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**THE EPIDEMIOLOGY OF SILICOTIC CASES  
RECORDED AT GOLD FIELDS GHANA LIMITED  
HOSPITAL, TARKWA FROM JANUARY 1973 TO  
DECEMBER 1996.**

**SUBMITTED BY KWAKU A. B. A. KARIKARI**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE  
MASTER OF PUBLIC HEALTH DEGREE.**



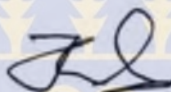
**SCHOOL OF PUBLIC HEALTH, UNIVERSITY OF GHANA,  
LEGON, ACCRA.**

**JUNE 1997.**

## **DECLARATION.**

I, Kwaku A. B. A. Karikari, declare that this dissertation is an original work done by me and that I have not either in part or wholly presented it anywhere for award of degree or publication.

Signed-----



(Kwaku A. B. A. Karikari)



**NAME OF ACADEMIC SUPERVISOR- DR. A. B. QUAINOO.**

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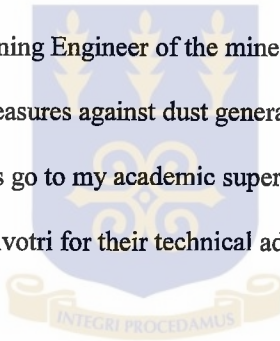
## **DEDICATION.**

This dissertation is dedicated to my uncle, Mr. Enwi Kofi Cobbinah, my father, Mr. Kofi Karikari and my wife, Ama Kyere.



## **ACKNOWLEDGEMENTS.**

My great gratitude and thanks go to Dr. Tuffuor-Kwarteng, the Chief Medical Officer for **GGL** who offered me a lot of technical advice and also offered me a lot of assistance during the collection of my data. My thanks also go to Mr. Francis Arthur, the Training Manager of **GGL**, Mr. Stephen Aidoo, the Senior Ventilation Officer of the mine and Mr. Joseph Holdbrook Smith, a Mining Engineer of the mine for their guidance during my data collection on the safety measures against dust generation and inhalation at the mine. Finally my gratitude and thanks go to my academic supervisor, Dr. A. B. Quainoo and my field supervisor, Dr. T. S. M. Avotri for their technical advice and guidance during all the phases of my study.



**TABLE OF CONTENTS.**

<b><u>TOPIC</u></b>	<b><u>PAGE</u></b>
Title page	
Declaration	i
Dedication	ii
Acknowledgements	iii
Table of contents	iv
List of tables	x
List of figures and illustrations	xiii
Abbreviations	xiv
Abstract	1
CHAPTER ONE	3
1.0. Introduction	3
1.1. The problem statement	5
1.2. Objectives of the study	7
1.2.1. Broad objective	7

1.2.2. Specific objectives	8
1.3. Justification for the study	9
1.4. Explanation of terminology	10
1.5. Research Methods	11
1.5.1. Type of study	11
1.5.2. Study population and units	12
1.5.3. Sampling	13
1.5.4. Data collection techniques and tools	15
1.5.5. Data analysis and dissemination	17
1.5.6. Limitations of the study	18
1.5.7. Ethical issues	19
1.6. Literature Review	19
1.6.1. Epidemiology of silicosis	19
1.6.1.1. Occupational groups and individuals at risk of developing silicosis	20

1.6.1.2. Prevalence rates and incidence of silicosis in some industries and countries	21
1.6.1.3. Trend of silicosis in some countries and industries	24
1.6.1.4. Comparison of incidence and prevalence rates of silicosis among various occupational groups	25
1.6.1.5. Sex distribution of silicotic cases	27
1.6.2. Personal protective and general safety measures undertaken by mining companies and individuals to reduce exposure of miners to dust.	27
CHAPTER TWO	30
2.0. Background information about the Wasa West district, the Gold Fields Ghana Limited mine and the silicosis situation in the Wasa West district.	30
2.1. Profile of Wasa West District relevant to silicosis epidemiology	30
2.1.1. Physical Characteristics of the Wasa West District	30

2.1.1.1.	Location and size of the Wasa West District	30
2.1.1.2.	Climate	33
2.1.1.3.	Geology	33
2.1.2.	Population	33
2.1.3.	Economic activities in the district	34
2.2.	Mining at Gold Fields Ghana Limited ( <i>GGL</i> )	35
2.2.1.	History of the mine	35
2.2.2.	Major sections of the mine	36.
2.2.3.	Sequence of major activities carried out during mining at the mine.	37
2.2.4.	Activities during which mineworkers at <i>GGL</i> are at risk of exposure to large quantities of dust at <i>GGL</i>	39
2.3.	The problem of silicosis in the Wasa West District	39
2.4.	Gold Fields Ghana Limited ( <i>GGL</i> ) Hospital	39
2.5.	How silicosis is diagnosed at <i>GGL</i> Hospital	40
	CHAPTER THREE	43

3.0. Findings of the study	43
3.1. Distribution of total number of silicotic cases recorded at <i>GGL</i> Hospital from 1973 to 1996 by place of work	43
3.2. Sex distribution of silicotic cases recorded at <i>GGL</i> Hospital From 1973 to 1996	45
3.3. Trend of annual incidence rates of silicosis among <i>GGL</i> workers from 1973 to 1996	45
3.4. Comparison of trends of annual incidence rates of silicosis among <i>GGL</i> underground and among <i>GGL</i> surface workers from 1973 to 1996	47
3.5. Period incidence rates of silicosis from 1973 to 1996 among various occupational groups of <i>GGL</i>	51
3.6. Comparison between mean annual incidence rates of silicosis among <i>GGL</i> workers for the periods 1973-86 and 1987-96	55
3.7. List of general safety and personal protective measures in place at <i>GGL</i> aimed at reducing the amount of dust	60

inhaled by workers	
3.7.1. Compliance with use of respirators by risk	66
groups at <i>GGL</i>	
CHAPTER FOUR	69
4.0. Discussions and Conclusions	69
4.1. Discussion	69
4.1.1. Silicosis among small scale miners	69
4.1.2. Sex distribution of silicotic cases	70
4.1.3. Trend of annual incidence rates of silicosis	71
among <i>GGL</i> mine workers	
4.1.4. Mean annual incidence rates of silicosis among	77
various occupational groups of <i>GGL</i>	
4.1.5. Safety measures at the <i>GGL</i> mine and recommendations	78
4.2. Conclusions	82
References	85
Appendix	88

## LIST OF TABLES.

<u>TABLE</u>	<u>PAGE</u>
1.1. Number of workers of various occupational groups at <i>GGL</i> at risk of dust exposure observed during survey	16
1.2. Prevalence rates of silicosis in some industries in China as at 1985	22
1.3. Prevalence rates of silicosis in some industries in India	22
1.4. Overall incidence rates of silicosis and silicotuberculosis for a 14-year period for <i>TGL</i> and for a 10-year period for <i>AGC</i>	24
1.5. Incidence of silicosis and silicotuberculosis in various occupational groups of <i>TGL</i> for period 1973-86	26
3.1. Distribution of total number of cases of silicosis recorded at <i>GGL</i> Hospital from 1973 to 1996 by place of work	43
3.2. Number of silicotic cases reported annually at <i>GGL</i> Hospital among small-scale miners, <i>GGL</i> underground workers and <i>GGL</i> surface workers from 1973 to 1996	44

3.3. Annual incidence rates of silicosis among workers of <i>GGL</i> from 1973 to 1996	46
3.4. Period (1973-96) incidence rates of silicosis among the various occupational groups of <i>GGL</i>	52
3.5. Comparison of 1973-96 period incidence rates of silicosis among <i>GGL</i> underground workers and <i>GGL</i> surface workers	54
3.6. Comparison of 1973-96 period incidence rates of silicosis among <i>GGL</i> underground workers and vulnerable <i>GGL</i> surface workers	55
3.7. Mean annual incidence rates of silicosis among <i>GGL</i> workers for periods 1973-86 and 1987-96	56
3.8. Mean annual incidence rates of silicosis among underground workers and among surface workers of <i>GGL</i> for the periods 1973-86 and 1987-96	57
3.9. Mean annual incidence rates of silicosis among various occupational groups of <i>GGL</i> for periods 1973-86 and 1987-96	58
3.10. List of observed general safety and personal protective measures in place at <i>GGL</i> against dust inhalation by workers	61

3.11.	Compliance with use of respirators at <i>GGL</i>	67
4.1.	Percentage distribution of the annual labour force of <i>GGL</i> from 1973 to 1986 by length of service in the company	73

**LIST OF FIGURES AND ILLUSTRATIONS.**

<b><u>FIGURE</u></b>	<b><u>PAGE</u></b>
2.1. Wasa West District in the Ghanaian context	31
2.2. Wasa West District in the Western Regional context	32
3.1. Trend of 5-year moving average incidence rates of silicosis among <i>GGL</i> workers from 1973 to 1996	47
3.2. Trend of annual incidence rates of silicosis among <i>GGL</i> underground workers and among <i>GGL</i> surface workers from 1973 to 1996	48
3.3. Trend of annual incidence rates of silicosis among underground <i>GGL</i> workers and among vulnerable <i>GGL</i> surface workers from 1973 to 1996	50
3.4. Trend of 5-year moving average incidence rates among <i>GGL</i> underground workers and vulnerable <i>GGL</i> surface workers from 1973 to 1996	51
3.5. Mean period (1973-96) annual incidence rates of silicosis among various occupational groups of <i>GGL</i>	53
3.6. Mean annual incidence rates of silicosis among various occupational groups of <i>GGL</i> for periods 1973-86 and 1987-96	59

## **ABBREVIATIONS.**

ABA	Amalgamated Banket areas
ACGIH	American Conference of Governmental Industrial Hygienist
AGC	Ashanti Goldfields Corporation
CNSA	Caisse Nationale Suisse d'assurance en cas
DHMT	District Health Management Team
GGL	Gold Fields Ghana Limited
ODMWA	Occupational Diseases in Mines and Work Act
PNDC	Provisional National Defence Council
SGMC	State Gold Mining Corporation
TGL	Tarkwa Goldfields Limited
WHO	World Health Organisation

## **ABSTRACT.**

The annual distribution, distribution by place of work and by occupational group of all the silicotic cases recorded at Gold Fields Ghana Limited (*GGL*) Hospital, Tarkwa from 1973 to 1996 were analysed. The trends of annual incidence rates of silicosis among *GGL* workers as a whole and separately among *GGL* underground workers and *GGL* surface workers were also analysed for the period. Data was obtained from *GGL* Hospital periodic reports and *GGL* Personnel Department records. Safety measures in place at the *GGL* mine against dust generation and inhalation were also observed and described.

One hundred and sixty (160) cases of silicotic cases were recorded at the hospital during the study period. Of these, 133 (83.1%) were underground workers of *GGL*; 19 (11.9%) were surface workers of *GGL* and 8 (5%) were small-scale miners in the Tarkwa area. All the cases were males.

The annual incidence rate of silicosis among *GGL* workers fell gradually from 6.1 cases per 1000 per year in 1993 to 0.4 cases per 1000 in 1993 and to 0 case per 1000 per year from 1994 to 1996.

For the study period, the highest mean annual incidence rate of silicosis among *GGL* workers was observed among the mill crushers (13.4 cases /1000/year). The second and third highest rates were found among the drillers (11.1

cases/1000/year) and the blastmen (7.7 cases/1000/year) respectively.

Considering the underground workers as one group and the surface workers as another group, it was observed that the mean annual incidence rate of silicosis among the underground workers of the mine was 5.3 times higher than among the surface workers (3.7 and 0.7 cases/1000/year respectively). However, when among the surface workers, one considers only the vulnerable occupational groups (exposed to large quantities of dust) of mill crushers and other mill workers, then the mean annual incidence rates are almost the same for both the underground and the vulnerable surface workers (3.7 and 3.6 cases/1000/year respectively).

The safety measures in place at the *GGL* mine against dust generation and inhalation are good ventilation, exhaust ventilation systems, wet methods of drilling, water blasts to allay dust and use of respirators. Good supervision and continual education of workers about the hazards of mining are other ways of minimising the exposure of the workers to dust.

It is recommended dust sampling should be re-introduced at the mine for protective and research purposes. Regular supply of appropriate respirators to workers as well as emphasis on the attention to the environmental working conditions of the drillers is also recommended.

## CHAPTER ONE.

### 1.0. INTRODUCTION.

The purpose of this study is to find out the occupational groups in the Tarkwa area who are at risk of developing silicosis and the trend and magnitude of incidence rates of silicosis among various occupational groups of Gold Fields Ghana Limited (*GGL*) mines at Tarkwa in the Western Region of Ghana from 1973 to 1996. It is also intended to find out the various measures that have been instituted by the mining company in order to reduce the amount of dust generated, the amount of dust that becomes airborne and the amount of dust inhaled by workers during mining activities. For this research, only cases of silicosis reported at *GGL* Hospital, Tarkwa were chosen for reasons to be mentioned in Chapter 2, section 2.4 of this work. The *GGL* Hospital is a 60-bed hospital sited at the *GGL* mine and patronage is open to all patients irrespective of their place of work or abode.

Silicosis is the name given to the fibrotic disease of the lungs caused by the inhalation of dust containing free silica (silicon dioxide) or quartz. It is one of a group of fibrous or non-fibrous diseases of the lungs called "*Pneumoconioses*" caused by different kinds of dust. Anatomically, the response and damage to the lungs will occur to a varying degree in the large or small conducting airways, the respiratory parenchyma, the pulmonary vascular beds, the pleura and the interstitial reticuloendothelial system. The interstitial reticuloendothelial reaction

to silica and other dust is seen when the dust particles are in the 2 to 5 micron range (1).

According to the time period of exposure to silica dust before the development of clinical picture, we have 3 types of silicosis (1) namely;

- a) Acute silicosis- this condition is very rare and is found within weeks or months of exposure to very high levels of silica dust. The main occupation giving rise to this state is sandblasting, sandpulverising, rockdrilling in quarries and tunnels, lens grinding and manufacture of abrasive soaps.
- b) Accelerated silicosis- this is the term used for the disease that occurs within 5-10 years of indulging in an occupation with a high risk of exposure such as has been described in sand blasters.
- c) Chronic silicosis- develops gradually and shows symptoms after a long time of exposure more than 10 years.

Silicotuberculosis is a type of silicosis in which tuberculous infection (infection by *Mycobacterium tuberculosis bacilli*) supervenes on silicosis.

Silica is a tetrahedron crystal of silicon dioxide ( $\text{SiO}_2$ ) and is found in most rock particles. Thus, granite is up to 70% silica, slate 40% and sandstone itself is almost pure silica. Mining is one of the activities during which such silica dust is generated and inhaled by miners. The majority of metallic ores which are mined are found in silica-containing rock and thus recovery of such ores involves a risk

of developing silicosis (2).

Underground gold mining activities on the concessions being mined by *GGL* started in 1878. Small-scale mining has also been practised in the Tarkwa area for some time. Miners have over the years been exposed to the hazards of mining including the exposure to silica dust. *GGL* Hospital reports indicate that silicosis exists in the Tarkwa area. This forms the basis of this study.

### 1.1. The problem statement.

- a) Tarkwa is the administrative capital of the Wasa West District. It and its surrounding areas are a major gold mining area. The concession for *GGL* has been mined underground for more than a century and many workers have been exposed to variable degrees of dust. Small-scale mining is booming in the area and within a short period, these small-scale miners are exposed to large concentrations of dust because they do not protect themselves from dust. It is known that the majority of metallic ores which are mined are found in silica-containing rocks and thus recovery of such ores involves a risk of developing silicosis (2). The Tarkwaian system of rock which also contains a lot of silica, is concentrated mainly at the southwestern part of Ghana in the Tarkwa area where it outcrops in a north east-south west trending belt (3).

Clinical records at *GGL* Hospital indicate that the problem of silicosis exists among miners in the area. Tuffuor-Kwarteng (4) did an analysis of the period incidence rates and annual trend of silicosis among the workers of *GGL* (then

called Tarkwa Goldfields Limited) for the period 1973-86. He observed a falling trend of annual incidence rates over the years from 1973 to 1986. A glance through the records at the **GGL** Hospital indicates that the problem of silicosis persisted after Tuffuor-Kwarteng's work. It is therefore appropriate to carry out another and more involving analysis of the trends of annual incidence rates of silicosis and period incidence rates among the workers of different sections of the mine and among the various occupational groups of the mine from 1973 to 1996.

In Tuffuor-Kwarteng's work, silicosis data was on only workers of the then Tarkwa Goldfields Limited (**TGL**). It is important to examine the records of the hospital from 1973 to 1996 to see whether there are any other occupational groups outside **GGL** who are at risk of developing silicosis.

With silica dust being a major occupational hazard among mine workers at, it is expected that the Management of the mine would take steps that ensure that dust inhaled by the workers is minimal in quantity. The Mining Regulations of Ghana, 1970, L.I. 665 (5) makes provision to guide employers and employees against excessive air-borne dust that may cause silicosis. The Regulations 147 to 154 inclusive are specific to control of dust. It would be appropriate by this study, to find out all measures that have been introduced in the mines to minimise exposure of workers to dust and relate it to the problem of silicosis at the mine. Recommendations may then be made on further measures necessary to eliminate the hazard of silica dust in the mines.

To summarise, the following are the problems to be tackled in this study:

- a) Identifying occupational groups in the Tarkwa area at risk of developing silicosis.
- b) Analysing the trend of annual incidence rates of silicosis among workers of the main sections of the *GGL* mine from 1973 to 1996.
- a) Analysing the period incidence rates (from 1973 to 1996) of silicosis among various occupational groups at *GGL*.
- b) Finding out the general safety and personal protective measures instituted at the mines to reduce the exposure of workers to dust.
- c) Exploring other safety measures which, when undertaken by the *GGL* mines could further reduce the hazard of silica dust in the mines.

## **1.2. Objectives of the study.**

### **1.2.1. Broad objective.**

The broad objective of the study is to identify the various occupational groups in the Tarkwa area at risk of developing silicosis, study and compare the trends of annual incidence rates of silicosis among underground and surface workers, compare the period incidence rates among various occupational groups at *GGL* and observe measures taken by the *GGL* management to protect the workers against exposure to silica dust.

### ***1.2.2. Specific objectives.***

In order to achieve the broad objective of the study, the following specific objectives would be pursued:

- a) To calculate the proportion of the total number of silicotic cases reported at **GGL** Hospital from 1973 to 1996, who were not workers of **GGL** and identify the occupations of these cases.
- b) To show the sex distribution of the total number of silicotic cases reported at the **GGL** Hospital from 1973 to 1996.
- c) To show the trend of annual incidence rates of silicosis among **GGL** workers from 1973 to 1996.
- d) To show and compare the trends of annual incidence rates of silicosis among **GGL** underground workers and among **GGL** surface workers.
- e) To compare the period (1973-96) mean annual incidence rates of silicosis among various occupational groups of **GGL**.
- f) To compare the mean annual incidence rates of silicosis among **GGL** workers for the periods 1973-86 and 1987-96.
- g) To compile a list of the general safety and personal protective measures undertaken at **GGL** to reduce the amount of dust inhaled by workers with an

indication of when these measures were introduced.

- h) To make recommendations on how to minimise or eliminate the risk of developing silicosis among workers of *GGL*.

### 1.3. Justification for the study.

Gold is one of the major foreign exchange earners for Ghana. Gold mining therefore, has to go on in the country to create jobs and earn the country foreign exchange. Gold mining activities, however, do not have to go on at the expense of human resource and ecological environment of the country. Efforts have to be made to detect all hazards associated with the activity. A lot of research has been undertaken and many of the hazards in gold mining have been detected. Silica dust generated in the course of mining is one of the major hazards both in the organised mining corporations and especially in small-scale mining. We have moved from an era when workers were not protected much from this hazard to an era when the formal gold sector has put in place measures to protect the workers from the dust. Silicosis usually develops several years of exposure to silica dust. It therefore takes several years after institution of protective measures to see the effect of the measures. Tuffuor-Kwarteng's work indicated a falling trend of silicosis at the then *TGL*. The rationale of this study is to carry out an up-to date analysis of the silicosis situation in the Tarkwa area as indicated in the problem statement and objectives of the study. Apart from being an academic exercise, it will give the *GGL* Management a basis of assessment of the protective measures

against silica dust generation and inhalation in the company. The findings can also act as a basis for educating the workers of the mines about the importance of personal and other protective measures during mining activities.

It is suspected that some of the workers of the company do part-time small-scale mining. With education, these people may start protecting themselves during small-scale mining activities and also educate the full-time small-scale miners about the dangers of exposure to silica dust and the benefits of self-protection and proper environmental housekeeping. The findings can also act as the basis for health education activities by the Wasa West District Health Management Team (*DHMT*) and occupational physicians in the area.

#### **1.4. Explanation of terminology.**

For the purpose of this study, the following terminology used in a subjective sense are explained as follows:

- a) **Large quantities of dust-** Ideally, the measured levels of respirable dust (dust particles of aerodynamic diameters between 0.5 and 5 microns) in the environment should have been used as a guide for the level of dust in the atmosphere. However, for this study, because dust sampling is not performed at the GGL mine, by large quantities of dust is meant visible dust to which the workers are exposed when their routine daily activities stir up the soil and rocks. The assumption here is that, given the geology of the Tarkwa area, there is a lot of silica in the dust to which the workers are exposed.

- b) Gold Fields Ghana Limited (**GGL**)- This company took over mining at the concession only 4 years ago. However, the study is concerned with what has been happening at the concession site where **GGL** is currently operating since mining on the concession started years ago. By the events and staff of **GGL**, one is referring to events and staff of the concession from the period of previous administrations of the concession to the present.

## 1.5. Research Methods.

### 1.5.1. Type of study.

The first part of the study is a descriptive study of silicotic cases diagnosed at the **GGL** Hospital from 1973 to 1996 using secondary data from periodic reports and office records. The second part of the study is an exploratory study of

- a) the permanent structures in place at **GGL** to reduce dust generation and flight of dust into the air
- b) Safety measures undertaken by workers while at work to reduce dust generation and flight of dust into the air
- c) Personal protective measures by workers minimise dust inhalation at the mine and the level of compliance with personal protective regulations among risk occupational groups.

### ***1.5.2. Study population and units.***

For the descriptive study, the study population comprised all non-*GGL* workers who patronised the *GGL* Hospital for the period 1973-96 and all the workers of *GGL* during the period.

For the exploratory study of the safety structures in place at the mine against the generation, flight of dust into the air and inhalation of dust, the study units were the underground section (which consists of three shafts- the Ackon vertical shaft, the Apinto vertical shaft and the Fanti inclined shaft) of the mine and the sections of the mine at the surface where it is known that a lot of dust is generated during activities (the crushing plant section, the Assay and the ball mill section).

For the exploratory study of the safety measures undertaken by workers to reduce dust generation and flight of dust into the air while at work, the study population were the workers in the underground section of the mine and those in the crushing plant section, the Assay and ball mill section. The current total workforce in these hazardous sections is 993.

For the exploratory study of the personal protective measures against dust inhalation by workers at the mine and compliance with them, the study population comprised all the current underground workers and workers at the mills on the surface (mill crushers, ball mill workers and other mill workers).

### ***1.5.3. Sampling.***

For the descriptive study of silicotic cases over the study period, no sampling was done. Silicotic cases among all patrons of the hospital who were non-workers of **GGL** for the period as well as among all the workers of the mine during the period were taken into consideration.

For the exploratory study of the safety structures in place at the mine against the generation and inhalation of dust by workers during mining activities, out of the three mining shafts, one (the Ackon vertical shaft) was chosen. All the sections on the surface where visible dust is generated during mining activities (the crushing plant, the Assay and ball mill sections) were studied. The choice of the Ackon vertical shaft for study was purposive because the Chief Medical Officer of the mine chose it as the most hazardous of the three shafts and therefore the most useful for the study of hazards.

For the exploratory study of the safety measures undertaken by workers to reduce dust generation and flight of dust into the air and of personal protective measures against dust inhalation at the mine and compliance to them, a sample of 50 by convenience was chosen. Out of this number, 5 were mechanics who were not permanent workers in the dust hazardous areas of the mine. The sample was chosen by convenience because, given the time constraint for my data collection, one could not afford to embark on a probability sampling. For convenience, when

the selected sections of the mine (the Ackon shaft, the crushing plant, the Assay and the ball mill section) were visited, observation was made on any one seen at work at a time when a dust generating activity was going on. The following is a breakdown of the number of people observed in each occupational group of the mine:

**Table 1.1.**

**Number of workers of various occupational groups at GGL at risk of dust exposure observed during survey.**

Occupational group	Number observed
Machine drivers (Drillers)	1
Spannermen	2
Shovelmen	3
Blastmen	1
Pumpmen	2
Winch drivers	1
Winder drivers	2
Loco drivers	4
Binmen	6
Conveyor crew	10
Hoist gang	4
Mechanics	5
Trackmen	3
Millcrushers	3
Ball mill workers	3
<b>TOTAL</b>	<b>50</b>

These people on whom observation was made were also interviewed to obtain their opinion about what should be done to reduce the amount of dust which is inhaled by workers at work. Also, those who were observed not complying with personal protective regulations were interviewed to elicit from them their main reason for non-compliance.

#### ***1.5.4 Data collection techniques and tools.***

In order to arrive at data for the achievement of the objectives of the study, for different parts of the study, different techniques and tools were used to collect the data. They were as follows:

- a) For data on the cases of silicosis recorded at the **GGL** Hospital from 1973 to 1996, the technique was to make use of available data from monthly, quarterly and annual reports of **GGL** Hospital. The tool for data collection was Data compilation form (see appendix 1).
- b) For data on the annual workforce of various occupational groups in the **GGL** mine at the middle of each year from 1973 to 1996, the technique was to make use of available data from the Personnel records at the Administration. The tool for data collection was a Data compilation form (see appendix 2).
- c) For data on the protective measures at the mine against generation and inhalation of dust at the **GGL** mine, use was made of the following techniques and tools:

- i) interview with the Chief Medical Officer of the company, Dr. Tuffuor-Kwarteng and the Senior Ventilation Officer, Mr. Stephen Aidoo to inquire about the safety measures currently in place at the mine and when they were instituted.
- iii) observation of permanent safety structures in place against dust generation or prevention of flight of dust into the atmosphere using a checklist (see appendix 3).
- iv) observation of safety measures undertaken by workers at work to reduce generation of dust and flight of dust into the atmosphere using the checklist in appendix 3.
- v) observation of use of personal protective measures on conveniently selected workers at dust-generating work using a checklist (see appendix 4).

For data on reasons for non-compliance to personal protective measures, the technique used was interviewing non-complying workers about their main reason for not using the personal protective measures.

Information on the safety measures against dust at the mine was first collected from the interviews in order to get an initial checklist for measures to look out for during observation. During the observation, other measures about which no information was obtained from the interviewees were looked out for. After the observation, the interviewees were contacted again for information about the time of introduction of the measures that they did not mention earlier. A Shift supervisor, Mr. Hippolyte who has been working in the mine since for about 29

years was also interviewed about the time of introduction of some of the protective measures and his opinion about what should be done to reduce the problem of dust exposure in the mine. Dr. Tuffuor-Kwarteng has been working at the mine hospital for about 14 years while Mr. Aidoo has been working at the mine for about 22 years.

For my observation of the safety measures at the mine, on the first day, the Training Manager of the mine, Mr. Francis Arthur who has worked for the mine for about 21 years, accompanied the researcher.

#### ***1.5.5. Data analysis and dissemination.***

After collection of the data, analysis was done manually and graphs were plotted using the computer software Microsoft Excel. Simple proportions and rates were used in the analysis. Trends were shown by moving averages (see appendix 5 for formulae used for calculations). Copies of this dissertation would be distributed to the School of Public Health, University of Ghana, Legon, the Graduate Board of the University, the Management of *GGL* and the Wasa West *DHMT*.

Data collection was started on April 15 1997 and ended on May 15 1997. Some data analysis was performed during the data collection period but on the whole, the main data analysis took place from May 16 to 26, 1997.

### ***1.5.6. Limitations of the study.***

- a) Due to several changes in ownership of the mine, some of the records of patients of the *GGL* Hospital have been misplaced. It was therefore difficult to obtain the history cards for most of the silicotic cases. One had to rely more on available periodic reports for most of my data. The reliability of the data therefore depends on the reliability of the reports used.
- b) Because of time constraint, the selection of workers for observation of safety measures was not done by a probability sampling method. They were selected as they were met. The findings may not be representative of all the workers of the mine.
- c) One could not obtain reliable data on when various safety measures were introduced at the mine. One relied mostly on information given by interviewees who had worked on the mine for a long time. This may introduce some recall bias into the study.
- d) During the period of observation of safety measures on the mine in the company of Mr. Arthur, the Training Manager on the first day, workers who heard of Mr. Arthur coming automatically tried to comply with safety rules. Therefore, the situation observed on the level of compliance to personal protective measures may not be a true reflection of the actual state of affairs.

- e) For the calculation of the incidence rate of silicosis, the denominator should have been the sum of the length of time during which each person in the risk population had been exposed to the dust at work. However, data on the periods of exposure were not available. As the denominator, for each year, the mid-year population at risk was used. For a period of years, the mean annual number of workers (population at risk) was used as the denominator (see appendix 5 for formula for mean number of workers for a period of years)

### ***1.5.7. Ethical issues.***

The study involved looking through records of the **GGL** Personnel Department and Hospital, some of which may be confidential. This is an ethical issue but the non-personal nature of the write-up of this work reduces the magnitude of impingement on confidentiality. However, investigating an occupational disease, any unfavourable findings if widely circulated, may tarnish the image of the company. This is a very sensitive issue so that the School of Public Health assured **GGL** Management of careful handling of the dissertation.

## **1.6. Literature Review.**

### ***1.6.1. Epidemiology of silicosis.***

According to Jeyaratnam (6), it is often difficult to estimate the extent of pneumoconioses especially in developing countries. Although national systems of routine notification of occupational diseases in some countries may include

pneumoconiosis, this can rarely be relied upon because of gross under-reporting. In many countries for instance, silicosis is often misdiagnosed as tuberculosis. When pneumoconiosis is scheduled as compensable disease of occupation, registration is likely to be more complete but the accuracy of case detection may nevertheless, be subject to great variation in diagnostic evaluation. Also, owing to the large number of industries in which there is the risk of silicosis, the irregular employment and transient nature of the labour force and differences in notification practices of different states and countries, it is hard to get an idea of prevalence of silicosis.

#### 1.6.1.1. Occupational groups and individuals at risk of developing silicosis.

As silica compound forms the greater part of the earth's crust, the possibilities of exposure to the dust are numerous and have been, ever since man first took to making tools and weapons from flint. Morgan et al (7) make mention of "Notes in Diagnosis and claims for industrial injuries Scheme Benefits", compiled by the Department of Health and Social Security of the United Kingdom in 1979, in which they list the following occupations and industries as being at risk to silicosis:

- a) Quarrying, mining and dressing of sandstone, granite and slate.
- b) Mining of tin, haematite, graphite, copper, gold and other minerals.
- c) The pottery industry.

- d) Manufacture of refractory products such as bricks, flint crushing, silica milling and millstone.
- e) Manufacture of abrasive soaps.
- f) Iron and steel foundries.
- g) Sandblasting, boiler scaling, coal mining for men engaged in sinking shafts or developing roadways through silica-containing rocks.

According to Seaton et al (8), silicosis has been detected among barium miners in Scotland and Ng et al (9) mention silicosis in jade workers in Hong Kong where the source was found to be the silica flour that was added in a polishing process. A study in two communes in Minghua, a windy sandy area in Gansu province of China by Xu et al (10) in 1993 shows that long-term living in sandstorm areas can lead to silicosis.

#### 1.6.1.2. Prevalence rates and incidence of silicosis in some industries and countries.

In some industries in China and especially India, silicosis seems to be a major problem. Jeyaratnam (6) gives tables showing the prevalence of silicosis in various industries in China and India in 1985 (Tables 1.2 and 1.3).

**Table 1.2.****Prevalence rates of silicosis in some industries in China (1985).**

<b>Industry</b>	<b>Prevalence of silicosis (%)</b>
Overall	3.1
Metallurgy	5.5
Coal-mining	3.5
Construction	1.7
Railwork	1.2
Chemical industry	0.7
Others	2.6

**Table 1.3.****Prevalence rates of silicosis in some industries in India (1985).**

<b>Industry</b>	<b>Prevalence of silicosis</b>
Mica-mining	32.1
Metal grinding	27.2
Refractory brickworks	21.1
Potteries	15.7
Slate pencil workers	54.6
Stonecutter	3.5

Leger (11) in his study of the incidence of silicosis among black South African miners, found out that from 1980 to 1989, between 1,500 and 3,500 black miners were certified annually under Occupational Diseases in Mines and Works Act, Act 78 of 1973 (*ODMWA*) in South Africa, as having silicosis or

silicotuberculosis giving a crude incidence rate of between 1.7 and 5.2 per 1000 employed miners per year.

In the United States of America, Landrigan et al (12) in 1986 reported of an industrial hygiene and medical survey in an iron foundry (in Pennsylvania) to study the occurrence of silicosis. A radiographic evaluation of 188 workers revealed silicosis in 18 (9.6%).

In Switzerland, in 1982, the Caisse Nationale Suisse d'assurance en cas d'accident (CNSA) had a conference to review the position of silicosis in Switzerland after 50 years of fight against silicosis since 1932. Several authors presented papers. In the compilation "Fifty years' fight against silicosis in Switzerland" (13), Maillard and Zufferey stated that 9690 cases of silicosis were accepted by CNSA in 50 years, most of which (70%) were related to mining and stone-cutting.

In Ghana, work on silicosis is scanty. Before 1960, mines and other industries existed in Ghana but there was little occupational health awareness. Quainoo (14) in an article for a workshop on Health and Safety in Workplaces in 1992, mentioned that accidents, injuries and deaths occurred at the Akosombo Dam site, during the construction of the Tema Port, the new townships and factories. The Government of the day sought International assistance. As one of the results of the subsequent events towards the establishment of an occupational health system in the country, the *ILO* advised the Ministry of Labour on the occupational safety and health at the mines where they found conditions to be most unsatisfactory.

Between 1963 and 1971, the *ILO* experts pursued their studies. J.C. Nowacki wrote about the hitherto unknown prevalence of silicosis and silicotuberculosis at the then Tarkwa Mines (Tarkwa Goldfields Limited). Meanwhile, the Tarkwa Goldfields Limited (*TGL*) employed an Occupational Physician around 1973 and it was from that time that the company started diagnosing silicosis regularly. Tuffuor-Kwarteng in his work in 1988 (4) found a total cumulative number of silicotic cases of 127 among *TGL* workers from 1973 to 1986. With an average annual workforce of 2966 for the period, he found an overall incidence rate of 42.8 per 1,000 workers per 14 years. In his work in 1992, Forson (15) made use of data from Tuffuor-Kwarteng's work and compared the incidence rate with that calculated for Ashanti Goldfields Company (*AGC*), Obuasi for a ten-year period (years not mentioned in article). This is shown in Table 1.4 below.

Table 1.4.

Overall incidence rates of silicosis and silicotuberculosis for a 14-year period for *TGL* and for a 10-year period for *AGC*.

<b>COMPANY</b>	<b>Total no. of workers at risk (Average)</b>	<b>Total no. of new cases</b>	<b>Rate/1000 /14yrs and 10 yrs.</b>	<b>Rate/1000/yr.</b>
TGL	2,966	127	42.8	3.1
AGC	10,000	7	0.7	0.07

#### 1.6.1.3. Trend of silicosis in some countries and industries.

Due probably to better occupational hygienic practices as the years go by, the incidence of new cases of silicosis is going down in many countries. However,

many of the studies do not give an indication as to the population of risk occupations as the years go by. In many of these studies, figures have been given for the whole country, so that it would be simplistic to attribute the fall in the incidence of new cases of silicosis to better hygienic practices. At the review conference for silicosis in 1982 by the *CNSA* (13), Maillard and Zufferey observed that the incidence of new cases of silicosis in Switzerland rose until 1940, levelled off at 200-300 per annum, then fell after 1974 to less than 100 per annum. Tuffuor-Kwarteng (4) observed a falling trend of the incidence rates of silicosis among *TGL* workers from 1973 to 1986. Since the population base of all the at risk occupational groups was known, incidence rates could be calculated.

#### 1.6.1.4. Comparison of incidence and prevalence rates of silicosis among various occupational groups.

Tables 1.2 and 1.3 (cited in section 1.6.1.2) compare the prevalence rates of silicosis among various industries and occupational groups. Talking about prevalence means that the silicotic cases are kept on the job. With a chronic disease like silicosis, it is expected that, after several years, companies, which keep the silicotics on the job, would have high prevalence rates. However, it is worth noting the prevalence rate differences among the various industries and occupational groups. Thus, in China, metallurgy workers are at the greatest risk of developing silicosis. In India slate pencil workers are at greatest risk of developing silicosis.

In Ghana, silicosis has been reported almost exclusively among miners, mainly gold miners. Among the gold miners, different occupational groups may be at different risks of developing silicosis depending on the level of exposure to silica dust. In Tuffuor-Kwarteng's work (4) on *TGL* workers for the period 1973-86, he found the following period (1973-86) incidence rates of silicosis among the various vulnerable occupational groups of the mine (Table 1.5):

**Table 1.5.**  
**Incidence of silicosis and silicotuberculosis in various occupational groups of**  
**TGL for period 1973-86.**

<b>OCCUPATIONAL GROUP</b>	<b>AVERAGE NO.OF WORKERS AT RISK</b>	<b>TOTAL NO. OF CASES</b>	<b>RATE PER 1000 PER YEAR</b>
Drillers	99	14	10.1
Blastmen	93	12	9.2
Shovelmen	362	24	4.7
Spannermen	73	5	4.8
Loco Drivers	87	3	2.5
Other underground workers	997	52	3.7
Mill crushers	57	15	18.7
Mill others	177	2	0.8

He showed that the highest mean incidence rate of silicosis was recorded among workers at the crushing plant (18.7 per 1000 per year) followed by the drillers

(10.1 per 1000 per year) and then by the blastmen (9.2 per 1000 per year).

#### 1.6.1.5. Sex distribution of silicotic cases.

Silicosis is mainly a disease of industries in which only men work. However, with the sociological changes going on in the world, it is possible that some women are engaged in some of these industries. Pottery is one of such professions in which women are engaged. In Ghana, women are involved in small scale mining activities. Also, as indicated earlier in section 1.6.1.1 (13), even the place of abode can be a risk area as exemplified by the desert area in China. Many of the works on silicosis do not categorise silicotic cases into sex groups. However, in a study by Kostinen (16), out of 144 silicotic cases he reviewed in Finland in 1979, 6 were women. It is therefore possible that some of the cases that are reported in some studies are women.

#### ***1.6.2. Personal protective and general safety measures undertaken by Mining companies and individuals to reduce exposure of miners to dust.***

In the fight against silicosis, the first line of attack is to prevent the dust becoming air-borne. As a second line of attack, the dust which cannot be kept out of the air is either exhausted directly at its source or diluted as effectively as possible by means of clean ventilating air. The third line of attack is filtration, which may be either respirators attached to the face or a large volume filter at the source of the dust.

The amount of dust particles permitted in the air during mining activities depends on the silica content of the rock being dealt with. Hartman (17) mentions that on the basis of extensive studies by the American conference of Governmental Industrial Hygienists (*ACGIH*), the following threshold limits have been established:

For high silica rocks (more than 50%), threshold dust particle count is 175 particles per cubic centimetre (p.p.c.c.). For medium silica rocks (5-50%), threshold dust particle count is 7,000 p.p.c.c. and for low silica rocks (less than 5%), the threshold dust particle count is 17,500 p.p.c.c.

The emphasis now is on gravimetric measurements in which the weight of silica dust in a given volume of air is measured. Measurement is made of the silica dust which is respirable and the concentration of silica dust in the air. A World Health Organisation (*WHO*) study group (18) carried out a study for recommending health-based limits in occupational exposure to selected dusts (silica and coal). The group had serious reservations about much of the data concerning silica but recommends as a tentative limit for free crystalline silica a time-weighted average (8-hour shift, 40-hour working week, 35-year working life) concentration of 40 micrograms per cubic metre. For coal-dust containing no more than 7% silica by mass it recommends tentatively a range 0.5-4.0 milligram dust per cubic metre. When silica content exceeds 7% of the respirable dust the limit for free crystalline silica (40 micrograms per cubic metre) should be applied.

**The Ghana mining regulations (MR) (5) lists regulations on ventilation, blasting and dust prevention.**

## **CHAPTER TWO.**

### **2.0. BACKGROUND INFORMATION ABOUT THE WASA WEST DISTRICT, THE GOLD FIELDS GHANA LIMITED MINE AND THE SILICOSIS SITUATION IN THE WASA WEST DISTRICT.**

#### **2.1. Profile of Wasa West District relevant to silicosis epidemiology.**

##### **2.1.1. Physical Characteristics of the Wasa West District.**

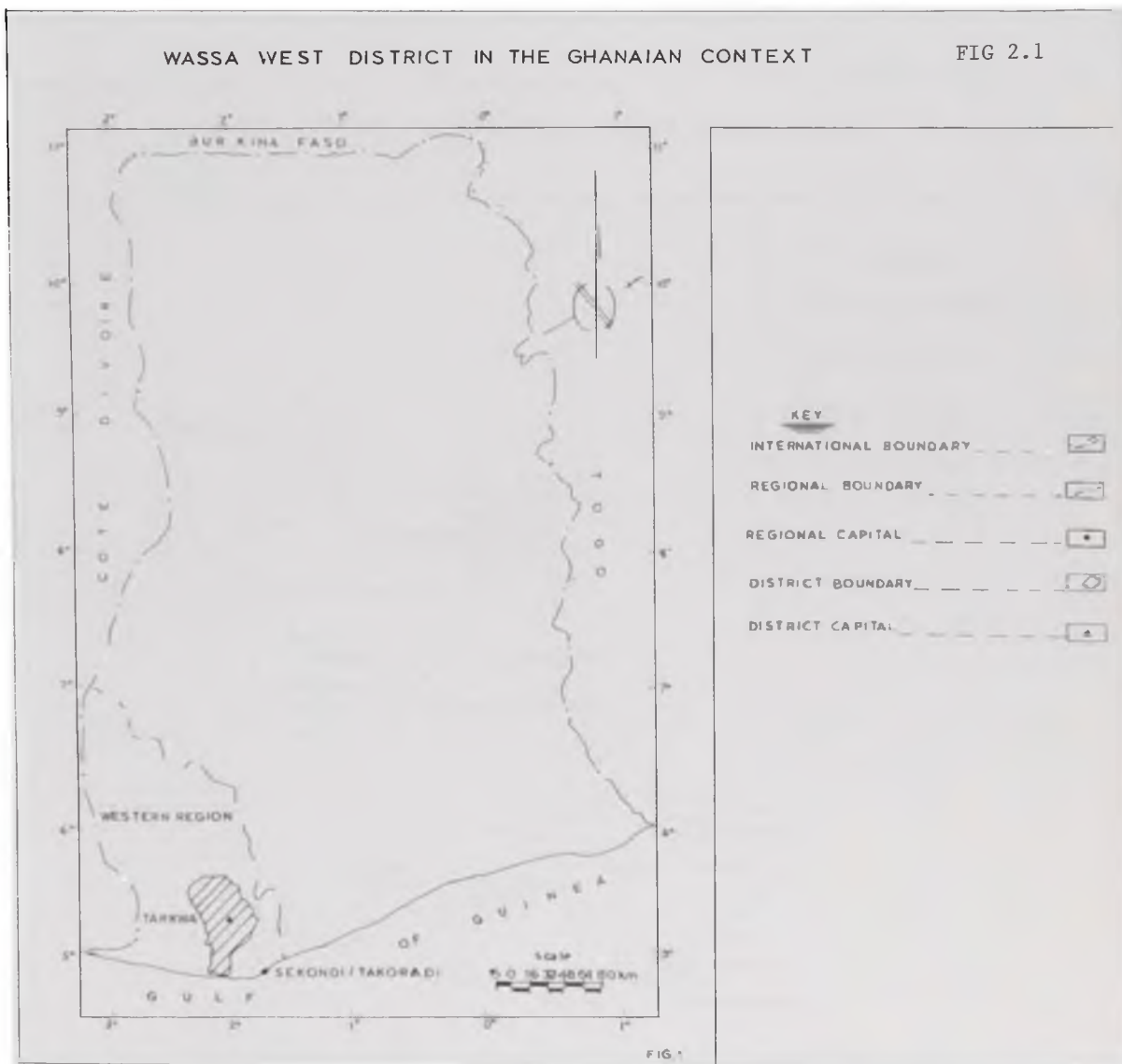
###### **2.1.1.1. Location and size of the Wasa West District.**

The Wasa West District is one of the eleven districts of the Western Region of Ghana. The district is located between the latitudes 4 degrees north and 5 degrees and 40 seconds north; and between the longitudes of 1 degree and 40 seconds west and 2 degrees and 10 seconds west. It is bounded to the north by Wasa Amenfi district; to the south by the Ahanta West district; to the west by the Nzema East district and to the east by the Mpohor Wasa East district (see figures 2.1 and 2.2).

The district capital is Tarkwa. The district has a total land area of 2,354 sq. km.

WASSA WEST DISTRICT IN THE GHANAIAN CONTEXT

FIG 2.1





#### 2.1.1.2. Climate.

The district lies within the southwestern Equatorial zone marked by double maximum rainfall starting in March and September. The mean annual rainfall is 187.83cm.

The district has a fairly uniform temperature ranging from 26 degrees centigrade (in August) to 30 degrees centigrade (in March). Relative humidity is generally high throughout the year between 70 and 80% in the dry season and between 75 and 80% in the wet season.

#### 2.1.1.3. Geology.

The district is underlain by two geological formations- the Birimian and the Tarkwaian rocks. The Tarkwaian rocks are more solid than the Birimian rocks and has characteristics mentioned in section 1.2.

#### 2.1.2. Population.

The estimated population of the district (projected from the 1984 census) is 239,297 in 1997. The estimated growth rate is 3% per annum. The male: female ratio for the district, according to a survey carried out by the District Assembly in 1996, is estimated to be 1: 0.92. This could be explained by the high level of male immigration into the district due to the predominant mining activities in the

district.

According to a field survey carried out in 1996 by the District Assembly, children (0-14years) constitute 24.8% of the total population. The working age group (15-64 years) constitutes 70.6% of the total population and the old-age group of 65 years and above constitutes 4.65% of the total population.

The district experiences a considerable movement of people into the district as indicated by 59.4% of a sample population surveyed in 1996 by the District Assembly. The high migrant population could be attributed to the establishment of large-scale mineral (gold and manganese) companies and the widespread small-scale mining in the district.

### **2.1.3 Economic activities in the district.**

About 66.3% of the labour force (between 15 and 64 years of age) are employed, according to a survey carried out by the District Assembly in 1996. The occupational structure is as follows:

- a) Agriculture employs 42.6% of the employed labour force.
- b) Industry employs 21.6% of the employed labour force.
- c) Commerce employs 20.3% of the employed labour force.
- d) Services employ 15.5% of the employed labour force.

There are 37 small-scale industries (industries employing up to 30 people)

according to a socio-economic survey carried out by the District Assembly in 1996. These employ 7.4% of the people engaged in the industrial sector.

There are currently eight large-scale established gold mining companies in the district, the oldest being Gold Fields Ghana Limited (*GGL*) and Prestea Goldmines. About 67% of mining in the district is open-cast (surface mining).

## **2.2. Mining at Gold Fields Ghana Limited (*GGL*).**

### **2.2.1. History of the mine.**

The Gold Fields Ghana Limited (*GGL*) mines which has a concession area of 225 square kilometres, is one of the oldest mines in the country. The original Aboso mine was obtained in 1878 and it started producing gold from the banket reefs in the Tarkwa district. The company, Tarkwa and Aboso Mines Limited came into existence in 1927 and continued operating the mines concession (3). The mines have undergone several close-downs and changes of ownership. Just before the 1960's, the mine was under a South African Company, the Amalgamated Banket Areas (*ABA*). The government of Ghana completely took over the mines from *ABA* in May 1961 and changed the mine's name to "Tarkwa Goldfields Limited" (*TGL*) as a subsidiary of the State Gold Mining Corporation (*SGMC*). The other two subsidiary Goldmines of the corporation were the Prestea Goldfields limited and the Dunkwa Goldfields limited (an alluvial gold mine).

In June 1993, the company was sold to a South African company and it is

currently called “Gold Fields Ghana Limited” (*GGL*). Even though the mine has been operating during different periods under different management, there has been quite some consistency in the labour force and operations of the medical department of the mine.

Before the current company took over the mine, they undertook a thorough medical screening of all the staff and many of the staff was laid off. However, However, there are still many workers who have worked for several years in the mine.

Throughout its period of existence, mining on the concession has been underground. It is only this year that the company is exploring surface mining in some areas.

### **2.2.2. Major sections of the mine.**

The major sections of the mine are:

- a) Underground
- b) Mill crushing plant and assay
- c) Ball mill plant and
- d) Smelting.

For underground operations, during the *TGL* days, the mine operated with three vertical shafts and two inclined shafts. Currently, the mine mainly operates with

two vertical shafts (the Ackon and Apinto vertical shafts) and to a little extent, the Fanti inclined shaft.

**2.2.3. Sequence of major activities carried out during mining at the mine.**

Even though some of the activities may go on concurrently or in different order, the following sequence of activities is broadly what takes place during mining at **GGL**:

- a) Wetting of rocks with water- this is carried out mainly to reduce the amount of dust that would go air-borne during subsequent mining activities. It is also done to allay fumes from blasts. The main occupational group involved in this initial wetting activity is the blastman.
- b) Demarcation of space for subsequent drilling- the main occupational groups involved here are the blastmen and shovelmen.
- c) Drilling of holes in the rocks for insertion of explosives needed for the blasting operation-The main occupational groups involved here are the Machine drivers (Drillers), the blastmen, the spannermen and the shovelmen.
- d) Blasting of rocks using explosives- the main occupational groups involved here are the blastmen and their assistants.
- e) Timbering- this is rarely done at **GGL** because of the solid nature of the rock. Supports and barricades are erected to make the roof of stopes (steep small

tunnels created after blast) safe, The occupational groups involved here are the timbermen and the blastmen. Apart from timbering, the blastmen also make the working place safe by barring down and allaying the dust with water.

- f) Cleaning operation of the stope which involves loading of rocks into trucks, scraping, lashing and so on. The main occupational groups involved here are the blastmen, the shovelmen, the winch drivers and the Rocker shovel operators.
- g) Trimming of rocks in locomotives on levels- the main occupational group involved here is the loco driver who drives and maintains the locomotives.
- h) Tipping into bins and through chutes into trucks and conveyor belts- the main occupational groups involved here are the binmen, winder drivers and hoist gang.
- i) Conveyance of rocks on conveyor belts to higher levels of the shaft- the main occupational group at risk here is the conveyor crew.
- j) Hoisting of rocks to surface from underground- the main occupational group involved here are the shaftmen.
- k) Crushing and milling of ore into fine sand at the crushing plant and Ball mill plant. The occupational groups involved here are the mill crushers and the ball mill workers.

- l) Gold extraction from the fine sand by the processes of chemical concentration using cyanide and by gravity concentration. The Smelt room workers are involved here.

***2.2.4 Activities during which mineworkers at GGL are at risk of exposure to large quantities of dust at GGL.***

The activities during which the workers are at risk of exposure to large quantities of dust are:

- a) Drilling
- b) Blasting
- c) Tipping and loading
- d) Scraping, barring and lashing
- e) Crushing and milling.

All occupational groups underground are at risk (albeit to varying degrees) of exposure to large quantities of dust. At the surface, only mill crushers (including assay men) and to a certain degree, ball mill workers are at risk of exposure to large quantities of dust.

**2.3. The problem of silicosis in the Wasa West District.**

The *GGL* mine has existed for more than a century under different management and workers who worked there may have been exposed to a lot of silica dust.

Small-scale mining has been practised in the Tarkwa area in recent years. They may also have been exposed to silica dust for long periods. In spite of this, there are no records of silicosis in most of the health institutions in the district. The only available records of silicosis in the district are those recorded at the *GGL* Hospital.

At the Tarkwa General Hospital, many cases which are not sputum-positive for acid-fast bacilli but are with some radiographic opacities are managed as pure tuberculosis. For instance, in 1996, 279 new cases of tuberculosis were diagnosed at the hospital whilst only 140 of them were tested sputum-positive for acid-fast bacilli (1996 Ministry of Health annual report). It is possible that this may also be happening in other health institutions apart from *GGL* Hospital. In a mining area like Wasa West District, it is possible that some of these radiographic opacities are due to silicosis but are not diagnosed as such. Even some of the sputum positive cases may have silicosis at the background. In such a situation, in general practice, pure tuberculosis may be over-diagnosed whilst cases of silicosis (including silicotuberculosis) may also be under-diagnosed.

#### **2.4. Gold Fields Ghana Limited (GGL) Hospital.**

Apart from the District Hospital at Tarkwa, the *GGL* Hospital is the next major hospital in the district. This is a 60-bed hospital situated at the mine. This hospital caters for all the staff of the *GGL* mine, their dependants and other patients from the general public who can afford to pay for the health services offered there. For

the past 25 years, the hospital has always had an Occupational Physician. For a study on silicosis in the Tarkwa area, the **GGL** Hospital is an ideal for an institutional-based study for the following reasons:

- a) All kinds of people patronise the hospital so that all diseases which exist in the Tarkwa area are likely to be reported at the hospital. Unfortunately, one very important group of people so far as silicosis epidemiology is concerned, was not patronising the hospital. The **PNDC Law 218** gave small-scale mining in the country a legal status only in 1989. It was from then that small-scale miners started registering and legalising their operations. According to information gathered from a discussion with Dr. Tuffuor-Kwarteng, the Chief Medical Officer for GGL, before 1993, small-scale mining in the area was mainly illegal. The concession for **GGL** was then under the **SGMC**. The small-scale miners saw themselves as illegally competing with the government for gold so that they avoided the then **TGL** Hospital. They reported their illnesses to Tarkwa General Hospital and other health institutions. Since 1993, when **GGL** took over the mine, small-scale miners have been patronising the hospital.
- b) For the past 25 years, the hospital has always had an Occupational Physician who is more skilled in radiographic diagnosis of silicosis than the other hospital and general medical practitioners.
- c) A large proportion of the patients who visit the hospital are workers of the

mine. Therefore, in the physician's differential diagnosis of respiratory diseases, he will have silicosis in mind.

- d) All the workers of *GGL* have since 1988 been undergoing annual medical examinations including chest radiography. All symptomatic and asymptomatic silicotic cases are detected.
- e) There is a three-man team of Occupational Physicians (a silicosis board) at Tarkwa which sits on every suspected silicotic case to confirm the diagnosis.

Because of the above reasons, data on silicosis from the *GGL* Hospital is likely to be very reliable.

### **2.5. How silicosis is diagnosed at *GGL* Hospital.**

At *GGL* Hospital, silicosis is suspected on the basis of the clinical picture or is detected during routine medical examinations. In either case, the cornerstone of the diagnosis is chest radiography. Silcotuberculosis is confirmed by direct smear of sputum using the Zeil-Nielson method.

After the company medical Officer has detected a possible case of silicosis, the silicosis board sits on the case to either confirm or reject the diagnosis.

## **CHAPTER THREE.**

### **3.0. FINDINGS OF THE STUDY.**

#### **3.1. Distribution of total number of silicotic cases recorded at GGL Hospital from 1973 to 1996 by place of work.**

The total number of cases of silicosis, which was recorded at the *GGL* Hospital from 1973 to 1996, was 160. Out of this number, 152 were workers of *GGL* while 8 of them were non-workers of *GGL*. We may group the cases into those who were working underground at *GGL*, those who were working at the surface at *GGL* and those who were not working at *GGL*. By this categorisation, it was found that 8 (5%) of the cases were people who did not work for *GGL*; 133 (83.1%) were underground workers of *GGL* and 19 (11.9%) were surface workers of *GGL*. The distribution of the cases according to place of work is shown in Table 3.1 below:

Table 3.1.

Distribution of total number of cases of silicosis recorded at GGL Hospital from 1973 to 1996 by place of work.

<b>Place of work</b>	<b>No. of silicotic cases</b>	<b>Percentage of cases</b>
Outside <i>GGL</i>	8	5.0
Underground, <i>GGL</i>	133	83.1
Surface, <i>GGL</i>	19	11.9
<b>TOTAL</b>	<b>160</b>	<b>100.0</b>

Source: Periodic reports, *GGL* Hospital.

All the cases who were non-workers of the *GGL* mine were small-scale

(Galamsey) miners.

As it was pointed out in section 2.4, small-scale miners started reporting freely to the *GGL* Hospital from 1993. To get a more realistic picture of the silicosis situation among the three groups mentioned above, one might present the data for the number of cases reported among each group annually from 1993 to 1996. Table 3.2 below shows the annual distribution of silicotic cases among the three groups from 1993 to 1996.

Table 3.2.

Number of silicotic cases reported annually at *GGL* Hospital among small-scale miners. *GGL* underground workers and *GGL* surface workers from 1993 to 1996.

YEAR	<i>TOTAL NO. OF CASES AMONG</i>			GRAND TOTAL
	Small scale miners	<i>GGL</i> underground workers	<i>GGL</i> surface workers	
1993	2	1	0	3
1994	3	0	0	3
1995	3	0	0	3
1996	0	0	0	0
<b>TOTAL</b>	8	1	0	9

Source: *GGL* Hospital periodic reports.

It can be seen from Table 3.2 that since 1993 when small-scale miners started

patronising *GGL* Hospital, most of the cases reported at the hospital are among them. In 1993, 2 (67%) out of the 3 cases reported were small-scale miners while 1 (33%) was an underground miner of *GGL*. In 1994 and 1995, all the 6 cases of silicosis reported at the hospital were small-scale miners. No case of silicosis was recorded at the hospital in 1996. On the whole, between 1993 and 1996, 8 out of the 9 cases (88.9%) reported at the hospital were small scale miners whilst 1 (11.1%) was an underground worker of *GGL*. No case was reported among surface workers during the period. It should be noted however that we cannot compare the rates of incidence among small-scale miners and the *GGL* workers since we do not know the population of small-scale miners.

### **3.2. Sex distribution of silicotic cases recorded at GGL Hospital from 1973 to 1996 .**

All of the 9 cases of silicosis which were recorded at the *GGL* Hospital from 1993 to 1996 when small scale miners patronised the *GGL* Hospital, were males. Also, all the 151 cases of silicosis, which were recorded at the hospital before 1993, were males.

### **3.3. Trend of annual incidence rates of silicosis among GGL workers from 1973 to 1996.**

Table 3.3 on the page 46 illustrates the trend of annual incidence rates of silicosis among *GGL* workers from 1973 to 1996. Generally, the annual incidence rate of silicosis among *GGL* workers fell gradually from a 1973 rate of 6.1 cases per 1000 workers to a 1996 rate of 0 cases per 1000 workers . However, this falling trend was not smooth. There were years when rates rose again after a

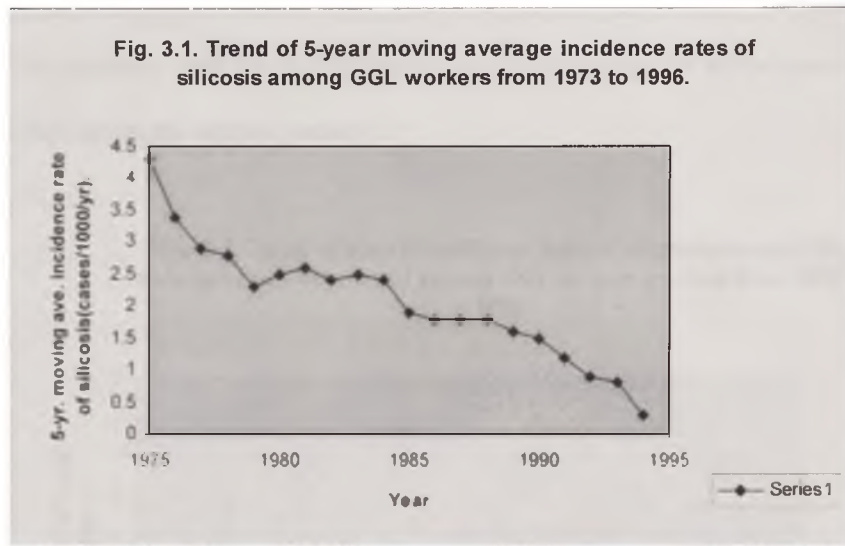
falling trend had been observed for the previous years. There were therefore multiple peaks ( 1973, 1976, 1982 and 1990) of incidence rates (These multiple peaks are marked by \* in Table 3.3).

**Table 3.3.**  
**Annual incidence rates of silicosis among workers of *GGL* from 1973 to 1996.**

<b>YEAR</b>	<b>Total workforce as at end of June.</b>	<b>No. of silicotic cases recorded</b>	<b>Annual incidence rates per 1000 workers</b>
1973	3621	22	6.1*
1974	3646	17	4.7
1975	3643	8	2.2
1976	3384	15	4.4*
1977	2995	12	4.0
1978	2817	5	1.8
1979	2979	6	2.0
1980	2531	4	1.6
1981	2327	5	2.2
1982	2702	13	4.8*
1983	2732	6	2.2
1984	2782	4	1.4
1985	2682	5	1.9
1986	2676	5	1.9
1987	2685	5	1.9
1988	2688	5	1.9
1989	2604	4	1.5
1990	2502	5	2.0*
1991	2505	2	0.8
1992	2500	3	1.2
1993	2500	1	0.4
1994	1400	0	0
1995	1400	0	0
1996	1401	0	0

Source: *GGL* Hospital periodic reports and *GGL* Personnel Department records.

The falling trend of annual incidence rates of silicosis may be better appreciated if one presents the trend in the form of five-year moving averages. This is illustrated in figure 3.1 below (see appendix 8 for the calculated figures for the five-year moving averages).

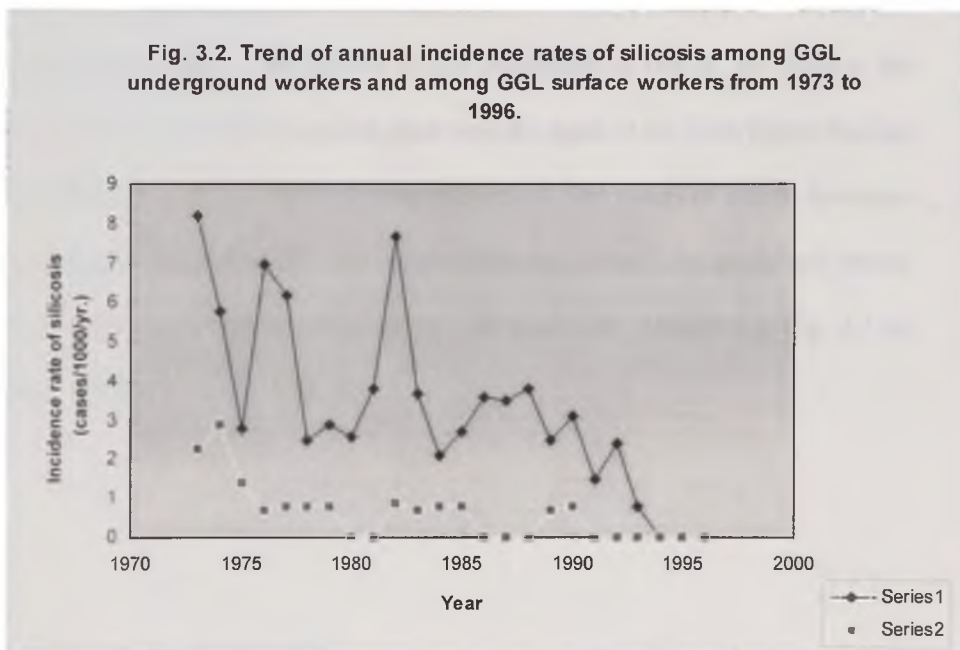


From figure 3.1, a smooth trend of fall of incidence rates was observed from mid-period years 1975 to 1994. The trend is more or less a secular one. The only rise after a gradual fall is observed between 1980 and 1983.

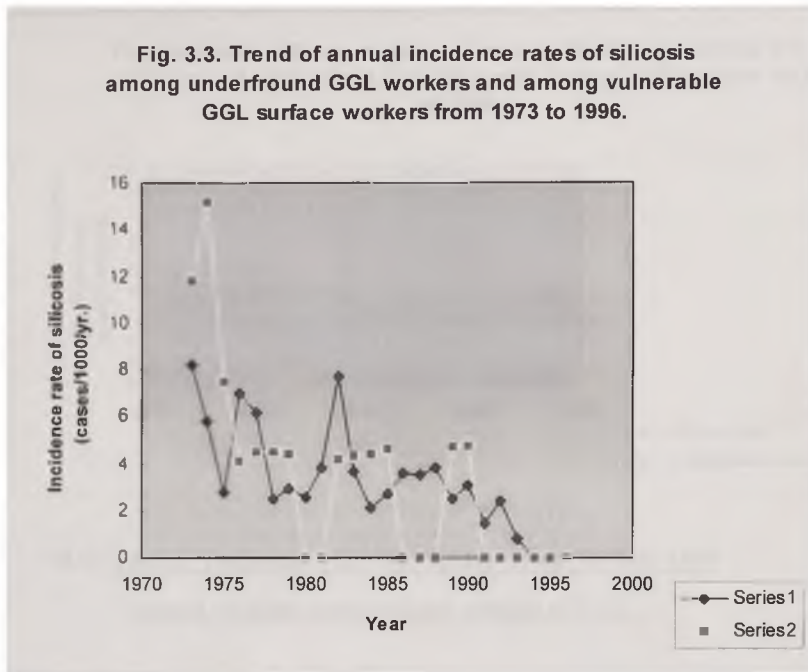
### **3.4. Comparison of trends of annual incidence rates of silicosis among GGL underground and among GGL surface workers from 1973 to 1996.**

Generally, for both underground workers and surface workers of *GGL*, the annual incidence rates of silicosis fell gradually with intermittent rises from 1973 to

1994 (see Fig. 3.2 below and figures in appendix 9), but in the case of surface workers (series 2 of graph), there were years during the period when no silicotic cases were recorded at all (1980, 1981, 1986, 1987 and 1988). From 1991 onwards, no case was recorded among surface workers whilst it was only from 1994 onwards that no case was recorded among underground workers. Generally, the incidence rates among the underground workers were for all the years higher than among the surface workers.

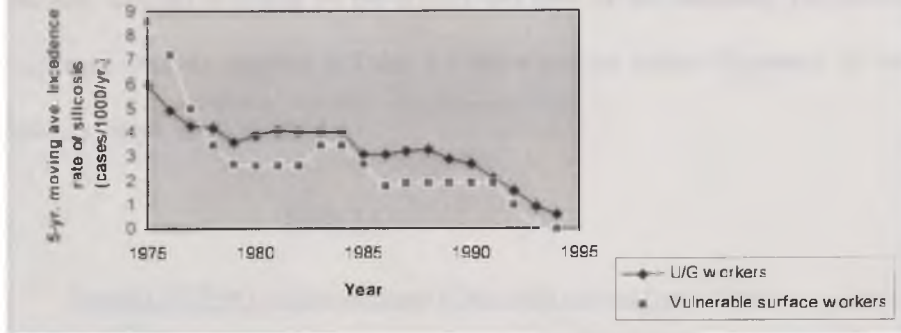


Among the surface workers at *GGL*, it is only the mill crushers and other mill workers who are exposed to large quantities of dust as are all the underground workers. It is therefore proper to determine the annual incidence rates of silicosis among those vulnerable groups at the surface. When this is done, the trend of incidence rates of silicosis among the vulnerable surface workers also shows a falling trend just as was observed for all surface workers. However, the magnitude of the incidence rates is greater for all the years for the vulnerable surface workers than for all the surface workers together. Also, when one considers only the vulnerable groups at the surface as the population at risk at the surface, the incidence rates of silicosis among them were for some of the years higher than the incidence rates among the underground workers. The trends of annual incidence rates of silicosis among the underground workers (series 1 on graph) and among the vulnerable surface workers (series 2 of graph) are compared in Fig. 3.3 on page 50( figures in appendix 10):



The trends of incidence rates among the underground workers and among the vulnerable surface workers are better illustrated by five-year moving averages as in figure 3.4 on page 51 (see the figures for the moving averages in appendix 11).

Fig. 3.4. Trend of 5-year moving average incidence rates among GGL underground workers and GGL vulnerable surface workers from 1973 to 1996.



### **3.5. Period incidence rates of silicosis from 1973 to 1996 among various occupational groups of GGL.**

For the period 1973-1996, the mean annual number of workers of *GGL* was found to be 2658 (see appendix 5 for formula used in calculating the mean number of workers over the period). The total number of silicotic cases recorded among workers of the company over the period was 152. This gave a mean incidence rate of 57.2 cases per 1000 workers over the 24-year period. This gives a mean annual incidence rate of 2.4 cases per 1000 workers per year. Distributing the cases by occupational group, it was found that, among the underground workers, the highest period incidence rate was among the machine drivers (drillers) (a mean incidence rate of 265.8 cases per 1000 drillers per 24 years or 11.1 cases per 1000 drillers per year) followed by the blastmen. With surface workers, the highest period incidence rate was found among the mill crushers (a mean

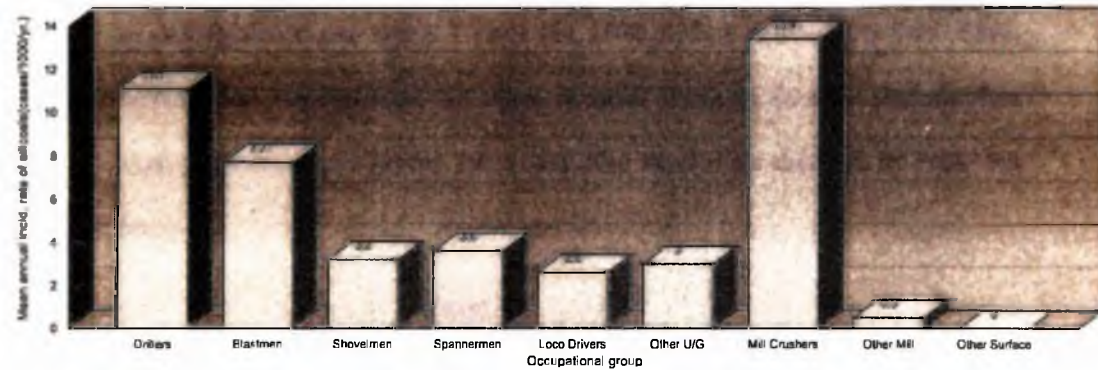
incidence rate of 320 cases per 1000 mill crushers per 24 years or 13.4 cases per 1000 mill crushers per year). Overall, the highest incidence rate was found among the mill crushers followed by the drillers and then by the blastmen. The period incidence rates are depicted in Table 3.4 below and are further illustrated by bar chart in figure 3.5 on page 53.

**Table 3.4.**

**Period (1973-96) incidence rates of silicosis among the various occupational groups of GGL.**

<b>Occupational group</b>	<b>Mean no. of workers for period</b>	<b>Total no. of silicotic cases recorded</b>	<b>Mean incidence rate/24yrs/1000</b>	<b>Mean annual incidence rate/1000/yr</b>
Drillers	79	21	<b>265.8</b>	<b>11.1</b>
Blastmen	76	14	<b>184.2</b>	<b>7.7</b>
Shovelmen	349	27	<b>77.4</b>	<b>3.2</b>
Spannermen	70	6	<b>85.7</b>	<b>3.6</b>
Loco Drivers	81	5	<b>61.7</b>	<b>2.6</b>
Other U/G	834	60	<b>71.9</b>	<b>3.0</b>
Mill crushers	53	17	<b>320.8</b>	<b>13.4</b>
Other mill	167	2	<b>12.0</b>	<b>0.5</b>
Other surface	945	0	<b>0</b>	<b>0</b>

Fig.3.5. Mean period(1973-96) annual incidence rates of silicosis among various occupational groups of GGL



One may also compare the period incidence rate of silicosis among underground workers and that among surface workers. Among a mean of 1,489 underground workers, 133 new cases of silicosis were recorded during the 24-year period, giving an overall period incidence rate of 89.3 cases per 1000 underground workers per 24 years. The mean annual incidence rate was 3.7 cases per 1000 underground workers per year.

Among a mean of 1,169 surface workers at the mine, 19 new cases of silicosis were recorded during the 24-year period of study giving an overall period incidence rate of 16.3 cases per 1000 surface workers per 24 year. The mean annual incidence rate was 0.7 cases per 1000 surface workers per year. Thus, underground workers were 5.3 times as more likely to develop silicosis than surface workers were during the period. The figures are depicted in Table 3.5 below.

Table 3.5.

Comparison of 1973-96 period incidence rates of silicosis among  
*GGL* underground workers and *GGL* surface workers.

Category of workers	Mean no. of workers for period	Total no. of new silicotic cases	Period incidence rate/1000/24 yr.	Mean annual incidence rate/1000/yr.
Underground	1489	133	89.3	3.7
Surface	1169	19	16.3	0.7
ALL	2658	152	57.2	2.4

As was mentioned in section 3.4, among the surface workers at *GGL*, it is only the

mill crushers and other mill workers who are at risk of exposure to large quantities of dust. On comparing the incidence rates among the underground workers and the vulnerable surface workers, it was seen that between the underground workers and the vulnerable surface workers, there is little difference between the incidence rates (mean annual incidence rates of 3.7 and 3.6 respectively per 1000 per year) (see Table 3.6 below). This contrasts drastically with the picture seen when we use all surface workers as the population at risk .

Table 3.6.

Comparison of 1973-96 period incidence rates of silicosis among GGL underground workers and vulnerable GGL surface workers.

Category of workers	Mean no. of workers for period	Total no. of new silicotic cases	Period incidence rate/1000 /24yrs	Mean annual incidence rate/1000/yr.
Underground	1489	133	89.3	3.7
Vulnerable surface	220	19	86.4	3.6

### 3.6. Comparison between mean annual incidence rates among GGL workers for the periods 1973-86 and 1987-96.

Table 3.7 on page 56 compares the mean annual incidence rates among the mineworkers for the two periods, 1973-1986 and 1987-1996. The mean period (14-year) incidence rate for the period 1973-86 was 42.8 cases of silicosis per 1000 workers for the 14-year period giving a mean annual incidence rate of 3.1 cases per 1000 workers per year. The rate fell drastically for the period 1987-96. The mean period (10-year) incidence rate for the period 1987-96 was 11.3 cases of

silicosis per 1000 workers giving a mean annual incidence rate of 1.1 cases per 1000 per year.

Table 3.7.

Mean annual incidence rates of silicosis among *GGL* workers  
for periods 1973-86 and 1987-96.

<b>Period</b>	<b>Mean annual workforce</b>	<b>No. of silicotic cases</b>	<b>Mean period incidence rate/1000</b>	<b>Mean annual incidence rate/1000/year</b>
1973-86	2966	127	42.8	3.1
1987-96	2219	25	11.3	1.1

One may also do this comparison of mean annual incidence rates between the two periods among underground workers and among surface workers. The figures for this breakdown are shown in Table 3.8 on page 57. It illustrates the fact that silicosis was virtually non-existent among surface workers during the period 1987-96 unlike during the period 1973-86 when it was a problem. It is also important to note this differential between underground and surface workers during this second period.

silicosis per 1000 workers giving a mean annual incidence rate of 1.1 cases per 1000 per year.

**Table 3.7.**

**Mean annual incidence rates of silicosis among *GGL* workers  
for periods 1973-86 and 1987-96.**

<b>Period</b>	<b>Mean annual workforce</b>	<b>No. of silicotic cases</b>	<b>Mean period incidence rate/1000</b>	<b>Mean annual incidence rate/1000/year</b>
1973-86	2966	127	42.8	3.1
1987-96	2219	25	11.3	1.1

One may also do this comparison of mean annual incidence rates between the two periods among underground workers and among surface workers. The figures for this breakdown are shown in Table 3.8 on page 57. It illustrates the fact that silicosis was virtually non-existent among surface workers during the period 1987-96 unlike during the period 1973-86 when it was a problem. It is also important to note this differential between underground and surface workers during this second period.

Table 3.8.

Mean annual incidence rate of silicosis among underground workers and among surface workers of GGL for the periods 1973-86 and 1987-96.

Period	UNDERGROUND WORKERS				SURFACE WORKERS			
	Mean annual workforce	No. of silicotic cases	Mean period incidence rate /1000	Mean annual incidence rate /1000/yr	Mean annual workforce	No. of silicotic cases	Mean period incidence rate /1000	Mean annual incidence rate /1000/yr
1973-87	1709	110	64.4	4.6	1257	17	13.5	1.0
1987-96	1170	23	19.7	2.0	1049	2	1.9	0.2

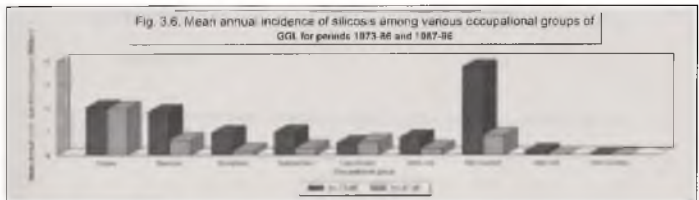
One may also compare the rates among the various occupational groups for the two periods (see Table 3.9 on page 58). It could be seen that unlike during the period 1973-86 when the mill crushers had the highest mean annual incidence rate, for the period, 1987-96, the drillers had the highest incidence rate, followed by the mill crushers. The other mill workers had no case during the second period. The incidence rate among blastmen, shovelmen and spannermen also dropped drastically during the second period.

**Table 3.9.**

**Mean annual incidence rates of silicosis among various occupational groups of GGL for periods 1973-86 and 1987-96.**

<b>OCCUPATIONAL GROUP</b>	<b>Mean annual inc. rate/1000 for period</b>	
	<b>1973-86</b>	<b>1987-96</b>
Drillers	10.1	9.9
Blastmen	9.2	3.2
Shovelmen	4.7	0.9
Spannermen	4.8	1.5
Loco men	2.5	2.8
Other U/G workers	3.7	1.4
Mill crushers	18.7	4.2
Other mill workers	0.8	0
Other surface workers	0	0

The chart in figure 3.6 on page 59 further illustrates the pattern of incidence rates of silicosis among the various occupational groups for the two periods.



### **3.7. List of general safety and personal protective measures in place at GGL aimed at reducing the amount of dust inhaled by workers.**

In the fight against silicosis and other respiratory diseases caused by dust, several measures are currently in place at *GGL* to reduce the quantity of dust which is inhaled by workers at risk of exposure to large quantities of dust during work. The measures, which were observed during this study, will be presented for each major activity during which workers are at risk of exposure to large quantities of dust. Table 3.10 on pages 61 and 62 presents a summary of the measures, which can be grouped into three categories namely:

- a) Measures which are permanently in place to prevent flight of dust into the atmosphere.
- b) Safety measures taken by workers whilst at work to reduce generation of dust or flight of dust into the atmosphere
- c) Personal protective measures for workers.

In addition, the table gives the researcher's subjective opinion about the quantity of dust in the atmosphere after the first two categories of measures have been put in place during activity. The quantity of dust was assessed as little, moderate and large quantity.

Table 3.10.

List of observed general safety and personal protective measures in place at GGL against dust inhalation by workers.

Process	Permanent structures	Measures by workers	Quantity of dust after measures	Personal protective measures
DRILLING	Good general ventilation	<ul style="list-style-type: none"> <li>- Wetting of rock surface with water</li> <li>- Catching of dust by water flow through axial hole in drill steel</li> </ul>	Little to moderate dust	Disposable filter respirators
BLASTING AND RE-ENTRY	-Good general ventilation Auxilliary ventilation in blast area through meco fans	<ul style="list-style-type: none"> <li>-Blasting done off-shift after all persons not engaged in operation are removed from area</li> <li>-Period of 4 hours allowed before re-entry</li> <li>-Water blast to cause spray to allay dust</li> <li>-Timbering, barring down and allaying dust with water by blastman before others re-enter</li> <li>-Manager ensuring precautions before re-entry</li> </ul>	Little to moderate dust mostly in the form of mist	Disposable filter respirators

Table 3.10 (contd.).

Process	Permanent structures	Measures by workers	Quantity of dust after measures	Personal protective measures
BARRING, SCRAPING AND LASHING	Good general ventilation	Ensuring that rock is kept wet to keep dust out air stream	Little to moderate dust	Disposable filter respirators
TRAMMING AND HOISTING	Good general ventilation	Relying on wetness of rocks rendered so by earlier handlers	Moderate quantities of dust when rocks have relatively dried up	-Disposable filter respirators -Dust foe respirators
TIPPING AND LOADING AND CONVEYANCE OF ROCKS ON CONVEYOR INCLINE	-Good general ventilation	Relying on wetness of rocks rendered so by earlier handlers	Moderate quantities of dust when rocks have relatively dried up and when ventilation doors are open	Disposable filter respirators
MILL CRUSHING AND MILLING	-Open ventilation of crushing plant -Local exhaust fans for suctioning of dust through hoods and metal pipes into a larger common tube and suctioning system		Moderate to large	Disposable filter respirators -Dust foe respirators

One may summarise all the safety measures against dust currently in place at *GGL*. During the interview with the three long-serving officials of the mine, information was obtained on the approximate year of introduction of some of the measures. The following is a summary of the safety measures with an indication of the approximate years when the measures were introduced:

- 1) General good ventilation of underground section of the mine- since mining activities started at the concession, efforts have been made to ensure good ventilation underground by mechanical ventilation. However, as the years go by and with development of technology, better mechanical ventilation is ensured so that the general ventilation in recent years is far better than in earlier years of the mine.
- 2) Timbering and barring down after blasting by blastman before any other people enter the blast area- since time immemorial.
- 3) Blasting off-shift after all persons not engaged in the operation are removed from the area- since time immemorial.
- 4) Allowing a lag-period of 4-6 hours before re-entry into blast area after a blasting operation- since time immemorial.
- 5) Manager ensuring that all precautions are taken before blast- since time immemorial.

- 6) Use of respirators-Since time immemorial, but there was less compliance when ventilation underground was relatively poorer thus increasing discomfort during use of respirators. As the years go by, with more awareness of the effects of dust among the workers, better supervision and institution of sanctions for non-use compliance with use of respirators, compliance is believed by safety officials to be improving over the years.
- 7) Wetting of rock surface with water before drilling-Before 1970 but over the years, more attention has been paid to the intensity of the wetting.
- 8) Water blast to cause a spray of water to allay the fumes and dust from blast-around 1970. Since 1993, more sophisticated machines have been introduced for the process.
- 9) Allaying dust with water by blastman after blast before others enter blast area-around 1970.
- 10) Ensuring that rock is kept wet to keep dust out of the air-stream during barring scraping and lashing- around 1970.
- 11) Local exhaust systems using hoods and 16- inch fans at the assay-Early 1980's.
- 11) Constant auxilliary ventilation in blast area using meco fans- since early 1980's.

- 12) Two local 24-inch exhaust fans for suctioning of dust through hoods into large metal pipes leading into a larger common pipe and connection of system to a 60-inch fan- This mechanism was installed in the early 1970's but has undergone modifications over the years. Initially, there were no pipes with hoods so that the exhaust system suctioned the dust from the open air so that it was not effective. The current larger fans being used were installed recently.
- 13) Underground booster ventilating fans- One was introduced in 1986 but three more were introduced in 1993.

Apart from the above measures, efforts are made to regularly educate the workers about the hazards of the occupation. In fact, during my visits to the various sections of the mine, the workers were reciting the safety slogans they had been taught. Efforts are made to supervise workers well so that they adhere to safety regulations. Sanctions exist for non-compliance with regulations.

According information gathered from interviewing the Chief Medical Officer of the mine, all newly engaged employees go through an induction course at the Training School. Health hazards are highlighted and precautionary measures are fully explained to them before they are assigned to various working places. Re-education of susceptible workers and immediate supervisors on the hazards of airborne dust and the means of filtration need to be implemented. All supervisors are regularly re-educated on the need to regularly ascertain ventilation conditions and record breaches of regulations.

**3.7.1. Compliance with use of respirators by risk groups at GGL.**

Table 3.11 on the page 67 illustrates the level of compliance with use of respirators by various occupational groups as was observed during the study. Out of the 50 workers observed, 33 (66%) were using respirators whilst at work whilst 17 (34%) were not using them. 2 out of the 33 who were using respirators were using dust foe respirators whilst 31 were using disposable filter respirators. Out of the 17 who were not using respirators, 5 were mechanics and 3 were conveyor crewmembers. In fact all the mechanics observed were not using respirators.

**Table 3.11.****Compliance with use of respirators at *GGL*.**

<b>Occupational group</b>	<b>Number observed</b>	<b>Number observed using disposable filter respirators</b>	<b>Number observed using dust foer respirators</b>	<b>Total number observed using respirators</b>	<b>Number observed not using respirators.</b>
Drillers	1	1	-	1	-
Spannermen	2	2	-	2	-
Shovelmen	3	3	-	3	-
Blastmen	1	1	-	1	-
Pumpmen	2	1	-	1	1
Winch drivers	1	1	-	1	-
Winder drivers	2	-	1	1	1
Loco drivers	4	3	-	3	1
Binmen	6	4	-	4	2
Conveyor crew	10	7	-	7	3
Hoist gang	4	3	-	3	1
Mechanics	5	-	-	-	5
Trackmen	3	2	-	2	1
Mill crushers	3	2	1	3	-
Ball mill workers	3	1	-	1	2
<b>Total</b>	<b>50</b>	<b>31</b>	<b>2</b>	<b>33</b>	<b>17</b>

When those who were not using respirators were asked to give their main reasons (one each) for not using them, 2 of them said that their disposable respirators were dirty and they had not gone for new ones. 6 of them said that their disposable respirators were spoilt or dirty and when they requested for new one, there was

none in stock. 2 of them said that they had the respirators but they were not comfortable. 7 (5 of them mechanics) felt that they were not threatened by the dust hazard. The mechanics claimed that they had come underground temporarily to work and were not there permanently so that they had not requested for the respirators. The other two felt that at that moment there was not much dust in the atmosphere so that they had put the respirators aside because they are otherwise uncomfortable.

## **CHAPTER FOUR.**

### **4.0. DISCUSSION AND CONCLUSIONS.**

#### **4.1. Discussion.**

##### **4.1.1. Silicosis among small-scale miners.**

The observation that 8 out of the 9 cases of silicosis recorded at the *GGL* Hospital from 1993 to 1995 were small-scale miners is of great public health importance because of the predominance and importance of small-scale mining in the Tarkwa area. No figures were available for the population of the small-scale miners in the area who patronise the *GGL* Hospital so that rates of silicosis incidence cannot be calculated. Since small scale miners have been operating for some time in the district, the above data points to the fact that a lot of silicotic cases among small scale miners may have been misdiagnosed at other health institutions during the period when they were not patronising the *GGL* Hospital.

The possible reasons for the large accumulation of cases among small scale miners are the non-use of protective measures like filter respirators and poor ventilation in the underground tunnels they use. Also, the crude way of pounding of rocks in mortars without protection of the respiratory system is another possible cause of the accumulation of cases among small scale miners. These factors need to be researched into.

I found no literature on the incidence rates of silicosis among small-scale miners and therefore, this finding is an important base for further studies on the problem of silicosis among this particular group of miners.

#### **4.1.2. Sex distribution of silicotic cases.**

No female was found among the 8 cases of silicosis recorded among small-scale miners between 1993 and 1995. Although a number of females are exposed to large quantities of silica dust through small scale mining activities, so far, no case of silicosis has been recorded among them. It is important to note that silicosis was recorded among females in Kostinen's study (16) during which there were 6 women out of 144 silicotic cases he reviewed in 1979. In the formal mining sector, females are not employed in dusty areas so that no cases of silicosis are expected among them. In the small scale mining sector, the roles of females and all the hazards they encounter during their activities have to be studied and documented.

The possible reasons for no cases being reported among females are that a) females are relatively new entrants into the small scale mining industry and b) females may work less regularly in sections where they are exposed to large quantities of dust. These has to be investigated.

#### **4.1.3. Trend of annual incidence rates of silicosis among GGL mine workers.**

The general falling trend of incidence rate of silicosis at the *GGL* may be explained by several factors, which may need further investigation.

The main factor which determines the development of silicosis in a person is the degree of exposure to silica dust which in turn depends on

- i) the duration of exposure
- ii) the concentration of dust in the atmosphere
- iii) the percentage of free silica in the dust
- iv) the size of the free silica particles

The percentage of free silica in the dust and the size of the free silica particles, are on the average, not likely to change much at the mine over the years. However, the two main factors we have to consider in the circumstances of *GGL* are

- a) the duration of exposure to dust and
- b) the concentration of dust in the atmosphere.

Also important is the quantity of dust which finally reaches the lungs of workers.

Given that all the above factors (except the duration of exposure) are more or less equal in a given environment and population, one expects people who have been exposed for longer periods to the dust to be more likely to develop silicosis than

those exposed for shorter periods. In comparing annual incidence rates of silicosis, one has to remember that the disease usually develops after several years of exposure to silica dust. In comparing the incidence rates in any two given years, one has to make sure that the populations at risk (exposed to large quantities of dust) in those two years have been exposed to dust for equivalent lengths of period. For instance, in a situation where there is a high turnover rate of the labour force in a mining company, one automatically expects silicosis to be virtually non-existent or minimal. Before finding reasons for any change in the incidence rates of silicosis over the years, one needs, first of all to find out whether the exposure periods of the labour force to silica dust in those years are relatively equal. If this were to be the case, then one could look out for other reasons for the change in incidence rates.

Data available for the labour force from 1973 to 1986 (see table 4.1 on page 73) shows that between 1973 and 1986, the percentage of the labour force which had spent 10 or more years at the mine fell gradually. About 60.6% of the labour force in 1973 had worked for the mine for 10 or more years but by 1986, only 30.9% of the labour force had worked for the mine for 10 or more years. There was no readily available data on the length of service of the labour force from 1987 to 1996. However, from the data on the relative lengths of service of the labour force in the various years from 1973 to 1986, the different year groups of workers might have had different lengths of periods of exposure to dust.

Table 4.1.

Percentage distribution of the annual labour force of GGL from 1973 to 1986 by length of service in the company.

YEAR	<i>Workers with less than 10 years of service</i>		<i>Workers with 10 or more years of service</i>		<i>TOTAL</i>	
	No.	%age	No.	%age	No.	%age
1973	1427	39.4	2194	60.6	3621	100
1974	1539	42.2	2107	57.8	3646	100
1975	1621	44.5	2022	55.5	3643	100
1976	1557	46.0	1827	54.0	3384	100
1977	1474	49.2	1521	50.8	2995	100
1978	1389	49.3	1428	50.7	2817	100
1979	1504	50.5	1475	49.5	2979	100
1980	1359	53.7	1172	46.3	2531	100
1981	1264	54.3	1063	45.7	2327	100
1982	1637	60.6	1065	39.4	2702	100
1983	1839	67.3	893	32.7	2732	100
1984	1903	68.4	879	31.6	2782	100
1985	1851	69.0	831	31.0	2682	100
1986	1852	69.2	824	30.8	2676	100

Source: *GGL* Personnel Department records.

It should be noted however that even though the percentage of the labour force, which had spent 10 or more years at the mine, fell gradually from year to year between 1973 and 1986, even in those years, the annual incidence rates did not follow a smooth pattern of fall. Also, the annual fall in the percentage of workers who had spent 10 or more years with the mine did not match the fall in the incidence rates between 1973 and 1986. Therefore, even though the different lengths of exposure to dust over the years could account for some of the fall in incidence rate of silicosis at the mine, it cannot account for the drastic fall.

The factor, which may have most significantly influenced the incidence rates, is the concentration of dust in the atmosphere. In section 3.7, we listed the measures that have over the years been taken at the mine to reduce the amount of dust inhaled by workers. It could be seen that from year to year, workers were more protected by measures like wet methods of mining, use of respirators, education and good supervision. It is therefore likely that over the years, the quantity of dust in the working environment and in the air inhaled by workers has reduced. Before 1993, conimeters were used to count dust particles in dusty environments. Available data for 1980 to 1984 for locations of the mine where drilling and shovelling were being done show that the quantity of dust particles in the atmosphere was generally between 50 and 70 dust particles per cubic centimetre and occasionally around 80. This value is low as compared to the threshold dust count of 175 particles per cubic centimetre permitted by the American Conference of Governmental Industrial Hygienists in high silica rock area (17). The values over those years did not vary much daily. Figures were not available for years before the introduction of wet methods. Measurement of dust particles was stopped at the mine by the headquarters of the Mines Department by a letter dated 15 June 1993. The conimeter was only measuring the number of dust particles per volume of air. The Mines Department recommended the use of gravimetric methods, which could distinguish between the different dust elements and separate respirable dust from coarse dust particles in the atmosphere, as well as the weight of the particles per volume of air. The instrument has since not been

acquired and no measurement of the quantity of dust is currently done. The absence of this instrument may compromise the healthy conditions under which the current crop of workers are working since a fall in the the safety standards in the company may not be detected on time.

About 66% of the workers observed, complied with the use of respirators. Awareness of the dust hazard was found to be high. With a more regular provision of the right quality of respirators, compliance with their use may be higher. It is possible that better compliance to the use of respirators and better occupational hygienic practices may have contributed to the falling trend of silicosis over the years.

In summary, the possible factors, which may have led to the falling trend of silicosis over the years, are:

- a) Improved safety measures at the mine
- b) Increased compliance with the use of respirators and better occupational hygienic practices
- c) Increased awareness among workers of the dust hazard
- d) Improved supervision
- e) Different lengths of periods of exposure to dust during different years.

The influence of these factors on the trend of silicosis incidence needs to be

studied further preferably, with a prospective study. The acquisition of dust samplers including personal ones would help to compile data on the concentration of dust as well as the proportion of respirable in the atmosphere of work for various occupational groups.

Literature on the trend of incidence rates of silicosis is scanty. Murray et al (19) rather studied the trend of prevalence rates of silicosis among black South African miners from 1975 to 1991. The prevalence rates increased from 9.3% to 12.8% over the period. One cannot deduce incidence rates from this data. In Switzerland, the incidence of new cases rose until 1940, then levelled off at 200-300 cases per annum and then fell after 1974 to less than 100 per annum (13).

The same reasons for the falling trend of silicosis incidence for all the **GGL** workers may apply to the trends observed for both underground and surface workers. However, the faster fall of the incidence rate of silicosis among vulnerable surface workers (mill crushers and other mill workers) may be because of the introduction of exhaust fan systems with metal pipes and hoods at dust generation points in the 1970's with subsequent improvements in the 1980's. Since surface workers have good ventilation the presence of such an exhaust system together with compliance with use of respirators greatly reduces the danger of dust inhalation at the mills.

In 1973, the incidence rate of silicosis among **GGL** workers was 6.1 cases per 1000 for the year. Between 1974 and 1993, this rate varied from 0.4 to 4.7 cases

per 1000 per year. Between 1994 and 1996, no case was recorded. The incidence rates observed over the years compare with the rates observed by Leger (11) in his study of silicosis among black gold miners in South Africa in which he found a crude annual incidence rate of between 1.7 and 5.2 per 1000 per year in the years from 1980 to 1989. The smaller mean annual incidence rate of silicosis among mine workers for the period 1987-96 as compared to the period 1973-86 (1.1 and 3.1 respectively) reflects the sharp falling trend of silicosis since Tuffuor-Kwarteng's study for the period 1973-86. The falling trend also explains the fact that for the whole period of study (1973-96), the mean annual incidence rate of silicosis was 2.4 as opposed to 3.1 for the period 1973-86.

#### **4.1.4. Mean annual incidence rates of silicosis among various occupational groups of GGL.**

Among the underground workers, the highest mean annual incidence rate was among the drillers (machine drivers). Tuffuor-Kwarteng (4) in his study found the same situation. In fact, the drillers had the highest mean annual incidence rate of silicosis among all the occupational groups during the period 1987-96. Seven out of the 23 underground cases (30.4%) and out of all the 25 cases (28%) recorded during this second period (1987-96) were drillers. During this second period, drillers also had the highest mean annual incidence rate even among all the occupational groups, both surface and underground. This was unlike during the first period (1973-86) when mill crushers had the highest mean annual incidence rate among all the occupational groups.

The high incidence rate of silicosis among the drillers is probably due to the fact that the drillers work in dust which is constantly being freshly produced but has been redistributed in the atmosphere in such operations as shovelling, loading, haulage and so on. Also records from the ventilation department indicate that dust emitted from the drilling operations consists of a higher percentage of respirable (and toxic) dust particles than the dust emitted in other underground operations. The introduction of dust sampling at the mine would help us investigate further why in recent times, drillers are the occupational group at most risk of developing silicosis. Jorgensen (20) in a study of silicosis in the iron-ore mine in Kiruna, Sweden in 1986, observed that silicosis was no longer a major health risk among those were then starting work at the mine. He recommended that only those who had been employed in drilling, loading and tapping operations before 1980 should continue to undergo regular health examinations for silicosis. This points to the fact that, in spite of all safety measures, working conditions of drillers should be regularly evaluated.

Blastmen also involve themselves in supervision of drilling operations and are also the first to enter a blast area after the time lag. They may also be exposed to large quantities of dust. However, the incidence rates have fallen drastically among the blastmen just as among all the other occupational groups.

#### **4.1.5. Safety measures at the GGL mine and recommendations.**

As mentioned earlier in the discussion, the safety measures in place at the GGL

mine may have contributed to the falling trend of silicosis incidence over the years. Efforts have been made by management to go by the tenets of the 1970 mining regulations (5). However, based on the findings of my study, the following facts should be noted:

- 1) Just before 1993, silicosis was still a problem among drillers. Because silicosis takes long periods of exposure to silica dust before developing, the cases may have developed because of working conditions years back. However, it is very important to earmark drillers as a major risk group so that they would be supervised strictly for them to adhere to safety rules.
- 2) Small-scale miners are now a major risk group for silicosis. Since future employees of the mine may be former small-scale miners, it may be useful for *GGL* to collaborate with the *DHMT* to organise health education programmes for the small-scale miners. Such education should also go on among the *GGL* miners so that those who may engage in part-time small-scale mining may take precautions when doing so. Also, the mine may assist the *DHMT* to research into the prevalence of silicosis among small-scale miners.
- 3) Some sections of the mine like the conveyor incline, the crushing plant and the loading and tipping bays are still hazardous area so far as dust is concerned. Constant supply of neat disposable filter respirators or longer-lasting but comfortable ones and good supervision are very necessary to reduce the quantity of dust inhaled by workers in these areas.

The following recommendations are made for the *GGL* mine:

- 1) The management of the mine should make all efforts to acquire dust samplers for monitoring dust at the mine. This would help management to control dust exposure in the mine on a continual basis. It would also help to monitor adherence of workers to safety rules concerning dust generation and flight into the atmosphere during mining activities. Dust sampling data would also provide the scientific basis for assessing the success of safety measures in combating occupational respiratory diseases among mineworkers.
- 2) The management should monitor regularly all dusty areas. For this purpose, a safety committee made up of Top Management, Physicians and representatives of the various sections of the mine should be established.
- 3) Most of the workers I interviewed were describing a particular type of respirators, which would be more convenient for them. The management may find out the type preferred by the workers since their provision would improve compliance with use of respirators.
- 4) Adequate provision should be made for regular discarding and replacement of worn out respirators in order to ensure better compliance with the use of the respirators.
- 5) Artisans who work underground temporarily should be educated to carry along respirators so that they may be protected from excessive dust exposure.

Since they may be visiting underground several times in the course of their working life, they should prevent respiratory diseases resulting from accumulation of dust in the lungs.

- 6) Education and re-education of the workers about the hazards of the profession as is currently going on should be sustained.

To the *DHMT*, the following recommendations are made:

- 1) With the predominant mining activities in the Tarkwa area, some silicotic cases are likely to report to other health institutions in the district apart from the *GGL* Hospital. The *DHMT* should endeavour to organise workshops for diagnosticians in the district about the diagnosis of silicosis and other pneumoconioses. In this way, reporting of silicosis would be improved thus bringing out the real situation of silicosis in the district.
- 2) The *DHMT* should try and come out with a proposal for prevalence study of silicosis among small-scale miners in the district and make all arrangements for carrying out such a research.
- 3) The *DHMT* should in collaboration with the Mines Department educate small-scale miners about the dangers of silica dust.
- 4) The *DHMT* should collaborate with the Mines Department in an inter-sectoral crusade against the dust hazard among miners in the district.

#### 4.2. Conclusions.

Of all the 160 cases of silicosis recorded at the *GGL* Hospital from 1973 to 1996, 133 (83.1%) were underground workers of *GGL*; 19 (11.9%) were surface workers of *GGL* and 8 (5%) were small-scale miners in the Tarkwa area. However, if we consider only the cases from 1993 to 1996, then, 88.9% of the cases (8 out of 9) were small scale miners whilst only 11.1% (1 out of 9 cases) were underground workers of *GGL*. No case was reported among surface workers of *GGL*.

Of all the 160 cases of silicosis reported from 1973 to 1996 at the *GGL* Hospital, none of them was female.

The annual incidence rate of silicosis among *GGL* workers fell gradually from 6.1 cases per 1000 per year in 1973 to 0.4 cases per 1000 in 1993 and 0 from 1994 to 1996, even though the falling trend was not consistent and smooth. However, showing the trend by 5-year moving averages, a more or less secular falling trend was observed.

Among both underground and surface workers of *GGL*, a falling trend of silicosis incidence was observed from 1973 to 1996. However, the fall was faster for the surface workers and also there were several periods when no case was recorded at all among the surface workers.

For the period 1973-96, among underground workers, the highest mean annual

incidence rate of silicosis was among the drillers (11.1 cases per 1000 per year) followed by the blastmen (7.7 cases per 1000 per year). Among the surface workers, the mill crushers had the highest mean annual incidence rate (13.4 cases per 1000 per year). Overall, the mill crushers had the highest mean annual incidence rate among all the occupational groups of the mine, followed by the drillers and then by the blastmen. On the whole, the mean annual incidence rate among the *GGL* workers for the period 2.4 cases per 1000 per year. Among the underground workers, the rate was 3.1 cases per 1000 per year whilst it was 0.7 cases per 1000 per year among surface workers. Breaking the 24-year period into two periods (1973-86 and 1987-96), however, it was observed that during the second period (1987-96), the mean annual incidence rate (1.1 cases per 1000 per year) was far lower than during the first period (3.1 cases per 1000 per year). Also during this second period, silicosis was virtually non-existent among the surface workers (0.2 cases per 1000 per year during the second period as compared to 1 case per 1000 during the first period). The mean annual incidence rate was also smaller in the second period (2 cases per 1000 per year) than in the first period (4 cases per 1000 per year) for the underground workers.

For the entire 24-year period of this study, among the various occupational groups, mill crushers had the highest mean annual incidence rate of silicosis. However, during the second period (1987-96) alone, the drillers had the highest mean annual incidence rate (9.9 cases per 1000 per year as compared to 4.2 among mill crushers and 3.2 among blastmen). It means that in recent times,

incidence rate of silicosis was higher among drillers than among any other occupational group of the mine.

Safety measures taken against dust generation and inhalation at the GGL mine are:

- a) Good ventilation and exhaust ventilation systems for suctioning dust from the source of dust production and atmosphere
- b) Wet methods of drilling and water blasts to allay dust
- c) Use of respirators.

Good supervision of workers and continual education of workers about the hazards of mining are other measures in place to ensure that workers inhale minimal quantity of dust.

Dust sampling is currently not being performed at the mine to assess the quantity of dust in the various working environments.

It is recommended that dust sampling should be re-introduced at the mine using gravimetric methods to detect any danger of excessive dust exposure and for research purposes. Supply of appropriate respirators and ensuring of compliance with their use, education and re-education about occupational hazards should be sustained. The DHMT should collaborate with the Mines Department to educate small-scale miners about the dust hazard and to organise an inter-sectoral crusade against the dust hazard.

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# **APPENDIX.**





**APPENDIX 3.****Checklist for observation of permanent safety structures in place at GGL and safety measures taken by workers at work against dust generation and flight into the atmosphere.**

Section of mine	Process	Permanent structures	Measures taken by workers whilst at work	Subjective assessment of level of dust in atmosphere after measures
UNDER GROUND				
ASSAY				
CRUSHING PLANT				
BALL MILL				



**APPENDIX 5.****Formulae for indices used in text.**

- 1) Mean number of workers for a period of years =

Total of annual number of workers ÷ Number of years in period.

- 2) Annual incidence rate of silicosis =

$$\frac{\text{Number of new cases of silicosis recorded in the year} \times 1000}{\text{Mid-year population (workforce) at risk.}}$$

- 3) Period incidence rate of silicosis =

$$\frac{\text{Total number of new cases of silicosis recorded within the period} \times 1000}{\text{Mean number of workers at risk for the period.}}$$

- 4) Period mean incidence rate of silicosis =

Period incidence rate of silicosis ÷ Number of years in the period.

- 5) 5-year moving average incidence rates of silicosis from 1973 to 1996 were calculated by finding the mean incidence rates for the following series of 5-year periods:

<b>5-yr. Period</b>	<b>Middle year of period</b>
1973-77	1975
1974-78	1976
1975-79	1977
1976-80	1978
1977-81	1979
1978-82	1980
1979-83	1981
1980-84	1982
1981-85	1983
1982-86	1984
1983-87	1985
1984-88	1986
1985-89	1987
1986-90	1988
1987-91	1989
1988-92	1990
1989-93	1991
1990-94	1992
1991-95	1993
1992-96	1994

In plotting the moving averages against time, the mid-period years are used.

**APPENDIX 6.**

**Distribution of the mid-annual workforce of GGL from 1973 to 1996 by occupational groups.**

Year	<i>Mid-annual workforce for various occupational groups</i>									
	UNDERGROUND WORKERS						SURFACE WORKERS			TOTAL
	Drillers	Blast men	Shovelmen	Spanners	Loco Drivers	Other U/G	Mill crushers	Other mill	Other surface	
1973	99	90	360	70	88	1616	64	190	1044	3621
1974	98	92	360	72	90	1540	65	199	1130	3646
1975	82	88	360	73	87	1489	65	203	1196	3643
1976	88	88	362	74	92	1292	61	185	1142	3384
1977	88	88	364	70	88	1081	56	167	993	2995
1978	87	88	368	74	88	898	56	167	991	2817
1979	82	88	365	72	87	1039	60	168	1018	2979
1980	86	90	362	73	86	826	58	160	790	2531
1981	85	86	360	73	85	631	56	157	794	2327
1982	78	87	361	74	85	866	47	192	912	2702
1983	80	79	364	73	85	681	50	185	1135	2732
1984	80	79	365	73	85	781	59	166	1094	2782
1985	83	78	362	70	85	802	53	167	982	2682
1986	79	82	362	70	82	805	51	167	978	2676
1987	76	76	362	70	82	749	50	168	1052	2685
1988	77	76	363	70	80	637	51	168	1166	2688
1989	80	75	350	70	80	566	50	164	1169	2604
1990	81	75	351	70	77	647	50	160	991	2502
1991	82	72	348	68	75	658	50	160	992	2505
1992	66	50	330	68	74	678	50	158	1026	2500
1993	66	50	321	65	68	698	50	142	1040	2500
1994	66	50	301	62	66	333	38	141	343	1400
1995	58	50	290	64	65	343	38	145	347	1400
1996	54	50	288	65	60	358	38	140	348	1401
Ave. annual	79	76	349	70	81	834	53	167	945	2654

**APPENDIX 7.****Annual distribution of silicotic cases recorded at GGL Hospital from 1973 to 1996  
among the various occupational groups of GGL.**

Year	<i>No. of silicotic cases reported among various occupational groups in each year</i>									
	Drill ers	Blast men	Shov elme n	Span ner men	Loco Driv ers	Othe r U/G	Mill crus hers	Othe r mill	Othe r surf ace	TOT AL
1973	5	3	3	1	1	6	2	1	0	22
1974	1	2	3	1	0	6	3	1	0	17
1975	1	0	1	1	0	3	2	0	0	8
1976	4	0	3	0	1	6	1	0	0	15
1977	0	1	4	0	0	6	1	0	0	12
1978	0	1	1	0	0	2	1	0	0	5
1979	0	1	1	0	0	3	1	0	0	6
1980	1	0	1	0	0	2	0	0	0	4
1981	0	1	1	1	0	2	0	0	0	5
1982	1	2	1	1	1	6	1	0	0	13
1983	0	0	2	0	0	3	1	0	0	6
1984	0	1	1	0	0	1	1	0	0	4
1985	1	0	1	0	0	2	1	0	0	5
1986	0	0	1	0	0	4	0	0	0	5
1987	2	0	1	0	0	2	0	0	0	5
1988	1	0	1	0	1	2	0	0	0	5
1989	2	0	0	0	0	1	1	0	0	4
1990	0	0	1	1	1	1	1	0	0	5
1991	1	1	0	0	0	0	0	0	0	2
1992	1	1	0	0	0	1	0	0	0	3
1993	0	0	0	0	0	1	0	0	0	1
1994	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0
<b>TOT AL</b>	21	14	27	6	5	60	17	2	0	152

**Appendix 8.**

**Figures for 5-year moving average incidence rates of silicosis among GGL workers from 1973 to 1996.**

<b>Period</b>	<b>Middle year of period</b>	<b>5-yr moving ave. incidence rate /1000/yr.</b>
1973-77	1975	4.3
1974-78	1976	3.4
1975-79	1977	2.9
1976-80	1978	2.8
1977-81	1979	2.3
1978-82	1980	2.5
1979-83	1981	2.6
1980-84	1982	2.4
1981-85	1983	2.5
1982-86	1984	2.4
1983-87	1985	1.9
1984-88	1986	1.8
1985-89	1987	1.8
1986-90	1988	1.8
1987-91	1989	1.6
1988-92	1990	1.5
1989-93	1991	1.2
1990-94	1992	0.9
1991-95	1993	0.8
1992-96	1994	0.3

**APPENDIX 9.**

Annual incidence rates of silicosis among *GGL* underground workers and among *GGL* surface workers from 1973 to 1996.

YEAR	UNDERGROUND WORKERS			SURFACE WORKERS		
	Total workforce as at end of June	No. of silicotic cases	Annual incidence rates per 1000 workers	Total workforce as at end of June	No. of silicotic cases	Annual incidence rates per 1000 workers
1973	2323	19	8.2	1298	3	2.3
1974	2252	13	5.8	1394	4	2.9
1975	2179	6	2.8	1464	2	1.4
1976	1996	14	7.0	1388	1	0.7
1977	1779	11	6.2	1216	1	0.8
1978	1603	4	2.5	1214	1	0.8
1979	1733	5	2.9	1246	1	0.8
1980	1523	4	2.6	1008	0	0
1981	1320	5	3.8	1007	0	0
1982	1551	12	7.7	1151	1	0.9
1983	1362	5	3.7	1370	1	0.7
1984	1463	3	2.1	1319	1	0.8
1985	1480	4	2.7	1302	1	0.8
1986	1374	5	3.6	1302	0	0
1987	1415	5	3.5	1270	0	0
1988	1303	5	3.8	1385	0	0
1989	1221	3	2.5	1385	1	0.7
1990	1301	4	3.1	1201	1	0.8
1991	1303	2	1.5	1202	0	0
1992	1266	3	2.4	1234	0	0
1993	1268	1	0.8	1232	0	0
1994	878	0	0	522	0	0
1995	870	0	0	530	0	0
1996	875	0	0	526	0	0

Source: *GGL* periodic Hospital reports and *GGL* Personnel Department records.

**APPENDIX 10.**

**Annual incidence rates of silicosis among *GGL* underground workers and among vulnerable *GGL* surface workers (mill crushers and other mill workers from) 1973 to 1996.**

YEAR	<i>UNDERGROUND WORKERS</i>			<i>VULNERABLE SURFACE WORKERS</i>		
	Total workforce as at end of June	No. of silicotic cases	Annual incidence rates per 1000 workers	Total workforce as at end of June	No. of silicotic cases	Annual incidence rates per 1000 workers
1973	2323	19	8.2	254	3	11.8
1974	2252	13	5.8	264	4	15.2
1975	2179	6	2.8	268	2	7.5
1976	1996	14	7.0	246	1	4.1
1977	1779	11	6.2	223	1	4.5
1978	1603	4	2.5	223	1	4.5
1979	1733	5	2.9	228	1	4.4
1980	1523	4	2.6	218	0	0
1981	1320	5	3.8	213	0	0
1982	1551	12	7.7	239	1	4.2
1983	1362	5	3.7	235	1	4.3
1984	1463	3	2.1	225	1	4.4
1985	1480	4	2.7	220	1	4.6
1986	1374	5	3.6	218	0	0
1987	1415	5	3.5	218	0	0
1988	1303	5	3.8	219	0	0
1989	1221	3	2.5	214	1	4.7
1990	1301	4	3.1	210	1	4.8
1991	1303	2	1.5	210	0	0
1992	1268	3	2.4	208	0	0
1993	1268	1	0.8	192	0	0
1994	878	0	0	179	0	0
1995	870	0	0	183	0	0
1996	875	0	0	178	0	0

Source: *GGL* Hospital periodic reports and *GGL* Personnel Department records.

**APPENDIX 11.**

**Figures for 5-year moving average incidence rates of silicosis among GGL underground and vulnerable GGL surface workers.**

Period	Middle year of period	5-yr moving ave. incidence rate/1000/yr among	
		U/G workers	Vulnerable surface workers
1973-77	1975	6.0	8.6
1974-78	1976	4.9	7.2
1975-79	1977	4.3	5.0
1976-80	1978	4.2	3.5
1977-81	1979	3.6	2.7
1978-82	1980	3.9	2.6
1979-83	1981	4.1	2.6
1980-84	1982	4.0	2.6
1981-85	1983	4.0	3.5
1982-86	1984	4.0	3.5
1983-87	1985	3.1	2.7
1984-88	1986	3.1	1.8
1985-89	1987	3.2	1.9
1986-90	1988	3.3	1.9
1987-91	1989	2.9	1.9
1988-92	1990	2.7	1.9
1989-93	1991	2.1	1.9
1990-94	1992	1.6	1.0
1991-95	1993	0.9	0
1992-96	1994	0.6	0