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# Occupational Safety and Health in Mining

Anthology on the situation in 16 mining countries

*Ed. Kaj Elgstrand and Eva Vingård*

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## List of contents

Safety and health in mining; <i>Eva Vingård &amp; Kaj Elgstrand</i> .....	1
Photo collage.....	15
Safety and health in mining in China; <i>Dave Feickert</i> .....	23
Safety and health in mining in India; <i>P K Sishodiya &amp; Rahul Guha</i> .....	31
Safety and health in mining in Indonesia; <i>Rachmadhi Purwana</i> .....	42
Safety and health in mining in Iran; <i>Mostafa Ghaffari</i> .....	50
Safety and health in mining in Poland; <i>Stanisław Krzemień &amp; Alicja Krzemień</i> .....	59
Safety and health in mining in Spain; <i>María Mercedes Tejedor Aibar, Marta Zimmermann Verdejo &amp; José Ignacio Martín Fernández</i> .....	67
Safety and health in mining in Sweden; <i>Bengt Järholm</i> .....	77
Safety and health in mining in Turkey; <i>Yücel Demiral &amp; Alpaslan Ertürk</i> .....	87
Safety and health in mining in Congo (DRC); <i>Myriam Molayi Elenge</i> .....	94
Safety and health in mining in South Africa; <i>Gill Nelson &amp; Jill Murray</i> .....	105
Safety and health in mining in Australia; <i>Ian Eddington</i> .....	118
Safety and health in mining in Canada; <i>Susan Haldane</i> .....	129
Safety and health in mining in the US; <i>Susan M. Moore, Jeffery L. Kohler &amp; Gregory R. Wagner</i> .....	137
Safety and health in mining in Brazil; <i>Mario Parreiras de Faria &amp; Tom Dwyer</i> .....	150
Safety and health in mining in Chile; <i>Verónica Herrera Moreno</i> .....	160
Safety and health in mining in Ecuador; <i>Raul Harari A. &amp; Florencia Harari Freire</i> .....	171
Technical notes.....	179



Eva Vingård & Kaj Elgstrand

# Safety and health in mining

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Kaj Elgstrand was a researcher in work physiology and ergonomics in Stockholm, 1964–1968. He worked at the University of Cauca in Popayan, Colombia, 1968–1970. He was Director of the Swedish national training programmes for specialists in occupational health services and labour inspection, 1971–1988, and Director of the Nordic Institute for Advanced Training in Occupational Health in Helsinki, Finland, 1988–1992. During 1993–2007, he worked at the Swedish National Institute for Working Life as Director of international training programmes, and on international technical cooperation programmes in Poland, Central America and Southern Africa. Since 2007, he has been an occupational health consultant, first at the Royal Institute of Technology in Stockholm, and currently at Uppsala University.

This anthology reviews the current situation related to safety and health in mineral mining. The situation in 16 countries is described. Of the ten most productive mining countries in the world<sup>1</sup>, eight are represented: China, USA, Australia, Canada, India, Chile, South Africa and Brazil; two are missing: Russia and Japan. In addition, there are articles from Indonesia, Iran, Congo (DRC), Poland, Spain, Sweden, Turkey and Ecuador. All five continents are represented. In 2010, these 16 countries had about 65% of the total world production of minerals.<sup>1</sup> An additional 12 countries were approached. For most of these countries, agreements were made with possible authors, who either failed to supply manuscripts or submitted inadequate material.

Besides a few external references, this introductory article is based on the information in the 16 articles. They all have the same structure: (1) Mining activities, (2) Safety and health, (3) Current needs. The reader will find, however, that the articles differ greatly in details. This may be a reflection of the situation in the countries, and/or of the authors' interests and competencies. It makes strict comparisons between countries difficult, but hopefully it makes the reading more stimulating.

## 1. Mining

The extraction of minerals has been going on since prehistoric time, in many parts of the world. Today, mining exists in most countries, and includes exploration for minerals, extraction of minerals, and preparation, including crushing, grinding, concentration or washing of the extracted material. Mining operations can be grouped into five major categories in terms of their respective products: coal mining, metal ore mining, non-metallic mineral mining and quarrying, oil and gas extraction, and support activities for mining. Oil and gas extraction is not considered in this anthology.

Mining is a prerequisite for much industrial production: the products of mining are necessary for the production in manufacturing, construction and many other sectors.

The four major mineral mining commodities that produce most revenue are coal, copper, iron ore and gold; more than 70% of the production of these four minerals come from the 16 countries represented in the anthology<sup>1</sup>. In spite of the debate on global warming, coal fires the furnaces in many industries. Coal contributes about 27% of the world total energy supply.<sup>2</sup> The demand for coal has never been greater, and it is a major mining product in China, USA, India, Australia, Russia, Indonesia, South Africa, Germany and Poland<sup>1</sup>. Coal provides 70% of the primary energy in China and has expanded along with the increase in energy demand. According to the International Energy Agency, IEA, coal use has never stopped increasing and the forecasts indicate that, unless dramatic policy actions occur, this trend will continue in the future<sup>2</sup>.

In the last ten years, industrial development has accelerated in many countries, including huge countries like China and India, and this has impacts all over the world. Rising demands of minerals have resulted in booming mining activities. Mining companies have increased employment and have had excellent financial performances. What is regarded as industrial development in some countries, however, may only result in increase of primary production in other countries, the production being exported and not used for manufacturing in the mining country. The driving force for growth of the mining sector is highly dependent of continued confidence in the Chinese economic expansion. On the other hand, the more vulnerable the global economy, the greater is the demand for some mining products, like gold and silver.

Mineral mining is carried out in enterprises that are very different in size and character. At one extreme of the spectrum there are the big multinationals that have tens or hundreds of thousands of employees, and run huge mining operations all over the world. At the other extreme there is artisanal and small-scale mining.

In Table 1, a summary is given of the ten biggest mining companies in terms of number of employees. Most of them are multinationals, and some of them are global. These mining giants all have well-developed websites, so information about their size, ambitions and activities is easily accessible. They are committed to environmental sustainability, social responsibility, and the protection of the health and wellbeing of their employees. Most of them adhere to “safety first”, and some of them mention ‘zero accidents’ as an objective. However, there are also reports from other sources, like Wikipedia and Human Rights Watch, about controversies due to removal of local populations from their land, or toxic waste from mining processes that causes contamination of soil, groundwater and surface water. Every now and then the international media report about spectacular accidents or other events in mining.

According to ILO there are between 10 and 15 million people working worldwide in artisanal and small-scale mining, and an estimated 100 million depend on it for their livelihood<sup>3</sup>. Artisanal and small-scale mining extracts a wide range of minerals in large quantities, ranging from gold and precious stones to zinc, coal and bauxite. Women provide up to 50% of the small-scale mining workforce, and a large number of children still work in small-scale mining.

Development of the mining industry is in progress everywhere, to achieve higher efficiency, higher productivity, and also better working conditions. The main tools are mechanization, computerization and automation, work organization and globalization. Evidently, the conditions in major mining companies differ greatly from the situation in artisanal and small-scale mining. The mining companies are resourceful and well organized, and many of the mining processes highly mechanized and automated. The artisanal and small-scale mining is mostly carried out in remote rural areas, exploiting small deposits of minerals in a labour-intensive and extremely hazardous way without any control or support by authorities.

Even if the mining sector is not one of the most important sectors in relation to the number of employees, it employs many millions. The total number of mining employees in the 16 countries represented in this anthology is approximately 11 million (of which 8 million in China). To this figure should be added several million subcontracted workers and suppliers of goods, transportation and other kind of support. Furthermore, millions are active in informal, artisanal and small-scale mining, most of them illegal, in China, India, Indonesia, Congo (DRC), Brazil, and Ecuador.

Large companies will continue to mechanize and automate mining, and this is reaching the small mining companies. Besides its positive outcomes of improved efficiency and productivity and higher benefits from the mining, this development will also dramatically change the working conditions. Heavy manual work will disappear and the risk of some types of accidents and occupational diseases will disappear or be reduced, but other types of accidents and diseases will occur or increase in risk, and employment will go down.



**Table 1.** Major mining companies. The information is derived from the companies' websites. "Number of employees" in some cases also includes subcontracted personnel.

Name, ownership & headquarter	Production	Operations in	Number of employees
Vale; public, Brazilian multinational; HQ: Rio de Janeiro	Nickel, iron ore, iron ore pellets, manganese ore, ferroalloys, aluminium, fertilisers, copper, coal & others	South America, Africa, Asia, Australia	200,000
Shenhua Group; Chinese, state-owned company; HQ: Beijing	Coal	China + investments in Asia & Australia	172,000 (2011)
Aluminium Corporation of China; public, state-backed holding company; HQ: Beijing	Alumina, primary aluminium	China + 9% stake in Rio Tinto (iron, Australia) + investments in Peru	108,000 (2008)
Anglo American; public, British multinational; HQ: London	Copper, diamonds, iron ore, coal, platinum	Africa, Asia, Australia, Europe, North & South America	100,000 (2011)
BHP Billiton; public, Anglo-Australian multinational HQ: Melbourne & London	Iron ore, diamonds, coal, manganese, gold, aluminium & other	Africa, Asia, Australia, South & North America, Europe	41,000 + 65,000 contractors (2011)
Glencore; Public Swiss multinational; merger with Xstrata announced (2012); HQ: Baar	Metals & minerals, energy products, agricultural products	Europe, North, Central & South America, Asia, Australia, Africa & the Middle East	61,000 + Xstrata 39,000 (2011-12)
Norilsk Nickel; public Russian mining & smelting company; HQ: Moscow	Nickel, palladium, copper, platinum, gold, cobalt, selenium & others	Russia, Europe, Africa, Australia	79,000 (2011)
Rio Tinto Group; public, British-Australian multinational; HQ: London & Melbourne	Aluminium, iron ore, copper, uranium, coal & diamonds	Asia, Africa, Australia, Europe, North & South America	68,000 (2011)
Anglo Gold Ashanti; public multinational; HQ: Johannesburg	Gold, silver, uranium oxide	Africa, Asia, Australia & South America	61,000 (2011)
Anglo American Platinum; Public, Anglo-American main shareholder; HQ: Johannesburg	Platinum	South Africa	58,000 (2011)

## 2. Safety and health

**Working conditions:** The traditional picture of the working conditions in mining and quarrying is that the work is physically demanding and dangerous due to heavy and awkward loads, unstable underground structures, heavy tools and equipment, great accident risks, exposure to toxic dusts and chemicals, heat and cold. The mining work often takes place underground with bad lightening, high up in the mountains or in remote areas where schools, health care and other social services are scarce or non-existent as well as family- and community support. This may be the situation in artisanal and small-scale mining in China, India, Indonesia, Brazil, Ecuador, Congo (DRC), for example, but does not reflect the working conditions in most big mining companies today.

**Legislation, supervision and control:** ILO's Safety and Health in Mines Convention of 1995 (No. 176) has been ratified by 26 countries (by December 2012), including six of the 16 countries represented in this anthology: Brazil, Poland, South Africa, Spain, Sweden and USA<sup>4</sup>. ILO's Asbestos Convention of 1986 (No. 162) has been ratified by 35 countries (by December 2012), of them seven are represented in this anthology: Australia, Brazil, Canada, Chile, Ecuador, Spain and Sweden.<sup>4</sup>

Generally, the national legislation includes special acts, codes or ordinances related to safety and health in mining. In Turkey and Iran, however, there is no such special legislation related to mining. In most of the 16 countries, the legislation is considered adequate.

Evidently, governments and supervision and control authorities play a crucial role in stimulating the mining enterprises to provide safe and healthy working conditions. The supervision and control is insufficient within formal economy mining in China, India, Indonesia, Congo (DRC), and South Africa. The reason may be low priority and resource allocation by the government, and/or difficulties in attracting and holding qualified inspectors who can earn higher wages elsewhere. In Iran and Turkey, inspection of safety and health in mining is divided between different authorities, and their deficient cooperation contributes to an ineffective supervision and control. When there is informal economy mining (artisanal, small scale and illegal) there is also, by definition, a lack of supervision and control. This is the case in China, India, Indonesia, Congo (DRC), South Africa and Brazil and Ecuador.

**Statistics:** Our knowledge about the working conditions and safety and health in mining is dependent on available data. Reference is often given to national registers of accidents and disease. In India, the national accident records have been meticulously maintained since 1901, and therefore allow for long-term evaluation of the safety work in formal mining. Comparisons between countries are often made in relation to fatal occupational accidents, as the statistics in these cases are supposed to be more reliable than other kinds of occupational safety statistics. Such data is presented in all the articles. Injuries are underreported in many countries and injury rates cannot be calculated due to lack of information concerning working hours. Occupational diseases are generally underrepresented in statistics because of deficient diagnosis and lack of acknowledgement of their relation to working conditions. In Ecuador, only one case of silicosis has been recognized during 50 years. Where reliable national statistics exist, mining is generally the sector having the highest, or among the 2-3 highest, rates of occupational fatal accidents and notified occupational diseases.

**Accidents:** Every year, thousands of miners die in accidents and many more get injured, especially in the processes of coal mining and hard rock mining. The accidents may be caused by gas or dust explosions, gas intoxications, improper use of explosives, electrical burn, fires, collapsing of mine structures, rock falls from roofs and side walls, flooding, workers stumbling/slipping/falling, or errors from malfunctioning or improperly used mining equipment.

Coal mining in China is of special interest, as it employs 5 million miners. Since the establishment of the People's Republic of China in 1949, more than 250,000 Chinese coal miners have died in mining accidents. This compares with figures for the UK where over 100,000 miners were killed since records were first kept in 1850. The UK industry never reached even 10% of the size of the present Chinese coal industry. In terms of fatal accident rates, up until the 1940s the UK had a higher rate than China has today.

Many miners are also employed in coal mining in India – 370,000. From the national records it can be seen that coal mining for many years, up to the 1980s, has had a higher rate of fatal accidents than non-coal mining. In later years, the fatal accident rate has been about the same for coal mining and non-coal mining. In general, there has been a constant decline in fatal accident rates in all mining from 1901 to 2010 due to changing technology, mechanization and growth of a safety culture. However, during the last decades there has been an increasing trend in the rates of fatalities in non-coal mines. Deeper mines and mining under more difficult geotechnical conditions may have been important factors for this increase. Furthermore, the increasing number of small mines, which do not take adequate safety measures, may also be an important contributor.

While in many countries the fatal accident rate in mining has been reduced during the last decades, mining is still ranked high amongst the formal economy sectors for leading fatality rates. The informal mining (artisanal, illegal and/or small-scale mining) is not represented in the national records. Generally, it is estimated that the working conditions in informal mining are worse than in the formal mining sector: heavy manual work, no facilities for safety and health, etc

**Occupational disease panorama:** The most frequent occupational diseases in mining are respiratory diseases (coal workers' pneumoconiosis, silicosis, asbestosis, emphysema, chronic bronchitis), noise-induced hearing loss, and musculoskeletal disorders (joint, tendon or muscle inflammation; back problems). Our comments here, on coal workers' pneumoconiosis, silicosis, asbestosis, hearing loss and musculoskeletal disorders are based upon the 16 articles.

Statistics on diseases like pneumoconiosis and cancer are difficult to establish and follow-up, as such diseases develop during many years (20 or more) before they become clinically manifest. Many workers have at that time left the mining trade. The migrant workers may also have left the country they worked in, which makes it even more complicated to follow them.

**Coalworkers' pneumoconiosis**, or black lung disease, is caused by long-term exposure to coal dust. The dust builds up in the lungs and cannot be removed, which leads to inflammation, fibrosis and in the worst cases, necrosis. The mechanism behind coalworkers' pneumoconiosis was not well understood until the 1950s. In many mining countries, it is still a common occupational disease.

**Silicosis** is caused by inhalation of dust that contains free crystalline silica. The mechanism of formation of silicosis has been known for hundreds of years. Despite all efforts to prevent silicosis, it still afflicts tens of millions of workers in hazardous occupations in mining and quarrying, construction and other sectors, and kills thousands of people every year. With its potential to cause progressive and permanent physical disability, silicosis continues to be one of the most important occupational diseases. Recent research has found that silicosis is closely associated with tuberculosis and, together, silica dust, silicosis and Human Immunodeficiency Virus (HIV) have a multiplicative effect on the development of tuberculosis.<sup>6</sup> In South Africa, tuberculosis causes more deaths in mine workers than mine accidents.

Records of coalworkers' pneumoconioses and silicosis are often presented jointly. In China, over 6,000 miners die every year due to coalworkers' pneumoconioses and silicosis. The total number of sufferers is not known, but it is estimated that around 600,000 miners suffer from these lung diseases. These diseases also remain important problems for active and retired miners in the US. Evidence even suggests that the rates of coalworkers' pneumoconioses are increasing in the US.

The prevention of silicosis has been the subject for many national and international initiatives during the last hundred years, but only in a few mining countries is the disease fully controlled or eradicated. Sweden is one of these countries.

To address the prevention of silicosis globally, the ILO and WHO established in 1997 the *ILO/WHO Global Programme for the Elimination of Silicosis*. This was identified as a priority area for action in occupational health, obliging countries to place it high on their agendas. The objective is to reduce the incidence of silicosis drastically by 2015, and have silicosis as a public health problem eliminated by 2030. It was believed that the experience gained would provide a prevention model for other pneumoconioses and a proven system to manage exposure to mineral dusts. This goal was re-affirmed in 2003 at the 13th Session of the ILO/WHO Joint Committee on Occupational Health, which strongly recommended that "special attention should be paid to the elimination of silicosis and asbestos-related diseases in future ILO/WHO co-operation."<sup>7</sup> Of the 16 countries represented in this anthology, five have established national programmes for eliminating silicosis, following the ILO/WHO initiative: Brazil, Chile, India, Iran, South Africa and Turkey. China has other programmes related to prevention of silicosis.

**Asbestosis:** There are four main diseases caused by the inhalation of asbestos fibres: mesothelioma, lung cancer, asbestosis and diffuse pleural thickening. The three first may be fatal, and they can all be very debilitating. People with occupational exposure to asbestos fibres in the mining, manufacturing, handling, or removal of asbestos are at risk of developing asbestos-related diseases. According to WHO, about 125 million people in the world are currently exposed to asbestos at their work place. In 2004, asbestos-related lung cancer, mesothelioma and asbestosis from occupational exposures resulted in 107,000 deaths and 1,523,000 Disability Adjusted Life Years (DALYs).<sup>8</sup>

The extraction, import and use of asbestos has been banned in a number of individual countries. In 1999, the European Union decided to ban all types of utilization of asbestos from 1<sup>st</sup> January 2005.<sup>9</sup> In addition, the extraction of asbestos and the manufacture and processing of asbestos products were banned.<sup>10</sup> However, exposure to asbestos in the course of removal, demolition, servicing and maintenance activities remains to be regulated.

Canada is currently the only G8 nation exporting chrysotile asbestos. In 2010, the Canadian Public Health Association issued a position statement calling for the ban on the mining, transformation and export of chrysotile asbestos. However, proponents argue that exposure to the cancer-causing agents in the mineral can be limited through proper extraction and handling methods. In 2011, Canada blocked an international agreement to restrict the sale of chrysotile and add it to the UN list of hazardous materials. The vast majority of medical and safety professionals in the country oppose the mining, use and export of chrysotile.

Brazil is another of the few countries around the world that is still producing, using and exporting asbestos.

In China, it is estimated that over 100,000 workers are exposed in factories using asbestos in the production, most of the asbestos being imported from Russia. South Africa has a legacy of asbestos-related disease due to uncontrolled asbestos exposure, which peaked in the 1970s and 1980s. Large parts of the country remain contaminated with asbestos and disease continues to be diagnosed amongst those who worked with asbestos or lived in the vicinity of the asbestos mines and mills.

**Hearing loss:** Noise-induced hearing loss is mentioned as one of the most reported occupational diseases in mining in the articles from India, Iran, South Africa, Poland, Sweden, Chile, Canada, USA and Australia.

A survey conducted in an Indian underground metal mine has shown that almost 75% of the mine workers had evidence of noise-induced hearing loss; another survey showed that 20-25% of workers in opencast mines had evidence of noise-induced hearing loss.

Noise-induced hearing loss is also a recognized problem in the South African mining industry, but the mines appear to have been more successful in complying with reducing noise levels than silica dust levels. Current data indicate that the coal, copper, iron ore and manganese mines are 100% compliant. Both the gold and diamond mining sectors report that around 1% of their employees are exposed to noise levels exceeding 105dB LAeq over an 8 hour shift. However, the proportion of over-exposed workers in the chromium and platinum mining sectors is almost 10 fold higher.

In Sweden, the national statistics of reported occupational diseases (asking for compensation) included 24 cases among employees in the mining industry in 2010. Of these, 13 involved hearing problems caused by high noise levels.

In Australian mining, 9% of injuries are caused by long-term exposure to noise, “an untenable statistic given the now long-established technical efficacy of the science and technology available for the prevention of industrial deafness”.

**Musculoskeletal disorders** are reported to have high prevalence among miners in Spain, Sweden, India, Iran, USA and Australia. A variety of such disorders are mentioned: joint, tendon or muscle inflammation or irritation, backache, etc. In most countries musculoskeletal disorders are not recognized as work related and there is often a lack of statistics and awareness of the problem.

### 3. Current needs

In *South Africa*, improvement in **living conditions**, both in the mines and in the communities, is important to lessen the burden of disease. Much needs to be done to address the far-reaching negative health effects of the **migrant labour system**, and appropriate and relevant policies need to be instituted to ensure that ex-miners, in particular, have access to healthcare and compensation services. This is probably also true for other countries with migrant workers.

In *Iran*, the **lack of proper investments** in health and safety is an important and neglected issue. The **safety culture** in mine activities demands serious action. Education in how to work in a safe manner will help workers to do their job with less risk, but safe tools and safe instructions are also important aspects of the safety culture. While there are quite acceptable investments in this field in large-scale mines, they are still unable to meet international standards. In medium-scale mines, the health and safety situation is not acceptable and the situation is even worse in small-scale mines. It seems that special health and safety programmes for small-scale mines, with attractive incentives for employers of a similar kind, will be demanded. The health and safety culture in *Turkey* is still very weak and needs to be strengthened. This is a problem that cannot be solved quickly. It demands long-term joint efforts and solidarity by the trade unions, professional associations and relevant governmental and non-governmental organizations. In *China*, lack of investment characterises small mines in particular, less so the large mines, where investment levels are increasing. Too many small mines are still operating without all their licences and/or exceeding their production limit licence. It is in this sense that mines operate illegally, although there are also small mines that are totally illegal in both coal and non-coal sectors. In *Chile*, the contrast between mortality and morbidity indicators at big companies and those at small and medium-sized companies reflects a huge safety gap. Furthermore, **subcontracted miners** have a high and unacceptable level of mortality. This has made mining companies demand the same safety standards for subcontracted companies as for their own workers. In the article from *Turkey*, it is proposed that subcontracting should be strictly regulated and be banned in core mining activities. In *Sweden*, the present high demand for metals leads to the start-up of new often rather small mines, sometimes with limited resources and experience in work safety. The challenge for society is to increase the safety of miners under such circumstances. In *Brazil* it is estimated that the formal economy is associated with far less safety and health damage than the informal and illegal economies. Yet the former receives far more official attention than the latter. From a prevention view-point, one important challenge is for the State to exercise its sovereignty, to bring all mining activities under its jurisdiction, and contribute to adequate solutions.

In *Ecuador*, **formalization of informal activities** in mining is urged; credits should be given to change technology and create better working conditions and training of informal miners. In *Congo (DRC)* and *Indonesia* artisanal mining is, and will likely remain, an important part of mining activities. Initiatives that could accelerate the formalisation of artisanal mining might include introducing a permit for the activities, and to encourage miners to organize themselves around a mine belonging to them, exclusively, even for a reduced term.

Overall in *China*, there is an inadequate system of **risk assessment** in place at any level, although some state-owned mining groups are implementing some of the basic elements of such an approach and with good effect. However, risk assessment requires quite a sophisticated safety culture and organisation to carry it through. The State Council has

published an extensive guidance for high-risk mines, which requires risk assessments to be carried out monthly at every plant or mine. To make proper risk assessments is considered one of the most important issues for improving safety and health in mining in *Iran* and *Indonesia*. According to regulations in *Iran*, this is the duty of the health and safety officer in each mine. Their activities should be supervised by inspectors from the ministries of health and labour. It seems, however, that both the officers and the inspectors lack up-to-date knowledge and other tools for these assessments. Introducing the concept of "Risk Assessment", together with "Safety Management Plans", is advocated in the article from *India*. The new thinking required must embrace organizational, behavioural and cultural systems in addition to hazard control, analysis to anticipate hazards and engineering solutions to prevent accidents and occupational diseases. A current project in *Sweden* is aimed at reducing the risks by focusing on individual risk assessment, attitudes and behaviour.

**Legislation and regulatory issues** are mentioned in some of the articles, but the **supervision and control** of that legislation and compliance with regulations is what is really needed to improve the situation in several of the countries. In *India*, compliance with the legislative requirements is inadequate for work environment monitoring in most mines. While the mining industry has been negligent, the enforcement agencies find it difficult to enforce the monitoring standards and crosscheck compliance with permissible levels due to limited infrastructure and manpower. The present system needs to be strengthened with adequate technical support services and strict enforcement. Concerning prevention of accidents, the existing traditional system of administration of occupational safety and health legislation in mines through inspections, statutory and other investigations has reached its limit of effectiveness. The time is now ripe to introduce new initiatives and focus on areas of high risk in order to bring them down to acceptable risk levels. Taking into account that there are insufficient labour inspectors in *Turkey*, it is suggested that the professional organizations as well as the labour unions should take part and provide additional expertise services for the mining sector. In *South Africa*, the Mine Health and Safety Inspectorate is underresourced. From 2002 to 2008, there were only four to five mine inspectors per 10,000 mine employees, and the proportion of vacancies increased from 13% to 30%. The inspection agencies in *Chile* must be empowered with personnel and authority to develop their function; today, there is a total of 42 inspectors, which clearly is not enough to control all the mining sites operated in the country.

The need to develop **organisational issues** is mentioned in some of the articles. In *Iran*, there are three groups of inspectors inspecting safety, health and insurance issues in the mines. They perform regular inspections, but unfortunately there is little communication between them. In *Turkey*, it is believed that the Ministry of Health should establish a strong national agency for occupational safety and health, including provincial organizations. In *Congo (DRC)* it is suggested that a concept of third-party responsibility for artisanal mining should be developed. The holder of the mining rights, with exclusive purchase rights for the product of artisanal mining, should have a third-party responsibility for health and safety of all people working in their mining areas. Furthermore, it is believed that all aspects of occupational health and safety should be gathered within a specific service, as stipulated in the ILO Convention 176. In *China*, the knowledge and skills among the whole workforce is not being exploited to its maximum, especially among experienced miners. This partnership should be constructed as a triangle between the manager, who is responsible under the law, the government inspector, and the worker safety representative. Each should be supported by strong organisations – company, government, and trade union. There has been insufficient

involvement of worker safety representatives in state-owned mines. In township and village mines, worker safety representatives have not existed until recently.

The need to update and improve **disability evaluation and worker compensation** is mentioned in the articles from *China, India* and *South Africa*.

Most health-related **research** in the mining industry in *South Africa* has been conducted on gold miners, followed by asbestos and coal miners. More recently, there has been some work on platinum and diamond miners. However, many mining sectors are under-researched and the health status of miners in these sectors is unknown. The authors from *Brazil* urge that research pay more attention to social relations at work, such as training, workplace organization, payment and rewards systems that induce people to work unsafely and, as is especially evident in the illegal mines, the role of unequal power relations in causing illness and accidents.

In the articles from *China, India, Turkey, Brazil* and *USA*, extended and/or improved **training** for different target groups is mentioned as important means for improving safety and health in mining.

**Pneumoconiosis/silicosis** is considered the singular most serious health risk in many of the 16 countries. Improved work environment to prevent pneumoconiosis is the most urgent need for many countries. In *India*, a nodal agency is needed to conduct surveys and studies in mines for detection of cases of pneumoconiosis and provide reliable estimates. A central registry and database of all cases of pneumoconiosis diagnosed and detected and a referral centre for detection, certification (and disability evaluation) needs to be established with programmes and systems to provide advice and treatment to pneumoconiosis victims and develop strategies for management and rehabilitation. In *South Africa* the health of miners, in contrast to safety, has worsened, clearly illustrated by increasing rates of silicosis and tuberculosis. The national target to prevent silicosis will not be met unless concerted efforts are made to reduce silica dust to safe levels. Adherence to the occupational exposure limit needs to be monitored and enforced, which will require extended resources. In addition to dust control, disease prevention also requires effective surveillance systems. Disease surveillance programmes need to be established and monitored, both at a national level and at an individual mine level. Although silicosis has been the most important occupational disease in *Chile* for the last 50 years, the magnitude of this disease remains unknown.

Other actions to prevent health risks are programmes to control and prevent **noise-induced hearing loss** (*India* and *USA*) and actions to prevent **musculoskeletal disorders** (*India, USA, Spain* and *Sweden*). In *Sweden*, **diesel exhausts and radon** continue to be a major source of air pollution in many mines and the development of technology to further decrease and monitor the exposure is urgent. In *Ecuador* and *Indonesia*, high priority should be given to improvements in the processes avoiding or replacing the use of **mercury and cyanide** in gold mining. Furthermore, the control and prevention of environmental consequences of the use of mercury, other heavy metals and cyanide, should be further developed.

In *USA*, the Mine Safety and Health Administration and the National Institute of Occupational Safety and Health have developed what in summary is a comprehensive **national program for occupational safety and health in mining**, that can also be of interest in other countries:



### *Strategic goals*

- (1) to eliminate respiratory diseases by reducing exposure to airborne contaminants,
- (2) to reduce noise-induced hearing-loss,
- (3) to reduce the risk of musculoskeletal disorders,
- (4) to reduce the risk of traumatic injuries,
- (5) to reduce the risk of mining disasters, improve post accident survivability and enhance the safety and effectiveness of emergency responders,
- (6) to reduce ground failure fatalities and injuries,
- (7) to reduce adverse health and safety consequences through effective interventions with new technology.

### *Improved regulation*

- (1) development of regulations mandating the use of proximity detection and collision avoidance systems for underground coal mining machinery,
- (2) revision of current regulations pertaining to underground coal mine workers' exposure to coal mine dust, the cause of coal worker's pneumoconiosis and emphysema,
- (3) revision of current regulations to reduce the explosiveness of coal dust.

### *New engineering or training interventions*

- (1) improved practices for monitoring and managing methane gas on active longwall mines and in gobs of underground coal mines,
- (2) improved practices for reducing the explosivity of coal dust,
- (3) new approaches to improve the effectiveness of mineworker training,
- (4) new technology to provide breathable air to miners in a post-accident environment,
- (5) improved design and monitoring practices for safer ground control designs, especially in deep mines,
- (6) improving safety and health, by employing strategies found in occupational safety and health management systems.

## 4. Conclusion

Mining is a worldwide activity that employs millions of people. Mining can range from a high technology activity in big mines with a proper working environment and safety for the miners to a big, medium or small-scale activity with a very dangerous work environment. Although the diseases connected to mining, such as silicosis, and other penumoconioses, have been well known for centuries, together with the rates of fatalities and serious accidents, much preventive work still needs to be done. Legislation, supervision and control of the mines, good statistics of accidents and occupational diseases, and the development of safety programs and safety culture are crucial for the sound development of mining in the world.

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The Argyle Diamond Mine, which is 100 per cent owned by Rio Tinto, has been operating since 1983. The mine has produced over 750 million carats of rough diamonds and generated more than US\$6 billion in revenue. Located in the east Kimberley region in the remote north of Western Australia, the Argyle mine is the world's largest supplier of diamonds. The Argyle Mine's production accounts for approximately one-fifth of the world's natural diamond production.

Source: website "Rio Tinto Diamonds".



Photo: Dave Feickert

Miner being trained at a surface facility on an underground longwall shearer cutting machine, with powered roof supports in the background, at a Xinwen company mine, Shandong province, China.



Photo: Sylwester Rajwa, Central Mining Institute, Katowice, Poland

Polish hard coal mining: an example of a longwall equipped with hydraulic chocks (powered roof supports), conveyor and shearer, in an underground coal mine in Silesia.



Photo: Ralph Orlowski/Getty Images/All Over Press

The subsidies to the coal mines in the EU that were adopted in 2002 would have ceased at the end of 2010/2011. But after lobbying by coal producing countries, the decommissioning of operating aid was moved to 2018.



Photo: Renata Falzoni.

The *Serra Pelada* mine in Pará, Brazil, was a huge open cast goldmine where more than 100,000 persons were involved in heavy manual work during the 1980s, moving vast amounts of ore and dirt by hand. The *Serra Pelada* mine was considered to be the greatest concentration of human work since the building of the pyramids. The official production record is 44.5 tons of gold, whereas the black market estimate is 360 tons. The mine was closed 1986.

Since 2008, the Canadian company Colossus Minerals Inc. has a joint venture with the Brazilian cooperative COOMIGASP to further explore and extract the remaining minerals of *Serra Pelada*, the “*Serra Pelada* Gold-Platinum-Palladium Project”.

Sources: [deckmelo.blogspot.com](http://deckmelo.blogspot.com) & Colossus Minerals’ website.



Photo: Raúl Harari

A miner in a small gold mine in Ecuador, mixing the mineral extracted from the mine with mercury in order to extract the gold. From this process he gets an amalgam, a ball containing gold and mercury, which afterwards will be burned to take away the mercury and to get the pure gold to be sold. He is exposed to mercury and other metals, such as cadmium. The risks of exposure to mercury and the resulting health effects, including renal and neurological effects, are well known among gold miners in Ecuador.



Photo: Gwenn Dubourthoumieu, 2010.

Children washing and sorting copper ore in water and mud, at an open-air mine in Kamatanda in Katanga, southeastern Democratic Republic of Congo (DRC). Some 400 children from Kamatanda and surrounding villages, who have dropped out of school, help miners transport, sort or wash the mineral. They work around ten hours per day, for less than two dollars.





Photo: Boliden

Modern mining equipment is developed, refined and implemented in order to improve work safety at the same time as increasing productivity and cost efficiency. The photo shows an example of an underground drilling equipment.

“Suppliers of underground drilling equipment today have very many things to consider. There is little doubt that the global mining industry’s future direction is underground, for both environmental and geological reasons. The major deep mines of the future will be planned and built on a far grander scale than those of today. High speed ramp drivage and mine development will be of importance, and benchmarking and comparisons with the methods used by contractors in tunneling can be useful for speeding up operations, Accuracy and speed in all operations in the drill and blast cycle has to be improved. Greater accuracy is required to avoid overbreak and reduce mucking time and transport, and to reduce time spent on scaling and rock reinforcement.” “With increased automation and reduced manning there is a growing need to remote surveillance.”

Source: International Mining, May 2007



Photo: LKAB

LKAB has been mining iron ore in Kiruna and Malmberget, in the north of Sweden, for more than 100 years. The ore bodies get purer, richer and bigger the deeper you go. No-one knows where they end. Drill tests have been carried out down to 2,000 metres in Kiruna, and to 1,800 metres in Malmberget.

However, there's one serious complication. The ore bodies slope down beneath built-up areas. When open pit mining began it was natural to build housing close to the workplace. No-one knew then that 100 years later there would be mining deep underground. The communities that sprang up thanks to mining must now be moved if operations are to continue. At Malmberget, several ore bodies lean in beneath the community, but Malmberget's built-up area has already changed since mining began 100 years ago.

Great parts of the city of Kiruna, around 3,000 apartments, will have to be removed over the next 20 years to allow continued mining operations. The creation of the new city - infrastructure, housing, moving the townhall and other official buildings - is a challenge that faces everyone; residents, municipalities, landowners, authorities, LKAB and so forth. Since it is LKAB's mining operations causing the city to move, LKAB has to cover the costs.

Source: LKAB's website, December 2012.

Dave Feickert

# Safety and health in mining in China

## Basic facts about China

Size of area	9,597,000 sq km
Population	1,350 million
Capital	Beijing
Literacy	92%
GDP per capita (PPP)	US\$ 9,100
Gini index	48
Infant mortality rate	16 deaths before age 1 year/1,000 live births
Median age	36 years
Life expectancy at birth	female: 77 years, male: 73 years

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Dave Feickert holds academic qualifications in Asian studies (BA New Zealand), safety engineering (MSc United Kingdom) and a MA (New Zealand) on the safety problems of the Chinese coal industry. He is a consultant on mine safety and energy, mainly in China and New Zealand. Dave has been a health and safety professional since 1978, spending 10 years in the British coal industry as head of research for the National Union of Mineworkers. Another 10 years working on European Union affairs, covered health and safety, general social policy and economics. He is substitute member of the European Coal and Steel Consultative Committee, a member of its safety and health and ergonomics subcommittees, and a member of the European Economic and Social Committee.

## 1. Mining activities

China has the largest coal industry in the world and a significant non-coal mining industry as well. These industries are widely distributed throughout the country. The size of the mining industry can be indicated by the number of employees. Coal mining employs nearly 5 million while non-coal mining (from gold, through other metals to rare earths) employs around 3 million. Many millions of others work in the wider coal economy, including transportation, the manufacture and use of equipment, and the processing of non-coal minerals.

Coal provides 70% of the primary energy in China and has expanded along with the increase in energy demand. Large new wind, solar, hydro and nuclear power plant are being built and natural gas and oil are increasing as well, but it looks likely that coal will dominate energy production for several decades to come. In essence, as in Europe and North America, coal has powered China's industrial revolution. China also leads the world with the installation of the cleanest coal power plant, with some 235 supercritical boiler power stations, bringing in improvement of energy efficiency of over 20% and associated carbon dioxide reductions of a similar amount compared with existing plants that they have replaced.

In the non-coal sector, China is not self-sufficient in many metals, importing 619 million tonnes of iron ore in 2010, for example. Nevertheless, non-coal mining is also a huge industry, with thousands of mines producing a wide variety of minerals. Many of these mines are very small and inefficient. A significant part of this sector is the 'rare earth' sector of metals and minerals essential for modern electronics and the manufacture of other specialist products. Other countries, such as the US, have placed pressure on China to export more of these, as China is a major centre of world reserves. China's non-coal mining companies have been investing both in China and overseas.

In 2011, China produced over 3 billion tonnes of coal - three times the output ten years earlier. Net coal imports in 2010 were over 170 million tonnes. The enormous increase in production is centred on very large new mines, concentrated in 6 large provincial state owned enterprises (SOEs), around which the coal industry is being restructured. At the same time, the number of small private mines has been drastically reduced from around 30,000 a decade ago towards a new target of around 10,000. The structure of the non-coal mining sector is very similar. Many of these small mines in both sectors have been closed on safety grounds or, in the case of coal, they have been merged into neighbouring SOE mines. The third group of mines consists of reasonably large, older SOE mines and mines owned by townships or other municipal organisations.

The vast majority of mines are owned by either state organisations or small private companies. One large company, the Yitai Coal Company in Inner Mongolia, is owned by its employees, according to the wishes of its founder. Most large SOE companies have floated some shares on the stock market and have bought mines overseas, especially in Australia. In the last three years, around US\$21 billion has been invested in mining, generally overseas, by Chinese companies. A few mines are owned by foreign companies in China, but this is insignificant compared to the size of the industry overall. The majority of the mining industry, and even the majority of small private mines, are within the formal economy. Where they

operate illegally, which is often the case with small private mines that have had serious accidents, companies become heavily regulated, with the owners and/or managers imprisoned and the mines closed.

Nearly half of the workforce involved in mining is made up of Chinese migrant workers from the countryside, with some groups of workers recruited through short-term contracts of up to three years between the mining companies and their local county organisations. Women are not allowed to work underground, but there are many working in surface-related activities. The mining workforce is unionised via the All China Federation of Trade Unions mining section. Health and safety representatives have been appointed and there is a trade union structure in the large mines, which runs parallel to the mine management structure.

The State Council decided five years ago that representatives for worker safety should be appointed in the small and township mines as well and made arrangements for the appointment of 100,000 such representatives. It is difficult to know how far this appointment process has been implemented in all provinces, but in one, Yunnan, they have been appointed in the majority of the 1,200 small mines. The local State Administration of Work Safety (SAWS) division has requested that these representatives be trained in line with mineworker representatives in the UK and this has been proposed for a pilot training under the 9 million euro EU-China safety and health programme for high risk industries due to run for 4 years.

The EU-China programme will include a significant element of training for worker representatives, managers and engineers, inspectors and mines rescue staff. These training programmes will be rolled out in the coal industry and then spread, with adaptation to non-coal mining and to other high-risk industries such as the chemical industry. Other training programmes, run in co-operation with other countries, such as Japan, the US, Australia and New Zealand, have trained a mixture of coal mining employees. Japan has concentrated on training under-ground supervisors, while the US, Australia and New Zealand have trained other groups, mainly mine managers and engineers, inspectors and rescue staff.

## 2. Safety and health

The headline statistic that places Chinese mine accidents in the global context is the official fatal accident number per year. In recent decades, this reached a peak of 6,995 in 2002 and has since fallen steadily, being 1,973 in 2011 and 1,384 in 2012. Given that output has more than trebled in the last decade, the rate per one million tonnes has fallen dramatically - by over 70%. The exposure rates cannot be calculated as it is not known how many shifts are worked in the nation's mines and the total employee count is not precise either.

A general problem of under-reporting will persist until a more modern accident reporting system can be established that gathers data on exposure (hours worked), and as the deliberate under-reporting in the small mine sector is dealt with. Substantial progress has been made in some of the SOE's at the mine and company level. How to do this at a company level was demonstrated in the four-year US-China mine safety co-operation, which ended in 2007. One of the aspects of the four-year EU-China co-operation will be to help build a better accident reporting system.

Notwithstanding the huge progress made, or the fact that China now has modern mines that have safety standards comparable to western large mines, the country still has the highest accident rates in coal mining, although Turkey and Ukraine follow close behind. Official statistics indicate that, since the establishment of the People's Republic of China (PRC) in 1949, more than 250,000 Chinese coal miners have died in mining accidents. This compares with figures for the UK - for example over 100,000 miners killed since records were first kept in 1850. The UK industry never reached even 10% per cent of the size of the present Chinese coal industry. In terms of fatal accident rates, the UK had a higher rate than China does today, up until the 1940s.

A list of very serious accidents (10 or more fatalities) for 2002 and illustrative for that year was compiled by the United States Mines Rescue Service. It reveals the following breakdown: private mines with permits, 3; private mines without a permit, 9; township mines, sometimes with a linked private mine, 16; township/ private mines linked without a permit, 3; SOE mines, 14; unpermitted activities such as sub-contracting in SOE mines, 2. A later analysis of fatalities by causal category for 2001 shows that the percentages identified by earlier research have continued: explosions and fires, 43%; roof falls, 33%; flooding, 8%; and coal transport, 9%. With the exception of explosions, the non-coal mines show a similar pattern.

Taking the single largest category in coalmines – explosions – it is difficult to analyse this further without access to the records of disasters. However, it is understood that these have been kept since 1949. Anecdotal evidence indicates that blasting, electrical faults and illegal smoking underground are common causes of gas explosions. In addition, there are serious gas source/accumulation problems arising from failures in ventilation and gas drainage, gas flow through blocked-off areas, sudden emissions from the mine floor, and outbursts. Experience in the developed countries shows why accurate information is essential, especially as causes of explosions vary over time with the change in production technology, and as old problems are solved and new ones arise.

The State Administration of Work Safety provided the author with a short set of case studies of recent gas and coal dust explosions, as recorded through its accident reporting and investigation system. This kind of data has been collected since 1949, but it does not appear to have been analysed for trends. This, together with the establishment of an accurate accident reporting system, would be very valuable in providing useful trend analysis for action at the company- and regional level.

The summary details of four cases are:

**Caijiagou Mine:** In May 2004, 33 miners were killed at this small private village mine that employed 92 miners on two shifts, established 1987 but operating with overdue licences after 2003. Originally, it was designed for 20,000 tons annual output, increased to 60,000 but actually produced 300 tons per day (approximately 90,000 tons/yr). The accident was a coal dust explosion (it was known that the coal dust explosion index was high risk), killing 33 and causing an indirect economic loss of RMB 2.933 million. The immediate cause was a heavy build-up of dust from underground transport and miners carrying out high temperature working (unspecified). There was no effective monitoring or control action by the supervisory

authority of the local government. The report recommended administrative fines, demotions of 27 officials with shared responsibility, and the closure of the mine.

**Xinjian Mine:** In December 2001, 20 miners were killed and 28 injured in this gassy state-owned mine, with an annual output of 600,000 tons per year. The direct economic loss was RMB 1.843 million. The report noted that the measures needed to prevent gas outbursts were not taken, ventilation was ‘in disorder’ and miners in adjacent areas were not withdrawn to the safe area.

**Gangzi village mine:** In July 2001, 92 miners were killed in a combined gas and coal dust explosion in this village mine with an annual capacity of 40,000 tons per year. A permit had not been obtained and the ventilation system was badly designed, with many dead-end roadways. The ignition source of the explosion was blasting.

**Chengjiashan Mine:** In April 2001, there was a gas explosion in this state-owned mine, producing 1.5 million tons per year. The explosion killed 38 miners and injured 16. The direct economic loss was RMB 1.36 million. The ventilation system was in poor condition and the explosion took place near a conveyor, with a likely ignition source being electrical sparking.

The SAWS report summarised the causes of these and other gas and coal dust explosions as being attributable to:

- Illegal mining
- Township and village mine management in disorder
- Working coal-face design rules not followed, especially regarding ventilation; no gas-monitoring systems installed
- Mines working more coal faces than permitted in their agreed plans, sending more men underground than permitted, some of whom are not registered as being underground
- Local government supervision not in effect

In terms of occupational disease, miners in both the coal and non-coal industries suffer greatly from pneumoconiosis (coal dust disease) and silicosis (stone/mineral dust disease), with over 6,000 dying every year. While the total number of sufferers is not known, it is estimated that around 600,000 miners are suffering from these lung diseases. This compares with a very large figure for the US of 1,000 fatalities per year from a much smaller workforce and retired workforce. In China, SAWS and the Department of Health have responsibility for the reduction and control of exposure, health surveillance and treatment. SAWS has a hospital and sanatorium at Beidaihe on the east coast, where over 6,000 miners with both lung disease and other diseases have been treated with lung lavage with some success. This treatment is currently being evaluated and the programme has recently received new funds. SAWS operates other occupational health hospitals for the mining industry, as do some of the large companies. Most asbestos is imported from Russia and it is thought that over 100,000 workers are exposed in asbestos factories.

### 3. Current needs

The current needs of the Chinese coal industry can be summarised as follows:

**Risk Assessment:** Overall, there is an inadequate system of risk assessment in place at any level, although some state-owned mining groups, such as Shenhua are implementing some of the basic elements of such an approach and with good effect. However, risk assessment requires quite a sophisticated safety culture and organisation to carry it through. This has only relatively recently been introduced into the laws of developed countries, let alone in developing countries. At several large mines visited by the author, a version of this system was clearly in practice. The mines are equipped with computer-based control of underground coal transport and monitoring of the mine environment, with key parts of the transport of men and materials systems on camera, in the surface control rooms. Often, these companies operate comprehensive health monitoring systems, with annual lung function check-ups and in some cases their own group hospitals for rehabilitation of pneumoconiosis sufferers. At the mines operated by these companies, the surface- and underground layouts were among the best seen by the author in any country visited. These mines had excellent simulation training facilities, with some underground in real life situations, in exhausted areas of the mine. For other SOE mines and certainly township and small village mines, the picture is sharply different.

In 2010 the State Council published an extensive guidance for high-risk industries (including both coal and non-coal mines), which requires risk assessments to be carried out monthly at every existing plant or mine. Previously, the requirement was for new plants or mines to get a risk assessment certificate before operations could commence.

**Regulatory environment:** China's safety regulations are quite good (especially those adopted in the 1990s covering technology and management) but the enforcement of them via inspection is poor, especially at local authority level and in particular with regard to smaller private and township mines. National political leadership from the President downwards and via SAWS cannot be criticised. There is a clear determination to improve the situation substantially, with clear targets set and with a reduction in accident rates stipulated. Some improvements could be made to the legislation, but it is the area of inspection and enforcement that needs strengthening. Too many small mines are still operating without all their licences and/or exceeding their production limit licence. It is in this sense that mines operate illegally, although there are also small mines that are totally illegal in both coal and non-coal sectors. Penalties (fines, dismissal, disciplinary action, mine closures), on the other hand, are quite severe, but are unlikely to solve the problems alone. Clarity is needed, too, in the law under which inspectors operate, which is civil law in the first instance in China, whereas in western countries it is directly under criminal law.

**Lack of investment:** This characterises small mines in particular, less so the large mines, where investment levels are increasing. Uneven development results from the already highly differentiated nature of the industry and the lack of funds, especially in the small-mine sector. However, investment in engineering solutions is a necessary, yet insufficient condition for success.



***Inadequate training and other manpower aspects:*** At all levels, this means that the people with the right skills are not always available, or not attracted to work in the industry, once they have been through university, as the image of the industry is poor. SAWS and other agencies are involved in extensive training but this remains insufficient. So far, foreign expertise in training is being applied only to a limited degree. Migrant workers, who form around half of the workforce, are trained in large SOE mines but often not at all in small mines. In one mine visited, the migrant workers work on a one-year renewable contract for 8 years. These migrant workers are then free to return to their villages or to work elsewhere in the coal-rich province. The company would like to extend this state/provincial rule to a longer period, as these miners become skilled in their highly mechanised operations.

***Participation:*** This means that the knowledge and skills among the whole work-force is not being exploited to its maximum, especially among experienced miners. This partnership must be constructed as a triangle between the manager (usually deputy manager), who is responsible under the law, the government inspector, and the worker safety representative. Each must be supported by strong organisations – company, government, and trade union. There has been insufficient involvement of worker safety representatives in state-owned mines. In township and village mines, worker safety representatives have not existed until recently (although they are now being appointed to township and some village mines). The overall union role needs to be strengthened. Without the safety triangle operating effectively, there is a temptation for mining engineers among the large mine management at mine- and area level to define problems as engineering ones and fail to see the solutions as organisational as well as technical, which would help to create a strong safety culture. At the best mines, the rather narrow engineering safety culture is so strong alongside high investment in mechanisation that the safety performance compares well with developed countries, but this is not replicated across the SOE sector, let alone the medium-sized and smaller mine sector. As mining industries of developed countries have a sound system of risk management, and have concluded that, for it to work, there must be a bottom-up approach, not merely a top-down one. Ideally, everyone in a mine needs to be trained to the degree needed for daily engagement in risk assessment. This, of course, is a huge task for such a large and diverse group as China's miners. The impact of marketization in the state sector, too, is likely to change the emphasis on the balance between factors in company and mine cost structures, with less expenditure on social and labour-related costs. As has been seen with marketization – both liberalisation and privatisation – in Western coal industries, new pressures have been created on safety performance. The management at large mines have expressed some doubt about the capacity of their operations to continue with relatively high labour costs (40-60%), while at the same time continuing a high capital investment strategy, especially if the present high coal prices were to fall. The new mines being constructed by companies will have much lower manpower levels.

***Pressure for production:*** As a result of high energy-demand and high prices, safety is often sacrificed for the sake of production and profit, especially with the rush to production, which was a major factor in the flooding of the new coking coal mine at Wangjialing in 2010. Fluctuating and high coal prices act as strong incentives for small mines to over-produce. The large SOE mines are caught in a dilemma – whether to invest in production expansion, under central government pressure, with the risk of

being left with surplus capacity and manpower if coal demand and prices should fall. Their present cost structure is as follows. Total costs make up \$40 per tonne, compared to a selling price of \$55 per tonne. This price is only partly determined by the international price, as China is not exporting much coal (this is discouraged by central government) but is importing more, especially as China closed so many small private coking coalmines on safety grounds during a boom in steel production.

**Worker compensation:** The former ‘iron rice bowl’ system is finished and the new arrangements are still under construction. The question of which route to take (public, public/private or private) and how to operate it is, as yet, undecided, with a very uneven situation operating in practice. Consequently, there are great differences in approach between employers, with injured miners and their families left with considerable uncertainties. The standard payment after a fatality by large companies is now around 200,000 yuan or US\$ 35,000.

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# Safety and health in mining in India

## Basic facts about India

Size of area	3,287,000 sq km
Population	1,221 million
Capital	New Dehli
Literacy	61%
GDP per capita (PPP)	US\$ 3,900
Gini index	37
Infant mortality rate	46 deaths before age 1 year/1,000 live births
Median age	27 years
Life expectancy at birth	female: 68 years, male: 66 years

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## 1. Mining activities

### 1.1 Mining and employment

India has a unique blend of big and small, manual and mechanized, opencast and underground mines. 89 minerals are produced out of which 4 are fuels, 11 metallic, 52 non-metallic and 22 minor minerals. India is largely self sufficient in most minerals which include barytes, bauxite, chromite, dolomite, fluorspar, gypsum, iron ore, kyanite, limestone, manganese ore, magnesite and sillimanite. Other important minerals include copper, zinc, oil & gas, uranium, rare earths, etc.<sup>10</sup> In addition, India is considered to have large naturally resources, not yet fully assessed.

The majority of large mining companies are partly or wholly owned by the state or by the central government. The Indian mining industry is characterized by a large number of small operational mines especially of minor minerals which continue to be operated manually either as proprietary or partnership ventures owned by private entrepreneurs and remain the major area of concern for health and safety.

There are 565 working coal mines which provide direct employment to about 370,000 persons. There are 8,268 registered metalliferous mines in the country which provide direct employment to about 157,000 persons. In addition there are thousands of small and seasonal mines which are not included in mine statistics and about which very little information is available. Many of these small mines may be considered as illegal mines. Overall, the average employment in Indian mines is estimated to be about one million persons.<sup>2</sup>

During 2009-10, the Public Sector accounted for 74% of the total value of mineral production. Small mines, The public sector accounted for production of 91% of coal, 86% of crude petroleum, 77% of natural gas, 58% of tin concentrate, 99% of barytes, 84% of kyanite, 74% of sillimanite and 60% of magnesite.<sup>11</sup>

### 1.2 Economic importance

The total value of mineral production (excluding atomic minerals) during 2010-11 has been estimated at 40 Billion US dollars, showing an increase of about 12% over the previous year. Estimated value for fuel minerals accounts for 67%, metallic minerals 21%, and non-metallic minerals including minor minerals 12% of the total value.

The advance estimates of GDP for the year 2010-11 in respect of mining and quarrying sector accounted for 2.5% of GDP, indicating an increase of 18% over the previous year.<sup>11</sup>

## 2. Safety and health

### 2.1 Legislation and rules

Under the Constitution, safety, welfare and health of workers employed in mines are the concern of the central government. Mines are regulated by the Mines Act, 1952 and the rules and regulations framed there under.

Following diseases have been notified as the diseases connected with mining operations;

Pneumoconioses	Silicosis Coal Workers' Pneumoconiosis Asbestosis
Poisoning	Manganese poisoning (nervous type)
Cancers	Cancer of lung, stomach, pleura and peritoneum (due to asbestos dust exposure)
Others	Noise induced hearing loss, contact dermatitis Pathological manifestations due to radium and radioactive substances. <sup>3</sup>

### 2.2 Organisation

The Mines Act, rules and regulations are administered by the Directorate-General of Mines Safety (DGMS), under the Union Ministry of Labour. The directorate has specialist staff officers in mining, electrical and mechanical engineering disciplines and medical doctors in occupational health. The field organisation has a two-tier network of field offices. The country is divided into eight zones, 29 regional offices and 3 sub-regional offices. The directorate at present has 117 inspectors in various disciplines including 91 in mining, 16 in electrical, 7 in mechanical and 3 in occupational health. In view of the inadequate number of inspectors, the government has recently increased the number of sanctioned posts to 269 including 159 in mining, 51 in electrical, 50 in mechanical and 9 in occupational health. The inspectors are required to be graduates in their respective fields with adequate experience.<sup>4</sup>

At mine level, depending on the mineral produced and number of persons employed, the mine is required to appoint Safety Officer, Medical Officer and other competent persons to ensure safe and healthy working conditions. Every person employed in mine is required to undergo initial medical examination at the time of appointment and once every 5 years thereafter. Every mine is also required to conduct survey for airborne respirable dust at every workplace where dust emission is likely at least once every six months.

Workers' Unions or Trade Unions have an important role to play in health and safety in mines as every mine is required to have Safety Committee with workman representative as one of the members. The Mines Act also requires that workman inspector should be appointed for every mine. The Conferences on Safety in Mines, a tripartite national forum, consisting of management, trade unions and government representatives, debates on various current issues

related to health & safety which may not be covered by the statute and makes recommendations which are binding on all stakeholders.

In the context of health and safety, persons employed in mines which are not registered with the health and safety authority are mostly in the unorganized and/or illegal sectors.

### **2.3 Important health and safety issues**

*Dust related diseases;* The dust related diseases, mainly coal worker's pneumoconiosis and silicosis, still remain the most important occupational lung diseases in mine workers. Statistics are available for notified diseases reported to enforcement authorities since 1954 for silicosis and coal workers' pneumoconiosis. Number of cases of notified disease reported to Directorate General of Mines Safety (DGMS) for last decade has varied between 0 in, 2001 & 2009, and 30 in, 2004.<sup>1,5</sup>

It is reasonable to presume that large number of cases of notified diseases go undetected and unreported and the official statistics are not representative of the occurrence of the notified diseases. Survey conducted by Directorate General of Mines Safety in an underground metal mine showed that almost 50% of chest radiographs of workers had pneumoconiotic opacities.<sup>6</sup> In two routine medical examination surveys conducted by National Institute of Miners' Health, (NIMH) in opencast mines in 2005 and 2011, the prevalence of pneumoconiotic opacities in chest radiographs was 5.7%<sup>12</sup> and 5.3%<sup>13</sup>, respectively.

Recently (2011), NIMH evaluated medical records of 101 persons from stone mining area suffering from respiratory disorders, referred to it for opinion, of which 93 had history of work in stone mines. The evaluation of medical records showed that 73 workers had been suffering from silicosis/silico-tuberculosis, of which 16 had silicosis with progressive massive fibrosis (PMF).<sup>10</sup> Though, these studies may not be representative of the entire mining sector, they indicate that occurrence of silicosis in metalliferous mines remains a very important issue.

*Noise induced hearing loss;* The noise level in mining operations such as drilling, crushing, screening, blasting, etc. are far higher than the recommended levels for noise. The surveys conducted by various institutions have shown that noise exposure levels in most mining operations are higher than the recommended limit of 90 dB(A). A survey conducted in an underground metal mine has shown that almost 75% of the mine workers had evidence of noise induced hearing loss.<sup>6</sup>

A recent survey (2011) by NIMH of 682 workers in opencast mines showed that 20-25% had evidence of noise induced hearing loss.<sup>13</sup>

*Vibration hazards;* Introduction of heavy earth moving machines has increased the hazards of whole body vibrations among operators. Long term exposure to whole body vibrations is known to cause backache and other degenerative spinal disorders. The surveys conducted in Indian mines have shown that most Heavy Earth Moving Machinery (HEMM) have vibration

levels higher than recommend-ed ISO standards and persons employed on HEMM are at risk of developing adverse effects.<sup>9</sup> In a recent survey conducted by NIMH in various mines, out of 117 HEMMs, 100% Dozers, 95% Loaders, 90% Dumpers & Tippers, 15% Excavators, and 8% Shovels showed moderate to high health risks to operators due to whole body vibrations. 85% of 48 HEMM operators complained of various musculoskeletal disorders related to back, shoulder, neck and knees.

*Sudden death at work;* There is increasing evidence that the coal miners are at higher risk of developing cardiovascular diseases and chronic low level exposure to carbon monoxide. Irregular episodic physical stress, shift work, etc. may be important contributing factors.

Analysis of cases of sudden death at work by DGMS revealed that more than 80% of deaths are due to cardiovascular causes. The incidence is 3-4 times higher in coal mines and the underground coal mines have incidence 3 times higher than opencast mines. In some coal companies, the incidence is almost 10-15 times higher than others. Prima-facie, it appears that difficult and arduous working conditions are contributing factors in these companies.<sup>7</sup>

*Musculoskeletal disorders;* Musculoskeletal disorders of mine workers such as backache, joint pains, cervical spondylitis, etc have somehow not received due attention in India although they probably contribute to high morbidity and absenteeism. Difficult and ergonomically unsuitable postures and tools in mining are probably responsible for majority of the musculoskeletal disorders.

No systematic epidemiological study is available on prevalence of musculoskeletal disorders, however, empirical evidence suggests that persons employed in under-ground mines have high prevalence of musculoskeletal disorders.

*The safety scenario;* The right to safe working environment in mines has been recognized for more than 100 years in India. Over the years, the legislation has been updated and newer provisions have been incorporated to ensure safe and healthy working conditions in mines.

The incidence of accidents is an important indicator of the status of safety in mines. The accident records in mines have been meticulously maintained over the years since the enactment of Indian Mines Act, 1901. They are available in the library of DGMS.

In Table 1, the ten-yearly average of fatal accidents, fatalities and fatality rates for both coal and non-coal mines are shown for the period from 1901 to 2010.

From the table it is observed that during this long period there has been a constant decline in fatal accident rates in both coal as well as non-coal mining. This has been due to changing technology, mechanization and growth of a safety culture. It is also likely that the fatal accident rates may have been substantially influenced due to acquisition by government of large mining companies in the non-coal sector as public sector undertakings and nationalization of coal mines in 1974. During the last decades, however, there is an increasing trend in the rates of fatal accidents and fatalities in non-coal mines. Deeper mines and mining under

more difficult geotechnical conditions may have been important factors for this increase. Furthermore, increasing number of small mines which do not take adequate safety measures may also be an important contributor.

A further reduction of the accident and fatality rates require improvements in technology and safety culture.

The fatal accidents in the illegal mines are investigated by the police, and not by DGMS. It is very difficult to get reliable statistics, though it may be estimated that the number of fatal accidents and fatalities in such mines are small.



**Table 1.** Number of fatal accidents and persons killed in mining in India; ten-yearly averages, 1901-2010.

Year	Number of fatal accidents	Number of persons killed	Fatal acc rate/1,000 persons employed	Death rate per 1,000 persons employed
<u>Coal mines</u>				
1901-1910	74	92	0.77	0.94
1911-1920	138	176	0.94	1.29
1921-1930	174	219	0.99	1.24
1931-1940	172	228	0.98	1.33
1941-1950	236	273	0.87	1.01
1951-1960	222	295	0.61	0.82
1961-1970	202	260	0.48	0.62
1971-1980	187	264	0.46	0.55
1981-1990	162	185	0.30	0.34
1991-2000	140	170	0.27	0.33
2001-2010	186	107	0.21	0.27
<u>Non-coal mines</u>				
1901-1910	16	23	0.52	0.76
1911-1920	29	37	0.57	0.73
1921-1930	42	50	0.54	0.66
1931-1940	35	43	0.41	0.51
1941-1950	26	31	0.24	0.29
1951-1960	64	81	0.27	0.34
1961-1970	72	85	0.28	0.33
1971-1980	66	74	0.27	0.30
1981-1990	65	73	0.27	0.31
1991-2000	65	77	0.31	0.36
2001-1010	55	65	0.34	0.40

### 3. Current needs

#### **3.1 Prevention and control of pneumoconiosis**

With appropriate national prevention and control programmes, a nodal agency need to conduct surveys and studies in mines for detection of cases of pneumoconiosis and provide reliable estimate. A central registry and database of all cases of pneumoconiosis diagnosed and detected and a referral centre for detection, certification and disability evaluation need to be established with programmes and systems to provide advice and treatment to pneumoconiosis victims and develop strategies for management and rehabilitation.

#### **3.2 Hazard monitoring at workplace in mines**

It is no secret that compliance with the legislative requirements is inadequate for work environment monitoring in most mines. While the mining industry has been negligent, the enforcement agencies due to infrastructural and manpower constraints find it difficult to enforce the monitoring standards and crosscheck compliance with permissible levels. The present system of enforcement needs to be strengthened with adequate technical support services and strict enforcement.

#### **3.3 Noise induced hearing loss and hearing conservation programs**

Though, audiometry is recommended as part of medical examination, no epidemiological surveys have been conducted. There is urgent need for implementation of comprehensive hearing conservation programmes to prevent and control noise induced hearing loss.

#### **3.4 Vibration and assessment of ergonomic risk**

There is need to develop standard protocols for evaluation of vibration levels in HEMMs and determine health risks due to vibrations considering the specific ergonomic requirements of Indian workers.

#### **3.5 Prevention of sudden death at work**

There is a need to conduct epidemiological studies to identify various factors contributing to sudden death at work including difficult and arduous travel and develop prevention strategies including role and management of non-communicable diseases.

### **3.6 Prevention of musculoskeletal disorders**

Epidemiological studies to detect musculoskeletal disorders and develop programmes for education of workers and managers in best practices and management of musculoskeletal disorders to reduce morbidity need to be conducted.

### **3.7 Development of human resources**

The major cause of failure to detect cases of occupational diseases in general and pneumoconiosis in particular, is the poor quality of health surveillance program and training of medical officers in detection of pneumoconiosis in organized sector and lack of health surveillance in unorganized mining sector. There is also strong prejudice in reporting cases of occupational diseases..

There is need to conduct regular training programmes for medical officers on ILO classification for detection of Pneumoconiosis and other occupational diseases and also for mines officials in hazard monitoring to comply with legislation.

### **3.8 Accident prevention and safety**

From the observations, it has been established that the existing traditional system of administration of Mines Act and subordinate legislation framed there under through inspections, statutory and other investigations into fatal accidents and dangerous occurrences and follow up measures arising out of the traditional approaches to ensure that risk is kept within acceptable levels have reached its limit of effectiveness. Time is now ripe to introduce new initiatives and stress upon areas of high risk in order to bring them down to acceptable risk levels. This can be achieved by introducing the concept of "Risk Assessment" and "Safety Management Plans", the concepts widely accepted and practiced in many countries.

An outline of the steps required to be taken to effect necessary changes are given below;

1. Evaluation of organisational structures for effectiveness to achieve set safety objectives.
2. Employee involvement with appropriate training and necessary resources.
3. Change of supervisory role from “doer” to “facilitator”.
4. Search for cost-effective new technology.
5. Development of Safety programs based on "Risk Management" principles.

With respect to current needs in health and safety in mining sector, the resources provided by the mining companies and the government organizations in the form of manpower and equipments are inadequate. However, there is increasing awareness among workers, unions, mine managements and the government about level of occupational safety and health and prevention of accidents and occupational diseases in mines. The government has formulated a National Policy on Occupational Safety & Health and the Mines Act is also being amended

to address the needs of changing mining scenario. However, more resources would be needed on part of the mining companies and the government to ensure that health and safety is given due priorities in mining sector. The 12<sup>th</sup> Five year Plan (2012-2017) of Government of India is laying special emphasis on health which will give boost to outlay for health and safety. The present legislation also needs to cover the mining activities in unorganized sector which employs a large number of persons and remains the major area of concern as health and safety provisions are inadequately implemented.

### **3.9 Summary and conclusions**

India has a unique blend of big and small, manual and mechanized, opencast and underground mines with average employment of about one million persons per day and an annual turnover of over 40 Billion US dollars and contributing to about 2.5% of GDP. The rapidly changing scenario of mining industry in India has introduced newer hazards and safety concerns at workplace posing new challenges to occupational health and safety professionals while the traditional health hazards are yet to be fully controlled. The dust related diseases mainly Coal Worker's Pneumoconiosis and Silicosis still remain the most important occupational lung diseases in mine workers though very few cases are detected and fewer are notified and compensated. The noise and whole body vibrations are emerging as new challenges and prevalence of Noise Induced Hearing Loss (NIHL) could vary up to 25% depending on the nature of mining operations. Also, there is need to have large scale systematic surveys to study factors contributing to sudden death at work and musculoskeletal disorders among mine workers.

The accident scenario and safety experience in Indian mines for more than 100 years show that both fatal accidents and fatalities have come down over the years. However, the death rate per 1000 persons employed in mines has been hovering around 0.30 in coal mines and in non- coal sector after steady decline for some period, the trends of fatal accidents have been again on the rise during 80s and 90s.

The observations indicate that the existing traditional system of administration of occupational safety and health legislation in mines through inspections, statutory and other investigations have reached its limit of effectiveness. An approach based on a combination of "strategic" and "systems" thinking needs to be devised to prepare the mining industry to achieve better safety and health standards for persons employed in mines. The new thinking must embrace organisational, behavioural and cultural systems in addition to hazard control, analysis to anticipate hazards and engineering solutions to prevent accidents and occupational diseases.

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Rachmadhi Purwana

# Safety and health in mining in Indonesia

## Basic facts about Indonesia

Size of area	1,905,000 sq km
Population	251 million
Capital	Jakarta
Literacy	90%
GDP per capita (PPP)	US\$ 5,000
Gini index	37
Infant mortality rate	27 deaths before age 1 year/1,000 live births
Median age	29 years
Life expectancy at birth	female: 74 years, male: 69 years

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# 1. Mining activities

Lying between Asia and Australia and between the Indian and Pacific Oceans, the tropical archipelago of Indonesia consists of 17,500 islands (of which 6,000 are inhabited). The islands bear various potential natural commodities, from agriculture, fishery, forestry, to mining<sup>1</sup>.

## 1.1 Structure and production

The mining industry contributed approximately 8% to the Gross Domestic Products of Indonesia, in 2012<sup>2</sup>, oil and gas being the main contributors. Other important mining products include coal, tin, nickel, gold, bauxite, silver, and copper. Projected from 2010, the mining industry is expected to grow by 11 per cent in 2015. With this promising situation, it is understandable that mining industries in Indonesia attract foreign as well as national investments, capital, and modern technology<sup>3,4,5</sup>.

The copper mining, as well as gold and silver mining, is dominated by Freeport Indonesia and Newmont Nusa Tenggara. Both are joint capital companies with owners from USA. They have their mining activities mostly in the eastern part of the country. For many years, Freeport has been one of the largest taxpayers to the Indonesian government.

Indonesia is the second largest coal exporting country in the world<sup>7</sup>. Adaro Energy is the largest coal mining company in Indonesia, the largest single-site coal producer in the southern hemisphere and the fourth largest in the world. Adaro Energy produced 42 million tons of coal in 2010, mostly in the central part and in Borneo. Bukit Asam is a state owned company, carrying out coal mining activities mostly in Sumatra, and produced 13 million tons coal in 2010. There are other coal mining companies that operate mostly in the Sumatra and Borneo islands, and there are also traditional, informal mining activities run by individual citizens<sup>6</sup>. Indonesia is the second biggest tin producer in the world (China is first)<sup>7</sup>. The state owned PT Timah is the largest tin producer in Indonesia, mostly operating in the Sumatra island.

Indonesia is the second biggest nickel producer in the world (after Russia)<sup>7</sup>. Most of the production is carried out in the Sulawesi island by PT Inco. The company was originally state owned but has recently become a subsidiary of Vale (under the name of PT Vale Indonesia), one of the world's biggest mining companies. Despite the extensive capital and technology flow into the country, manpower is still a major factor for the operation of the mining industry machinery. In 2004, of all registered workers in the country, 774,000 workers (0.9 per cent) were employed at mining and quarrying<sup>8</sup>. In mid-2011, the figure increased to 1,465,000 workers (1.4 per cent of the total of 109,670,000 workers enrolled in the country)<sup>9</sup>. Significant numbers of miners work in very remote and harsh areas, where safety and health require special considerations.

Reports in 2010 revealed that 54 per cent of the population lived below a decent standard of living, with an income of less than 2 US Dollar per day. With back-grounds of a low level of education and skills, many people became a target for exploitative business practices

such as the artisanal and small-scale gold mining<sup>15</sup>. When an area is known to have a potential mining material such as gold, flocks of migrated and local people – later called ‘artisanal and small-scale miners’ or ‘illegal miners’ – invade the area and do the mining activities with all the simple technologies they have to hand. They are categorized as workers in the informal economy. In 2010, around 900 small-scale gold mining sites were reported with this label. These sites were run illegally by around 250,000 miners including women and children<sup>23</sup>. No up-dated record can be completed on the total numbers of this type of miners in Indonesia, because they also include seasonal workers who depend on harvest time in their farmyards and leave the mining activities when harvesting is due. In 1999, ILO estimated that approximately 77,000 small-scale mines existed in Indonesia, comprising 300,000 to 500,000 miners, including women and children<sup>32</sup>.

## **1.2 Conflicts and disasters**

The Indonesian mining industries have faced great problems from time to time. The Ertsberg mine, owned by Freeport, was a big copper and gold mine in Papua, New Guinea. It was opened in 1973. In 1977, the separatist group Free Papua Movement attacked the main slurry pipe and the mine facilities. The Indonesian military reacted harshly, killing at least 800 people<sup>10</sup>. In the end of the 1980s, Freeport-McMoRan established the Grasberg mine, 3 km from the Ertsberg mine. The Grasberg mine is now one of the largest gold mines in the world, as well as one of the largest copper mines. It was often a source of friction due to the environmental impacts of the mine, the perceived low share of profits going to local Papuans, and the questioned legality of payments made to Indonesian security forces for guarding the site<sup>11</sup>. In 2004, after seven years of mining, the Newmont Mining Corporation closed down its gold mine in Northern Sulawesi. It was claimed that the dumping of highly toxic mine wastes had caused the death of 30 villagers due to a severe form of mercury poisoning. This claim was inspired by the sad experience of the Minamata mercury pollution victims in Japan in the mid 20<sup>th</sup> century. Newmont and its chief executive in Indonesia went on trial charged by the Indonesian government. The company denied any wrongdoing and referred to the fact that mercury is used by thousands of illegal gold miners in the area anyway. The civil suit filed by the government was settled by Newmont, who paid 30 Million USD<sup>12</sup>.

The East Java Province is an important concession area for mineral exploration. In 2006, the Sidoarjo mud flow was a major disaster for the general population living nearby. Hot mud, water and gases suddenly erupted and displaced tens of thousands of residents and destroyed large parts of the local infrastructure. A number of people lost their lives when a gas pipe ruptured and exploded as a result of the mudflow. An ever-widening social disaster was created<sup>16</sup>. The triggering of the mudflow has caused controversies and no final conclusion has been reached; geologists have asserted that the mudflow was caused by oil and gas drilling operations misconducted by Lapindo Brantas Inc., while company officials state that the mudflow was caused by a distant earthquake<sup>17,18</sup>.



## 2. Safety and Health

### 2.1 Policy and legislation

Two ILO conventions related to occupational safety and health have been ratified by Indonesia: No. 045 on Underground Work (Women) of 1950, and No. 120 on Hygiene of 1969.

Ordinarily, mining industry is managed by the Government issuing concessions and authorization to run mining activities in selected areas. These mining industries have made effective investments from outside the country as well as home financing sources, and run mining activities under several rules and regulation applied by the Government.

Under the Law No. 40 on National Social Security System, 2004 and the Law No 24 on Social Security Provider, 2011, in general all registered workers in Indonesia are safeguarded by the *BPJS* (*Badan Penyelenggara Jaminan Sosial Tenaga Kerja*, Employment Social Security Provider) for employment and health matters<sup>19</sup>. With regard to mining, there are at least 17 rules and regulations documents recorded in relation to mining activities in Indonesia<sup>20</sup>. Among those, there are documents of guidelines, Ministerial Decree, and Laws dealing with Safety and Health for workers in mining. One of the Ministerial Decrees on Safety and Health for the miners is *Kepmen*<sup>21</sup>. Public safety is also covered in the latest law on mining i.e. Law of the Republic Indonesia Number 4 of 2009, concerning Mineral and Coal Mining Chapter XIX<sup>22</sup>.

It should be noted that occupational safety and health regulations are also included in laws such as the Health Act, as well as regulations related to mining (and other sectors) under the jurisdiction of Government agencies such as the Department of Mining and Energy, which is responsible for mining inspection<sup>8</sup>.

The control of occupational safety and health in mining is hardly effective. Indonesia faces problems with enforcement of occupational safety and health: few competent inspectors, limited resources to conduct adequate number of inspections, and limited follow-up inspections after the citations or violations. Inspections focus mainly on the formal sector. Governors together with other local authorities should supervise mining operational safety, and occupational health and safety of the miners. The public has the right to claim damages related to mining. However, a claim means entering a myriad of laws and regulation articles that mostly give no benefits to the claimant.

### 2.2 National statistics

The statistics of occupational accidents in Indonesia is compiled based on accidents reported by the companies to the Department of Manpower and Transmigration, and the data based

on Workers Compensation Insurance. It has not been possible to find any such data on occupational accidents for the last ten-year period. No specific data on occupational diseases in mining seem to exist.

### **2.3 Accidents and diseases in mining companies**

It is worth considering, that a greater part of mining activity is usually done in forests or jungles and areas where people are scarce. Hence, destruction of areas of natural forest and the immediate mining areas are inevitable. Furthermore, silt dumping destroys rivers, leading to flooding and alterations in the habitat for the fauna and flora of the sites. Underground mining is especially dangerous for the miners; they often die in tunnel collapses, gas explosions, fires, floods, and elevator failures. Moreover, both underground and surface miners suffer from lung diseases due to many years exposure to coal or other mineral dust<sup>8</sup>.

Mining activities are categorized as a hazardous occupation and industry. Work accidents in the mining industries from 1996 to 1999 ranged from 4,429 to 14,487 cases<sup>8</sup>. These numbers applied to registered mine workers and did not represent the unrecorded numbers of accidents or deaths among the illegal small-scale miners. The reason for the great differences between the lowest and highest figures during such a short period may have to do with the non-standardized reporting and registration of data, expansion of mining industries, etc. Some accidents and deaths might be under reported. For example, the official police reports of 44 deaths in a Bangka Island tin mine in 2011 did not match a claimed actual number of dead around 100 to 150 deaths every year reported by activists<sup>24</sup>.

The distance between the mining areas and places where the public reside is to some extent regarded as a natural barrier for a direct transmission of diseases from the mining areas to the distant living areas of people not involved with the mining activities. In the past, taking this situation for granted, public health impacts from the mining activities on the general communities were mostly considered negligible. Public health impacts of mining activities were perceived more as attributable to persons working in the mining area and categorized as occupational accidents and diseases. Later on, with the enforcement of the Law Number 4 of 2009 on mining, public rights have been more accommodated.

Accidents and diseases in the vicinity around the mining areas cannot be completely separated from mining activities in the mining area. Some accidents and diseases outside the mining area might also be attributed to mining activities. For example, problems emerge when mining products are hauled to different places. Reports on increase of Acute Respiratory Infections Rates are related to the transfer of coal or due coal dust polluting places around and in the coal mining area. A report based on a survey in 2006 revealed the high concentration of coal dust of 2.19 mg/m<sup>3</sup> around the vicinity of a coal mining area in Kalimantan<sup>25</sup>. In 2007, an increase of 9 per cent of respiratory tract diseases from the previous year was also reported from Kutai Barat District, Kalimantan Timur Province near a coal mining area<sup>26</sup>.

## 2.4 Diseases in artisanal gold mining

The small-scale miners usually live in different conditions than those of the officially registered miners. Provision for basic sanitation is limited along with compromised food quality and quantity. Records on their safety and health are not at hand other than from limited sporadic research reports. In Galangan and Talawaan (Kalimantan Island) for instance, the small-scale gold miners live with water supply from rainwater accumulated in abandoned mining craters or dug-wells<sup>27</sup>. The multipurpose uses of these man-made craters raise the risk for transmission of infectious disease among the miners and their family. This is also the place where the use of mercury is uncontrolled. To make the situation worse, Kalimantan is also an endemic place for malaria. Craters after mining are left abandoned, regardless the enforcement of Governmental Decree No. 78, 2010 on Reclamation and Post Mining<sup>28</sup>.

Today, artisanal small-scale gold mining is by far the greatest cause of mercury emissions in Indonesia, in Kalimantan and Sulawesi as well as other islands, including Java<sup>13,14</sup>. The way in which the miners use mercury to extract gold from the ore results in heavy mercury pollution of the air, water, and sediment around the mining sites. A recent report revealed that approximately 280 tons of mercury (related to artisanal gold mining) was imported illegally to Indonesia in 2010 and the figure doubled in 2011<sup>31</sup>. Rivers or creeks from the mining areas might carry mercury-loaded wastes flowing into villages downstream of the mining area. In Kalimantan, surveys have shown significant pollutions of mercury in rivers and fish away from the gold-mining area. Mercury concentration in various parts of the Barito and Kapuas Rivers in Kalimantan ranged from the lowest 0.55 µg/liter to the highest 7.03 µg/liter in 2008<sup>29</sup>. This is one among many examples of potential threats to public health far beyond the mining areas.

## 3. Current needs

Understanding the urgency of safety and health issue in the mining arena, risk control is indispensable for the benefit of the mining organization, the mineworkers, and the local populace. For the authorized mining companies, risk control programs depend on the availability of all resources owned by the mining companies. Human resources, financial institutions, and choice of equipment and systems should be coordinated to improve the safety and health of workers as well as the inhabitants around the mining area. Although many mining companies have reported their compliance to the current set of rules and regulations of mining, enforcement of the existing law has still left many unsolved problems in the safety and health of mining activities.

Companies should coordinate to integrate Risk Assessment and Risk Management steps. Furthermore, under the control of dedicated authorities, the organization should observe steps of this integration beginning with Defining Risk, Identifying Resource, Assessing and Valuing Risks, followed by Developing Risk Reduction and Avoidance Alternatives, Prioritizing Opportunity, Implementing of Selected Program and Evaluation of the Results<sup>30</sup>.

At this point, perhaps the most important step is to increase the value of the human resource put at risk. Many potential hazards should be considered, including the risks of fire, blast, land-slide, toxic gases, extreme temperatures, etc. All are potential hazards for human life.

Due consideration should also be given to the situation of private small-scale miners. There is actually a labyrinth of predicaments in social, economic, educational, health, and environmental degradation. The problems should be addressed by various ministries. One important initiative has been taken by the Ministries of Environment, and Energy and Mineral Resources: to develop national action plans for the abatement and/or abandonment of the use of mercury in small-scale gold mining.

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## Safety and health in mining in I.R.Iran

### Basic facts about the Islamic Republic of Iran

Size of area	1,648,000 sq km
Population	80 million
Capital	Tehran
Literacy	77%
GDP per capita (PPP)	US\$ 13,100
Gini index	45
Infant mortality rate	41 deaths before age 1 year/1,000 live births
Median age	27 years
Life expectancy at birth	female: 72 years, male: 69 years

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## 1. Mining activities

Iran is rich in natural resources and the economy is dominated by oil and natural gas production and export. The most important mines in Iran include coal, metallic minerals, sand and gravel, chemical minerals and salt. In 2010, almost 6,000 mines were exploited in 30 provinces. The Khorasan provinces have most of the operating mines in the country. The majority of the mines are small-scale operations with private owners. Most of the bigger mining operations belong to the government.

Mining in Iran is under-developed and under development. Yet the country is ranked among the 15 major mineral rich countries, with some 68 types of mineral, and has 37 billion tons of proven reserves and more than 57 billion tons of potential reservoirs. Large deposits include zinc (the world's largest), copper (the world's second largest), iron, uranium and lead. In total, Iran has more than 7% of the world's total mineral reserves.

The Ministry of Industries and Mines of Iran is the sole authority responsible for issuing licenses for conducting exploration and exploitation of mines. The current Legal Act on mines is from 1998. By virtue of this law, the mines fall into four categories:

*a) Class I mines:*

1. Limestone
2. Gypsum
3. Salt
4. Sand
5. Gravel, etc

*b) Class II mines:*

1. Iron, gold, chrome, lead, zinc, copper and other metals
2. Nitrates, phosphates, sulphides, carbonates
3. Graphite, mica, feldspar, bauxite, etc.
4. Precious and semi-precious stones
5. Ornamental stones
6. Various types of coal and non-oil shale
7. Mineral resources extracted from water, and mineral gases except hydrocarbons

*c) Class III mines:*

1. Crude oil,
2. Natural gas, etc.

*d) Class IV mines:*

1. Radioactive and radiant substances.

Private sector and cooperatives are permitted to excavate Class I and II mines, but exploitation of Class III and IV mines is restricted to operations run by the government.

Iranian Mines & Mining Industries Development & Renovation Organization (IMIDRO) is a major holding company that comprises eight major state-owned companies and 55 operational subsidiaries active in steel, aluminium, copper, cement and mineral exploitation fields. In 2002, IMIDRO and its subsidiaries had 50,000 employees.

The main annual mining production in Iran is summarized in Table 1.

**Table 1.** Iran’s main mining production.

	Annual production, million tonnes	World rank	Source
Aluminium	0.5	17 <sup>th</sup>	List of countries by aluminium producers, 2006
Aluminium oxide	0.1	26 <sup>th</sup>	British Geological Survey, 2006
Bauxite	0.5	10 <sup>th</sup>	US Geological Survey, 2008
Coal	1.7	43 <sup>th</sup>	US energy information administration, 2009
Copper	0.2	12 <sup>th</sup>	British Geological Survey, 2006
Cement	74	3 <sup>th</sup>	List of countries by cement producers, 2010
Iron ore	35	9 <sup>th</sup>	British Geological Survey, 2006
Iron	33	8 <sup>th</sup>	US Geological Survey, 2009
Steel	11	16 <sup>th</sup>	World Steel Association Geological Survey, 2009
Lead	0.02	16 <sup>th</sup>	US Geological Survey, 2007
Manganese	0.1	12 <sup>th</sup>	British Geological Survey, 2006
Perlite	0.03	10 <sup>th</sup>	British Geological Survey, 2006
Silver	0.1	19 <sup>th</sup>	The Silver Institute, 2008
Strontium	0.01	5 <sup>th</sup>	British Geological Survey, 2007
Turquoise	No data available	1 <sup>st</sup>	US Geological Survey, 2002
Zinc	0.2	14 <sup>th</sup>	US Geological Survey, 2006

The total value of mineral output in 1998 reached IRR 2,695 billion (equivalent to 2.2 billion US dollars) including revenues from the major contributors iron ore, coal and ornamental stones of IRR 495 billion, 494 billion and 441 billion, respectively. Based on the report from the Ministry of Industries and Mines in 2009 – 2010, the mining sector export revenues reached \$8 billion, accounting for 32% of the country’s non-oil exports.

However, mineral production contributes only 0.6% to the country’s GDP. If other mining-related industries are added then this figure increases to just 4% (2005). The reasons for this include lack of suitable infrastructure, legal barriers, exploration difficulties, inadequate investments, government control over all resources, and low private sector involvement and investments in mining.

Data from the Iran Statistical Center in 1998 indicate that 52,732 persons at that time were engaged in operational mines, of which 31% were unskilled labour, 27% were skilled, 3% technicians, 3% engineers and 36% engaged in administrative and transportation services. With increasing investments in the mining sector in Iran during the last decade, more than 100,000 people are currently engaged in direct mining activities. A total of 75% are engaged in the extraction of minerals, and 25% in the extraction of oil and natural gas. Considering other businesses related to the mining (exploration activities, exploitation activities, machinery, processing, construction, and business of finish product), as a whole, some



500,000 people are employed in the mine sector. Most of the employees are Iranian males. A few women work in administration. Some immigrants are active in mining, usually in small-scale mines. Child labour is not common in mining.

Of the different kinds of mines, the majority of the workforce is involved in mining coal, sand, gravel and ornamental stones. Of 2,436 operational mines, some 1,498 mines employ fewer than 10 persons each, 851 mining pits engaged 10-20 persons each, and 87 mines employed more than 50 persons.

## 2. Safety and health

### 2.1 Policy and legislation

The Labour Law of 1990 covers the rules of employment in Iran. One chapter is devoted to health and safety at the workplace, including annual occupational exposure and risk evaluation, and medical examinations of workers at risk. The law regulates the labour market in general, and does not include any parts specifically related to the mining sector<sup>17</sup>.

Iran is a member of the International Labour Organisation (ILO) and takes the ILO conventions and recommendations on occupational safety and health into consideration, but has not yet ratified any such convention.

The 1990 Labour Law is pro-labour, but amendments have been made in the direction of promanagement and a new law is under consideration<sup>17</sup>. Temporary employment contracts have been allowed, and companies with five or fewer workers have been exempted from some of its provisions. According to the Labour Law, employers in the mining sector should address health and safety issues. Three organizations, including the Ministry of Health, Ministry of Labour and the national insurance organization, inspect the level of health and safety depending on their responsibilities.

### 2.2 Organization

The following governmental bodies are responsible for occupational health and safety of all workers, including mine workers:

The Ministry of Labour and Social Affairs, MLSA, and its Occupational Safety Inspection Department, responsible for occupational safety policy and inspections.

The Ministry of Health and Medical Education, MHME, and its General Department of Environmental and Occupational Health, responsible for occupational health policy and inspection of workers' health.

The Social Security Organization, SSO, and its Occupational Medicine Office and Health

Services, responsible for social insurance and compensation issues.

IMIDRO has a special department for Environmental, Health and Safety Management, which has as one of its activities the provision of health and safety services for IMIDRO's companies, as well as registering occupational accidents.

In mines and factories with more than 500 employees, the employers should establish an occupational health centre. This centre usually has a team comprising an occupational medicine specialist or trained general physician in the field of occupational medicine, an occupational hygienist and a safety expert. The team provides occupational health services to the workers with the assistance of other experts. For the time being, however, the main focus of these centres is curative services, and the attention that is paid to preventive activities is insufficient<sup>16</sup>.

In small-scale enterprises, occupational health services are supposed to be integrated with the network of primary health care (PHC). The PHC has a good coverage in the whole country, especially in the rural areas. Due to lack of competence related to occupational safety and health it may be questioned if the PHC really can contribute to the prevention of occupational accidents and diseases<sup>16</sup>.

### **2.3 Occupational accidents**

There are major deficiencies in the current national reporting system of occupational accidents and diseases, including under-reporting, lack of coverage of self-employed workers, lack of data on workers not covered by national social insurance, and inadequate data standards.

Accidents are the second leading cause of death in Iran<sup>12</sup>. One report from the National Social Insurance Organization included 14,114 occupational accidents with 268 fatalities among insured people in 2001<sup>15</sup>. Of these, 641 were in the mining sector<sup>14</sup>.

The pattern of occupational accidents was studied among all insured workers in Iran who had an occupational accident between 2001 and 2005 based on inspection reports<sup>14</sup>. Data were analysed for 86,437 injured victims including 85,279 males (99%) and 1,161 females (1%). On average, 4% of the annual work-related injuries happened in the mining sector<sup>14</sup>. Mine workers represent 0.4 % of the Iranian labour force.

The most valuable data concerning mine-related injuries were collected in the IMIDRO system for registration of occupational accidents and trauma among miners. Based on the IMIDRO statistics from January 2003 to September 2008, there were 22,359 cases of injuries during these 69 months, 15,000 were categorized as mild and 7,000 as moderate to severe. All injured were male with a mean age of 37 years, and with a low educational level (54%).

The fatal work-related mine injuries were relatively stable in IMIDRO from 2003 to 2008; the number of workers who died each year ranged from 22 to 28, and the overall annual rate

of death was 24 per 100,000 miner population. There is no previous data for death rates in Iranian miners to compare to. Machine-related injuries and falls were the main leading causes of death as can be seen in Table 2.

**Table 2.** Etiology of work related deaths in miners, according to IMIDRO statistics.

Cause	Frequency
Machine crashing	41 (29%)
Falling down	31 (22%)
Explosion	13 (10%)
Destruction of the mine	11 (8%)
Fallen things crashing	11 (8%)
Trapped between two hard things	10 (7%)
Thermal shock	8 (5.5%)
Electrical shock	7 (5%)
Gas intoxication	6 (4.5%)
Others	1 (1%)

## 2.4 Occupational diseases

The most frequently reported occupational diseases in industry and mining are musculoskeletal disorders, lung disorders and noise-induced hearing loss. The relationship between mining and lung diseases has been documented for many years. Although mine workers are exposed to multiple air born particles, exposure to silica remains the major occupational health problem even after the individual has stopped working in the mine<sup>18</sup>. In one retrospective study in Iran<sup>2</sup>, all biopsy specimens with pathologic diagnosis of silicosis during 2000 – 2009 were reviewed. Among 25 biopsyproven cases, 80% were males and 20% females. Among these, 32% were sandblasters, 20% mine workers, 8% ceramicists, and 4% glass makers<sup>2</sup>.

Currently, silica exposure in stone-cutter workshops and factories is a major cause of occupational exposure for workers in Iran. However, there are fewer health and safety inspections since they are distributed in all parts of the country and most of them are small-scale workshops. In one study in Iran, more than 10 % of workers still active in stone-cutter factories with 5 years of working experience had silicosis<sup>3</sup>.

Due to the increased number of workers exposed to silica, in 2007 the MHME started a “Prevention and Control of Silicosis” programme, in collaboration with the World Health Organization (WHO)<sup>16</sup>. According to this programme, all high risk groups of workers and workshops should receive four different services, including increasing their knowledge about health effects of exposure to silica, minimizing the exposure through engineering interventions, provision of protective devices, and early detection of the problem. Occupational hygienists and doctors are trained in this programme to be able to detect exposure and provide medical examination for early detection of health effects caused by exposure to silica. Based on this intervention, the number of acute silicosis cases has been reduced and the workers in exposed workshops have received a better hygienic situation.

### 3. Current needs

In spite of having rich mineral deposits, Iran's mining industry remains underdeveloped. Nevertheless, the Iranian government is giving top priority to the development of the mineral industry and also encourages foreign participation. The mining environment still has a high risk for accidents and diseases compared to most other workplaces, and both employers and employees should be fully aware of that. The expected development also needs to include improvements in the safety culture. One of the most important issues for the promotion of safety and health in mining work is to make proper risk assessments. According to regulations, this is the duty of the health and safety officer in each mine. Their activities should be supervised by inspectors from the ministries of health and labour. It seems, however, that both the officers and the inspectors lack up-to-date knowledge and other tools for these assessments.

Iran's health and safety regulations are quite good but the most challenging situation is that responsibilities are divided between three authorities that do not cooperate sufficiently to ensure a safe and healthy environment in the mine sector. Three groups of inspectors inspect the mines: Ministry of Health inspectors for the health situation, Ministry of Labour inspectors for the safety situation, and national social security inspectors for the insurance of miners. They perform regular inspections of the mining industry, but unfortunately there is little communication between them. Most experts believe that, with efficient cooperation between these three national authorities, it would be possible to improve the conditions for safety and health in the mines.

One important and neglected issue is the lack of proper investments in health and safety in Iranian mining. First of all, the safety culture in mine activities is a neglected issue and it needs serious action. Education in how to work in a safe manner will help workers to do their job with less risk, but safe tools and safe instructions are also important parts of the safety culture. While there are quite acceptable investments in this field in large-scale mines, they are still not meeting the international standards. In medium-scale mines, the health and safety situation is not acceptable and the situation is even worse in small-scale mines. Fortunately, governmental bodies have passed regulations that ensure that some of the health and safety investments - under certain conditions and with approval from the Ministry of Health - can be considered as tax payment for employers. However, this is a more appropriate solution for large- and medium-scale mines. It seems that special health and safety programmes for small-scale mines, with attractive incentives for employers of a similar kind, will be demanded.

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# Safety and health in mining in Poland

## Basic facts about Poland

Size of area	313,000 sq km
Population	38 million
Capital	Warsaw
Literacy	100%
GDP per capita (PPP)	US\$ 21,000
Gini index	34
Infant mortality rate	6 deaths before age 1 year/1,000 live births
Median age	39 years
Life expectancy at birth	female: 80 years, male: 72 years

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# 1. Mining activities

## 1.1 Structure and employment

In Poland, 320 large companies extract basic minerals in underground, open-pit and hole-mining operations. In addition, 5,859 companies extract so-called common minerals, e.g. gravel, sand and clay. In Table 1, a summary is given of the structure and employment in mineral mining.

**Table 1.** Mining structure and employment in Poland, 2011. Oil and gas extraction not included. Source: The State Mining Authority.

Mining companies	Workers employed	Extracting
42 underground mining companies;		
32 hard coal mines	111,032	75,515 thousand tons
3 copper ore mines	12,590	31,241
2 zinc and lead ore mines	1,150	2,463
1 salt mine	887	1,255
2 ceramic clay mines	---	15
2 plaster and anhydrite mines,	263	192
	125,922	110,681 thousand tons
101 open-pit mining companies;		
12 brown coal mines	12,782	63 million tons
89 companies extracting rock and clay minerals, moulding and glass-making sand	2,865	120
	15,647	183 million tons
4 hole-mining companies;		
2 hole salt mines	94	2,714 thousand tons
2 sulphur mines	305	668
	399	3,382 thousand tons

Apart from the companies mentioned in Table 1, there are also underground-mining companies extracting medical water and brines, methane from coal deposits, an underground gas store, and an underground waste dump.

A total of 1,680 service companies operate within the mining companies, employing 38,578 workers. In total, the Polish mining industry employs 210,310 workers. Of these, 73% are employed in underground mines, the great majority in coal mines. The employees in mining are almost entirely Polish citizens; there is no information on employment of foreigners. Only men are employed at underground workplaces. Hard-coal mining, brown coal mining and copper mining have the best development prospects. The hard-coal resources are substantial and allow for a stable and longstanding



extraction. The reserves for 2010 totalled 45,144 million tonnes. Energy coals represent almost  $\frac{3}{4}$  of the resources and coke coals represent about  $\frac{1}{4}$ , and the share of other types of coals is negligible. The production of the exploited coal deposits was 16,852 million tonnes, accounting for 37 % of the total anticipated production.<sup>5</sup> Anticipated coal reserves in Upper-Silesian basin, estimated to a depth of 1,000 meters, amount to 34 billion tons, and industrial resources amount to 6.8 billion tons<sup>6</sup> At this depth, there are deposits of both power and coking coal that are 1.5 meters thick. Brown coal extraction is carried out in 12 open-pit mines situated in different regions of Poland. The average thickness of brown coal deposits varies from 6.5 to 55 meters; extracted and new resources nearby Lubin ensure long-standing and stable extraction.

Copper ores are mined in the Legnicko-Głogowski Copper Region. The industrial cupriferous series appears at depths between 600 and 1,400 metres, and is generally extracted deeper than 1,000 metres. Other metals, such as silver, gold, platinum, rhenium and lead, are also recovered from copper ores.

The prospects for extracting zinc and lead ores are limited. The output is on the decrease. In contrast, rock-salt deposits in Poland are substantial and ensure a stable output. Salt mining involved extracting salt domes in central Poland. Poland also has potassium salt deposits, but they are not extracted. This is also true for rich poly-metallic deposits of iron ores located at depths of over 3,000 metres in the western and eastern regions.

## **1.2 The importance of mining for the Polish economy**

Mining played and still plays an important role in the Polish national economy. In Poland, the share of gross value added of industry in GDP (constant prices) was 33% in 1993 and decreased to 21% in 2010. The category "Mining and quarrying", which includes the coal industry, contributed 2% of the GDP in 2003 and is still relatively high.<sup>2</sup> Poland is an important copper and silver producer in the world. Coal and lignite are key strategic fuels for power generation in Poland.

In 1972, Poland was Europe's biggest coal producer, with an annual output of 150.7 million tonnes. By 1979, it was the second largest coal exporter in the world, after the USA. The role of Poland as an exporting country started to decline in the 1980s, but output was maintained at a significant level (193 million tonnes in 1988) compared with other European countries. By 2002, production had fallen to 102.1 million tonnes.<sup>8</sup> Currently, Poland is the largest producer of hard coal in the European Union. In 2010, hard coal production amounted to 76 million tons. Poland exports over 10 million tons of hard coal annually. This mostly involves power coal, which makes about 86% of all Polish coal transported to the Union markets. Hard coal production makes up over 50% of the Union production, with power coal making about 59% and coking coal about 39%. Poland is, after Germany, the second producer of coking coal in the European Union.

Coal is a dominant fuel for electrical energy production in Poland, generating 95% of the total production. The price of electrical energy produced from coal is one of the lowest in

comparison to the energy produced from other sources. There are large reserves of hard coal: about 16,000 million tons of anticipated economic resources and over 11,000 million tons of sub-economic resources in active mines. The aim of the state policy with regards to the hard coal mining sector is to ensure the rational and effective management of coal deposits lying on the territory of Poland, thus securing energy safety and maintaining competitiveness of Polish coal within the free-market economy.

### **1.3 Ownership**

The majority of large mining plants extracting fundamental materials belong to joint-stock companies of the State Treasury. One of these companies extracting coking coal, Jastrzębska Mining Company, has undergone privatization and is listed on the stock market. Among 32 large mines, two are private mines. Small mining plants extracting common minerals are privately owned.

### **1.4 Trade unions**

Many trade unions are active in the Polish mines. Those with the highest membership are: NSZZ Solidarność, Polish Miners' Union and the Trade Union of Mining Inspectors 'Kadra'. The degree of unionization in the whole mining industry is 67%. Trade unions represent the miners concerning social protection and occupational safety. Social Labour Inspectors (SIP) are elected by workers in many mining plants. They are independent, unassisted representatives of mining crews in matters of safety and work protection. They are supervised by the National Labour Inspectorate, which works under the Polish Parliament.

### **1.5 Supervision and control**

All mining enterprises in Poland, large and small, state and private, are supervised and controlled by the State Mining Authority and regional mining authorities. The range of supervision and control is defined by the Act on Geological and Mining Law. It comprises:

- occupational safety and hygiene as well as fire safety,
- mining rescue service,
- management of deposits in the process of extraction,
- management of deposits during extraction,
- environmental protection,
- building, closing and decommissioning mining plants,
- rehabilitation and management of land after a mining activity.

## 1.6 Training and research

Poland has considerable resources for research and training in relation to mining, including the improvement of occupational safety and hygiene. Institutions with courses of study in mining and geology include the Silesian University of Technology in Gliwice, the University of Science and Technology in Cracow and Wrocław University of Technology. At the Silesian University there is a training programme on Safety Engineering with specializations including Technology and Organization of Occupational Safety and Hygiene, and Protection Engineering and Crisis Management. There are also scientific centres that conduct research in the field of mining safety. The Central Mining Institute in Katowice plays a leading role in this, together with the Experimental Mine 'Barbara' in Mikołów. There are standards for qualifications in training in mining-related fields, including occupational safety and hygiene. Those engaged in occupational safety and hygiene services in mining plants and service companies must graduate from a technical college, or have studied at a higher level with occupational safety and hygiene as a specialization. Persons having a diploma in another field are required to undergo post-graduate studies with occupational safety and hygiene as a specialization. Moreover, there are periodic courses aimed at all workers in mining enterprises.

## 2. Safety and health

Mining, especially underground, is one of the Polish economy sectors with most occupational diseases and accidents, especially fatal accidents. The hazards of underground mines include bumps (seismic jolts), methane, gas and rock bursts, coal dust explosions, water, radiation risks, roof falls, and rock falls from roofs and side walls. The most serious hazard is methane, mostly in hard coal mining. Between 2000 and 2009, there were 24 methane fires or explosions, which caused altogether 203 accidents (59 fatal, 51 serious and 93 'light' ones). Methane explosions are often connected with coal dust explosions. A total of 69 miners died as a result of methane and coal dust explosions between 2000 and 2009. Bumps hazards exist in 22 hard coal mines and 3 copper ore mines. Between 2000 and 2009 there were 33 bumps in hard coal mines, which caused 145 accidents, of which 12 were fatal. In the same period in copper ore mines there were 48 bumps, causing 136 accidents, of which 18 were fatal. Altogether 49 miners died as a result of roof falls, rock falls from roofs and side-walls in underground mines in this period.

Underground mines in Poland are generally modern and mechanized. The usage of technical devices may give rise to hazards as a result of energy-mechanical, thermal factors and vibrations as well as occupational noise. Between 2000 and 2009 there were 70 fatal accidents caused by energy and mechanical factors. Those accidents occurred on carrier routes (27), underground railway routes (19), or as a result of electric shock (15) near mining machines.

In total there were 311 fatal accidents in underground and open-pit mining between 2000 and 2009. In 2010 alone, there were 3,342 accidents in basic minerals mining, including 24 fatal and 31 serious ones.<sup>1</sup> In summary, the reasons were:

- bumps,
- the presence of workers in forbidden places during transport,
- lack of safety devices while switching on and off conveyors during their movement,
- underground railway transport not in conformity with regulations,
- crossing the conveyor during its movement,
- execution of shot work not conforming with its organization and rules,
- rock falls from roofs and side walls,
- work at height with no safety equipment,
- lack of eye protection.<sup>7</sup>

The accident rate analysis (the frequency of accidents, expressed per one million tons output and per 1000 employed workers) shows that during the period 2004 - 2011 there was no clear increase or decrease in the rate of fatal accidents in reference either to the production level or the number of employees, Table 1.<sup>3,7</sup>

**Table 2.** The accident rates in underground hard coal mining, 2004-2011.

Source: The State Mining Authority, WUG.

	2004	2005	2006	2007	2008	2009	2010	2011
Frequency of fatal accidents per one million tons output	0.10	0.15	0.48	0.18	0.30	0.46	0.20	0.26
Frequency of accidents per 1,000 employed workers	15.5	14.9	16.3	18.4	19.5	20.5	19.4	17.3

Most of the occupational diseases in Polish mining tended to decrease during the period 2001-2010, Table 3. Pneumoconiosis is an important exception: the rate was more or less constant during the period and even increased during the last year in the period; considering the period of onset of symptoms, these figures reflect the working conditions in Polish mining in the 1990s.

**Table 3.** Occupational diseases in Polish mining.<sup>4</sup>

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Pneumoconiosis (includes silicosis)	458	414	495	448	397	428	489	466	409	548
Occupational hearing loss	291	217	194	132	72	77	57	75	74	71
Vibrational syndrome	49	69	38	31	36	23	31	34	38	29
Bronchitis	22	10	9	5	1	4	5	2	3	2
Other diseases	40	41	38	39	26	37	26	33	22	21
TOTAL	860	751	774	655	532	569	608	610	546	671

In 2010, 23% of all registered occupational diseases in Poland belonged to the mining sector. This is a very high figure, considering that only 1.2% of the working population are involved in mining.

To ensure and improve work safety in the Polish mining industry, the government has developed two strategy documents, one concerning the coal mining industry until 2015<sup>9</sup> and one concerning the State Mining Authority for the years 2010-2014<sup>10</sup>. The aims can be summarized as follows:

- safe and hygienic work conditions in mining,
- mining rescue service development,
- efficient exploitation of mineral resources,
- environment and buildings protection,
- safety and efficiency of new mining technologies,
- creating conditions for effective functioning of underground gas stores,
- improvement of regulations and efficient customers service,
- consideration of international determinants and cooperation in actions for the well-being of Polish mining.

A set of projects has been implemented in order to modernize existing systems for improving work safety in mining. Among them we can find the following: implementation of occupational health and safety management systems in coal companies, simplification of the organizational structures in mining companies, legislation related to mining in order to obtain a higher level of safety, and use of systems for occupational risk assessment. In summary, they have the following objectives:

- reducing the accidents number caused by the 'human factor',
- reducing the accidents number and dangerous events related to machines, devices and products introduced into mining,
- avoiding mining disasters effectively,
- reducing the number of occupational diseases,
- executing of occupational safety and hygiene regulations effectively,
- working out legal and organizational solutions necessary for efficient management of safety in mining,
- monitoring of hazards, risk prediction and warning systems.<sup>7</sup>

The accidents caused by the 'human factor', mentioned above, are understood by the State Mining Authority as being the result of incorrect organization of work, unsafe behaviour of the worker, or making a mistake while at work.

### 3. Current needs

The situation of the mining sector in Poland is dynamic. There are continuous changes in the employment structure, management methods and mining technologies. The organization and the functioning of the mining rescue service are undergoing changes. New technologies are promoted for energy acquisition from deposits, especially coal, in order to reduce the impact of current exploitation methods on the natural environment. It is also a priority to extend and efficiently use underground gas stores in order to increase the country's energy security. A rise in the number of accidents caused by mistakes made by workers clearly shows the need for new, more effective forms of supervision and control.

The projects and actions implemented as the result of the two strategic documents described above have so far lead to the following: safety management certificates obtained by mines and mining companies, the appointment of representatives for safety management systems in each mining company, and the establishment of special committees by the State Mining Authority to reduce risks to safety, such as natural hazards.

Procedures for conducting mining activities are being created. Education of health and safety mining engineers is being developed according to the Directive 89/391/EEC.

Among researchers and other mining professionals there is a belief - supported by external audits - that significant improvements have been made in the occupational safety management and risk management of mining in Poland.

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## Safety and health in mining in Spain

### Basic facts about Spain

Size of area	505,000 sq km
Population	47 million
Capital	Madrid
Literacy	98%
GDP per capita (PPP)	US\$ 30,400
Gini index	32
Infant mortality rate	3 deaths before age 1 year/1,000 live births
Median age	41 years
Life expectancy at birth	female: 84 years, male: 78 years

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## 1. Mining activities

Spain dominates the Iberian Peninsular, where every kind of rock can be found, including a world-class range of mineral deposits. In 2009, Spain was a significant European producer of minerals, including celestite, the principal source of strontium (ranked as second most important producer in the world), cement (ninth), fluorspar (sixth), gypsum (third), and sand and gravel (industrial) (sixth).

In terms of sales value, the mineral commodities produced are, in descending order: limestone, sand and gravel, anthracite, ornamental slate, coal and granite. The great majority of the 3,852 working mines in Spain mines are stone quarries (2,862) or those that produce ornamental stones (742).

The mining sector in Spain is in a general state of decline, in terms of number of working mines, level of employment, and tonnage of extracted products. According to the mining statistics of 2009, mining production was 3,550 million Euros, 14% less than in 2008. Only the production of metallic minerals has increased with the establishment of new working mines during the last few years. Imports of mined materials generally exceed exports (Table 1), with the exception of quarried ornamental and building stone, limestone, gypsum, chalk and slate, and the mining of chemical and fertiliser minerals, and the extraction of salt.



**Table 1.** Import-export balance, 2009.

	2009 ( thousand euros)	
	EXPORT	IMPORT
Mining of coal and lignite	123,100	1,220,500
Extraction of crude petroleum and natural gas	28,600	23,594,700
Mining of metal ores	224,400	2,165,200
Other mining and quarrying	524,800	368,300
<b>Total</b>	<b>900,900</b>	<b>27,348,700</b>
<b>Total (excluding petroleum and gas)</b>	<b>872,300</b>	<b>3,754,000</b>

The majority (61%) of the 3,852 mines are small operations, with less than 10 workers, employing 27% of the total workforce. Of the remainder, companies with 100 - 500 workers employ 30% of the workforce, and companies with more than 500 workers employ 13%. Most mining companies are privately owned. There are only three large partially state-owned enterprises in Spain that dedicate a significant part of their activity to mining extraction or refining: ENUSA (nuclear fuels), MAYASA (mercury), and HUNOSA (coal). The mining sector in Spain employed 32,800 workers in 2010, which represented less than 0.2% of the population affiliated to the Social Security System. Less than 10% of the total were women, who work mainly in “Other mining and quarrying” and “Mining support service activities” (Table 2). Migrant workers affiliated to the Social Security system represent 7.3% of all mining workers, with Rumanian workers representing 33% of the migrant mining population. See Table 2.

**Table 2.** Number of workers by gender and economic activity, 2010.

	Total		Male	Female
	Thousand	%	Thousand	Thousand
Mining of coal and lignite	6.9	21	6.5	0.4
Extraction of crude petroleum and natural gas	0.1	-	0.1	0.0
Mining of metal ores	1.5	5	1.3	0.3
Other mining and quarrying	22.7	69	20.5	2.2
Mining support service activities	1.6	5	1.2	0.4
<b>Total</b>	<b>32.8</b>		<b>29.5</b>	<b>3.3</b>

The majority of the mining workers (69%) fall into the category “Other mining and quarrying” where almost half of the workers work in stone quarries. The distribution of workers in mining sectors has changed dramatically over the last decades. For example, in 1994 more than 55% of mining workers worked in coalmines while nowadays less than half do. This could be explained by the fact that coal has not been profitable for several decades but has been supported by European and national aid. However, a 1993 European Commission decision established EC rules for State aid to the coal industry, determining that aid should be progressively reduced in line with reduced coal production. All the information in this article refers to formal economy as the estimated presence of the informal economy in this sector is very small. The degree of unionization varies greatly depending on the mining sector; the coal mining sector is estimated to be over 90 % unionized, while less than 25% of workers mining metal ores are union members with even fewer union members in quarries producing ornamental and building stone.

The legal framework of the mining sector in Spain is comprised of Acts, usually developed into regulations (statutes, or Royal Decree, RD), some of which are intended to regulate labour and social security conditions. These include OSH regulations (Occupational Safety and Health), and Inspectorate regulations that are the responsibility of the Ministry of Employment and Social Security. Acts and Royal Decrees specific to the mining sector are controlled by the Ministry of Industry. The following regulations are most relevant to safety and health at work:

- Act 22/1972 of Mining Activities,
- RD 3255/1983, which approves the Miners Statute,
- RD 863/1995, which approves the General Catalogue of Basic Rules for Mining Safety and its amendment that includes an Annex with the obligations in terms of OSH of the employer and the minimum requirements in safety and health at work, and

RD 1389/1997 approving minimum requirements to protect the safety and health of workers in mining activities. These regulations are complemented by ITC (Complementary Technical Instructions). The Commission of Mining Safety is the advisory body of the Ministry of Industry that proposes rules and lines of action concerning safety in mines.

## 2. Safety and health

### 2.1. Social security system

The Social Security System (SSS) is a set of regimes through which the State guarantees suitable protection in the contingencies and situations defined by the legislation. All Spanish citizens and foreigners who legally reside in Spain are included in the scope of the Social Security System as long as they work in Spanish territory. The SSS is divided into the General Regime and Special Regimes, however, only the Special Coal Mining Regime is relevant here.

Both employers and employees pay into the Social Security System except in the case of work-related injuries and occupational diseases and the Wage Guarantee Fund that are paid exclusively by the employer. The contribution rate related to occupational injuries is based on the activity risk, and several mining activities (e.g. coal mining and the extraction of ornamental stones) pay the highest rate. The main benefits of the social security system are medical assistance, temporary disability payments and retirement pension. Self-employed workers can, on a voluntary basis, include payments to cover work-related accidents and occupational diseases.

## **2.2 Safety and health regulations**

The main Act regarding Occupational Safety and Health (OSH) is the “Act on Prevention of Occupational Risks”. This act transposes the EU Directive 89/391/CEE to the Spanish legislation and introduces measures to encourage improvements in the safety and health of workers and to comply with ILO Convention 155.

A worker has a right to protection of their safety and health at work. This protection must be guaranteed by an employer and includes the right to information, consultation and participation, training in risk prevention, stoppage of activities in case of serious and imminent risk, and surveillance of a worker’s health, within the terms of the Act.

Therefore, the employers shall prevent occupational risks by integrating preventive actions into the company’s general management system, and by adopting all necessary measures to protect the health and safety of workers. To achieve this, the employer must have an occupational risk prevention plan, which must include the occupational risk assessment and the planning of preventive actions to eliminate or minimize those risks. In addition, the employer must provide the organization with the resources (human and material) necessary for the development of preventive activities. The legislation specifies the minimum requirements of the preventive organization, based on the number of employees and the type of activity. Demands range from the most restrictive - establishment of an internal prevention service for companies with more than 500 employees - to the minimum requirement for low risk micro enterprises, where the company owner can be personally responsible for the activity if he/she fulfils all the requirements.

The mining companies are included in the category of special-risk companies. They have to establish an internal prevention service if there are more than 250 employees but if there are less than 250 employees, the owner can contract an external prevention service or designate a qualified worker. Additional requirements that mining employers must comply with include an annual L labour plan and an external audit. One example of specific requirements in the mining regulations is the Miners Statute that establishes the role of the Miner’s Safety Representative (SMR) that is very similar to the Prevention Representative established by OSH legislation. To become an SMR requires a minimum level experience and competence, and requires the employees to elect one of three candidates proposed by the Enterprise Committee. A SMR has a number of functions, including collaboration with the employer in preventive work, promotion of co-operation of workers regarding OSH, and consultation

with the employer about activities that potentially have an impact on the safety and health of employees, before they are implemented. A Safety and Health Committee, (“Safety and Hygiene committee” in the mining sector), must be established in enterprises with 50 workers or more. The committee is a bipartite and corporate body that is required to consult regularly concerning risk prevention in an enterprise. The committee is comprised of an equal number of employee and employer representatives.

One particularly relevant feature that distinguishes the regulation of the mining sector from the general working sector concerns working hours. Please note that the maximum working week for indoor labour is 35 hours. In mining, the working day starts when the first employee enters the mine (a bocamina) and ends when the first employee exits the mine entrance. Some reductions are stipulated, including restricting the working day to a maximum of 6 hours when conditions are especially hard. This can be restricted further to a maximum of 5 hours per day when an employee must work the whole shift in wet conditions. Collective Agreements can set out other working conditions, but must respect the stipulated 6 hour minimum.

### **2.3 Responsible bodies for supervision and control**

In Spain, there are two bodies devoted to the supervision and control of safety and health in mining: the Labour and Social Security Inspectorate and the Mining Inspectorate.

The Labour and Social Security Inspectorate have the following areas of responsibility:

- Everything related to OSH in enterprises devoted to the preparation, concentration and treatment of minerals after extraction.
- Everything related to the Social Security System.
- Everything related to working hours.
- The surcharge of the social security economic benefits that are paid to injured employees, in connection with a work-related accident or occupational disease. This surcharge ranges from 30 % to 50% of the economic benefits when an injury occurs due to a lack of safety measures. This surcharge must be paid solely by the employer. The proposed surcharge is based on the report made by the competent body that investigated the accident.

The actions of the Mining Inspectorate require two conditions: the work must be regulated by the Mining Act, and a mining technique must be applied.

### **2.4 Accidents at work**

The Spanish definition of an occupational accident includes any physical injury suffered by an employee in the course of, or as a consequence of, his/her employment. The law also establishes several considerations and presumptions to determine if an injury is work-related. Accidents resulting in more than one day of absence from work are included in the statistics. Spanish statistics include incidents during working hours that are excluded from other nations’ schemes, such as traffic accidents, heart attacks and other non-traumatic accidents.

From 2003 - 2010, 31 fatalities due to work-related accidents were reported in the coal-mining sector, compared to 69 for mining of non-energetic minerals:

Number of fatalities	2003	2004	2005	2006	2007	2008	2009	2010	Total
-Coal mining	5	4	7	2	5	4	3	1	31
Non-energetic mineral mining	20	14	1	2	10	10	6	6	69

Extractive industries, historically, have the greatest incidence rates for work accidents. In this sector, workers involved in coal mining are more likely to suffer a work accident due to an unsafe working environment. The accident rate in coal mining industries is eight times higher than that of the Spanish industry as a whole. Coalmining is the most dangerous occupation in Spain. See Table 3 and Figure 1.

**Table 3.** Extractive industries working accident incidence rates per 100,000 workers

	2006	2007	2008	2009	2010
Coal Mining	42,400	45,100	43,900	45,000	41,200
Gas and fuel extraction	9,800	7,800	14,900	10,200	9,800
Metallic minerals mining	4,800	9,600	9,100	5,200	6,200
Other mining industries	11,600	12,000	10,000	8,600	7,600
Mining support service activities	3,100	3,600	3,900	3,000	2,200

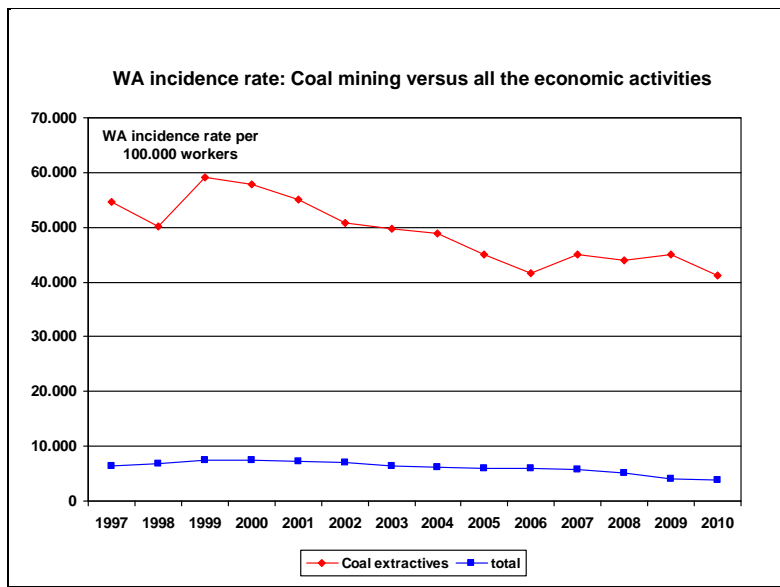
The following figures describe the work-related accident profile in mining sector from 2010 national statistics. According to these statistics, 99% of the work accidents in mining only resulted in minor consequences for health. Nevertheless, the mortality remained quite high compared to other sectors. The most affected sector was coal extraction (63% of mining sector accidents) followed by ‘Other mining industries’ (36% of sector’s accidents). The most common profile is a male (98%) between 35 and 44 years-old (49%). A total of 58% of accidents took place in underground mines, followed by 19% in opencast quarries. Despite the classical risks linked to these activities, 30% of work accidents resulted from musculoskeletal strain. Musculoskeletal strain is the most common injury from work accidents, followed by injuries from falling objects (20%).

## 2.5 Occupational diseases

In 2010, 378 occupational diseases were reported by extractive industries. Coal mining was the most affected sector, with 268 cases, followed by 106 cases in ‘Other mining industries’. Tendinitis and other musculoskeletal disorders characterize the occupational disease profile for this sector. See Table 4. Since the current system of notification and list of occupational

diseases was established in 2007, the severity of occupational diseases has not been classified. Data from previous years show that no fatalities in mining were registered due to occupational diseases during the period 2000 to 2006.

**Figure 1.** Work accident incidence rate, 1997-2010, for coal mining versus all economic activities in Spain.



**Table 4.** Occupational diseases notified in mining, 2010.

	%
Tendinitis	47
Meniscus damage	23
Synovitis	12
Nerve paralysis	5
Neurovascular diseases caused by vibrations	1
Diseases caused by silica dust	7
Diseases caused by other mineral dusts	1
Diseases caused by coal dust	1
Nistagmus	1
Respiratory diseases caused by low molecular weight substances	1
Respiratory diseases caused by high molecular weight substances	1
Hearing loss	0
<b>Total</b>	<b>100</b>

### 3. Current needs

In Spain, activities in the mining sector have substantially and progressively decreased since the coal reform in the 1990's. The extraordinary boom in the construction sector in the past decade led to an increase in the mining activities related to construction materials (e.g. sands or ornamental stones). However, the general economic crisis of the past few years has resulted in serious impacts on the Spanish building industry together with the economic activities associated with construction. Therefore, the future development of the mining sector will depend, at least partly, on the development of the construction industry. As has been mentioned in this article, mining in Spain is subject to the general rules of occupational safety and health promoted by the Ministry of Employment and Social Security, plus specific rules relevant to the remit of the Ministry of Industry. Both sets of regulations have gone through a process of adjustment since Spain joined the European Union and Spanish regulations now mirror the new EU Directives in the field of safety and health. It is well known that the EU's interest in the future is to consolidate existing regulations and, in the spirit of the "better regulation" policy, avoid additional and unnecessary regulations. As a result, it is generally thought that there will be fewer regulations coming from the EU in future. Despite the low number of miners, public authorities are particularly concerned about their safety conditions as mining is a sector with high rates of accidents and occupational diseases, and these accidents are often serious and attract public attention. Future efforts will focus on improving safety conditions, specifically on monitoring occupational diseases with long latency periods. In addition, efforts will be made to improve working conditions in order to ameliorate those conditions that might lead to occupational diseases, currently dominated by musculoskeletal disorders.

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Note: In 2012, the Ministry of Labour and Immigration changed its name to Ministry of Employment and Social Security and the Ministry of Industry, Tourism and Commerce became the Ministry of Industry, Energy and Tourism.

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Bengt Järholm

# Safety and health in mining in Sweden

## Basic facts about Sweden

Size of area	450,000 sq km
Population	9 million
Capital	Stockholm
Literacy	99%
GDP per capita (PPP)	US\$ 41,700
Gini index	23
Infant mortality rate	3 deaths before age 1 year/1,000 live births
Median age	42 years
Life expectancy at birth	female: 84 years, male: 79 years

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Valuable comments were given by Cecilia Andersson Industriarbetsgivarna, Vagn Englyst Boliden AB, Lars-Erik Folkesson, IF Metall and Mats Lejerbäck, LKAB.

## 1. Mining activities

Sweden has a long tradition of mining industry starting with copper and iron mines in the middle of Sweden. The first copper mine started in the 700:s. During several decades, many mines have closed, but in the last decade new mines have been started or are in the planning stage. The Swedish mining industry is now concentrated mainly in the north of Sweden. Major products are iron ore, gold, copper and zinc. Iron mining is dominated by LKAB, with two underground mines producing about 40 million tons of raw iron per year. Boliden AB runs a large open pit copper mine, but other mines are mainly underground. LKAB is state owned, while other mines are owned by Swedish and foreign private companies. LKAB and Boliden AB are the largest mining companies, with activities in both Sweden and abroad.

The exploration of new mines is on the increase. The costs for exploration have increased from about 200 to 700 million SEK between 2002 and 2010 (from 30 to 103 million USD) and several small mines are now starting or are in the planning stage. Several metals are of interest for the exploration companies, including gold, copper, zinc, nickel, lead, molybdenum, wolfram, vanadium, tellurium and lithium.<sup>1</sup> The total production value of the mining industry was about 23 billion SEK in 2009, corresponding to 0.8% of the Swedish GNP.

A large part of the iron ore is exported, while other metal ores are mostly refined in smelters. The largest facility is Rönnskärsverken in Skellefteåhamn in Northern Sweden.

The number of employees has decreased from about 15,000 at about 100 sites in the 1950s to about 6,000 employees at about 15 sites in 2010. Six thousand people represents 0.1-0.2 % of the Swedish work force. Some work in the mines is done by contractors e.g. those specialized in methods of rock drilling. It is estimated that, in 2010, about 14 % of the workforce in mines were contractors<sup>1</sup>; 86 % of the total workforce in mines and quarries were men<sup>2</sup>.

## 2. Safety and health

### 2.1 Supervision and control

There are several regulations regarding the work environment that are enforced by the Swedish Work Environment Authority (SWEA, [www.av.se](http://www.av.se)). According to law, the employer has the main responsibility for a safe work environment. There are special regulations concerning mining<sup>3</sup>. These include general rules about safety and, for example, rules about measurements of pollutants, such as radon. Certain air pollutants have national permissible levels and those most relevant are presented in Table 1.

**Table 1.** Permissible levels (PELs) of interest for the mining industry<sup>26</sup>

<b>Pollutant</b>	<b>Agent</b>	<b>PEL</b>
Dieasel exhaust	Nitrous dioxide	2 mg/m <sup>3</sup>
Dust	Inhalable	10 mg/m <sup>3</sup>
	Respirable	5 mg/m <sup>3</sup>
	Iron oxide	3.5 mg/m <sup>3</sup>
	Silica	0.1 mg/m <sup>3</sup>
Radon (yearly dose)		2.5 MBqh/m <sup>3</sup>

Mines are inspected by the authority and can be enforced to increase safety. If regulations are not followed, the authorities have the power to close dangerous work places. The mining activities are also controlled in other ways, e.g. by environmental laws and authorities.

Most mines have occupational health centres with medical and technical staff, either owned by the mining company or on contract. The provision of occupational health centres is not obligatory for Swedish companies, but is often agreed upon between union and employer organizations on the national level. Health controls are mandatory for certain types of work and exposure. In mines, it is often the occurrence of silica that demands obligatory examinations. If the concentration of silica is above 0.05 mg/m<sup>3</sup> (half of the permissible level) such controls are mandatory. There is an agreement between different industry sectors in Europe, including the Swedish mining industry and unions, to work for the protection of workers from the health risks caused by exposure to silica<sup>4</sup>.

The companies have their own statistics for accidents and absence from work, and usually have targets. The following is cited from the annual report from the largest Swedish mining company<sup>5</sup>:

“One of the most important strategic tasks for the period 2010–2012 is to reduce the number of accidents leading to absence by at least half. 2010 was a poor start. The frequency of accidents per million work hours increased by 23 per cent, and the worst thing that can happen in our operation also occurred. Two employees of a contractor died while working on the construction of the new main level in Malmberget. Now, work on Safety First will be intensified with a programme entitled Order and Upkeep. Safe workplaces are a necessary condition for attracting new co-workers to LKAB. On a positive note, absence due to illness remains at a relatively low level, at an average of 2.6 per cent. Long-term absence due to illness stands out at a mere 0.4 per cent.”

At each work site, there are safety representatives from the unions. Swedish employees have in general a high degree of unionization and miners are no exception. There is a safety committee in each company and safety representatives from the unions are member of such committees. According to law, the representatives have the possibility to stop dangerous work - the inspectors from SWEA visit and make their decision within one day. There is also a national committee for health and safety, with representatives from industry, unions and SWEA.

## 2.2 Statistics

Companies must report severe accidents to SWEA, and such information is the basis for statistics of fatal accidents. Any accidents and diseases can be reported to the Swedish Social Security if the individual asks for compensation, i.e. the individual considers their condition to be of occupational origin. Statistics based on such reports are presented yearly by the industry and available on the internet<sup>6</sup>. A significant advantage of the statistics is that they are up-to-date and cover all activities in the country. The statistics are, however, based on reports from persons who want compensation for their disease/accident, and are dependent on the reporting frequency, which may vary over time. The mining industry is also compiling statistics of accidents through the mining employers association. An advantage of this is that those compiling the statistics are very knowledgeable of the industry; a drawback is that reporting only covers certain companies.

Occupational accidents and diseases are also compensated by a collective insurance system that also provides statistics of accidents/diseases<sup>7</sup>. The advantage of this system is that it contains detailed information of each case and only includes cases that are accepted as occupational accidents/diseases. The drawback is a rather long delay between the diagnosis of disease/accident and inclusion in the statistics.

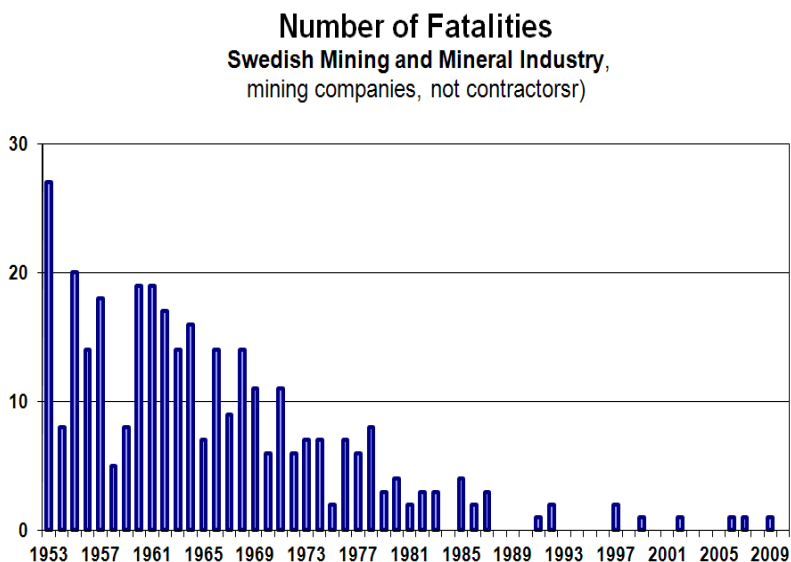
The statistics from SWEA and AFA Insurance include data from the combined occupational group of workers in mines and quarries. Thus, trends and incidences may differ between statistics partly depending on differences in classification.

### *Fatal accidents*

Statistics for fatal occupational accidents in Sweden have been compiled since the 1950s. The number of accidents has decreased from about 400 per year in the mid-1950s to around 50 in the period 2008-2010, or from about 15 to 1.4 per 100 000 employees. The official statistics reported a total of 4 fatal accidents in mining and related industries between 2007-2010, or on average one death per annum, or around 15 deaths per 100,000 employees and year, i.e. much higher than the average in Sweden<sup>8</sup>.

SweMin (Swedish Association of Mines, Minerals and Metal Producers) reported a total of 4 fatal accidents between 2001 and 2010. That is about 7 fatal accidents per 100 000 workers. The difference between the statistics is mainly due to the fact that SweMin does not include all mines/entrepreneurs. Furthermore, they report data from entrepreneurs separately (4 fatal cases in their statistics among entrepreneurs between 2007 and 2010). SweMin also have statistics since 1953 that show a considerable decrease in the number of fatal accidents, especially between the 1950s and 1980s, fig 1. The number of mines and employees has also decreased (from 15,000 to 6,000), but the risk of fatal accidents has decreased, even considering the decrease in number of workers.

**Figur 1.** Number of fatalities in mining industry. Source: personal communication with Cecilia Andersson, Industrierbetsgivarna.



Thus, the frequency of fatal accidents is low in number, but high in relative terms compared to the average risk for Swedish workers.

#### *Other accidents*

Among the group classified in in the official statistical system as miners or rock workers there were in total 57 accidents (54 of these involved men) in 2010. The accident rate for employees in the mining industry is high compared to the average Swedish employee (16 vs. 6 accidents per 1 000 employees and year)<sup>8</sup>.

The statistics from SweMin reported 119 accidents, excluding entrepreneurs, in 2010. In their classification, 15 cases were considered to be severe accidents (excluding fatal accidents) and most common causes were repair service (6 cases), crush injury (5 cases) and tumble/slipping (3 cases). Their statistics show a decreasing trend over the last years, with the incidence per year being reduced by about half in the last 10 years.

The statistics from AFA Insurance show that male miners had the next highest incidence of severe accidents (more than 30 days absence from work) of all reported occupational groups<sup>9</sup>.

Thus, statistics show a decreasing trend of fatal and non-fatal accidents over the last decades. The reduction is an effect of several factors, such as increased automation and accident prevention using technical, behavioural and managerial methods.

### *Air pollutants*

Air pollution in the mines comprises a complex mixture of dust from the ore and rock, radon gas, and exhausts from vehicles, mainly diesel exhaust. Early on, underground mines were only ventilated through natural ventilation, but the introduction of diesel trucks demanded forced ventilation. Silica is a natural constituent of most Swedish rocks and high exposure over a long time may cause silicosis. Radon is a decay product from uranium, which is a natural constituent in the bedrock of most mines; for example, the iron mines in north of Sweden has a uranium concentration of about 2-5 ppm. Radon may dissolve in water. Thus, a major cause of high concentrations of radon may be high amounts of ground water leaking into the mine. Previously, fresh air to the mines was heated through waste rocks, which contributed to high concentrations of radon.

### *Silicosis*

Silicosis was previously a major risk in many Swedish mines. A cohort study of miners working in iron mines showed 58 silicosis deaths in 7,729 miners, with a crude mortality rate of 53 cases per 100 000 person-years<sup>10</sup>. However, major steps have been taken to reduce the exposure to silica in Sweden<sup>11</sup>. Today, silicosis is a rare disease in Sweden and also very rare among miners. Furthermore, miners with a high exposure to silica should be offered health checks (see below). There are also obligatory measurements of silica. The risk of silicosis is considered to be well controlled and very low in the traditional mines. However, small mines have been started and the knowledge and experience of management and miners may be lower. As a result, SWEA fear that new cases may occur in such work sites.

### *Lung cancer*

There are several Swedish studies showing increased risk of lung cancer in iron and zinc mines<sup>12-16</sup>. The risk has been high. Relative risk levels of up to about 5 have been reported in highly exposed groups<sup>16</sup>. The increased risk has mainly been attributed to radon exposure, but recent research has indicated that high exposure to silica may be a contributing factor. 'The radon concentration was rather high earlier and average concentrations in the range 2,500 – 4,000 Bq/m<sup>3</sup> were reported from an underground iron mine in 1969-74<sup>16</sup>. The highest permissible dose of radon is 2.5 MBq/m<sup>3</sup> per year, which is equivalent to 1,500 Bq/m<sup>3</sup> on average during 1,600 working hours per year. The concentration is routinely measured in the mines (area and personal sampling).

Major exposure to diesel exhausts in underground mines started when diesel trucks were introduced in the 1960s. Measurements in an underground mine indicated levels about ten times higher than in street traffic<sup>17</sup>. Diesel exhaust is a probable carcinogen, according to IARC (International Agency for Research on Cancer) (group 2A). There are some epidemiological studies of lung cancer in Swedish miners, but the power of the studies to estimate the risk due to diesel exhausts is still low. Furthermore, it is difficult to identify a contribution from diesel exhausts where the exposure to radon may be substantial.

Silica is a group 1 carcinogen according to IARC, and a recent Swedish study found an increased risk of lung cancer in miners with a low exposure to radon (open pit miners) and attributed the increased risk to exposure to silica<sup>13</sup>.

#### *Chronic obstructive lung diseases and chronic bronchitis*

Exposure to dust may increase the risk for bronchitis. The phenomenon is well known in several industrial environments and is sometimes called industrial bronchitis<sup>18</sup>. Such bronchitis may persist even when the miner stops working as a miner<sup>19</sup>. Chronic obstructive pulmonary disease (COPD) has been linked to exposure to dust in industry, e.g. in the mining and construction industries<sup>20-22</sup>. Some studies indicate an increased risk of COPD in Swedish miners<sup>18, 23</sup>.

#### *Other diseases*

The national statistics of reported occupational diseases (asking for compensation) contains 24 cases among employees in the mining industry in 2010. Of these, 13 involved hearing-problems caused by high noise levels, 9 were attributed to ergonomic factors, and there was one case attributed to chemical exposure (and one where the cause was not stated)<sup>8</sup>.

Miners may be exposed to vibration, both from handheld tools and from whole body vibration. This exposure can cause white fingers, and neurological and musculoskeletal problems. In modern mining, the exposure from handheld vibrating tools has decreased, but the exposure to whole-body vibrations from heavy machinery may have increased. A recent study found an association between whole-body vibration and the risk of heart disease in miners and suggests that there may be a causal link<sup>24</sup>. There are no statistics on the risk of disorders in Swedish miners caused by vibration. However, there is a national database of measurements of vibrating tools and vehicles, including those that are used in the mines<sup>25</sup>.

Sick leave of at least 90 days is compensated through a special insurance on top of the compensation from the social security (see below). According to the statistics, male workers in mines and quarries have an absence level that is similar to the average in Swedish industry (13.2 vs. 14.4 per 1000 employee and year in 2009)<sup>9</sup>.

## 2.3 Social security

Swedish workers who must be on sick leave (independent of type of disease/ accident) receive a state-financed economic compensation. Medical services and treatment in hospitals are available almost free to all citizens. Accidents and diseases that are considered to be caused by work are compensated additionally. The individual can choose to retire between 61 and 67 years of age and the pension increases if he/she retires at an older age. Women were previously forbidden to work underground, but there is no longer any such law. However, the employer should make a special assessment of the work environment for pregnant and nursing women and, if that shows risk (e.g. high levels of whole body vibration), the woman will be allowed to continue with such work and will be reassigned to other jobs.

## 3. Current needs

Even if a lot has been done over the years to decrease the risk of accidents, the mining environment still has a high risk compared to most other industrial branches. Large employers seem to be aware of the risk and focus on reducing it, but there are several new smaller work sites that have less experience and resources.

A present project in the industry, “Safety Culture”, is aimed at reducing the risks by focusing on individual risk assessment, attitudes and behaviour. Silicosis was previously a large problem even in large mines, but today the risk is low. However, the awareness and technology in smaller work sites may be less good and SWEA has announced that as a special area for control.

Diesel exhausts and radon continue to be a major source of air pollution in many mines and technology to further decrease and monitor the exposure is important. Noise should not be forgotten as a problem. Musculoskeletal load has changed over the years, from being mostly involving very heavy work to including computer work and steering equipment with joysticks. Heavy work is still performed, sometimes by contractors, which puts special demands on the organization of the safety work.

The present high demand for metals leads to the start-up of new often rather small mines, sometimes with limited resources and experience in work safety. The challenge for society is to increase the safety of miners under such circumstances. Even the large companies, as the citation above exemplifies, have challenges to reach the goal of decreasing risk and improving health. There is a need for new methods, both organizational and technological, to reach these goals.



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# Safety and health in mining in Turkey

## Basic facts about Turkey

Size of area	784,000 sq km
Population	81 million
Capital	Ankara
Literacy	87%
GDP per capita (PPP)	US\$ 15,000
Gini index	40
Infant mortality rate	23 deaths before age 1 year/1,000 live births
Median age	29 years
Life expectancy at birth	female: 75 years, male: 71 years

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## 1. Mining activities

In terms of global mineral resources, Turkey is ranked 10<sup>th</sup> in mineral diversity and 28<sup>th</sup> in production capacity. Turkey has a global share of 30% of natural stone, 2.5% industrial raw materials, and 1% of coal. Mining production provides 1.5% of the Gross National Product. About 50 different ores are mined in Turkey, resulting in an added annual value of more than two billion US dollars. Assuming the current consumption level, the duration of the various mine reserves would be as follows: aluminium, 1027 years; coal, 400 years; platinum, 360 years; phosphorous, 345 years; chromium, 143 years; nielium, 90 years; copper, 75 years; uranium, 59 years; gold, 45 years<sup>1</sup>. Turkey is dependent on foreign energy supply: seventy-five percent of the energy is imported. The share of renewable energy sources is under 9% and coal contributes 30% (of which 20% is imported) of the energy supply<sup>2</sup>.

There is no deep mining activity in Turkey, with the exception of hard coal mining. Approximately 80 % of the mining enterprises are small-scale. According to 2010 statistics, 125,500 workers are employed in the mining industries. Of those, 42% were employed in quarries, 40% in coal and lignite mining, and 16% in the mining of metallic ores. It has been estimated that 6% of the workers are employed informally<sup>3</sup>. Excluding the quarries, a little more than 1% of the mine workers are women, working in auxiliary jobs. According to the Labour Law, the employment of women is restricted in several hazardous industries, including mining. There are 1,768 mining work units, of which 96% are private companies that are mostly small- and medium-sized. Public sector owned 4% of the enterprises, where 20% of all miners are employed. The private mining companies are therefore smaller workplaces than the public enterprises. Most of the miners in the public sector are working in coalmines (94%).

The main mining export products are chromite, copper and boron, in addition to natural stones and marble. Excluding petroleum and natural gas, the main import products are gold, coal and iron. There is a large gap between export and import volumes in Turkey. The main strategy of mining activities is focused on export of raw ores. For example, Turkey has 63% of the boron reserves in the world and 31% of the annual world production of boron. On the other hand, Turkey has only 18% of the global boron end-product trade.

The Mineral Research & Exploration General Directorate is the authority responsible for mining research and exploration in Turkey. The Directorate was established in 1935 and has lost some of its authority due to changing economic and mining policies in recent years. A number of national public properties have either been re-structured, closed or privatized during the last 20 years: this includes the Turkish Hard Coal Mining Institution, ETIBANK (mining metallic ores, boron, sulphur, phosphate etc.), Black Sea Cooper Institution, and Turkish Iron and Steel Industries Institution. While the public investments in mines were 4.5% of total governmental investments in 1981, this declined to 0.5% in 2002. In particular, coal mines that were established to supply to the thermic reactors have been privatized and this process continues.

Employees in the mining sector have mostly lower educational level than other workers. One study showed that 70% of the workers have only primary schooling. Additionally,

there are not enough training programmes for workers. Education is one of the most important factors for achieving rights and contributes to the empowerment of the workers. Training of engineers and technical staff at universities is also an important factor for the development of the mining sector. Approximately 1,000 engineers have graduated from the 21 mining engineering departments in the universities during the last years. This number is far above the requirements of the sector and has caused rising unemployment among the mining engineers and technical staff, and also resulted in decreased quality of education and training.

The official unionization rate is 60%, but this data is not considered to be reliable. Studies have estimated the unionization rate to be as low 10%, or even lower. There has been a swift decline in general unionization rate after the military coup in 1980. While the unionization rate was 47% before the 1980's, it was less than 20% at the end of the 1980's. There are a number of obstacles to unionization and authorization procedures at workplaces. First of all, if a particular union does not have enough members nationwide (e.g. 10% in the whole country), then this union cannot be authorized in any workplace. Secondly, even if a union is authorized in a certain sector, the collective bargaining is limited to the unionized workers. Furthermore, as a result of recent changes of regulations, there are an increasing number of employees with a fixed period contract, in part-time work, or in sub-contracted or outsourced workshops. These factors have affected the unionization rate negatively.

## 2. Safety and health

Turkey is ranked third in the world with respect to work accidents. There have been a number of catastrophic accidents in the public and private enterprises in recent years. Official records showed that 62,903 work accidents occurred in 2010 and there were 1,444 fatalities. Among these accidents, 14% occurred in mining industries. Given the 1.2% share of the total employment, the accident rate in mining is much higher than the average for all sectors of the labour market. A total of 130 fatalities occurred in mining, representing 9% of all occupational fatalities. In addition, 76 workers became incapacitated because of mining accidents in 2010<sup>4</sup>.

There have been 30,154 accidents in coal mining enterprises in the last five years (representing 8% of total work accidents). There were many firedamp explosions between 2009 and 2010 and they have raised the attention of the public and media. The most recent explosion was in May 2010, causing 30 deaths in a state-owned mine. It occurred just four months after another explosion that killed 13 workers in a private mining company.

The Presidential Audit Board has prepared a comprehensive report on mining accidents in Turkey<sup>5</sup>. Some of the issues raised in the report are as follows: employers do not give enough attention to control measures; there are insufficient numbers of experienced specialists on occupational safety and health; there is a lack of risk assessment methods that are adapted to specific workplaces and sectors; there is a lack of clear definitions that describe the responsibilities and duties of institutions related to the management of occupational safety and health. An auditing function has been assigned to the Labour

Inspection Board under the Ministry of Labour and Social Security (MLSS). While the Board is fairly competent in terms of quality and structuring, the number of labour inspectors is far from adequate. There are approximately 1,000 labour inspectors in the whole country. The absence of cooperation between supervisory authorities results in contradictory administrative transactions and dispositions in the mining sector. Moreover, this lack of cooperation may mean that some mines are audited a few days apart by the different institutions, while other mines are audited after a long time, or not audited at all. As a result of these political circumstances, working within the mining sector is unregulated and uncontrolled; it has diverged from engineering science and techniques; there is a lack of supervision and auditing, and the conditions are primitive in both public and private enterprises.

In Turkey, the diagnosis of occupational diseases lags far behind what it should be. The expected number of occupational diseases is estimated to be between 25,000 and 90,000 but only about 500 are notified each year. Most of the occupational diseases have been notified in the mining sector in Turkey. For instance, 1,001 out of 1,208 diseases in 2007, 328 out of 539 in 2009, and 300 out of 429 were notified from the mining sector in Turkey<sup>4</sup>. The reason for these higher notification rates in mining activities is the higher public sector share of the mining activities in comparison to other industrial activities. Moreover, until recently there were only three hospitals that specialized in occupational diseases in the whole country. One of them is allocated in the Black Sea Region, where there are intensive mining activities. Therefore, most of the cases have been reported from this specific hospital, having good experience in mining related diseases, especially pneumoconiosis. The overall annual occupational disease incidence rate in Turkey is 0.01%, while it is 0.20% in the coal mining sector. Pneumoconiosis constitutes the major portion of the occupational diseases in mining. The research reported that 14 % lignite miners in Turkey suffered from pneumoconiosis<sup>6</sup>.

The procedures for diagnosis of occupational diseases, as well as treatment and rehabilitation are problematic. It has been estimated that more than 20,000 occupational diseases among the insured workers are not notified<sup>7</sup>. With a new arrangement, the authority to diagnose occupational diseases has been given to state university hospitals and several state hospitals. However, there has been no progress in the officially registered statistics on occupational diseases, as the notification of the occupational diseases is only based on compensation. Data on occupational injuries and diseases are collected and published via the social security agency. Only compensated occupational diseases are shown in the official statistics. Most of the cases have been reported from the public sector.

The MLSS is responsible for the organization and coordination of occupational health in general. The current Labour Act of Turkey came into force in 2003. There has been a rapid transformation of the legal basis of occupational health, due to Turkey's involvement within the EU accession process. Following the 2003 Labour Act, legal regulations on occupational health and safety have been harmonized with EU Directives and a number of regulations on occupational safety and health have been issued. The most important effects of these regulations are to provide flexibility in working life and fixed-period service agreements, and broaden sub-contracting, which is especially important in the mining industry. A new and the first OSH law have been ratified in June 2012. It should be considered as a progress in

OSH legislation as it is stated that the law to be applied, regardless of activity and subject, refers to work and work-places in both the public and the private sector. Although it has been postponed to enter into force for two years for small enterprises, the coverage of the OSH legislation is expected to expand<sup>8</sup>. On the other hand, it is emphasized that the new law does not contain significant changes in the general framework and it seems to have caused confusion rather than being explanatory. It is criticized for being enacted without social dialogue. Therefore, we may expect some implementation problems.

The current conditions of the legislative arrangements can be summarized as inadequate and incomplete, and therefore not implemented.

### 3. Current needs

In the long term, Turkey should shift from being a country that produces and sells raw materials on the world markets, to the exporter of value-added high-end products. This will have great implications for the working conditions and the possibility to ensure occupational safety and health for the workers.

In the short term, there are a number of issues that might be considered as the priorities for the development of occupational safety and health (OSH) in mining in Turkey. These priorities could be divided into two main levels: policy level and workshop level practices. These two levels are not separate entities but rather interconnected and they influence each other.

As a result of recent trends in the working life, there has been widespread application of sub-contracting and out-sourcing in the mining sector in Turkey. It is well known that this phenomenon negatively affects health and safety practices in the mining industry. Two problems need to be addressed. Firstly, sub-contracting adversely affects the unionization rate, which is already low and weak in Turkey. The collective bargaining parties were generally given considerable influence over the setting of national standards and inspection procedures. Decreased power of the unions may also cause a decrease in the demand to work under safe conditions. Secondly, subcontracting hinders the provision of occupational health services in the workplace. It is difficult to define the responsibilities of the sub-contractor and the main employer in terms of OSH services. In some cases, the primary employers engage sub-contractors to avoid OSH practices. Changes in sub-contractors might also complicate auditing services. Furthermore, bipartite safety committees should be established at company level to ensure the implementation of laws and standards. This is difficult to achieve in the case of sub-contracting companies. Therefore, subcontracting should be strictly regulated and should be banned in core mining activities.

A number of European Union directives related to OHS, including ECC 89/381 and many specific ones, have been issued during Turkey's EU accession period. These directives have been simply "translated" into Turkish and are not adapted or harmonized with the local regulations<sup>1</sup>. The government has not spent enough time and effort to prepare these directives to cohere with local regulations and to prepare workplaces for their implementation. This

has caused incompatibilities between the “translated” and “national” regulatory infrastructure. Therefore, the regulations have not been put into practice. These directives could be taken as framework guidelines and sound regulations that respond to local needs should be established within the traditional regulatory infrastructure. The new OHS law is not providing clear frame-work in terms of OHS service provisions especially for the small enterprises.

The government has initiated the use of market driven policies in the OSH area. Education and training activities for occupational health professionals as well as OSH practices have been opened up to private companies. As the result of recent arrangements, un-standardized education and training programmes are increasing in an uncontrolled way without ensuring the quality of and compliance with the training programmes and the competencies of the trainees.

Although there have been some efforts from the Ministry of Health (MoH) to raise awareness in diagnosis of occupational diseases, there are still many structural weaknesses. First of all, the MoH should establish a strong institution and department for occupational safety and health. There is only one section under the Public Health Institution, entitled “Department of Consumer and Safety”. Furthermore, there are no provincial institutions that work with OSH. The MoH should establish a strong department including provincial organizations, especially in organized industrial areas.

Accredited occupational health and safety equipment calibration and testing units are not available in Turkey. To develop this, the governmental agencies should take initiative and share the responsibilities with the professional non-governmental organizations.

Taking into account that there are insufficient numbers of labour inspectors, the professional organizations as well as the labour unions should take part and provide additional expertise services for the mining sector.

The health and safety culture in Turkey is still very weak and needs to be strengthened. This is a problem that cannot be solved quickly. It demands long-term joint efforts and solidarity by the trade unions, professional associations and relevant governmental and non-governmental organizations.

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Myriam Molayi Elenge

## Safety and health in mining in Congo (DRC)

### Basic facts about the Democratic Republic of Congo (DRC)

Size of area	2,345,000 sq km
Population	76 million
Capital	Kinshasa
Literacy	67%
GDP per capita (PPP)	US\$ 400
Infant mortality rate	77 deaths before age 1 year/1,000 live births
Median age	18 years
Life expectancy at birth	female: 57 years, male: 54 years

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Her experience as Corporate Adviser Doctor, in the Democratic Republic of the Congo (DRC), from 1996 to 2002, stimulated Myriam Elenge to specialize in occupational medicine. She undertook the School of Public Health, University of Brussels, and took the *Diplôme d'études spéciales* in Immunohaematology and transfusion at the University of Liege. In 2011, she was awarded a Ph.D. in Public Health, after a master degree in epidemiology and statistics (2006), a certificate in radiation protection (2007) and an advanced Master in Occupational Health (2008). Dr Elenge has focused her research on health and safety in mines and mining environment, and has conducted several assignments as such, in African countries other than DRC, her country of origin.

## 1. Mining activities

The large size and diversity of the deposits in the Democratic Republic of Congo (DRC) make it a significant mining country. The development of this potential is, however, a source of many concerns, including those related to environmental protection<sup>1</sup> and promotion of occupational health and welfare. Indeed, extracting minerals is inherently a hazardous activity<sup>2</sup>. Transforming the minerals is not without risk either. While pointing out the important place of mining in DRC, we will also assess whether this importance is balanced by promotion of occupational health and safety within this industry.

In DRC, the exploration of mineral resources is still in its infancy and there is no reliable estimation of exploitable deposits. Indeed, most deposits were discovered over a century ago, with prospecting techniques so rudimentary that it is likely that the use of modern instruments will adjust the earlier estimates significantly. The value of the 10 most important mineral resources<sup>3</sup> has been estimated to be \$ 24 trillion (equivalent to the GDP of Europe and the US combined)<sup>4</sup>. In Table 1, the current estimates of the ten most important mineral resources are listed.

**Table 1.** Mineral reserves of DRC. Source: Congolese Ministry of Mines.  
[http://mines-rdc.cd/fr/index.php?option=com\\_content&view=article&id=53](http://mines-rdc.cd/fr/index.php?option=com_content&view=article&id=53)

N°	Mineral ores	Estimated deposits	Worldwide ranking
1	Copper (tons)	75,000,000	2 <sup>nd</sup> after Chile
2	Lithium (tons)	3,100,000	
3	Niobium (tons)	30,000,000	
4	Manganese (tons)	7,000,000	
5	Zinc (tons)	7,000,000	
6	Cobalt (tons)	4,500,000	1 <sup>st</sup>
7	Iron (tons)	1,000,000	
8	Cassiterite (tons)	450,000	
9	Gold (tons)	600	
10	Diamond (carats)	206,000,000	3 <sup>rd</sup> in quality but 1 <sup>st</sup> in volume

Nearly all mining companies were established in the DRC since the colonial period, and have been nationalized after independence in June 1960. Mismanagement of these public enterprises has resulted in the collapse of most of them<sup>5</sup>. To fight against unemployment, many former miners have switched to artisanal mining, followed by other unemployed people<sup>6</sup>.

With the promulgation of a new mining code<sup>7</sup> and the reform the state portfolio<sup>8</sup> the Government has opted to rely on private international investment to boost mining activities<sup>9</sup>, through partnerships. The kick-off of these partnerships has resulted in a certain recovery of industrial production of minerals, so that today, mining has two forms: the classic industrial and the artisanal.

At the end of 2007, more than 4,350 research permits were granted to private mining companies alone, or in partnership with public enterprises. More than 470 operating licenses and 59 permits for small-scale mines were also granted<sup>10</sup>. Table 2 summarizes annual mineral reserves, production capacities and shareholdings, for the main industrial units.

**Table 2.** Size and shareholding of mining societies of the DRC

Mines and holders title of mining rights	Ore exploited and reserves	Production capacity (year)	Shareholding
GECAMINES	Copper 55,512,000 tons Cobalt 3,664,000 tons Zinc 6,400 tons	Copper 470,000 tons Cobalt 16,000 tons Cadmium 300 tons	100% Congolese commercial society of the State
Society of industrial and mining development in Congo "SODIMICO"	Copper ore 3% 1,914,000 tons Copper ore 5% 124,000 tons		100% Congolese commercial society of the State
TENKE FUNGURUME "TFM"	136.800.000 tons of ore containing 3.0% Copper and 0.3% Cobalt	Copper 125,000 tons Cobalt 12,000 tons	Partnership Freeport- McMoRan Copper & Gold Inc. 56% Lundin 24% Gecamines 20%
SICOMINES	Feasibility studies in progress		Partnership: Chinese consortium 68% Gecamines 20% Simco 12%
Mining enterprise KISENGE Manganeseze "EMK-Mn"	Pyrolusite : 5,348,000 tons (wet at 50% of manganese) Carbonate : 6,000,000 tons (wet at 35% of manganese)	360,000 tons	100% Congolese commercial society of the state
Gold mines office of KILO-MOTO "OKIMO"	Reserves estimated: 560 tons	6 tons of Gold (in the seventies)	Partnership OKIMO 20% Moto Goldmines 80%
The Mining of BAKWANGA, "MIBA"	Mining reserves at the end of 1997: 70,960,000 carats of diamonds	10,000,000 carats	
Industrial Mining society of KIVU "SOMIKIVU"		Production accrued from 1978 to 1992 is 3,800 tons of concentrated niobium	Partnership: Congolese State 20% German group "GEF" 70% Somikivu 10%

In 2002, the largest public enterprise in charge of copper production in the Katanga Province, GECAMINES (Quarries and Mines General Corporation), had over 45,000 employees<sup>11</sup>.

Under adjustment programmes sponsored by the World Bank, many of the public enterprises issued cost-cutting policies including massive retirement programmes. In line of these massive retirement programmes, the figure of manpower in mining fell down. Based on 2006 data, the number of workers in all state mining companies was estimated to be slightly less than 30,000. Trade union freedom is real and elections are held in the various mining companies<sup>12</sup>. However, there are such a great variety of union workers that it is not the same unions that receive the favour of workers in different companies.

The origin of current artisanal mining derives from population displacements resulting from ethnic tensions and secessionist movements that accompanied the first years of independence, by the end of 1960. These displaced people, without resources or public support, were struggling to survive and were thus introduced to artisanal mining as the only option<sup>13</sup>.

Choosing this kind of activity is justified by the fact that, contrary to agriculture for example, it does not require significant investment and can generate revenue relatively quickly. This is especially the case of diamond mining in both provinces of Kasai. This artisanal mining has spread throughout almost all the provinces, following the successive closures of industrial units. During the entire period of armed conflicts (1996-2003), which have resulted in a *de facto* partition of the country, there was no investment in mining.

There are several estimates of the number of persons employed in artisanal mining. In its report above on the sources of growth in the DRC, the World Bank indicates that 500,000 to 2,000,000 persons are directly or indirectly involved in artisanal mining (from the digger to the dealer). Half of these are working in the diamond sector, mainly in the two Kasai provinces and nearly 250,000 people are involved in the exploitation of heterogenite in Katanga.

These miners are all informal workers without employment contracts. They are not unionized, strictly speaking. However, there are associations to defend their interests; the most organized are those operating in the Province of Katanga and both Provinces of Kasai namely EMAK (Association of Artisanal Miners of Katanga), UCDAK (Union of Diamond Diggers of Kasai) and the association of furnace workers or diamond dealers. In 2004, these associations claimed a total membership of over 50,000, but this is difficult to verify<sup>14</sup>.

Within this population, there are also many children who are used both for light work and tasks such as working in narrow underground tunnels where adults would have great difficulty to move. Quoting a UNICEF report, the observatory of Urban Changes of the University of Lubumbashi estimates that, in 2007, more than 50,000 children were involved in artisanal mining; among them, 20,000 worked in Katanga and slightly less than 12,000 in Western Kasai<sup>15</sup>.

According to regulations, artisanal mining should take place only within boundaries established for that purpose, after prospecting carried out by relevant public services<sup>16</sup>. In reality, artisanal mining occurs mainly in mining perimeters already granted to private companies, with or without the consent of the owners of mining rights. This is especially the case of diamond mining in both Kasai Provinces<sup>17</sup>. It even happens that, under public pressure, artisanal mining areas are instituted within perimeters covered by mining titles still in force. Such is the case, for the artisanal mining of copper ore and cobalt (also known as heterogenite) in Katanga Province, whose main artisanal mining sites are listed in Table 3. All are concessions of GECAMINES, the public enterprise in charge of copper production in the Katanga Province.

**Table 3.** Artisanal mining exploitation sites allowed in Katanga, in 2004.

Name of the artisanal exploitation zone	Reserves estimated in copper
KARAJIPOPO	50,000 tons
KAROANO	Not available
SHAMITUMBA	3,381 tons
KAMPINA	100,000 tons (probable reserves)
KARUKURUKU	60,380 tons
TOMBOLO	Not available

A study on the artisanal mining sector carried out by the Project PROMINES, funded by the World Bank, has specified more than 214 Artisanal Mining Zones created throughout the country, covering 5,580 km<sup>2</sup> <sup>18</sup>.

When considering the production of various forms of mining, as shown in Table 4, artisanal mining has taken a disproportionate importance in terms of contribution to export earnings. Until recently, more than 70% of copper-cobalt exports came from the artisanal sector. As we noted earlier, this is mainly a consequence of the collapse of industrial mining.

**Table 4.** Quantities exported from DRC in the first half of 2011.

Product	Origin	Quantity exported Tons (except for gold and diamonds)					
		January	February	March	April	May	June
Copper	Artisanal	35,150	22,031	33,203	27,313	22,940	29,162
	Industrial	30,095	30,895	35,503	34,602	34,203	38,616
	Total	65,245	52,926	68,706	61,915	57,143	67,778
Cobalt	Artisanal	38,519	37,970	42,283	41,416	37,738	44,051
	Industrial	15,596	11,631	16,270	12,782	12,869	12,795
	Total	54,115	49,601	58,553	54,198	50,607	56,846
Zinc	Industrial	2,327	1,501	2,013	1,527	1,794	1,751
Tin	Artisanal	179	390	2,708	234	107	497
Coltan	Artisanal	7	5	135	0	0	22
Wolframite	Artisanal	0	0	12	22	0	0
Gold (Kg)	Artisanal	3	21	17	28	36	18
Diamond (carat)	Artisanal	98,944	803,511	592,138	1,098,397	1,512,683	718,423

Many observers have emphasized the impact of fiscal fraud in artisanal mining sector. Even if such issues of governance weakness greatly challenge policymakers, they should not overshadow other equally important problems, such as the current state of occupational health and safety.

## 2. Safety and health

The legislative and regulatory framework of health and safety management system in mining is based on Title 7 of the Labour Code<sup>19</sup> and Article 207 of the Mining Code. The first text provides general principles for health and safety management. It institutes the Enterprise Medical Unit and the Committee of Health, Safety and Workplaces Embellishment. However, these provisions of the Labour Code are still waiting for implementing regulations. They are therefore ineffective, except where these units are established as per good practice.

Article 14 of the Mining Code establishes the responsibility of the Directorate of Mines, in the inspection and monitoring of mining safety and hygiene. Article 207 of the Mining Code states the principle that the only measures that are binding in mining, in terms of security, hygiene and protection, are those issued by special regulations. In compliance to such specific regulations, Article 209 stipulates that any serious or fatal accident occurring in a mine or an open pit or any branch thereof shall be brought without delay and by the fastest media, to the attention of Directorate of Mines and administrative and judicial authorities of the district. Article 210 imposes on all holders of mining rights the obligation to adhere to elaborate safety guidelines, to transmit them to the Administration of Mines and ensure their dissemination within their staff. Referring to the ILO Convention on the Safety and Health in Mines (C176) and the supplementing Recommendation 183, these regulations should set out specific rules relating, *inter alia*, to:

- ability requirements and training;
- checking of the mine, its materials and all the installations;
- organization and checking of handling, transportation, storage and use of explosives and hazardous substances used or produced during the mining process;
- work on electrical installations and equipment;
- measures and emergency and rescue procedures in case of serious accidents, and
- follow up of workers.

Instead of introducing specific provisions related to health and safety in mines, Article 492 of the current Mining Regulations refers to other regulations that must be set at the ministerial level. At the time of writing, these regulations had still not been enacted. As a consequence, Appendix XVI of the Mining Regulations, which is supposed to set the terms and conditions of the use of explosives, still refers to Order No. 43/266 from 8 August 1955. This is a provision that is considerably older than the majority of mining codes promulgated so far.

However, Article 497 of the Mining Regulation requires that any holder of mining licenses, keeps a diary called "Journal of site", which must record all events occurring within the mining, including accidents. Despite many attempts, we were not able to obtain copies of these diaries or any accident reports. If these statistics are indeed kept, this means that either the relevant administrative authority does not track them, or the mining management lacks transparency.

The requirement to report accidents also emerges in the Appendix V of the Mining Regulation, titled "artisanal miners' code of conduct"<sup>20</sup>. This regulation is more detailed than the Appendix relating to industrial mining; however, it contains very few provisions

dealing with health and safety of the artisanal mine operator. Indeed, it focuses more on site preparation operations, use of wood and water supply needs for the operation, conservation of vegetables cut during the mining operations, and so on.

Specific rules declare that artisans have to be taught about artisanal mining techniques by Specialized Technical Services of the Ministry of Mines. Among the few specific rules dealing with safety in the artisanal miners' code of conduct, one provision concerns the prohibition of operations in tunnels and the obligation to respect a maximum slope of 15% in excavations, with tunnels having a minimum width of 1 meter and a maximum height of 2 meters.

In fact, none of these provisions are enforced. Galleries are the main method of exploitation, since they are less expensive to execute than excavations. "Open pits" are characterized by steep slopes on at least three of their four walls, which exposes miners to landslides. This makes open pits as risky as galleries without supports. For example, in the artisanal mining site called "Pompage", no less than 13 landslides in a calendar year have been reported<sup>21</sup>. This figure is probably an underestimate since these accidents are usually reported only when they result in loss of life.

Landslides and other similar accidents are also reported in the diamond mining, particularly in the provinces of Kasai, where a study suggests figure of 14 landslides or collapsed mines per year<sup>22</sup>.

Investigations that highlight non-fatal accidents show a very high frequency of incidents that affect over 72% of miners sampled, 40% of whom have experienced more than one accident during the survey period<sup>23</sup>. The impact of bad working conditions on the health of miners is also indicated by the higher frequency of symptoms of diseases related to musculoskeletal disorders, lung problems, etc., as compare to the general population<sup>24</sup>.

A study on the level of toxic heavy metals in the hair of artisanal miners in the Katanga province<sup>25</sup> showed that the concentration of toxic metals is very much higher for the miners than for a control group of students, for most of the 22 identified and quantified elements. This reveals the importance of developing strategies for preventing toxicological hazards associated with artisanal mining.



**Table 5.** Record of fatal accidents due to landslide in the ‘POMPAGE’ quarry during eight months, 2005-2006.

Month	Site	Number of accidents	Number of deaths	Causes	Observations
November	Cobalt	3	–	Drowning after a rain flood	3 survivors after 3 days under ground
	Red	1	3		
December	BAMBATA	1	1	Landslide	
				Closing of the entry of the cave	
January	Kimono	1	3	Seeping of the rain	
February	“Red embankment”	1	3	Cave-in an embankment	
March	None	0	0	–	
April	“Red embankment”	1	2	Landslide	
May	Cobalt	3	6	Landslide	
June	Kimono	1	7	Suffocation caused by insertion of a motor-driven pump in the well.	
July	None	0	0	–	Dry season
August	None	0	0	–	
September	BAMBATA Sect. Mahembe	1	4	Landslide	
October	“Engine”	1	2	Inaccessible well: because of splits	
	7 different sites	13 accidents	35 deaths	4 different causes	

### 3. Current needs

The mining sector is currently under re-industrialization but this will not necessarily result in a decline of artisanal mining. Strategies for promoting occupational health and safety in this context will therefore reflect this duality.

#### 3.1 Completion of the legal framework of promotion of health and safety

Several authors have criticized how privatization of public mining took place, including the selling of state property<sup>26</sup>. In addition, the privatization marginalized the management of occupational health and safety.

This is why it is important that the regulations in this area are complemented with specific rules that promote health and safety. Regulations controlling mining date back to October 1930; those concerning compliance to security measures in opencast mines, came into effect

in 1955. Internationally, there is legislation that stimulates the issuance of such regulations: this is the case of the ILO Convention 176 and Recommendation 183 on Safety and health in mines. Legislative efforts will have to be supplemented by the dissemination of technical standards, guidelines and practical directives to managers, occupational health and safety professionals, as well as to the workers themselves.

It is also important to question delegating the promotion of occupational health to the directorate that also monitors regulations related to mining production, transportation, marketing and which is also responsible for compiling and publishing statistics (Article 14 of the Mining Code). In contrast, environmental issues related to mining are managed by a newly created dedicated department; the issue of occupational health should have been handled in the same way in order to stress the importance of promoting health in this area.

In my opinion, compliance with safety rules should be reinforced, and include transparency if the Authority in charge of monitoring the implementation of regulations has the mandate to do so. I believe that efforts should be made to gather all aspects of occupational health and safety within a specific service, as stipulated in the ILO Convention 176. The risk of not doing so is to relegate the problems of health and safety to the background, as it is now.

### **3.2 Re-thinking supervision of artisanal mining**

The mining craze in DRC and the fact that some deposits may not, in any case, be exploited industrially, means that artisanal mining will continue. Hence, it is necessary to develop supervision strategies to fight against various problems arising from such exploitation, including problems of health and safety.

Various studies in this area conclude that the choice of supervision depends on the degree of formalisation of this activity<sup>27</sup>, which is still carried in the ignorance of regulations, including those specifically enacted for artisanal mining. The level of ignorance cannot be solely a result of the inability of services that are responsible for supervising artisanal miners<sup>28</sup>. Initiatives that could accelerate the formalisation of artisanal mining might include introducing a permit for artisanal mining, to encourage miners to organize themselves around a mine belonging to them, exclusively, even for a reduced term<sup>29</sup>.

In this kind of artisanal mining, it is easy to introduce a certain degree of mechanization, because the cost of this mechanization can be offset by a more or less guaranteed production level over time in the appropriated mine. Such mechanization could, even briefly, help to reduce the physical strain encountered by workers in artisanal mining and which is the main source of musculoskeletal disorders in this sector.

In addition to this incentive to formalise and mechanise, there are other ways to achieve compliance with safety standards. Indeed, the basic principle in management of occupational health and safety is to call upon the responsibility of the employer rather than the worker's awareness of danger. But, in informal artisanal mining, there is no employer;

so the current regulations assume that, under such circumstances, training will make the artisanal worker more conscientious. In fact, this approach to promoting occupational health and safety based solely on training is ineffective since artisanal miners are no more conscientious than workers in the formal sector and industry. We should instead develop a concept of third-party responsibility for artisanal mining – the holder of the mining rights, with exclusive purchase rights for the product of artisanal mining should have a third-party responsibility for health and safety of all people working in their mining operation.

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# Safety and health in mining in South Africa

## Basic facts about South Africa

Size of area	1,219,000 sq km
Population	49 million
Capital	Pretoria
Literacy	86%
GDP per capita (PPP)	US\$ 11,300
Gini index	65
Infant mortality rate	43 deaths before age 1 year/1,000 live births
Median age	25 years
Life expectancy at birth	female: 48 years, male: 50 years

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We thank Martin Kohler and Made Hugo, Department of Mineral Resources, for providing health and safety statistics, and Dr Deodat Kritzingler for information about noise-induced hearing loss.

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## **1. Mining activities**

### **1.1 Importance of mining to the South African economy**

South Africa is a middle-income country and the dominant economy on the African continent. The country's economy was built on mining, which began with the discovery of diamonds and gold in 1866 and 1886, respectively. Mining was a major contributor to the national Gross Domestic Product (GDP) throughout the Apartheid era but, as the South African economy diversified, mining became less dominant, and the industry contributed only 10% to the national GDP in 2009. However, it contributed 32% to the total export of goods in that year<sup>1</sup>, and accounted for 43% (R1.9-trillion) of the Johannesburg Securities Exchange at the end of 2010<sup>2</sup>. Thus, mining remains central to the South African economy, and will continue to do so well into the 21<sup>st</sup> century. The fundamental global role that mining currently plays is likely to be a long-term one as world demand for minerals continues.

South Africa produced 53 different minerals from 1,548 mines in 2009<sup>1</sup>, although many of these mines are small operations. The wide spectrum of minerals and other commodities mined is dominated by the large reserves and high value of the platinum group metals, gold, manganese and chromium (Table 1).

South Africa has some of the most highly developed primary processing facilities worldwide, including those for carbon steel and stainless steel, and produces large quantities of processed commodities, some of which are listed in Table 2. Other processed commodities not listed in the table include antimony trioxide, low manganese iron, phosphoric acid, titanium slag, zinc metal, elemental phosphorous, and aluminium.

Although large proportions of both primary and processed commodities are exported (Tables 1 and 2), much is used locally. For example, 98% of the country's cement and more than 90% of the country's steel is produced from locally mined minerals<sup>5</sup>. In 2009, minerals were exported to 82 countries; Europe and the Pacific Rim countries are the most important export destinations, accounting for 73% of primary minerals and 51% of the selected processed minerals, respectively<sup>1</sup>.

**Table 1.** South African production, export, global reserves, and rankings of major primary mined commodities <sup>1,3,4</sup>

Commodity	Total sales value 2010	Export value (%) 2010	Reserves 2009		Production 2009	
	(Rands X 10 <sup>9</sup> )	(Rands X 10 <sup>9</sup> )	Global %	Ranking	Global %	Ranking
Platinum group metals	73.8	65.9 (89)	87.7	1	54.8	1
Coal	73.2	36.8 (50)	7.4	6	3.6	7
Gold	53.1	51.0 (96)	12.8	2	7.8	5
Iron ore	43.4	40.2 (93)	0.9	9	4.7	5
Manganese	10.7	9.3 (87)	24.1	2	25.1	2
Chromium	6.6 <sup>a</sup>	2.5 (38) <sup>b</sup>	72.4	1	17.4	1
Nickel	6.0	4.9 (82)	5.2	8	2.4	12
Copper	4.4	1.2 (27)	2.4	14	0.6	12
Vermiculite	0.2	0.2 (100)	26.4	2	39.0	1
Vanadium	2.5	2.2 (88)	23.0	3	25.0	3
Zircon	NA	NA	25.0	2	32.2	2
Titanium	NA	NA	9.8	4	19.2	2

Notes:

- a The average monthly Rand:Dollar exchange rate ranged from 7.5:1 to 10.0:1 in 2009, and from 6.8:1 to 7.7:1 in 2010
- b chromite; NA: not available
- c South Africa was also the third largest producer of asbestos in the world, and mined all three commercial types (chrysotile, crocidolite and amosite) from 1800 until the last mine was closed in 2002. The use, export and import of asbestos in South Africa is now banned.

**Table 2.** South African production and export of major processed commodities, 2010 <sup>1,3</sup>

Commodity	Total sales value (Rands X 10 <sup>6</sup> )	Export value (%) (Rands X 10 <sup>6</sup> )
Ferro alloys	36.9	32.7 (89)
Chromium alloys	27.1	24.2 (89)
Manganese alloys	7.6	7.0 (92)
Vanadium	2.5	2.2 (88)
Silicon alloys	2.3	1.5 (65)

## 1.2 Structure of the South African mining industry

From the late 1800s, the South African mines have been privately owned, initially by individuals and then by white-owned companies that gradually grew into large multinational companies, such as Anglo American, De Beers, Gencor, BHP Billiton, Goldfields, JCI,

Anglovaal and Rand Mines<sup>1</sup>. Post-Apartheid, there has been a move by the Government towards black ownership through the Broad-Based Socio-Economic Empowerment Charter for the South African Mining Industry of 2002 (The Mining Charter)<sup>6-7</sup>, but this process has been slow. In 2009, only 9% of the country's mining assets were black-owned, against a target of 15%<sup>7</sup>.

There have been recent calls for nationalisation of the mines from some political sectors, but this has not been supported by the National Union of Mineworkers, the Government, or the Chamber of Mines<sup>8</sup>.

The Government has a policy to encourage small mining companies and to legitimise small-scale operations<sup>7</sup>. Many junior exploration companies are now active in developing several small- to medium-scale operations, mainly in diamonds, gold and platinum<sup>9</sup>.

There is also illegal mining in South Africa, most of which is run by crime syndicates. In 2010, it was estimated that illegal mining cost the industry around R5 bill. per year (around \$ 0.6 bill.)<sup>10</sup>.

### **1.3 Employment in the South African mining industry**

Mining in South Africa is largely a formal sector economy; only 1,000 to 5,000 workers were employed in the informal mining sector in 2010.

Employment in the mining industry has decreased by around 40% in the last 25 years, adding to South Africa's high unemployment rate, which is currently estimated to be around 25%. However, the industry still employed almost 500,000 workers in 2010<sup>3</sup>, representing 3% of the country's economically active population<sup>1,7</sup>, plus an additional 400,000 employed by suppliers of goods and services to the industry<sup>13</sup>. The sector mining platinum group metals is the largest employer, contributing 36% of total mining employment, followed by gold at 32%<sup>3,7</sup>.

Generally, mine workers have a low level of literacy<sup>14</sup>. The industry is male-dominated, but there is a move to increase the proportion of women employed. The Mining Charter aimed for 10% of women to be employed by 2007<sup>6</sup> but the proportion in that year reached only 6%, increasing to 8% in 2010<sup>3</sup>.

The South African mining industry is synonymous with migrant labour. The practice of employing migrants from both within the borders and neighbouring countries began in the late 1800s in the diamond mines, but was soon adopted by the gold mines. Initially, most workers were oscillating migrants on short-term contracts<sup>15</sup>. Changes gradually resulted in employment becoming more permanent but the migratory nature of mining employment is entrenched and, although the numbers have decreased, migrants remain a major source of labour in all South African mines (Table 3).



**Table 3.** Number of foreign workers employed by South African gold, platinum and coal mines, 1996-2010<sup>16</sup>

Year	Swazilan	Mozambique	Lesotho	Botswana	Total
1996	14,371	55,022	81,357	7,932	158,682
1997	12,960	55,027	76,360	7,536	151,883
1998	10,338	52,011	60,450	6,223	129,022
1999	9,307	46,890	52,436	5,130	113,763
2000	8,160	44,014	51,351	4,343	107,868
2001	7,794	45,254	49,599	3,651	106,298
2002	8,587	50,589	54,390	3,551	117,117
2003	7,885	52,205	54,202	4,246	118,538
2004	7,521	48,099	48,437	3,923	107,980
2005	6,878	46,256	43,693	3,257	100,084
2006	7,124	46,709	46,082	2,992	102,907
2007	7,099	44,879	45,608	2,845	100,431
2008	6,397	43,004	42,851	2,654	94,906
2009	5,855	39,090	38,559	2,357	85,861
2010	5,009	35,782	35,179	2,042	78,012

In recent years, the practice of contract labour (whereby individuals are employed by external companies contracted by the mining company to work at a particular mine) has increased in all commodities (Table 4). Many of these contractors are ex-migrant workers seeking work, and so the migrant labour system has, to some extent, simply become informal.

Approximately 80% of mine workers are union members. Most belong to the National Union of Mineworkers, which was formed in 1982. The union represents workers in the mining, construction and electrical energy industries in South Africa, and is the largest affiliate of COSATU (Congress of South African Trade Unions). The current unrest in the South African mining industry, which started in the platinum mining sector, is a contentious issue, with numerous reports suggesting that the NUM is not representing mine workers' interests with regard to wages. Other workers belong to the United Association of South Africa, and Solidarity<sup>1</sup>. Many co-operative organizations serve the interests of the smaller groups and independent operators, or specific sectors of the industry. All the unions are active in issues of occupational safety and health.

The Chamber of mines, formed soon after the Rand gold fields were proclaimed in 1886, is the industry employer's organisation with representation from all mining sectors.

**Table 4.** Number and proportions of contractors employed in different mining sectors in 2010<sup>17</sup>

Mining sector	Total employees	Contractors	
	n	n	%
Iron ore	18,578	10,963	60
Manganese	5,690	3,274	57
Coal	71,588	34,640	46
Chromium	13,719	5,697	42
Copper	3,309	1,171	35
PGMs*	168,591	57,591	32
Diamonds	11,159	2,694	24
Gold	143,750	22,338	14

\* Platinum Group Metals

## 2. Safety and health

The South African mining industry has a poor health and safety record and performance levels for both are far below international standards. In 2003, the Department of Mineral Resources identified three major areas for improvement of health and safety in the mining industry (Table 5).

### 2.1 Safety

There has been some improvement in safety in the South African mining industry over the past 10 years (Table 6), but both fatality and injury rates remain high, especially in underground gold mines. The improvement in safety was largely the result of the findings of the Leon Commission of Inquiry into Safety and Health in the Mining Industry<sup>18</sup>, which was shortly followed by the promulgation of the Mine Health and Safety Act of 1996<sup>19</sup>. The Leon Commission estimated that, at 1993 accident levels, a worker who spent 20 years underground faced a 1 in 30 chance of being injured or killed in the gold mines. In that year, 578 mineworkers died in accidents - more than 1/1000 of the workforce. In the same year, 8,532 mineworkers were seriously injured (more than 15/1000).

**Table 5.** Occupational health and safety mining industry targets and milestones

Target	Milestone
Zero rate of fatalities and injuries	To achieve safety performance levels equivalent to current international benchmarks, by 2013.
Elimination of silicosis	To reduce 95% of all respirable crystalline silica measurements to below 0.1mg/m <sup>3</sup> by December 2008 and, after December 2013, to have no new cases of silicosis amongst previously unexposed individuals.
Elimination of noise-induced hearing loss	To have no deterioration in hearing greater than 10% amongst occupationally exposed individuals after December 2008 and, by December 2013, for the total noise emitted by all equipment to not exceed a sound pressure level of 110dB(A).

**Table 6.** Fatality and injury rates in the gold, coal and platinum mining sectors, 2001 - 2010

Year	Fatality rate (per 10 000 workers)* Mining sector			Injury rate (per 10 000 workers)* Mining sector		
	Gold	Platinum	Coal	Gold	Platinum	Coal
2001	8.9	4.9	3.7	167.4	80.0	35.7
2002	8.6	4.8	4.4	165.0	59.4	33.9
2003	7.5	4.5	5.1	155.2	58.2	39.8
2004	6.1	4.3	4.0	159.5	59.6	37.6
2005	6.5	3.0	2.8	145.5	74.5	31.8
2006	7.1	2.4	3.5	145.1	80.0	46.0
2007	6.9	2.8	2.5	136.9	66.0	33.9
2008	5.1	1.8	3.1	116.4	60.5	50.9
2009	5.1	2.2	2.5	109.8	70.5	41.7
2010	3.9	1.9	1.5	88.1	79.4	36.7

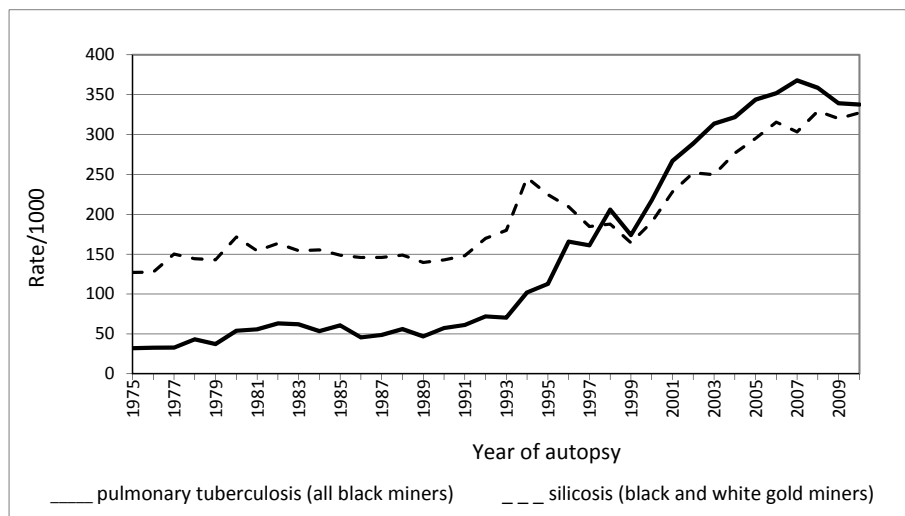
\* calculated from DMR labour statistics<sup>3</sup> and safety statistics provided by the DMR

## 2.2 Silica dust, silicosis and tuberculosis

The Leon Commission also reported that, while statistics for fatal accidents and serious injuries were available, there were none for diseases caused by the mining industry. An exception to this are the data on occupational respiratory disease at autopsy recorded at the National Institute for Occupational Health. Provided the next of kin gives his/her consent, the attending medical practitioner is obliged to send the cardio-respiratory organs of a deceased miner or ex-miner to the National Institute for Occupational Health for examination for compensable disease, regardless of the clinical cause of death. If an occupational disease is diagnosed, a report is sent to the Compensation Commissioner, together with supporting documentation such as employment records, for consideration for financial compensation. Data are available electronically from 1975, and show the high rates of tuberculosis and silicosis in the South African mining industry, largely as a

result of uncontrolled exposure to silica dust (Figure 1). Silicosis is the now the occupational respiratory disease of major concern in the South African gold mining industry: by 2007, rates at autopsy amongst black gold miners had risen to 32%<sup>20</sup>. Silicosis is closely associated with tuberculosis and, together, silica dust, silicosis and Human Immunodeficiency Virus (HIV) have a multiplicative effect on the development of tuberculosis<sup>21</sup>. Mining is one of the industries that is hardest hit by South Africa's dual epidemics of HIV and tuberculosis<sup>15</sup>. HIV rates in the mines are around 25%<sup>22,23</sup> and tuberculosis rates are also at epidemic proportions. In 2007, the South African Department of Health estimated the incidence of tuberculosis in the mining industry to be around 3,000 – 7,000 per 100,000 population per year<sup>24</sup>. Tuberculosis causes more deaths in mine workers than mine accidents.

**Figure 1.** Rates of disease at autopsy, 1975 – 2010. Source: Pathology Division, National Institute for Occupational Health, National Health Laboratory Service.



The milestone to reduce silica dust exposure<sup>25</sup> was not met by 2008, and the proportion of mines reaching 95% compliance decreased from around 94% in 2006 to less than 85% in 2010. Consequently, the Department of Mineral Resources' milestone to have no new cases of silicosis after 2013 is also unlikely to be met<sup>26</sup>.

## 2.4 Noise-induced hearing loss

Noise-induced hearing loss is also a problem in the mining industry, but the mines appear to have been more successful in complying with reducing noise levels than silica dust levels. Current data indicate that the coal, copper, iron ore and manganese mines are 100% compliant<sup>26</sup>. Both the gold and diamond mining sectors report that around 1% of their

employees are exposed to noise levels exceeding 105dB LAeq over an 8 hour shift. However, the proportion of over-exposed workers in the chromium and platinum mining sectors is almost 10 fold higher, at 8%. The number of claims registered with the relevant insurance company has decreased from 2005 to 2010; rates have stabilised since around 2007 in all work areas (unpublished data).

## **2.5 Health and safety agencies and legislation**

Subsequent to the Leon Commission of Inquiry, the Mine Health and Safety Inspectorate, which falls under the Department of Mineral Resources, was established, in terms of the Mine Health and Safety Act, to safeguard the health and safety of mine employees and communities affected by mining operations. The main functions of the Inspectorate are to oversee policies regarding equipment and general safety and health standards at mining operations, and to provide an effective support and inspection service. It is headed by the Chief Inspector of Mines.

The Tripartite *Mine Health and Safety Council* was also established in terms of this Act, and consists of members representing the State, employees and employers in the mining industry. The Chief Inspector of Mines is also the Chairperson of the Boards of the *Mine Health and Safety Council* and the *Mining Qualifications Authority*. In brief, the Council advises the Minister of Mineral Resources on health and safety at mines, promotes a health and safety culture in the mining sector, and liaises with other statutory bodies concerned with matters relating to health and safety in the mining industry. *The Mining Qualifications Authority* is responsible for addressing the education and training needs of the minerals and mining sector.

In accordance with the Mine Health and Safety Act, mines must have health and safety committees, and safety representatives elected by the workers. The Act comprehensively describes the requirements in terms of the representatives' training, election and appointment, rights and powers, qualifications and responsibilities. However, research has shown that neither the health and safety representatives themselves, nor the workers, are fully aware of all these roles, functions and responsibilities<sup>27</sup>.

Two Acts address mine workers' compensation, viz. the Occupational Diseases in Mines and Works (ODMW) Act of 1973 and the Compensation for Occupational Injuries and Diseases (COID) Act of 1993. The ODMW Act provides for compensation for occupational respiratory diseases, such as silicosis, coal workers pneumoconiosis, tuberculosis, obstructive airways disease, and asbestos-related lung diseases. The COID Act covers injuries and some diseases not covered by the ODMW Act, such as noise induced hearing loss. The ODMW Act is administered by the Department of Health and the COID Act is administered by the Department of Labour, which creates some disparities as described by White<sup>28</sup>. Compensation is unavailable to many diseased and injured miners due to difficulties related to access, proof of eligibility and lack of knowledge of legal rights<sup>29</sup>.

## 2.6 Other diseases

There are several other occupational respiratory diseases for which compensation is payable under the ODMW Act, but statistics for these diseases are sparse and less readily accessible than for those discussed in above. The diseases include pneumoconioses in addition to silicosis (asbestosis, coal workers pneumoconiosis and mixed dust fibrosis), obstructive airways disease, progressive systemic sclerosis, asbestos-related lung cancer, mesothelioma, and platinosis which is specific to the platinum refining industry. South Africa has a legacy of asbestos-related disease due to uncontrolled asbestos exposure, which peaked in the 1970s and 1980s. Large parts of the country remain contaminated with asbestos and disease continues to be diagnosed amongst those who worked with asbestos or lived in the vicinity of the asbestos mines and mills<sup>30</sup>. Health effects of mining of many of the smaller mineral reserves in South Africa are under-researched, as are diseases caused by inadvertent exposure to minerals other than the one being mined. For example, recent work has shown that diamond mine workers are at risk of exposure to asbestos<sup>31</sup> and that platinum miners may be exposed to silica dust<sup>32</sup>.

## 3. Current needs

While much research has been conducted in the South African mining industry, its impact on policy implementation and the health and safety of mine workers has been unsatisfactory, as discussed in detail in a recent paper by Murray and coworkers<sup>29</sup>.

Efforts to further reduce mine fatalities and injuries must continue, despite the improvement in safety in the mines. The health of miners, in contrast to safety, has worsened, clearly illustrated by increasing rates of silicosis and tuberculosis. The Department of Mineral Resources' target to prevent silicosis will not be met unless concerted efforts are made to reduce silica dust to safe levels. Adherence to the occupational exposure limit needs to be monitored and enforced by Government agencies, but this will require extended resources. The Mine Health and Safety Inspectorate is under-resourced: from 2002 to 2008, there were only four to five mine inspectors per 10,000 mine employees, and the proportion of vacancies increased from 13% to 30%<sup>33</sup>.

The current occupational exposure limit for silica of 0.1 mg/m<sup>3</sup> may need to be re-evaluated in light of evidence from other countries that the safe level for respirable silica dust may be as low as 0.025 mg/m<sup>3</sup>. At the same time, the unions need to promote the issue of disease prevention on their agendas, which currently focus on safety and wage issues.

In addition to dust control, disease prevention also requires effective surveillance systems. The Department of Mineral Resources needs to establish and monitor disease surveillance programmes, both at a national level and at an individual mine level. In 2011, the South African Constitutional Court ruled, for the first time, that a former gold miner with silicosis could lodge a civil claim against the mining company that employed him, despite qualifying for compensation in respect of the ODMW Act. Currently, more than 300,000 retired gold mine workers with silicosis or tuberculosis are planning a multibillion-Rand class

action against the gold mining companies<sup>34</sup>.

Much needs to be done to address the far-reaching negative health effects of the migrant labour system, and appropriate and relevant policies need to be instituted to ensure that ex-miners, in particular, have access to healthcare and compensation services. This includes boosting health services at all points of contact for migrant workers, viz. labour-sending areas, communities where workers live, and the mines themselves.

One of the grievances of the platinum mine workers during the recent (August 2012) uprising in Marikana, Rustenburg, where 34 striking workers were shot and many more wounded, was the living conditions of migrant workers. While some workers are provided with a 'living out' subsidy, some still live in housing provided by the mines. Improvement in living conditions, both on the mines, and in the communities, is important to lessen the burden of disease.

South African compensation legislation needs to be updated. The COID Act was promulgated in 1993 and the ODMW Act has not been amended since 1994. Both are in need of extensive revision. The amount paid to diseased or injured workers is in the form of a lump sum and is indisputably inadequate.

Most health-related research in the mining industry in South Africa has been conducted on gold miners, followed by asbestos and coal miners. More recently, there has been some work on platinum and diamond miners<sup>16</sup>. However, many mining sectors are under-researched and the health status of miners in these sectors is unknown. South Africa is rich in a diverse range of minerals and there are abundant opportunities for research.

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Ian Eddington

# Safety and health in mining in Australia

## Basic facts about Australia

Size of area	7,741,000 sq km
Population	22 million
Capital	Canberra
Literacy	99%
GDP per capita (PPP)	US\$ 42,400
Gini index	31
Infant mortality rate	5 deaths before age 1 year/1,000 live births
Median age	38 years
Life expectancy at birth	female: 84 years, male: 79 years

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## 1. Mining activities

Prior to colonisation, aboriginal Australians fossicked for stones suitable for tools and hunting instruments, and for pigments for painting. Ever since the first non-indigenous discoveries of minerals beginning with coal in the 1790s, followed by gold, silver-lead, and copper, minerals have played an important role in Australia's economic development.

Under the Australian and New Zealand Standard Industrial Classification (ANZSIC)<sup>1</sup>, mining is understood as the extraction of naturally occurring mineral solids, e.g. iron, liquids such as crude oil, or gases such as methane. First-stage processing of extracted commodities is classified as manufacturing, not mining. In its definition of mining, the Minerals Council of Australia includes primary processing of minerals up to the first pouring of the refined metal.

Australia's deposits of major minerals are considerable. Australia is ranked first in the world for recoverable brown coal, lead, zircon, rutile, nickel, uranium and zinc, second for bauxite, coal, copper, gold, silver, ilmenite, and titanium, third for industrial diamonds, and fourth for iron ore and manganese ore<sup>2</sup>.

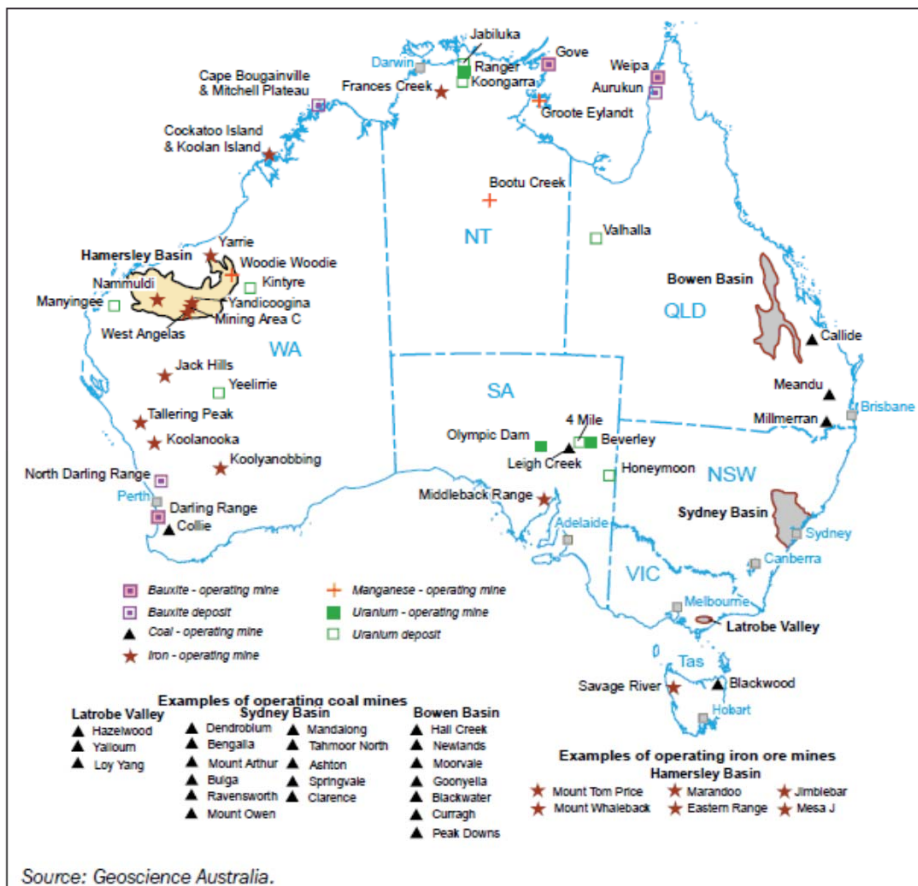
Figure 1 indicates the remoteness of locations of selected deposits and mines. Similar maps are available that illustrate the remote locations of gold and diamond deposits, as well as base metals and mineral sands<sup>3</sup>.

Distances involved are considerable. For example, the distance from the Callide coal deposit in the East to the bauxite deposit near Manyingee in the West is some 3,477 km as the crow flies (4,980 km by road). The remoteness of resources has implications for occupational health, public health and social security as the fly in/fly out rotational shifts stress workers, communities, and social life and structure.

The total value of goods and services produced in Australia in each year is measured by Gross Domestic Product (GDP). The mining industry's contribution to GDP rose from an annual level of 5% throughout the 1990s to some 8% for 2009-2010, with the all-industries average for 2009-10 being 6%<sup>4</sup>. This growth in mining's share of GDP places mining among the leading Australian industry sectors. In the period 2009-2010, after-tax profits for leading mining firms in Australia were some 30% - a rise from 26% in 2008-09, when the all-industries average was 8%<sup>5</sup>. Continued demand for mineral products ensures the importance of mining for the Australian economy.

In 2011, profit margins are considered to be high amongst the big mining firms. For example, BHP-Billerton's profit margin rose from 25% in 2002 to 45% in 2010, with the margin for iron ore reaching 62%<sup>6</sup>. State and federal governments collect substantial revenues from mining royalties. For the period 2006-07, oil and gas provided 46% of the 6,573 million royalty dollars levied; metal ore other than iron provided 14%, iron ore, 13%, and coal, 26%<sup>7</sup>.

**Figure 1.** Selected mines and deposits of bauxite, coal, iron ore, manganese and uranium.  
 Source: *Commonwealth of Australia Year Book 2009-2010* (p. 545).  
 Australian Bureau of Statistics: Canberra.



From 2004 to 2009, the value of mining exports almost tripled, to account for some 51% of total export revenue. Japan, China, South Korea, and India have been major destinations for Australian mineral and petroleum exports since the early 1990s<sup>8</sup>. Consistently high export revenue earners include black coal, oil, and gas, comprising crude oil and other refinery feedstock, liquid natural gas (LNG), and liquid petroleum gas (LPG), iron ore and pellets, and refined gold. Yet export revenues are sensitive to price fluctuations driven by the vicissitudes of world events. In recent years, copper, alumina (ore from which aluminium is extracted), lead, titanium and diamonds have performed well as export earners. During 2011, the demand for Australian minerals to fuel the growth aspirations of China and India, when added to speculative demand for the Australian dollar generated by uncertainty in world financial markets, caused the Australian dollar to appreciate so much as to threaten export earnings from tourism, agriculture, beef and sheep production, and education.

Mining in Australia is largely capital intensive, with the labour force accounting for some 135,000 persons - approximately 1.5% of total employment<sup>9</sup>. Males outnumber females some 7 to 1. A total of 82% of female mining employees perform clerical, administrative and professional work. Some further 5% are miners and 4% are truck drivers. Coal and metal ore mining account for some 54% of total mining industry employment. Exploration and support services account for another 19%, oil and gas exploration for 8%, and non-metallic mineral mining and quarrying, 6%.

While some migrant labour might be employed in support services, for example in maintenance and fabrication, the mining labour force in Australia is largely drawn from Australian citizens, including indigenous Australians. With the possible exception of parts of the precious stones sector, for example opal, amethyst, sapphire and ruby, mining in Australia is decidedly part of the formal economy. Formal and informal employment statistics for the gemstones sector are not readily available because of the small-scale nature of operations and/or the pervading closed-shop culture. The informal gemstones economy has traditionally been the stuff of such practices as the heat treatment of sapphires, export of opal-bearing rock to Germany as core drilling samples, and brown paper bag cash payments.

Union membership has generally declined over the past fifteen years. Under the previous government led by John Howard, Work Choices legislation permitted employees to negotiate individual Australian Workplace Agreements. In 2011, under the Rudd-come-Gillard government in power since 2007, if 50% plus 1% of workers agree, unions may negotiate collective work agreements on behalf of all workers on site.

Workers in the mining industry belong to a range of unions, but the Australian Workers Union (AWU) and the Mining and Energy Division of the Construction, Forestry, Mining and Energy Union (CFMEU) are the most notable. The CFMEU is the principal union in the black and brown coal mining industries. Beginning in 2010, the CFMEU and the AWU are reported to have begun membership campaigns in 12 non-unionised mine projects, the CFMEU mainly targeting coal mines in New South Wales and Queensland, and the AWU targeting hard rock mining in Western Australia and South Australia<sup>10</sup>. The campaigns include in- forming about union advocacy for improved pay and workplace health and safety.

Statistics for foreign ownership and industry structure for Australian mining leave much to be desired. Yet there is firm evidence of high levels of foreign private ownership of Australian minerals resources. For example, foreign ownership of BHP-Billerton, Rio and Xstrata, Australia's biggest mining companies is 76%, 83% and 100%, respectively<sup>11</sup>. In total, some 83% of mining production is foreign owned<sup>12</sup>. In the 12 months to March 2011, \$7 billion of the \$37 billion mining profits generated in Australia flowed directly overseas as dividends or income withdrawals, and \$30 billion were reinvested in further acquisitions or otherwise retained in Australia. There is also increasing public concern that state-owned Chinese companies are gaining control of Australian minerals resources<sup>13,14</sup>. These changed foreign ownership levels, and perceptions of possible geo-political control, are unsettling to the Australian public.

Edwards estimates that under current extraction rates, economic deposits of known iron ore holdings will be depleted by 2036 and for gold by 2026<sup>15</sup>.

## 2. Safety and health

Occupational Health and Safety (OSH) Legislation in Australia is currently addressed under ten federal and state jurisdictions, and in the case of mining, under particular Acts as well. In January 2012 a Commonwealth Model Work- place Health and Safety Bill and Regulations became law. Under this Modal Law OSH is renamed WHS (workplace health and safety). The new law establishes unified and harmonious procedures for public management of WHS by requiring that all states and territories redraft sections of their existing legislation in specified ways. In January 2013 four of the eight jurisdictions had yet to effect such changes.

OHS education and training is available through the trade unions, private providers, state technical and further education colleges, and universities. In some jurisdictions, and depending on circumstances, basic OHS training is a statutory obligation.

The statistics that inform Safe Work Australia are mainly derived from successful workers compensation claims and are thus deficient to the extent that they include some bogus injury and exclude some genuine injury not reported. In spite of these difficulties, officials consider these statistics, and others<sup>16</sup>, to be comprehensive for industrial mortality and morbidity in Australia.

Health and Safety Representatives (HSRs) are provided for under the 2012 Model Act, which specifies their rights, duties and responsibilities irrespective of the industry in which they are working<sup>17</sup>. These powers of HSRs are further qualified by Regulations and caveats governing terms, relationships and procedures. In general, HSRs are elected by workers, after egotiation and agreement between the workers and the person conducting the business or undertaking (PCBU). HSRs represent these workers, monitor measurements taken by the PCBU under the Act, investigate complaints made by workers, and enquire into perceived conditions of OHS risk.

A National Mine Safety Framework to complement the Model OHS Legislation is under development. It will contain a nationally coordinated protocol on enforcement for mining inspectors, who as crown employees, are bound by the laws and regulations of their jurisdictions. Actions allowed range from warnings and fines to restorative court justice. Extreme opinions about the efficacy of the inspectorate are rarely expressed. However, the Queensland Ombudsman found that a perception that inspectors have been captured by industry was reasonable<sup>18</sup> and that governments have difficulty in attracting and holding qualified inspectors who can earn higher wages elsewhere. A long period of fatality-lead mine safety reform in Queensland<sup>19</sup> does, however, question the efficacy of preventive legislation in general, and the inspectorate in particular. Sometimes the need for some types of inspection has been reduced, when, on the basis of user pays, governments have successfully added enforceable rehabilitation clauses to mining lease development.

Non-managerial employees in the mining sector enjoy higher weekly average remuneration than those in any of the other sectors. However, they and their managers have longer average weekly working hours than workers in other sectors<sup>20</sup>. Serious injury claims emerging from these longer working hours are above the all-industry average (Table 1). The fatality rate is in the order of some 7 per 100,000 employees, which is three times the all-industry rate of 2. Mining fatalities in 2008-09 placed mining third highest in the 18-row ANZSIC industrial classification<sup>21</sup>.

Table 1 presents a general profile of the OHS condition of the Australian mining sector. Males are injured at more than three times the rate of females, a factor that may be explained by the high proportion of females employed in administrative tasks. Statistics for time-lost for the mining industry are close to the all-industry average. Incidence of injury is higher for both the youngest, and the relatively older groups, with the incidence of injury increasing with age from year 20 onwards. Labourers, those involved in intermediate production, transport workers, and tradespersons and related workers, are injured at substantially higher rates than workers performing other duties. Injury incidence differs by type of mining. The descending rank order is: other mining, coal mining, and services to mining. Mining not classified elsewhere, which has an incidence rate of 55 per 1000 workers, warrants further attention.

**Table 1.** Fatal and non-fatal injury in the mining sector in Australia <sup>(1)</sup>: incidence, frequency, time lost, mechanism and nature of injury or disease.

Area of Operations	Details											
All accepted workers' compensation claims <sup>(3)</sup> from the mining industry	Fatal/Non-Fatal (F/NF)	Mining industry claims as a % of all industry claims					Mining industry sector % F/NF					
		F					NF					
		3					2					
	Fatality statistics by accident or disease are not available. In 2008-09, mining recorded the third highest fatality rate of the 18 industries.											
	Annual Fatalities 2000-2009	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	09-09		
		18	10	13	8	7	15	7	7	12		
	Serious Claims <sup>(2)</sup>	Mining accounts for some 2% of all serious claims, some 7 such claims per day, which is 32% higher than the national rate.										
	Incidence Rate (Claims per 1000 employees)	Mining = 19/1000 workers for an industry average of 14/1000, making it 5/18 in industry rank; incidence rate is 22.5% for males, 6.0% for females.										
	Frequency Rate by Gender (Claims per million hours worked)	Males = 10; Females = 3										
	Time Lost: % of total weeks lost for mining and for all industries	< 1 wk.		1 < 2 wks.		2 < 12 wks.		12 < 26 wks.		26+ wks.		
		Mining	All	Mining	All	Mining	All	Mining	All	Mining	All	
		14	5	17	26	44	45	14	13	11	11	
	Time Lost: % of total weeks lost in all industries, classified by sex	< 1 wk.		1 < 2 wks.		2 < 12 wks.		12 < 26 wks.		26+ wks.		
		M	F	M	F	M	F	M	F	M	F	
		4	1	18	9	31	14	8	5	7	4	
	Mechanism of Injury or Disease							% of all industry claims	% of mining industry claims			
	Falls, trips and slips							4	22			
	Hitting objects with a part of the body							1	6			
	Being hit by moving objects							4	18			
	Sound and pressure							2	10			
Body stressing (materials handling)							7	33				
Heat, radiation and electricity							0	0				
Chemicals and other substances							0	0				
Biological Factors							0	0				
Mental stress							0	0				
Other and unspecified mechanisms of injury							1	7				
Falls, trips and slips, bodily contact with a moving or stationary object, and materials handling account for some 79% of injury. Muscular stress is involved in (26%) of body stress injury, falls on the same level represent (15%), and falls from a height (7%). Long-term exposure to sound (9%).												
Nature of Injury or Disease							% of all industry claims	% of mining industry claims				
Injury and poisoning							1.5	76				
Diseases of the nervous system and sense organs							2	11				
Diseases of the musculoskeletal system and connective tissue							1	7				
Diseases of the skin and subcutaneous tissue							0	1				
Diseases of the digestive system							0	2				
Infectious and parasitic diseases							n.p. <sup>(4)</sup>	n.p.				
Diseases of the respiratory system							0	1				
Diseases of the circulatory system							0	0.2				
Neoplasms (cancers and benign tumours)							n.p.	n.p.				
Mental disorders							0	1				
Other diseases							n.p.	n.p.				
In the injury and poisoning category, sprains and strains of joints and adjacent muscles explain 48% of claims, and fractures, 12%.												
<b>Deaths from Mesothelioma 1997-2007</b>												
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	
	416	403	390	436	519	490	510	545	537	476	551	

Notes: (1) Statistics are for 2007-2008. Numbers in this table, and throughout the chapter, have been rounded to the nearest decimal for ease of reading. (2) An injury classified as serious results in one or more weeks off work, a permanent disability, or fatality. (3) Claims that resulted in a fatality, permanent incapacity or temporary incapacity, with an absence from work of one working week or more (excluding journey claims). (4) n.p. = data not available due to confidentiality restriction.

Source: Adapted from Safe Work Australia. (2011). *Work Related Traumatic Injury Fatalities, Australia 2008-09*. (passim). Commonwealth of Australia: Canberra; Safe Work Australia. (2011). *The Safe Work Australia Online Statistics Interactive National Workers' Compensation Statistics Databases*. (multiple electronic generations by numerous paired variables). Commonwealth of Australia: Canberra; Safe Work Australia. (2010). *Compendium of workers' compensation statistics Australia 2007-08*. (passim). Commonwealth of Australia, Canberra; Pink, B. (2010). *Year Book, Australia 2009-2010*. (pp. 527-540). Australian Bureau of Statistics: Canberra; Safe Work Australia. (2011). *Mining Information Sheet*. (p. 1). Commonwealth of Australia: Canberra; Safe Work Australia. (2011). *Mesothelioma in Australia* (p.18), Commonwealth of Australia: Canberra.



The most heavily implicated causes of injury are mobile plant, non-powered hand tools appliances and equipment, materials and substances, and environmental factors such as sun, dusts, particulate matter. This is a situation that begs questions about training in safe job practice, and usage of personal protective equipment. Falls, trips and slips, bodily contact with moving or stationary objects, and materials handling, account for some 79% of injuries. Muscular stress is involved in 26% of body stress injury. Falls on the same level represent 15% of all falls, and falls from a height, 7%. Long-term exposure to sound pressure represents 9%, an untenable statistic given the now long-established technical efficacy of the science and technology available for the prevention of industrial deafness.

Comprehensive statistics for occupational disease by industry are not readily available in Australia. Eight all-industry classes of industrial “disease” attract priority preventative interventions: musculoskeletal disorders, mental disorders, noise induced hearing loss, infectious and parasitic diseases, respiratory diseases, contact dermatitis, cardiovascular diseases, and occupational cancers<sup>22</sup>. Most recent statistics indicate that the incidence of these diseases has decreased from 2000-01 to 2006-07, except for the incidences of noise-induced hearing loss, respiratory diseases, and occupational cancers, which have remained relatively steady<sup>23</sup>.

Unfortunately, it is not possible to isolate the contribution made by mining to these diseases although, in general reports, mining support workers and drillers’ assistants are named amongst workers most afflicted by body stressing and industrial deafness. Much of Australia’s mining is carried out by open cut methods, which may help explain the relatively low incidence of hospitalisations for pneumoconiosis resulting from coal dust or dust containing silica. Over the period from 1998 to 2007, hospitalisations remained below 5 per million adults per annum except 1999-2000. Other, more qualified indicators of pneumoconiosis are needed, since the disease is debilitating long before hospitalisation, and not all adults work in the mining industry.

The mesothelioma statistics reported in Table 1 require further comment. From 1937 until 1966, mining of asbestos was dominated by extraction of blue asbestos (crocidolite) from the Wittenoom mine. Complementary imports came from South Africa and Canada. Manufactured asbestos products also flowed into Australia from the USA, UK, Federal Republic of Germany and Japan. Some 90% of asbestos consumption was for asbestos sheeting and roofing. During this period, those working with disintegrating and pulverising asbestos in the asbestos cement industry were exposed to 150 fibres/ml. Those working as baggers at Wittenoom were exposed to 600 fibres/ml<sup>24</sup>. Exposure limits of 0.1 fibres/ml and 0.1–1.0 respectively for blue (crocidolite) asbestos and brown (amosite) asbestos were imposed throughout the 1970s and 80s and the use of all forms of asbestos, excepting asbestos products already installed, was banned in 2003<sup>25</sup>. The emergence of mesothelioma may be the result of exposure to, and inhalation of, asbestos 20-40 years earlier. According to various models, mesothelioma notifications are predicted to peak in 2014, 2017 or 2021<sup>26</sup>. Many of the workers afflicted with mesothelioma migrated to Australia during the two decades following the end of World War 2, in order to start new lives.

### 3. Current needs

The future of atomic energy is once again under debate after the tsunami that struck the coast of Japan in 2011. Coal is also becoming increasingly unpopular since it causes externalities, such as extensive pollution and release of greenhouse gases. Thus, uranium industry research into commercially viable fusion-generated electricity might bring longer term health and safety benefits occasioned through reduced handling, transport, storage and disaster management of hazardous wastes. Likewise, coal industry research into viable CO<sub>2</sub> capture and sequestration might help reduce exposure to occupational hazards induced by climate change. Unfortunately, researchers in these fields face very substantial technical problems.

More comprehensive foreign ownership statistics, collected and published by the Australian Bureau of Statistics (ABS), might better serve more measured and sustainable exploitation of Australian minerals which, in turn, might reduce the economic and work stress externalities the present mining boom is having on other industrial sectors. It is questionable whether available public domain statistics on foreign ownership of Australian minerals resources, on rates of extraction and depletion of those minerals, and on the effect of boom-time work schedules on industrial mortality and morbidity are sufficient to enable Australian citizens to inform themselves about actual conditions, or, for that matter, are a sufficiently valid basis for public policy decision making. Citizens continuously voice concerns about the availability and nature of work when depletion follows boom-time extraction, but authorities appear to pay little attention to these psychologies of work anxieties. Politicians should urgently address such questions.

OHS professionals are encouraged by Safe Work Australia again after being sidelined for a long period. Safe Work Australia might well rebuild its OHS research capacity and publish reports that drill down and investigate conditions that lie behind the statistics now available. In rebuilding its research staff, Safe Work Australia might consider appointing sociologists, ethicists, industrial psychologists, and epidemiologists to complement those specialists needed in science, ergonomics, medicine, health economics, and the like. More comprehensive statistics about industrial diseases are needed. The ABS might well also regularly complete and publish studies on mining industry structure, conduct and performance.

Mining is an important part of the Australian economy and an important revenue earner for the government. High profitability notwithstanding, much of the industrial mortality and morbidity of the mining sector is preventable.

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Susan Haldane

## Safety and health in mining in Canada

### Basic facts about Canada

Size of area	9,985,000 sq km
Population	35 million
Capital	Ottawa
Literacy	99%
GDP per capita (PPP)	US\$ 41,500
Gini index	32
Infant mortality rate	5 deaths before age 1 year/1,000 live births
Median age	41 years
Life expectancy at birth	female: 84 years, male: 79 years

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## 1. Mining activities

Canada has traditionally been known as a land of ice and snow, rocks and trees. While the country has become increasingly urbanized and its economy increasingly diversified, it maintains a reputation for rich natural resources. Canada is a top producer of a number of minerals, and a leader in exploration and in mining finance.

Canada is a country of 10 million square kilometres, stretching 5,000 kilometres from east to west and covering more than 40 degrees of latitude. In 2009, there were 961 mining establishments – 71 metal mines and 890 non-metal mines, which is a substantial increase from the 757 mines in 2004<sup>2</sup>. Together, the mines provide virtually every mineral known to man. With more than 30 refining and smelting plants across the country, production of refined minerals is also vital to Canada's mining industry.

In 2009, Canada was the world's top producer of uranium, with a fifth of global production, and of potash, with a third of production. It was the second leading producer of nickel and cobalt; the third producer of titanium concentrate, platinum group metals and aluminium; and a top-five producer of diamonds, chrysotile, zinc, molybdenum and salt<sup>3</sup>. Mineral production contributed \$32 billion to the national economy in 2009 – 2.7 per cent of the gross domestic product<sup>4</sup>. Canada's exports in 2009 were valued at roughly \$66 billion – notably in iron and steel, aluminium, copper, gold, and nickel<sup>5</sup>.

Canada is currently the only G8 nation exporting chrysotile asbestos, which is mined almost exclusively for export in the province of Quebec. In 2011 Canada blocked an international agreement to restrict the sale of chrysotile and add it to the UN list of hazardous materials. The vast majority of medical and safety professionals in the country oppose the mining, use and export of chrysotile. The Canadian Public Health Association issued a position statement calling for the ban on the mining, transformation and export of chrysotile asbestos<sup>6</sup>. However, proponents argue that exposure to the cancer-causing agents in the mineral can be limited through proper extraction and handling methods.

Canada also plays a key role in global mining finance. According to the Mining Association of Canada, "Canadian firms are responsible for the largest share of exploration spending in Canada, the U.S., Latin America, Central America, Europe and, most recently, Africa. This exploration strength, combined with the ability to turn properties into mining projects, has helped make Canada a world centre for mining finance<sup>7</sup>. Canada claims 16 per cent of the world's exploration budget<sup>8</sup> and more than a third of worldwide mining equity is raised on the Toronto Stock Exchange<sup>9</sup>. The largest share of exploration spending – \$607 million in 2010 – lands in the province of Ontario<sup>10</sup>.

At the same time, however, mineral reserves in Canada are shrinking. Known copper and nickel reserves, for example, are less than half what they were in 1980, while reserves of lead, zinc and silver are a fraction of former levels. Only gold reserves have increased marginally since 1980<sup>11</sup>. As a result, mining companies are searching farther and farther afield, trekking into more remote areas to find new reserves, moving deeper underground, or re-opening older mines as mineral prices make extraction more economical. Remote and

revived operations present a host of safety and health issues, including travel distances and transport of injured workers, severe winter conditions, dewatering, and ventilation of older and deeper workings.

The mining industry in Canada is challenged by a broad demographic trend that troubles businesses of all sorts in the country. Half of the Canadian population is aged 40 and over<sup>12</sup>. In Canadian mines, it is estimated that between 60,000 and 70,000 workers may retire by the year 2021<sup>13</sup>. Mining companies have difficulty recruiting skilled workers, particularly as operations develop in the far north and in remote regions further from established communities. As the older workforce retires, it is replaced by young workers whose inexperience exposes them to a greater risk of injury.

Canada's mining industry employs just over 300,000 people, including 51,000 workers in mineral extraction, 9,000 in primary metal manufacturing, 49,000 in non-metallic mineral product manufacturing and 47,000 in fabricated metal product manufacturing<sup>14</sup>. This is a reduction from close to 400,000 employed a decade earlier.

It is estimated that only approximately 14 per cent of workers engaged in mineral extraction and processing are women<sup>15</sup> and only about 1.5 per cent are drawn from Canada's Aboriginal populations<sup>16</sup>. However, as the search for reserves increasingly moves into Canada's remote areas, where populations are more predominantly Aboriginal, it is anticipated that this ratio will increase. New Canadians – immigrants to the country – are also under-represented in the mining workforce, comprising only nine per cent of the mining workforce, while they total 21 per cent of the general Canadian workforce<sup>17</sup>.

## 2. Safety and health

The central role that mining has long played in Canada's national story has led to the establishment of health and safety standards, regulations and achievements which are among the highest in the world.

Canada's political structure is federal, with power and responsibility shared between a national government and 13 provinces and territories. Health and safety is primarily a provincial matter, and as such it is difficult to obtain national health and safety statistics or identify national health and safety trends. The remainder of this section will focus on mining health and safety in the province of Ontario. Ontario is the leader – albeit by a small margin – in the value of mineral production compared to the other provinces, and is the leading producer by quantity of gold, nickel, sand and gravel. Ontario does not currently produce coal, potash, iron ore or uranium in any significant amounts.

Mining and mine contracting companies in Ontario directly employed more than 18,000 people in 2011, with many thousands more employed by mining support industries. In 2009, the province was responsible for roughly \$6 billion of Canada's \$32 billion in mineral production, making it the leading province.

While programs and structures for health and safety may differ from one jurisdiction to another in Canada, standards – both legislated and voluntary – are similar across the country.

## **2.1 Current status of health and safety in mining in Ontario**

The shape of health and safety in Ontario today was to a large extent determined by a catastrophic fire in the Hollinger gold mine in Timmins Ontario in 1928. Of 51 men trapped underground, only 12 were rescued – the greatest tragedy in Ontario mining in the modern era. The Ontario government launched a commission of inquiry, which led to the establishment of both an accident prevention association and an organization to oversee mine rescue. Both of these organizations exist today, their budgets provided through mandatory insurance dues that companies pay on behalf of their workers to provide insurance coverage in case of workplace-related injury or death.

In the 1930s, following the Hollinger fire, an average of 39 miners were killed on the job per year in Ontario<sup>18</sup>. In the most recent decade, 2001-2010, the annual average was 2.3. Another 17 per year on average die due to occupational disease (including lung cancer and other respiratory diseases, cancer and diseases of the stomach and abdominal cavity)<sup>19</sup>.

In 2010, the most recent year for which statistics are complete, lost-time injuries in Ontario's mines occurred at a frequency of 0.5 per 200,000 hours worked. (These are injuries serious enough for the worker to miss time at work, averaged roughly per 100 workers.) The most frequent causes of injury are being struck by objects, overexertion, bodily reactions, falls on the same level, and being caught in or compressed by equipment or objects<sup>20</sup>. The most common causes of fatalities are powered haulage and motor vehicle accidents, falls from heights, and machinery<sup>19</sup>. In plain language, while the rate of injuries has declined substantially, the hazards most likely to cause serious injury or death for miners in Ontario today are the same hazards which have endangered miners for decades: falling rock underground, falls down shafts and other openings, and large powered equipment such as load-haul-dump machines.

The age breakdown of lost-time injuries in Ontario mining reflects the workforce demographics, with 44 per cent of injuries affecting workers aged 45 and older<sup>21</sup>. (These workers make up roughly half the workforce.)

Insurance claims for disease are largely due to noise-induced hearing loss and hand-arm vibration syndrome (non-fatal disease claims), and lung cancer and silicosis (fatal disease claims).

## **2.2 Health and safety policy issues**

Health and safety in Ontario – not only in mining, but also in all industries – is predicated on a concept called the “Internal Responsibility System” (IRS). This concept was first described



during a commission into mining safety in the 1970s, and later came to be the cornerstone of Ontario's Occupational Health and Safety Act, which governs virtually all workplaces in the province. The IRS has more recently been described as "a system, within an organization, where everyone has direct responsibility for health and safety as an essential part of his or her job. It does not matter who or where the person is in the organization – they achieve health and safety in a way that suits the kind of work they do. Each person takes initiative on health and safety issues and works to solve problems and make improvements. They do this both simply and cooperatively"<sup>21</sup>. Ensuring health and safety, according to this belief, is not the task of government or safety associations – although they play a contributory role. Health and safety can only be ensured if suitable measures are built into every person's job in the workplace, with senior managers and board of directors taking direct and ultimate responsibility. If an incident or injury occurs, it is seen as a failure of a company's internal responsibility system. The mining industry has adopted the IRS as a philosophy, with varying degrees of success in its application. The mining industry in Ontario, while spread out geographically, is relatively labour-efficient and compact in terms of personnel. The workforce is also fairly mobile, with employees from production miners to executives moving from one company to another for work. This has allowed the development of a sense of community within the industry, which is beneficial to development of a safety culture. Many mines, mining contractors and diamond-drilling firms belong voluntarily to safety organizations whose goal is to share information about hazards and health and safety programs. In 2005-6, during a series of roundtable meetings, industry representatives committed to a vision of zero harm (elimination of fatalities, injuries and illnesses) with a goal of achieving zero injuries by 2015. In addition to the founding of Ontario's health and safety legislation, another key development during the 1970s was the establishment of a mandatory training program – Common Core for Underground Hardrock Mining Skills. Anyone who was going to work underground was required to complete this suite of training modules, designed to ensure they had at least basic skills including drilling, blasting, bolting and mucking. The requirements were later expanded to include mandatory training for soft rock miners, mill workers, surface miners, diamond drillers and trades, as well as for supervisors. Today, the Ontario Mining Association estimates that the industry spends \$16 million per year on safety training - roughly \$1,000 per worker<sup>22</sup>.

### **2.3 Roles in health and safety**

One of the requirements built into the Occupational Health and Safety Act when it was passed in 1979 was that any workplace with 20 or more workers must establish a joint health and safety committee made up of representatives from both workers and management. The job of the committee is to inspect the workplace, identify situations that may be hazardous to workers, make recommendations to management for improvement, and make recommendations regarding health and safety programs and procedures. Most operating mines in Ontario are required to have a joint health and safety committee; however, for smaller workplaces with between five and 19 employees, the law still requires that a health and safety representative be appointed.

Virtually all mines in the province employ safety staff whose responsibility is to oversee the health and safety program, including coordinating training, working with the health and safety committee, developing and maintaining policies and procedures, conducting research, and identifying trends. Many operations also employ specialists in areas such as ventilation and occupational hygiene. In most cases, these professionals are university-educated and certified by professional bodies. Excellent programs exist across Canada in mining engineering, industrial hygiene, ergonomics, occupational health and safety. A number of operations also employ physicians and nurses. This is particularly vital in the case of remote operations where hospitals may be many hours away. Mines in Ontario are required by law to maintain a fully-equipped first aid room overseen by a trained and certified first aid attendant.

The provincial government continues to establish, revise and enforce legislated standards for health and safety in Ontario. Input into legislation is provided by a Mining Legislative Review Body, which includes members from mining corporations and organized labour. The provincial government, through its Ministry of Labour, employs labour inspectors who visit and inspect mine sites to ensure compliance with the law. Of the 430 full-time occupational health and safety inspectors in Ontario, only a small percentage – 20 inspectors – specialise in mining. In a highly competitive labour market, it can be a challenge for the government to recruit and retain inspectors knowledgeable about the mining industry.

The role of the safety association is to provide training, consulting services and information to support companies in building stronger health and safety programs. The association has gone through numerous changes since its establishment in 1930, and currently exists as Workplace Safety North (WSN). While WSN offers a range of training programs, mines are not required to use the association's services and are free to find other providers or develop their own programs to meet the training requirements.

A recent review of health and safety in Ontario will result in changes to these roles and structures. Under legislation passed in 2011, the province's four safety associations, which support most industrial sectors in Ontario, will come under the umbrella of the provincial government and a new Chief Prevention Officer. The review also recommended entry-level health and safety awareness training for all workers in every sector, training for supervisors, and broad changes to incentive programs, enforcement, and health and safety education.

## **2.4 Mine rescue**

While Ontario mines have been relatively successful in reducing the numbers of injuries and fatalities in their operations, when accidents do happen, emergency response is provided by on-site responders trained and equipped through the Ontario Mine Rescue program, part of the safety association Workplace Safety North. Operating mines in Ontario are required by law to have mine rescue teams trained, equipped and prepared to respond to emergencies of all sorts underground. The Ontario Mine Rescue program ensures that both training and equipment are consistent across operations. This facilitates not only mutual aid responses between operations, but also the movement of employees

from company to company. While mine rescue team members are employees of the mine, their participation in a mine rescue team is voluntary. Currently, Ontario has roughly 800 active mine rescue volunteers. Mine Rescue Officers employed by the program provide competency-based training and refresher training to all volunteers, as well as training for equipment technicians and managers.

Ontario's size means that, in addition to a number of mine rescue stations around the province, mines have their own sub-stations equipped with Drager BG4 breathing apparatuses, gas testers, rope rescue equipment, foam generators, hydraulic splitters, lifting bags and other necessary equipment. Equipment is provided by the Mine Rescue program to ensure consistency.

Annual competitions in mine rescue further reinforce consistency and provide teams with an opportunity to test their skills and share knowledge. Teams compete with one another in regional competitions for the chance to represent their district at the province-wide championship.

### 3. Current needs

In 2010-11, the mining industry in Canada rapidly recovered from recession and was booming again, with new operations opening up and the workforce expanding substantially. During times of expansion, it can be difficult for any business to maintain a focus on health and safety. With the added pressure of high mineral prices – particularly gold – preserving the balance between safety and production proves a challenge for the mining industry. In Ontario alone, while lost-time injury rates in the first part of 2011 remained similar to the previous year, total medical injury frequencies were up substantially. Even more troubling, the province had experienced six mining fatalities by October – its worst performance in well over a decade. Industry leaders in the province were preparing to gather to re-evaluate their commitment to zero harm.

While Canada has been a leader in mineral exploration and development over the years, and has established a reputation for high health and safety standards, the recent spike in injuries and fatalities – at least in Ontario – reinforces the fact that health and safety is not a destination, but a journey, requiring constant effort and attention.

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Susan M. Moore, Jeffery L. Kohler & Gregory R. Wagner

# Safety and health in mining in the US

## Basic facts about the United States of America

Size of area	9,827,000 sq km
Population	317 million
Capital	Washington D.C.
Literacy	99%
GDP per capita (PPP)	US\$ 49,800
Gini index	45
Infant mortality rate	6 deaths before age 1 year/1,000 live birth
Median age	37 years
Life expectancy at birth	female: 81 years, male: 76 years

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*Disclaimer: the views expressed in this article are those of the authors and do not necessarily reflect the views of the National Institute for Occupational Safety and Health or the Mine Safety and Health Administration.*

## **Definition of terms**

*Continuous mining method*—mining in which the continuous mining machine cuts or rips coal from the face and loads it onto conveyors or into shuttle cars in a continuous operation. Thus, the drilling and shooting operations are eliminated, along with the necessity for working several headings in order to have available a heading in which loading can be in progress at all times.

*Conventional mining method*—the cycle of operations that includes cutting the coal, drilling the shot holes, charging and shooting the holes, loading the broken coal, and installing roof support. Also known as cyclic mining.

*Longwall mining method*—a full-extraction method for mining large panels of coal; a system of mining in which all the minable coal is recovered in one operation; a method of mining flat-bedded deposits, in which the working face is advanced over a considerable width at one time.

*Metric ton*—unit of mass equal to 2,204 pounds or 1,000 kg

*Short ton*—unit of mass equal to 2,000 pounds, used in the United States

*Trillion* – one million million, in most English-speaking countries

*Billion* – one thousand million, in most English-speaking countries

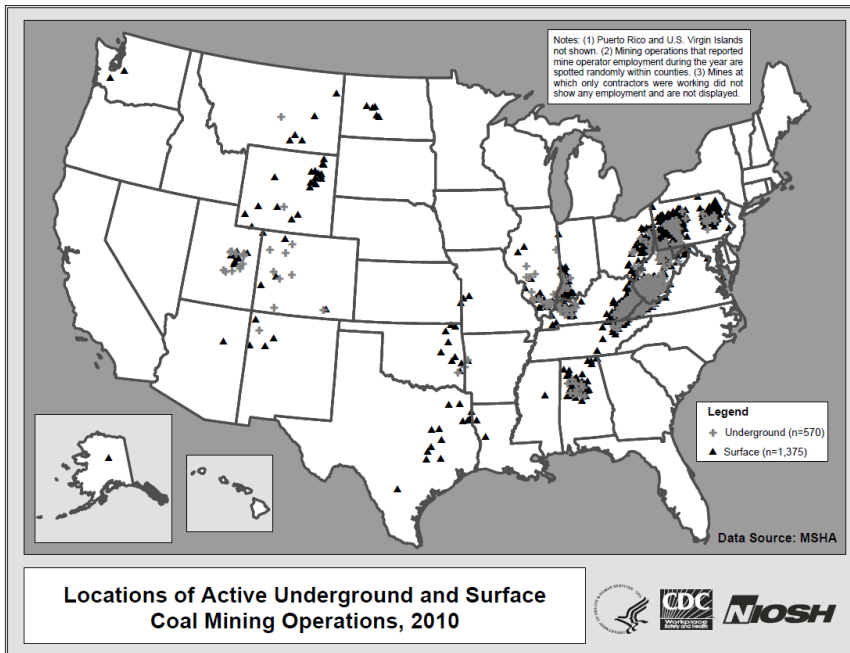
# 1. Mining activities

## 1.1 Coal economics

The United States has vast coal deposits, and the mining, transportation, sale, and export of coal together play a significant role in the US economy. In 2010 the coal industry employed over 86,000 workers involved in the production of over 1,084 short tons of coal. While coal production was up slightly compared to 2009, employment fell by 1.8%.

## 1.2 Coal production

Active coal mines, surface and underground, are generally concentrated in three geographical areas within the United States known as the Appalachian Region, Interior Region, and Western Region (Figure 1).



**Figure 1.** Locations of active coal mining operations.

Table 1 shows the number of US coal mines, in 2009, by region. The Appalachian Region had the largest number of coalmines (n=1,210). The majority of the coal produced in the Appalachian Region is bituminous and is mined at hundreds of underground operations. In contrast, the majority of coal produced by the Western Region is subbituminous and is mined at 37 large surface mines. The Western Region accounted for 49% of the total United States coal production in 2009. Nearly a quarter

of the United States coal production comes from mines where miners have union representation. In 2009, union mines produced 22.1% of the coal in the Appalachian Region, 20.4% in the Interior Region, and 12.7% in the Western Region.<sup>1</sup>

**Table 1.** Number of mines, production, and mining methods for the three coal-producing regions.<sup>1</sup>

		Number of Mines in 2009	Production in 2009 (thousand short tons)	Continuous Mining Method (thousand short tons)	Conventional and Other Mining Methods (thousand short tons)	Longwall Mining Method (thousand short tons)
Appalachian Region	Underground	487	209,824	106,254	2,412	101,158
	Surface	723	131,619			
	Bituminous	1,146	339,712			
	Subbituminous	ND	ND			
	Lignite	ND	ND			
	Anthracite	64	1,731			
Interior Region	Underground	34	67,574	52,915	2,471	12,188
	Surface	75	78,237			
	Bituminous	94	103,621			
	Subbituminous	ND	ND			
	Lignite	15	42,191			
	Anthracite	ND	ND			
Western Region	Underground	19	54,664	1,592	2	53,070
	Surface	37	530,317			
	Bituminous	20	58,271			
	Subbituminous	31	496,422			
	Lignite	5	30,288			
	Anthracite	ND	ND			

\*ND=no data reported

### 1.3 Mineral economics

Each year, the United States Geological Survey (USGS) publishes Mineral Commodity Summaries providing information on approximately 90 commodities mined across the country. These commodities also play a substantial role in the United States economy. According to the USGS<sup>9</sup>, in 2010:

- Net exports of mineral raw materials totalled \$2.4 billion USD
- Value of domestic mineral raw materials from mining totalled \$64 billion USD
- Value of shipments of mineral materials processed domestically totalled \$578 billion USD
- Value added to the United States' Gross Domestic Product (GDP) by major industries that consume processed mineral materials was estimated to be \$2.1 trillion USD (14% of the GDP)

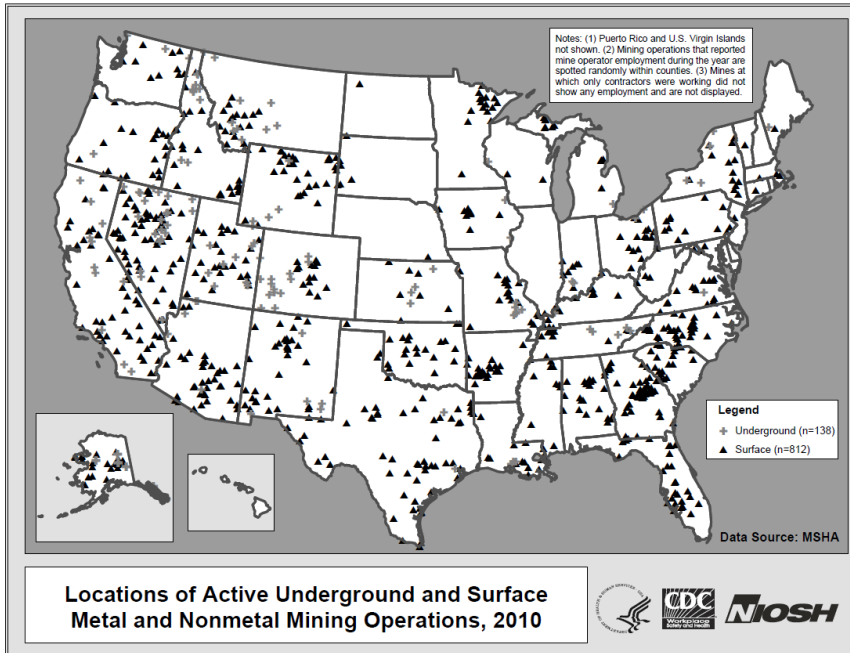


## **1.4 Mineral production**

Unlike coal, non-fuel mineral mines are widely dispersed in the United States (Figure 2). Stone, sand, and gravel mines and quarries are not shown in Figure 2 and are densely distributed throughout the entire country, primarily in the form of surface (n=11,277) rather than underground (n=111) mines. In 2009, non-fuel mines, excluding stone, sand, and gravel mines, produced approximately 135 billion metric tons of materials. Metal production was 35 billion metric tons with non-metal production being 100 billion metric tons. Stone production was 1.3 trillion metric tons, while the production of sand and gravel combined was 805 billion metric tons. Production reflects economic conditions and has fallen from its prerecession peak. For example, in 2009, metal mines reported the lowest production for a decade, down from 65 million to 35 million metric tons. Stone mines also reported the lowest production in ten years. Reductions in construction also resulted in a substantial decrease in sand and gravel mining.

## **1.5 Coal and mineral mineworker demographics**

The National Institute for Occupational Safety and Health (NIOSH) Office of Mine Safety and Health Research recently conducted a survey of the United States mining population.<sup>3</sup> Using statistical methods, national estimates were computed to provide demographic and occupational characteristics of the United States mineworker. Table 2 highlights some of the salient results for each sector. Across all three sectors, it was estimated that there were 231,549 employees in Spring/Summer of 2008. The total mining experience for coal workers was 16 years while the experience for workers in metal/non-metal and stone, sand, and gravel mining was closer to 11 years. The hours worked per week ranged from 43 to 47.



**Figure 2.** Locations of active metal and non-metal mining operations.

**Table 2.** National estimates of mine worker demographics across United States – data represented as national estimate

National Estimate				
		Coal	Metal/Non-Metal	Stone, Sand, and Gravel
Gender	Male	65,374	50,803	95,293
	Female	2,559	7,457	7,197
Age (years)		43,8	41,7	43,9
High School Education or Equivalent		47,548	30,176	58,875
Ethnicity	Hispanic or Latino	1,222	10,851	14,548
	Non-Hispanic or Non-Latino	64,548	44,179	84,113
Race	White	62,528	44,843	86,645
	American Indian or Alaska Native	1,635	1,159	1,256
	Black or African American	774	3,971	4,149
	Asian	NA	DSU	179
	Native Hawaiian or Other Pacific Islander	NA	376	257
Hours worked (per week)		47,3	42,6	45,8
Total Mining Experience (years)		16,0	11,1	11,8

\*NA, not available – survey did not have any respondents

\*DSU, data suppressed due to less than five responses

\*This table is based on the JKCOEF = 0.999999

\*Confidence intervals excluded for simplicity

## 2. Safety and health

In the US, the safety and health of miners is, by law, the responsibility of the mine operator with the assistance of miners. In addition, two US federal agencies, by statute, have complementary responsibilities for contributing to miner safety and health. These two government entities work in conjunction to facilitate a systems approach to safety and health through training and education, regulation and enforcement, development of engineering best practices and new technology, and research.

The Mine Safety and Health Administration (MSHA), located in the Department of Labor, has the statutory responsibility to develop and enforce the mining regulations, as well as the approval and certification of certain equipment used in mines. In 2011, MSHA had a budget of approximately \$360 million USD, and a staff of approximately 2,400. MSHA

has approximately 100 offices around the country to facilitate inspection and enforcement, plan approvals, and communication with mine operators and miners. Some important activities MSHA is explicitly responsible for under United States law include, but are not limited to<sup>5</sup>:

- Performing complete inspections of each underground mine four times per year, and each operating surface mine twice each year, to assure compliance with mining safety and health standards and regulations;
- Investigating mine accidents, complaints of retaliatory discrimination filed by miners, hazardous condition complaints, knowing or wilful (criminal) violations committed by agents of mine operators, and petitions for modification of mandatory safety standards;
- Developing improved mandatory safety and health standards;
- Assessing and collecting civil monetary penalties for violations of mine safety and health standards; and
- Reviewing for approval mine operators' mining plans and education and training programs.

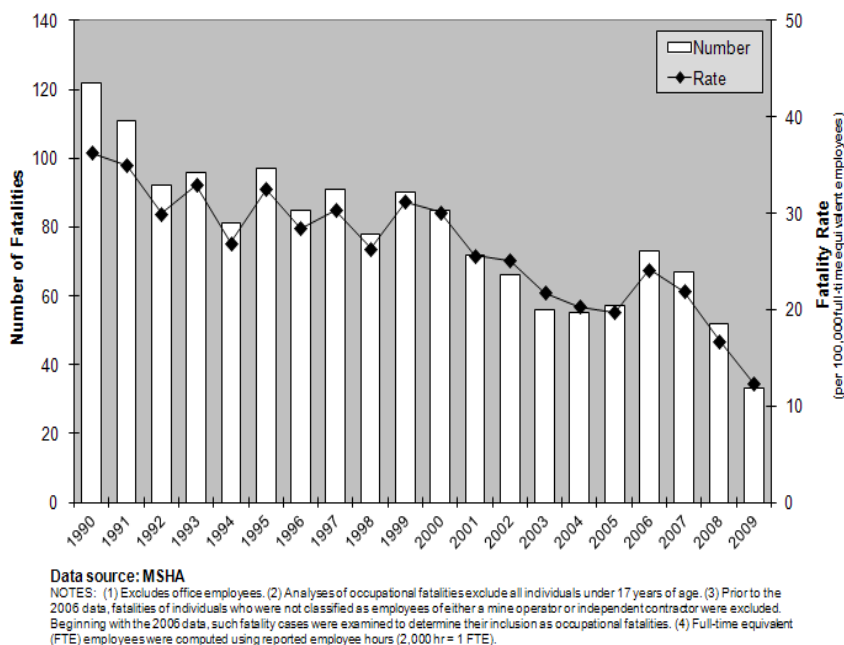
MSHA operates the National Mine Health and Safety Academy, a national training centre where instructional programs are designed and conducted to assist the efforts of the government, industry, and labour to reduce accidents and health hazards in mining.<sup>6</sup> MSHA inspectors receive mandatory initial training and periodic re-training at the Academy. The Academy is also used by mining professionals from across the United States and many foreign countries.

Mine operators are required to report fatalities, injuries, and illnesses experienced by mine workers. This reporting system includes information regarding the injured worker's demographics (e.g., age, gender, mine experience, job experience), accident type (e.g., struck against stationary object, fall down stairs, over-exertion in lifting objects), mine worker activity at the time of injury (e.g. operating haulage truck, working with solvents, walking/running, moving equipment), nature of injury/illness (e.g., dislocation, crushing, electrical burn, dust in eyes), and many other pertinent categories. Moreover, following each fatality, injury, or illness, the mine operator must include a narrative describing the events that led to the incident. Thus, this reporting system provides the opportunity to investigate injury trends and potential hazards using both longitudinal and cross-sectional statistical analyses. While fatalities are accurately reported, there is substantial evidence that injuries are under-reported and diseases from mining are rarely reported. The reporting system and the enforcement of the operators' responsibility to report are currently being evaluated in order to improve the accuracy of important injury and illness data.

The National Institute for Occupational Safety and Health (NIOSH), which is located in the Department of Health and Human Services, has statutory responsibility for research to determine the causes of safety and health problems, to develop training and engineering interventions or solutions, and to recommend criteria for new regulations. The NIOSH Office of Mine Safety and Health Research has an annual appropriation of \$50 million USD, consists of 250 scientists, engineers, and support staff, operates a 180-acre research campus in Pittsburgh, Pennsylvania, a lab in Spokane, Washington, and has two underground

mines to support research activities. The NIOSH Office of Mine Safety and Health Research develops and transfers practical solutions to the mines, and enjoys strong support from both labour and industry.

The efforts of these two government agencies, coupled with significant health and safety technological advancements in the mining industry, have helped to drive a decrease in injuries, illnesses, and fatalities. Figure 3 illustrates the substantial decline in both the number and rate of fatalities across all mining in the United States from 1988 to 2008.



**Figure 3.** Number and rate of all occupational mining fatalities by year, 1989-2009

In the mid to late 1990's, mining's fatality rates averaged 24.5 per 100,000 full-time workers.<sup>2</sup> By 2008, this rate had dropped to 18.1 and continued to drop in 2009. While significant reductions in fatality rates have been accomplished, mining still ranked second amongst industry sectors for leading fatality rates, with agriculture, forestry, fishing, and hunting being first (IR 30.4). Transportation and warehousing was third (IR 14.9) and construction was ranked fourth (IR 9.7). Thus, continued improvements in mining health and safety are still necessary. NIOSH uses relevant information from reports of injuries, accident investigations, and stakeholder interaction to shape the priorities of the Office of Mine Safety and Health Research.

Seven accident classes are most frequently associated with lost-time injury reports for both underground (UG) and surface (S) operations across all commodities (Table 3). Both injury frequency and severity are considered in setting research priorities.

**Table 3.** Seven accident classes most frequently associated with lost-time injuries

2006-2010 (5 years)—Percent of Nonfatal Lost-time Injuries and Total Days Lost by Underground/Surface Work Location by Accident Class (Excludes Office Employees; Data Source: MSHA <sup>4</sup> )				
Accident Class	Underground		Surface	
	% of Nonfatal lost-time injuries	% of Total Statutory Days Lost	% of Nonfatal lost-time injuries	% of Total Statutory Days Lost
Handling materials	29%	25%	34%	28%
Slip or fall of person	19%	18%	28%	30%
Fall of ground (from in place)	16%	18%	0%	0%
Powered haulage	12%	17%	9%	14%
Machinery	11%	11%	10%	13%
Hand tools	6%	5%	10%	7%
All Other	7%	6%	8%	7%

\*Columns may not sum to 100% due to rounding

More detailed analyses enable MSHA and NIOSH to design programs to address the causes of fatalities, injuries, and illnesses. Moreover, investigations conducted by MSHA following mine disasters such as explosions, substantial falls of ground, fires, or inundations also aid in the development of regulations and research projects. Finally, industry and labour partners are extremely active in assisting in the development and execution of both the regulatory and training program conducted by MSHA as well as the research, technology development, and training program at the NIOSH Office Mine Safety and Health Research. In the United States, industry and labour partners both have significant influence on the mining industry. In addition, both groups have demonstrated their commitment to safety and health through participation in the efforts of the NIOSH Office of Mine Safety and Health Research to develop technologies such as the Continuous Personal Dust Monitor and Coal Dust Explosibility Meter. This support has included providing information regarding implementation strategies and by allowing device testing in active mines. Additional examples include industry and labour assistance in spearheading the need for advancements in breathable air supply technology and identifying research needs regarding the use of advanced technology (e.g., virtual reality) for mineworker health and safety training.

There is no comprehensive health surveillance program for US miners. The only public program is for underground coal miners, who are entitled to periodic chest X-rays to detect coal workers' pneumoconiosis (CWP). Some companies choose to run their own health screening and surveillance programs; however, the results of these programs are not reported. It is clear, however, that illness and disease from work remain significant problems for US miners. As noted earlier, the underreporting of illness makes accurate calculation of rates impossible. Data, including exposure information, obtained from sources other than mine operator reports indicate that respiratory diseases (e.g., pneumoconiosis, silicosis, emphysema, chronic bronchitis), hearing loss or impairment, and problems related to the musculoskeletal system (i.e., joint, tendon, or muscle inflammation or irritation) remain

important problems for active and retired miners. For example, evidence from the Coal Workers X-ray Surveillance Program (for underground miners) suggests that CWP rates are increasing.

### 3. Current needs

Based on data such as those described above, both MSHA and the NIOSH Office of Mine Safety and Health Research have identified areas within the mining industry in need of additional research. MSHA has identified several key areas in need of improved regulation and is pursuing the rulemaking process as defined by United State's law. The areas currently being pursued or recently concluded include:

1. Development of regulations mandating the use of proximity detection and collision avoidance systems for underground coal mining machinery such as the continuous miner and shuttle car;
2. Revision of current regulations pertaining to underground coal miners' exposure to coal mine dust, the cause of coal worker's pneumoconiosis and emphysema; and,
3. Revision of current regulations pertaining to the use of rock dust in underground coal mines to reduce the explosiveness of coal dust.

NIOSH has identified key areas in which the need for new engineering or training interventions is especially acute, and these include:

1. Improved practices for monitoring and managing methane gas on active longwall mines and in gobs of underground coal mines;
2. Improved practices for reducing the explosibility of coal dust through enhanced rock dusting practices and real-time measurement of mine dust explosibility;
3. New approaches to improve the effectiveness of miner training given the increasing complexity and inherent hazards of mining as well as practical limitations on the time available to train miners;
4. New technology to provide breathable air to miners in a post-accident environment, to overcome the limitations of current self-contained self-rescuers (SCSRs), which include: the inability to use voice communications while wearing the device; size, weight, and capacity issues; and reliability issues;
5. Improved design and monitoring practices for safer ground control designs, especially in deep mines;
6. An integrated approach to improving safety and health, by employing strategies found in occupational safety and health management systems.

Past research performed by The NIOSH Office of Mine Safety and Health Research along with statistics on fatalities, injury, and illness form the cornerstone for MSHA's development or revision of regulations. In addition to these examples of priority areas, the NIOSH Office of Mine Safety and Health Research pursues a comprehensive program to develop and diffuse practical interventions for mine safety and health problems, and this work is captured in its seven strategic goals:

1. Eliminate respiratory diseases in mine workers by reducing exposure to airborne contaminants.
2. Reduce noise-induced hearing loss in the mining industry.
3. Reduce the risk of musculoskeletal disorders in mine workers.
4. Reduce the risk of traumatic injuries in the mining workplace.
5. Reduce the risk of mine disasters (fires, explosions, inundations), improve the post accident survivability of miners and critical mine systems, and enhance the safety and effectiveness of emergency responders.
6. Reduce ground failure fatalities and injuries in the mining industry.
7. Reduce adverse health and safety consequences in the industry through effective interventions with new technology.

The United States has a continuing commitment to improve the health and safety of miners through adoption of new technologies, training, regulation and enforcement, and research. Further gains will continue to depend on the active collaboration of mine operators, mineworkers, and the government.

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Mario Parreiras de Faria & Tom Dwyer

# Safety and health in mining in Brazil

## Basic facts about Brazil

Size of area	8,515,000 sq km
Population	201 million
Capital	Brasilia
Literacy	89%
GDP per capita (PPP)	US\$ 12,000
Gini index	52
Infant mortality rate	21 deaths before age 1 year/1,000 live births
Median age	30 years
Life expectancy at birth	female: 77 years, male: 69 years

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Mário has been an OSH inspector of the Ministry of Labour and Employment in Minas Gerais State since 1984. He directed the state's OSH services 1987 – 1990 and 1992 – 1994. Originally trained as a medical doctor, he subsequently specialized on OSH and obtained a Master's degree in public health from the Federal University of Minas Gerais. Dr Parreiras de Faria coordinates, at a national level, many of the Ministry's efforts concerning mining safety. Specifically he oversaw the revision of the legal measure, NR 22, that governs OSH issues in the sector. He also trains Brazilian OSH inspectors in mining activities.

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Tom Dwyer is a full professor of Sociology at the University of Campinas (Unicamp), São Paulo, and a researcher of the National Council for Scientific and Technological Research (CNPq), Brazil. He is a former president of the Brazilian Sociological Society, and currently a member of the Executive Committee of the International Sociological Association. He has a doctorate in Sociology from the École des Hautes Études en Sciences Sociales, Paris, France. The author of *Life and Death at Work: Industrial accidents as a case of socially produced error* (New York, Plenum), Dr Dwyer was guest editor of *OSH & Development* no. 8, 2006, a special issue on Occupational Safety and Health in Brazil.

## 1. Mining activities

In 2010, Brazil had 11 percent of the world's iron reserves, being the fifth most important country in the world. This position is also held with bauxite (10%), magnesite (12%) and manganese (10%). Brazil has the world's principle deposits of some rare metals: niobium (98%) and tantalum (67%). The country is in third place with tin (13% of reserves). These reserves have resulted in Brazil becoming an important producer of numerous minerals: the world's primary producer of tantalum (27%), tertiary producer of iron ore (16%), the tertiary producer of bauxite (14%), chrysotile (15%) and magnesite (8%) and the primary producer of niobium (97%) and the secondary producer of manganese (18%).<sup>8</sup>

In 2000, the mining sector had a total of 97,507 formal employees; this number rose by 50% over a decade to reach a total of 156,254 workers, registered with the Ministry of Labour and Employment (MTE) in 2010. Of these, approximately 90% were men. According the National Department of Mineral Production (DNPM), there are also a large number of workers employed by sub-contractors - 26,704 people employed in 2009. In the same year, a further 2,343 people were registered by the same body as working in cooperatives, organized essentially in small craft mines, *garimpos*.<sup>6</sup> Workers who have some degree of formal status in the labour market total around 185,000.

The value of commercialized mineral production in Brazil was R\$ 32 billion in 2005<sup>5</sup> and this has more than doubled over the past six years to reach a total of R\$ 37 billion in the first six months of 2011<sup>7</sup>. The impact of mining exports on international trade statistics is very important; mining exports (excluding petrol) rose to US\$35 billion in 2010, and the sector contributed US \$27 billion to the balance of trade.<sup>7</sup>

In 2005, the main countries to import Brazilian raw mining products were China (22%), Japan (10%), Germany (9%), USA (8%) and South Korea (6%). The picture was quite different for semi-manufactured items: USA (38%), Japan (8%), and Holland (5%).<sup>5</sup>

Table 1 depicts the distribution of all mines according to size, and then according to whether they are opencast, underground or mixed. The table only includes mines that produce over 10 thousand tons 'run of mine' per annum (ROM, mineral in its natural state, as it comes out of the mine, before any grading according to size or quality).

**Table 1.** The distribution of mines according to size and type of mining activity in Brazil 2009.<sup>6</sup>

**Size of mines:** Large, annual production greater than 1,000,000 ROM tons; Medium, greater than 100,000 ton and less than 1,000,000 tons; small, more than 10,000 tons and up to 100,000 tons. **OC**, Opencast mine; **U**, Underground mine; **M**, Mixed mine (U + CA).

Size	Large			Medium			Small			Subtotal			Total
Type of mine	OC	M	U	OC	M	U	OC	M	U	OC	M	U	
Number of mines	148	4	3	806	1	20	2,364	-	11	3,318	5	34	3,357

The table shows that the typical Brazilian registered mine today produces between 10,000 and 100,000 tons per annum (71% of mines), and is opencast (99%). In other words, the proportion of underground mines is tiny. Approximately 95% of the mines employ less than 50 people, and these accounted for nearly half of mining employees in 2001 (48%). Also the reverse is true - a very small number of mines employ a great number of people.

Only a few of the mines that produce under 400 tons per day have mechanized operations. Some of these co-exist with semi-mechanized operations and the level of technological development of the operations is to some extent homogeneous. However, we find greater development in one or another area of a given company or mine, depending on local conditions. The technologies employed in some of these mines are frequently very different from what are defined internationally as ‘best practices’.

Such statistics show that most mines in this sector in Brazil are quite different to those that are most commonly shown to the world as representing Brazil. Sebastião Salgado’s famous photos of *Serra Pelada* mine in the 1980s portrayed a sea of informal workers. This mine was closed in 1986. Carajás, in the Amazon region, is the largest iron ore mine in the world and many processes are highly industrialized.<sup>1</sup> A total of 6,670 registered workers were employed in 2010, of which 871 were women.<sup>16</sup> These figures exclude sub-contracted workers.

However, the industry varies a lot; many mines are not included in the official statistics. There are two reasons for this. Firstly, mines producing less than 10,000 tons per annum fall below the radar screen of official statistics. Secondly, many mines open without being registered at the Ministry of Mines and Energy (MME). These unregistered mines are illegal and under normal conditions are unlikely to draw the attention of the OSH (Occupational Safety and Health) inspectorate of the MTE.

Except in rare cases, such as stories in the press or TV documentaries, or university-based studies, most of these workplaces are invisible: for example, gold in the states of Amapá, Pará, Rondônia and Tocantins, and illegal mines for emeralds, diamonds and gold in Minas Gerais. Such activities are typically carried out in remote areas. The workers are extremely poor, high value concealable items are produced, and no taxes are paid. Barreto adapted International Labour Organisation statistics from 1999 to estimate that, in addition to the mine workers within the formal economy, there are 100,000-250,000 workers engaged in small mines in Brazil, of whom 90% are illegal.<sup>3</sup>

In many parts of Brazil there are numerous small mines, underground and opencast, that use craft techniques. In such mines, the technology used to mechanize operations is typically antiquated. The workers are from very poor social backgrounds, earnings permit a subsistence living and, occasionally, there may be a lottery win - 'a big find'. Descent down the mine conjures up images of early 19<sup>th</sup> century British underground coalmines. For example, to enter a typical one of these mines, you have to sit in a belt (made from a car tire) and be lowered by a motorized winch down an unbricked shaft. After some 30 meters, the surface operator uses a piece of wood to brake the cable (for the return journey, there is no automatic brake to prevent the worker or material that is being raised from being 'wound over the top' and falling back down into the mine shaft). Upon arrival at the mine face, a small group of emerald miners toiled away in the galleries, wooden props line the walls and support the roof, small exploratory galleries barely fit a crouched man, dynamite is armed ready for detonation after the crew leaves the mine. Here, centuries seem to separate the level of technological and social development from that to be found in large opencast mines in the formalized sector. However, the product of these particular mines finds its way into the global market. In a nearby town, buyers are at work, and the stones are said to be subsequently smuggled to India.

The last two and a half decades have been marked by political, economic and social transformations in Brazil, many of which had effects on the mining sector. In the mid 1980s the military regime ended, and a protected economy was opened up to the world. Later, chronic inflation would come to an end. Privatization of state-owned mining companies permitted new investments and subsequent increases in mineral supply. There was also privatization outside the mining sector. Consequently, capital investments led to greater efficiency and production. The privatization of railroads and some port activities permitted more efficient mineral exports. With these came investments in technologies of information and communication (TICs) and the introduction of modern management methods. Firms became smaller, and better prepared to adapt to rapid change and become more competitive.

Today, ownership of an important number of Brazilian mines is in the hands of national and international capital. Recently, international capital investment has come predominantly from Canada, China, the United Kingdom and Australia.<sup>13</sup> By law, to operate in this sector, a foreign company must have Brazilian partners, even in a minority holding. Today, some of the biggest mining companies are listed on the stock exchange and have mixed local and foreign ownership. The Carajás mine, for example, is run by the largest Brazilian mining company, Vale, the second largest mining company in the world. This formerly state-owned enterprise was privatized in 1997 and today it is listed on the Brazilian and four other world stock exchanges. Its biggest shareholders are Brazilian public sector pension funds. The company employs worldwide a total of 174,000 people, of whom 71,000 are directly employed and 103,000 are sub-contracted.<sup>18</sup>

Economic globalization has played an important role, especially the recent rise of China and its demand for raw materials. The new scenario has led to reassessments of corporate missions and strategies. Some large companies have exchanged paternalistic and bureaucratic forms of management for modern rational ones. There has been a considerable renewal of the

entrepreneurial spirit. New methods of workplace organization have been implanted that rely not only on profit calculations, but also on assessments of environmental impacts and quality. There are discussions about what all this development has meant for the quality of life of mineworkers, particularly in relation to OSH. As seen from statistics and qualitative reports, the mining sector in Brazil has been extremely dynamic during recent years, and subjected to a series of complex forces.

The formal economy mining workforce is almost entirely Brazilian. The exception is to be found in rare cases of skilled foreign professionals and managers. Internal migration exists within Brazil, from the poorer areas to the richer ones, but there are no figures relating to its impact on mining. Females are generally employed in administrative positions, and on rare occasions may drive trucks or operate other heavy equipment. Child labour has disappeared from the formal economy, although it can still be found in small mines and quarries in remote areas in the informal economy.

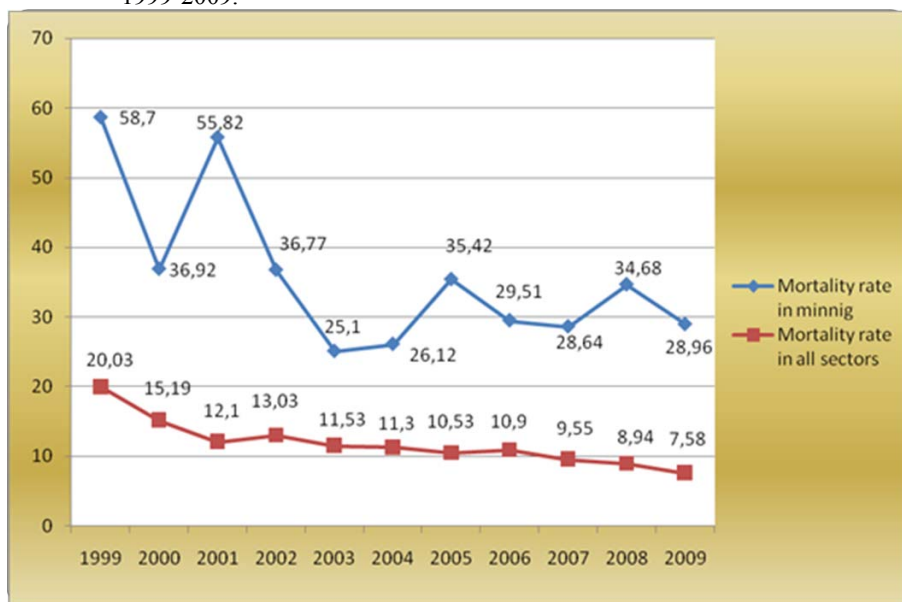
## 2. Safety and health

Mining activities are subject to inspection by state government environmental agencies and by the MME. However, it is the MTE's OSH inspectorate that is responsible for worker health and safety. From 1999, OSH in mining became subject to revised regulations under NR-22 (Occupational Safety and Health in Mining). Parameters for working conditions were established in the sector and these incorporate the principles of ILO Convention 176 on OSH in mining. The regulations were developed through an elaborate tripartite process of consultation involving government, employers and trade unions. According to NR-22, all mines with over 15 employees must have a bi-partite accident prevention committee. The right of workers to refuse dangerous work is recognized. There are regulations for the evaluation and control of exposure to certain hazards in the work environment. These include chemical products, silica, noise, radiation and heat. In addition, there are limits to workers' exposure to certain hazards. Today, we can say that the implementation of NR-22 is only partial, and this is especially so in the smaller mines in the formal economy (of course, the mines in the informal and illegal economy are not regulated). Firms must communicate all accidents to the INSS, an agency of the Ministry of Social Welfare (MPAS), which administers a compulsory employer-funded compensation insurance system. There is a series of complex mechanisms that permits the INSS and employee victims to seek further compensation and damages in certain cases where OSH regulations have been ignored. OSH inspectors have the power to fine in cases of violation of norms and can halt activities in cases of high risk for worker safety or health. In spite of the legislative and regulatory processes, public sector activity in this field is very limited. This is largely due to the fact that there are very few specialized professionals and they are dispersed throughout the country.<sup>4</sup>

Figure 1 shows a sharp decline in the sector's mortality rates, from 59 per 100,000 formal economy workers in 1999, to 29 in 2009. Over the period 1999-2002, the average fatal accident rate was 47 per 100,000 workers; this dropped to 31 for 2006-9. The overall national mortality rates due to work-related accidents fell from 20 to 8 between 1999 and 2009. While there has been a rapid improvement over recent years in other industries, improvement has

been proportionally lower in mining. Miners are at much greater risk of being victims of fatal accidents than other Brazilian workers.

**Figure 1.** Rate of fatal work accidents per 100,000 workers per annum in Brazil 1999-2009.<sup>15</sup>



Productivity has risen enormously in the sector. In 2000, the total production was worth US\$ 8 billion; by 2010 this had increased 400% to US\$ 40 billion in spite of only a 50% increase in the labour force<sup>15</sup>. While commodity prices rose during this period, volumes also greatly increased. A rapid increase in both personnel and productivity could have been expected to result in increased accidents given the high number of under-qualified workers, and the amount of disorganization that could be expected in new or rapidly changing workplaces. Some firms have changed their practices for training, workplace organization and logistics, while there has also been an increase in sub-contracting. Trade unionists allege that the latter practice has a negative impact on OSH management standards. Also, they allege that sub-contracting weakens the protection afforded to workers by the employment legislation, leading workers to lose both rights (retirement, social security coverage, overtime pay) and security (OSH standards etc.). Unfortunately the available data does not permit us to evaluate such hypotheses.

Beyond adjusting to the requirements of NR-22, larger firms have invested in actions to improve both quality and environmental protection (ISO 9000, ISO 14000 and OHSAS 18001).

The number of work accidents and work-related diseases are summarized for the years 2007-2009, in Table 2.

**Table 2.** Incidence per 100.000 formal employees of occupational accidents and occupational diseases in Brazil, 2007-2009.<sup>15</sup> The occupational accidents include work accidents as well as accidents going to and from work. Occupational diseases represent new cases, which have been legally accepted.

	2007	2008	2009
Incidence of occupational accidents in all sectors	2,215	2,402	2,290
Incidence of occupational accidents in mining	3,512	3,824	3,286
Incidence of new cases of occupational diseases in all sectors	75	65	54
Incidence of new occupational diseases in mining	101	91	79

The mining sector's incidence of the occupational accidents was on average 53% higher than all sectors and the mining sector's incidence of occupational diseases was on average 40% higher than all sectors during these three years. So we can see that mining has a relatively higher incidence of both occupational accidents and diseases than other parts of the Brazilian labour market.

Mendes estimated at 1978<sup>14</sup> that there were between 25 and 30 thousand cases of silicosis in the country. Algranti et al quoted 2003<sup>2</sup> national data from the Ministry of Health that pointed to Minas Gerais State having 7,416 cases of silicosis, the largest number for any of the country's 26 states and the Federal District. The cases are based on a diagnostic process carried out independently of the INSS, and include formal and informal economy workers and people who are not members of the workforce. This state's name, in use since 1720, translates as "General Mines", and reflects the large number of gold, iron, manganese, precious stones and other minerals extracted from its earth. In 2005, Minas Gerais had one third of the formal mining labour force in the country, was responsible for one third of the sector's production, and had the largest proportion of underground mines in the country. Also there are a considerable number of doctors in this state who are specialized in diagnosis of mining-related illnesses in comparison with the rest of the country.

The MPAS only diagnoses work-related illness among those who are registered in the formal economy. MPAS criteria are extremely rigid, early diagnoses of silicosis are not recognized, and allowances are only conceded in latest stages of the ailment, when the worker is severely incapacitated for work. Between 2000 and 2006, only 892 benefits were given to silicosis victims in Brazil. Of these 16% worked in mining. A further 9% worked with adding value to the products of mining activities, such as cutting marble, stone in quarries, and precious and semi-precious stones. Since 2002 there has been a 'National Program for the Elimination of Silicosis' which follows the World Health Organization and ILO proposals. The program aims to significantly reduce the incidence of silicosis by 2015, and to eliminate it as a Public



Health problem by the year 2030. Legal changes, professional training, and incentives for research activities are incorporated into the program. More than 400 doctors have been trained to read X-rays to detect pneumoconiosis, and legislation forbids dry drilling and polishing rocks in mining and finishing activities.

It is possible to eliminate silicosis with technical and organizational measures. In the name of social justice, elimination has become a political priority in many countries. Where this has not happened investment is required for diagnosis and treatment. However, such investments must only be seen as temporary while both medical and engineering professions combat exposure to silica and join forces with politicians to end the occurrence of silicosis itself.

### 3. Current needs

Over recent years the growth of the mining sector has been faster than the average growth rate of the Brazilian economy. The formal mining sector is in a process of continuous transformation and this also applies to work organization and working conditions. While some firms make investments in improvements in OSH, others lag behind.

In spite of important improvements in safety in the formal economy, there still appear to be grounds for further improvement. Particularly important is the diagnosis, treatment and elimination of silicosis, and other largely unrecognized illnesses. One of the problems is the lack of well-designed research that goes beyond a case study approach. Most of the documented information, predominantly from Medical and Engineering faculties of universities, has a very narrow focus that impedes the building of a more general understanding. Also, there is an excessive reliance on technical criteria for judging whether work is safe. We would urge that research pay more attention to social relations at work: training, workplace organization, payment and rewards systems that induce people to work unsafely and, as is especially evident in the illegal mines, the role of unequal power relations in causing illness and accidents.<sup>9</sup>

Nowhere is the lack of knowledge more evident than in relation to the very smallest mines, those that do not make it into the official statistics, and where workers do not have official protection. In a continental-sized country such as Brazil, where small mineral deposits are to be found in sparsely populated areas that are extremely difficult to access, such knowledge is certainly easier to demand than gain. However, such informal and/or illegal activities produce many negative side effects: worker injury and death, pollution of rivers with mercury, invasion of forest reserves, diseases and death to isolated indigenous populations, etc.

Right now it may be estimated that the formal economy is associated with far less OSH damage than the informal and illegal economies. Yet the former receives far more official attention than the latter. This is unjust and inequitable; a new OSH paradigm is necessary to deal with such an issue.<sup>10</sup> From a prevention viewpoint, one important challenge is for the State to exercise its sovereignty, to bring these mines under its jurisdiction, and contribute

to adequate solutions.

Indeed, close comparison with other countries, and especially with other developing countries, should help put our statistics into perspective, and should raise new questions for debate and research.

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(Consulted on 12.03.12)

Verónica Herrera Moreno

## Safety and health in mining in Chile

### Basic facts about Chile

Size of area	756,000 sq km
Population	17 million
Capital	Santiago
Literacy	96%
GDP per capita (PPP)	US\$ 18,400
Gini index	52
Infant mortality rate	7 deaths before age 1 year/1,000 live births
Median age	33 years
Life expectancy at birth	female: 81 years, male: 75 years

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# 1. Mining activities

## 1.1 Mineral reserves and production

Chile has important mineral reserves and mining activities. The mineral reserves include copper, molybdenum, manganese, lead, zinc, silver and gold. Over 80% of the natural resources comprise copper ores. The copper and gold mining is forecast to grow 2.8% per year in the period 2010 – 2020.<sup>1</sup> The metallic minerals are expected to continue to dominate the market, with a share of 50%, followed by non-metallic minerals and coal, with shares of 34% and 16%, respectively.

The biggest mining pits are located in El Loa, Chañaral Province and Cachapoal in northern Chile. The Consejo Minero (Mining Council) represents the large-scale companies which include 15 private multinational companies and the state-owned Chilean Copper Corporation -CODELCO.

CODELCO is the main copper producer in the world and controls around 20% of the world reserves of this metal. It is an autonomous company owned by the Chilean State that is responsible for the exploration, development and exploitation of copper mineral resources and by-products, and processing to refined copper and commercialization. The company operates the following mines: Andina, Chuquicamata, El Teniente, Minera Gaby, Ministro Hales, Radomiro Tomic, Salvador and Ventanas. Over the last 40 years, CODELCO has produced 49 million tons of fine copper; it has always ranked first among the world's top copper producers. In 2010, it produced 11 % of the world's copper.

Several of the world's leading private mining companies, such as Anglo American, Barrick Gold Corporation, BHP Billiton, Falconbridge Ltd, Phelps Dodge Corporation, and Placer Dome Inc., are also active in Chile.

Large-scale mining in Chile produced 5.1 million metric tons of copper in 2010, while medium and small-scale mining produced 0.4 million metric tons.<sup>2</sup> Copper is exported mainly to China, Japan, Europe and USA.<sup>7</sup> The main copper products exported are copper cathodes with 99.99% purity. Cathodes are used in the manufacture of copper rods for the wire and cable industries, and copper tubes.

Medium, small-scale and artisanal copper mines are usually low-tech and employ poorly trained people. The Chilean Government declared in 2009 its aim to “generate conditions so that small and medium size mining companies can get access to financing of their projects by granting credit at favourable rates to companies”.<sup>3</sup>

Approximately 9% of the world's silver is mined in Chile, and 60% of this production is extracted from copper mines. Also, 40% of gold is a by-product of copper mines and the country owns 4.3% of the world's gold reserves.

The country has been ranked second in mine production of molybdenum; its reserves are estimated to be the third largest in the world. Concentrates are processed to obtain various products by only three companies: CODELCO, XSTRATA, MOLYMET. CODELCO is the world's second molybdenum producer; its output was 22,000 metric tons in 2010. Chilean law does not allow monopolies in production of steel or steel-related raw materials such as molybdenum.

The Chilean share of world iron resources and reserves is only 0.5% (1.5 billion metric tons of mineral), and the yearly production is 9 million metric tons of mineral, produced by two companies.

The country also has non-metallic minerals, such as cement, ceramics, lithium-bearing compounds (lithium carbonate), rhenium, potassium nitrate and lime. These minerals are characterized by the transformation of naturally occurring minerals through an energy-intensive process. The products are used in a wide range of applications, from the construction industry to consumer products such as decorative goods. The operators are usually medium-to-small companies.

In 2010, the mining industry provided more than 22% of Chile's GDP, over 50% of export receipts and one third of the state revenues from taxes, according the Government's National Service for Geology and Mining, SERNAGEOMIN.<sup>4</sup> This Service is located within the Ministry of Mining and its mission is to assist the government with inspection and training activities in mining safety, and technical assistance and publications in geology and mining subjects, thus contributing to a sustainable development.

## **1.2 Workforce**

In 2010, the mining workforce consisted of 191,000 individuals, an increase of 10% from 2009. Of these, 48% work in large-scale mining, 46% in medium-sized companies and only 6% in small-sized companies. The number of women employed in mining increased by 86% in the last five years, accounting for 6% of the total workforce in 2010.

The workforce involved in large-scale mining is highly qualified, in contrast to small-scale mining. Chilean Law restricts child labour. Children between the ages of 15 and 18 may work with the permission of their parents or guardians. However, the minimum age for working in an underground mine is 21. Also, special regulations control the ability of 18 to 21-year-olds to work at other types of mining site. Child labour is most prevalent in the informal economy, since this area is more difficult to regulate.

Another characteristic of the workforce is the presence of subcontracted workers, a group that is playing an increasing role in mining. Usually, subcontracted workers have limited experience and a high injury rate. To address this issue, new legislation was passed in 2006 that obliges the company that subcontracts services to take all necessary measures to protect the worker's health.

The legal working week is six days or 45 hours. The maximum working day length is 10 hours and workers have at least one 24-hour rest period during the working week. Workers at high altitudes may exchange a work-free day each week for several consecutive work-free days every two weeks. The law includes fines for employers who do not comply.

In Chile, workers do not have to request authorization to join or form a union. Members of unions are free to withdraw from union membership. The unions have the right to organize and bargain collectively, and the government protects this right. Temporary workers may form unions, but their right to collective bargaining is limited. Intercompany unions are permitted to bargain collectively only if the individual employers agree to negotiate under such terms. The law permits replacement of striking workers, subject to the payment of a cash penalty that is distributed among the strikers.

In 2011, there were 45,300 unionized workers in the mining sector (42,600 men and 2,700 women) - 24% of all mine workers. There are two main unions in mining: Confederación de Trabajadores del Cobre and Federación de Trabajadores del Cobre, the latter formed by CODELCO workers.

Copper mining provides the highest salaries of the industry. The yearly average was US\$ 54,000 per worker in 2010. According to company size, the salaries range from US\$ 70,000 per worker in large-scale mining to US\$ 8,000 per worker in small-scale companies.

## 2. Safety and health

### 2.1 Legislation and institutions

The mining operations are regulated by the government. The Ministries of Labour and Health regulate the working conditions. The Labour Inspectorate (LI), within the Ministry of Labour, is ultimately responsible for ensuring hygiene and safety regulation in workplaces are complied to, even though other official bodies may be involved these matters. In particular, the LI controls the basic measures that are required by law over the functioning of machines, work instruments and environments. Their inspectors are entitled to visit and inspect workplaces, and to order immediate suspension of labour activities if they constitute immediate danger to the health of the workers. The inspectors can enforce penalties to companies not complying with the regulations.

SERNAGEOMIN authorizes the functioning of mineral extraction operations and carries out inspections. It also certifies those professionals trained to work as safety experts in mining and provides technical assistance to mining companies. During 2011, SERNAGEOMIN's 42 inspectors performed 5,050 inspections, and trained 1,660 mining safety monitors with a total of 170,000 training hours.

In Chile, the Labour Inspection, which is within the Ministry of Labour, holds the power to close a workplace if the safety of workers is in doubt. In the mining sector, this power belongs to SERNAGEOMIN. However, informal activities may take place mainly due to

the huge geographical area where minerals can be found, which makes it virtually impossible to control everything at all times.

Insurance for employees against work-related injuries and diseases is mandatory and is paid in full by their employers. This insurance can be provided by the state-owned Labour Safety Institute (*Instituto de Seguridad Laboral*) or by one of three private non-profit insurance funds (*mutuales*). The insurance finances the provision of the worker's compensation and health care in case of injury or disease, and occupational safety training for the private and public sectors. In order to provide this service, the *mutuales* have created a large network of healthcare centres where injured or sick workers get preferential healthcare throughout the country. All three *mutuales* have major hospitals, two in Santiago and one in Valparaíso, which have specialized on the treatment of traumatic injuries related to work and also occupational diseases. At these healthcare centres, workers receive preferential treatment according to the severity of their injuries, until they fully recover or until there are no more medical actions that can improve their final condition. When this time is reached, injured workers are evaluated to determine their disability.

Since, by law, these *mutuales* also have to provide training and education on OSH, they usually employ safety engineers who collaborate with the affiliated companies in developing safety programs and health hazard evaluations at their work sites. This has therefore become the leading effort in the country to promote health and safe working environments. The price of the insurance is fixed by law, and it can be modified according to the frequency and severity of work-related injuries and diseases suffered by the company's employees. This therefore encourages the company to enforce preventative measures.

In terms of regulation, these insurance organizations, both public and private, are not empowered to close any working facility. However, they must give assistance in terms of safety and health protection to their insured companies. Also, these insurance organizations must provide all health care required by workers in the case of work-related injuries and diseases, sick leave payment, and permanent compensation in the case of loss of working capacity caused by accident or disease.

Of the three private, non-profit *mutuales*, the largest one is the Chilean Safety Association, a 54 year-old company that insures 2,200,000 workers, of whom only 1.6% belong to the mining sector. The largest mining company in Chile, CODELCO, is self-insured for work-related injuries and diseases. The main laws that regulate working conditions are: a) the Labour Code (1927); b) the 1968 OSH Act and accompanying regulations; c) the 1938 Health Code, which provides environmental and biological standards regarding allowable concentrations of chemical, physical, biological and organizational hazards in workplaces; d) the subcontractors act (mandatory implementation of OSH systems independently of the owner); and e) silicosis eradication. Also, the following ILO Conventions have been ratified by Chile: Radiation Protection (No. 115, 1960), Occupational Cancer (No. 139, 1974), Occupational Health Services (No. 161, 1985), Asbestos (No. 162, 1986), and List of Occupational Diseases (No. 194, 2002).



Chilean law makes no distinctions among economic sectors or ownership types that could give rise to discriminatory or preferential treatment between national or foreign investment. All companies and workers in Chilean territory are regulated by the same legislation and they must all comply with it. Mining activities are regulated by the Mining Code, Law 18.248 and several other regulations.

Thirty-three Chilean miners were trapped 700 meters underground after a cave-in at the San José copper pit, in August 2010. They were all finally rescued. The rescue work was televised and raised a lot of attention both in Chile and around the world. Due to the San José accident, occupational safety and health became a national priority. As a result of this accident, the government put in place a special commission to review the overall picture regarding health and safety of workplaces in Chile. This Commission delivered a report in November 2010 where they proposed several improvements, such as the reorganization of the Social Security Superintendency, under the Ministry of Labour, in order to have a special, dedicated Superintendency to work on safety in the country. Also, SERNAGEOMIN was to be reorganized and provided with more inspectors to develop their mission in the mining sector.<sup>5</sup>

## **2.2 Accidents**

All statistics presented here concerning accidents have been received from the Department of Mining Safety at SERNAGEOMIN. As shown in Table 1, the frequency of accidents requiring medical care has decreased since 1982, reaching 3 per million man-hours of work in 2011, among the lowest by economic sector in the country, where the national frequency rate is over 6. The distribution of the accident frequency rate by gender is shown in Table 2. The rates are lower for females, 1.2, than for males, 3.2.

As for deaths, there was a steady decrease in annual mining deaths until 2000. Since then, the rate has tended to stabilize at around 0.10 per million working-hours. In 2010, 45 deaths were recorded, corresponding to a rate of 0.13 per 1,000,000. Of these, 19 deaths occurred in the informal mining sector (42%) and more than half (55%) concerned subcontracted miners. In 2010, companies with 400 workers or more employed about 92,000 workers and 13 died in a mining accident. In contrast, companies with less than 12 workers, employing around 11,000 individuals, registered 21 fatal accidents. The miners died in accidents caused by cave-ins, electrocution, explosions, asphyxiation and falls from heights.

## **2.3 Diseases**

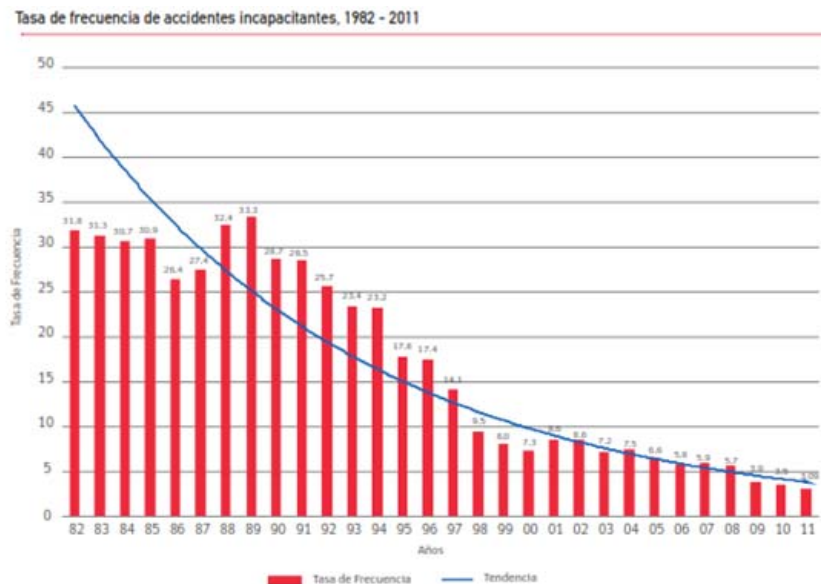
Among workers in the mining sector in Chile, the occupational diseases identified are mostly silicosis and noise-induced hearing loss. Since both diseases take a long time to become symptomatic, there is under-diagnosis and under-reporting. The Social Security Superintendency has launched a new occupational health statistics system, known as

*SISESAT*, which is intended to collect all data from occupational injuries and diseases in order to provide information at the national level.

Although silicosis has been the most important occupational disease in Chile for the last 50 years, the magnitude of this disease remains unknown.<sup>9</sup> In 2009, a National Silicosis Eradication Plan<sup>6</sup>, *PLANESI*, was established in a cooperation between the ministries of Health and Labour, workers compensation companies, companies with workers exposed to silica, workers organizations, and academics. Its main objectives are to diminish and control silica exposure in working environments and to diminish the prevalence of silicosis. Up to November 2012, the following actions have been taken:

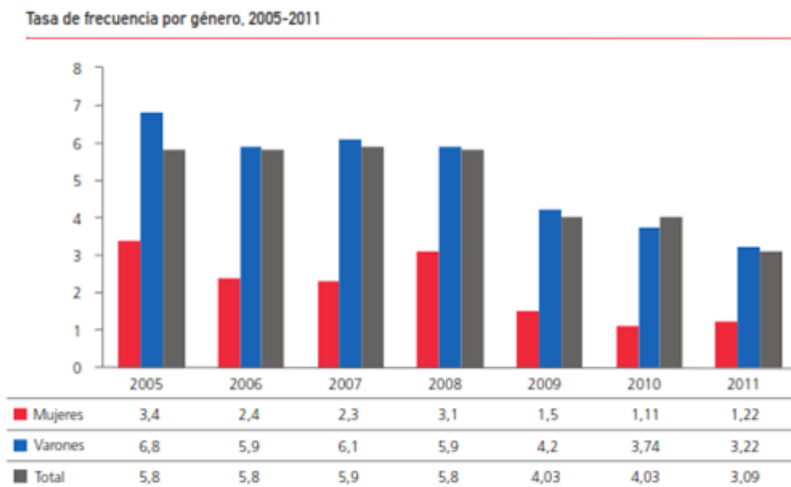
1. One national and many regional working groups have been established, working on a regular basis,
2. Fourteen physicians have been trained to take X-rays according to the ILO technique (the National Institute for Public Health plans to hold this course annually),
3. One national and many regional working groups have been established, working on a regular basis,
4. Fourteen physicians have been trained to take X-rays according to the ILO technique (the National Institute for Public Health plans to hold this course annually),
5. Environmental evaluation of workplaces is being completed,
6. Plans have been established for medical surveillance, with periodical X-ray exams, of up to 40,000 workers,
7. The National Institute for Public Health has proposed a quality-assurance system for healthcare centres developing biological surveillance and the diagnosis of workers exposed to silica; one clinic has been certified in the mining area of central Chile.

**Table 1.** Frequency of accidents requiring medical care (*accidentes incapacitantes*) in mining, 1982-2011. The frequency is measured as number of accidents per million manhours of work. Source: SERNAGEOMIN.



Fuente: SERNAGEOMIN

**Table 2.** Accident frequency rate related to gender in mining, 2005-2011.  
*Mujeres* = women,  
*Varones* = men. Source: SERNAGEOMIN.



Fuente: SERNAGEOMIN

PLANESI is a strategy for the period 2009-2030. A national committee is evaluating the fulfilment of the strategy and actions taken.

## 2.4 High altitude

Another important health challenge for Chilean mining is work at high altitude - many mining sites are over 3,000 meters over sea level and workers have to adjust to conditions with low oxygen.<sup>8</sup> Health exams have been put in place to avoid exposure to high altitude of workers with susceptible health conditions, such as heart or lung disease. This challenge has brought the occupational health community together in order to develop strategies to protect workers' health.

### 3. Current needs

Mining is a key sector in Chile. It is growing and new exploitation sites are being developed, and the mining production will continue growing in the near future. However, the mining and processing costs have been increasing due to the environmental regulations, the operating costs related to energy, labour, and the costs of purchasing and maintaining mining equipment. Another source of concern is the probable extension of the Specific Tax on Mining Activity. Despite higher costs and the peso's recent appreciation against the dollar, mining in Chile is profitable. If the mineral prices fall then companies may rethink their plans.

The law establishes occupational safety and health standards, administered and enforced by the Ministries of Health and Labour. Safety standards, similar to those in more developed countries, are not followed by small- and medium-sized enterprises. The contrast between mortality and morbidity indicators at big companies and those at small and medium-sized companies reflects a huge safety gap. Furthermore, subcontracted miners have a high and unacceptable level of mortality; this has made mining companies demand the same safety standards for subcontracted companies as for their own workers.

The government must promote, support and enforce the safety and occupational health, especially in the small-scale mining industry, by implementing legislation and providing training and educational assistance. Inspection agencies must be empowered with personnel and authority to develop their function; SERNAGEOMIN has a total of 42 inspectors, which clearly is not enough to control all the mining sites operated in the country.

The above-mentioned and other needs for improvement of the safety and health in mining in Chile have been taken up in the report by the special commission appointed after the San Jose Mine accident. The report was presented in November 2010, but the proposed actions were still being analysed by Congress at the end of 2012.

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# Safety and health in mining in Ecuador

## Basic facts about Ecuador

Size of area	284,000 sq km
Population	15 million
Capital	Quito
Literacy	93%
GDP per capita (PPP)	US\$ 8,800
Gini index	47
Infant mortality rate	19 deaths before age 1 year/1,000 live births
Median age	26 years
Life expectancy at birth	female: 79 years, male: 73 years

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## 1. Mining activities

The potential of mining resources estimated in Ecuador is around 2,000 tons of gold, 4,000 tons of silver, and 30 million tons of metallic copper. The value of the reserves of gold and other metals is estimated to about 200,000 million USD.<sup>1</sup>

Gold, silver, copper, molybdenum, iron, and zinc are extracted. Most of the production is performed at a small scale. The present production of gold, legally recognized, is around 12 tons per year, but this does not represent the actual production due to unknown illegal extraction. Ninety per cent of the gold is exported and 10% is used in Ecuador to produce jewels and handicraft.

The formal sector in the mining industry currently consists of two medium sized enterprises, owned by Ecuadorians. They extract gold and they each have around 50 workers in the industrial plants and more than 100 workers involved in extraction. In these two enterprises, it seems that labour rights are recognized and payments are made according to the Ecuadorian legislation.

The government is preparing some contracts with big transnational companies to produce silver, copper and gold on a large scale. These programs are in the first step of exploration and the extraction of minerals will start in 2013. The mining areas are located in the Provinces of Azuay, El Oro, Zamora Chinchipe, Morona Santiago and Esmeraldas. There are other large projects for large-scale mining on the way to being signed with international companies. In March 2012, a contract was signed with a Chinese company (ECUACORRIENTE), to extract copper.

The establishment of formal mining activities has met with many difficulties in Ecuador. Nearby Indian populations resist the presence of large-scale mining because they believe that open sky mining, in particular, will use too much water and produce too much waste. It will destroy the environment and not give many employment possibilities for the communities. They say it will change social, cultural and economic traditions, altering or transforming their life style. They say that it is impossible to have responsible mining without environmental impacts and they think that they can develop their regions with other strategies. The Government's standpoint is that mining is needed for the development of the country, and that a strict control of the mining activities is possible.

About ten years ago, the government in Ecuador gave more than 6,000 permissions to extract minerals (concessions), in particular gold, in different areas of the country. Two years ago, the Government withdrew these permissions and established new conditions for mineral extraction, the so-called *Mandato Minero No. 6*. This is an act that regulates the extraction of minerals and production of metals, especially considering the impacts on the environment. Currently there are around 1,700 legal concessions under the *Mandato Minero No. 6* but not all of them are in production.<sup>2</sup>



It is not known how many illegal mines there are in Ecuador, but it is calculated that there are several of these mines in isolated places in different provinces.

Most of the small-scale mining is part of the informal economy. The government has tried to establish formal contracts with the enterprises but these efforts have not resulted in any important improvements, up to now. Concessions have been given, but the application of the rules of *Mandato Minero* is causing problems, as they are not easy to follow. Most of the owners of the small-scale mining enterprises are Ecuadorians in legal forms as cooperatives, associations, co-owners, or individual concessions. The owners may have more than one mining enterprise. These enterprises have only a few workers, not more than five in each workplace.

Most mining workers are men while women work in the mines as cooks or clean the rooms; they do not participate in the extraction and production processes. The census for artisanal mining in 2010<sup>3</sup> indicated that there were around 10,000 persons working in the small-scale mining industry in Ecuador. Since these miners belong to the informal economy, including illegal mining, they are not registered by the census, and therefore the actual number of mining workers is probably much higher - up to 60,000. In addition, it is estimated that more than 2,000 children and adolescents between 5 and 17 years old are working in mining activities and performing the same activities as the adults.<sup>4</sup> One project supported by ILO (International Labour Office) to reduce child labour in the Ecuadorian mines was relatively successful, but poverty always presses to move children to work.

Gold, for example, is extracted using very basic procedures. The miners make holes in the walls of the tunnels, where they put the dynamite. When it explodes, many stones fall down in the tunnel and lots of gas and dust are produced. The stones are collected in small wagons and moved outside the galleries, to the mills. The mills produce fine sand that is then prepared for separation to obtain the gold. The working conditions include, in most workplaces, overload from moving bags with heavy materials (more than 40 kilograms each) and/or pulling or pushing the wagons in the tunnels. There is frequently lack of light and ventilation in the tunnels, as well as exposure to silica dust, noise, and different chemicals. Safety conditions are poor: tunnels are built in a primitive way and there are no alternative exits. The miners have no personal protection. There are no organizations for safety and health, such as committees.

There are no unions for mine workers and they do not have labour rights. They get a monthly salary of 4-500 USD. This may look bigger than the basic salary in the formal economy, 292 USD, but since the mineworkers are not affiliated to the social security system, they do not receive the two legal extra monthly salaries or money for extra working hours, they do not have vacations, and safety and health is not considered. So, at the end of the day, they are getting less money and no social benefits compared with the workers of the formal sector of industry.

Migration has become important for small-scale mining in Ecuador. Most of the mines are located in the south of the country, close to Peru. Ecuador has the US dollar as the national currency, which makes the salaries worth more than in Peru. Therefore, many Peruvians

have come to work in the mines in Ecuador. The Peruvian workers may represent about 5% of the total mining work force and they often get less salary than Ecuadorian workers. The result is a kind of social dumping and a competition at the bottom, where both Ecuadorian and Peruvian workers fail to have acceptable working conditions and other labour rights.

## 2. Safety and health

### 2.1 Policy and legislation

Ecuador has ratified many conventions and recommendations of the International Labour Organization (ILO). Unfortunately, legislation and international agreements are not observed and there is minimal supervision and control. There are many national laws that strive for better safety and health conditions in all the sectors and also particular rules for the mining activities. The legislation on occupational safety, hygiene and health, however, is of general character rather than explicit. So, it is difficult to apply the legislation in these isolated, heterogeneous and complicated areas where mining is carried out.<sup>5</sup>

In 1996, the Government published the Mining Safety Regulation (*Reglamento de Seguridad Minera*) and the following year the Environmental Regulation for Mining Activities (*Reglamento Ambiental de Actividades Mineras*) was established. Other legislation, like the *Código del Trabajo* and some regulations from the Ecuadorian Institute of Social Security (*Instituto Ecuatoriano de Seguridad Social*), include some articles about the recognition of work-related diseases.

The central governmental agencies involved in safety and health are the Ecuadorian Institute of Social Security, the Public Health Ministry, the Ministry of Labour Relationships and Employment, the Ministry of Mines and Energy, and the Ministry of Environment. There is a lack of labour inspectors. The Ministry of Mines and Energy is responsible for supervision and control of safety and health in mining. Due to unclear policies and lack of resources (including lack of technical expertise), inspectors frequently feel unprotected, ignore priorities, or have only a partial view of problems due to lack of input from workers.

A new Constitution of Ecuador was established in 2008, introducing new principles about environment and health in all aspects of life. In terms of prevention, it included the precautionary principle and some specific criteria for the working environment and health of workers and the general population. Other articles focus on control of soil, water, and air quality and the role of official institutions. Now, four years after the establishment of the new constitution, there have been changes that indicate better intentions. For example, there is a serious attempt to control mining activities and to regulate and improve the sector. The General Mining Act, the Mining regulation and the Environmental regulation were established in 2009 and include many articles aiming at improvement of the present situation. There are specialized courses in safety, health and the environment (including Masters Programs) organized by the Central University of Ecuador, and by some private institutions. These are theoretical courses providing a low level of academic tuition. There are no special

courses on safety and health in mining.

## **2.2 Statistics**

The national statistics of occupational accidents and diseases is very general and misleading. There are no specific statistics of injuries and diseases in mining. However, it is well known that many people die in the mines due to the lack of safety measures in the tunnels. In 2011, four miners died trapped in a tunnel and a few months later a similar accident occurred and two workers died. It is very common to hear about work-related accidents, such as knocks, cuts, injuries and falls. The bad construction of the tunnels and the lack of emergency exits are the most common causes of such accidents.

Occupational diseases are not well registered. A striking example of this is that the Social Security has recognized only one case of silicosis during fifty years. There are various reasons for this. There is a severe under-reporting and incorrect registration due to lack of knowledge among occupational health specialists and therefore also among managers, workers and inspectors. There is a lack of appropriate methods and techniques to identify sub-clinical problems such as those produced by long-term low dose exposures, minor acute effects, and chronic effects. Furthermore, most of the mineworkers are not affiliated to the Social Security system and therefore receive no protection.

## **2.3 Research data**

The dust produced during the explosion of the dynamite in the tunnels contains high levels of silica. Measurements have demonstrated that total dust and in-halable dust are high. There are no systems to extract the dust or good methods for personal protection of the miners, resulting in high exposure of the workers. In 1999, 260 miners from Portovelo and Zaruma were studied for respiratory diseases using the International ILO Classification of Radiographs of Pneumoconiosis. This is a system of classification of radiographs where the size and shape of lung tissue abnormalities are expressed quantitatively - the higher number the more abnormalities. Twenty-seven subjects (10%) reported different levels of silicosis according to the ILO Classification, and two of them had the most severe degree of lung affection.<sup>6</sup>

In addition, dynamite contains nitrogenous derivatives and is a highly explosive compound that gives a high risk of asphyxiation. The use of dynamite is also known to be associated with cardiovascular disease. In Ecuador, there are no precise data available on the incidence of health effects related to the use of dynamite in mining. Recently, an accident was reported that was caused by unsafe detonation of dynamite inside a mine located on the Ecuadorian coast. Two miners died, probably due to the high presence of nitrogenous gases and the absence of ventilation in the tunnel.

The use of mercury through the burning of amalgam to purify gold exposes the miners to elemental mercury vapour<sup>7,8,9</sup> and other metals, such as cadmium. When the process is done with cyanide, a mixture including lead is used, adding a new source of exposure. The risks of

exposure to mercury and the resulting health effects, including renal and neurological effects, are well known among gold miners.<sup>7,8,9,10,14</sup> In 2000, a study found high exposure to mercury in miners in Bella Rica, Azuay, and neurological effects like tremor, equilibrium disorders, and coordination problems.<sup>10,11</sup>

During 2008-2010, a study done within the PHIME Project (Public Health Impact of long-term, low-level mixed element exposure in susceptible population strata) showed associations between biomarkers of mercury exposure in the gold miners and neurological effects. In particular, mercury concentrations in blood and urine were associated with increases in the centre frequency of the tremor, as well as increased reaction time and reduced postural stability. In addition, retention of mercury and the elimination rate appeared to be modified by polymorphisms in a gene for an enzyme involved in glutathione synthesis.<sup>13</sup>

Not only miners are exposed to mercury. The people that buy the gold from the miners are also highly exposed to mercury. They need to fire, most of them on a daily basis, the so-called metal ball that still has some mercury residues, before weighing the ball before paying the miners. As a result, this occupational group has a much higher exposure and risk than the gold miners.<sup>13</sup>

The use of elemental mercury in gold mining causes environmental contamination, particularly in the surrounding areas, with exposure of the population to this metal as well as contamination of the aquatic environment.<sup>9,10</sup> As a result, methyl mercury is formed and accumulated in fish, increasing the risks for the population due to exposure to mercury through food consumption.<sup>12</sup> Results of a recent study showed high exposure to mercury and other metals such as lead and cadmium in children and women living in the surrounding areas of the mine.<sup>15,16</sup> The exposure to mercury and cadmium in children was the highest compared to six European countries, China and Morocco and the second highest exposure to lead, after Morocco. These results confirm the important impact of this kind of mining where these activities are performed.<sup>15,16</sup>

### 3. Current needs

Ecuador is currently in a transitional period where efforts to control and improve the small scale mining activities are urgently needed, at the same time as the establishment of large scale mining operations is increasing. In consequence, various demands are emerging.

Stopping dangerous activities and preventing accidents and diseases in the small scale mining operations is critical. The following actions should have highest priority:

- Formalization of informal activities; credits to change technology, better working conditions and training of informal miners
- Respecting the labour rights of the workers
- Improvements in the processes avoiding or replacing the use of mercury and cyanide, as much as possible

- Control of environmental consequences of the use of mercury, other heavy metals and cyanide

Some of these initiatives should be taken by the on-going project “Improvement of Working Conditions in Small-scale and Artisanal Mining” (*Mejoramiento de las Condiciones de Trabajo de la Pequeña Minería y Minería Artesanal*), promoted by the National Institute of Geological Surveys and Artisanal Mining. Additional activities should be carried out by the Ministries of Labour, and Public Health and Social Security.

The development of large-scale mining should be preceded by an action plan to:

- take into account environmental and occupational health principles and laws, with severe punishment to offenders,
- establish a baseline of the present conditions for comparison in the future,
- develop a specific plan for occupational safety and health in the mining sector, by applying the general rules to the particular needs of this industry,
- ensure that working conditions really are supervised and controlled,
- create resources for environmental and occupational monitoring and bio-monitoring, and encourage the surrounding communities participation, with informed consent to allow, or forbid the mining operations.

To be successful in these activities, this plan must be developed nationally, with strict control by the national authorities in cooperation with the private sector, NGOs, on-site institutions, unions and other social organizations.

The present government is currently (October 2012) analysing the needs of large-scale mining together with reinforcing environmental control. The challenge now is to find the required human, technical and economic resources, and to involve the companies in order to quickly establish control and implement proper action plans. It seems, however, that more pressure is needed to force the companies to follow the new rules.

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# Technical notes

## Basic country facts

The basic facts listed for each country are taken from the CIA World Factbook, in March 2013; <https://www.cia.gov/library/publications/the-world-factbook/>

## English language appraisals

English language appraisal of the articles in the anthology has been made by Nigel Tooke;

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