It will be seen that the surface group includes all Natives of inferior physique. During the year 1929–30 the average number of Natives employed underground was 153,462, and the average number employed on the surface was 38,279. The number of cases of tuberculosis from the underground group was 1,128, or 735 per 100,000, while the number of cases from the surface group was 205, or 535 per 100,000. On the whole, then, the physiological stress of underground work plays a greater part than does feeding or housing, as far as concerns the Native labour force. The fact that 22 per cent. of the tuberculosis in the surface group was tuberculo-silicosis renders the underground factor still more important.

Surface workers, constituting 20 per cent. of the total complement, only produce 15 per cent. of the total tuberculosis.

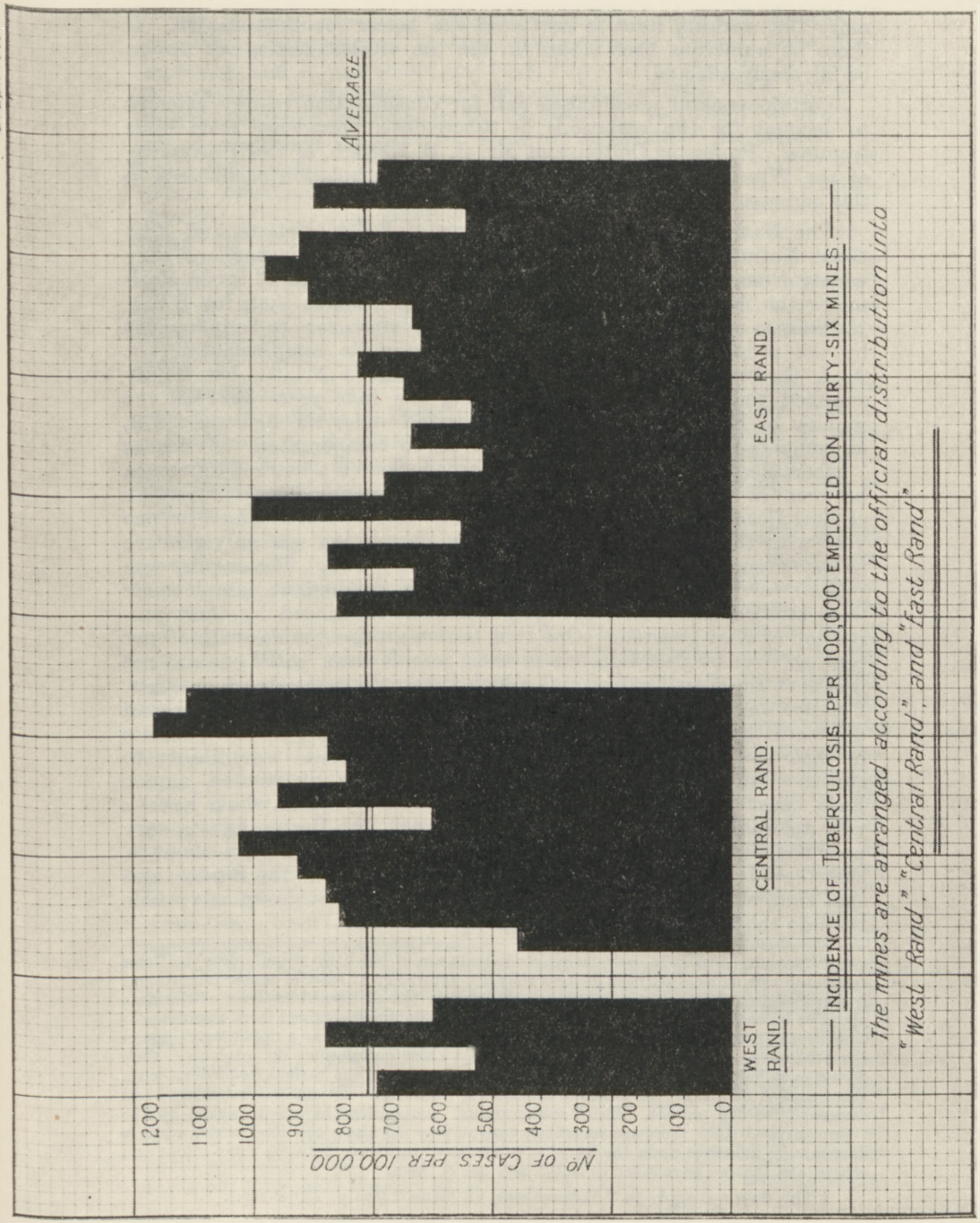
These surface workers include all Natives of inferior physique, including " old " boys, who constitute about 35 per cent. of the surface complement, although only about 10 per cent. of the total complement. Such " old " boys have a high tuberculosis mortality rate (see Graphs 1 and 2 in the main Report, pp. 118 and 119). Nevertheless, tuberculosis incidence in surface workers is less than that in underground workers.

Seeing that compound conditions (housing, feeding, etc.) are the same for the two groups, the inference seems irresistible that underground factors are more important in the incidence of tuberculosis than compound conditions.

There is one feature in an established mining industry which always calls for consideration. There come times in the history of a mine when the powers-that-be have to decide whether to sink a new shaft and revise the haulage or shut down. When they decide to carry on, that mine is likely to become increasingly uncomfortable until the new work comes into use. The transition period usually affects vital statistics adversely. Should it be decided to let the mine run down, then the " bone-picking " stage is often, though not always, associated with a falling-off in the health of the complement, particularly from the tuberculosis standpoint.

It is all very well to write of the physiological stress of underground work but—how does it come in ? A mine's Native labour force resembles a body of athletes in training to the extent that 99 per cent. improve in physical condition, while 1 per cent. breaks down. One expects a Native to start putting on weight at once, and if he does not he is watched. It is not the physical labour that is the important element in physiological stress underground, it is the conditions under which this labour is performed. Tuberculosis rates tend to run higher on the older, deeper and steeper mines. These are to be found chiefly in the Central Rand area (see Graph VII). The deeper mines are the hotter mines. There are exceptions but, in the main, the hotter mines are the less healthy, though even this applies to health in general rather than to tuberculosis in particular. The lay-out renders impracticable really satisfactory districting and splitting of the air supply. The

Graph VII


AVERAGE
No OF CASES PER 100,000
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
WEST RAND.
CENTRAL RAND.
EAST RAND.
INCIDENCE OF TUBERCULOSIS PER 100,000 EMPLOYED ON THIRTY-SIX MINES
The mines are arranged according to the official distribution into "West Rand", "Central Rand", and "East Rand".

more the working force is scattered the better for their health. If there be numerous back-stopes in use the vital statistics are apt to be adversely affected.

Certain general possibilities call for consideration in any attempt to account for the variations in tuberculosis prevalence from mine to mine. Professor Dalton and Mr. J. B. Kerrich, of the University, of the Witwatersrand, worked out a series of correlation coefficients in this connexion from data supplied to them.*

The Native labour force is made up of B.S.A. Natives and East Coast Natives in the ratio of about 10 : 8, but the proportions vary widely from mine to mine. The tuberculosis rate for "tuberculosis under the Act," runs higher for East Coast Natives than for B.S.A. Natives, so one might expect a mine's tuberculosis rate to be influenced by the proportion of East Coast Natives in its complement.† Dr. A. I. Girdwood, Chief Medical Officer of the W.N.L.A., has kindly supplied the following figures. During the four years 1927–30 the number of East Coast Natives compensated under the Act was 2,678, as compared with 1,659 B.S.A. Natives, so compensated. As far as "tuberculosis under the Act" is concerned, there is a marked difference between the two groups. The correlation between the mine's proportion of East Coast Natives and its tuberculosis rate was determined for one year with the surprising result that the correlation was only positive to the extent of 0·16 with a probable error of $\pm$0·12. The enquiry was pushed further. The group of mines with the highest complements were studied separately but they were not influenced by their proportion of East Coasters. One then took a group of mines with 50 per cent. or over of East Coasters in their complement. Still one did not find that the East Coaster and a high tuberculosis rate went together. Finally, one took the mines with the highest tuberculosis rates and did learn that they had above the average proportion of East Coasters in their complements. One can only conclude that susceptibility to effective infection by tuberculosis is unequally distributed among East Coast Natives. While the B.S.A. Natives as a whole have a very tolerable resistance to effective infection, the Basuto have a very poor resistance, and one must assume, until one knows more about it, that there is a group of East Coasters corresponding to the Basuto, and that they bear a higher proportion to the East Coast group as a whole than do the Basuto to the B.S.A. group as a whole.

* Speaking generally, correlation coefficients are of but little value unless the items correlated can be isolated from factors that are neutral or at least of minor importance. A consideration of the low coefficients obtained in the statistical analysis of the data about to be considered does but confirm our previous opinion—gained from experience—as to the impossibility of isolating any of the items enumerated as a dominant factor in the production of tuberculosis. This is all that these correlations do teach us; they do not even help us in arriving at the relative importance of the various items dealt with. The question of making an attempt at securing partial correlations was considered and dismissed for the present. The "scattergrams" emphasize the lesson taught by the "step-graphs," that there are several factors at play all along the Reef which exert a determining influence upon the varying tuberculosis incidence between some mines and others, and that we have failed to isolate any one of them.

† This does not apply to "Tuberculosis, all forms" (see p. 139 *et seq.*).

In the early days of the industry, when Drs. Irvine and Macaulay[46] made their investigation, a large proportion of "raw" boys were employed, and it was these raw boys who dominated vital statistics. The majority, though not all, of the raw boys working their first contract on the mines will come under the heading "recruited" as opposed to "non-recruited." Recruited boys run to about 56 per cent. of the total complement. The correlation between percentage of recruited boys in complement and tuberculosis prevalence is $-0{\cdot}23$ with a possible error of $\pm 0{\cdot}11$. This result is probably influenced by the fact that many non-recruited boys use the recruiting corporations as a convenience and appear under the caption "recruited." Still, the distinction between a non-recruited and a recruited boy is no longer significant from the tuberculosis point of view. The important section of "old boys," who now influence tuberculosis statistics so largely, and who are nearly all "non-recruited," did not exist in the early days.

Although old boys of continuous service have a high tuberculosis rate, the proportion of them in a complement, perhaps 4 per cent., is not sufficient to influence returns. Actually the correlation between percentage of old boys of more than five years' continuous service in complement and tuberculosis rate is $+0{\cdot}02$ with a possible error of $\pm 0{\cdot}12$.

The feeding question is always important. Mines differ widely in the amount spent per head on feeding their Native labour force. The managements have been good enough to supply the data and the correlation between cost of food per man per day and tuberculosis rate is $-0{\cdot}12$ with a possible error of $\pm 0{\cdot}12$. There cannot be much wrong with the feeding, since the vast majority of Natives put on weight and improve in physique during a contract; still, if there be a way of fending off tuberculosis by feeding, we have not found it. One does not like leaving the question there. To begin with, the Native has very definite views on the time and place for meals. He likes his main meal after work, yet there is some evidence pointing to the conclusion that the fuller the stomach the Native takes to work the better his health. The Native is not enthusiastic about eating underground, and a ration for consumption there must be tempting and readily accessible. To get such a ration where it is wanted and to provide tolerable facilities for consuming it is far from an easy matter. In some cases the difficulties have been overcome and encouraging results secured. A further complication is introduced owing to the fact that certain tribes will not willingly touch certain foods, *e.g.*, fresh vegetables of all inconvenient taboos. Experience with scurvy illustrates this feature. Despite intensive work, scurvy still is met with in the Native labour force and falls into two classes. One class is the scurvy of the new arrival, who reaches his mine in the pre-scurvy stage and develops the overt disease under stress of mining work. The other class is the old long-service boy. When such boys belong to tribes who reject fresh vegetables, after doing so for a long period they may develop scurvy. The baby new to earth and sky brings a store of vitamin into the world which will last for some time, and the boy arriving for work on the Reef usually brings

a sufficient store to see him through an ordinary contract, even though he rejects the vegetables provided. The old de-tribalized boy who is a permanent employee and never returns to his kraal and never restores his vitamin-content may work through his reserves and develop scurvy if he has rejected the vegetable portion of his diet for sufficiently long. We have to learn what is the source of anti-scurvy vitamin for tribes that taboo the ordinary vegetables.

The Native labour force being drawn from many different tribes with many different diet traditions, there are bound to be many and varied difficulties when it comes to housekeeping for a family of 200,000 changing at a rate of over 90 per cent. per annum.

Professor E. V. McCollum mentions similar troubles when the North American Indian takes to " living on the grocer " and South Sea Islanders have suffered greatly as the result of changing from their natural roots to cereals. There seems to be scope for further enquiry into the vitamin-content of the roots consumed by the dark races all the world over, as long as the European leaves them alone.

In this context mention may be made of an expedient on trial by certain mine managements. In the days when tropical Natives were recruited, they were not allowed to take part in underground work until three weeks after their arrival on the mine to which they had been allotted. The results as far as improvement in health was concerned were quite disappointing. The present idea is to put newly-arrived Natives on to training-gangs for three weeks after their arrival. These gangs are purely instructional and for acclimatization ; there is no concern over output of work. All Natives in a training-gang are weighed once a week and experience shows that they usually start putting on weight at once. Any Native losing weight is put on an extra ration of fat meat three times a week. The results are encouraging ; most Natives respond to this extra ration by recovering the weight lost, and Natives who start routine work on the rising weight-curve do not break down. It appears that 99 per cent. of the Native labour force are suited by the routine, but that a fraction of 1 per cent. will respond to individual attention. As to whether individual attention can be satisfactorily arranged in the case of mines having 20,000 to 30,000 Natives to deal with per annum is another question.* One remembers that in the Russo-Japanese War, and before the days of vitamins as a recognized consideration in diets, Dr. Takaki, head of the Japanese Medical Service, gained a great reduction in sickness in general and in beri-beri in particular by adding a meat ration to the diet. One has a suspicion that provided care be taken regarding the " animal-food " the vitamins will take care of themselves. Of course, the meat ration, as far as possible, should consist of fat meat to give vitamin A its chance.

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* The procedure outlined above is at the stage of small-scale experiments and is not representative of general practice. The data so far secured are insufficient for far-flung conclusions to be drawn.

One does not associate the carnivora with deficiency diseases and Polar expeditions suffering from scurvy did not find this condition to be an abiding trouble for the Eskimo.

Since employment underground seems to be such an important factor and mines differ a good deal in the amount of time their Native labour force spends underground, one might expect some correlation between hours spent underground and tuberculosis prevalence. Actually the correlation secured was mildly negative. The Government Mining Engineer has explained to the writer that this is inconclusive because while the data supplied by him related to mean time spent underground on each mine, the time spent by those engaged on different classes of work on each mine varies considerably, and that differences within the mine may be greater than from mine to mine. The fact remains that one cannot help feeling that if time spent underground were of great significance, something other than a mildly negative correlation would have been secured. Managements give special attention to getting the Natives to and from their work with as little walking as possible.

One would like to correlate general health with tuberculosis by getting the factor for total shifts lost owing to sickness and tuberculosis. Unfortunately, all mines do not have the same system of keeping their sickness records. Two separate enquiries yielded positive correlations of 0·22 and 0·4.

Of course, it is suggested that a low sickness rate means that a mine repatriates sickly Natives in preference to trying to patch them up on the mine. If there were anything in this suggestion there would be a correlation between rate of change of complement and total shifts lost owing to sickness. A low sickness rate would mean a high rate of change of complement, and *vice versa*. There is no significant correlation either for total sickness or tuberculosis.

One important factor has been active during the last four years and accounts for a good deal. This refers to the special examinations of old boys (see p. 112). A mine whose return for a particular year includes one of these special examinations is bound to have the returns for that year adversely affected.

To summarize, 29 mine histories can be followed from 1916 to 1930. There have always been wide variations in tuberculosis prevalence from mine to mine. 14 mines have kept their rate pretty steady, whether low, medium or high. Of late years 9 mines have been showing a falling rate, and 6 mines a rising rate. Improvement appears to be associated with the overcoming of mining difficulties, increased scattering of working parties, reduction in number of back-stopes, improvements in feeding and housing, and special efforts at better ventilation. These suggested factors would be simpler of acceptance were it not that the same processes are at work in both the " dis-improving " and the stationary mines. A very wise and experienced consulting engineer, while rather astonished at the wide variation in prevalence rates, only got six actual surprises—three mines were, to him, unaccountably bad, and three mines were, to him, unaccountably good.

2. Tuberculosis in Boys of Long Service and Influence of Length of Service on Tuberculosis Prevalence.

These figures are particularly difficult to deal with, as they come from various sources and the sets of figures are more or less incomplete. The matter cannot be left out, because it has important bearings. Boys of long service are our nearest approach to a fixed population and thus afford the most direct comparison with conditions elsewhere. The group also yields some information as to the Native's ability to control his tuberculosis and direct it to a chronic course. In conclusion, one may learn something as to the comparative influence on tuberculosis incidence of acclimatization to our mining conditions and duration of exposure to our mining conditions.

The most complete set of data available are for " tuberculosis under the Act " (see p. 116 of main Report). For the past eight years the W.N.L.A and the Miners' Phthisis Medical Bureau have ascertained, as far as possible, the length of service of each boy compensated and the figures secured are on record.

The returns for the last four years and the average of these four years are given in Table I (p. 354). The annual total is from 25 to 30 per cent. below that for " tuberculosis, all forms," as given by the mine medical officers. In this latter return length of service data are not included and the extra cases are mostly those of " tuberculous septicaemia " and " surgical tuberculosis." One knows from other sources that most of these cases arise in the course of the first year of employment. Referring back to " tuberculosis under the Act " and Table I, it will be seen that more than half the cases detected arose during the first year of employment and that the actual figures for the third, fourth and fifth years are quite low. As to whether these figures are absolutely low or only relatively low depends upon the number of the labour force having a similar length of service. This matter will be discussed presently.

The next set of figures to be considered has the following history. It is well known that comparatively little " simple silicosis " is detected in the ordinary Native mine labourer, a fact that is more likely to be related to the duration and discontinuous nature of his underground service than to any special immunity. Several years ago the Miners' Phthisis Medical Bureau decided to hold a special examination of mine boys *known to be* of over five years' continuous service. While there are large numbers of Natives on re-engagements who will be of over five years' total service, those of whom one can be sure are those who have been not less than five years continuously on one mine. With the co-operation of the managements, the Bureau secured a random sample of just over a thousand of such boys. The investigation showed a silicosis rate of about the same order as that met with in European miners, but nearly 5 per cent. of the boys examined were found to be suffering from tuberculosis, mostly tuberculo-silicosis and chronic. On the strength of this enquiry, one of the first acts of the Tuberculosis Research Committee was to arrange for a systematic examination of these long-service boys to be held every year. In the first examination, 1926–27,

the number of boys examined was 2,508 and " tuberculosis, all forms," and silicosis was detected to the extent of 3·8 per cent. in those examined. The next year's examination was on a larger scale ; 12,383 boys were examined and the tuberculosis return was 3·2 per cent. It will be noticed that these two examinations found tuberculosis in long-service boys to the extent of over 30 per 1,000 of those examined. One result has been a big reduction in the number of cases of this type appearing as " tuberculosis under the Act "—a pool has been drained (see Table II, col. (3), p. 354). The cases appearing in the annual returns summarized in Table III are either boys in whom tuberculosis has been detected or boys presenting claims for compensation. The high rate in the special examinations presents cases which would have turned up sooner or later in the ordinary course but have been concentrated into a brief period ; tuberculosis has been sought and not left to obtrude itself.

Two other sources of information remain to be considered :—The investigation into tuberculosis prevalence, 1916 to 1920, conducted by the Mine Medical Officers' Association (Table IV), and Dr. Loeser's study on the Crown Mines.

The mine medical officers' figures are in terms of duration of employment on the mine where the boys were working when the investigation was made, and no attempt was made at securing total employment figures. The total number of cases considered for the five years was 5,703, and 69 per cent. of these arose in boys with under one year's working history on their particular mine. This would, therefore, include both raw recruits with under one year's total service and re-engaged boys who had worked before.

Taking total engagement figures (see Table I), 53 per cent. of the cases arise in boys with not more than one year's total mining history.

The higher figure found when re-engaged boys are included suggests that boys can de-acclimatize as well as acclimatize, so that the re-engaged boy coming back after a period away from the mines runs more or less the same risk as the raw recruit during his first year. This is not actually the case, because the number of boys who have been not more than one year on their present engagement is more than doublé that of the number of boys with not more than one year's total mining history, so the high *number* of cases in boys in the first year of present engagement does not mean a correspondingly high *rate* of incidence as compared with boys of less than one year's total mining history. (See further consideration on p. 352.)

This question interested Dr. H. A. Loeser when medical officer on the Crown Mines, and he has been good enough to put his records at the disposal of the Committee.

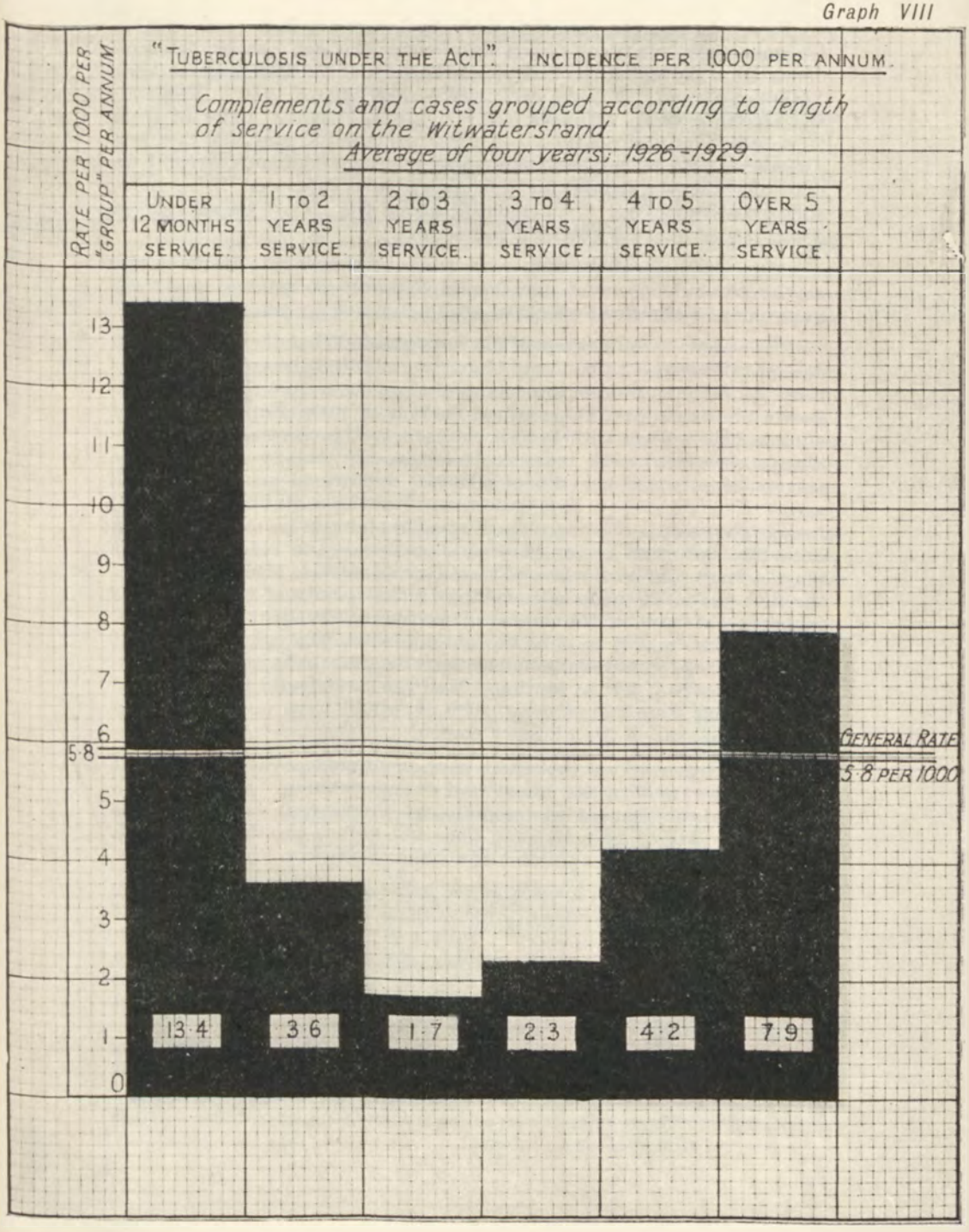
Dr. Loeser followed up over 1,000 cases of tuberculosis for the three years 1912–14 inclusive. In each case a record was made of the length of time the Native had been on his contract when tuberculosis was detected. The result was as follows, in round numbers :—25 per cent. within three months ; 55 per cent. within six months, and 78 per cent. within twelve months.

On summarizing some of the points brought out, it appears from the " tuberculosis under the Act " series that 53 per cent. of all the cases had had not more than one year's total employment ; from the mine medical officers' series that 69 per cent. of all the cases had not been more than one year on present engagement ; and from Dr. Loeser's series that 78 per cent. of all the cases had been not more than one year on present engagement. On turning to the other end, it is learnt from the " tuberculosis under the Act " series that over 13 per cent. of all the cases detected arose in boys of more than five years' service, while the special examinations showed rates of over 30 per 1,000 of those examined for boys of over five years' service, as compared with a general rate of about 7 per 1,000. The suggestion is that entering the mines, whether on first engagement or re-engagement, is to enter a danger zone for tuberculosis, and that staying on the mines for more than five years is to find oneself once more in a danger zone for tuberculosis. It is possible to get a little further by " marrying " the figures just discussed to the figures for estimated distribution of the labour force in terms of length of service as given in Graph 2 in the main Report (p. 119). The offspring of this "marriage" is given in Table V in so far as concerns the " tuberculosis under the Act " series, and again in Graph VIII. It will be seen that with a general rate of 5·8 per 1,000, the under twelve months group shows over 13 per 1,000, while the over five years group shows practically 8 per 1,000. The intermediate years are comparatively low. The average for the four years after the first year, taken together, is 353 cases of tuberculosis per annum in a complement of 123,113, or a rate of about 2·9 per 1,000 per annum. Since the rate of change of complement is about 100 per cent. per annum, one will not go far wrong in assuming that half the complement at any one time are in the first year of their present engagement. If this assumption be applied to the mine medical officers' series, we learn that over the five years 1916 to 1920 there were 3,930 cases, say 786 cases per annum, in boys in first year on present engagement. For that period the average complement was about 148,000, so that we arrive at 786 cases arising in a population of 74,000, or a rate of 10·6 per 1,000 per annum. For the same period there were, on the average, 355 cases per annum in boys who had been more than one year on present engagement, or a rate of 4·8 per 1,000 per annum. Turning back to the " tuberculosis under the Act " series, we find a rate of 3·5 per 1,000 in all boys of more than one year's total service.

One must admit that the data dealt with in this section are hardly such as " would yield a refined statistician intelligent pleasure," still, one does feel inclined to draw certain general conclusions.

The first year on the mine, whether on first engagement or re-engagement, is the great danger zone. The liability to contract tuberculosis is far greater on first engagement, however, than on re-engagement. As has been stated, the incidence of " tuberculosis, all forms," exceeds that of " tuberculosis under the Act " by from 25 per cent. to 30 per cent., and most of this excess falls on the first year, irrespective of first engagement or re-engagement.

Graph VIII


"TUBERCULOSIS UNDER THE ACT". INCIDENCE PER 1000 PER ANNUM.
Complements and cases grouped according to length of service on the Witwatersrand.
Average of four years: 1926-1929.
RATE PER 1000 PER "GROUP" PER ANNUM.
UNDER 12 MONTHS SERVICE.
1 TO 2 YEARS SERVICE.
2 TO 3 YEARS SERVICE.
3 TO 4 YEARS SERVICE.
4 TO 5 YEARS SERVICE.
OVER 5 YEARS SERVICE.
13
12
11
10
9
8
7
6
5·8
5
4
3
2
1
0
GENERAL RATE 5·8 PER 1000
13·4
3·6
1·7
2·3
4·2
7·9

Boys who run the gauntlet of the first year are in a good position for some time. In the "tuberculosis under the Act" series, the incidence from the end of the first year to the end of the fifth is under 3 per 1,000 per annum. For the decennial period 1901 to 1910 in England, the *mortality* from "tuberculosis, all forms," among males of from 20 to 40 years was nearly 2 per 1,000 per annum, and this means a prevalence rate of not less than 5 per 1,000 per annum. Even if we take the English figures for pulmonary tuberculosis as being more comparable with our "tuberculosis under the Act," we still get a death-rate of over 1·5 per 1,000 per annum.

After the close of the fifth year, the tuberculosis rate starts to rise as the baneful effects of duration of exposure to mining conditions overcome the beneficial effects of acclimatization to mining conditions.

The special examinations of old boys showed that there was a good deal of tuberculosis to be found if sought. Acute tuberculosis obtrudes itself, so one may assume that many of these cases were chronic. As is shown elsewhere (see Pathological Section of main Report), cases of chronic tuberculosis with lesions confined to the chest are practically always associated with more or less silicosis. Among mine Natives tuberculosis, in the absence of silicosis, appears to generalize at all ages. If a mine boy does get miners' phthisis (tuberculo-silicosis) he gets the same sort as does the European and gets no more of it than does the European either here or elsewhere. The silicotic element plays a large part in the rise of the tuberculosis rate after the close of the fifth year. It must be remembered that plenty of tuberculosis is found in old boys in the course of routine, quite apart from special examinations, and it is only the chronic cases that were picked out by the special examinations sooner than they would have forced themselves on notice if left to routine. Half the cases found by the special examinations were tuberculosis, such as would have been recognized at the same time in the ordinary course.

Of all boys working their first year on present engagement, about half will be raw boys and about half re-engagements. Since the rate of change of complement approximates to 100 per cent. per annum (see Table 13, p. 117 of main Report), these two groups together amount to about half the total complement of a mine at any one time.

There is a high rate for sickness in general for all boys in the early months of their first year on present engagement and to this extent they seem to "de-acclimatize" while away from mining. This de-acclimatization hardly applies to tuberculosis. About 65 per cent. of "tuberculosis, all forms," is now detected in boys working their first year on present engagement, giving a rate of about 10 per 1,000, but this group includes all raw boys whose rate is 13 to 14 per 1,000. If the re-engagements have the rate of 3 to 4 per 1,000 now usual for boys who have been more than one year on present engagement, the rate for first year on present engagement is accounted for without predicating any extra liability to effective infection by tuberculosis of those Natives who resume mining after an interval.

In so far as the gold-mining industry is concerned, the part played by duration of employment attains a peculiar significance when considered from the following standpoint.

The rate for simple tuberculosis, all forms, on the Native labour force is about 5 per 1,000 per annum, and the rate for simple tuberculosis, all forms, on the European labour force is about 2·5 per 1,000 per annum. The rate for tuberculosis, all forms, including tuberculo-silicosis and for silicosis on the Native labour force is 7 to 8 per 1,000 per annum, while the rate for tuberculosis, all forms, including tuberculo-silicosis and for silicosis on the European labour force is 28 per 1,000 per annum. In the one case, simple tuberculosis is the major risk; in the other case the dust-hazard is the major risk. In fact, as far as the European is concerned, *simple* tuberculosis is of negligible importance.

There is an explanation of this discrepancy. Of the 150,000 Natives employed underground at any one time, not more than 14,000 have been so employed for more than five years though, even for this group, the rate for tuberculosis, all forms, including tuberculo-silicosis and for silicosis, is only about 10 per 1,000. This is because their mean duration of employment does not exceed nine to ten years. If we turn to the Europeans, we find about 10,000 employed underground at any one time, and of these, 6,000 to 7,000 have been employed for more than five years, with a mean duration of employment of about fourteen years. It needs about thirteen years before the dust affects the general run of underground workers as opposed to a comparatively small group of men who are particularly susceptible. The mean duration of employment for the Native labour force is far short of the danger zone and only those who are particularly susceptible go down before the dust. The mean duration of employment for the European labour force is well into the danger zone.

If all dangerous trades with occupation maladies were run on the lines of the old British Army, with enlistment for a period of years as opposed to for working-life, one could reduce most occupation maladies to matters of no community importance. Enlistment would be permitted only for a period definitely short of the danger zone. Of course, any attempt to turn this idea into a working hypothesis lands one in a jungle of sociological difficulties. If you interfere with a man's liberty to the extent of limiting his period of enlistment, you incur some sort of obligation to enable him to maintain a decent standard of life after his discharge. It is impracticable to meet this contingency by the payment of a sufficiently large lump sum or by the provision of an adequate pension. To put it brutally, the man, from the community standpoint, is not worth it. There are plenty of reserves to fill gaps in the firing-line. It is of interest to learn that Russia, accepting this working hypothesis, has solved the problem—on paper.

So much for this section of our enquiry and in the words of the immortal Tony Weller, "Vether it's worth while goin' through so much to learn so little, as the charity boy said ven he got to the end of the alphabet, is a matter o' taste."

TABLE I.

NUMBER OF CASES OF "TUBERCULOSIS UNDER THE ACT" DETECTED PER ANNUM ARRANGED ACCORDING TO LENGTH OF SERVICE ON THE WITWATERSRAND.

(Figures supplied by the W.N.L.A.)

Year.	Number of Cases of under 12 Months' Service.	Number of Cases of 1 to 2 Years' Service.	Number of Cases of 2 to 3 Years' Service.	Number of Cases of 3 to 4 Years' Service.	Number of Cases of 4 to 5 Years' Service.	Number of Cases of over 5 Years' Service.	Complement.	Total Cases.	Rate per 1,000 per Annum.
1926	568	179	68	65	68	251	176,035	1,199	6·8
1927	564	198	68	50	56	104	180,533	1,040	5·8
1928	536	176	64	50	47	128	190,473	1,001	5·2
1929	604	170	51	56	47	97	187,968	1,025	5·4
Totals ...	2,272	723	251	221	218	580		4,265	
Annual Average	568	181	63	55	54	145	183,752	1,066	5·8

TABLE II.

TUBERCULOSIS INCIDENCE, AUGUST, 1926, TO JULY, 1930.

Year.	"Reef Complement."	(1) Tuberculosis All Forms and Silicosis.	(2) Tuberculosis All Forms Only.	(3) Pulmonary Tuberculosis All Forms Only.	Rates per 1,000 per Annum.			Tuberculosis other than Pulmonary.	Rate per 1,000 per Annum.	Silicosis.	Rate per 1,000 per Annum.
					No. 1.	No. 2.	No. 3.				
1926–27	183,154	1,596	1,395	1,159	8·7	7·6	6·3	236	1·3	201	1·1
1927–28	193,086	1,617	1,455	1,099	8·4	7·5	5·7	356	1·8	162	0·8
1928–29	193,493	1,445	1,279	852	7·5	6·6	4·4	327	1·7	166	0·8
1929–30	194,084	1,401	1,282	904	7·2	6·6	4·6	378	1·9	119	0·6

TABLE III.

TUBERCULOSIS RATES FOR NATIVE MINE BOYS, 1922 TO 1929.

Date.	Rate per 1,000 Tuberculosis, All Forms.	Rate per 1,000 "Tuberculosis" under the Act."	Average Complement.
1922	10·25	5·2	154,814
1923	8·20	4·7	170,259
1924	9·3	5·0	171,508
1925	9·25	5·1	168,794
1926	10·1	6·8	176,035
1927	7·75	5·7	180,533
1928	7·75	5·2	190,473
1929	6·7	5·4	187,968

TABLE IV.

SUMMARY OF INVESTIGATION BY MINE MEDICAL OFFICERS' ASSOCIATION INTO TUBERCULOSIS ON THE WITWATERSRAND GOLD MINES DURING THE YEARS 1916 TO 1920, INCLUSIVE.

TUBERCULOSIS, ALL FORMS, AND SILICOSIS.

Repatriations and Deaths.

Total number of cases detected: 6,037, or 1,207 per annum.
Average complement for this period: 148,163.
Rate per 1,000 per annum: 8·1.

Data available for 5,703 cases show following distribution, in terms of duration of employment. 25 shifts to the month:—

Worked 25 Shifts	303
Worked 50 Shifts	429
Worked 75 Shifts	483
Worked 150 Shifts	1,355
Worked 300 Shifts	1,360
Over 300 Shifts	1,773
Total	5,703

3,930 cases detected in the course of their first year on present contract.

Average, 786 cases per annum.

1,773 cases in subsequent years.

Average, 355 cases per annum.

TABLE V.

NUMBER OF CASES OF "TUBERCULOSIS UNDER THE ACT" DETECTED PER ANNUM. AVERAGE FOR THE FOUR YEARS 1926–1929.

Cases recorded according to Length of Service on the Witwatersrand with Estimated corresponding Complements.

Length of Service.	Proportion of Complement with this Service.	Number of Cases of Tuberculosis.	Rate per 1,000 per annum.
Under 12 months ...	42,263 (23%)	568	13·4
1 to 2 years	49,613 (27%)	181	3·6
2 to 3 years	36,750 (20%)	63	1·7
3 to 4 years	23,888 (13%)	55	2·3
4 to 5 years	12,862 (7%)	54	4·2
Over 5 years	18,375 (10%)	145	7·9
Totals	183,751	1,066	5·8

APPENDIX NO. 6.

BACTERIOLOGICAL INVESTIGATIONS IN CONNEXION WITH TUBERCULOSIS AMONG SOUTH AFRICAN NATIVES.

BY J. H. HARVEY PIRIE.

1. TYPE OF TUBERCLE BACILLI ASSOCIATED WITH TUBERCULOSIS AMONG SOUTH AFRICAN NATIVES.

In this investigation no general discussion of types and sub-types of tubercle bacilli is attempted, the position outlined by Cobbett[87] being accepted. This writer, although recognizing that some investigators of wide experience, *e.g.*, Rabinowitsch, do not hold the types to be so sharply defined or so distinct from one another as do most persons, concludes that the three types—human, bovine and avian—do really exist, in the main clear and distinct. Anomalous strains *are the exception* and, whatever we may think of them, they cannot upset the broad distinctions which separate the great majority of tubercle bacilli into these three types.

The investigation has been conducted mainly among mine Natives. Its scope was deliberately widened in a few instances (12 cases out of the 100), so as to include cases of tuberculosis of bone, joints and glands—types not commonly encountered amongst the mine Natives but by no means unknown in other sections of the Native community.

Herewith follows a summary of the sources of the materials from which the cultures were obtained :—

Sputum.—22 cases. 19 of these were mine Natives' sputa positive for tubercle bacilli, selected at random. 1 was from a mine Native with tuberculous cervical glands. 2 were sent by Dr. Allan from the Transkei from Natives who had previously worked on the mines.

Lungs.—13 cases. Post-mortem material ; all mine Natives.

Tracheo-bronchial Glands.—13 cases. All mine Natives except 1, which was a Native girl *aet.* one year and nine months, dying from tuberculous meningitis. The only other tuberculous focus was one caseous tracheo-bronchial gland. Of the 12 mine cases, 7 had no obvious pulmonary lesions. In 5 of the 7 the tubercle was limited to the tracheo-bronchial glands ; in 1 these glands and other gland groups were affected ; in 1 there was a tuberculous pleurisy.

In all of these 48 cases infection may be presumed to have been by the respiratory route and pulmonary tuberculosis is universally admitted to be almost entirely due to the human type of bacilli, the finding of bovine bacilli in pulmonary tuberculosis being exceedingly rare.

The other 52 cases were therefore selected so as to offer a greater chance of finding bovine types. In other words, material was taken for culture from lesions other than pulmonary. It must be admitted, however, that in many of these, although the main brunt of the disease was extra-pulmonary, the source of spread in many of them was obviously from the tracheo-bronchial glands. Abdominal tuberculosis, for instance, is commonly regarded as being frequent among mine Natives. So it is, if one only regards the site of the main incidence of the disease, but most of these cases are only secondarily abdominal, the original route of infection being respiratory and the initial lesion being in the tracheo-bronchial glands. It is noted below in how many instances the primary infection appeared to have been by the abdominal route.

Heart and Pericardium.—3 cases, all mine Natives. All 3 had older foci in the tracheo-bronchial glands.

Spleen.—12 cases, all mine Natives. Only 2 had no obvious pulmonary or tracheo-bronchial glandular lesions which might have been the primary lesions. In 1 the lesions were confined to the spleen, liver and abdominal glands, and in the other to the spleen and abdominal glands.

Liver.—1 case, a mine Native. There were caseous foci in the epididymis, seminal vesicles, retro-peritoneal glands and liver, but none in the thorax.

Abdominal Glands.—15 cases, all mine Natives. 1 case had tuberculous caries of the lumbar vertebrae, but there was caseation not only in the abdominal glands but also in cervical and thoracic glands. 1 case showed several large, partially calcified mesenteric glands with no other lesions. 1 had caseous abdominal glands and tuberculous peritonitis, but no tuberculosis beyond the abdomen. 2 had caseous abdominal glands and caseous nodules in the spleen, with a terminal general miliary spread but with no obvious older lesions outside the abdomen. The other 10, although showing mainly abdominal lesions, might have been cases of spread of infection from pulmonary or tracheo-bronchial glandular lesions.

Omentum or Peritoneum.—12 cases, all cases of tuberculous peritonitis. 10 of them mine Natives, the other 2 cases in Transkei Natives; material sent by Dr. Allan. In none of these cases was the tuberculosis entirely limited to the abdomen.

Epididymis.—1 case, surgically removed material sent by Dr. Macvicar, Lovedale.

Bone or Joint.—5 cases, none of them being mine Natives. In 2 cases the material was obtained by excision from the knee-joint; in 1 it came from a hip-joint; in 1 from a psoas abscess and in 1 (post-mortem) from a sacro-iliac synchondrosis in a Zulu girl *aet.* 17. In the last case there was also caseation in the pelvic organs and abdominal retro-peritoneal glands, with a terminal general miliary spread.

It will be noted that in only 8 out of the 52 later cases was it possible to say definitely that there were no old lesions in the thorax, or, in other words, that they were cases of infection by the abdominal route. In most of the others, although the lesions were predominatingly extra-thoracic, the source of spread was in all probability thoracic.

Technique.

The primary cultures were all obtained by following the method described by Petroff.[88] Although this method was recommended by him for isolating tubercle bacilli from sputum or faeces, it has proved to be satisfactory also when dealing with tissues. Completely caseous material was simply emulsified with the soda solution employed prior to planting on the media. More solid tissue was firstly cut up into small pieces with scissors and then ground in a small agate mortar, with or without sterile sand, as seemed desirable.

Actually, these 100 strains of tubercle bacilli were obtained from 166 attempts at cultivation. The 66 negatives may be accounted for in some instances because the material was not tuberculous. In others, the tubercle bacilli, although present, were probably not viable, *e.g.*, some cases of old, extremely calcified glands; also, probably, some cases in which several days had elapsed between the time of the death of the patient and the receipt of the material from which the cultivation was attempted. The largest number of failures, however, was probably due to spoiling of the cultures by the growth of moulds or other bacteria. It should be remembered that most of the material was obtained post-mortem and not under ideal conditions, and despite the supposed sterilization of the material by passage through soda, and the inhibitory action of the gentian violet in the media, contaminations were still rather common. Moulds and chromogenic bacteria which liquefied the culture media were the commonest types.

Fewer failures might have been recorded if systematic inoculation of guinea-pigs had been practised, the primary cultures being then obtained from the guinea-pigs, but the sacrifice of so many animals was not desirable at the time.

As a general rule, four culture tubes were inseminated from each specimen, two of Petroff's medium with glycerine, and two without glycerine.

From the primary culture all stock cultures were kept on non-glycerinated Petroff medium.

Each strain was grown for purposes of comparison in the first or second generation of sub-culture on glycerinated and on non-glycerinated Petroff medium. Also, at the same time, each strain was planted out on glycerine agar and glycerine veal-broth potato.

For comparison with the strains obtained from human sources, material was also obtained from the Johannesburg Municipal Abattoir, and I have to thank Col. Irvine-Smith, Director of the Abattoir, and Mr. Kirkpatrick, M.R.C.V.S., his assistant, for supplying me with this material. Specimens were received from 7 cattle and 8 pigs. These were treated in exactly the same way as the human material and growths of tubercle bacilli were obtained from 3 cattle and 4 pigs.

Description of Cultures.—This can be stated very briefly. Every one of the 100 obtained from human sources was of a luxuriant type of growth (eugonic) and was, in addition, glycerophilic, *i.e.*, grew even more luxuriantly on egg medium with glycerine than on egg medium without glycerine. They also grew luxuriantly on glycerine agar and on glycerinated potato.

They were not all perfectly equally eugonic in character, but it was not possible to arrange them in anything like a series according to luxuriousness—they were too nearly alike for that. Four cultures which seemed to be definitely less eugonic than the majority were submitted for an opinion to Dr. S. Griffith. He reported upon them as "typical eugonic human strains in cultural characteristics." If the least luxurious of the lot were so regarded by an expert on tubercle cultures such as Dr. Griffith, little doubt need be felt as to the eugonic character of the others.

Of the cultures obtained from animal sources, all three from cattle were of characteristic dysgonic type. From the pigs, one was typically dysgonic, the other three eugonic. One of these three was rather less eugonic than the others and was submitted to Dr. S. Griffith along with the four from human sources regarding which there was an element of doubt, but he reported upon this one as also being typically eugonic in cultural characters.

It may be mentioned here that many pigs in the vicinity of Johannesburg are fed largely upon refuse food material obtained from the mine compounds, so that contamination of their food with human tubercle bacilli is not unlikely to occur.

Biological Test of Cultures.

Eugonic and dysgonic cultural types can in the main be regarded as synonymous with human and bovine types, but there are some exceptions to this general statement.

Eugonic virulents have been described, *i.e.*, cultures combining the free growth on artificial media of the human type with the wide range of virulence of the bovine type, but according to Cobbett (*loc. cit.*) these have often been proved to be mixtures. In the other direction, there are some which combine the dysgonic growth of the bovine type with the limited range of virulence of the human type (a class which might be called the *dysgonic human* type), and some others which resemble the human and bovine types except that their virulence is not so high.

In view of the possibility of atypical strains being present in this series, rabbit inoculation was carried out with all the strains from cattle or pigs, with all the doubtful strains, and with the first 50 strains from human sources irrespective of any doubt as to their eugonic character.

The method employed was that described by Fraser[89] of inoculating the bacilli (primary cultures or first sub-cultures were always employed) into the knee-joint. This method has the advantage of giving within three weeks a clear-cut distinction in the degree of the local reaction within the joint. With the human type of bacillus the local reaction is slight, often practically nil, and at most a chronic synovial thickening. There is no stiffening of the joint, no pain and, moreover, the animal does not lose condition and there is seldom any spread of the disease beyond the synovia. With the bovine type there is an acute synovial tubercle, with caseous debris in the joint cavity and erosion of the articular cartilages. The joint becomes swollen, stiff and painful; there is a progressive loss of weight and finally a more or less generalized spread of the disease occurs with a fatal issue.

This differentiation was found to hold good for all the strains tested. With the dysgonic strains (three cattle strains and one pig strain) disorganization of the joint and a generalized spread occurred in all four cases. With the other three pig strains and all the strains from human sources synovial thickening was the most that occurred within the joint. In a few cases there were small caseous abscesses formed outside the joint, probably from leakage of bacilli into the subcutaneous tissues when introducing or withdrawing the needle, but in no case was there loss of weight or condition, or generalized spread of the infection.

With the second 50 strains from human sources, all typically eugonic culturally, rabbit inoculation was not carried out. It may be held, therefore, that it is not fully proven that they were of human type. This must be admitted, but, in view of Cobbett's dictum that atypical strains are rare and that in the case of the *eugonic virulents* many have been shown to be mixtures, it is improbable that many were other than they appeared (from cultural considerations) to be, *i.e.*, of typical eugonic human type.

Calmette's Bile Medium for differentiating Human and Bovine Types.

Calmette[14] describes a method of distinguishing between human and bovine types by planting them upon potato cooked in 5 per cent. glycerine bile and leaving them to grow in the presence of an excess of biliary fluid. According as one uses human or bovine bile, so he says, only the human or bovine bacillus can be grown on the medium.

This method was apparently first described by Calmette and Guerin in 1908, but it does not seem to be mentioned in any standard text-books of bacteriology, nor can I find any reference to its employment by others. Whether the method has been overlooked or it has been tried and found wanting without the failure having been recorded, I cannot say.

Calmette (*loc. cit.*, p. 44) describes the growth on such bile-treated potato as being very rapid and quite different in appearance from that on ordinary glycerine potato. By the end of ten days the whole surface becomes covered with a thin, creamy, greenish-grey layer of growth which thickens little by little to reach a maximum at the end of 45 days. At that time the potato is covered with a uniform glossy coating, of a light buff colour and resembling an old culture of glanders bacilli. Elsewhere (*loc. cit.*, p. 287) he says : " Bacilli of human type develop only with great difficulty and very sluggishly in the presence of ox bile, whereas they develop readily in the presence of human bile. Inversely, the bovine bacillus grows quickly and abundantly on potato with ox bile, while culture is very difficult on media with human bile."

This method was tried, but I can only record a complete failure to distinguish between the two types of bacilli by means of it. The instructions given for preparing the bile potato were strictly followed, and it was tried three times with three different lots of human bile and three different lots of ox bile. All the four bovine strains and 16 human strains were planted on these ox bile and human bile potato media, but in no single instance was a luxurious growth obtained. Slight growths of human type bacilli were obtained on both human bile and ox bile potato and *vice versa*, but no differentiation between the two types was possible.

I can only record, therefore, that in my hands this method did not prove to be of value in distinguishing between the two types of bacilli.

Acid Fast Bacilli other than Tubercle Bacilli.

During the course of this investigation a growth was obtained in four instances of acid fast organisms which proved not to be tubercle bacilli.

(1) Mine Native with 6 years' mining service.—Cultures made from a grossly caseous spleen showing numerous acid fast organisms probably tubercle bacilli, in smears. No growth of tubercle bacilli was obtained, probably because the particular batch of media employed was unsatisfactory (this was discovered later). On one of the four tubes inseminated, two colonies of acid fast organisms grew.

(2) Mine Native with eight months' mining service.—Cultures also from spleen, which was of the acute tuberculous " monkey " type. No growth of tubercle bacilli but one colony of an acid fast organism.

(3) New arrival on mines who, from the condition of his lungs, had obviously never had previous mining service. Tuberculin reaction positive. Death a few days after arrival from an acute confluent broncho-pneumonia. At the post-mortem examination a small bunch of much calcified glands was found in the mesentery opposite the uppermost loop of the jejeunum. This was the only focus which looked like an old tuberculous lesion. Smears of the ground-up glands showed no acid fast organisms. Inoculation of a guinea-pig with the calcified material produced no tubercle. Cultures yielded no growth of tubercle bacilli but two colonies of an acid fast organism appeared, one on a glycerinated, the other on a non-glycerinated tube.

(4) Mine Native with one year's service.—Death from primary cancer of the liver. Several of the retro-peritoneal glands presented an appearance to the naked eye which might have been due either to tuberculosis or to metastases from the liver growth. Actually, on section, they proved to be due to the latter condition. Cultures, however, had been made and in one tube a single acid fast colony made its appearance.

It should be noted that in three of the four cases the subjects from whom the material was obtained had worked on the mines, the fourth case had not. Also, that in each case the growths were very scanty, never more than two colonies.

In all four cases the growths were similar in appearance. The primary colonies were small, hemispherical, smooth, slightly moist and of a faint yellowish tint. They appeared sooner and grew more rapidly than is the case with primary tubercle cultures. In subcultures streaked from the original colonies, growth took the form of a smooth, moist layer of a considerably deeper yellow colour, looking, after a week or two's growth, like a smear of yellow paint on the surface of the medium. Growth also occurred to some extent into the medium as well as on the surface. It was found that growth took place almost as well at room temperature as at 37°C. The type of growth was more like that of avian tubercle bacilli than that of human or bovine types. Only in the oldest culture, after about a dozen transplants, does the surface growth begin to show some wrinkling suggestive of the human type.

Stained films show the individual organisms to be mostly much shorter than typical human tubercle bacilli, but some beading is to be observed.

All four cultures were tested on rabbits, guinea-pigs and fowls by subcutaneous inoculation, but in no instance was anything like tuberculous disease produced.

It was concluded that these cultures were not tubercle bacilli, but they were submitted to Dr. S. Griffith for a further opinion He examined them culturally and, in the case of one strain, also by rabbit, guinea-pig and fowl inoculation One guinea-pig, after subcutaneous inoculation of 50mg. of bacilli, showed an abscess in the abdominal wall, the pus of which contained numerous acid fast organisms This was the only animal which developed any lesion. Dr. Griffith gives it as his opinion that these organisms are acid-fast saprophytes which somehow or other have gained access to the body.

As regards their source, the possibility of mine water occurred to me when I remembered that I had heard Dr. Orenstein state that he had given up a hunt for tubercle bacilli in mine soils, etc., because of the common presence therein of other acid-fast organisms. To test this hypothesis, Dr. Orenstein kindly sent me six samples of water and mud from various mines. From three of these, six growths of acid-fast organisms similar to those described were obtained. Mine water or soil would, therefore, appear to be a likely source from which these

organisms gain access to the human body, although some other source would have to be postulated for the case which died before actual mine service had started and the organisms were recovered from an old lesion in the mesenteric glands.

2. Examination of Samples of Mine Dust, Soil and Air, and of Specimens of Sputum collected Underground for Tubercle Bacilli.

The object in view in making these examinations is discussed in Chapter IV of the main Report (p. 150). Briefly stated, it was to see whether direct evidence could be obtained that the mines themselves were infective.

(*a*) *Mine Dust and Soil.*

For this purpose, samples of mine dust, soil, mud, etc., were collected in various situations. The situations picked were such as seemed likely to offer a fair chance of tubercle bacilli being present in the material selected, *e.g.*, dust or moist scrapings from the floor, walls or roof of waiting-places, where Natives congregated for some time and where coughing or spitting was likely to take place. Drives, ladderways, the neighbourhood of working stopes, etc., were also investigated, rock surfaces on which air currents impinged being specially selected as likely to harbour air-borne germs. Actual deposits of sputum were avoided in this investigation, as these were the subject of a separate study later. After collection the samples were taken to the South African Institute for Medical Research and their subsequent treatment was carried out on the same day. The situations where the samples were obtained are given in the table at the end of this appendix.

The samples were treated as if they were specimens of sputum being investigated by the method of Petroff (*loc. cit.*). Each sample was first of all well shaken up with a small quantity of sterile water ; the suspension thus obtained then had added to it an equal quantity of 3 per cent. NaOH, and was placed in the incubator at 37°C. for half an hour. After neutralization with HCl from 0·5 to 1c.c. of the suspension was injected subcutaneously into a guinea-pig.

As heavy infections were not expected, the guinea-pigs were kept six months before being killed for examination. 18 died before their six months was up ; several of them within a few days of inoculation from septic infections, the others at various longer periods. None of the 18 showed any evidence of tuberculous infection.

From the first 40 or so samples, cultures were also planted on Petroff's medium in the hope that tubercle bacilli might be grown, but this practice was given up, as it was found that the tubes invariably became overgrown by moulds. Apparently, the Petroff technique, although highly satisfactory for eliminating most bacteria other than acid fast bacilli, is not sufficient to kill off the moulds, which seemed to be present in all such mine material as was being investigated.

Smears of the suspensions used for inoculating the guinea-pigs were also subjected to direct examination for acid-fast organisms and although no prolonged or exhaustive search was made, such bacilli were found in 48 of the 100 samples examined. These acid-fast bacilli varied considerably in number from one sample to another; sometimes only one or two were found, whilst in other samples they might be abundant, and in that case they were usually aggregated into clumps. In one sample (No. 63) they were particularly abundant. It had been noted at the time of collection that cockroaches were numerous near the site of collection and it was further observed that what appeared to be cockroach excrement was present in the sample. With the object of seeing whether these organisms flourished in the intestinal tract of the cockroach, a supply of these insects was later obtained from the same vicinity and their intestinal contents (Sample No. 66a) examined. Acid-fast organisms were not found in them, however, so it was concluded that they merely flourished well in the soil contaminated with the excrement. The acid-fast bacilli seen in the various samples varied not only in numbers but also in size and appearance. Some were short and stout, others long and thin; in some there was no obvious beading, whereas in others beading was very distinct. If was felt that it was quite impossible on morphological grounds alone to distinguish between tubercle bacilli and the non-pathogenic acid fast bacilli already referred to in the first part of this report.

Of the 82 guinea-pigs which survived their inoculations for six months and were then killed and examined, not one showed any trace of tuberculosis, either local or general.

It is realized that great caution has to be exercised in drawing conclusions from negative findings, and particularly so in this instance, when it is remembered that the samples with which it was possible to deal represent such very minute portions of the mines.

Seeing, however, that most of the samples were taken from picked spots where tubercle bacilli might have been expected to have lodged, it seems not unreasonable to draw the following deductions :—

(1) That the soil, mud and dust of the mines cannot be regarded as highly infective.

(2) That the tubercle bacilli (which must unquestionably frequently be expectorated underground), if they lodge in dry dust, become non-infective there, just as they have been shown to become in other similar situations (see, *e.g.*, Calmette, *loc. cit.*, p. 143), or they are immobilized or destroyed by the frequent limewashing which is carried out in the vicinity of all waiting-places.

(3) That tubercle bacilli lodging in moist places are either diluted in numbers to such an extent as to be harmless, or are carried away and lost.

(b) Mine Air

The ordinary methods of examining air for bacteria apply only to such organisms as will grow on gelatin or agar, so that in order to obtain possible tubercle bacilli from the air, a special technique had to be devised.

The method adopted was one which made use of the sugar-tube commonly employed on the mines of the Rand for dust estimation. These tubes have been shown to trap efficiently dust particles of the same order of size as tubercle bacilli. A description of these tubes of the " Lauf " pattern is given in the General Report of The Miners' Phthisis Prevention Committee, Appendix No. 3, p. 66. The tubes were sterilized and filled with separately sterilized sugar before use.

From 400 to 600 litres of air were drawn through the tubes on each occasion, the suction being obtained by an electrically driven apparatus of the type of a vacuum cleaner. The air volumes were not measured precisely because quantitative estimations of tubercle bacilli were out of the question, but a very close approximation could be obtained from a previous knowledge of the capacity of the apparatus when being used for accurately measured volumes.

On transference to the laboratory, the sugar-tube (the contents of which on each occasion showed more or less obvious discolouration from dust) was washed out with about 250c.c. of sterile distilled water and the sugary solution obtained was subjected to lengthy centrifugalization in a high-speed centrifuge. From each of the tubes in which the sugar solution was centrifuged, the deposit and the bottom few drops of liquid were taken, mixed together, and treated as described above for soil samples for injection into a guinea-pig

Direct examination of some of the deposit from the tubes for acid-fast bacilli was also made and in 3 out of the 14 specimens acid-fast bacilli were found.

Even if these acid-fast bacilli were only the non-pathogenic bacilli of the mine soil and water, their being found in the air is of some significance, for obviously, if they can be floating in the mine air, so can tubercle bacilli which happen to be expectorated in the mine.

Some attempts at cultures on Petroff's medium were also made with these air samples, but they were foiled by overgrowth of moulds, just as in the case of the soil samples.

The air samples were mostly taken at or near waiting places either whilst the Natives were actually present waiting to go off shift or just after they had gone. The situations where they were taken are given in the list at the end of the Report.

Four of the specimens were taken in skips when the skips were packed with Natives going off shift. On these occasions an apparatus of a similar type but on a somewhat smaller scale was employed. The main difference was that the suction was obtained as in the carburettor

of a motor car by release of oxygen from a cylinder ; this had to be employed because electric power was not available in the travelling skips.

The collection of these specimens necessitated from six to ten trips up and down in order to give time to get a sufficiently large volume of air through the sugar-tube.

The Natives coming off shift pack into the up-going skips as tightly as they can and the skips are regarded by some mine medical officers as a situation where the inhalation of tubercle bacilli might very readily take place.

It may be noted that one of the three samples in which acid-fast bacilli were observed in the deposit from the sugar-tube was a skip sample.

Of the 14 guinea-pigs treated, 1 died a month after inoculation ; the other 13 lived out their six months. None of the 14 showed any evidence of tuberculosis, local or general.

It would, of course, have only been the sheerest bit of luck if tubercle bacilli had been recovered from any of these air samples, and the failure to find any cannot be regarded as of any significance.

That the dust from the air in 3 of the 14 samples contained acid-fast organisms is not, however, without significance. for it indicates that, in addition to the possibility of tubercle bacilli being sprayed directly into the air by coughing, bacilli deposited on the soil or dust in sputum might again find their way into the atmosphere and so be inhaled. If their return to the air took place soon after their original deposition, they might quite well be infective.

(c) *Specimens of Sputum from Underground Workings.*

In Appendix No. 10 to the General Report of the Miners' Phthisis Prevention Committee, Dr. Watkins-Pitchford gives his results of the examination of 370 specimens of sputa ; 250 collected from underground workings and 120 from surface premises.

He reports 38 of the underground specimens (15·2 per cent.) as being tuberculous, and 3 of the surface specimens (2·5 per cent.).

He accounts for the greater proportion amongst the underground specimens as follows : " I think the physical characters of tuberculous sputum account very largely for the discrepancy ; it is usually opaque, creamy-white in colour, and disintegrates very slowly when immersed in water ; non-tuberculous sputum, on the other hand, is usually translucent, inconspicuous and diffuses into water much more readily. For these reasons, tuberculous sputum deposited in dark places is more visible in the light of the examiner's lamp than non-tuberculous, and it is, moreover, less likely to become disintegrated when deposited on the surface of wet rock."

It is possible that this explanation put forward by Dr. Watkins-Pitchford may account either in whole or in part for the difference between the two series, but in view of the fact that his examination of these sputa was merely a bacterioscopic one, another possible explanation must be considered, viz., that all the underground specimens supposed to be tuberculous were not really so, the acid-fast bacilli seen being merely contaminating non-pathogenic organisms from the mine soil.

From personal experience, I know that it is practically impossible to collect a specimen of sputum underground without at the same time gathering up a certain amount of soil, mud or dust with it, so that the possibility of the sputum as collected containing acid-fast organisms derived from the soil cannot be ignored.

It must be remembered, however, that underground conditions in 1912-13 and in 1929 were probably not strictly comparable. It is quite likely that in the earlier period a higher percentage of truly tuberculous sputa would have been obtainable, but this cannot now be definitely ascertained, and we can only criticize the figure given by Dr. Watkins-Pitchford on the ground mentioned.

That tuberculous sputa are still expectorated underground may be taken for granted, and, in view of the possible error in the 1912-13 figures and of the long time which had elapsed since the observations were made, it seemed desirable to the Committee that another investigation of underground sputa should be made, the diagnosis of " tuberculous " this time only to be accepted after biological confirmation.

Unfortunately, the decision to have this examination made was only arrived at very late in the day by the Committee, and, six months having to be allowed for the guinea-pigs to live after inoculation, very little time was available for the tests without unduly hanging up the publication of the Report. Consequently, only 33 specimens have been examined, this being the most that could be done in the time available.

The mines where the specimens were obtained are recorded in the table at the end of this Report. As the exact localities in the mines where they were obtained were merely of fugitive interest, they are not specified.

Of the 33 specimens, direct observation of smears showed acid-fast organisms in 7 (20 per cent.).

5 of the 33 guinea-pigs inoculated died soon after inoculation, 1 of the 5 being an animal whose inoculum had shown acid-fast organisms. The test in these 5 cases cannot be regarded, therefore, as satisfactory. In the other 28 the guinea-pigs lived the full six months before being killed and examined.

1 guinea-pig (S11) developed a typical local tuberculosis in the gland corresponding to the site of inoculation (caseation, acid-fast bacilli and characteristic histology), but without generalization. The others showed no evidence, local or general. In the 1 positive case, direct examination of the sputum had not shown any acid-fast organisms.

Although acid-fast bacilli were found in 7 of these 33 sputa, conclusive proof of the presence of tubercle bacilli was, therefore, only obtained in 1.

From this investigation it must be inferred that the figures given by Dr. Watkins-Pitchford in 1916 should only be accepted with reservation.

Herewith follows a list of the situations where the various samples of dust, soil, air and sputum were collected.

LIST OF MINES AND OF SITUATIONS IN THESE MINES WHERE SAMPLES WERE COLLECTED FOR EXAMINATION FOR TUBERCLE BACILLI.

No.	Mine.	Situation in the Mine.	Nature of Material.
1	Village Deep	30. Ventilation shaft	Dust on floor.
2	Do.	30. E. drive	Scrapings from wall.
3	Do.	30. Main cross-cut, roof	Scrapings from timbers.
4	Do.	32. Main station	Dust from wall.
5	Do.	Do.	Do.
6	Do.	33. W.1 near working face	Scrapings from props and timbering.
7	Modder Deep	Waiting-place. Foot of vertical shaft	Wall dust.
8	Do.	Main E. waiting-place	Do.
9	Do.	Main incline, about midway along	Mud from walls.
10	Do.	Main W. waiting-place	Do.
11	Do.	Old waiting-place	Dust from walls
12	Do.	Main drive	Scrapings from props and timbering.
13	Consolidated Main Reef	20. Waiting-place, Main Leader drive	Scrapings from walls.
14	Do.	20. Mouth of old drive connecting two shafts	Do.
15	Do.	Near top of inclined shaft	Do.
16	Do.	35. W. drive, stope near the working-place	Dust from floor.
17	Do.	Near the top of same stope	Moist soil from floor.
18	Do.	28. Drive	Scrapings from roof timbers.
19	City Deep, No. 2 Shaft	18. W.3 working-place	Mud from floor.
20	Do.	18. W.3. Further from the working-place.	Do.
21	Do.	18. W.3 central stope, just above working-place	Do.
22	Do.	Do.	Do.
23	Do.	18. Station	Do.
24	Do.	Station, foot of vertical	Do.
25	Crown Mines, No. 5 Shaft	26, 15/16. Reclamation stope	Scrapings from hanging-wall.
26	Do.	Do.	Scrapings from floor.
27	Do.	Do.	Mud from floor.
28	Do.	19. Waiting-place, top of 2nd vertical	Scrapings, floor and walls.

No.	Mine.	Situation in the Mine.	Nature of Material.
29	Crown Mines, No. 5 Shaft	19. Waiting-place, foot of 1st vertical	Scrapings, floors and walls
30	Do.	19. Travelling-way between the two verticals	Do.
31	Govt. G.M. Areas, No. 4 Shaft	25. Main cross-cut S.	Scrapings from walls.
32	Do.	25. Stope E.1	Dust from supporting pillars.
33	Do.	26. Cross-cut E.3	Dust from walls and floors.
34	Do.	27. E.3 stope	Do.
35	Do.	24. W. haulage, waiting-place	Do.
36	Do.	26. S. cross-cut, waiting-place	Do.
37	Modder East, No. 2 Shaft	11. Cross-cut W. A mule haulage-way	Scrapings from walls.
38	Do.	11/6 stope. Original winze	Do.
39	Do.	13/5A. A main upcast air-way	Dust from walls.
40	Do.	13. 4S. Old stope near main haulage-way	Scrapings from a hanging.
41	Do.	11. Station waiting-place	Scrapings from wall.
42	Do.	Waiting-place, S. drive	Dust from walls.
43	W. Rand Cons. W. Shaft	16. Main station	Do.
44	Do.	18. Stope near original winze	Scrapings from pack and hanging
45	Do.	18. Junction of stope and drive	Scrapings from walls and timbering
46	Do.	20. Station	Wall scrapings.
47	Do.	27. Station.	Do.
48	Do.	Do.	Do.
49	Van Ryn Deep, W. Shaft	Main station, foot of vertical	Do.
50	Do.	10/3. Waiting-place on drive	Do.
51	Do.	11. E.5. Waiting-place in return airway	Do.
52	Do.	11. E.5. Stope	Dust from pillars and floor.
53	Do.	12. Drive at top of E.2 stope	Scrapings from wall.
54	Do.	11. Sub-shaft station	Do.
55	Rose Deep, No. 1 Shaft	Station waiting-place, foot of vertical	Do.
56	Do.	7. Station	Do.
57	Do.	7. E. drive	Scrapings from wall and hanging.
58	Do.	7. 20-foot high stope in line of upcast air	Scrapings from wall and floor.
59	Do.	7. W. Near main latrine	Scrapings from wall.
60	Do.	9. W. Travelling-way	Do.
61	Springs Mine, No. 2 Shaft	Foot of vertical. Waiting-place, W. haulage	Do.
62	Do.	Waiting-place, N. haulage	Dust from walls
63	Do.	Stope 8E, 1	Dust from pack and hanging.
64	Do.	Stope 7E, 41	Dust from packing.
65	Do.	Same stope, lower down	Scrapings from floor.
66	Do.	Around door of underground drill shop	Dust from walls.
66a	Do.	Same situation as No. 63	Cockroaches.

No.	Mine.	Situation in the Mine.	Nature of Material.
67	Langlaagte Ests., Hebbard Shaft	Foot of vertical station	Scrapings from walls.
68	Do.	26. W.3 stope	Dust from walls.
69	Do.	25/26. Top of stope opposite an upcast shaft	Scrapings from walls.
70	Do.	Do.	Do.
71	Do.	25/26 ladderway	Do.
72	Do.	27. Station	Dust from walls.
73	Randfontein Est. S. Vertical Shaft	29. Station	Scrapings from walls.
74	Do.	28. Waiting-place on main drive	Do.
75	Do.	27. Station. Dead-end used as waiting-place	Scrapings from wall and hanging.
76	Do.	27. Top of stope	Scrapings from floor.
77	Do.	27. Stope. Hanging on which upcast impinged	Scrapings.
78	Do.	Do.	Do.
79	Durban-Roodepoort Deep, Circular Shaft	17. Station	Dust from walls.
80	Do.	17. W. incline station	Scrapings from hanging.
81	Do.	17. Princess incline station	Do.
82	Do.	18/13 stope near station	Do.
83	Do.	18/6 stope. Top of S. Reef	Scrapings from timbering.
84	Do.	17. Main haulage-way	Scrapings from walls.
85	New Modder, I.C. Shaft	13. Station	Dust from walls.
86	Do.	15. E.1 stope near original winze	Dust from pack and hanging
87	Do.	16. E.2 stope	Scrapings from pack and hanging.
88	Do.	16. E.3 stope	Do.
89	Do.	16. Ladderway near station	Scrapings from wall.
90	Do.	14. Station	Do.
91	Nourse Mines, No. 3 Shaft	20. Station	Dust from walls.
92	Do.	22. E.3a stope, S. Reef	Scrapings from hanging.
93	Do.	25. E.11 stope, S. Reef. Upcast winze	Dust from walls and hanging.
94	Do.	27. E.1 S. Reef. Top of stope. Upcast	Scrapings from hanging.
95	Do.	27. Station, waiting-place	Dust from walls and floor.
96	Simmer & Jack, Rhodes Shaft	37. E. travelling-way	Scrapings from hanging.
97	Do.	37. E. stope	Do.
98	Do.	38. Station, waiting-place	Scrapings from walls and hanging.
99	Do.	38. Top of a stope. Ventilating manhole	Scrapings from hanging.
100	Do	35. Foot of vertical station	Dust from walls and piping.
A 1	Village Deep	Main cross-cut	Air.
A 2	New Modder	I.C. Shaft, 14 station	Do.
A 3	Durban Roodepoort Deep	Foot of vertical	Do.
A 4	City Deep	Main station, No. 4	Do.
A 5	Robinson Deep	———	Do.

No.	Mine.	Situation in the Mine.	Nature of Material.
A 6	Cons. Main Reef	———	Air
A 7	Langlaagte Ests.	Hebbard Shaft cross-cut between vertical and inclined	Do.
A 8	New State Areas	———	Do.
A 9	Springs	No. 2 Shaft	Do.
A10	Brakpan	No. 3 Shaft	Do.
A11	Crown Mines	No. 15 Shaft, in skip	Do.
A12	Nourse	No. 1 Shaft, in skip	Do.
A13	E.R.P.M.	Angelo W. Vertical Shaft, in skip	Do.
A14	Randfontein Ests.	S. Vertical Shaft, in skip	Do.
S 1–5	Crown Mines	Various	Sputum.
S 6–10	Modder B	Do.	Do.
S11–15	E.R.P.M.	Do.	Do.
S16–17	Durban Roodepoort Deep	Do.	Do.
S18–23	Cons. Main Reef	Do.	Do.
S24–27	Durban Roodepoort Deep	Do.	Do.
S28–33	Modder East	Do.	Do.

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I have to express my indebtedness to Dr. S. Griffith, Cambridge, for examining the various cultures submitted to him, and for his permission to make use of his reports thereon.

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SUMMARY.

(1) 100 strains of tubercle bacilli isolated from various types of cases of tuberculosis among South African Natives all proved to be of human type.

(2) Although about half the cultures were obtained from extra-thoracic lesions, in only 8 instances could it be asserted that the original infection had been by the abdominal route.

(3) Bovine tuberculosis is rare in South Africa, and a case of human infection with bovine type of bacilli has not yet been found.

(4) An attempt to differentiate between human and bovine types of tubercle bacilli by means of Calmette's bile media was unsuccessful.

(5) 4 cases are described of isolation of saprophytic acid-fast bacilli from human tissues.

(6) 100 samples of mine-dust and soil showed acid-fast bacilli present in 48, but biological tests failed to establish the presence of tubercle bacilli in any of them. The inference is drawn that the dust and soil of the mines cannot be regarded as highly infective.

(7) 14 samples of mine-air showed acid-fast bacilli present in 3 of them, but biological tests for tubercle bacilli were all negative. The presence of acid-fast bacilli in the air may be of significance as indicating that tubercle bacilli deposited in sputum might also again become suspended in the air and so be potentially infective.

(8) 33 samples of sputum collected underground showed acid fast bacilli present in 7, but biological tests for tubercle bacilli were only positive in 1 case. A diagnosis of " tuberculous " based on bacterioscopic examination alone is therefore not reliable in such conditions.

APPENDIX NO. 7.

PATHOLOGICAL ANATOMY OF TUBERCULOSIS AMONG NATIVE MINE LABOURERS ON THE WITWATERSRAND.

By J. H. Harvey Pirie and A. Mavrogordato.

This report is an analysis of 600 post-mortem examinations made during the years 1927, 1928 and the first half of 1929, on cases of tuberculosis, or on cases showing tuberculous lesions, amongst Native labourers on the gold mines of the Witwatersrand. The cases actually fall into three groups :—

(*a*) A group of 350, in which the autopsies were made by the writers. This group covers all the cases dying during the period mentioned in the Witwatersrand Native Labour Association's hospital, and includes, firstly, all cases of recruited labourers dying before they had been allotted to any mine—" new arrivals "—and, secondly, all cases diagnosed as tuberculous on the mines and sent to the W.N.L.A. for repatriation to their homes but dying before they could be repatriated.

(*b*) A group of 7 cases of mine accidents examined by the writers at the Johannesburg Government Mortuary. For permission to examine accident cases there we are indebted to the Chief Magistrate, Johannesburg, and to the District Surgeons—Drs. W. Girdwood, R. Ray and J. J. Levin—responsible for the pathological work at the mortuary. These 7 cases are all those showing any tuberculous lesions out of a considerable number of accident cases examined. They are included in this survey because they furnished some opportunity of seeing the disease in the process of development.

(*c*) A group of 243 cases dying on the mines and reported by various mine medical officers on the forms drawn up by the Tuberculosis Research Committee (Form 1, Pathological Section, see pp. 409–411).

The writers are responsible for the analysis only of the data recorded in the last group. It is probably inevitable in dealing with returns of this nature, made by a variety of individuals, that there should be some variation in standards and accuracy, especially as regards the smaller details. It has been possible, however, to have the reports checked in almost every case in so far as the lungs are concerned, by Dr. A. Sutherland Strachan, of the South African Institute for Medical Research, who is deputed by the Institute to conduct pathological investigations for the Miners' Phthisis Medical Bureau and, judging by the essential accuracy of the main mass of the reports on the lungs, it is felt that the reports as a whole may be taken as being sufficiently accurate and detailed to give a reliable picture. In one particular only

have we felt impelled to cut out a comparison of this group with our own group of 350, viz., with reference to the silicotic and tuberculous lesions of the various groups of lymphatic glands in the cases where the tuberculosis was associated with silicosis (see pp. 390 and 391).

It has seemed to be important to include the three groups of cases in one analysis as, by so doing, we cover every class of case of tuberculosis as it is encountered in the population under consideration, with the exception of one, viz., the Native repatriated with tuberculosis. The repatriates form a big proportion of the whole, as figures given below will show, but it has not been possible to obtain any pathological data about the anatomical evolution of the disease in the Native at his home after his return from the mines. Dr. Allan's clinical investigations in the Transkei, however, indicate that there is another side to the tuberculosis picture from that presented here. This report may suggest that tuberculosis here (apart from tuberculosis associated with silicosis) is largely " natural " tuberculosis. It is important to remember, therefore, that this is not necessarily the case and, indeed, is probably not the case.

The objects in view in making this report are :—

(1) To put on record the pathological anatomy of tuberculosis as seen in the Native mine labourers of the Witwatersrand, basing the record on a reasonably large amount of material. To any one accustomed to see many autopsies on Natives connected with the gold mines, tuberculosis is only too familiar, but there is surprisingly little available published accounts of such tuberculosis, and it was felt, therefore, that it would be of value to have this record made.

(2) To see how far pathological anatomy would go in helping to answer certain practical questions, such as the question of the portal of entry of the tubercle bacillus and the question of whether the mine Native's tuberculosis comes in the main from infection received after his arrival on the mines, or whether he comes already infected and the disease lights up either through super-infection or from physiological stress.

Population Dealt With.

The Native mine labouring population is a floating one, and exact figures cannot be given in this connexion, but from the data supplied by the Chamber of Mines it may be taken that the mean complement of Native labourers, including both surface and underground workers, on the Reef, over the year 1927, was 185,479. For 1928, the mean complement was 195,210, and for the first half of 1929 it was 196,897. The actual number of individuals passing through in any one year was probably about twice the mean complement.

Tuberculosis Production and Mortality Rates.

Returns from the mines on the Rand as regards their cases of tuberculosis and silicosis, for the year 1927, are as shown in Table I.

TABLE I.

TUBERCULOSIS AND MINERS' PHTHISIS PRODUCTION, WITWATERSRAND GOLD MINES, 1927.

DEATHS ON MINES.				DISPOSED OF OTHERWISE.			
Pulmonary Tuberculosis.	Tuberculosis and Silicosis.	Silicosis.	Other Forms of Tuberculosis.	Pulmonary Tuberculosis.	Tuber- Tuber- and Silicosis.	Silicosis.	Other Forms of Tuberculosis.
138	35	12	60	694	240	130	213
245				1,227			

From the pathologist's point of view, one might query the absolute correctness of these figures as regards the returns for simple silicosis, but, taking the figures as they stand as giving a fair index of the production and mortality rates for tuberculosis and miners' phthisis, they show a production rate of 820 *per* 100,000 *per annum*, and a mortality rate *on the mines* of 132 *per* 100,000 *per annum*.

To get the mortality rate *on the Rand* from tuberculosis and miners' phthisis amongst the Native mine labourers, one must add to the 245 deaths which occurred on the actual mines, the 170 which took place in the W.N.L.A. hospital where the cases had been sent pending repatriation. This makes a total of 415, which gives a mortality rate of 223 per 100,000 *per annum*. Of course, this still takes no account of deaths that may have occurred amongst the remaining 1,107 cases, which either took their discharge locally or were (in the majority of instances) repatriated.

The corresponding figures for 1928 are shown in Table II.

TABLE II.

TUBERCULOSIS AND MINERS' PHTHISIS PRODUCTION, WITWATERSRAND GOLD MINES, 1928.

DEATHS ON MINES.				DISPOSED OF OTHERWISE.			
Pulmonary Tuberculosis.	Tuberculosis and Silicosis.	Silicosis.	Other Forms of Tuberculosis.	Pulmonary Tuberculosis.	Tuberculosis and Silicosis.	Silicosis.	Other Forms of Tuberculosis.
134	37	8	82	490	330	174	293
261				1,287			

During 1928 there were 131 deaths from tuberculosis at the W.N.L.A. hospital.

The production rate for tuberculosis and miners' phthisis for 1928 works out at 793 *per* 100,000 *per annum ;* the mortality rate *on the mines* at 134 *per* 100,000 *per annum ;* and the mortality rate *on the Rand* at 201 *per* 100,000 *per annum*.

Age, Service and Tribal Distribution of Cases.

It is convenient to mention at this point, seeing that general statistical statements are being given, that when ages are referred to, these must always be regarded as only approximations. The Natives are, in most cases, rather vague as regards their age, and many of the ages given are really only estimates.

Similarly, records of mining service cannot always be taken as strictly accurate. These records are kept by the mines and, so far as any one mine is concerned, may, of course, be taken as accurate. When a boy's service is not continuous, however, and may, moreover, have been on several different mines, it is possible for some of his service to be overlooked. It may be taken, therefore, that the records of service given are never over-statements, but they may sometimes be under-statements. We have had to exercise our discretion and discard some of the records given, as they simply did not accord with the physical state of the lungs. For example, it would be absurd to accept as correct the statement of only a few months' service in a case showing deeply pigmented lungs and well developed tuberculo-silicosis. Such a condition can only mean several years' mining service.

The Native mine labourers are divided into two large groups—firstly, those recruited in Portuguese East Africa, known generally as "East Coast Natives," including the following tribes: Tonga, Mchopi, Nyambaan and Shangaan; secondly, those recruited from within the Union and neighbouring Protectorates, known generally as "British South African (B.S.A.) Natives." These include Xosa, Pondo and Fingo from the Transkei; Zulu from Natal; Msutu from both Basutoland and the Northern Transvaal; Swazi from Swaziland; and Bechuana from British Bechuanaland.

For 1927 East Coast Natives constituted on an average 44·31 *per cent.* of the total complement, and for 1928 46·53 *per cent.* For the total period 1927, 1928 and first half of 1929, East Coast Natives constituted 50·6 *per cent.* of the 600 tuberculous cases, so that from this point of view there is nothing to indicate that there is any great difference between the one group of Natives and the other as regards their susceptibility to tuberculosis.

The 243 cases reported by various mine medical officers are simply such cases dying from tuberculosis (or showing tuberculous lesions) in the mine hospitals as were voluntarily reported by them during 1928 and the first half of 1929 to the Tuberculosis Research Committee.

The 350 cases in the writers' group come from a total of 467 post-mortem examinations made, being an examination of every case dying in the W.N.L.A. hospital. As this figure of 467 includes the vast majority of new recruits dying before commencing service (excluding only those cases engaged directly by mines and not passing through recruiting depôts), it may be of interest to refer briefly to the 117 cases in whom no tuberculosis was found.

Of these 117 cases, 109 occurred in new recruits who had not been drafted to any mine, or who had under one month's service; 90 of these being East Coast and 19 B.S.A. Natives. Only 8 cases were not new recruits, their service periods ranging from six months to eleven years.

The causes of death in those 117 cases were as follows :—Influenza or other broncho-pneumonias, 33 ; lobar pneumonia, 24 ; dysentery, 9 ; meningococcal meningitis, 16 ; cancer of the liver, 8 ; empyaema, 4 ; enteric fever, 2 ; valvular disease of the heart, 3 ; cerebral injury and softening, 2 ; pyonephrosis, 2 ; pneumococcal meningitis, pericarditis, appendicitis, gumma of the brain, carbon tetrachloride poisoning, " acute mania," congenital cystic kidneys and haemorrhage into suprarenal, chronic nephritis, cirrhosis of the liver, volvulus and ruptured aortic aneurism, 1 case each ; " nothing discoverable," 3 cases.

The 600 cases dying from tuberculosis or showing tuberculous lesions have been grouped for descriptive purposes as is shown in Table III.

TABLE III.

600 Cases of Tuberculosis Examined Post-mortem.

Tribe.		A. Tuberculosis but not as Cause of Death.		B. "Chronic." Associated with Silicosis.		C. "Acute." Lesions mainly Thoracic.		D. "Acute." Lesions mainly Extra-Thoracic.		Totals.	
East Coast	Shangaan ...	18		66		54		27		165	
	Nyambaan ...	8		21		18		6		53	
	Mchopi	11		22		13		8		54	
	Tonga	2	41	7	117	8	95	8	51	25	304
	"Tribe Uncertain"	2		0		1		1		4	
	Blantyre ...	0		1		0		0		1	
	Mozambique ...	0		0		1		1		2	
B.S.A.	Msutu (Basuto)	3		15		71		18		107	
	Xosa	8		29		44		19		100	
	Pondo	4		16		8		3		31	
	Fingo	1	21	10	83	7	145	2	46	20	295
	Swazi	3		4		5		1		13	
	Bechuana ...	0		4		10		1		15	
	Zulu	2		5		0		2		9	
Unidentified		0		0		1		0		1	
Totals		62		200		241		97		600	

Note.—The Blantyre and Mozambique cases, although coming from farther north than the recognized " East Coast " recruiting limits, have for convenience been included with the East Coast cases.

There is only one feature brought out by Table III in relationship to tuberculosis in its tribal aspects that seems to us to be of much significance, and that is the preponderance of Basutos, which figure in

the "acute" section, especially with lesions mainly thoracic. With this exception, there is nothing very much indicative of any great difference between one tribe and another in so far as its reaction to tuberculosis goes.

GROUP A.

62 *Cases showing Tuberculous Lesions, but in which Tuberculosis was not the Cause of Death.*

Of these 62 cases, 41 occurred in East Coast Natives and 21 in B.S.A. Natives.

Herewith follow brief summaries of the case findings. The numbers given to the cases are their serial chronological numbers; those with a number only being in the writers' series of 350; those with an M are from the mine medical officers' series of 243, and those with an A are accident cases.

It will be noted that in this group the service record was frequently not obtained. This is explained by the fact that when death is not due to tuberculosis or there is no pulmonary tuberculosis, there is no statutory return made to the Miners' Phthisis Medical Bureau, and the official machinery for obtaining the record of service is not set in motion.

(57) Shangaan, *aet.* 34.—Service not obtained but probably quite short. Death from valvular disease of the heart. Had a few early white tubercles in the tracheo-bronchial glands. In the lungs there were a few sub-pleural commencing silicotic foci but no obvious tuberculous lesions.

(66) Shangaan, *aet.* 29.—Death from meningitis. Service not obtained but condition of lungs and bronchial glands suggested about one year. There was enlargement of many of the mesenteric glands, but only one had an appearance suggestive of tuberculosis. Its tuberculous character was confirmed by section.

(70) Nyambaan, *aet.* 27.—New recruit. Given 3c.c. carbon tetra-chloride for treatment of ankylostomiasis. Death with features of poisoning by this drug. Must have had previous service, as the tracheo-bronchial glands and lungs showed well-developed tuberculo-silicosis. There was also caseation and recent acute spread of the lung tubercle and tuberculous ulceration in the ileum. He would probably very soon have died from the tuberculosis.

(88) East Coast Native, *aet.* 32.—New recruit with no signs of previous service. Epileptic fits. Had cysticerci and cortical haemorrhages in brain. Had a recent development of tubercles in a bunch of glands in the mesentery of the uppermost loop of the jejeunum. The tuberculous nature was confirmed by smears and sections.

(99) Nyambaan, *aet.* 40.—Death from cancer of liver. Service not obtained but must have had a year or two, as he had a few small tuberculo-silicotic nodules in one lung and definite tuberculo-silicosis of the tracheo-bronchial glands. There were no other tuberculous lesions.

(115) Unidentified East Coast Native, just arrived, wildly maniacal. The degree of pigmentation of the lungs and tracheo-bronchial glands suggested at least a year's previous mining service. Two of the tracheo-bronchials were definitely caseous. There were also caseous hilus glands. Tubercle bacilli of human type were grown from these. No actual tuberculous foci were found in the lungs. There was no tuberculosis anywhere else. A case which could not have been detected by the stethoscope but might have been by X-rays.

(137) Shangaan, *aet.* 30, with six years four months mining service.—Death from lobar pneumonia. Had early silicotic lesions and, in the right lung especially, a fair number of tuberculo-silicotic nodules and small areas. The tracheo-bronchial glands

were also tuberculo-silicotic, but without any breaking down. The portal glands were pigmented but not apparently tuberculous. The upper retro-peritoneal glands were also pigmented and with probably early tuberculous lesions. Other glands and organs showed no tuberculosis.

(142) Zulu, *aet.* 46, with eight years' mining service.—Death from lobar pneumonia. Lungs considerably pigmented in large black discrete islands. No obvious tuberculous lesions. Tracheo-bronchial and hilus glands deeply pigmented, but not much enlarged nor fibrosed. One calcareous gland shelled out. Almost certainly an old healed tuberculous focus, but no tubercle bacilli found. Other glands and organs show no tuberculous lesions.

(148) Pondo, *aet.* 30.—Death from lobar pneumonia. Mining service not obtainable, but probably not very long, as there was very little pigmentation of the lungs. The tracheo-bronchial glands, however, contained a fair amount of pigment and one presented the typical appearance of a tuberculo-silicotic gland. Another para-tracheal gland was markedly calcified. There was also a single calcified gland in the mesentery, about the middle of its length. Apparently a case with old healed tuberculous glandular lesions.

(167) Shangaan, *aet.* 46, with 15½ years' mining service.—Death from cancer of liver. Had a bilharzial bladder. There were tuberculo-silicotic lesions in the lungs and tracheo-bronchial glands.

(185) Mchopi, *aet.* 36.—Mining history unobtained. Death from lobar pneumonia. Had fairly extensive tuberculo-silicotic lesions in the lungs and tracheo-bronchial glands.

(193) Shangaan, *aet.* 24.—A new recruit. Death from influenza. Lungs unpigmented, no scarring of tuberculous lesions detected. Tracheo-bronchial and hilus glands unpigmented. One gland at root of right lung the size of a hazel-nut and largely caseous; two others nearby with small recent tubercles in them.

A clear case of a Native coming from his kraal with infection already present in the root glands. Could not have been detected by stethoscope. Query: Would X-rays have shown up lesion either?

(203) Mchopi, *aet.* 39.—Mining service not obtained, but probably not very long, as lungs only moderately pigmented. Calcified mitral cusps and evidence of chronic back pressure. Tracheo-bronchial and hilus glands pigmented and fibrosed, probably early tuberculo-silicotic. Definite tuberculosis of portal and lower retroperitoneal glands and of one gland of a high loop of the mesentery. A caseous nodule in the wall of the right auricular appendix, which is thrombosed. No involvement of the pericardium. Query: Is the limitation of the tuberculosis an example of the antagonism between valvular heart disease and tuberculosis? The auricular thrombosis was probably at least a factor in the cause of death, and in this sense, perhaps, the tuberculosis might be said to have been a cause of death.

(214) Msutu, *aet.* 36.—Mining history not obtained, but cannot have been long, as lungs showed very little pigment. Death from acute osteomyelitis of dorso-lumbar spine with myelitis and paraplegia. Very small caseous areas in one "clavicular" gland, tracheo-bronchial and portal glands. Slight scarring at apex of left lung with some recent caseous tubercles in the immediate vicinity of the scar.

(215) Nyambaan, *aet.* 28.—Mining service not obtained, but lungs show very little pigment. Death from *sweating sickness.** There were also several cysticerci in the cerebral cortex. No lung lesions found but the tracheo-bronchial glands showed definite caseation, and there was probably commencing caseation in the portal and upper retro-peritoneal glands.

(222) Shangaan, *aet.* 22.—Mining service, ten months' lashing. Death from carcinoma of bladder and pyonephrosis. Bladder bilharzial. Lungs show practically no pigment and no tuberculous lesion detected. Tracheo-bronchial glands show very definite enlargement and caseation. No other tuberculous lesions found.

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* "Sweating sickness" is the term applied locally to a disease not uncommon amongst Native miners, in which profuse perspiration is one of the most striking symptoms. The disease is frequently fatal, but its etiology has not yet been discovered.

(229) Swazi, *aet.* 52.—Mining service, eight years five months.—Death from pneumonia. Had old healed fibrotic scars at both apices, almost certainly tuberculous, also one small bronchiectatic cavity, but apparently a recent acute thing not tuberculous. The tracheo-bronchial glands were enlarged and fibrosed, but showed no definite tuberculous character.

(234) Xosa, *aet.* 23.—New recruit. Death from dysentery. Had two small sub-pleural calcified nodules in each lung, probably healed tuberculous foci. No other evidences of tuberculosis.

(243) Nyambaan, *aet.* 26.—At least one year's mining service, perhaps two years. Death from enteric fever. Caseation in one gland at the bifurcation of the trachea. No other tuberculous foci found.

(252) Xosa, *aet.* 42, with two years eleven months' service.—Death from sub-acute mitral endocarditis. Had fibrosed and slightly caseous retro-peritoneal glands, mainly the lower group, and one small caseous spot in the spleen (tubercle bacilli present in smears). Some pleural adhesions on both sides. ? Tuberculous.

(255) Nyambaan, *aet.* 39.—Mining service not obtained. Lungs show a considerable degree of pigmentation. Death from pneumonia. One small chronic caseous focus in tracheo-bronchial gland. Right pleural effusion and some granulation tissue, possibly tuberculous. One small calcified nodule found near apex of left lung.

(256) Shangaan, *aet.* 24, new recruit.—Lobar pneumonia and an enteritis of undetermined origin. Bilharzial bladder and cirrhotic liver. The spleen was considerably enlarged and showed numerous carneous areas. These suggested tubercle but there was no definite caseation and it was only on microscopic section that it was found that they were definitely tuberculous. No other tuberculous lesion found. It is possible, in view of the opinions generally expressed *re* primary tuberculosis of the spleen, that some small glandular focus was overlooked, but it must have been very small, and this case must be regarded as nearly approaching a primary splenic tuberculosis as it is possible to meet with.

(258) Xosa, *aet.* 40.—Mining service not ascertained. Death from acute generalized peritonitis, origin not further determined. Had well-marked tuberculosis of clavicular, tracheo-bronchial, diaphragmatic, upper and lower retro-peritoneal and portal glands, but no obvious involvement of any organs. The tracheo-bronchial glands were practically tuberculo-silicotic in type and were probably the originally infected group. The lungs, it may be said, showed some excess of pigment, but nothing that could be called silicosis.

(289) Shangaan, *aet.* 54.—Mining service not obtained. Death from pneumonia. Had discrete tuberculo-silicotic nodules in both lungs and a tuberculo-silicotic condition of the thoracic, portal and upper retro-peritoneal glands.

(292) Shangaan, *aet.* 24.—New recruit. Death from pneumonia. Scarring at right apex and some pleural adhesions over left lung, possibly tuberculous. Definite tuberculous caseation in one of the tracheo-bronchial glands on the right side.

(306) Mchopi, *aet.* 25.—New recruit. Death from lobar pneumonia. Tuberculin test on arrival, positive. Lungs and thoracic glands quite free from pigment. An isolated caseo-calcareous gland was found in the mesentery of the uppermost loop of the jejeunum.

(327) Swazi, *aet.* 47.—New recruit. Lungs not suggestive of any previous service. Death from enteric fever. Showed two old densely-calcified masses, one in a gland of the paratracheal group, the other embedded in the pericardium.

(341) Nyambaan, *aet.* 35, with four years' service.—Death from septic abscess in lung. Tuberculin reaction PP six months before death. Had several caseous tracheo-bronchial glands and a caseous patch in one kidney.

(349) Zulu, *aet.* 50.—Service not ascertained. Cause of death not obvious. Had well-marked tuberculo-silicotic lesions in the tracheo-bronchial and upper retro-peritoneal glands, although only very slight lesions (pigmented scar at one apex) in the lungs. One of the tracheo-bronchial glands was breaking down and was on the point of perforating the oesophagus.

(355) Swazi, *aet.* 42.—Service not ascertained. Death from lobar pneumonia. Had slight tuberculo-silicotic lesions in lungs and tracheo-bronchial glands.

(358) Nyambaan, *aet.* 24.—New recruit. Death from lobar pneumonia. The tuberculin reaction was negative but one tracheo-bronchial gland was found to be caseous. Sections of the gland showed a healing tuberculous process but cultures yielded a growth of tubercle bacilli of human type.

(364) Shangaan, *aet.* 50.—Service not ascertained. Death from lobar pneumonia. Had tuberculo-silicotic tracheo-bronchial and upper retro-peritoneal glands, also recent caseation in one cervical gland.

(369) Shangaan, *aet.* 54.—Service not ascertained. Death from broncho-pneumonia. Had several small pigmented fibrous nodules, apparently healed tubercle, in different parts of the lungs.

(401) Shangaan, *aet.* 28.—Service not ascertained. Death from lobar pneumonia. Positive tuberculin reaction. The only thing noted at the post-mortem examination that was suggestive of tuberculosis was a porcellaneous thickening of the capsule of the spleen, a type of chronic inflammatory reaction which is suspect of being sometimes, at all events, tuberculous. Near the hilus of the spleen was a small body which was cut to see whether it was a splenunculus or a haemo-lymph gland. It proved to be the former and, to our surprise, also showed acute tuberculous lesions. These had not gone the length of caseation and to the naked eye raised no suspicion of tubercle. The true spleen was, unfortunately, not examined microscopically.

(406) Shangaan, *aet.* 48.—Service not ascertained. Death from gangrene of lung. Well-marked tuberculo-silicotic lesions in lungs, with much scarring. Tracheo-bronchial glands also markedly affected; one just below the bifurcation had broken down, established an oesophageal fistula, and was also on the point of opening into the left bronchus.

(420) Mchopi, *aet.* 25.—Service not ascertained. Death from dysentery. Extensive caseation in the lower retro-peritoneal glands, with an apparently more recent extension to the upper retro-peritoneal glands and slightly to the tracheo-bronchial glands.

(422) Mchopi, *aet.* 36.—Mining service two years eleven months. Death from empyaema. Tuberculin reaction, positive. Had slight caseation in two tracheo-bronchial glands.

(438) Pondo, *aet.* 47.—Service not ascertained. Death from typhus. Lungs had very little pigment in them, although there was a little, mostly sub-pleurally. The tracheo-bronchial glands were fairly heavily pigmented—practically tuberculo-silicotic in character—and there was definite caseation in one gland of the pancreatico-lienal group. The appearances suggested previous service some considerable time ago, the lungs having almost cleared themselves of pigment in the interval.

(441) Xosa, *aet.* 42.—Service three years eleven months. Death from lobar pneumonia. Lungs showed several fair-sized tuberculo-silicotic nodules; the tracheo-bronchial glands were also tuberculo-silicotic.

(444) Xosa, *aet.* 38.—Service four years six months. Death from lobar pneumonia. Slight tuberculo-silicotic lesions in the lungs and well-marked lesions in the tracheo-bronchial and upper retro-peritoneal glands. Breaking down of gland below the bifurcation of the trachea and establishment of an oesophageal fistula.

(447) Nyambaan, *aet.* 45.—Service not ascertained. Death from cancer of liver. Pigmented fibroid scar at the apex of the right lower lobe, presumably a healed tuberculous focus.

(452) Xosa, *aet.* 45.—Service, two years nine months. Death from lobar pneumonia. Slight tuberculo-silicotic lesions in lungs and tracheo-bronchial glands.

(457) Shangaan, *aet.* 45.—Service, four years one month. Death from broncho-pneumonia. Slight tuberculo-silicotic lesions in lungs and tracheo-bronchial glands.

(459) Msutu, *aet.* 45.—Service, six years nine months. Death from enteric fever. Slight tuberculo-silicotic lesions in the tracheo-bronchial glands only.

(462) Shangaan, *aet.* 22.—New recruit. Death from lobar pneumonia. Lungs not indicative of any previous service. Tuberculosis of tracheo-bronchial, pancreatic and portal glands. Histologically all the affected glands considerably fibrosed with a very striking hyaline degeneration of the fibrous tissue.

(464) Xosa, *aet.* 26.—Service, two years six months. Death from lobar pneumonia. Calcified tuberculo-silicotic tracheo-bronchial glands.

(M 3) Msutu, *aet.* 25, with one year's service.—Death from enteric fever. He had caseo-calcareous tracheo-bronchial glands, fibrosis of most of the groups of abdominal glands but without obvious caseation, and miliary tubercles in the spleen and liver.

(M 34) Shangaan, *aet.* 25, with four years nine months' service.—Death from acute dysentery. The apices of both lungs showed pigmented scars, the portal and upper and lower retro-peritoneal glands were caseous, and there were numerous caseous areas in the spleen.

(M 50) Shangaan, *aet.* 22, with one year's surface work on the mines.—Death from enteric fever. He had tuberculous glands on the left side of the neck, and the right suprarenal was tuberculous.

(M 54) Mchopi, *aet.* 34, with 3½ years' mining service.—Death from lobar pneumonia. There was a small area of early tuberculous caseation near the base of the right lung and the tracheo-bronchial glands showed characteristic tuberculo-silicotic appearances.

(M 79) Tonga, *aet.* 20, with six months' service.—Death from ulceration of urinary bladder and bilateral pyonephrosis. There was a small caseous focus at the apex of the left lung with caseous tracheo-bronchial glands and a slight direct spread into the hilus region of the right lung from these glands.

(M 94) Pondo, *aet.* 30.—Service not obtained. Death certified as being from oedema of the larynx. There were caseous cervical glands. No other lesions of any sort found.

(M 128) Tonga, *aet.* 55.—Service, three years six months. Death from chronic myocarditis and heart failure. Had scarred apices, presumably old healed tuberculous lesions.

(M 170) Fingo, *aet.* 52.—Service, five years eleven months. Death from lobar pneumonia. Had tuberculo-silicotic lesions in the tracheo-bronchial glands only.

(M 239) Mchopi, *aet.* 40.—Service, four years five months. Death from acute pericarditis (non-tuberculous). Had slight tuberculo-silicotic lesions in lungs and tracheo-bronchial glands.

(A 5) Xosa, *aet.* 40.—Service not ascertained. Accident. Had slight tuberculo-silicotic lesions in lungs and tracheo-bronchial glands.

(A 7) Mchopi, *aet.* 28.—Died two months after admission to hospital for an injury to one knee. Death partly from septic infection, partly from an acute tuberculous spread which had apparently taken place during the two months. He had tuberculo-silicotic lesions in the lungs and various gland groups with recent fairly extensive caseation in the spleen, liver and kidneys.

(A 9) Pondo, *aet.* 37.—Service not ascertained. Accident. Slight tuberculo-silicotic lesions in the tracheo-bronchial glands only.

(A 13) Mchopi, *aet.* 33.—Service not ascertained. Slight silicotic lesions in lungs and tuberculo-silicosis of tracheo-bronchial and pancreatic glands.

(A 16) Mchopi, *aet.* 26.—Service not ascertained. Accident. Slight tuberculo-silicotic lesions in the tracheo-bronchial glands only.

(A 17) Shangaan, *aet.* 21.—Service, ten months. Accident. Very little pigment in the lungs. One caseous clavicular gland.

(A 21) Mchopi, *aet.* 30.—Service not ascertained. Accident. Slight tuberculo-silicotic lesions in tracheo-bronchial glands only.

Notes on these 62 Cases.

These cases showing tuberculous lesions but dying from causes other than tuberculosis may conveniently be classified into three groups according to their length of service, viz. :—

Group I, with over one year of service, the evidence being either certain (documentary) or probable (pathological).

Group II, with service of under one year's duration.

Group III, new arrivals.

Group I.—34 cases are regarded as falling in this group (18 certain, 16 probable). Of these 34, 29 had more or less well-marked tuberculous or tuberculo-silicotic lesions, and would probably have died sooner or later from tuberculosis had the evolution of the disease not been cut short by death from other causes.

In 5 cases (142, 229, 369, 447 and M 128) the lesions were slight and apparently completely arrested or healed. They may be regarded, therefore, as evidence that tuberculosis may become arrested in the Native.

Case 203 is interesting as possibly an example of the alleged antagonism between heart disease and tuberculosis, but it is fairly clear that the tuberculosis played an actual part in the end in the causation of death through invasion of the wall of the auricle.

In 2 cases (406 and 444) with tuberculo-silicosis there were fistulae established between the oesophagus and breaking down tracheo-bronchial glands, and in a third case (349) a similar fistula was just on the point of forming.

Case 438 is a good example of lungs which had cleared themselves of pigment in the time between periods of mining service.

Group II.—16 cases with evidence of mining service, but either certainly or probably of under one year's duration. Of this group, 8 cases (66, 214, 215, 222, M 3, M 50, M 79 and A 17) showed active tuberculosis which would probably have spread had its course not been interrupted through death from other causes.

Case 57 is possibly another example of the antagonism between heart disease and tuberculosis, the tuberculous lesion being very limited, although this might equally have been because it was only of quite recent origin.

Case 148 is an example of a healed mesenteric gland lesion, but also showing slight lesions in thoracic glands.

Case 401 shows (?) chronic and recent acute tuberculosis limited in its distribution to the spleen.

In Case M 94, the tuberculous glands in the neck appeared to be the only lesion present beyond the fatal acute oedema of the larynx, and the two conditions may have been connected.

Case A 17 is a good example of commencing tuberculosis, limited to a "clavicular" gland, of the type reported by Borrel as commonly seen amongst the Senegalese troops in France.

Group III.—12 cases, new arrivals, but in 3 of these there was unmistakable evidence of previous service. Case 70 would, indeed, practically certainly soon have died from active tuberculosis. Case 99 had some tuberculo-silicotic foci in the lungs and tuberculo-silicotic tracheo-bronchial and pancreatic glands, but no signs of any very active tuberculosis. Case 115 had evidence of active tuberculosis in hilus and tracheo-bronchial glands, but nowhere else. It was a case which could probably not have been detected by stethoscopic examination, but might have been by X-ray examination.

The remaining 9 cases are of greater interest, as they were certainly new arrivals with no previous service and may, therefore, be regarded as definite examples of raw recruits arriving on the Rand already infected with tuberculosis.

Case 88 showed a quite recent development in mesenteric glands, but it is difficult to answer the query: Did this development begin just before leaving his kraal, on the journey to Johannesburg, or in the ten days or so during which he was in Johannesburg (mainly in hospital prior to his death)? Another point of interest about the case is the situation of the glands in which the infection occurred, viz., glands in the mesentery of the highest loop of the jejeunum.

Case 306 is another example of tuberculosis limited to the same glands, but in this instance the lesion was obviously of considerable age, and must have been acquired in the kraal.

Case 193 is a clear case of infection in the thoracic glands, brought with him on first arrival on the Reef. This case, also, was one which would probably have defied stethoscopic detection, but might have been detected by X-rays.

Cases 234 and 327 furnish further evidence that healed tubercle may be found in the Native.

Case 256 is interesting as a case of apparently primary and isolated tuberculosis of the spleen. We are not prepared to assert that a microscopic or X-ray examination would not have revealed some more primary (*sic*) focus in lung-tissue or in some gland, but any such lesion, if present, must have been very small, as a careful search showed no obvious macroscopic lesion either in the lungs or in any other organ or in any of the gland groups.

Case 292 is another clear case of infection being brought to the Reef from the kraal—in this instance lung-scarring with caseation in the corresponding tracheo-bronchial gland.

Case 358 was a Native *aet.* 24 who gave a negative tuberculin reaction but who proved to have one caseous tracheo-bronchial gland from which tubercle bacilli were grown.

Case 462 showed lesions of a rather curious chronic type in both tracheo-bronchial and abdominal glands.

538 Cases in which Tuberculosis was the Cause of Death.

Group B.—200 Cases associated with Silicosis.

In 200 cases, *i.e.*, a third of the whole, the tuberculosis was associated with a greater or lesser degree of silicosis.

The tribal distribution of the silicotic cases is shown in Table III on p. 378.

As silicosis is a disease which takes some time to develop, it would naturally be expected that the cases would be found mainly amongst boys of older age groups, and in those with longer periods of service, as compared with the incidence of tuberculosis pure and simple. That this is so is brought out by the figures in Table IV, which shows the age-distribution by decennial periods. Compare with Table VIII on p. 397 and Table X on p. 404.

TABLE IV.

Age Distribution of Cases of Tuberculosis Associated with Silicosis.

Under 20	0
20–29	14
30–39	50
40–49	113
50 and over	19
Not ascertained ...	4
	200

Even allowing for the fact that ages as given are not exact, it may be taken that this table shows with reasonable certainty that the great majority of the silicotic cases occur in subjects in the thirties and forties.

As regards length of service, returns were not obtainable, or were deliberately excluded for reasons already referred to on p. 377, in 45 cases. In the remaining 155, the mean period of service works out at 6 years 3½ months, the extremes being 1 year 5 months and 21 years 2 months. But, as already explained, also on p. 377, it is impossible to be certain as to the accuracy of all records of service. It is practically impossible that they should be overstated, but they may be understated. In the case mentioned as having 1 year 5 months' service, the silicotic lesions were of the very earliest stage detectable macroscopically. Compare with Table IX (p. 398) and Table XI (p. 404).

For the purposes of this report, which is concerned essentially with tuberculosis, it is not necessary to deal minutely with the pathology of silicosis further than to consider its relationship to tuberculosis and the modifications which the combination of the two conditions imposes upon the latter.

The inhalation of silica on the Rand is so intimately associated with the inhalation of carbon that silicosis is always a pigmented disease, and it becomes convenient practically to speak of silicosis in terms of pigmentation, although always bearing in mind that it is not

the pigment which is the cause of the pathological processes, but the associated silica. The essential feature of silicosis is fibrosis, and, therefore, it may be taken that pigmentation *plus* fibrosis means silicosis.

The earliest visible manifestation of silicosis may take the form of a fairly uniform diffuse pigmentation of the lungs. Microscopically, there will be found to be a fine fibrosis in and around the interlobular, peribronchiolar, and perivascular lymphatics. This fibrosis may be sufficient to be just visible and palpable, and unless it is so, the case is not regarded as definitely one of silicosis.

More commonly, instead of the diffuse pigmentation and fine fibrosis, the pigment tends to become aggregated in the form of discrete black specks dotted more or less evenly throughout the whole of the lung surface and under the pleurae. These specks are not distinguishable at first by touch from the rest of the lung substance, but as they increase in size and the degree of fibrosis increases, they become definitely palpable as hard little nodules and on a freshly cut lung surface they project visibly above the surrounding lung substance. These simple silicotic nodules are shiny and of a uniformly jet black colour in the lung substance ; and they attain a size up to about 2m.m. in diameter. Sub-pleurally, they tend to be more flattened out, not so raised but of a greater diameter and frequently have a white centre of unpigmented fibrous tissue, with a surrounding pigmented black ring.

It is doubtful if uncomplicated silicotic nodules in the lung ever get much bigger than about 2m.m. in diameter. Anything bigger than this may be looked upon with suspicion as being caused partly by an infective element, tuberculous or otherwise, in addition to the silicosis. An increase in the degree of simple silicosis is expressed rather by an increase in the number of the nodules than by an increase in their size.

The association of silicosis and tuberculosis may take any one of several forms (see footnote on p. 163) :—

(*a*) Their development may be independent, *i.e.*, one may have simple silicosis in the lungs and the development of a focus or foci of caseating tuberculosis quite unconnected with each other. This is sometimes seen, but it is not common.

(*b*) The tuberculous element may be definitely more prominent than the silicotic. This combination takes the form of a caseating area in or about which most of the pigment in the lung collects. There is never much fibrosis accompanying this accumulation of pigment, and it seems more reasonable to speak of this condition as pigmented tuberculosis rather than as tuberculo-silicosis, although there may be a slight silicotic element in it.

(*c*) The development of the two conditions may be intimately associated, taking the form of a mixed process which gives rise to very characteristic lesions generally spoken of as " tuberculo-silicosis."

Tuberculo-silicosis may manifest itself in the following forms :—

(1) Discrete nodules varying in size from about 2–6m.m. in diameter, usually very hard, more or less pigmented, but never of the shiny jet-black colour of the simple silicotic nodule. They are best described as of a steel-grey colour—dark steel-grey or light steel-grey, as the case may be—never quite uniform throughout the whole nodule but rather mottled or shading from one part to another. These variations in colour are accounted for by varying proportions of pigmentation, fibrosis, fatty degeneration and caseation, the four conditions which go to make up the tuberculo-silicotic nodule.

(2) Larger areas which are obviously composed of discrete nodules which have spread and met and have, to some extent, coalesced, but in which the outlines of the originally discrete nodules are still discernible.

(3) Gross areas of dense fibrotic consolidation which may be the end result of completely fused discrete nodules, but which more often look as if they represented a development which had been continuous over a fair-sized area from the outset. These areas may measure anything up to 7 or 10cm. across ; there may be only one, involving part or even the whole of one lobe, or there may be several smaller areas in different parts of both lungs. Combinations of the three types of tuberculo-silicotic lesions may also be encountered. The more massive developments, it may be said, are now rather rarely seen and only in cases with very long service.

(4) Caseation may go on to excavation even in the smaller discrete nodules, but it is more commonly seen in the gross areas. When excavation occurs, and sometimes even without it, there may be a spread of the tuberculous process beyond the limits of the tuberculo-silicotic foci, either as a limited acute caseation in the immediate neighbourhood of the tuberculo-silicosis, or as a more generalized caseating phthisis or miliary tuberculosis.

Great variations in the picture presented by tuberculo-silicosis are, therefore, possible, and in the analysis given below an attempt is made to indicate the extent of these variations.

Tuberculo-silicosis in Lymphatic Glands.

The lesions of silicosis and tuberculo-silicosis are not limited to the lungs but may be found also in various groups of lymphatic glands. Glands (especially the tracheo-bronchial and hilus glands, but not these exclusively) may be pigmented but still quite soft ; they may be pigmented and fibrosed, *i.e.*, silicotic, or they may show pigmentation, fibrosis and caseation, *i.e.*, tuberculo-silicosis. In appearance, such glands closely parallel the features of the lung lesions. In simple silicosis they are uniformly black and hard ; in tuberculo-silicosis they are not uniformly black, but show the same steel-grey tints, varying in shade from part to part of the gland Hardening is the rule, but

locally there may be softening where caseation predominates. Calcified foci are also sometimes present, as, indeed, they are sometimes also in pulmonary tuberculo-silicotic lesions.

Just as in tuberculosis uncomplicated by silicosis it is no uncommon thing to find obvious caseation in the tracheo-bronchial glands with either no foci in the lungs or foci only discernible by microscopic or X-ray examination, so, in the case of tuberculo-silicosis, it is not rare to find the first macroscopic evidence in the tracheo-bronchial glands. It is distinctly less common to find tuberculo-silicosis of any considerable degree of development in the lungs without a corresponding involvement of the tracheo-bronchial glands.

Any or all of the sub-groups of the tracheo-bronchial group may show tuberculo-silicotic changes, *i.e.*, the broncho-pulmonary or hilus glands lying between the branches of the bronchi, the superior and inferior tracheo-bronchials lying respectively above and below the main bronchi, and the para-tracheals lying higher up alongside the trachea.

Tuberculo-silicotic changes are, however, not limited in their distribution to the lungs and the tracheo-bronchial glands ; they may be found in other glands in addition, both higher up and lower down.

Higher up they may be found not uncommonly in the " clavicular," in the sternal or internal mammary glands, and occasionally in the lower cervical glands in the anterior triangle of the neck. (NOTE : For a definition of the term " clavicular," see p. 399.)

Lower down they may be found (*a*) in the diaphragmatic glands above the diaphragm. These glands occur around the reflection of the pericardium from the diaphragm, one being very common just behind the xiphisternum and others close to the oesophagus. (*b*) Below the diaphragm, very frequently in the portal glands lying in the hepatic fissure and in the glands which, for convenience, we have grouped together under the terms " upper retro-peritoneal " or " pancreatic." This really includes three distinct groups, viz., the coeliac group of the pre-aortic glands around the origin of the coeliac artery, the paracardial glands lying like a chain of beads round the neck of the stomach, and the pancreatico-lienal glands on the upper border of the pancreas. Very occasionally tuberculo-silicotic changes extend a little lower still into some of the lower retro-peritoneal (superior mesenteric group of the pre-aortic) glands below the level of the pancreas.

When tuberculo-silicotic changes are at all well developed in the lungs and tracheo-bronchial glands, similar changes are so commonly to be found in the diaphragmatic, portal and " pancreatic " glands that we have come to look upon this combination as " the normal zone of tuberculo-silicosis " or, " the tuberculo-silicotic zone."

The following table (Table V) shows numerically the frequency of occurrence of the various types of silicotic and tuberculous lesions in the lungs.