THE HEALTH OF PLUMBAGO WORKERS IN CEYLON

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Introduction

In the year 1945 the wages board for the plumbago trade directed the Ceylon Commissioner of Labour to hold an inquiry with a view to determining the period of work which a plumbago miner could

perform without undue physical distress, especially with regard to : (1) the maximum period of continuous work an underground miner can reasonably be expected to perform in a mine of a depth of (a) less than 300 feet, (b) 300 feet and over ; (2)

FIG. 1.—Mechanical windlass.

FIG. 2.—Trolleyways and galleries well lit with electricity, 500 feet below the ground level at Kahatagaha mines.

FIG. 3.—Plumbago miners at work in Kahatagaha mines, 800 feet below the surface. Note one miner carrying a coconut oil lamp and the height of the working galleries.

FIG. 4.—Plumbago collections are carried in trolleys to the curing sheds, Kahatagaha mines.

FIG. 5.—A man, aged 42, for thirty years worked as an underground plumbago miner. The radiograph shows diffuse fine nodulation.

FIG. 6.—A man, aged 38, for twenty years worked as an underground plumbago miner. The radiograph shows diffuse fine nodulation.

whether any work done in excess of the minimum period will be injurious to the health of the workers.

For various reasons, both technical and administrative, it was not possible to carry out the investigation till the middle of 1947, and the opportunity was taken at the same time to carry out this general survey relating to the health of plumbago workers.

Graphite, or plumbago, is a natural carbon, more or less pure, found in a crystallized state, or sometimes in brilliant amorphous masses which break easily. It is greyish black or steel blue in colour. Its presence in Ceylon has been known for a long time. Robert Knox, in 1681, mentions the existence of plumbago mines. The last Sinhalese King of Kandy in the very early eighties is said to have explored the possibilities of plumbago mining in Kegalle area as a method of increasing the State revenue. In 1825 the first known shipment was consigned to Mr. Joseph Dixon, founder of the great American Crucible Company; and in 1831 plumbago was included in the list of articles liable for export duty.

For the last hundred years Ceylon has been the principal supplier of superior-grade plumbago, which is the most valuable mineral asset of the island. Owing to its chemical purity and its perfect crystallization and physical structure, Ceylon plumbago is considered indispensable for the manufacture of crucibles for metallurgical use, the most important industrial application of the mineral. It is also used for paints, pencils, and lubricants and in the electro-carbon industries. The fluctuating condition of this industry is clearly recorded by Ceylon export statistics. From nearly 100 tons in 1834, export rose to nearly 31,000 tons in 1899. The plumbago industry reached its zenith in that year, when it brought into the country nearly 22,000,000 rupees, and established the fortunes of many Sinhalese business families. Since then the annual average export had varied from 10,000 to 20,000 tons, and the industry has employed large numbers of persons.

Geology

In Ceylon, plumbago occurs disseminated in the schists and marbles of Khondalite series, and also as vein deposits. It is the vein deposits that mainly provide the plumbago of commerce. Vein deposits comprise: (1) fissures filled with plumbago alone, either parallel or transverse to the foliation of the gneisses; (2) pegmatite veins, in which plumbago plays the part of an accessory mineral; (3) lenticular segregation in a highly sheared acid garnetiferous gneiss.

The three types of deposit are distinct morphologically only. They may occur in the same mine,

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and one form may graduate into another. Consequently the workable deposits of plumbago and the important mines are situated in well-defined belts following the strike of the gneisses. The belts are less than a mile in width, but they extend several miles along the strike.

Though plumbago is mined in various parts of the island, in its south-west quadrant the most important mining areas are: (1) the Ragedera, Maduragoda, Ruanwella area; (2) Pasdum Korale and Raigam Korale; (3) Galle and Matara districts. Three of the largest plumbago mines in the world, Kahatagaha mines, Kolongaha mines, and Bogala mines, are situated in the first-mentioned area. There are innumerable so-called plumbago pits but very few of them are proper mines. In the year 1941 there were over 2,000 pits, and most of them were of a speculative character of short working period.

Method of Mining

Whenever an outcrop of plumbago is found on the surface, the procedure is to follow the vein up to the rock. If it is by the side of a hill, earth is removed by what is called strip or open pit method, and the plumbago vein in the rock is exposed. In other places a trial shaft varying in size, usually 8 ft. $\times$ 8 ft., is sunk through the soft shale and earth formation, following the vertical vein until it strikes the solid rock. This portion of the shaft necessitates timbering, which is usually done by fixing long planks against the sides of the shaft, supported by transverse quarterings. After the solid rock is reached a tunnel is driven at right angles from the shaft in the direction of the plumbago vein. This tunnel ends in a small platform, from which the second shaft is sunk to a lower level. In this manner several shafts are driven, extending to total depths varying from 800 to 1,700 ft. In the lower levels tunnels are driven in the rock from a shaft in almost any direction indicating a vein of plumbago.

In the vicinity of the plumbago vein, solid rock is now blasted by drilling holes by hand to depths varying from 1 ft. to 4 ft. and then by firing them with blasting powder or dynamite charges.

After the blasting operations are completed and sufficient time is allowed for the fumes to clear away, usually about six hours, workers go down the shaft and tunnels, either by mechanical lifts (provided only in the Bogala mines) or ladderways, to the place where blasting operations were carried out. Here they break the plumbago-bearing rock to transportable sizes. Pieces of plumbago and plumbago-bearing rocks are transported on trolleys to the foot of the nearest shaft, where barrels drawn by a windlass provides the means of hoisting to the next level, and so on to the level at which the lift operates. From here a trolley filled with plumbago is taken up in the lift to the surface, where the trolley is directed on rails to curing yards. Except in two or three mechanized mines, haulage of plumbago from the mining head to the surface is by very crude methods, manually along ladderways.

Partial curing is performed at the mines by removal of gross pieces of attached rock and by the washing away of sand and mud. Plumbago is then transported to Colombo curing sheds. Here, after a preliminary selection by expert women workers, it is given a final curing and is then graded. For this purpose both manual labour and machinery are used. Larger blocks of graphite are reduced to the required size by wooden hammers, and stones are picked out by women workers. A sifting machine grades the plumbago into hard large lumps, ordinary lumps, chips, dust, and flying dust. Finally it is packed in barrels ready for export.

Number of Persons Employed

It is difficult to estimate the number of persons employed in the industry, as the numbers vary with the number of mines worked each year, which entirely depends on the price and prosperity of the export market. Except in the case of about half a dozen well-organized mines, which are mechanized, there is no regular employment for miners. Internal springs and monsoon rains cause work to be abandoned in the rainy season. Hence, except in the few organized mines, workmen are drawn from the nearby villages when work is available.

An estimate carried out in 1906 gave the number employed in the plumbago mining industry as 16,700 males, 3,750 females and 15,000 dependants—total 36,000. The Ceylon census of 1921 gave the number of plumbago miners as 2,226. Half-yearly reports collected during recent years by the Inspector of Mines give the figures of the number of mines worked and labourers employed (excluding those employed in the industry outside the mines) as shown in Table 1.

TABLE 1
NUMBERS OF PLUMBAGO MINES AND EMPLOYEES IN
CEYLON

Year	No. of mines worked in the year	No. of persons employed
1940	1,207	18,000
1941	858	16,500
1942	452	8,925
1943	199	8,452
1944	78	2,769
1945	60	2,153
1946	31	1,785

Nature of Labour in the Industry

Labour employed is totally indigenous and Sinhalese. The inhabitants of some villages have a special reputation as good miners, but the largest number of workers are obtained from the villages near the mines. It is common to find a familial tendency, a father teaching a son to follow the work he in turn had learnt from his own father. Women

are employed in the curing work near the mines. They are often wives and relations of the miners.

Work in the mining industry is reputed to be hard and risky but is not considered unhealthy except for the fact that some of the mines are situated in the malarial districts of Ceylon.

Changes of temperature, from moist heat at the bottom to the cold air at the surface, and the physical stress of negotiating ladderways, are serious strains on any constitution; yet illness amongst plumbago miners is rare. The best of Ceylon's virile and athletic manhood and womanhood are seen in the plumbago-mining industry. Though there is no medical inspection on admission to the industry, there is a type of selection usually adopted by the mines. Inquiries are made of new entrants regarding the father's abilities, especially in mining, and also regarding any physical disabilities such as deafness, indistinct vision, deformities, etc., and only those who can satisfactorily carry out the duties of a miner are employed. This explains to a large extent the physical fitness of the miners.

Classes of Workers

There are four great classes of workers: (1) underground workers; (2) surface workers; (3) underground and surface workers; (4) workers in curing sheds.

Underground Workers.—These consist of various skilled workers. There are drillers, who drill holes in the rock near the plumbago veins. It is mostly hand drilling, but water is used to prevent dust formation. It is a skilled job, since by intelligently directing the drill holes much waste of rock can be avoided.

Blasters charge the holes with dynamite and fire them. Here too a good deal of intelligence is required to get the best results. Shaft drivers are responsible for driving shafts to various depths. Excavators separate the plumbago from pieces of blasted plumbago-bearing rock and plumbago veins. Muckers and trolley-men are engaged on the transport of plumbago pieces from the working level up to the pit head. Timbermen timber those shafts and tunnels which are not in rock, and also construct and repair ladderways.

Surface Workers.—These include blacksmiths, drill sharpeners, boilermen, carpenters, masons, carters, watchers, firewood splitters, and carriers.

Underground and Surface Workers.—These consist of mechanics, electricians, winchmen, hoistmen, pumpmen, and enginemmen responsible for the mechanical and electrical machinery required in the mine.

Workers in Curing Sheds.—These, mostly women, are employed in sorting, chipping, crushing, screening, sifting, washing, polishing, and grinding the plumbago.

Depth at Work

Only five mines are worked below 300 feet, and out of these five only two are worked at 1,700 feet. These are the most important and well-organized mines in the island. Most of the other so called mines are worked within 100 feet of the surface.

Hours of Work

Several years ago there was a twenty-four-hour shift in the mining industry; a miner worked four shifts of five hours each; each shift was followed by an interval of one hour, and the following day he was free. This system does not exist in any of the plumbago mines today. The Wages Boards Ordinance, which was extended to the plumbago industry on September 1, 1945, defined the normal working day (inclusive of one hour for meals) as nine hours. A new Mining Ordinance, passed in 1947, limited the hours of work for underground miners to eight hours a day inclusive of an hour for meals, and to forty-eight hours during any six consecutive days; the time spent in the descent and ascent is included within this period. In practice, in some of the best-managed mines as Kahatagaha and Kolongaha, underground miners do not work more than five hours a day. They go down the mines at 7 a.m. and return to the surface before noon, after completing the task of work assigned to them. Usually two shifts are carried out in the underground mining work. Young persons and women are prohibited from doing underground work.

Occupational Hazards

Occupational hazards, if any, should be found mostly in the underground work and in the curing sheds. Samples from each group were subjected to clinical and x-ray examination, and the findings are given below. Fifty underground miners were obtained from Kahatagaha mines, Kolongaha mines in Dodangaslanda, and Bogala mines in Ruanwella. Those three mines were chosen as the oldest-worked (over seventy years) and deepest mines, and as being the only ones where there were miners who had worked regularly for more than fifteen years. Sixty-two plumbago curers were selected from five plumbago curing sheds in the outskirts of Colombo where work had been carried out for over thirty years. This group consisted of fifty-five females and seven males.

The occupational hazards in the industry were investigated under seven headings.

Accidents.—Accidents reported to the Inspector of Mines from all mines are shown in Table 2.

TABLE 2
ACCIDENTS IN CEYLON PLUMBAGO MINES

Year	Accidents	Deaths
1940	10	2
1941	19	16
1942	15	6
1943	8	3
1944	6	4
1945	—	—
1946	3	1

Absence of Sunlight.—The hæmoglobin percentages of the fifty miners examined did not show any anæmia. No diseases due to lack of sunlight were noticed amongst the miners. Nystagmus was looked for in 105 miners, but not a single case was detected. The three mines examined are well lit with electricity. When miners work in places not so lit, they usually carry with them a coconut oil lamp which gives them light.

Atmospheric Moisture and Temperature.—Both these depend to a great extent on the ventilation system of the plumbago mines. Readings were taken for a week at Kahatagaha mines by means of an automatic thermograph fixed at 400 feet below the pit-head. The temperature recorded was 78° F., with a variation of about a degree. The temperature in the electric lighted working galleries was one degree higher. Psychrometer readings were taken at the levels where automatic thermographs were fixed, and these showed relative humidities varying from 88 to 92 per cent.

Atmospheric Pollution.—Unlike the coal mines, plumbago mines are situated in solid granite rock and as such there are no fermentable carbonaceous matters to produce methane and other combustible gases within the mines. The only pollutions that can occur are from sulphuretted hydrogen, sulphur dioxide, and nitrous fumes emanating after blasting operations.

Working Posture.—Miner's beat elbow, miner's beat hand, and miner's beat knee cause a considerable amount of illness among coal-miners. These are due to the awkward and trying positions in which the coal-miners are obliged to work and which lead to undue pressure on certain portions of the body. Not a single case of these conditions was found among the fifty miners subjected to clinical investigation. Awkward working positions are lessened to a great extent, as the various galleries

and tunnels are nearly 6 feet in height, allowing miners to work and move about in normal posture. The skin, when covered with plumbago, has a protective slippery surface, which prevents the effects of undue pressure in one single place. Similarly eczematous dermatitis (miner's itch), commonly found in coal-miners due to the dust, to damp heat, and to friction, is not found among the plumbago miners. This is also probably due to the protective covering of plumbago on their skin which they get when at work, and to regular cleaning with soap and water.

Dangers of Infection and Infestation.—Well known infections, such as ankylostomiasis and spirochaetosis, which are common in mines of other countries, are not common in Ceylon. The plumbago miner works barefoot, and though there is a fair amount of ankylostomiasis in the general population of Ceylon, the hæmoglobin percentages of those inspected did not show any anæmic condition. Sanitary facilities are provided to prevent ankylostomiasis infection; and plumbago mines, except for the water that is sprayed to prevent dust, are dry. Similarly no case of jaundice suggestive of any spirochaetal infection is known to have occurred in the mines investigated.

Pneumoconiosis.—In plumbago mining a dust risk can occur in any of the following work processes: drilling of plumbago-bearing rocks, blasting, picking of plumbago, transport of plumbago from the bottom of the mines to the pit head, and curing of plumbago. To prevent dust formation, work places and plumbago collections during their transport within the mines are moistened with water. In this condition plumbago is not dust-forming. Plumbago dust is more adherent and heavier than coal dust and it is non-irritant. The consensus of opinion is that graphitosis due to continued inhalation of plumbago dust belongs to the harmless class of pneumoconiosis. To estimate the effects of continuous work in plumbago mines on the lungs, fifty persons who had worked continuously for over ten years in underground work were x-rayed. None of them had complained of any chest disease and at the time of examination no clinical signs or symptoms were detected.

The age groups of the underground miners examined and the length of time they had worked as underground miners, are shown in Tables 3 and 4.

Of the radiographs of fifty underground plumbago miners, thirty-five showed no abnormalities, while fifteen showed abnormal shadows. These consisted of three cases of nodulation (see figs. 5 and 6), four of diffuse fibrosis of lung, one of fibrosis of bases,

TABLE 3
AGE GROUPS OF UNDERGROUND MINERS EXAMINED

Age-group	No. of miners
25-30 years	6
31-35 "	8
36-40 "	17
41-45 "	14
46-50 "	5
Total ..	50

two of patchy opacity of uncertain ætiology, and five of calcified mediastinal glands.

The four persons who showed diffuse fibrosis of lungs had worked over twenty years as underground miners and were aged 45, 45, 50, and 38 respectively.

TABLE 4
YEARS OF WORKING UNDERGROUND OF MINERS EXAMINED

No. of years	No. of persons
10-15	10
15-20	19
20-25	16
25-30	5
Total ..	50

Plumbago Curers.—Sixty-two persons employed at the plumbago curing sheds near Colombo were clinically and radiologically examined (Table 5) and the findings are given in Table 6.

TABLE 5
AGE GROUPS OF THE PLUMBAGO CURERS EXAMINED

Age-group	Males	Females
10-30 years	3	16
31-35 "	—	6
36-40 "	—	9
41-45 "	2	5
46-50 "	1	7
50 years and over	1	12
Total ..	7	55

Physical signs of the lungs were normal in thirty-three persons. Radiologically, fifty-one showed abnormalities varying from fine striation to gross disease. Mantoux tests were carried out in this group, and 83 per cent. of positive results were obtained. The Mantoux incidence for the normal population of this area, according to the figures obtained from the medical officer in charge of the Tuberculosis Survey, is 55 per cent. Hence this group has a Mantoux incidence 28 per cent. higher than that of the normal population of the area.

TABLE 6
DURATION OF WORK AND ABNORMALITIES

Duration of work	Fine striation	Gross striation	Nodulation and mettling	Disease
Under 5 years	9 (2)	1 (1)	1 (x)	—
5-10 „	8 (2)	—	3 (p)	—
10-15 „	5	—	1	—
15-20 „	5 (2)	—	1	1
20-25 „	2	1	1	—
Over 25 „	2	3	1	—
Total ..	34	6	10	1

(x) = No. with eosinophilia over 20 per cent.

(p) = pleural effusion.

In my opinion, the dust hazard amongst plumbago curers in the sheds near Colombo is greater than in those working in the mines, as the finer curing processes cannot be moistened with water to prevent dust. Almost all the work is done by manual labour without the use of any protective measures.

Summary

1. The plumbago mining industry in Ceylon is only about 125 years old. Employment in the industry is intermittent; except in a few mines there is no regular employment.

2. In contradistinction to coal, marketable plumbago is found in deposits between solid granite rock. It is therefore necessary to blast shafts and tunnels through the rock.

3. Because of a method of selection carried out by the mine owners on admission of miners to the industry, the best of Ceylon's manhood is found in the mining industry.

4. With the exception of six well-managed mines, all are worked within 100 feet of the surface. The three best-managed mines are worked from 500 to 1,500 feet below the pit-head.

5. In three mines modern machinery and electricity are used to minimize the burden of the miners.

The safety measures and ventilation systems provided are up to modern requirements.

6. Conditions such as miner's elbow, miner's hand, miner's knee, miner's itch, and nystagmus are not common amongst plumbago miners.

7. To prevent a dust hazard, what is called the "wet system" is used in various work processes. Lung disease is very rare among underground miners. Fifty persons who had worked for over ten years as underground miners were examined radiologically and, though they had no clinical symptoms of chest disease, radiographs in four persons showed diffuse fibrosis of the lungs.

8. The general health of persons employed in the plumbago mining industry is satisfactory. Skin diseases are practically non-existent. The hæmoglobin percentage, urine, and blood pressure in fifty persons examined were normal.

9. Sixty-two persons employed in the plumbago curing sheds near Colombo where there is a greater dust hazard were examined clinically and radiologically. Clinically only thirty-three persons (53 per cent.) showed normal lungs. Radiologically fifty-one persons (82 per cent.) showed abnormalities varying from fine striation to gross disease. Lung abnormalities seem to increase with increasing of length of service in plumbago curing. Mantoux tests carried out showed an incidence of 83 per cent. of positive results.

10. The general health of the workers in the plumbago curing sheds is far from satisfactory. They incur a very considerable dust hazard in comparison to the underground miners in the plumbago mining industry. No protective measures are used by the plumbago curers to safeguard them from the dust hazard.

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