhead charges. It is interesting to note that the total charges - assistance to miners in the Harts Range mica belt, maintenance of Depot staff, and all Factory and overhead charges (excluding cutting) in Melbourne - are covered by the 10 per cent. added to purchase price, about 1/4d. per lb.

Total Costs. Totalling up the costs indicated above, a very rough picture may be obtained of the maximum costs which a company is likely to incur if mining on the Harts Range and shipping all crude to Melbourne, assuming that it restricted itself only to the present qualities and sizes of block. Portion of "other charges" is duplicated under "mining", but the picture is of maximum costs.

Mining	...	...	... 4/6 - 6/-	per lb. block
Freight	...	...	... 8½	" " "
Cutting	...	...	... 1/10d.	" " "
Other Charges	...	...	... 1/4d.	
			8/4½ - 9/10½	" "

On present purchase prices, Department of Supply and Shipping, this leaves a margin of about 3/6 - 5/- per lb. of block for profit and such further charges as a large company in this region may meet. On present Australian pool selling prices the margin would be 5/- - 6/6d.

For a mining company to operate in the manner outlined in the next section, I would be inclined to the view that mining costs should be below the maximum of 6/- quoted above.

Freight costs are at present nothing short of fantastic even allowing for the fact that the mica is brought 140 miles by road and 1,446 miles by rail. A mining company would be forced to consider other directions for transport, the most obvious route being direct to Dajarra by road, some 300 miles, and 600 miles to Townsville by rail.

Cutting costs are unlikely to be reduced under Australian conditions. This is the charge which is likely to be the deciding factor in developing a splitting industry from block mica. The development of such an industry would mean that mining and other charges would be reduced proportionately per lb. of mica - it would not be improbable that if all sizes were produced, mining costs per lb. would be reduced to as low as 1/6d. per lb. But cutting costs, if anything, would increase. Although for block mica Australia would appear to be able to compete with India, for the development of a splitting industry the availability of a suitable labour force - such as New Guinea labour - would be essential, and could not be considered otherwise.

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VI. SUGGESTIONS FOR THE DEVELOPMENT OF THE AUSTRALIAN MICA INDUSTRY.

In the Harts Range the present gouging methods by small miners can never give rise to a worthwhile industry. Indeed, it is impossible to visualise how production could be usefully increased by present methods. The establishment of a stabilised industry with a large exportable production would depend on the formation of one or more companies with adequate capital to develop a large number of mines. The success of such an organisation or organisations, particularly in this part of Australia, depends largely on the conditions which can be provided to attract labour. It has been possible to attract labour to places like Mt. Isa, Broken Hill and Kalgoorlie, in areas where conditions of climate and country are certainly no better than in the Harts Range, and perhaps not as good. With a well-designed settlement, providing reasonable amenities, and proper organisation for transport and labour, and supplies of water to the surrounding mines, it should be possible to attract labour into this belt at a reasonable standard of wages.

The organisation of mica mining is entirely different from the usual organisation of mining in Australia. A mica mine is essentially small as compared with a metal mine, and its life is comparatively limited. On the other hand, within a given area mica-bearing pegmatites are commonly far more numerous than is the case of other deposits. But by working a large number of mica mines simultaneously, all in different stages of development and stoping, a single organisation ensures a steady and continuous output. Such an organisation, to maintain an annual output of say 5,000 cwts. of the qualities and sizes of mica at present marketed, equivalent to breaking about 400 tons daily of rock containing .3 per cent. marketable block mica, would require to have between 20 and 30 mines in various stages of production, and would continuously need to prospect for new mica-bearing pegmatites - this estimate is based on mines worked by companies in India, and, assuming that the deposits are comparable as the evidence would suggest, this output might be improved upon with more rapid working of the mines and with more efficient Australian methods.

Mica mines do not require such expensive mine equipment as do large metal mines, and practically no equipment is required for treatment. Capital would be required mainly for the following purposes:-

(a) Mine equipment - portable compressors, air hoists, rock drills, pipes, rails, trucks, etc.

(b) Mine and factory buildings, workshops, housing and amenities for employees.

(c) Transport equipment for mica, stores, water and employees.

(d) Roads.

(e) Working capital, etc.

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Although £100,000 would cover (a) and (c), for an organisation of the size contemplated (b) and (d) are likely to be considerable in the Harts Range area, and the total capital requirements are likely to range up to £750,000 as the operations expand.

For the development of this region I would suggest the following organisation:-

(a) The formation of a Company registered in the Territory, authorised capital £750,000, to be called up as required.

(b) The construction of a settlement on the Plenty River, where there is an adequate supply of water. The settlement should be on modern lines, with homes designed for the climate and with all modern conveniences, including air conditioning as far as possible. Schools, shops, hotels and recreation amenities should be provided.

(c) Portable buildings, designed for the climate, would be used at the mines. They would be so designed that they can be easily taken down and transported for re-erection at another mine, as mines are worked out and new ones opened up.

(d) Mine labour would live at the mines during the week, Monday to Friday, and would be brought to the settlement, to their families, during the week-end. Alternatively, housing at the mines could be arranged for such of the miners as preferred to keep their families at the mines.

(e) Large areas of the mica belt would be taken on lease, and divided into zones, perhaps four, each under a Zone Manager, and containing six to ten working mines. Each mine would be under a mine boss. The Zone Managers would reside in the Zones.

(f) The main workshops and stores would be at the settlement, alongside the office of the General Manager.

(g) Crude mica would be collected daily in each zone, at the Zone office, and sent in periodically to the settlement.

(h) Mining, for the most part, would be by underground methods.

(i) Such of the present independent miners on the Belt as are willing to do so could be employed as prospectors. Portion of each zone could be allotted to them, with permission to mine and retain whatever mica they may win, for a period of one or two years, after which another area would be allotted. A bonus could be paid for any good deposits found.

The above brief outline is of the mining side of the proposed organisation. It visualises a settlement of some 1,000 people on the Plenty River, comparable with Alice Springs in size.

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The treatment side of the Company's operations would be separate. Although, from the point of view of transport costs it may be preferable to cut the crude mica to block form at the Settlement and thus eliminate 80 per cent. waste, it is doubtful whether adequate suitable labour would be available there. An annual production of 5,000 cwt. of block mica would require a cutting force of about 200. It may be possible to attract the miners' womenfolk to do such work, augmented perhaps by aboriginal labour for small sizes. But the ultimate object should be to endeavour to link the industry with the production of splittings, which so far is almost limited to India. If this can be developed, the amount of block from the same number of mines would increase to something of the order of 20,000 cwt., and as so much will be in small sizes a cutting force of over 1,000 would be required. This would seem to be an impracticable proposition in Central Australia.

The cutting and splitting of mica is an occupation peculiarly suited to native labour; I would suggest that the island labour in New Guinea, Papua and the Solomons, may be ideal for this work. It is a sedentary occupation and much of the splitting work can be carried out as a cottage industry.

The crude mica from the Settlement on the Plenty River could be despatched by truck to Dajarra on the Queensland railway, a distance of about 300 miles in a straight line - despatches would be of the order of 20 tons of crude mica per week in the early stages, but once a splitting industry were established in the Islands, this would increase to some 80 tons. From Dajarra the mica would be railed to Townsville and shipped to Port Moresby or some other suitable centre for cutting.

From the cutting centre, the sorted exportable block would be despatched abroad. The larger sizes splitting block would be split to bookform at this centre. Smaller sizes would be distributed amongst the villages by such traders as may become interested in the industry, on contract, and the mica split as a cottage industry. The splittings would be returned by the traders to the Company's centre for marketing.

The above outline of the suggested organisation follows the pattern of mica-organisations in India, with modifications for Australian conditions. The Company which took up such a project could also enter into micanite manufacture, utilising part of its own production.

For a new industry such as this costs are difficult to anticipate in detail. Those indicated on pages 20-22 provide merely a general picture of their order, and from them it will be noted that if certain assumptions are correct, the mining side has every possibility of being successful.

The treatment side requires to be made the subject of an enquiry in the Islands, particularly if it is intended to produce splittings. This again is a matter of careful organisation, preferably by some existing concern which has wide experience of island labour.

Government assistance in various forms would also be probably required. Such assistance is already given to

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the gold miners in the Territory. Compared with gold, mica has vital industrial uses, both in peacetime and in war. Adequately developed, the Harts Range mica deposits are likely to be of greater importance to the development of Central Australia than any other mineral at present known in that region. Any Company that may take up the development of this industry is likely to request assistance in the following forms:-

(a) Assistance in road construction - (i) the proposed road from Plenty River to Dajarra, and (ii) the main mine roads.

(b) Assistance in construction of the Settlement.

(c) Assistance in supply of water.

(d) Freight concessions on the railway, Dajarra to Townsville.

(e) Taxation concessions on dividends, on par with earnings of primary producers in the Territory.

(f) Taxation concessions to employees at the mines in order to attract labour. Independent mica miners are granted tax concessions, whereas employees of such miners pay tax.

VII. HAZARDS INVOLVED IN THE PROPOSAL.

The proposals for the development of the mica industry in Central Australia are of course subject to the hazards of any new industry. There are, however, two critical hazards which may be stressed:-

(a) the richness of the veins; and

(b) the future prices.

The factor, .3 per cent. cut block mica, which has been taken as the probable average payable richness of the pegmatite veins in the Harts Range is the most critical assumption that has been made in this report. It is based on the figures provided by Mr. H. B. Owen, and assumes also that sufficient mines of this degree of richness are available. However, from comparisons with Indian deposits, the acceptance of this factor as the payable average of block, of the type and quality now marketed, is justified. There is no way of proving it, short of working the deposits over a long period. This lack of ability to determine the richness of a mica pegmatite prior to actual development is characteristic of mica, and is a hazard which must be accepted. To those unacquainted with mica, it may appear to increase its speculative nature but, providing the operations are spread over a sufficient number of deposits, this hazard is no more speculative than in mining for other minerals.

The other principal hazard, price, will determine whether Australian mines can compete with Indian in the future. The present prices cannot be expected to persist indefinitely. At the same time they are not likely to recede to the pre-war level. At the present time, Australia could compete with India in higher quality block. If it is possible to establish

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the industry now, by the time prices fall to any appreciable extent mining efficiency should have reduced costs somewhat. Australian mining will always be more efficient than Indian, and despite the disparity of wages I would personally have no doubt that mining costs would be lower ultimately in Australia. Treatment costs will, however, be higher here. Per lb. of block the difference in cost between Indian exportable block and Australian block will be of the order of 1/- - 1/6d., but in view of the rather higher quality of Australian block the price hazard on block is of similar degree here as in India.

Should a splitting industry be developed, then competition with India will be keen indeed. From the mining point of view it would make little difference vis-a-vis Indian mining costs of comparable mica. The serious hazard here is splitting costs. It might be possible for Australian labour to compete with Indian in bookform splittings No. 5 and up, but for smaller size bookform, dust loose and loose splittings, which form the great bulk of the splittings industry, possibilities would depend entirely on developing the industry in the Islands. It is futile to speculate on comparative costs of splittings. The only feasible policy would be to start the splitting industry in a small way and gradually expand as market possibilities permit.

The above hazards have been emphasised, as they are so pertinent to mica. Other hazards are common to any mining industry in this country.

VIII. FURTHER ENQUIRIES NECESSARY.

In this report, apart from a recent market report and prices from Messrs. Hart and Haylards, London, I have been guided entirely by my own experience of mica. It should be remembered that in some important respects that experience is 18 months old. In the interval which has elapsed I am out-of-date on the following information, which is really vital if this industry is to be developed:-

(a) The general present condition of the Indian mines, the position of labour, general co-operativeness of the mining firms, ability and willingness to adjust prices, general trend of the industry, upkeep of standards, and other pertinent questions.

(b) The present and probable future general position of the mica industry in U.K. and U.S.A., for both block and splittings, marketing, general likely trend of prices, requirements of consumers as to quality and sizes, likely increase or decrease in demand, new uses, new methods of manufacturing micanite, possible substitutes, etc. Would U.K. and U.S.A. consumers support an Australian industry, or are they content to continue to get their supplies from India?

These are questions on which no amount of correspondence could provide an adequate picture. They should be discussed personally only by someone from this country familiar with and able to discuss all phases of the industry. I feel that, until this is done, the present report will be incomplete.

Further, enquiries should be instituted in Papua and New Guinea, as to whether it will be possible to set up a

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treatment centre there, primarily for the cutting of block mica. The possibilities of developing a splitting industry may also be examined but may be regarded as of secondary importance for the moment.

The above are enquiries which should be taken up at once. Later, and of long term interest, the Bureau of Mineral Resources would presumably enter into the geological survey of the mica belt.

Finally, if it is intended to develop this industry, no time should be lost. Marketing conditions are most favourable abroad at present, and undue delay may mean that the most favourable conditions for establishment of the industry may be missed.

(Sgd.) J. A. Dunn

Mineral Economist.

21.10.47.

APPENDIX I.

EXTRACT FROM LETTER RECEIVED FROM HART, MAYLARD & CO. OF 66 FENCHURCH STREET, LONDON, E.C.3, DATED 25TH SEPTEMBER, 1947.

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The Mica trade has been very brisk since I got back in May, 1946, and for about a year prices rose steeply so that rates are now considerably higher than those that were being paid by the Mission. About the beginning of this year, prices became more stabilized, with the exception of one or two descriptions of which there was a shortage and still is, and of which prices have continued to rise. Even these few descriptions are now steadying a bit, because the demand is less, presumably on account of our industrial troubles here and Africa seems to be increasing its production and being willing to accept much lower prices than India. It seems to be filling the reduced demand with the result that Buyers are refusing to pay the advanced rates demanded by India.

All the time there has been a steady flow of Mica into this country, partly against firm shipment orders, but mainly on a consignment basis which is to say, that the goods are shipped here for sale on arrival.

I am afraid the qualities have dropped very much, and the standard of packing is now nothing like as good as that which we managed to maintain - however imperfect it may have been. Buyers have been able to pick and choose and buy just what they wanted from London stock when they wanted, and whilst throughout 1946 the sales more or less kept up with the arrivals, since the beginning of the year, due to both increased consignments and reduced consumption, we have now a very considerable stock in London of practically everything.

The main demand has been for the cheaper qualities, that is to say, Spotted, Stained, Heavily Stained and Densely Stained. The amazing feature has been the almost complete absence of demand for Clear and Fair Stained which caused us all so very much concern during the war years.

Prices are all over the place because of the present variety in standard, some Shippers have the holding power and optimism to cause them to price their stocks at above the market in the hope of forcing the prices still higher, and because others want to realize their money and are quoting reduced rates.

The best guide to prices we can give you is to let you have the present Government selling prices which I enclose, and to make this more helpful, those items marked with 'o' are not selling and a price reduction is to be anticipated, and those items marked with an 'x" are selling well and prices for private sales are higher. Where they are very much higher I have put the present market price in brackets. These prices may be taken as being for more or less standard descriptions and ignoring inferior or superior lots which may sell at considerably below or above Government rates.

Government prices were fixed as a basis for the sale of the balance of stocks purchased by the Mission, but which were not used during the war. An arrangement has been made with the Indian Government and with the Trade here that Government stocks are to be liquidated at the rate of 15% of all private sales so that Buyers and Sellers have undertaken to buy or sell the requisite percentage of Government Mica at the

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same time as their private sales. Due to stocks being exhausted or certain descriptions having been withdrawn from the market, the Government sale does not always apply, but I am sure you do not want me to go into this in detail.

We have, of course, known for many years of the existence of exceptionally fine quality Mica in Australia, but from the very beginning it has been one long series of failures and bankruptcy. Everyone who has touched it seems to have come out on the wrong side and I suppose this is why Australia is not, today, one of the big exporting countries of Mica. My impression is, as far as quality and grading is concerned, that Australia under certain conditions can compete favourably, if not with India, certainly with Africa, Brazil and Argentina. The whole trouble has so far been, labour costs, coupled with high transport costs from the mining area to the coast. I believe most of the mining has been done in the vicinity of Alice Springs and the cost of maintaining a mining establishment and then transporting the production to the coast has killed the business.

Perhaps now that Indian prices have risen so considerably the mines can be run at a profit. Perhaps with improved methods of transport and possibly construction of roads etc. costs might be reduced to an economical level, but quite apart from this, my own personal view is that it is an industry which the Australian Government should cultivate, even at a loss, because of the strategic value especially in view of the unsettled state of India which makes the future of Mica supplies from there very uncertain.

The superfine Clear Mica that Australia produces will not be of very much interest to the Trade at present, but possibly because of the high prices in the past, the Australian Miners may have rejected the Stained variety and not shipped it. Perhaps now that there is a good demand at good prices for the lower qualities, the whole thing may take on a different aspect.

Spotted Mica has also increased considerably in prices, and whereas the last Australian No. 2 Spotted was probably sold at somewhere around 6/- per lb., Indian No. 2 Spotted, as you will see from the list, is priced at 17/6 to 23/- which is about the price at which the African Mica has been sold, whereas Indian actually sells at from 25/- to 30/-. I would recommend you not to neglect the Spotted producing mines and to get as much of this as you can. The small sizes can be put aside for the time being as there is no demand for them, but a good No. 4 grade, free from red sells readily at 11/- to 12/-, whilst the 3 and up all sells freely in large quantities on the basis of Government prices or more.

There is not really much point in going into the market in detail, because things may have completely changed by the time you are in a position to really talk business, but I am always prepared to give you market reports when you have made more progress.

As regards Splittings, you will, of course, have a lot of teething troubles and your native labour will probably take many months to train to the stage where they can put up Splittings equal to the Indian Splittings. If it can be done there will be a terrific demand for Ruby Splittings from both this country and America.

SUMMARY OF THE REPORT ON POSSIBILITIES OF DEVELOPING THE HARTS RANGE MICA BELT.

1. The Harts Range Mica Belt, Central Australia, is of similar extent to the Bihar Mica Belt, India.

2. The degree of concentration of the mica-bearing pegmatites of the Harts Range Belt is comparable with the Indian Mica Belts.

3. The percentage of mica present in the pegmatites is about the same as in the Indian deposits.

4. The average quality of the Ruby mica obtained in the Harts Range is superior to the average quality of Indian Ruby mica.

5. The average sizes of the Harts Range mica are about the same as Indian mica.

6. Mining costs per lb. of block mica in Australia would be about the same as Indian mining costs for equivalent mica. Cutting costs are rather higher in Australia. Total costs, for a company producing only block mica, as at present, may range between 8/4½d. and 9/10½d. per lb. of block mica, but should not approach the latter figure. On present Australian pool selling prices the margin would be 5/- - 6/6d. per lb.

7. Present gouging methods will never give rise to an industry. The development of this valuable natural resource can be undertaken only by a company with adequate capital backing (of the order of £750,000) able to provide amenities to its employees and thus attract labour to the field.

8. The mining organisation proposed is entirely different from previous mining organisations in Australia. A large number of mica mines, at least 20, would need to be worked simultaneously to ensure a steady output, new mines being constantly brought into production.

9. The production envisaged is of the order of 5,000 cwts. annually of the type of mica at present marketed. This is equivalent to breaking about 83,000 tons of rock annually about 400 tons daily, or an average of 20 tons daily from each mine.

10. The organisation proposed includes a settlement at the headquarters on the Plenty River, where there is adequate water. The settlement would be on modern lines, with schools, shops, hotels and adequate recreation facilities.

11. The miners would live at the mines during the week, and return to the settlement during week-ends. The mines would be grouped into zones, each zone under a Manager.

12. Existing miners would continue as at present to work independently. Those who wished could link up with the company and could carry out valuable prospecting work.

13. The treatment side of the company's operations would be separate. Although block mica could be cut in the settlement, it would probably be better to organise this at a centre on the Islands, from where the mica would be exported direct to the U.K. and U.S.A. markets.

14. Eventually, it may be possible to develop, in the Islands, a splitting industry, able to compete with Indian splittings.

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Much of this would be a cottage industry, peculi rly suited to native labour.

15. The main hazards of the industry are indicated in the Report, but are no greater than in many other industries.

16. The necessity for further enquiries abroad are indicated in order to make more complete the present picture of the mica industry as a whole.

17. The urgency is stressed of taking up this development at once in order to have the advantage of the present favourable market whilst establishing the industry.

18. The development of this industry should be regarded as of great importance, not only because of the peace-time value of mica, but also because of the vital nature of mica as a strategic mineral for defence purposes. The western nations cannot continue to rely on India for 80 per cent. of their high quality mica. Mica is, perhaps, the most important single natural resource of Central Australia awaiting development.

(Sgd.) J. A. Dunn

Mineral Economist.
22.10.47