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DATE: May 21, 1956

FROM : Roy E. Albert, M.D., Chief, Medical Branch
Division of Biology and Medicine

SUBJECT: MEDICAL SERVICES IN THE SOUTH AFRICAN GOLD FIELDS AND THE SHINKOLOBWE URANIUM MINE

SYMBOL: BMM:REA

This memorandum, together with a letter to Dr. S. Oosthuizen, dated April 24, 1956, and two memorandums from Mr. William B. Harris to Mr. Merril Eisenbud, entitled "Visit to Witwatersrand Gold Mine Area in Connection with Radon Determination," dated April 4, 1956, and "Visit to Union Miniere," dated April 10, 1956, constitute the complete report on the visit to South Africa and the Belgian Congo by myself and Messrs. Harris and Holaday during the period February 21 to March 16.

MEDICAL SERVICES ON THE WITWATERSRAND

Organization of Health Services in the South African Gold Fields

The following organizations are concerned with the miners' health activities:

1. Silicosis Miners Phthisis Bureau
2. Silicosis Board
3. Transvaal and Orange Free State Chamber of Mines
4. Medical Benefit Societies
5. Pneumoconiosis Unit of the Silicosis Bureau at the South African Institute for Medical Research

The Silicosis Bureau was established under the provisions of the Miners Phthisis Act of 1916, as amended subsequently in 1946 and 1956, to carry out periodic examinations on miners for the purpose of compensation certification. Part of this function includes autopsies on miners as a terminal evaluation procedure. The Silicosis Board handles the financial administrative procedures for disability compensation. Dr. W. H. DuPlessis finished his term as Chairman of the Silicosis Bureau on February 29, 1956, and Dr. P. J. Erasmus is Acting Chairman. The Bureau has records of periodic health examinations on all European miners for a period of 30-plus years. The

Silicosis Board has data on death notices of all miners receiving compensation for many years and these have been obtained for the period 1947-1955.

The Transvaal and Orange Free State Chamber of Mines is a federation of mine owners organized for the purpose of achieving uniform standards in wages, compensation, labor procurement and hospital regulations. It also operates the Dust Ventilation Laboratory, which works primarily in the field of silicosis research. This Laboratory is interested in the radon problem as part of its general interest in the field of mine toxicology. They are currently studying urinary uranium excretion in refinery operators, amongst other things.

The Chamber of Mines is headed by a Gold Producers Committee made up of representative mine operators. The Chamber has a technical adviser, Mr. M. Falcon, who has general supervision of the Dust Ventilation Laboratory and who therefore has considerable interest in the radon problem. The Chamber has extensive data on occupational histories on all European miners who worked in those mines which are associated with the Chamber. This includes all the gold and uranium mines. It does not have health data on miners except for accident reports and pre-employment and periodic physical examinations on uranium refinery operators.

The Medical Benefit Societies are operated by the individual mines as a group health insurance project.

The Pneumoconiosis Unit of the Silicosis Bureau, located in the South African Institute for Medical Research, was reorganized in 1953 for the purpose of carrying out biological research in the field of dust toxicology. This group also does all the autopsies on miners. Prior to 1953, the Unit's pathologists did autopsies but frequently without histological sections for confirmation of diagnosis. This group is headed by Dr. Ian Webster.

The mining population at the present time consists of about 28,000 European miners and approximately eight times this number of natives, or about 215,000. At any one time, about one half of the European miners are underground; however, the individual miners are usually rotated in their jobs and the average length of service is about eight years. The natives are employed under contract for 6-9 months in unskilled positions. They usually alternate one or two contracts with a period of about 14 months at home. This cycle is usually repeated about eight times. The intermittent service and general unreliability of the medical follow-up makes the native population unsuitable for the radon study. It is estimated that the European miner spends about one half of his time at the actual working face

of the stope, supervising the natives; the balance is spent in the corridor to and from working faces.

MEDICAL ASPECTS OF THE CONGO URANIUM MINING OPERATIONS

History of the Shinkolobwe Mine

This mine was first discovered in 1915. The initial drilling and shaft sinking for exploratory purposes took place in 1921. The first production also started in 1921 and was practically limited to surface operations. The first workings took place between 1921 and 1924 in open pits for radium. The mine was then closed and the second workings were done during 1928-1932, also for radium. The mine went underground from 1930 to 1932, at least in part, and the third working period took place from 1933-1937 for gold and palladium. At this time there were about 50 to 100 people underground. The fourth working began in July 1944, for uranium, and the actual mining commenced in March 1945. Between 1942 and 1944, the previously accumulated stock pile of uranium was used by the Manhattan Engineering District. At that time the ore was very high grade and hand picked. The radon concentrations during this period were also very high and averaged 10,000 uuc/l. The ore, of metamorphic sedementary type, had a low silica content. All of the high grade ore is now gone. There were no gamma measurements in the early period of operations but it is estimated that the levels may have been as high as 50 mr per hour.

The film badge program began in 1947 and the badge readings ranged from 0.5 r to 3.5 r per week, the highest being in a surface drum operation. The radon measurements were first made in late 1947 and the flasks were shipped to the Union Miniere laboratory in Brussels. The first radon measuring devices were set up in the Congo in mid 1949. In December 1949, the radon levels in a crushing operation were 8400 uuc/l. By February 1948 the underground return air measured 6790 uuc/l from a depth of 114 meters. The general return air from the mine was 1600 uuc/l. These early measurements are probably minimum estimates since the flasks could have leaked during shipment. In April 1948, eight samples for radon were obtained during blasting operations. The entry air (fresh) measured 150 uuc/l. At the 100-meter level the concentration was 300 uuc/l. The following table indicates the radon concentrations at a stope before and at one-half hour intervals following a blasting operation:

Time	uuc/l
1246	17,400
1300 - fired	
1340	15,000

Time	uuc/l
1425	15,500
1650	12,140
2000	12,150

In June 1948, radon measurements at an unworked dead end drift at the 150-meter level (one level below the actual working area) was 8500 uuc/l. This level was used as a water drain. In July 1948, the return air from the stope at the 100-144 meter level (probably rich ore) was 21,000 uuc/l. The return air from two other stopes from the same level was 26,000 uuc/l. From two stopes at the 70-meter level the concentration was 15,000 uuc/l. A dead end raise under construction in July 1948 had 20,000 uuc/l of radon. This was ventilated by forced circulation from the 114-meter level up 7 to 10 meters. In May 1949, the general return air was 22,600 uuc/l. In June 1949, a blocked dead end with no ventilation measured 36,000-130,000 uc. In July 1949, at the 114-meter level, two readings at a stope face were 4,050 and 3,930. In 1942, at the 250-meter level, there were 30,000 uuc/l.

At the present time, 25 per cent of the underground miners work in the stopes. Ten measurements under the worst conditions yielded less than 1,000 uuc/l and eight were between 1,000 and 2,000 uuc/l. Measurements at development sites varied from 1,000-3,000 uuc/l. Prospecting at the 250-meter level had concentrations of less than 1,000 uuc/l. It is estimated that 50 per cent of the miners are now exposed to concentrations of less than 1,000 uuc/l. Radon samples on the miners themselves started in 1951-1952. The measurements were always less than 0.2 uuc/l. (1 uuc/l is equivalent to 0.015 ug radium whole body burden.

In 1947, the maximum silica particle level was 100-300 particles per cc. At the present time, the rock at Shinkolobwe has 16 per cent silica, but in the ore body itself there is about 5 to 6 per cent silica.

MEDICAL DATA AT SHINKOLOBWE

On March 11, a conference was held at the native hospital in Jadotville, which included Dr. A. Demerre, Chief of the Medical Department, Union Miniere du Haut Katanga, and members of the medical staff of the mine. The following employment data was given to me at that time:

Year	Miners
1944	69
1945	142
1946	276

Year	Miners
1947	307
1948	409
1949	436
1950	729
1951	950
1952	1087
1953	1182
1954	1141
1955	1155

The above table refers to total underground employment, which consists mostly of natives; at the present time there are only about 50 white miners.

The average concentrations in the mine at the present time range 250 to 300 uuc/l, with maxima of 3,000-4,000 uuc/l at dead ends. The medical group organized the available health data on miners who have worked for six or more years at Shinkolobwe, and this is presented in the following table:

RESULTS OF EXAMINATION OF SIXTY-FOUR WORKERS WHO HAD MORE THAN SIX YEARS WORK AT SHINKOLOBWE

A. Extent of Exposure

Total Dose	Number of Workers	Weekly Dose	Number
10-20 r	15	0.02-0.04	3
20-30 r	21	0.04-0.06	25
30-40 r	20	0.06-0.08	12
40-50 r	8	0.08-0.10	16
		0.10-0.12	5
		0.12-0.14	3
	64		64

B. Results of Clinical Examinations and Previous Pathology

All appeared in good health. No enlargement of spleen or liver. During the years of examination, the following diagnoses were made:

1 - schistosomiasis
2 - amoebic dysentary

3 - enteritis
10 - pneumonitis or broncho-pneumonia
1 - psychosis
1 - aortitis
1 - hemorrhage

C. Laboratory Examination

1. No urinary abnormalities.

2. Blood

a. The two following tables give the average results of the white blood count (the polys, lymphocytes) and the hemoglobin. The averages are calculated first for the total group then in accordance with the total radiation or weekly radiation dose.

	Number in Group	White Cells	Hemoglobin	Polys	Lympho
In 4 groups		With Respect to Total Dose			
10-20 r	15	5610	15g 82	46.3%	44.3%
20-30 r	21	5249	15g 65	43.4%	47.4%
30-40 r	20	4938	15g 63	41.6%	48.4%
40-50 r	8	5483	15g 18	41.4%	49.9%
In 2 groups					
10-30 r	36	5399	15.7g	44.7%	46.1%
30-50 r	28	5093	15.5	41.5	48.8
		With Respect to Weekly Dose			
In 3 groups					
0.02-0.06	28	5331	15.9gr	45.6%	45.1%
0.06-0.10	28	5157	15.6	42.8	48.0
0.1 -0.14	8	5415	14.7	39.3	52.3
In 2 groups					
0.02-0.08	40	5331	15.7g	44.1%	46.4%
0.08-0.14	24	5156	15.4	42.0	48.7
		Total			
	64	5265	15.6	41.3	47.3

C. Laboratory Examination (Continued)

The following table gives the average radiation dose with respect to white cell count.

Number of White Cells	Number in Group	Average Total Dose (r)	Average Weekly Dose
In 3 groups			
3-5000	31	28.1 r	0.066
5-7000	27	30.9 r	0.076
7-9000	6	24.7 r	0.062
In 2 groups			
3-6000	45	30.1	0.072
6-9000	19	26.3	0.066

D. Family Situation

The 64 miners (99 wives) had, before work at Shinkolobwe, 135 children (31 dead); during work at Shinkolobwe, 157 children (17 dead).

E. Chest X-rays and fluoroscopies show nothing significant.

F. Causes of Death

Numbers of deaths by disease at Shinkolobwe compared with other miners since 1950:

	± 16,000 workers other mines	± 1100 ex-workers at Shinkolobwe	± 14 workers (current) at Shinkolobwe
1. Lung Cancer	0	0	1 (badge dose 29.15 5 yr. exposure
tbc	13	6	3
silicotbc	4	0	1
silicosis	2	0	0
pneumoconiosis	9	0	1
2. Blood			
anemia	2	0	0
leukemia	1	0	1 (30-month 9.62 r)

	± 16,000 workers other mines	± 1100 ex-workers at Shinkolobwe	± 14 workers (current at Shinkolobwe
3. Genital Organs			
seminoma	1	0	0
4. Misc. Cancers			
liver	21	0	6
intestine	4	0	0
pancreas	9	2	0
others	5	1	0

As evidenced by the data in the above table, there does not appear to be any indication of an unusual incidence of any one disease, except liver cancer, and this accounts for at least 50 per cent of all cancers in the African native. The medical group indicated their very considerable interest in the problem and their plans for follow-up of as many long-term miners as they could find in order to evaluate the cause of death. They plan on keeping us in touch with the progress for study, which is really only getting under way now.