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# THE HIGH MORTALITY OF BRITISH METAL AND SLATE MINERS AND BELIEFS ABOUT THE CAUSES (1556 to 1904)

R.A. Williams

"Each industrial occupation may be said to involve risks to health ....
the worst enemy of the miner is dust"
*Clement Le Neve Foster 1903*

**SYNOPSIS**

*Metal and slate miners in most British mining districts suffered a high mortality mainly due to siliceous rock dust inhalation causing the lung disease silicosis (miners' asthma) and its attendant complications. Lung disease caused by radon gas and smoking (i.e. cancer) may have been contributory factors in some districts. Accidents and other ailments were generally a much less important cause of death in comparison to lung diseases.*

*The earliest references to the high mortality and the supposed causes are examined and the development of ideas in Britain during the eighteenth, nineteenth and early twentieth centuries are chronicled.*

*Despite the insights of early European writers into the existence and cause of high mortality amongst miners, British writers were slow even to recognise there was an abnormal mortality. Few British writers, and none of the major Government enquiries of the nineteenth century, recognised dust as the principal cause of the high mortality. The widespread introduction of compressed air rock drills late in the nineteenth century, particularly in South Africa and Cornwall, produced a major increase in mortality rates. This led to the Haldane report of 1904 which finally recognised dust as the principal cause, not only of the recent increase, but also of the past high mortality rates.*

## INTRODUCTION

In this paper the writer outlines a brief chronological history of the development of ideas concerning the high mortality of the metal and slate mines up to 1904. It is based mainly on published works and should form a basis against which local studies of mining districts can be compared.

Mining has always been a hazardous occupation. Miners endured many hardships and suffered from many ailments. They generally died much earlier than agricultural labourers. The two main occupational hazards facing miners were lung diseases and mining accidents.

Coal mining usually involved the emission of methane from coal seams in soft strata liable to collapse and this gave rise to major disasters and numerous smaller accidents. As a result, coal miners were initially much more liable to die from accidents than metal miners working in normally gas free and generally more competent strata.

However this was not true in the latter half of the nineteenth century when mining safety legislation and other improvements began to take effect in coal mines.

Metal miners, even when suffering less accidents than coal miners, generally had a much higher mortality rate. This was principally caused by the fact that most metal miners worked in rocks or veins rich in free silica (e.g. quartz) whose pernicious dust produced the deadly lung disease silicosis. The various other ailments suffered by metal miners did not in general cause a major increase in mortality rates[1] and are not dealt with in this paper.

Coal miners rarely suffered from true silicosis (unless constantly driving headings in sandstone or shale) because of the low silica content of the coal seams. Excessive amounts of coal dust could give rise to another type of dust disease (coal workers' pneumoconiosis) and this did take its toll in some districts. However the mortality rates of coal miners from lung diseases were generally much lower than metal miners and this resulted in coal miners usually living longer.

**SILICOSIS**

Silicosis is the term coined by Visconti in 1870 to define the lung disease caused by the inhalation of any dust rich in free silica (e.g. quartz, flint, chert) over a period of years.[2a] It is the principal member of a group of lung diseases known as pneumoconiosis.[2b] Metal miners, metal grinders, stonemasons and several other trades have all suffered from the disease.

Metal miners only developed true silicosis when they worked rocks or veins rich in free silica. For example, the quartz (free silica) content of several rocks which commonly host metal ore deposits are given below:

| | Typical % Quartz |
|---|---|
| Sandstone | more than 95 |
| Slate | 35 |
| Granite | 30 |
| Limestone* | 1 |

*Some limestones contain siliceous impurities and so contain a higher level of free silica.

Vein material is often very rich in quartz in some districts and so increases the level of siliceous dust. Miners in districts where the rocks and veins are generally low in silica (e.g. Derbyshire lead mines) would generally not develop silicosis. Other factors which also affect whether a miner develops silicosis include:

– tendency of rock/vein to produce dust

– length of exposure to dust (eg. starting age, shift length, unemployment)

– working conditions (eg. amount of dust, fineness of dust, wet or dry)

A fuller understanding of silicosis has only emerged during the twentieth century. In an atmosphere rich in siliceous dust the coarser particles are caught by mucus in the nose, throat and other breathing passages and expelled by coughing.[3] However, the fine particles (less than 10 microns) enter the lung cells and cause lesions (wounds). Fibrous nodules form and spread, sealing cellular tissue and stopping aeration of the blood. Breathing becomes increasingly difficult and markedly increases susceptibility to tuberculosis and pneumonia.

Medical advances in more recent times also suggest two other factors which may have contributed towards the high incidence of lung diseases amongst miners:

– inhalation of radon gas and its particulate radioactive decay products which can cause lung cancer (radon is present in many Cornish mines and elsewhere)

– excessive tobacco smoking especially underground in confined spaces giving rise to lung cancer.



## DEVELOPMENT OF IDEAS PRIOR TO THE NINETEENTH CENTURY

### a) EARLIEST TIMES TO 1556

Prehistoric flint mining and processing in the Neolithic period (3000 BC - 1800 BC) in the south and east of England (eg. Grimes Graves) almost certainly gave rise to silicosis. This is supported by the "terrible mortality from phthsis" suffered by the flint knappers of Brand on in Suffolk earlier this century, who used similar techniques to prehistoric man.[4] Silicosis is therefore likely to be the earliest industrial occupational disease. The Greek physician Hippocrates *(*c.430 BC) mentions the case of a "man from the mines" being pale, livid and breathing with difficulty.[5]

The main comments of the Roman writers were as follows:

– Lucretius (99 - 55 BC) noted that a miner's life was very short.[6]

– Julius Pollux (AD 124 - 192) stated that miners covered themselves with bags and sacks or used bladders to cover their mouths as a protection against dust inhalation.[7]

The medieval period (5th to 15th century) is devoid of references to the health of miners anywhere in Europe and it is not until the sixteenth century that references reappear, mainly from Germany where metal mining was thriving.

### b) 1556 TO 1800

A major leap forward in ideas occurred with the publication of the classic work *De Re Metallica* in 1556, written by the German physician Agricola. He expressed highly advanced views about the cause of high mortality amongst metal miners. These had probably resulted from his practical experience in silver mining areas together

with his intimate knowledge of mining in all its aspects. After mentioning the ailments of wet mines he stated:[8]

Fig.1. *Georges Agricola* (1494 - 1555). *Author of De Re Metallica, in which he made accurate observations on the cause of miners' disease.*

"*On the other hand, some mines are so dry that they are entirely devoid of water, and this dryness causes the workmen even greater harm, for the dust which is stirred and beaten up by digging penetrates into the windpipe and lungs, and produces difficulty in breathing. If the dust has corrosive qualities, it eats away the lungs and implants consumption in the body; hence the mines of the Carpathian Mountains, women are found who have married seven husbands, all of whom this terrible consumption has carried off to a premature death.*"

Agricola implies recognition of two important factors which were to elude most British writers for another 350 years, namely that:

– stone dust is the principal cause of metal miners' lung disease which frequently kills them.

– only certain dusts are "corrosive" and cause the "terrible consumption".

He does not suggest any preventative measures for avoiding stone dust inhalation but for working poisonous ores he suggests fastening a loose veil over the face.

Agricola's startlingly accurate observations contrast sharply with the widespread belief at the time in the supernatural as the cause of many miners' ills. Even Agricola apparently believed in the presence of good and bad demons or gnomes in mines.

In 1567 a book on miners' diseases by the Swiss physician Paracelsus (Figure 2) was published posthumously.[9] He correctly noted that lung

Fig.2. *Paracelsus* (1493 - 1541), *a Swiss Physician who observed that lung diseases were common amongst miners.*

diseases were characteristic of miners and that as a result they were more likely to fall victim to other diseases. He ignored dust as a causative factor and explained the diseases in terms of climate, vapours in the mine and strange astrological theories.

During the seventeenth century several German writers (Panza 1614, Ursinus 1652, Lochneiss 1690)[10] briefly describe metal miners' disease and state that dust is a principal cause but add little to the work of Agricola.

The first systematic account of trade diseases was written in 1700 by an Italian Bernardino Ramazzini (1633 -1714). He was a professor of medicine and has been dubbed the "father of occupational medicine." In his chapter on "metal diggers" he mentions most of the earlier writers and attempts to correlate ores with ailments. The general danger from stone dust is not highlighted. The cause of the various diseases is given rather vaguely as the inhalation of vapours emanating from the ore veins:[12]

"*The pestilential steam hid within the metallic veins, make the first impression upon the mine diggers who spend their days in the subterraneous caverns of the earth.*"

Despite his failure to observe the role of dust in causing lung diseases, he did note that stone cutters breathe in small splinters and turn asthmatic and consumptive. Ramazzini also mentioned the traditional attitudes towards miners and their health which were still widely held:

"*In antiquity, mining was regarded as a base and mean employment, suitable chiefly as a punishment for criminals . .... indeed it seems to be a doubtful case whether we ought to reckon it a good and pious office to prescribe physic to such wretches and thereby prelong a miserable life.*"

German writers in the eighteenth century (Kochlatsch 1721, Neumann 1721, HaIler 1738, Henkel 1745)[13] considered dust a major cause of miners' disease although many also believed "fumes" from the rocks or ores were also important. [19]

It is interesting to note that all the 25 major references to the subject of metal miners' disease between 1600 and 1800 that Rosen (1943) traced were written by Central Europeans (17 of them German) and none of them were British. Considering the growth of sectors of the metal mining industry in Britain during the eighteenth century it is somewhat surprising that no significant British contribution to the subject emerged until the nineteenth century. In fact the ideas of the European writers do not appear to have been known to British writers. A.K. Hamilton-Jenkin (1925)[14] observed:

"It is a curious fact that older writers, though frequently dilating on the hardships of Cornish mining, never seem to have regarded it as a peculiarly unhealthy occupation".

The British writers cited by Hamilton-Jenkin generally recognised no long term occupational disease or curtailment of life:

– Richard Carew (1602)[15] noted only short term discomfort,
"*While the miners play the Moldwarps unsavourie Damps doe here and there distemper their heads, not so much danger in the consequence as annoyance for the present.*"

– Robert Boyle (1725)[16] the English scientist stated that Cornish tin miners "arrive at a great and vigourous age".

– William Borlase (1758)[17] wrote that
*"the miners, particularly* [those] *who escape accidents and live temperately, generally live to a great age."*

– William Pryce (1778)[18] a doctor and writer about Cornish mining failed to make reference to a miners disease apart from vaguely mentioning epidemics of fevers and diseases in the local communities caused by "vapour of the vitriolick kind" related to the mines and containing "watery and other grosser particles."

The only notable exception to the apparent ignorance of British writers on the subject is one Hamilton-Jenkin apparently overlooked but was highlighted by Barton (1968).[19] William Hals (1655-1737) a Cornish historian wrote that a metal mine is:

"*a place deadly, that bringeth, death or mischief .. from the dangerous, wet, deep and miserable occupation of labouring tinners therein, wherein great numbers of them are infected by the damps with incurable diseases, others slain by accidents and come to untimely deaths.*"

High mortality among British metal miners in the eighteenth century was therefore probably present at least in some districts amongst those who spent enough years underground. A few writers in the last decade of the century did observe the poor health of metal miners. Warner in North Wales noted the "unhealthy appearance" of miners at the Holywell Level[20] and Maton noted the "wretched and emaciated appearance" of miners in Camborne.[21]

## DEVELOPMENT OF IDEAS IN THE NINETEENTH CENTURY

### (a) 1800 TO 1831

Very few nineteenth century references to the health· and mortality of metal miners appear anywhere in Europe until the 1830s. The German physician Erdmann in 1831 mentions metal and anthracite miners[22] as commonly suffering asthmatic attacks and showing the "striking phenomenon" of appearing about 10 years older than they actually were. They exhibited "a pallid earthy complexion, sunken eyes ..... and such extreme emaciation that the skin sometimes appears to be pasted to the bones of the face." He noted these symptoms "are harbingers of a chronic incurable consumption".

In the nineteenth century Britain "was the first and foremost exponent of the new industrialism"[23] fuelled by her rapidly expanding coal mining industry. As the coal

and to a lesser extent metal mining industries expanded, larger numbers of miners must have been affected by health problems. This eventually resulted in some medical men in Britain taking more interest in miners' diseases as well as occupational diseases in other expanding industries.

**(b) CHARLES THACKRAH (1832)**

The first significant British contribution that ever appeared on the subject was contained in a book by a Yorkshire doctor, Charles Turner Thackrah (Figure 3).[24] His book entitled "*The effects of arts, trades and professions and of civil states and habits of living on health and longevity*" was published 1832 and was a masterly work which helped stimulate factory and health legislation in some sectors of British industry.

Unfortunately Thackrah's observations on metal miners were not taken up as later events will show. His footnotes show he had read all the important European works. He recognised that:

– metal miners generally had a higher mortality than coal miners

– dust inhalation was the main cause of early death

– certain rock types were more injurious to work in, than others.

"*Miners of lead suffer considerably from their employ. In the mines of the North of England the men are injured by working in sandstone, but are sensible of no inconvenience when the ore is in limestone.*"

*Fig.* 3. *Charles Turner Thackrah* (1795 -1832) *the Yorkshire doctor who wrote the first comprehensive British work on occupational diseases and correctly attributed metal miners' disease to dust inhalation.*
*(Courtesy of Leeds University Archive)*

Thackrah did not realise it was the composition of the dust that was important but instead thought that it was because limestone workings were wet producing little dust whereas sandstone workings were dry and so were very dusty. He noted the resulting mortality:

"*Miners rarely work more than six hours a day yet they seldom attain the age of 40 ..... Last year there were in the village of Arkendale ... not less than thirty widows under thirty years of age.*"

Thackrah's observations were based on the North Pennine orefield but he was aware of similar observations having been made in other districts and in a footnote quotes a man called Forbes:



*"An immense proportion of the miners in Cornwall are destroyed by chronic bronchitis; one of the principal but by no means the sole cause of which,* I *consider to be the inhalation of dust.*

The accurate observations of Thackrah did not have much influence nationally. Instead, erroneous ideas as to the cause of miners' disease took root, especially in Cornwall, and dominated official opinion for the next 60 years. Papers which fostered erroneous ideas include:

– Sir Charles Lemon (1838)[25] noted the high mortality from chest diseases (54%) amongst Cornish miners and considered that it was "arising almost entirely from the effort of ascending from the greatest depths with exhausted strength".

– Carlyon (1835)[26] and Lanyon (1830)[27] both mention the "pernicious" effect of ladder climbing and ladder racing as a major factor. Lanyon also considered the exertion of beating the borer as very injurious but also mentions "acrid and poisonous matters" in the air as being harmful.

**c) CHILDREN'S EMPLOYMENT COMMISSION 1842**

This Commission is best known for exposing the horrors of young children working underground, mainly in coal mines. Sub-commissioners were appointed to submit reports on various mining districts including metal mining areas. Some of these reports included observations and statistics on the health of adult metal miners.

(i) Cornwall (Dr Barham)[28]

Recent papers published by the Royal Cornwall Polytechnic Society provided useful statistics. The main points to emerge were:

– the mortality rate between the ages of 40 and 50 was, in some districts, twice as high as the rate for non-miners.

– up to 60% of miners died of lung diseases compared to 23% for non-miners; a specific type of consumption specific to miners was noted.

– about 15% of miners died due to accidents (c.f. non-miners 3%)

– Barham blamed the lung diseases on
*"sudden transitions in temperature ..... repeated inhalation of noxious gases and particles of matter"* and noted similarities with other dusty trades.

(ii) Alston Moor (Dr Mitchell)
– the agent of the Beaumont concern
"*boldly asserted that the miners lived beyond the average duration of life*".

– statistics told a different story, in Alston Moor, Allendale and Middleton-in-Teesdale the average age of death of miners (after 19 years of age) was 47.8 whereas non-miners in nearby Carlisle lived on average to 61.2

– about 54% of miners died of lung diseases and 4% of accidents

– Mitchell believed the lung diseases were caused by bad air with a contribution from dust:

"*minute particles of ore and stony materials ... contribute in no little degree to the production of those distressing complaints by which the latter years of a miner are almost always rendered miserable and the lives of all shortened many years*".

– George Arnison, surgeon to the London Lead Company, noted that dust was still inhaled in well ventilated mines due to the miners'
"*constant operation with the pick and jumper ....*"

(iii) Leadhills (Dr Martin)[30]
– miners are liable to difficulty of breathing arising from chronic affections of the chest which
"*helps to break him up sooner than occurs with the population generally.*"

– about 37% died from lung diseases (i.e. lower than other districts) and 7% died from accidents.

– lung diseases were attributed to the damp ill-ventilated working conditions in which the air was "loaded with fumes of gunpowder and broken particles of stone".

(iv) Flintshire (H.H. Jones)[31]
– lung disease, known as miners' asthma, was common amongst miners: "these diseases are felt in a painful degree as early as the age of 25 and they gradually increase between this age and 35" and they "terminate in a comparatively early death."

– witnesses drew comparisons with nearby colliers and stated
"few colliers come to the age of sixty, and still fewer (lead) Miners".

(v) Derbyshire (J.M. Fellows)[32]
– no specific reference to high mortality probably because silicosis was uncommon due to the low silica content of most of the limestone and the veins.

The 1842 Commission's primary purpose was to investigate the employment of children in coal and metal mines, however, some of the conclusions dealt with the health and longevity of adult metal miners. The main points were:[33]

– metal miners suffer "a rapid deterioration" of their "health and strength" due to a high incidence of lung diseases and so "existence is terminated" prematurely.

– it was erroneously concluded that the primary cause of the lung diseases was bad air due to imperfect ventilation which was much worse than coal mines.

– secondary causes were given as over exertion when young and fatigue from climbing ladders.

It is remarkable that the Commission omitted any reference to dust which was the principal cause of the lung diseases, especially as many of the doctors' reports highlighted dust as a major factor. Their reasons are thought unlikely to be conspiratorial. They probably concentrated too much on the obvious difference (i.e. ventilation) between coal and metal mines to explain the difference in the mortality levels.

**(d) 1843 TO 1861**

Interest in the subject of miners' health and longevity increased tremendously after the 1842 Commission resulting in a whole series of papers on various districts, particularly in the 1850s. They contain interesting statistics but no new insights emerge about the real cause of the lung diseases. The main points are discussed below by district.

In 1855 an anonymous author declared the lead miners of the North Pennines more affected by disease "than any other class of miner." His comments reflect the fatalism of the miners:[34]

"Nor can any doubt be left after looking upon their faces. Poor fellows! They know full well what their fate is. Slow but sure is the progress of disease."

In 1857 Thomas Jackson wrote a paper in the British Medical Journal[35] on the "*Diseases of the Miners of Arkengarthdale and Swaledale"* and noted they were liable to several types of lung disease. He blamed them on bad air, dust and "noisome exhalations from mud and moisture" emitted as they dried their clothes at home which were "most detrimental to longevity." He noted the average age at death to be 45 to 50. Besides lung diseases they also suffered from muscular rheumatisms and rheumatic fever.

The General Board of Health in 1858 carried out a short statistical survey of Alston and compared it with several other places including Liverpool.[36] They concluded that Alston "loses a larger annual proportion of its adult male inhabitants from diseases of the chest than the unhealthiest city in the kingdom" and had "a larger proportion of widows than in any other place in the kingdom."

In Cornwall the Royal Cornwall Polytechnic Society continued to publish reports on the subject. They found that the average age of working miners (28 to 30) was much lower than for non-mining labourers (34 to 40). The average age of death was also lower being only 47 in the St Just and Lelant area.

A paper entitled "*Lead Miners in Derbyshire and their Diseases*" appeared in 1857 written by William Webb.[38] His main points were:

– a lead miner "can generally be pointed out by his pallid face which contrasts with the florid and healthy visage of the agricultural labourer.

– they are subject to the effects of noxious vapours in the mine, lead poisoning, chest complaints including dust irritation, rheumatism, rheumatic fever and heart disease.

– despite all this they are "moderately hale, robust and vigorous" and remarkable for their "health and longevity".

As mentioned earlier, Derbyshire lead miners were apparently less prone to silicosis and related diseases due to the low silica content of the limestone and the veins they worked.

**(e) KINNAIRD COMMISSION 1862 - 64**

A Royal Commission started work in 1862 to investigate and make recommendations on the health and safety of mines not covered by existing legislation which in practice meant metal mines. The existing legislation related only to the regulation and inspection of coal mines and Coal Measure ironstone miners.

The Commission is generally known by the name of its Chairman Lord Kinnaird (George William Fox, Figure 4). He was "an energetic social reformer interested in railways, steam ploughs, popular education and free trade, being a close friend of Cobden and Bright."[39] Six MPs also served on the Commission along with P.H. Holland and Dr Greenhow.

The Commission was a major undertaking involving evidence being taken in 41 towns and mines in the main metal mining areas of England and Wales. In total 23,556 questions were asked, 254 witnesses interviewed and numerous detailed medical, scientific and other reports were received. The occupations of the witnesses are summarised below:

*Fig.* 4. *Portrait of George William Fox, 9th Baron Kinnaird (1807-78), an energetic social reformer who chaired the 1864 Commission which investigated the health and safety of British metal miners.*
(Courtesy of the Owner)

| | Number Interviewed | % |
|---|---|---|
| Mine Managers | | |
| Mine Captains | 140 | 55 |
| Mine Agents | | |
| Mine Owners | 22 | 9 |
| Miners | 24 | 9½ |
| Medical Men | 44 | 17 |
| Others | 24 | 9½ |
| TOTAL | 254 | |

Although many aspects of working conditions were examined, a major proportion of the Commission's time was spent on health matters. Two major health objectives are apparent in the Commission's questioning:

– establishing whether metal miners suffered abnormally poor health and a high mortality

– establishing what was the cause(s) of the alleged high mortality

The first of these two objectives was established beyond all doubt by the evidence of William Farr, Chief of the statistical department in the General Registrary Office. He presented the Commission with masses of statistical information.[40] The most striking data related to death rates per 1000 miners or non-miners for various age groups based on 1851 or 1861 census returns in conjunction with local registrary books. Some of the data has been used to illustrate the main trends (Figures 5 to 8) and the main points were:

– average annual death rate per 1000 males from all causes for the 15 to 25 age group (i.e. before silicosis developed) showed little difference between non-miners, coal miners and metal miners (Figure 5).

– however similar data for older age groups showed a marked difference, reaching a peak in the 55 to 65 age group which showed Cornish metal miners to be 300% higher and coal miners 50% higher than non-miners (Figure 6)

– equivalent data for other metal mining areas (Northern England, Flintshire) and other coal mining areas showed a similar picture; variations were probably due to local factors (e.g. free silica content of rock, cholera outbreaks, accident rate). (Figure 7)

– a breakdown of the death rate data showed that the main cause of the high mortality of metal miners was due almost entirely to lung disease

– converting Farr's data into pie charts (Figure 8) the various causes of death of coal and metal miners are highlighted; lung diseases killed 69% of Cornish miners but only 20% of Durham coal miners. Mining accidents and cholera type diseases due to poor living conditions, killed nearly half the coal miners

The poorer health of metal miners compared to coal miners was also borne out in the comments of witnesses who had experience of both groups:

"I see colliers who are old, but 1 cannot find an old miner."

– Peter Parry,[41] coroner, Mold, Flintshire.

The difference was despite the cleaner living of the metal miner in many districts:

"Which class of men lives best at home?"

[22]

"I think the miner; because he is more regular in his habits of living; he is more temperate; he has a better home; he has more cleanly habits; he is a better conditioned man, and therefore eats and drinks under circumstances; he is not often drunk. The collier will only work five days in the week, and will drink for the remainder of the time".

Thomas Taylor Griffith[42], surgeon, Wrexham.

The vast majority of witnesses agreed that metal miners lives were cut short by their occupation although there were a few die-hard witnesses who may have believed it was in their own interests to cover up the problem.[43]

"our men are a healthy lot of men."
Richard Boyns, mine captain, Wheal Owles

"no sick men here."
James Raw, mine captain, Cwmystwth Mine

" ... live better than agricultural workers."
Samuel Jones, miner, Snailbeach Mine

"I should consider them very healthy."
Edward Davies, surgeon, Wrexham

These comments are in stark contrast to the description of miners given in the medical reports and by witnesses:[44]

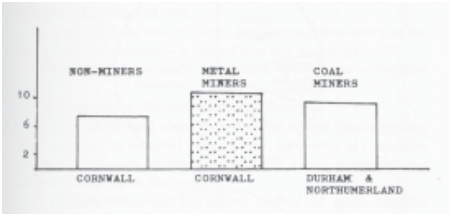


Fig.5. Histogram showing the death rate for Cornish metal miners, Durham coal miners and non-miners for the 15-25 age group. All are very similar.

AVERAGE ANNUAL DEATH RATE
PER 1000 MALES OF MINERS
AND NON-MINERS 1860-62.
AGE GROUP 55 TO 65
ALL CAUSES

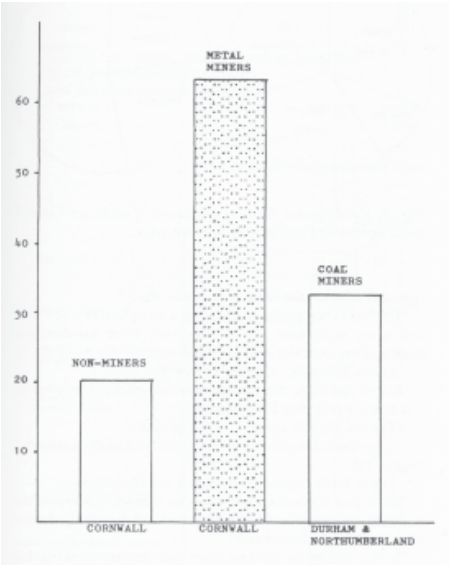


Fig.6. Histogram showing that the annual death rate for Cornish metal miners in the 55-65 age group was much higher than that for non-miners and Durham coal-miners.

" ... those who have long worked in the mines have a prematurely old appearance, a stooping gait, and an anxious expression of countenance. They are thin pale and sallow, and have peculiarly dingy complexions ..... the men often have the appearance of being thoroughly worn out and decrepit."
Thomas Peacock, medical report on Cornish miners

"I have seen men that 1 would say were not fit to crawl out of bed or over the door sill going to their work and doing a day's labour ..."
Robert Parry, surgeon, Mold.

"I cannot call to mind having met with a miner who is not more or less affected with shortness of breathing before he is 40 years old."
William Ewart, L.L.C. surgeon, Middleton.

"When a miner gets up about 40 years of age he is not worth the snap of a finger."
Capt. Richard Ridge, Rheidol Mine.

On the basis of Farr's statistics and the opinions of the overwhelming majority of witnesses the Commission easily

established that there was a serious health problem. The real challenge was to determine the cause(s) of the high mortality in the face of the widely differing views people held. Many thought that bad air was the main culprit especially as many miners worked in areas where a candle would hardly burn.[45]

“This cause seems indeed to be by far the most important in determining the unhealthy condition of the miners.”
Thomas Peacock, London Physician reporting on Cornish miners.

“I believe there are several causes to which it is to be attributed but chiefly to bad ventilation.”
Richard Couch, surgeon, Penzance.

“ ... what does far more harm than that (dust) is the foul air, bad atmosphere; it spoils the blood, ruins the constitution; that is the worst of anything”.
Jonathan Coatsworth, manager, Keldheads Mine.

“When you go in about 20 or 30 fathoms, you will perceive a smell which will almost knock you back, a nasty, filthy, bad smell; that is what kills the miners”.
Capt. Richard Ridge, Rheidol Mine.

Due to poorer ventilation, there was more bad air hanging around metal mines than in coal mines and many believed this was why metal miners had poorer health than colliers. The differences in health between and within metal mining districts was attributed by some to different strata giving off different amounts or types of bad air. Similar ideas had dominated the 1842 Commission’s conclusions.

Dust was recognised by some witnesses as being without doubt the main cause and many others saw it as a major contributory cause.[46]

“It (miners’ disease) may arise chiefly from dust, I should think when they are beginning to drill the holes.”
John Ridley, manager, Coalclough mine.

[23]

“ ... it was due to the dust settling upon the bronchial tubes, the windpipes, causing irritation and congestion there, and gradually, perhaps leading on to inflammation.”
William Hewitson, Surgeon, East Allendale.

“Do you ever feel much inconvenience from the dust?”
“Yes a great deal in the chest I felt tied up in the chest and breathing.”
“From what was the dust?”
“From the hole in boring.”
“ ... how did you know that it was from the dust?”
“I spat it up; a great quantity of clots ...”
A miner at West Caradon mine being questioned by Lord Kinnaird.

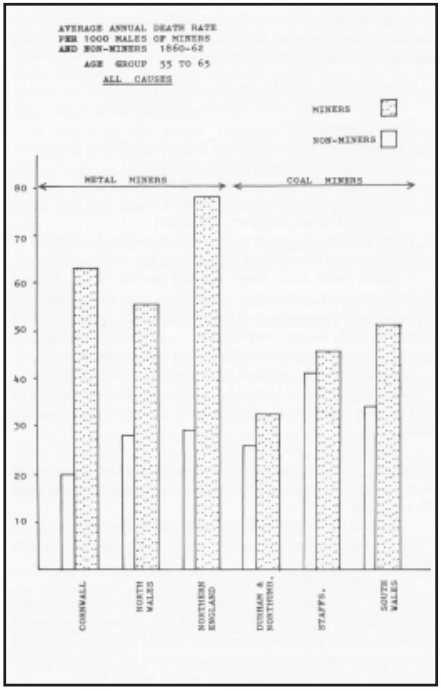


Fig. 7. *Histogram comparing the annual death rates for metal miners, coal miners and non-miners in various mining districts* (55 - 65 *age group).*

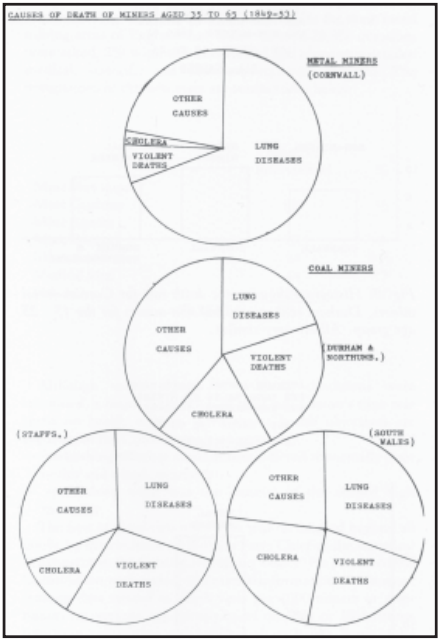


Fig. 8. *Pie diagrams showing the causes of death for Cornish metal miners and coal miners in three areas.*

"Is that [dust] in your opinion the chief cause?"
"Yes, it undoubtedly is, for there have been instances of individuals who had worked for a considerable length of time in this shale, and have gone to some watering places, and have sometimes vomited what has been a collection of that dust."
Thomas Watson, L.L.C. agent, Alston.

The miners' spit was often dark in colour and so was thought by many to arise entirely from carbonaceous matter in the gunpowder and candle smoke. However, this was not supported by Richard Couch the Penzance surgeon, who found "minute particles of stony dust" in the spit as had Rowland Rowland in Mid-Wales using a microscope.

Those who believed in dust as the main cause explained differences between mines and districts on the basis of rock type and whether the mine was wet or dry.[47]

"They say they prefer working in a wet place to a dry one, that is my experience ..... because they have less dust and smoke. They consider it more wholesome."
James Williams, surgeon, Holywell.

"In grit and shale there is the most unhealthy dust with us; it is much worst than lime (stone)."
Francis Taylor, agent, Old Gang mine.

" ... boring in the grit stone; that is the bane of this country." (Figure 18)
James Eddy, agent, Grassington and elsewhere.

"Have you observed a considerable difference between the health of the men who work in the chert and the health of those who work in the limestone?"

"In this district we have no chert that they are working; but in the Flintshire district there is a great difference. There is
about ten years in the average age in favour of those who are working in the limestone."

"To what do you attribute the great difference?"

"We think that the dust of the stone is more injurious to their lungs ..."
Edward Williams, manager, South Minera mine.

Several witnesses suggested miners should grow moustaches to reduce their dust intake but this would not have been very effective because it was the very fine particles that caused the problem. Another ineffective technique was advocated by a mine captain in Camborne:[48]



"Dust did not affect me, because I liked to work with my lips closed and as soon as my nose got pretty well filled I out with it."

The best way of controlling dust would have been the use of water but this technique was rarely mentioned and even then only in a half-hearted way.

In spite of all the oral evidence implicating dust many of the most influential witnesses denied it was a major factor:[49]

"That (dust) must only be looked upon as an occasional cause."
Robert Hunt, Keeper of Mining Records.

"... one miner said that 'dust was far worse than anything else' they had to contend with. So far, however, as I was able to judge I should doubt whether this cause generally acts unfavourably upon the men."
Thomas Peacock, physician, author of main medical report to the Commission.

A whole host of other factors were cited by witnesses as major or contributory causes of the high mortality. The great exertion of climbing ladders in deep mines, especially in Cornwall, was often mentioned with the older miners having great difficulty. This was almost certainly a symptom of miners' disease (i.e. silicosis) rather than a cause. As James Jago, a Truro physician drily put it when asked:[50]

CAUSE(S) OF MINERS' DISEASE STATED BT WITNESSES TO THE KINNAIRD COMMISSION (1862-64)
(159 WITNESSES EXPRESSED AN OPINION)

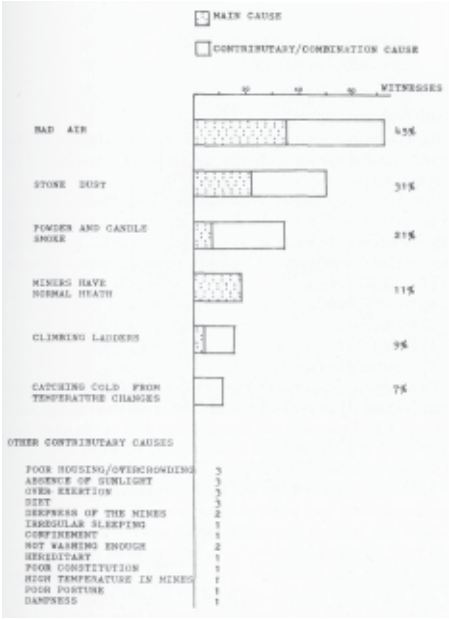


Fig. 9. *Histograms of the cause(s) of miners' disease stated by witnesses to the Kinnaird Commission. Percentages do not add up to 100% since witnesses often gave more than one cause.*

CAUSE(S) OF MINERS' DISEASE STATED BY MEDICAL MEN TO THE KINNAIRD COMMISSION (1862-64).
(37 MEDICAL MEN EXPRESSED AN OPINION)

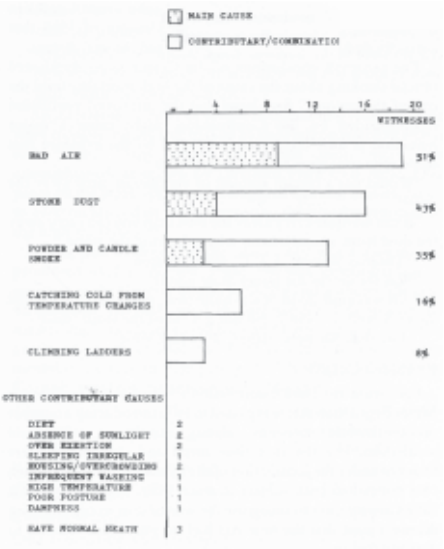


Fig. 10. *Histogram of the cause(s) of miners' disease given by medical men to the Kinnaird Commission. Percentages do not add up to 100% for same reason as in Figure 9.*

"Do you think that climbing the ladders would account for emphysema fairly?"

"I have no knowledge that sailors become emphysemateous from climbing ladders."

The change in temperature when miners emerged from working underground was also mentioned as a contributory
factor, resulting in miners catching cold:[51]

"I have seen the men come up (the shaft) and their clothes actually freeze on them before they could reach the cabin."
Edward Williams, manager, South Minera mine.

Other factors mentioned included the poor diet of the miners with the Cornish pasty being condemned as "an innutritious and indigestible article of food." Absence of sunlight, hereditary factors, pipe smoking, confinement, poor housing and deepness

of the mines were also suggested as causes. Thomas Sopwith, a prominent mining engineer, appeared reluctant to blame the mining occupation itself and so attributed the problem to a variety of incorrect causes mainly relating to the miners' habits and living conditions.[52]

Figure 9 summarises the main and contributory causes cited by 159 witnesses who expressed a view. Bad air was the most frequently cited cause (45%) followed by dust (31%) and gunpowder smoke (21 %). The same order emerges when the views of the 37 'doctors' and 'surgeons' are extracted (Figure 10).

[25]

Dust therefore was in a strong second place as a main or contributory cause of miners' disease. However, dust as a causative factor was given a very low key mention in the Commission's conclusions and no mention at all in the recommendations.[53] The conclusions were:

i) *"That there is a great excess of sickness and mortality amongst metalliferous miners, which is mainly attributable to the imperfect ventilation of mines.*" (low mortality and good ventilation of coal mines was cited.)

ii) *"That several other causes, both general and local, largely contribute to impair the health of the miner; namely*

– *exposure to cold and wet, and sudden alterations in temperature*
– *wearing wet clothes*
– *inhalation of gritty particles*
– *exertion of climbing ladders from great depths."*

Recommendations were made for:
– improving ventilation
– installing cages or man engines to avoid ladder climbing.
– providing proper buildings for changing and drying clothes.

Why did the Commission reach the wrong conclusion and virtually ignore the importance of dust? It was probably due to a combination of factors which involved:

– undue emphasis being put on the opinions of certain important witnesses (e.g. Thomas Peacock, Robert Hunt).
– the medical profession's poor understanding of the pathology of the disease, noted by the Commission, which was partly due to prejudice against post mortems in all the mining districts and that many doctors had never even been underground to see the dusty working conditions.
– vested interest may have played a part but on the whole the Commission was probably misguided by conflicting
evidence rather than being involved in any conspiracy.

Ironically an appendix of the Commission's report contains the extracts from Agricola's *De Re Metallica* of 1556 that
correctly deduced that certain dusts caused miners' disease.

The incorrect conclusions of the Commission dominated official thinking about the cause of the high mortality until the
end of the century. Any hope that the improved ventilation recommended by the Commission might cause a major reduction is dust levels was countered by the evidence that some witnesses gave to the Commission:[54]

"Would not a certain amount of ventilation carry away the dust?"
"It can no more carry away the dust than you can carry away the dust from a stonemason who is hewing the stone."
Thomas Watson, L.L.C. agent, Alston.

"Was the air (in the mine) quite good?"
"... it was quite good, it was quite clear, good air and it cleared the reek well ..... but it did not get rid of the stour (dust)."
Jonathan Morton, miner, Wire Gill mine.

**(f) 1865 TO 1898**

Following the 1864 Commission's report the Metalliferous Mines Regulation Act was passed in 1872 introducing a number of worthwhile measures relating mainly to safety and ventilation. For the first time metal and slate mines were brought under the jurisdiction of the mines inspectors to which coal mines had been subject to since 1850. The failure of the 1864 Commission to recognise the role of dust in causing lung disease meant that the new Act had no provisions relating to dust prevention.

Meanwhile in British medical circles developments relating to miners' diseases were taking place. Thomas Peacock, medical reporter to the 1864 Commission, exhibited the lungs of a Cornish miner before the Pathological Society of London in 1865.[55] While he is sometimes credited as being the first person to establish the existence of miners' disease as an entity and distinguish it clinically from pulmonary tuberculosis he still failed to find siliceous particles in the only known example of metal miners lung he examined. As a result he clung to his view that in Cornwall "impure air" inhaled by the miners was the predisposing cause and inflammation was activated by catching cold when coming to surface from hot workings. He did concede that dust "may be a cause" of lung disease in the lead mines of Northern England, a view he did not express in his report to the 1864 Commission.

Another prominent medical man of the time was Dr Edward Greenhow, attached to the Middlesex Hospital. In view of his connection with the 1864 Commission as a part time commissioner or consultant it is somewhat surprising to find that in a series of papers[56] he wrote between 1865 and 1869 he definitely attributed the condition known as miners' phthisis to the inhalation and deposition of dust in the lungs. He was the first person to find traces of silica dust in a miners lung in 1865, albeit in a collier, and in 1869 in a copper miners lung.

A clue as to why coal miners were not as severely affected as metal miners by the disease was contained in a paper by Begbie on lung diseases amongst coal mines and published in the Glasgow Medical Journal in 1866. He noted:[57]

*"that those men who were frequently engaged in using gunpowder for the purpose of blasting stone rock (silica rich), in order to reach the coal seam suffered more from the disease."*

A paper by Dr Barham, a contributor to the 1842 Commission, entitled *"The Diseases of Cornish Miners"* was published in the British Medical Journal in 1871. Most of the data he used was based on the 1864 Commission reports but he did present some data in a simplified way:[58]

| | % Male Deaths from Lung Disease (after 15 years of age) |
|---|---|
| England – all occupations | 29 |
| Cornwall – metal mines | 56 |
| Staffordshire – colliers | 27 |
| Durham – colliers | 20 |
| South Wales – colliers | 30 |

Barham mentioned the harsh working conditions of the miners but did not attribute the high level of lung diseases to any specific factor.

T.F. Evans, the mines inspector for North Wales, noted in his report[59] for 1875 that the average age of death of Ffestiniog slate miners was 38 while for non-miners it was 67. Faced with this "deplorable revelation" he looked into the causes of death and found they were:

| | |
|---|---|
| 40% | lung disease |
| 26% | accidents |
| 11% | typhoid |
| 23% | other diseases |

These figures indicate that slate miners suffered more dust related disease than coal miners but not as much as most metal miners. T.F. Evans did not identify slate dust as the cause but observed that it was difficult to distinguish between the effects of mining and the effects of poor living conditions:

– dwellings overcrowded and badly ventilated
– villages filthy and water unfit to drink
– poor diet (mainly tea, coffee, bread and butter)

In 1877 John Postlethwaite's book[60] on metal mining in the Lake District was published. His personal view was that bad air and dust acted together to produce miners' disease:

*"Noxious gases are frequently liberated from cavities in the rock, which have a very injurious effect upon the miners' respiratory organs; and these combined with the mineral dust which he inhales produces in him seeds of disease and premature old age."*

[26]

Postlethwaite went on to appeal for preventative measures:

"*... cannot some of scientific men invent a guard for the miners' lung, or some means of neutralizing the baneful effects of mineral dust and foul air?"*

In 1878 Dr Clement Le Neve Foster (Figure 11), the first metalliferous mines inspector for south-west England, noted the death rate from accidents in British metal mines was, despite immunity from explosions, only slightly lower than the rate for colliers.[61] This was due mainly to the dramatic improvement in coal mining safety since 1850 when mines inspection was introduced:[62]

| | Death rate per 1000 miners employed underground 1874-1882 |
|---|---|
| British metal miners | 2.37 |
| Cornish metal miners | 2.63 |
| Coal miners | 2.57 |
| | (c.f. 1850-5.0) |

Dr Foster also understood the true cause of the ill health among Cornish miners. In May 1879 he appeared before the Accidents in Mines Commission[63] and stated that ventilation in metal mines had not improved much since the 1872 Act because of its vague wording ("adequate amount of ventilation"). Foster was then asked by one of the commissioners:

"You know that the health of the men must be a good deal impaired by breathing this impure atmosphere?" Foster replied:

"I think it is not entirely from the extra proportion of carbonic acid gas that it is caused. I think that the danger to health is largely caused by solid matter, by dust suspended in the air."

Foster then described how he had observed that in wet ends the air was much clearer and had then devised an experiment in a mine were an intensive amount of blasting was being done. He persuaded the engineer in charge to use a water pipe, with a rose end fitted, to wash the air clean after blasting. As a result, an hour and a half was saved between blasts and most of the harmful dust was removed. One of the Commissioners commented:

Fig. 11. *Clement Le Neve Foster (1841 - 1904), the pioneering Government mines inspector who, in* 1879 *told the Accidents in Mines Commission that dust was the main cause of miners' ill health.*

"I think with your great intelligence you would perform a good work for mankind in general if you could get this system of washing air introduced. It would make the men more healthy and it would render them more efficient."

The innovative Foster was clearly ahead of his time in his thinking but implementation of his idea and its extension to include boring was still a long way off. The Commission was too concerned about explosions in coal mines to even mention Foster's comments in their conclusions or recommendations.

The discovery of the tubercle bacillus by Koch in 1882 marked a milestone in the medical field because pathologists were then able to distinguish more precisely between lesions in the lung caused by silicosis and those of simple tuberculosis.[64]

A leader article in the Mining Journal in December 1888 highlighted the continuing problem:[65]

*"Attention in some quarters is being again directed to the heavy mortality amongst those connected with our metalliferous mines, and to the reports on the subject by our Inspectors. The mines in which metallic ores are raised do not give off the dangerous gases inseparable from coal mining ..... Yet the coalminer, it appears, lives on an average to a greater age."*

The article then goes on to suggest the following areas as contributing to the problem:

– the severe exertion of descending and ascending considerable depths by means of ladders
– ventilation *"does not receive anything like the attention it does in collieries. "*
– poor sanitary conditions underground
– dust; *"in our coal mines that are dusty it is required by Act of Parliament that roads should be watered before the men commence work in the morning, and there is every reason to believe that were the same course adopted at our copper and lead*

*mines there would be an appreciable decrease in the disease from which the men who work in them are liable such as phthisis and ailments connected with organs of respiration. It was concluded that it was in the mine owners own interests to remedy the situation and this could be done with "little or no expenditure."*

An increasing number of people in the mining establishment were recognising the role played by dust but no effective action was taken. Many people it would seem were still unenlightened, as shown by Langford Price who, in an 1891 paper on the work systems and wages of Cornish miners, failed to even mention dust when discussing the possible reasons for the high mortality.[66]

Strong new evidence for the dust theory was drawn up and promoted by Dr William Ogle. He was superintendent of statistics at the General Registrar Office and gathered the type of data that Dr Farr used to successfully demonstrate the miners' high mortality to the Kinnaird Commission. Dr Ogle produced papers in 1881 and 1892 in which he analysed the mortality of various occupations.[67] The high death rate of Cornish metal miners was again highlighted:

| | Death Rate (25 to 65) Comparative Figure 1880-82 |
|---|---|
| All Males (England and Wales) | 100 |
| Healthy Districts | 80 |
| Cornish Miners | 184 |
| Quarrymen (inc. slate miners) | 112 |
| Coal Miners | 89 |
| Ironstone Miners | 83 |

Dr Ogle took the statistical examination one stage further by comparing the mortality rate from lung diseases for all occupations. He correctly concluded that the occupations [27] which involved working in dusty conditions had the highest mortality. So an objective study of the mortality situation from someone outside the mining industry had concluded that dust was the culprit.

Ogle's first major opportunity to present his findings to a government body came when he appeared before the 1893 Quarry Committee of Inquiry appointed to:[68]

*"Report on the conditions which the quarrying of stone, limestone and slate and clay is conducted with the object of diminishing any proved dangers to the life or health of the workpeople engaged therein. "*

This inquiry, chaired by F.N. Wardell, examined only open quarries. One of the committee members, Dr C. Le Neve Foster, was appointed to make a separate inquiry into the slate mines (i.e. underground quarries) of Merionethshire.

COMPARSION OF DEATH RATES FROM LUNG DISEASES
IN MALES 25 TO 65 YEARS OLD.

1880-82

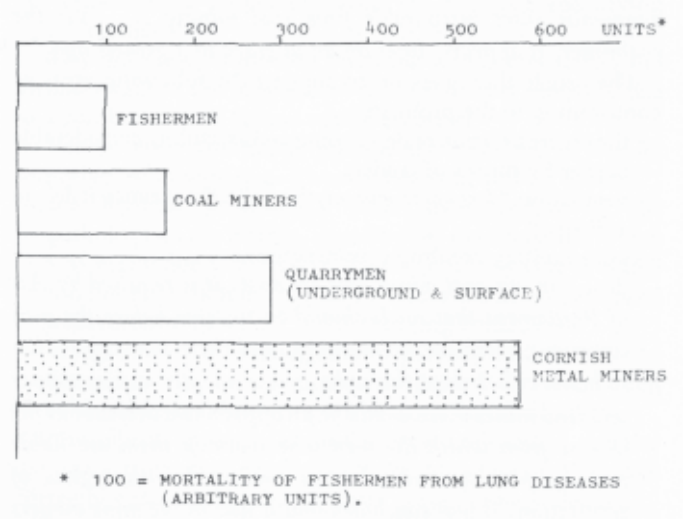


Fig. 12. *Histogram of Dr Ogle's data on the death rates due to lung diseases, showing that metal miners - and to a lesser extent, quarry men - (including slate miners) were worse off than coal miners.*

Ogle presented the statistical data discussed above to the Wardell inquiry showing the high mortality rate of slate and stone quarry men. He also produced figures showing that the excessive mortality was due to the incidence of lung disease (Figure 12). Ogle argued strongly that the evidence supported the theory that stone dust was the cause. This view was met by scepticism by several members of the committee, although Dr Foster, appeared to be more sympathetic. The committee threw at Dr Ogle all the reasons for the high mortality of quarry men put forward by the witnesses, many of them medical men employed by Welsh slate companies. Typical comments were:

"I have no hesitation in stating that I consider this occupation to be very healthy, indeed exceptionally so." Dr R.H. Roberts, Dinorwic Quarries."

The causes advocated by such men and many others covered virtually everything except the occupation:

– intermarrying or early marriage
– working in damp and high places
– drinking too much tea
– improper housing and poor sanitation
– taking a heavy meal at night just before going to bed.
– insufficient food

– poor clothing
– sleeping with closed windows in a bedroom with too many in the room.

Ogle patiently pointed out that most of these things would not affect the lungs with comments such as:[69]

"I should think that fishermen (low mortality) lives probably with his windows shut quite as closely as the quarrymen."

He concluded that dust prevention was more important than accident prevention in terms of the number of lives that could be saved. He suggested respirators might be used but he did not know "whether they (quarrymen/miners) could or would wear them."

The Wardell inquiry's conclusions show that they were not entirely convinced by Ogle's statistics. They pointed out that the death rate of slate or stone miner/ quarry men was no worse than many other occupations (e.g. cabmen, bargemen, plumbers, glassmakers). In retrospect the probable reason why the stone quarrymen/miner death rate was not a lot higher (i.e. nearer the metal miners) was because it was diluted by the inclusion of men working low silica rocks (e.g. limestone). The lack of total belief in the dust inhalation theory resulted in the inquiry making only a vague recommendation:

"The excessive death rate from these complainants is attributed by Dr Ogle mainly to the inhalation of dust. Whatever be the cause, we are led to the conclusion that it is a most important duty to protect the quarry men against any influences which would tend to promote these diseases."

Dr Foster's complimentary inquiry[70] into the Merionethshire slate mines appeared two years later in 1895. The causes attributed to the high mortality by most witnesses, some of them with vested interest, are the same as those listed for the Wardell inquiry. A few witnesses did believe the inhalation of dust was deleterious to health and one suggested "a post mortem examination of a slate-makers lung to prove the injurious effects of dust." The splitting sheds were described as being more dusty than the underground working. Preventative measures such as the use of a water spray, respirators, artificial moustaches and keeping mouths shut were mentioned by some witnesses.

Dust hardly featured at all in the conclusions and recommendations of the Foster inquiry which concentrated on accident prevention. The sixth sub-section of the third recommendation relating to "sanitary arrangements" mentions dust in passing:

"Every quarryman may, to a great extent, protect himself from the noxious influence of dust by breathing through the nose instead of through the mouth."

The low profile given to dust by Dr Foster is somewhat surprising considering the comments in his classic book[71] *"Textbook of Ore and Stone Mining"* published in

1894, a year before his inquiry submitted its report. He quotes Dr Ogle's statistics and concludes:

*"It is the opinion of the best qualified judges that dust is largely responsible for the respiratory ailments from which the miner so often suffers."*

He goes on to discuss dust prevention measures such as water spraying.

Despite the efforts of Dr Ogle and others, government complacency or ignorance about the dust problem continued. Burke (1978)[72] pointed out that the decline in the metal mining industry after 1873 probably contributed to an unwillingness by the state to take any action that might jeopardise the remaining mines.

A startling deterioration in the mortality figures occurred by the end of the century which was to finally establish beyond all doubt that dust was the main cause of the high mortality of metal miners. This was brought about by the use of 'dry' compressed air rock drills which became widely used in the last quarter of the nineteenth century. Their purpose was to [28] maintain output with a much smaller workforce and so reduce operating costs in the face of declining metal prices. They became known in some areas as "the widow maker". Burke (1985)[73] has pointed out that the increased use of dynamite following the expiry of Nobel's patent in 1875 may have also increased dust levels, particularly the more dangerous finer particles.

Fig. 13. *"Dry" compressed air drills being used in a South African gold mine (c.1905). Experience with such drilling equipment led to the realisation that dust was the cause of the high mortality from miners' disease on the Rand and elsewhere.*

**1899 -1904**

An important factor in bringing to light the dramatic deterioration in the mortality of miners and ultimately the role of dust, was the British metal mining industry's South

African connection. The discovery of rich seams of gold in the Transvaal in 1886 resulted in large numbers of British miners, particularly from Cornwall, going to work there. The combination of rock drilling machines and the hard highly siliceous gold bearing rock, produced large amounts of the silicosis inducing dust.

In 1899 the Boer War began and as the war progressed, many British miners returned home from the Transvaal. On their return home from the "dry and bracing air of the high veld, favourable to lung complaints, to the damp and trying climate of England"[74] minor symptoms of lung disease (i.e. silicosis) suddenly increased and many of them died soon afterwards.

One of the first reports of the situation appeared in a letter[75] from Nicholas Trestraill of Redruth to the Mining Journal in November 1901. He referred to "men returning from foreign mines who in a comparatively short time continuously working rock drills are reduced from strong, healthy individuals, first to mere shadows and then death." He attributed this to "the rock drill miner inhaling larger quantities of fine floating dust produced by boring the rock".

He pointed out that it was generally supposed that rock drillers worked under fair conditions because the compressed air supply gave "a plentiful supply of good air" but this was totally overshadowed by the "incalculable harm" done by the "fine floating dust". He noted that "when rock drills were first introduced, a part of the equipment which was considered absolutely necessary .." was a piped water supply to cool the bit, prolong its life and damp down the dust. This "little detail", he observed, is now "invariably ignored and should be insisted on".

Trestraill's letter appears to have gone largely unheeded but the topic surfaced again in the following year. Dr Thomas Oliver, a physician at the Royal Infirmary in Newcastle-upon-Tyne published his book *"Dangerous Trades"* in which he described metal miners' lung diseases as being caused by dust. In June 1902 the Mining Journal reproduced an article from the Lancet about Dr Oliver's comments on gold miners' phthisis[76] (i.e. silicosis). He had observed north-country colliers, who had returned from the South African gold mines, "present the appearance of men broken down in health who sooner or later succumbed to pulmonary disease". Oliver was an adviser to the Home Office and may have drawn the Government's attention to the South African situation.

The Boer War ended in May 1902 and this opened the way for an inquiry. A leader article in the Mining Journal in July 1902 stated that the "rapid decline into which so many returned miners fall ... (had) become so notorious that enquiries were instituted by the Transvaal Mines Department".[77] They found that 17% of rock drillers in the Witwatersrand had died in a period of 2½ years, nearly eight times higher than the rate expected in other trades. The report blamed "noxious fumes resulting from shot firing as the deleterious agent" whereas the Mining Journal believed the British experts who blamed dust.

In December 1902 the South African Miners' Phthisis Commission was appointed by Lord Milner to enquire into the extent, cause and prevention of the disease. Meanwhile back in Britain the subject remained in the columns of the Mining Journal from April to July 1903 with the serialisation of a paper by Mr Cullen on *"Miners Phthisis"* presented before the Chemical, Metallurgical and Mining Society of South Africa. Ironically the articles appeared alongside advertisements for the deadly rock drills (Figure 14).

Mr Cullen took "the view that dust (especially fine dust) is the probable cause of miners' phthisis" and he maintained "that the liberal use of water would overcome the evils incidental to drilling and shovelling rock." He also made the rather impractical suggestion that masks should be used "supplied with a current of cool air direct from the air pipe working the drill." Not everybody agreed with Cullen as shown by the comments made after the paper had been presented. Dr Aymard advocated the great rival to the dust theory, namely that gases (e.g. CO, $CO_2$ and $NO_2$) were the "foundation and the root of the disease." Mr Heymann agreed saying that there was "as much dust in the main street of Johannesburg on certain dusty days as there was in the mines."[78]

At about this time the South African Chamber of Mines offered prizes for "the best means of obviating the dangers to miners caused by the inhalation of fine dust produced by rock drills".[79] In Britain a prize was also offered by the Society of Arts for a "dust-arresting respirator" for use in all dusty trades.[80]

The South African Miners Phthisis Commission reported in 1903 and its findings were given prominent coverage in the British mining newspapers.[81] The Commission found that 23% of the gold miners examined had or were suspected of having the disease. They calculated that miners would typically breath in 2.38 grains of dust per hour and they recommended the use of respirators. The Commission acknowledged that the bulk of the medical evidence pointed to miners' phthisis as being the result of dust action upon the lungs but they still thought the deleterious gases in the mine might act as a predisposing cause or tend to accelerate the disease. Their recommendation that "the discharge of minute, hard angular particles of dust" should be prevented, but did not specify how this could be achieved. They also made recommendations on improving ventilation, sanitation and the provision of warm changing houses near each shaft.

Some of the articles on the South African situation appearing in Britain had tended to suggest it was a disease unique to gold miners using rock drills. The Mining Journal picked up this point:

"It is interesting to note that the malady in question, which is the same as "miners' rot" in this country, existed in England long before rock drills were known".


*Fig.* 14. *Advertisement in the 1903 Mining Journal for one of the "dry" compressed air drills which increased dust levels so much that a major increase in the death rate from lung diseases took place.*

All the interest created by the deaths of returning miners, the reports from South Africa and the health of rock drillers working in Cornish mines eventually culminated in a British inquiry.

Following the outbreak of miners' hookworm (ankylostomiasis) at Dolcoath mine at the close of the nineteenth century the Home Secretary appointed John Scott Haldane (Figure 15) to investigate. He successfully identified the cause and recommended appropriate action in his report in November 1902.[82] Following this successful work, the Home Secretary then appointed Haldane along with Joseph Martin (Mines Inspector, S.W. Region) and Arthur Thomas (Manager of Dolcoath):

"to enquire into and report upon the health of miners employed in mines in Cornwall, with special reference to the injurious effects alleged to be produced by the state of ventilation in the mines, the dust arising from the use of rock drills and the introduction of impurities into the working places through the use of compressed air."

Haldane was from Edinburgh and professor of physiology at Oxford. He was a very practical man, according to the description given by the Mining Journal's Cornish correspondent in 1903:[83]

"Those who have only met him, either in the laboratory or on the lecture platform, would have a better idea of a many sided personality could they but see him at Dolcoath, half a mile below surface, in ordinary miner's garb, pursuing his experiments as contentedly as though he were in his own well fitted laboratory at Oxford."

Haldane's investigations soon revealed that the production of dust from rock drills was the cause of the sudden increase in mortality in recent years. While work on the final report was still going on, Haldane and his co-workers invited 14 mine managers to Dolcoath mine in July 1903 to discuss their provisional findings:[84]

"In the forenoon a visit was made to the 375 fm level in order to see appliances at work for preventing the production of dust during the process of rock-drilling."

Water jets or sprays were the main part of the system demonstrated:

"After luncheon, which was served at the Account House, a meeting under the chairmanship of Mr Jos. Martin was held to discuss the question of miners' phthisis and its prevention". At the end of the discussion a resolution was unanimously carried:

"That we undertake to further to the best of our ability the introduction into Cornish mines, as soon as possible, of water jets or other means for the prevention of dust in rock drilling". Haldane and Thomas were credited with "the inception of the system".

The final report of Haldane, Martin and Thomas appeared in 1904 entitled *"Report on the Health of Cornish Miners"*.[85] This was a milestone in the history of miners' disease because it officially established that the "excessive death rate" amongst metal miners was "due solely to inhalation of stone dust". It "produces permanent injury of the lungs - gradually in the case of ordinary miners, and rapidly in the case of machine drill men".

Until 1892 silicosis mainly affected miners over 40 years old and death rates had changed little since the 1864 Kinnaird Commission. By 1902 many of the Cornish miners had used machine drills in the Transvaal and in other countries as well as in Cornwall. As a result there had been an enormous increase in the death rate from lung diseases amongst younger men 25 to 45 years old. Silicosis markedly increased susceptibility to tuberculosis and indeed 74% of rock drill men had died from this complication.

The dust causing the problem, it was concluded, was produced not only by dry drilling holes but by blasting, ore handling and other ways. The authors found "a very small water jet" could prevent the dust of rock drills and that "a powerful jet of water and air" would lay the dust after blasting. Ore handling could be made less dusty by keeping the workings damp.



The report also systematically dismissed each of the factors which had previously rivalled the dust theory as the principal cause of the lung diseases:

Fig. 15. *Photograph of John Scott Haldane (1860* - 1936), *professor of physiology at Oxford. This practical scientist finally identified dust as the principal cause of miners' disease in the 1904 report on the Health of Cornish miners. (National Portrait Gallery, London.)*

i) Bad air:- this theory was finally discredited by the fact that "an end with a (machine) drill at work may contain purer air (from the compressed air line) than any other part of a mine" and yet the miners still contracted lung disease.
ii) Climbing ladders:- any excessive exertion caused by this activity would not produce lung disease.
iii) Sudden temperature change:- facilities were better than at many collieries and yet colliers do not suffer excessive amounts of lung disease.
iv) High temperatures:- no evidence it is injurious as shown by colliers in hot coal mines.
v) Absence of sunlight:- no different to colliers.
vi) Metallic poisoning:- no evidence, even in lead mines, that there is appreciable mortality from metallic poisoning.

The Haldane report made three recommendations:

a) Prohibit the use of machine rock drills in hard stone where no dust prevention measures are taken.
c) Special Rules be established under the 1872 Metalliferous Mines Act for a mine to work in such a manner as to minimise the dust inhalation by the miners.
d) Special Rules be established to ensure "sanitary receptacles" are provided to prevent pollution of the mine with human faeces (i.e. hook worm prevention)

The long and complex history of the subject after 1904 is not covered in this paper but has been discussed by Burke (1978).[86] Suffice to say that both the mine owners and the miners themselves were reluctant to take dust prevention measures (e.g. "wet" drilling). Even the overwhelming evidence of the Haldane report did not convince everybody of the role of dust, especially in the slate mining and quarrying industry. The same year the Haldane report appeared the Merioneth medical officer of health stated:[87]

"... quarrymen were more prone to consumption than colliers because colliers had a daily bath from head to foot, whereas thousands of people in Ffestiniog never had a complete bath all their lives".

Even 18 years later, in 1922, the Penrhyn quarry doctor issued a notice stating:[88]

"I have become convinced after 4 years experience here that slate dust is not merely harmless but beneficial".

## CONCLUSION

Despite the insights of early European writers into the existence and cause of the high mortality amongst metal miners British writers were slow even to recognise there was a problem. Even when Thackrah in 1832 put his finger on the true cause of the problem it was not until 1904, after many false trials, that the truth became officially recognised.

This tragic delay has many parallels in other areas such as the recognition of the water borne nature of cholera and the role of coal dust in coal mine explosions. The factors that contributed to the delays were:

– partly due to medical science failing to understand the pathology of the disease early enough and so medical men were split in their subjective views.
– partly due to lack of public pressure to take action because the disease did not grab the headlines like gas explosions in coal mines.
– partly due to the fatalism of the miners who knew the long term effect of their occupation but did not agitate for action and even resisted preventative measures when the cause was known.
– the suppression of investigation or action by vested interest may have been a factor and this was particularly apparent in the slate mining industry.

Even today silicosis is still a problem in the international mining industry, partly because water does not entirely eliminate all fine silica dust and partly because some countries do not enforce basic dust prevention measures.

[31]

COMPARISON OF DEATH RATES FROM LUNG DISEASES
AGE GROUP 55 TO 65
MALES ONLY 1890-92

DEATH RATES FROM LUNG DISEASES IN CORNISH MINERS BEFORE AND AFTER COMPRESSED AIR ROCK DRILLS WERE WIDELY USED.

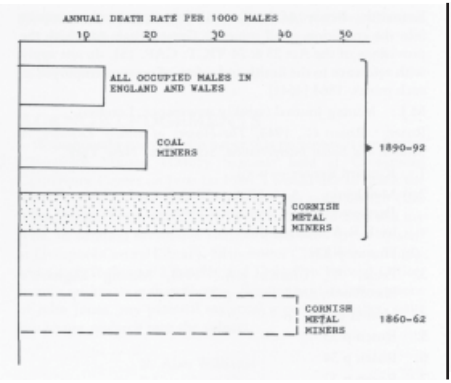


Fig. 16. *Histogram showing that there was no major change in the high death rate from lung diseases of Cornish Miners between 1860-62. (i.e. Kinnaird Commission investigations) and 1890-92.*

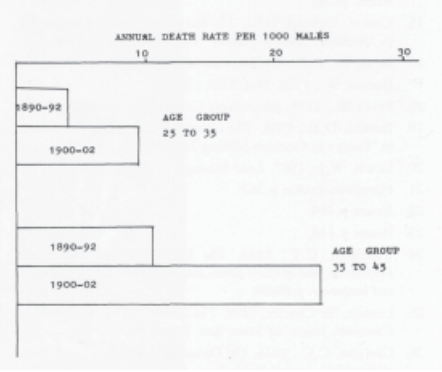


Fig. 17. *Histogram showing the death rate from lung diseases of Cornish miners before (1890-92) and after (1900-02) compressed air drills were widely introduced.*

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*Miners boring a hole downwards by hand.*
*Dust was produced by many underground activities, especially boring holes. Hand boring was done by one, two or three miners, horizontally as well as upwards and downwards. (From Simonin: Underground Life. 1869)*