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International Raw Materials Observatory

Fostering international raw materials cooperation

# Analysis of Education and Outreach

## Operational report

November 2016

**Abstract**

This operational analysis of education and outreach (D1.4) is the outcome of INTRAW Work Package 1.3, mapping the reference countries' raw materials educational context. The aims of this report are to review the mining & raw material supply education provision and skills availability among the Reference countries, their national workforce demands, perceptions of skill levels/qualities, and funding.

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# 1. Introduction

## 1.1 Aims of this report

This operational analysis of education and outreach (D1.4) is the outcome of INTRAW Work Package 1.3, mapping the reference countries' raw materials educational context. It will contribute to the development of an action plan for education and outreach in WP 2.3 and contribute to the design and functions of the EU International Observatory on Raw Materials in Work Package 3. It will to be disseminated through the activities in WP 4.

In the context of this report education will cover formal programmes of adult education leading to diploma, certificate, degrees, further and higher education qualifications, or vocational education programmes including apprenticeships, all of which lead to a formal award. The report does not look at school level general education provision other than to comment on its importance in basic literacy and numeracy. Outreach consist of a range of initiatives, courses, organisations and schemes specifically aimed at certain sections of society, especially those from historically disadvantaged, ethnic, or native populations who wish to learn more about mining and gain access to jobs in the mining industry.

As a review, Work Package 1 (WP1) has mapped the contextual environment of Canada, USA, South Africa, Australia and Japan (the 'reference countries'), and this is one of three reports focussing specifically on: raw materials research and innovation (D1.3); education and outreach (D1.4); and industry and trade (D 1.5). WP1 also reviews policies and practices to provide a platform for comparing the reference countries to the EU.

The specific aims of this report are to summarise the mining education provision among the reference countries, their national workforce demands, perceptions of skill levels/qualities, and funding. Reviews have been performed for each Target Country to provide data on courses, student numbers, centres of excellence, delivery mechanisms and, where possible, staff numbers. The internationalization of education and barriers to access are also analysed as part of this deliverable. Initially a Google Drive, and later, the INTRAW Repository database, was used to host an electronic library of reports, data, and other bibliographic material.

Part two of this introduction provides a literature based review on employment (1.2.1), global skills availability (1.2.2) and types of mining education (1.2.3). Previous research on education provision is described in Chapter 2, including a critique of the reports and data collection methodologies. Data is provided on each of the five reference countries in Chapter 3 including individual reviews of education demand and government funding provision. The chapter also describes some of the innovative joint initiatives between government-industry-academia to deliver improved mineral skills development.

This information is used to highlight major mining sector education themes and trends in Chapter 4, entitled 'Strategic Issues'. It identifies important educational and human resource issues such as gender imbalances, minority groups, local community skills development support, university recruitment and company strategy. Together these chapters provide the background for consideration of the metrics for EU comparison to be used in WP2, and an initial list of benchmarking metrics is provided in Chapter 5. Report conclusions are highlighted in Chapter 6, followed by a summative description of minerals education and the key findings for each target country in Chapter 7.

## 1.2 Mining industry skills

### *1.2.1 Mining Employment*

Mining is undertaken in over 100 countries, with more than 50 regarded by the World Bank as «mining countries» because of the importance of mining to their exports, domestic markets, or to employment. It is estimated that on a global basis the formal mining sector employs more than 3.7 million workers of which 1.5 million people were in the mining sector in developed nations, and 2.2 million in developing/emerging nations. There is however at least another 20 million people working in artisanal and small-scale mining (ASM) who indirectly support more than 150 million people worldwide (www.miningfacts.org).

#### *1.2.1.1 Mining Industry Skills*

Mining, in common with many industries, requires a mix of generic and specialist skills. Historically mining was a physically demanding and manual process requiring the ability to work in difficult and often dangerous conditions. Much has now changed and the modern mining operation is extensively automated with most activities involving a range of plant & machinery, so that hands–on miners have largely been replaced by equipment operators. This has allowed the mines to increase production and work larger, lower grade deposits economically. The mining skills set has therefore also changed and mining staff are more highly trained, operate in an environment where safety is paramount and enjoy pay and conditions that are highly attractive.

The modern industry therefore typically seeks skilled operators, graduates and technical specialists with not just mining knowledge but also digitally-literacy, problem solving ability and good personal skills, who can work safely in both a team and individual capacity.

#### *1.2.1.2 Mining Industry workplaces*

There is a commonly repeated truth that minerals can only be mined where they are found. With a long history in most countries of exploiting more easily accessible deposits this means that new mines are typically in remote areas far removed from the main population centres; and this has led to a range of mining employment models.

During exploration and initial development of a mine there may be a small exploration or mining camp with basic residential accommodation, catering and support facilities. The construction and operational phases will however need a much larger workforce and significant infrastructure development including a basic airstrip. Contractors undertaking construction typically work on rotation and fly-in, fly-out (FIFO) of the site, as well as constructing larger temporary facilities to be housed in. As the mine comes into production workers may be located in regional or national centres and a FIFO system is used for staff to work rosters of typically 2-8 weeks on site. In some cases staff may even be based in other countries.

If there are more accessible regional towns and cities it is possible for employees to drive to and from the site for similar periods of work (drive–in, drive-out or DIDO). Occasionally the mine is close to residential centres where staff can work in a normal daily pattern. These last two options facilitate the use of a high proportion of local community staff in the workforce. In many countries this is a major issue around a company's 'social license to operate' and there will be significant investment in assisting local communities to gain the skills required to become employees at the mine.

For larger mineral deposits hosting long-lived mines the more extensive mine infrastructure development will also include a 'company town' with good quality residential housing, recreational facilities, schooling, shops, a hospital and other healthcare facilities so that staff work on a residential basis, with their families.

Each of these require different compliments of contractor and company staff at the construction and operational stage based on the companies' level of investment in local facilities and infrastructure. It also means that the geographical area in which skills need to be available may extend from the local community to the national or even international level, and in turn places different demands on where mining education needs to take place.

In order to build industry skills and the experience required, and to learn relevant corporate best practice, most professional level mining staff, both technical and managerial, will circulate around the company's mining operations on a national or international basis. Mobility is therefore a critical requirement for professional mining staff.

#### 1.2.1.3 Mining Industry Roles

The staffing requirements at mines are based upon the fundamental processes that mining involves. The mining value chain typically comprises the exploration and evaluation of a deposit; its mine planning, permitting and design; construction, mine production, ore processing and recovery; and sales and export of the product.

While every mine is different, most operations require a similar range of essential staff to undertake the technical, regulatory and management functions required. Mining companies are usually led at a corporate level by a board of directors and functional senior management. These are experienced people with extensive track records of national or international mining but also of banking, law, and commercial experience in related sectors. At the individual mines there may typically be a General Manager and a team of managers leading mining, metallurgy, geology, administration, safety, external relations etc. Under each of these are technical specialists, supervisors, and operational staff overseeing a range of skilled and semi-skilled staff and associated contractors. ***Figure 1*** illustrates the simplified structure of the professional and technical roles in a mining operation.

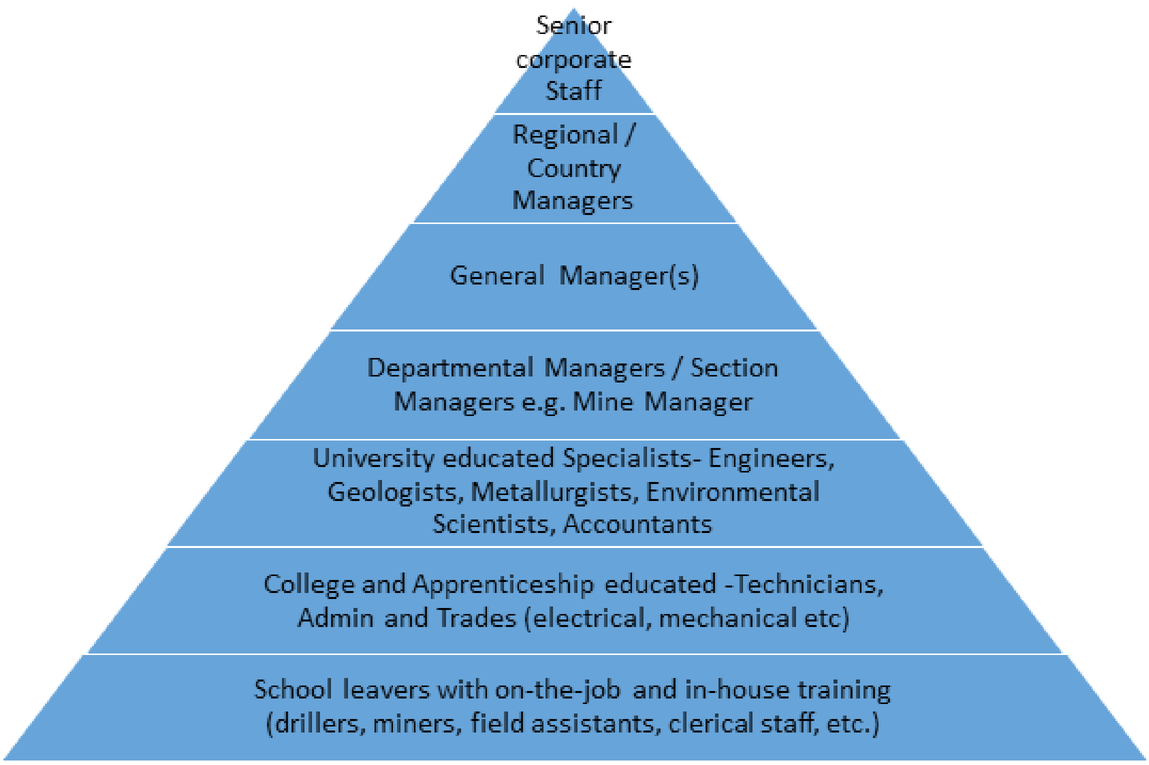



*Figure 1: A typical simplified organisational structure in a mining company.*

#### 1.2.1.4 Mining Industry jobs

Within this overall structure are employees who undertake the specific tasks required by the mining company. ***Table 1*** and ***Figure 2*** list many of the core job roles used in the development and operation of a mine. ***Table 1*** is based on Canadian terminology while ***Figure 2*** uses Australian terminology. Similar roles may have different names in other countries.

These roles are sometimes required more at different stages of a mining operation and increasingly these fluctuations in demand are being managed by the use of contractors. The contracting companies bring in specialists skills for temporary periods, or more general labour supply at peak demand. The use of contractors is growing especially as some are associated with the more frequently contracted-out mining functions such as drilling, blasting, haulage and equipment maintenance.

| Professional Jobs | |
|---|---|
| These jobs typically require you have a university degree | |
| Job title | Required most during |
| Geologist | Exploration and production |
| Hydrogeologist | Assessment and monitoring through life of mine |
| Geochemist | Exploration |
| Mechanical Engineer | Production |
| Mining Engineer | Design and Production phase |
| Chemical Engineer | Design and Production phase |
| Environmental Engineer | Exploration-mine closure |
| Surveyor | Exploration, production |
| Accountant | Feasibility and production |
| Nurse | Production |
| Manager of Training | Mine start-up and production |
| Human Resources Manager | Mine start-up and production |
| Materials Manager | Building and production |
| Mine Manager | Mine start-up and production |
| Mill Manager | Mine start-up and production |
| General Manager | Start-up and Production |
| Semi-Professional Jobs | |
| These jobs require a college diploma. Technology programs are generally two to four years in length. | |
| Mill Maintenance Foreman | Operation |
| Electrical Foreman | Operation |
| Mine Foreman | Operation |
| Mill Foreman | Operation |
| Safety Officer | Throughout mine life |
| Warehouse Supervisor | Operation |
| Technical Jobs | |
| These jobs need a technical college diploma. Generally, these are one or two year programs | |
| Mining Technician | Operation |
| Environmental Technician | Operation |
| Engineering Technician | Operation |
| Office Jobs | |
| For these jobs you must have at least a Grade 12 education and have some training or experience | |
| Mine Clerk | Operation |
| Accounts Clerk | Operation |
| Secretary | Operation |
| Apprenticeship / Trades Jobs | |

| | |
|---|---|
| These jobs require that you be a journeyman or certified trades person | |
| Carpenter | Construction (and maintenance during operations) |
| Cook | Construction (and maintenance during operations) |
| Electrician | Construction (and maintenance during operations) |
| Mechanic | Construction (and maintenance during operations) |
| Machinist | Construction (and maintenance during operations) |
| Plumber | Construction (and maintenance during operations) |
| Steamfitter/Pipefitter | Construction (and maintenance during operations) |
| Welder | Construction (and maintenance during operations) |
| Millwright | Construction (and maintenance during operations) |
| Crusher Operator | Production |
| Skilled Jobs | |
| These jobs require that you be able to read and have previous mining experience and may require some training / certification. | |
| Driller | Exploration and Production |
| Blast Hole Driller | Production |
| Blaster | Production |
| Entry Level Jobs | |
| These jobs require little or no previous experience. On-the-job training may be required for some of these jobs. You must be able to read and write, though some require at least a Grade 12 level of education. | |
| Labourer | Construction |
| Janitor/Dryman | Production |
| Blast Helper | Production |
| Driller's Assistant | Production |
| Equipment Operator | Production |
| Geophysical Asst. | Exploration |
| Mechanic's Helper | Production |
| Electrician's Helper | Production |
| Surveyor's Helper | Production |
| Sampler | Production |
| Grinding Operator | Production |
| Flotation Operator | Production |
| Reagent Operator | Production |
| Dewatering Operator | Production |
| Cook's Helper | Production |
| Warehouse Person | Production |
| JOBS SERVING THE MINING INDUSTRY | |
| There are many other jobs that are associated with the mining industry. A lot of companies sub-contract out different parts of the mining process. Some examples of jobs related to mining are: | |

| | |
|---|---|
| SERVICE ACTIVITIES | Metal Fabricator |
| | Heavy Duty / Commercial Transport Mechanics |
| Maintenance | Professional Cook Training |
| Camp Construction | Fitting and Machining |
| Expediting | Power Linesman |
| Staking Claims | Plant Mechanics |
| Security | in Electro-Technology |
| Line cutting | Boiler makers |
| Trucking | Mechanical fitters |
| Industrial Mechanic | Crane operators |
| Geophysical Surveying | Labourers |
| Sampling | Riggers |
| Supplying Food | Concrete placers |
| Trenching | Pipe layers |
| Camp Management | Steel erectors |
| Cooking | Estimators |
| Remote Communications | Project managers |
| Airplane Passenger and Freight Handling | Construction supervisors |
| Road and Airport Building and Maintenance | Foresters |
| | Environmental technicians |
| Supplying Construction Materials | Concrete finishers |
| Equipment Rental | Residential superintendents |
| Making Special Clothing or Equipment | Landscape maintenance and construction |
| Maintenance planners and supervisors | Building services |
| Regulators/mines inspections | Cabinet makers |
| | Sand blaster |
| | Painters |
| | Carpenters |

*Table 1: Job roles in a mining company or providing services to a mining operation.*

The number of people working in a mine is a function of the scale, level of automation and mechanisation, as well as complexity of the mining and milling processes, and extent of added value operations. Small mines may range from 10-150 people, while many mechanised mines have around 150-500 employees. Large mines with on-site smelters can employ up to 15, 000 people.

By way of example proportions of staff in the occupational categories of mining employees found in a national survey of the mining population undertaken by The National Institute for Occupational Safety and Health (NIOSH) for all types of mines in the US (***Figure 3***) shows the largest groups of staff are supervisors and equipment


*Figure 2: Mining Careers at different skills levels - Australian Mining Industry (miningcareers.com, accessed January 2016). Mining Careers at different skills levels - Australian Mining Industry (miningcareers.com, accessed January 2016).*

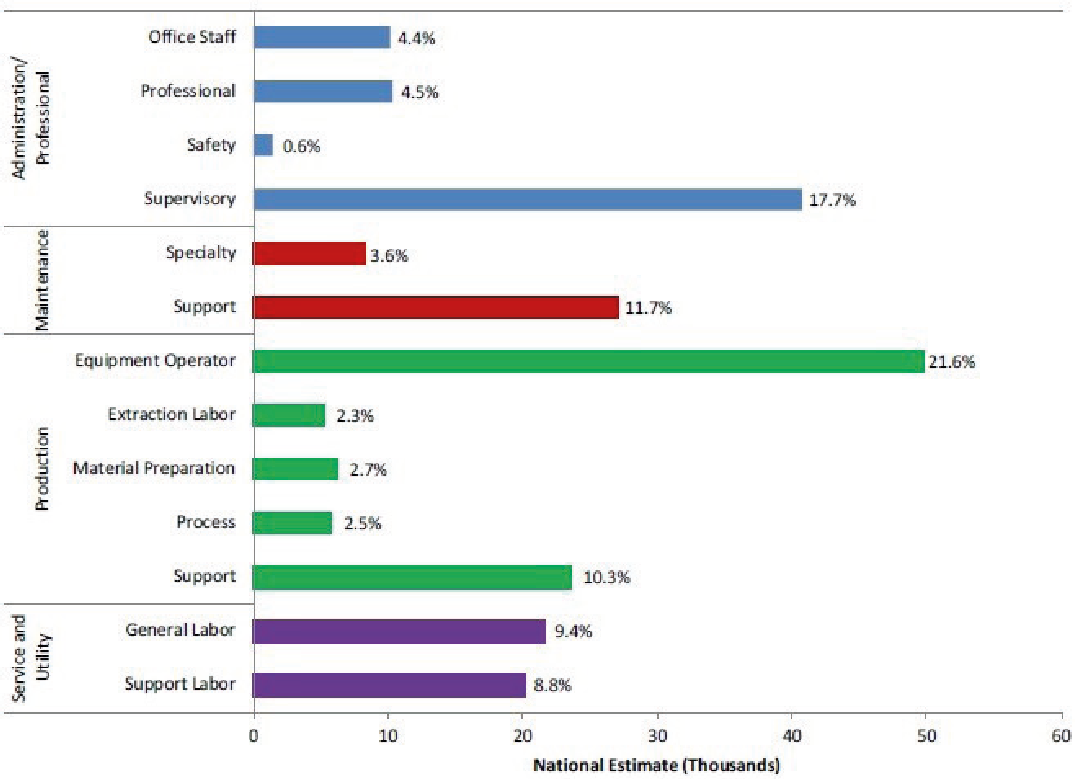



*Figure 3: Occupational Categories of US Mining staff – all mines (NIOSH 2012) (http://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/2012-152.pdf).*

operators, reflecting the large number of small but mechanised mines.

Different sectors within mining employ staff primarily according to the mining method and processing requirements. Most construction materials are worked in surface excavations with processing limited to crushing and sizing; but with added value operations in manufactured construction products such as concrete, blocks and tiles in addition to the primary aggregate products. Staffing is therefore relatively straight forward as mobile and fixed plant operators are quite widely available. By contrast, an underground metal mine will need specialist underground miners, and the extensive ore processing plant incorporating crushing, milling, flotation and tailings disposal require a much more extensive and specialist set of staff. On the whole, the level of mining and processing complexity increases from construction materials to industrial minerals, through metals to high value specialist materials; and with it goes increased skills requirements.

### 1.2.2 Global Skills Availability

Mining is a challenging, high capital investment industry which is extremely sensitive to economic cycles and now largely governed by the international commodities market. Regardless of location, all mines are competing on cost of production and efficiency of the project capital. Demand and supply can change rapidly and as a result, job security and long term viability of individual mines is always an issue. The industry has therefore recently seen rapid increases and decreases in the number of people it employs.

Commodity prices have historically demonstrated cyclicity over a range of scales and periodicities, and this is a primary influence of investment, mine output, mining company share prices and employment. If we look at Australia since the 1960's (***Figures 4 & 5***) there has been at least three mining booms, 1967-70, 1978-81, and 2003-11 although investment and output lag these by some years as the industry responds to new market conditions (Connolly & Orsmond 2011). A prolonged period of low commodity

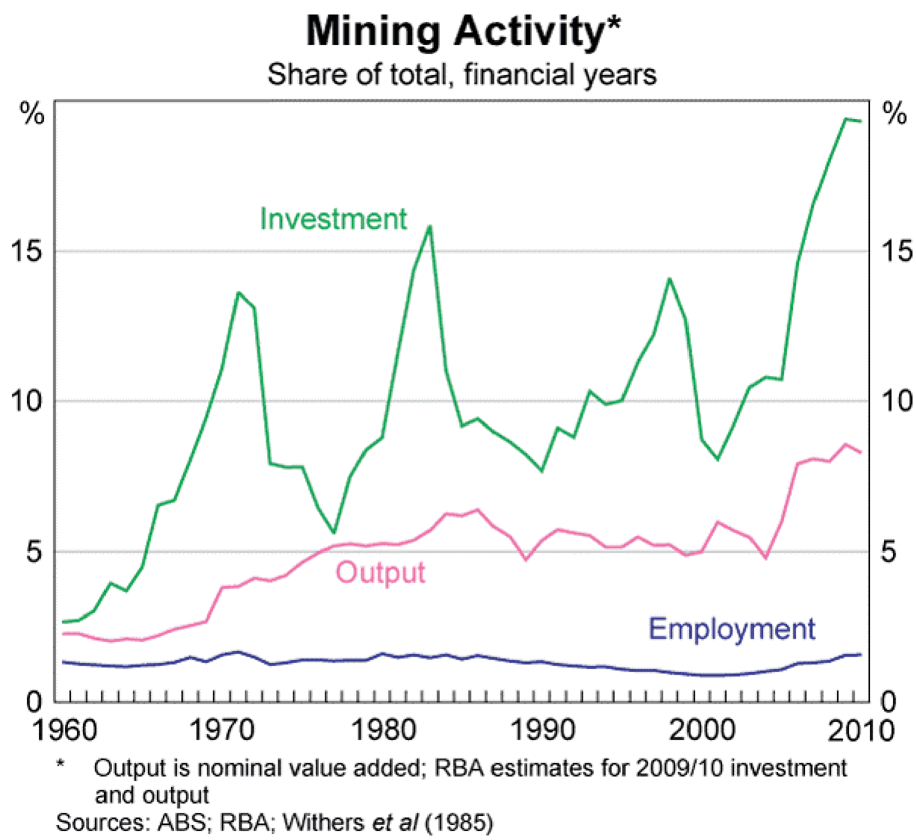



*Figure 4: Australian Mining Cycles 1960-2010 – showing investment, mine output and mining employment (Connolly & Orsmond 2011).*


*Figure 5: Mining Share process 1960-2011 (Connolly & Orsmond 2011).*

prices left the mining industry in stagnation during the 1980's and 90's. The earlier booms were not necessarily global, being fuelled by regional demand and major Australian mineral discoveries, while in the 2000's the extended boom was driven by international commodity prices, industrialisation and urbanization.

The growth and development in the BRIC's (and now the MINT's – Mexico, Indonesia, Nigeria and Turkey) in the last 15 years led to unprecedented demand for mineral raw materials and this caused the 'commodity super cycle' seen in recent years. With the growth of the mining sector new people had to be attracted to work in mining and this was often achieved through high wages, attractive work rosters and good working conditions. While commodity prices were attractive, mining companies invested large sums in exploration and as a result new discoveries were made. This led to new mine development which has now come into production, increasing mineral supply and re-balancing the market, thus reducing the demand for exploration, development and employment.

In the past, the demand for professional staff was largely satisfied by a collection of mobile expatriates who managed mines and led technical mining activities on a global basis. Such staff were typically trained in the UK, Australia, Canada, South Africa, and USA as well as regional centres, working both in their own mining sectors and in newly emerging mining nations. Mines were seen by governments as ways to derive large revenues through tax and royalty payments but played little role in the running of the operations. Today the mining staff are more diverse and increasingly 'home-grown', and mining countries exercise considerable influence over the mines that exploit their resources. The issue of 'resource nationalism' is discussed in more detail later.

The issue of mining skills shortages has been recognised as one of the major challenges facing the industry. Over the last decade it has been highlighted by industry executives, governments, workforce planners, industry commentators, and has been recognised as a threat to the development of the industry globally as well as in producing countries. While in

| Year | Ernst & Young Business Risk Ranking - Skills shortages |
|---|---|
| 15/16 | 11th |
| 14/15 | 9th |
| 13/14 | 5th |
| 12/13 | 2nd |
| 11/12 | 2nd |
| 10/11 | 2nd |
| 09/10 | 6th |
| 08/09 | 1st |

| Top 10 risks 2015 | | Over 8 years 2008 (peak of supercycle) | |
|---|---|---|---|
| 01 | Switch to growth | 01 | Skills shortage |
| 02 | Productivity improvement | 02 | Industry consolidation |
| 03 | Access to capital | 03 | Infrastructure access |
| 04 | Resource nationalism | 04 | Social license to operate |
| 05 | Social license to operate | 05 | Climate change |
| 06 | Price and currency volatility | 06 | Rising costs |
| 07 | Capital projects | 07 | Pipeline shrinkage |
| 08 | Access to energy | 08 | Resource nationalism |
| 09 | Cybersecurity | 09 | Access to energy |
| 10 | Innovation | 10 | Increased regulation |

*Table 2: Ernst & Young Ranking of skills shortages as a Business Risk.*

any given year the mining industry perceived a number of risks to be of paramount importance, on average over the recent mining boom, Ernst & Young, in their annual reviews of mining and metal industry business risks (EY 2008-2015), ranked skills shortages as the overall number 1 risk (EY 2015) facing the global mining industry (***Table 2***).

While some of this criticality has now declined with mining company retrenchments in many countries during 2012-2015, the issue of ensuring talent availability to the industry through the commodity cycle is still unresolved. The current 'demographic gap' in the industry caused by a lack of recruitment during the 1980's and 1990's remains, or is worsening, and this is discussed in more detail in Chapter 4.

Employment levels in major mining countries during the recent mining boom reached extremely high levels as mining companies sought to increase production and meet the global demand for minerals fuelled by industrialisation and growth in China and the other BRIC countries (***Figure 6***). This revealed both global and national shortages of mining skills required to support this activity level, especially when considered alongside the demographics of mining industry employees.

Below are examples of statements made by industry bodies in our reference

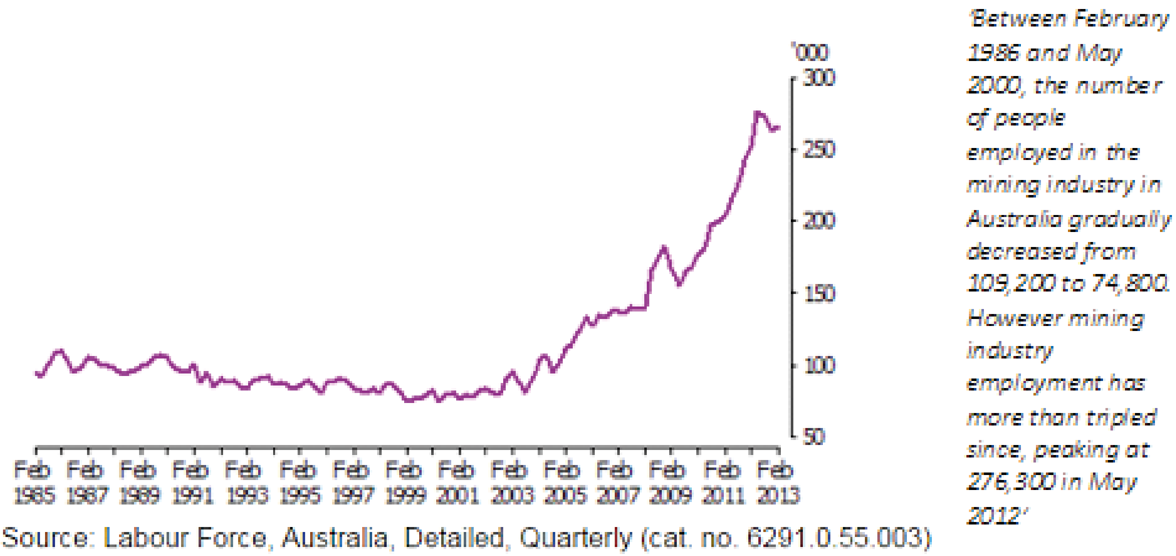



*Figure 6: Mining employment levels in Australia since 1985, Australian Bureau of Statistics, April 2013 (http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4102.0Main+Features10April+2013, accessed January 2016).*

countries:

- Over the next 10 years a third of all mining engineers in Australia will retire (Minerals Council of Australia, 2014);
- The Mineral Council of Australia in 2014 said "mining labour shortages have become a permanent feature of the Australian mining sector". The council has predicted the need for an additional 86,000 mining professionals and skilled mine workers by 2020;
- In 2009 the Canadian Mining Industry Human Resources Council stated that 'the combination of an ageing workforce, competition for skilled workers and declining enrolment in mining-oriented academic programs is the source of great concern in the mining industry;
- Canada will need to recruit 60-100,000 staff in the next decade (Minerals Industry Human Resources Council 2011);
- Up to 40% of Canada's mine and metals workers are expected to retire by 2014 and approximately 50% of workers will exit the industry by 2018' (Mining Industry Workforce Information Network 2009);
- 'In Ontario one-third of all mining industry workers are within the 55 to 64 years of age cohort. It is expected that in the coming years, the mining industry will experience a surge in the number of retirees as a greater share of their workforce approaches the average retirement age. This expectation is manifested in the higher retirement rates from 2015 onwards'; (Minerals Industry Human Resources Council 2009);
- Around 55,000 new employees need to enter the US mining industry just to maintain numbers (National Mining Association 2012);

In the last 3 years the demand for metals and other minerals has slowed and the fresh capacity created by investment in new mines and infrastructure has come on stream. The combination of these has led to a slump in commodity prices and resultant loss of mining jobs. Although the projections for major skills shortages have been reduced, the current low recruitment of younger staff into the industry is a major concern for maintaining the future supply of experienced staff. The current retrenchment of both professionals and trades will lead to many leaving the mining industry for allied employment sectors and many will not return, especially older and more experienced staff who retire and young professionals who decide to develop their career in other business sectors (AusIMM 2015).

Recruitment of young people into mine related training or education is also likely to decline as current graduates struggle to get into work. The lead times intrinsic to such apprenticeships, vocational training and higher education mean that they are a 'lagging indicator' and so when the mining industry again requires new recruits they will find such qualified staff again in high demand or unavailable. These issues are consequences of mining industry cyclicity and many companies lack of ability or desire to retain staff during the downturn. There are examples however of where more enlightened managers are ensuring staff are both retained and access training opportunities while they have the capacity to do so, ahead of the inevitable upturn.

#### *1.2.2.1 What the industry think*

The industry perception of skills availability is one of the issues companies consider when deciding where to focus exploration activities and potential mining investment. This is ranked annually by exploration and mining company staff through one element of the internationally recognised Fraser Institute Annual Report of Mining Companies (***Figure 7***).

Most of the reference countries or their component States lie in the upper quartile of this ranking although South Africa sits nearer the mid-point. The reference countries generally therefore are seen as having a pool of mining expertise that, along with mineral endowment and a good regulatory environment, make them attractive as places for exploration and mining activities. This contrasts with many new or growing mining countries. Because of the lack of indigenous mining activity most EU countries are not on the

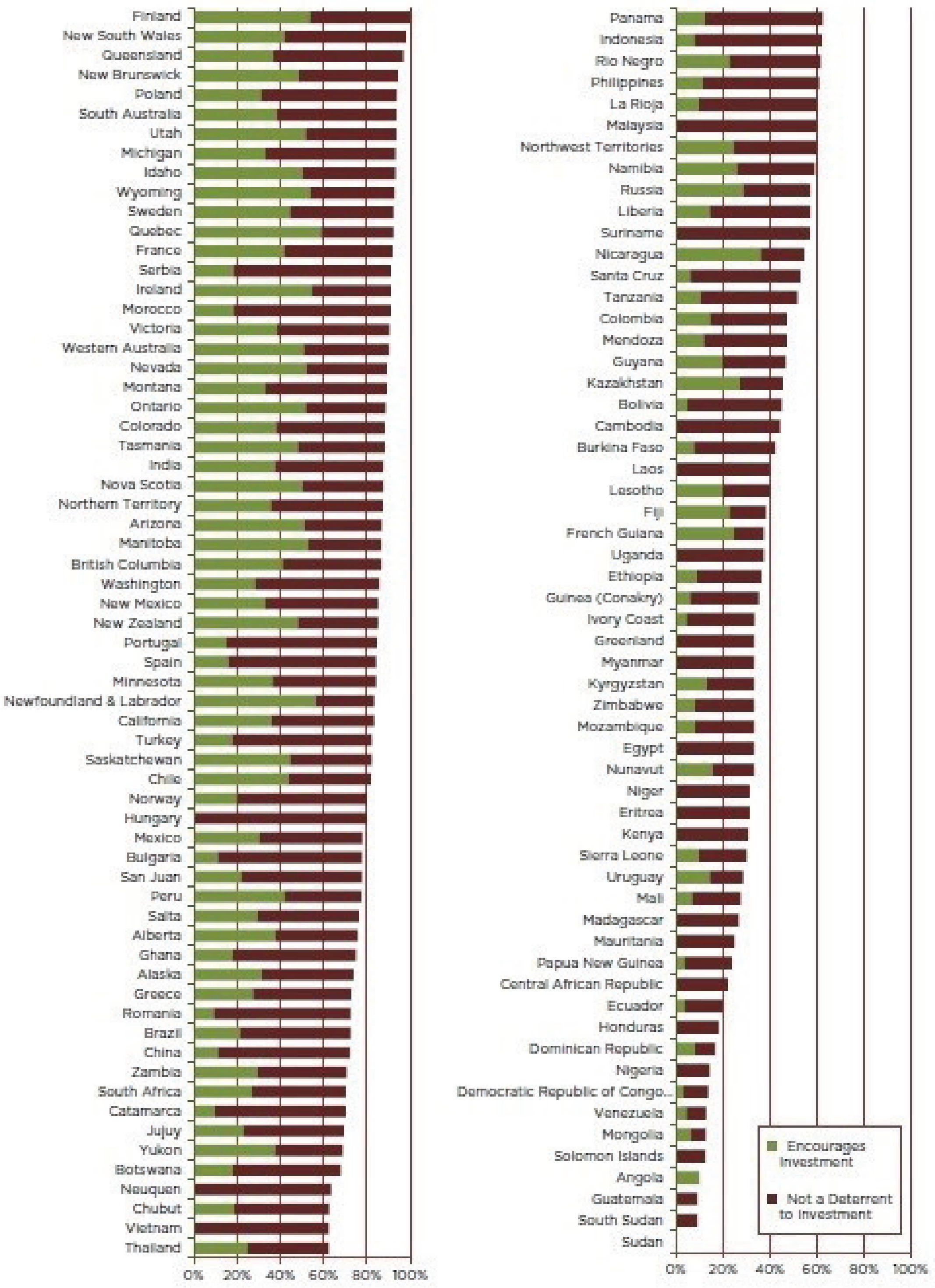



*Figure 7: Country Availability of labour & skills - Fraser Institute Report Survey 2014.*

list, but where present, they all sit in the upper half of the ranking largely due to the relatively high general educational levels and construction sector skills in those countries.

The industry is constantly changing with the introduction of new technologies and the drive to improve efficiency, increase profits by reducing costs and maintaining health and safety standards. Today's mining industry relies on highly skilled workers with a diverse skill set, the ability to use sophisticated technology and operate in challenging environments. These staff require initial training and must also continuously upskill as technology advances.

Mining is a global industry with companies operating mines in different countries and continents. The expertise that a major mining company has in designing, developing and operating mines resides in their staff and moving expertise from one project to another is an essential aspect of the mining business. As an industry mining therefore attracts multi-national staff, and mobility of skilled mining professionals is important for a functioning industry.

#### *1.2.2.2 Sectors providing Mining Skills*

While specialists such as mining engineers, metallurgists, mining and exploration geologists are closely aligned to the industry, many of the wider skills required can also come from related industries, particularly construction and general engineering. The availability of skills is therefore difficult to assess as the 'Trades' such as electricians, welders, pipefitters etc. are able to move in and out of the mining industry as the demand changes. Their status as one of the main skills shortages in the industry has occurred primarily because along with the mining boom, in countries such as Australia, there was also a construction boom and a simultaneous programme of major non-mining related infrastructure projects. It is easier to gauge the skills availability of specialist professionals both on a national and international basis, but the trades are often the source of mining company investment in local community training as a means to facilitate local employment.

#### *1.2.2.3 Mining skills frameworks and sector skills councils*

Most established mining countries, including the target mining countries of this project have Mining Sector Skills Councils and industry specific skills frameworks. These will be described in more detail in the country reports but all have structures that address role specific education and training pathways, course specifications and contents, competency standards or output based certification, co-ordination within national qualifications frameworks and a national VET (vocational education and training) structure, help promote diversity and access by disadvantaged and under-represented communities, and have links to apprenticeships schemes and funding routes.

In South Africa this includes the Mining Qualifications Authority established under law to set standards, develop training programmes, and administer grants & Learnership programmes, and provide quality assurance (QA) for training provision. In Canada the Mining Industry Human Resources Council (MiHR) has worked for the establishment of the Canadian Mining Industry Certification Program; and Mining Industry Training and Accreditation Program to recognize the skills, knowledge and experience of mining workers. In Australia the Mineral Council of Australia works with the VET sector to help define content for mining skills training courses accredited by the Australian Skills Quality Authority (ASQA). The Australian minerals industry spends more on training per employee than most industry sectors - in excess of $1.15 billion in 2011-12 (NCVER, 2013).

These bodies set the basis for and details of the sector training frameworks, agree the essential skills requirements with industry, accredit education and training providers as well as ensuring the recognition and accreditation within national qualification schemes. As such they are important drivers of mining education and training programme design.

#### *1.2.2.4 National workforce plans and demand review*

Mining is central to the economies of many countries around the world. This can be small-scale artisanal mining sector or large-scale mines owned by government or major mining companies. One role of government is therefore to ensure that the skills are available to allow the mines to employ local staff and develop the mining sector to the benefit of the country. Assessing the needs and ensuring that local people (or people in the country or mining jurisdiction) are trained to meet the demands of mining projects is a critical task, and is usually done via a national mining workforce planning exercise.

The planning process addresses the types of skills, number of people and locations at which they are required (***Table 3***). It also audits existing skills supply, likely demand scenarios and training options.

One of the most challenging issues is

| Quantity | Quality | Location |
|---|---|---|
| •How many people are required?<br>•How many people do we currently have and how many will we need with projected growth?<br>•Can the company transfer people to and from other mines, regions, countries?<br>•Can existing staff be promoted, re-trained, re-deployed and upskilled to meet the needs while less experienced staff replace them?<br>•What strategic partnerships can be used to manage skills development and cyclical change in demand? | •What skills are needed in the future?<br>•What skills are available currently and are there any gaps identified?<br>•Can people come from other areas/countries to train local staff or will they need formal training provisions?<br>•What training or upskilling may be required?<br>•Can internal knowledge transfer be used to achieve the upskilling required?<br>•Is their succession planning in place to ensure skills continuity? | •Is there a local community with skilled people?<br>•Will workers need to be brought in from outside the area?<br>•Where can we go to look for talented staff who will travel/relocate to the required area?<br>•Are staff mbile and able to move when jobs appear or are lost?<br>•Is there access to appropriate training and education provision for skills development?<br>•Are there accurate data and planning tools in place for the area covered by the plan? |

*Table 3: Issues addressed in National Workforce Plans.*

to assess workforce demand and design strategies that address the cyclicity in commodity prices and resultant mining activity. Accurate prediction remains elusive and this results in skills shortages and demographic gaps followed by retrenchments and over-capacity on a recurring basis.

This is mainly caused by the time required for training and education, creating a lag in trained staff becoming available to the industry. In the start of an upturn staff are not available but the industry becomes attractive for new entrants who start relevant education and training programmes. Unfortunately, 2-5 years later as they emerge, the peak has passed and these new graduates find it difficult to find jobs in a declining market. Staff are retrenched and frequently retrain and are lost to the industry. Through the downturn companies reduce or cease recruitment and, if prolonged, this creates a demographic gap in the company which later becomes critical as senior staff retire and there are few mid-career staff available to replace them. This is a current issue for the mining industry in the reference countries as a result of the prolonged recruitment downturn in the 80's and 90's. The industry requires non-cyclic strategies that address this inconsistent supply and demand for mining skills.

#### *1.2.2.5 Current Industry status*

The current state of the mining industry is hard to ignore. Following a decade of high raw material demand fuelled by growth in China, India, Brazil and Russia, commodity prices were at all-time highs. Also in recent years major mining companies have focused on large 'tier 1' projects and the high commodity prices have made it financially viable to upscale existing projects, ramping up production. It is no surprise that with the BRIC countries slowing down in growth and the increase in output from both existing mines and the new projects, commodity prices have fallen as production exceeds demand.

Over the upturn internationally recognised mining industry reviews have consistently listed 'skills shortages' as a major risk to the mining industry, while not always specifying the exact types of skills. Anecdotally the most critical shortages have been in mining engineering and the trades. This situation has changed in a very short period of time as the recent commodity slump has led to unprecedented redundancies. Anglo American has recently made 85,000 people redundant and will reduce the number of mines it owns from 55 to 20-25 in an effort to raise US $4 billion. As one of the world's major mining companies, reducing staff numbers from 135,000 to 55,000 is a major change, and the future of many of its operations is unknown. Almost all other major companies are also restructuring with substantial further job losses.

Those with transferrable skills typically move to other industries (administrators, information technology, accountants, and engineers etc). Many will reskill and move to what they perceive to be a more stable/secure industry such as academia, finance, government and teaching, taking years of experience with them. This reduces the opportunity for them to train or mentor the next industry generation and results in a major loss of industry knowledge, skills, corporate memory and potentially contribute to another gap in experience. It is anticipated that the current downturn will continue for several years before recruitment of staff again becomes an issue.

#### *1.2.3 Mining Education*

Mining education encompasses a wide range of education and training options that can be accessed by students seeking to enter the industry, mature entrants reskilling, in-work employees' upskilling and even those taking courses purely for interest.

Universities typically offer a range of mining focussed undergraduate degree options around applied geology, mining engineering, mineral processing and metallurgy, as well as a raft of generic but relevant subjects in engineering, business, environment, etc. At postgraduate level more directly vocational Masters courses focussed on mineral exploration, mining geology, geotechnical engineering, geometallurgy, construction, minerals engineering, minerals processing, metallurgy, and environmental impact are offered. These may be conversion courses to train existing graduates in other fields or advanced specialist preparation for those with generic geoscience or engineering degrees. Taking only parts of these programmes leads to the award of certificates and diplomas.  These courses are often accredited by professional organisations that assess their industry relevance and quality, and may use them as prerequisites for membership, chartership or other forms or recognition through their membership structures.

Advanced study through research Masters and PhD's are an important provision in many Universities and are typically based on industry related scientific issues and in collaboration with or sponsorship by individual companies, or as part of larger collaborative research programmes. Specialist research centres based in research-intensive universities also permit progression routes for doctorate students to move into research posts and academic positions in mining departments.

In Australia, for example, collaboration between universities under the Mining Education Australia banner (MEA) allows each partner to deliver teaching in its area of strength and students access modules across the University partners. This model is also being explored in countries such as South Africa and a similar model is now being re-developed in Europe. This is the European Mining, Minerals and Environmental Programme (EMMEP) programme which is the successor to the Federation of European Mineral Programs (FEMP) and will incorporate the European Mining Course (EMC) involving Aalto University (Finland), Delft University of Technology (Netherlands) and RWTH Aachen (Germany).

Universities may also have a range of continuous professional development (CPD) short courses, professional programmes and some distance learning provision accessed by those in the industry to address specific skills needs or for professional development. The Edumine programme from The University of British Columbia (UBC) in Canada is the best known example of this and is often used to support in-house training.

University programmes attract self-funded students but also receive sponsorship from industry and government where strategic skills shortages exist, to attract increased participation. In critical areas they may also provide incentives for people to retrain and meet the demands for skilled mining workers. Scholarships in developing mining countries are often

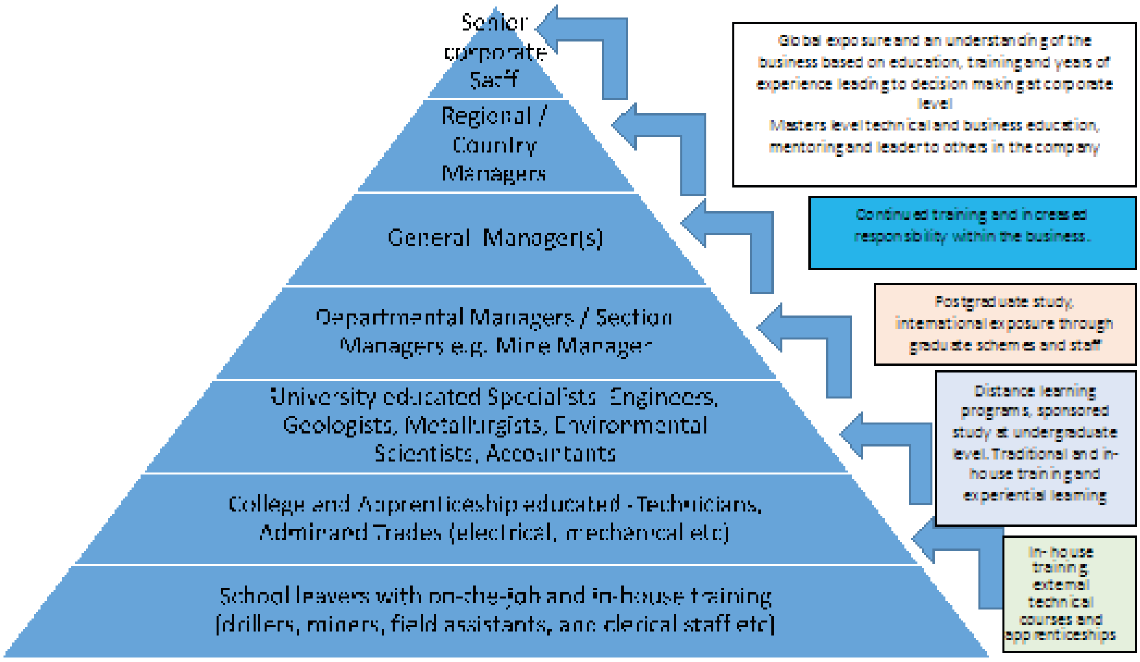



*Figure 8: Simplified mining company organisational structure with typical training and development routes between levels.*

available for students to study abroad to gain mining skills under the condition that they return to work in the company or national mining industry. Funding is also sometimes provided to improve the infrastructure and staffing at educational establishments providing a long term benefit in terms of the quality of graduates to the industry.

Training for technician and administrator levels in mining related areas is usually delivered by technical colleges and training centres. These normally involve a combination of conventional teaching with placements and work-based learning and include technical, commercial and clerical provision. Vocational training courses including artisan and trades (e.g. welders, drillers, maintenance mechanics, electricians, loader operators etc.) usually have many more training routes through both mining and other sector training organisations and typically are delivered by apprenticeships involving block or day release, combined with workplace skills development. These are often following programmes prescribed by training bodies, skills councils and industry. Training centres are generally in local mining centres and frequently benefit from direct industry support.

In some mining countries without a well-developed training infrastructure, training is undertaken largely by external private training organisations and by equipment and service suppliers. As part of equipment purchases, maintenance or contractor schemes, mining companies increasingly add training as part of the selection criteria and contract delivery requirements. This may involve the provision of bespoke training, simulators, and secondments, as well as on-site mentoring.

The potential role of these training and education courses in industry progression, combined with in-house training and work experience, is summarised in ***Figure 8.***

Individual ability will always dictate progression for mining industry professionals into more senior roles in the mining business. However, with volatility in the industry and increasing resource nationalism this is not a straight forward process. With the demand of producer countries for local staff to take over the more senior roles, this is also leading to a need for rapid upskilling and loss of experienced international staff.

### *1.2.4 Conclusion*

The mining industry is moving towards increasing scales of operation, more mechanised mining and staff with higher skills levels. The cyclicity in the industry has caused endemic skills shortages and then oversupply that lags the industry cycles and results in elevated costs and loss of experience from the industry. Generic trades move in and out of the industry as demand requires and shortages are usually only manifest when mining booms coincide with major construction or infrastructure programmes. Specialist professional staff may be able to sit out the downturns in related sectors but often retrain and leave the industry. The demographic gap caused by the 1980's and 90's downturn is a real issue in mining operations which may lack experienced staff when the next industry upturn occurs.

# 2. Education provision, demand and funding

This chapter reviews raw materials education provision in the Reference countries.

There is no agreement on what raw materials education encompasses, as it is a diverse, multidisciplinary concept. The scope of raw materials here is refined to include only non-renewable, non-energy minerals and therefore education provision is focused mainly on mining engineering. Mining engineering is the theory and practice of extracting valuable minerals from the natural environment. It is an engineering discipline foremost, but applies scientific principles and is closely related to geology, mineral processing, metallurgy, and geotechnical engineering. Mining engineers are often in overall mine management positions where they are responsible for all phases of the operation from initial discovery, design and mine planning, through to production, environmentally responsible processing and mine closure. They must be concerned not only with the financial bottom-line of exploiting the resource, but the mineral waste and social impacts, managing the mine to global standards of environmental sustainability and corporate social responsibility. Therefore, although proxy estimates are provided as to related engineering and geoscience education provision, the only useful comparator for this work package is in 'mining' education provision.

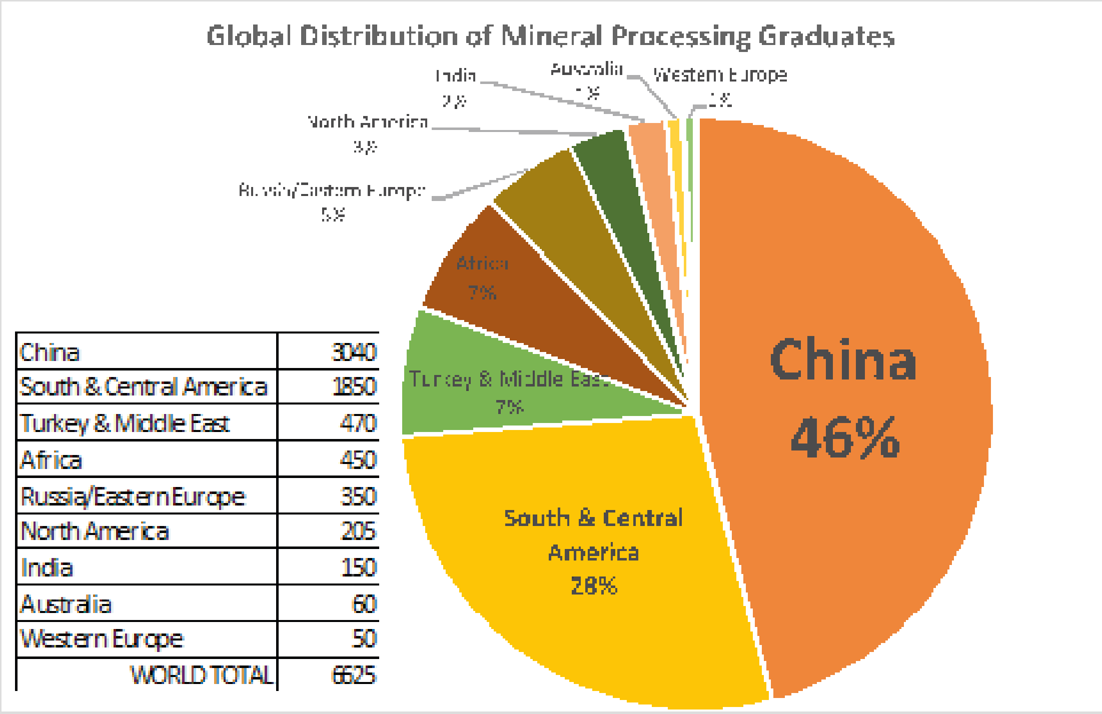
## 2.1 Previous studies

There have been several previous studies performed globally and regionally to assess mining education provision. These have highlighted the difficulty of gaining accurate, current information.

### *2.1.1 Society of Mining Professors*

Global studies come from the Society of Mining Professors/Societät der Bergbaukunde (SOMP) which was established in 1999 and meets annually to discuss mining education (***Figure 9***). There are approximately 200 members representing 70 universities across 40 countries. The presidency rotates amongst various mining schools, and each year a survey is produced of mining engineering student and graduate numbers. Much of the data is presented here, with revisions and re-analysis. There are major data gaps however, in that typically only half of the surveys are returned, and major mining countries are skipped all together such as China, Russia, Brazil, India, Mexico and Indonesia. The current president is Professor Vlad Kecojevic from West Virginia University; the Secretary General is Professor Bruce Hebblewhite of The University of New South Wales.


*Figure 9: Society of Mining Professors.*




| | |
|---|---|
| China | 3040 |
| South & Central America | 1850 |
| Turkey & Middle East | 470 |
| Africa | 450 |
| Russia/Eastern Europe | 350 |
| North America | 205 |
| India | 150 |
| Australia | 60 |
| Western Europe | 50 |
| WORLD TOTAL | 6625 |

*Figure 10: Global Distribution of Mineral Processing Graduates.*

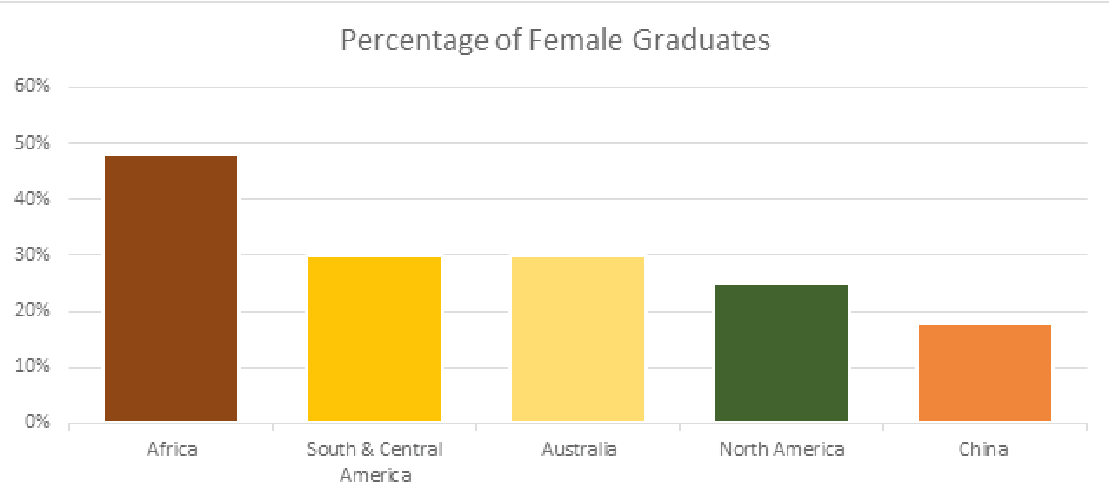



*Figure 11: Percentage of Female Graduates.*

### *2.1.2 Mineral Processing Council Commission of Education*

In 2008 the International Mineral Processing Council reported on the supply and demand of mineral processing graduates worldwide. There were thirteen colleagues participating across all regions of the world. Supply-side questions on graduate numbers, gender, the percentage entering industry and academic staff were collected for the first time, although there were major gaps from Asia, including no graduates reported from Japan, despite it being well known for expertise in mineral processing R&D. It is also unclear whether postgraduate courses and their graduates were included in the survey.

Obtaining demand data was "extremely difficult" as it was considered confidential or was not available. A proxy was used based on British Geological Survey mineral statistics to estimate demand. Results are summarised below.

***Figure 10*** shows that approximately half of the mineral processing graduates come from China. When considering about 20% - 30% of all mineral production comes from China, this suggests a surplus

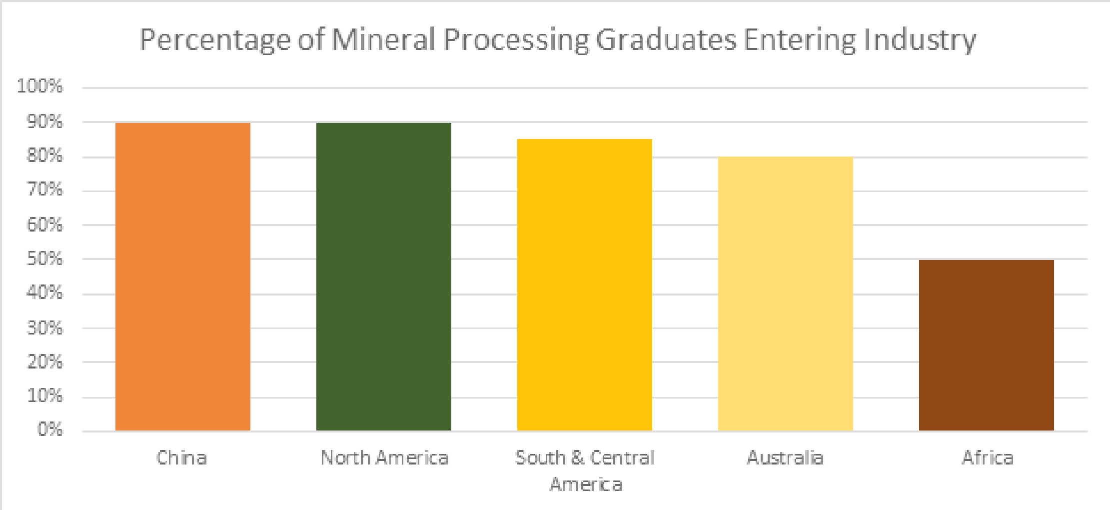



*Figure 12: Percentage of Mineral Processing Graduates Entering Industry.*

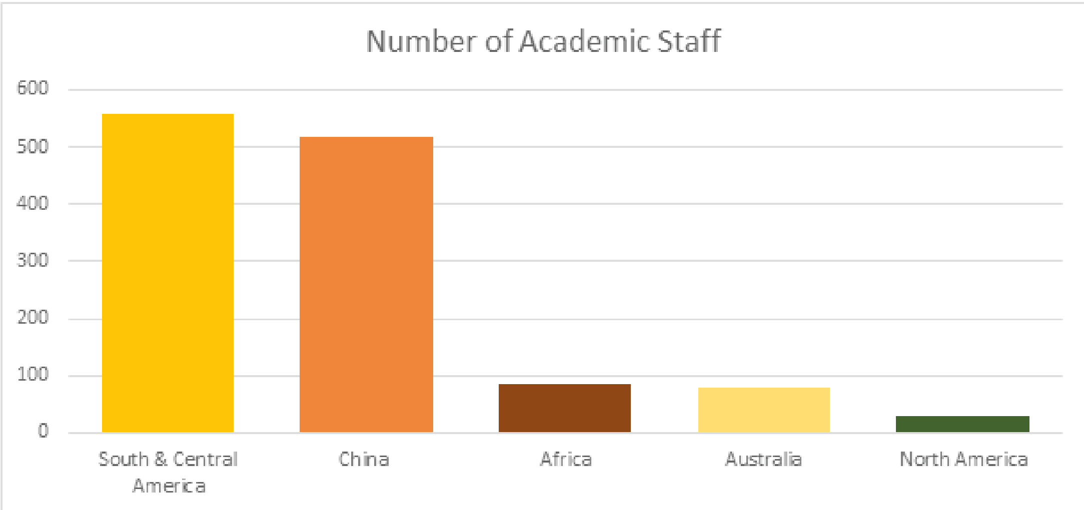



*Figure 13: Number of Academic Staff.*

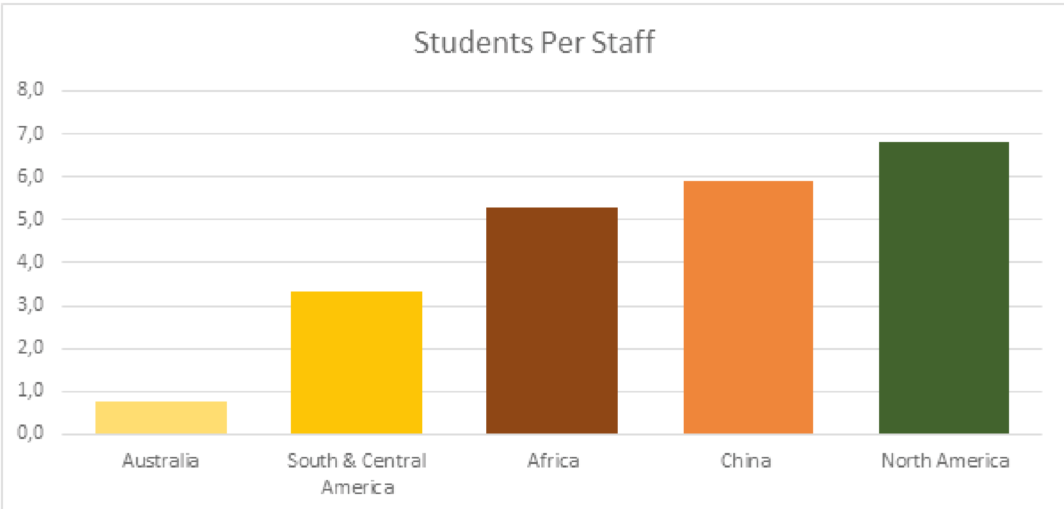



*Figure 14: Student to Staff Ratio.*

of graduates or that there are more smaller-scale operations each requiring these skills.

The percentage of those graduates that are female is on average 30%, with an increase in South and Central America from 18% in 2010 to 30% in 2015 (***Figure***

**11**). In Africa it's roughly half male and half female.

The global average percentage of mineral processing graduates entering industry is 79%, with the highest uptake in China and North America. Only half of African graduates enter industry ***(Figure 12***).

There are a total of 680 mineral processing staff around the world, though several regions do not have accurate data. The number of academic staff is greatest in the same regions producing the most graduates, South and Central America and China (***Figure 13***). In Australia there is an estimated pool of 80 staff, and in North America this is only 30.

There are generally small class sizes in mineral processing programs all around the world, ranging from Australia where there are nearly 2 staff per student on average, to North America where there are approximately 7 students per staff (***Figure 14***). The global average is 4.4 students per staff.

### *2.1.3 Mining Engineering Education Survey*

During 2000 – 2002 as part of the Mining, Minerals and Sustainable Development (MMSD) project under the auspices of the International Institute for Environment and Development, a survey was conducted of global mining engineering education. There were approximately 275 universities worldwide providing tertiary mining engineering training and the World Directory was started although this is no longer active. A survey was also conducted with data from 62 responses representing over 100 schools. The results indicated the decline of undergraduate programs in North America and Western Europe, and the shift to Eastern Europe and the global South – Asia, South and Central America. In the US in 2002, only three of four departments had near 100 students enrolled, in contrast to Stanislav Stacszic University of Mining and Metallurgy in Poland which had six departments within the Faculty of Mining with a total of 1,532 full-time students, 1,051 part-time students and 139 teaching staff. In Ukraine there were six applicants for each acceptance. The report describes the dismantling of programs or absorption and rebranding, such as in Japan where mining is now taught only in courses within a resource engineering or environmental engineering department. On the other hand, the University of Toronto received CAN $5 million in 2001 to rebuild their department (McDivitt, 2002). The MMSD report proposed an International Union of Mining Organizations linking geoscience bodies, mining ministries and industry associations. The result of the effort has been to establish the International Council of Mining and Metals (ICMM). Although the ICMM publishes dozens of reports on areas of mineral development each year, they have not done research into minerals education and outreach.

### *2.1.4 Other Information Sources*

Other information sources used in this report include national graduate surveys, government educational data, national industry associations (such as the U.S. American Geosciences Institute), and information taken from each educational institution surveyed on the internet, and in some cases, via communication with department heads.

## 2.2 Methodology

The methodology for this report consisted for each Target Country a literature survey, reviews of previous work, an extensive internet survey, communication with Expert Panel members and other contacts (industry, academic, governmental).

The survey was primarily limited to mining engineering education because, as discussed later, the definition of what to include or not include makes drawing conclusions very difficult. For each Target Country additional information on related education in mineral geoscience, geological engineering, extractive metallurgy and related fields has been supplied. This data was tabulated and results have been summarised and displayed graphically below.

Data was sought on every tertiary institution offering mining or mineral engineering education with details on: the number of courses available and duration, number of commencing and graduating students, and staff age and gender profiles where possible. Evidence is also provided on research-led teaching programs, the involvement of industry including examples of investments, scholarships, grants, etc. Further, for each country the trade skills programs have been reviewed including in-house company centres, specific short courses, and other education or outreach initiatives.

### *2.2.1 SOMP Data*

The SOMP survey data was used as the basis for data collection, as it has consistently been collected and includes limited information on each of the reference countries for many years back. There are many gaps in the data which have been filled in this study; however there are some outstanding issues regarding its use.

For example, the SOMP survey calculates the Staff/Student ratio as the number of staff divided by the total number of commencing and graduating students. First, this ignores year 2 and 3 students, as most courses around the world are a minimum of 4 years (in fact, many students take 5 or 6 years to complete, due to failed courses, re-takes, or inconsistent scheduling). The SOMP method is simplistic and therefore underestimates the full number of students per staff.

The dataset is incomplete in many areas and ignores some important trends. For example completion rates are calculated for each year as the number of graduating over commencing students, which ignores recent (5 year) trends and changes at the institution or in industry market cycles. If the number of commencing students expands rapidly over a short period of time (as has happened in South Africa), when compared to the number of graduating students from that year (which have a 4-6 year lag time), it could appear as extremely low completion rates. The calculation should rather be compared to the commencing student numbers of four or five years previous.

Due to known and unknown data gaps, the reliability of SOMP data is questioned. The figure below demonstrates this, based on four different data sources on the total number of mining engineering undergraduates at all universities in the U.S.A. The data consists of first, institutional data collected by the authors from each university registrar (light blue), the American Society for Engineering Education 2012 survey (green, Yoder, 2013), SOMP data from 2008 (gray) and SOMP data from 2012 (dark blue, 13 schools represented) the last year a complete set of data was available. SOMP data is also available from 2015, but only 2 of 14 schools have responded thus far.

As can be seen, the number of student awards granted based on actual institutional data is consistently higher than those reported or estimated based on academic staff surveys from SOMP and

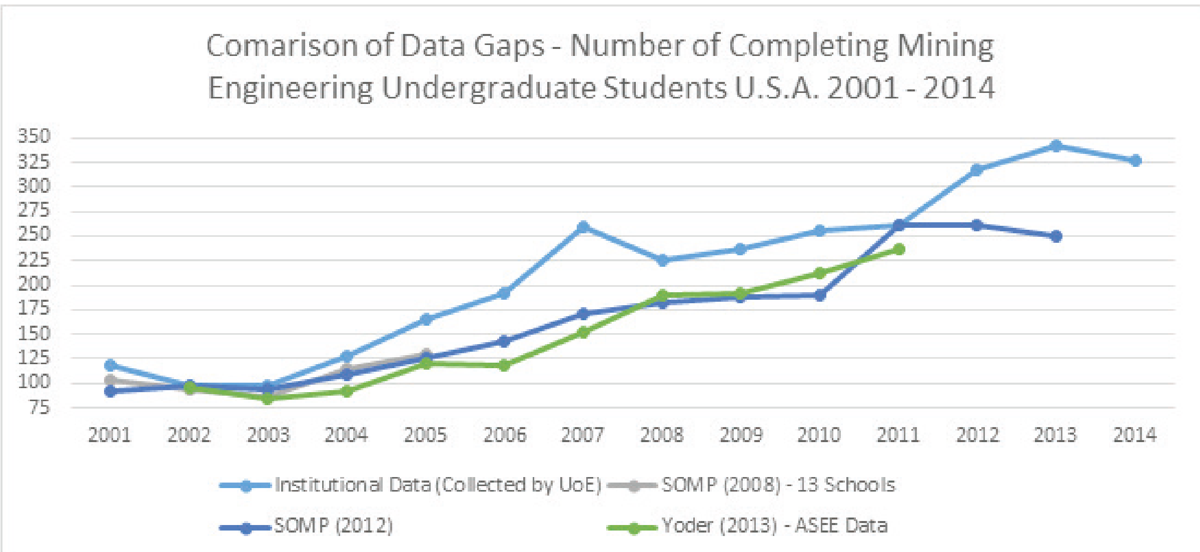



*Figure 15: Comparison of Data Gaps and Disagreements from SOMP U.S.A. Example.*

other organizations (***Figure 15***). The difference between the maximum and minimum figures reported for each year varies from 57% to 99%, questioning the reliability of surveys sent to mining professors.

# 3. Target country data

## 3.1 CANADA

### *3.1.1 Introduction*

Canada is a major mining country, with a significant resource industry and a very high potential for future mineral discoveries. It is both one of the largest mineral producers and most diverse, producing over 60 mineral commodities (metals and non-metals) (***Figure 16***). It is a top global producer of potash and uranium, and the world's third largest producer of diamonds (~10% of global production); and is a major producer of nickel, cobalt, titanium concentrate, aluminium, magnesium, platinum group metals, gypsum, asbestos, cadmium, zinc, salt and molybdenum.

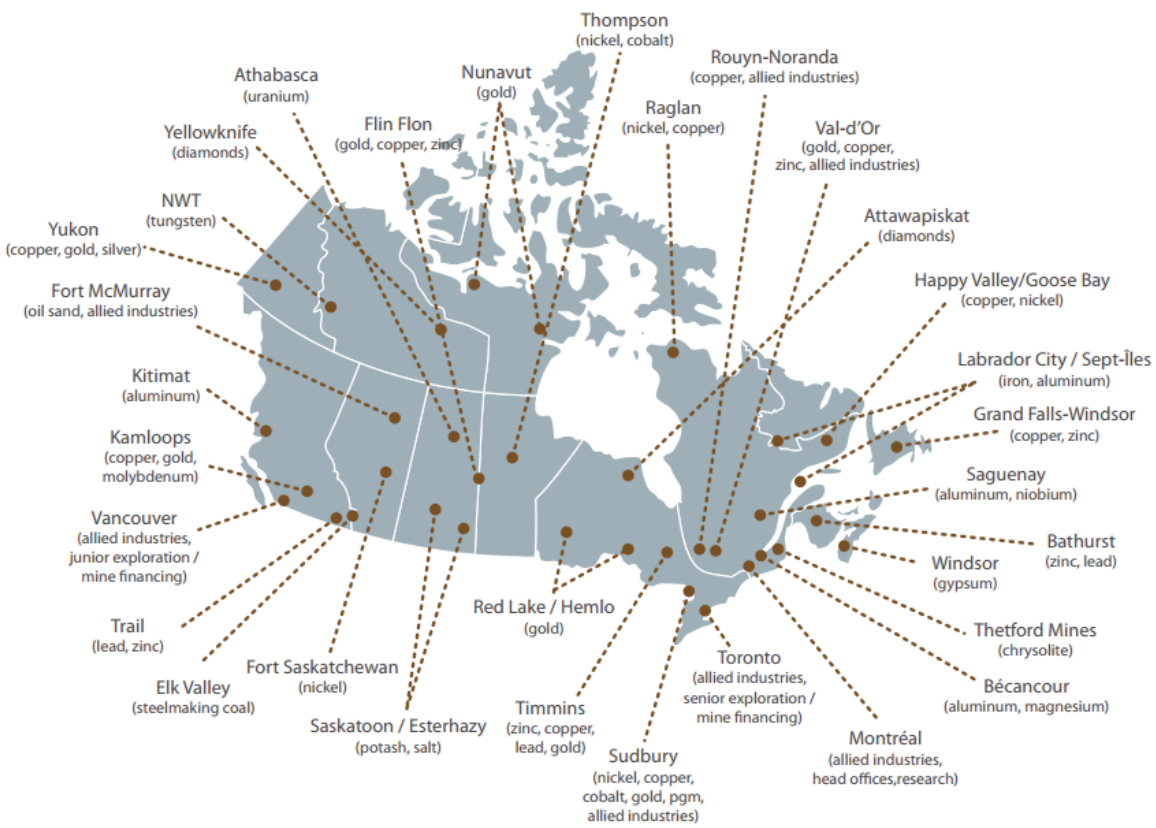



*Figure 16: Canadian Mining Industry Clusters-2013 data, The Mining Association of Canada, Facts and Figures 2015 (http://mining.ca/sites/default/files/documents/Facts_and_ Figures_2015.pdf ).*

To maintain its position as a leading mining country it has to manage its skilled workers though the cyclic nature of the industry and must ensure it provides training opportunities for the skills required to underpin the economic viability of its minerals industry.

National level planning around mining skills is undertaken through the development of sectorial workforce plans. In the following section workforce availability, training and funding will be examined.

### *3.1. Canadian National Workforce Plans*

Canada has a workforce plan for the mining industry at a national level rather than for individual States and jurisdictions. The Mining Industry Human Resource Council (MiHR), funded partly by the Canadian government, is the recognised industry agency in this area in Canada. MiHR brings together all the stakeholders with the aim of ensuring a strong, competitive, skilled and sustainable industry work force.

| Canadian mines (2014 data, The Mining Association of Canada, Facts and Figures 2015 document) | | |
|---|---|---|
| Total mining establishments | 1209 | |
| Metal mines | 77 | |
| Non-metals mines | 1132 | |
| | | |
| Provinces with the most metal mines | | Value of mining Canada-wide in 2014 $44.7 billion |
| Quebec | 26 | $8.7 Billion |
| Ontario | 19 | $10.9 billion |
| British Columbia | 9 | $6.9 Billion |
| Saskatchewan | NA (potash) | $7.1 Billion |
| | | |
| Main types of non-metal mines | | |
| Sand and gravel quarries | 834 | |
| Stone quarries | 267 | |
| Peat mines | 64 | |

*Table 4: Canadian Mining Industry 2015 (The Mining Association of Canada, Facts and Figures 2015 Report).*

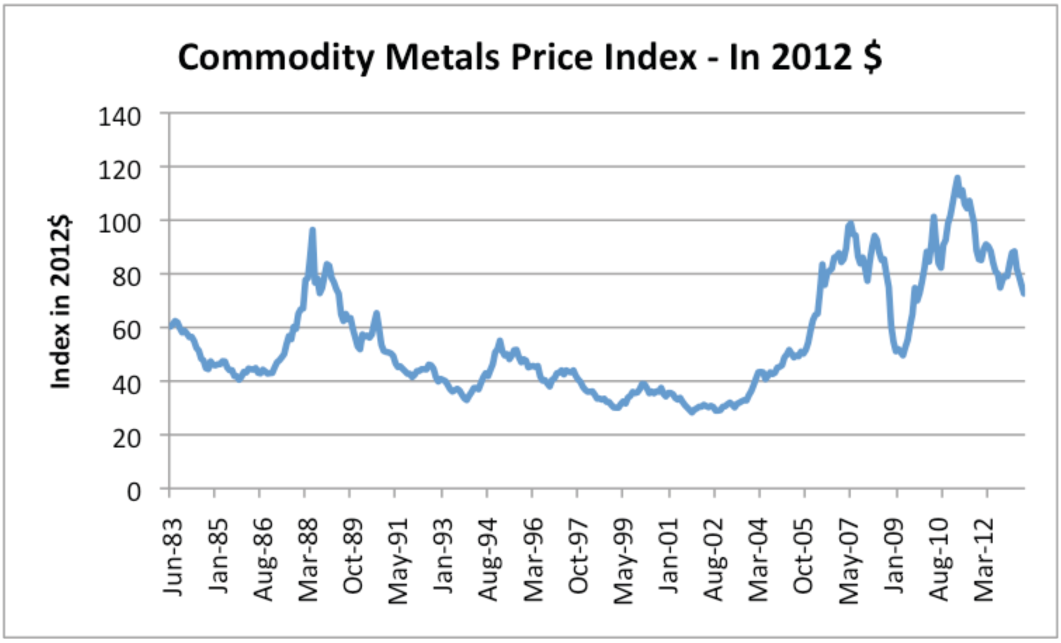
It is estimated that the Canadian mining industry will need 106,000 new workers over the next 10 years. These new hires are required to replenish almost half of the current workforce, replacing retirees and filling anticipated future labour demands. Canada needs to ensure that it is able to fill the gap that will be left by a high number of experienced staff who are due to retire in the near future. Replacing highly skilled and experienced personnel is not easy. It is possible to train individuals but experience requires time.

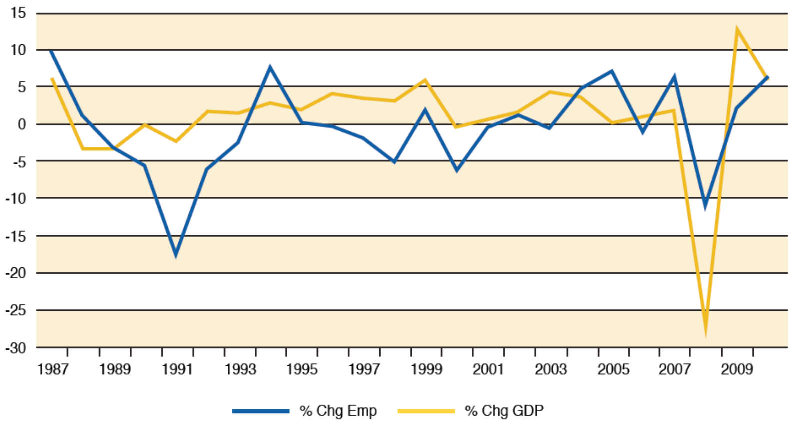
The Canadian mining industry employs 376,455 people (2014 data, Natural Resources Canada and data - Statistics Canada) equivalent to 1 in every 47 Canadian jobs. The participation of women in the sector grew 70% from 1996 – 2011, but this still only accounts for 17% of the mining workforce (The Mining Association of Canada, Facts and Figures 2015 Report). Female participation in the overall workforce in Canada is 47%, so mining still lags some way behind in terms of gender balance.

There is a strong correlation between workforce numbers, economic and commodity cycles (***Figure 17***).

Traditionally, the Canadian mining industry has operated with short term plans driven by the cyclic nature of the global commodities market, the need to remain economically viable and has changed employment levels quickly in response to commodity price fluctuations. This has resulted in periods of little or no recruitment now manifested as demographic gaps in the industry. It also saw skilled staff leaving and finding more stable opportunities in other industries and in some cases deterring people from joining the industry all together.

***Figure 17*** illustrates that in 1991 mining jobs were lost at the start of the 90's recession precipitated by a steady decline in metal prices and the oil price spike in 1990, however the economy as a whole was more robust. By contrast in 2008 the global financial crisis affected both mining and the overall economy. Commodity and economic cycles have made workforce planning difficult, especially for long term planning and for positions that require prolonged training and experience. Canada is affected by an ageing workforce and has an underrepresentation from indigenous communities, women, and young Canadians and the projected skills gaps make the planning process complicated. In response, the industry is now exploring longer term work force plans and a more strategic and proactive approach to staffing during economic downturns.



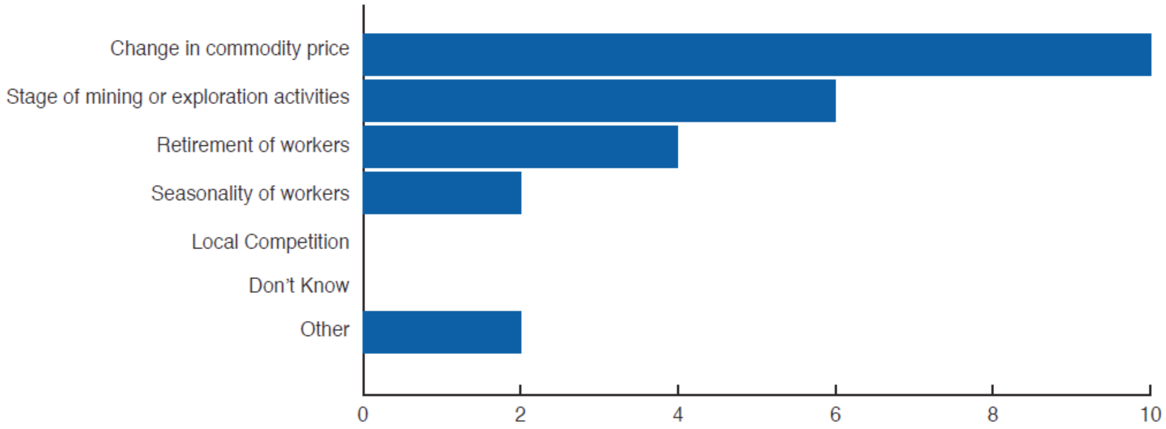

*Source: Mining Industry Human Resources Council, 2013; Statistics Canada*

*Figure 17: Upper: Commodity Metals Price Index from the International Monetary Fund, adjusted by the US CPI-Urban to 2012 price levels. Commodity Metals include Copper, Aluminium, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium. Lower - Change in gross domestic product and employment in the Canadian mining industry (1987-2010), MiHR, Canadian Mining Industry Employment and Hiring Forecasts 2011 (http://www.mihr.ca/en/publications/resources/Employment_HiringForecasts2011_FINALAug4_ENG.pdf ).*

As illustrated in ***Figure 18*** the cyclic nature of the industry was the most influential factor for workforce adjustment. This is closely followed by progression of an operation through the mining lifecycle; as the mine is developed from exploration through to construction and production, the skills required changed. This however is reasonably well understood over a 5-10 year period and it should be possible for companies to predict when certain skills will no longer be required and when new staff will have to be employed as the project develops.

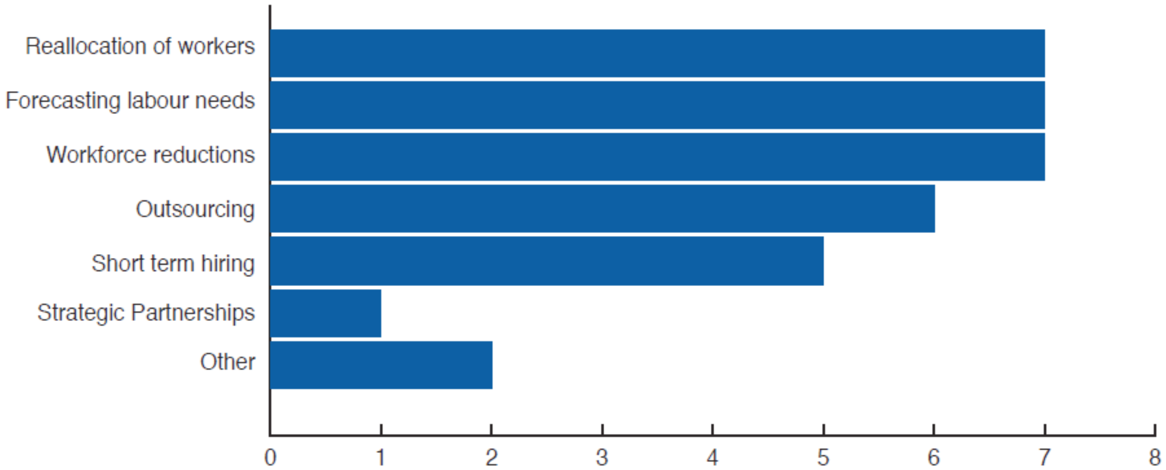
The use of contractors and outsourcing to meet short term needs, in addition to reallocation, reduced shifts, reducing output and moving staff from one operation to another to fill gaps, are widely used to retain experienced staff through the downturn so they are not lost by the industry thus avoiding permanent skills loss.

The difficulty in finding and training staff is starting to balance in favour of retention and development during the downturn as the preferred cost saving strategy rather than redundancy. This is a significant change in terms of training needs and the development of a continuously updating, iterative, workforce planning process (***Figure 20***).




*Source: MiHR Workforce Planning Survey, 2012.*

*Figure 18: Factors Driving Workforce Adjustments - the lower axis is the estimated % change in workforce caused by each factor (MiHR Workforce Planning Survey, 2012).*




*Source: MiHR Workforce Planning Survey, 2012.*

*Figure 19: Relative frequency of mining companies using strategies to counter the employment impacts during downturns in economic cycles (MiHR Workforce Planning Survey, 2012).*

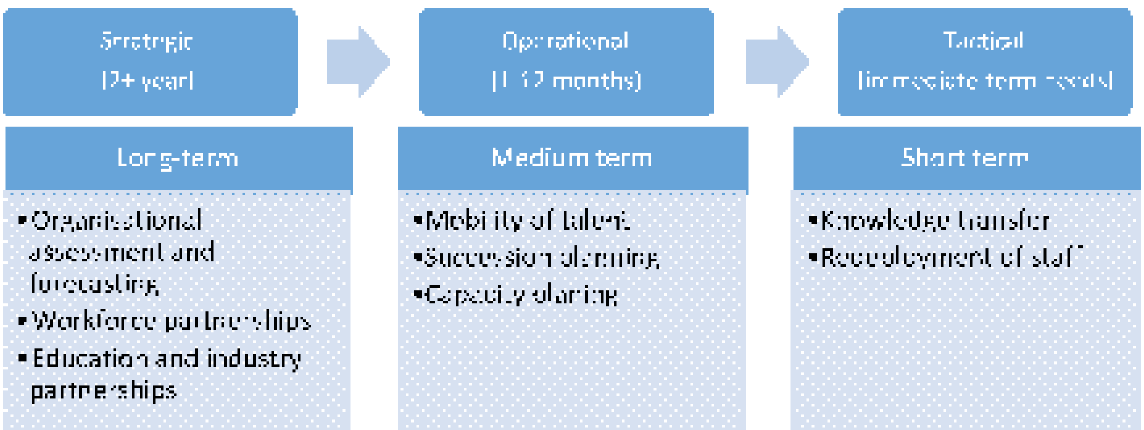



*Figure 20: Time scales of workforce planning strategies (MiHR 2013).*

Long term strategies are aligned to the long term needs of a company and its strategic goals. Medium term strategies are pre-planned changes to the workforce in response to external factors such as commodity prices and changes in demand; particularly through capacity building and retention, involving training and education. Short term strategies impact the immediate needs of a company in response to sudden and unexpected changes. This can be both positive and negative (increases or decrease in commodity price or demand) and in a downturn can often result in job losses as the company acts to protect its viability and remain competitive. To mitigate this and ensure that long and medium term needs are not impacted, organisations can redeploy staff to other operations or projects.

The cyclic nature of the industry is particularly evident in training provisions, as illustrated in ***Figure 21***. The numbers of Canadian mining apprenticeships are 'pro-cyclic' rather than 'counter-cyclic' i.e. more are training during the boom, and by the time their training is complete the industry is in a down turn and there are few jobs. This illustrates that people wishing to develop their skills for the industry are highly influenced by the short term job prospects. This situation differs from other mining educational provision which is generally counter-cyclic.

The Apprenticeship registrations were however also affected by funding arrangements. In 2008 when the industry was seeing high commodity prices the number of apprentices was approximately 98,000 across Canada. When the industry started to slow down in 2009 this number dropped by 13%, due to reduced industry funding of apprenticeship schemes through cost-cutting, and changes in budgetary priorities.

The Canadian Workforce Plan also emphasized the importance of mining companies knowing their workforce and training requirements for the future. This would then enable training organisations and colleges who work in partnership with them to develop industry relevant programmes and have training provision

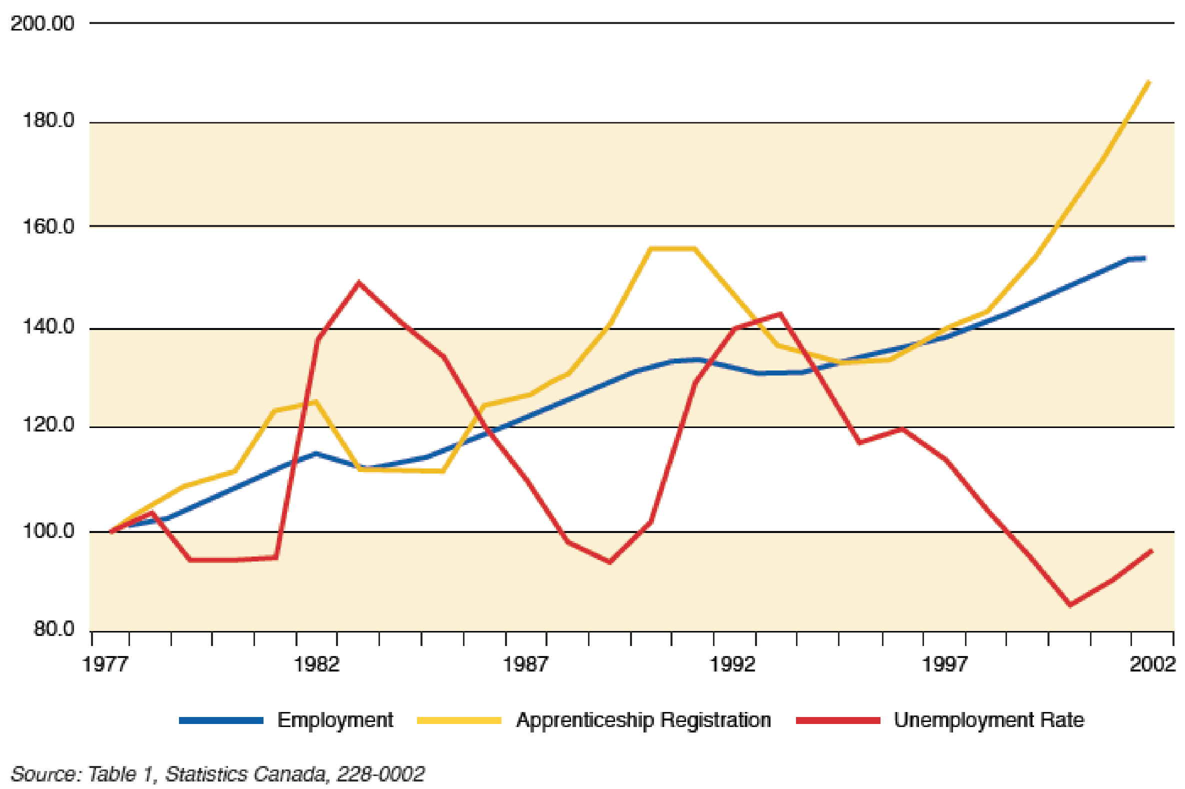



*Figure 21: Apprenticeship Registration and Employment Indices, 1977= 100 (http://www.csls.ca/reports/csls2005-04.pdf).*

for the numbers required by the industry. Due to the length of the mining cycles, those training during a boom normally completed their training and qualified during the subsequent down turn and found it hard to get work after completing their training. This was made worse by the fact that higher numbers tended to enrol on the programmes during a boom. The opposite is true during a down turn, far smaller numbers enrol during a downturn, but often completed their course at the start of a boom and there was a continuous mismatch between demand and skills availability.

### *3.1.3 Canadian Education Provision*

Canada has over 10 Universities (***Table 5***) delivering mining and mining related course (***Table 6***) and is home to several world class and prestigious mining schools. In addition, over 25 community colleges across Canada offer mining-related programmes.

| Universities offering mining degrees in Canada |
|---|
| University of Alberta, School of Mining |
| University of British Columbia |
| Dalhousie University, Department of Civil and Resource Engineering |
| Haileybury School of Mines, Northern College Ontario |
| Laval University, Department of Mining Engineering (Quebec) |
| Goodman School of Mines, Laurentian University |
| Centre of Excellence for Sustainable Mining and Exploration, Lakehead University (developing joint programmes with Queens University) |
| McGill University (Montreal), Department of Mining and Metallurgy |
| Ecole Polytechnique Montreal |
| Queens University, Department of Mining |
| Lassonde Institute of Mining, University of Toronto |
| Memorial University of Newfoundland, Earth Sciences |

*Table 5: Universities offering mining degrees in Canada.*

| Mining and Mineral Engineering | Metallurgical Engineering | Geological engineering |
|---|---|---|
| Dalhousie University (Halifax, NS)<br>École Polytechnique (Montréal, QC)<br>Laurentian University (Sudbury, ON)<br>McGill University (Montréal, QC)<br>Queen's University (Kingston, ON)<br>Université Laval (Québec, QC)<br>University of Alberta (Edmonton, AB)<br>University of British Columbia (Vancouver, BC)<br>University of New Brunswick (Fredericton, NB)<br>Université du Québec en Abitibi-Témiscamingue (Amos, QC)<br>University of Toronto (Toronto, ON) | Dalhousie University (Halifax, NS)<br>École Polytechnique (Montréal, QC)<br>McGill University (Montréal, QC)<br>Université du Québec à Chicoutimi (Chicoutimi, QC)<br>Université Laval (Québec, QC) | Queen's University (Kingston, ON)<br>University of Waterloo (Kitchener-Waterloo, ON)<br>University of New Brunswick (Fredericton, NB)<br>University of Saskatchewan (Saskatoon, SK)<br>University of British Columbia (Vancouver, BC) |

*Table 6: Education providers according to the three main mining disciplines.*

### *3.1.3.1 Metallurgical and materials engineering*

It is estimated that 104 metallurgical engineers will be required in Canada each year for the next 5 years and the majority (around 70%) of these vacancies will be to replace experienced staff who have reached retirement age. These demand levels for metallurgical engineers are approximately balanced to the supply of new graduates from Canadian universities. While over the last decade an influx of overseas staff has been required, there will be very little need for international inward migration to meet near term demand (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).

The number of metallurgical degrees granted in Canada by each province is shown in ***Table 7***. Universities in Ontario granted most metallurgical degrees (91) in 2013, and are the main source of graduates. The numbers do not show dramatic changes from year to year and although there are some anomalies (Nova Scotia 8 in 2012, 22 in 2013), the numbers remain consistent. This could be as a result of good workforce planning, but with graduate numbers being so low that they barely replace those retiring and available vacancies, any additional demand is being filled by inward migration from overseas and regional redeployment.

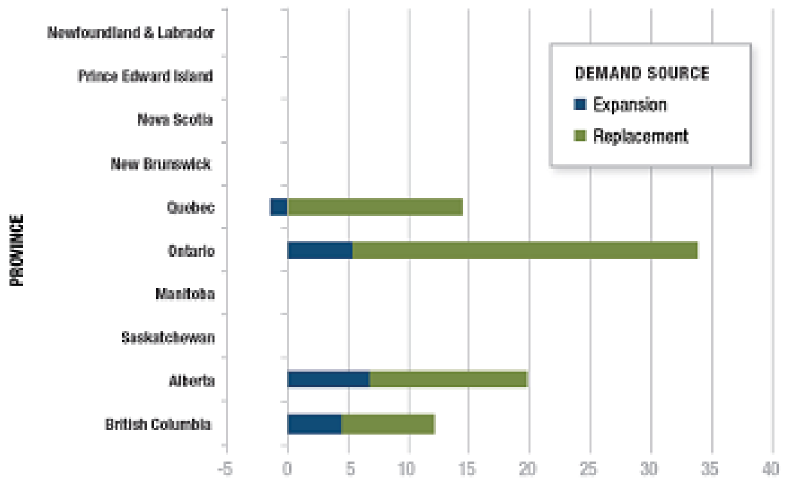
The average age of metallurgists in Canada is high (***Table 8***), suggesting that there are a considerable number of older staff and that a significant number of replacements would soon be required just to maintain the current level of activity.

| | Degrees granted, Metallurgical and Materials Engineering (2000-2013) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Enrolment and degrees awarded 2014 report | | | | | | |
| | Average (2000-2004) | Average (2005-2009) | 2010 | 2011 | 2012 | 2013 | Total (2000-2013) |
| British Columbia | 30 | 33 | 37 | 34 | 37 | 33 | 456 |
| Alberta | 23 | 25 | 34 | 45 | 48 | 40 | 407 |
| Ontario | 71 | 68 | 100 | 83 | 92 | 91 | 1061 |
| Quebec | 35 | 38 | 37 | 37 | 22 | 30 | 491 |
| Nova Scotia | 7 | 14 | 13 | 12 | 8 | 22 | 160 |
| Total for each year | 166 | 178 | 221 | 211 | 207 | 216 | 2575 |
| Total for the period | 830 | 890 | | | | | |
| Total graduate numbers from 2000-2013 | 2575 | | | | | | |

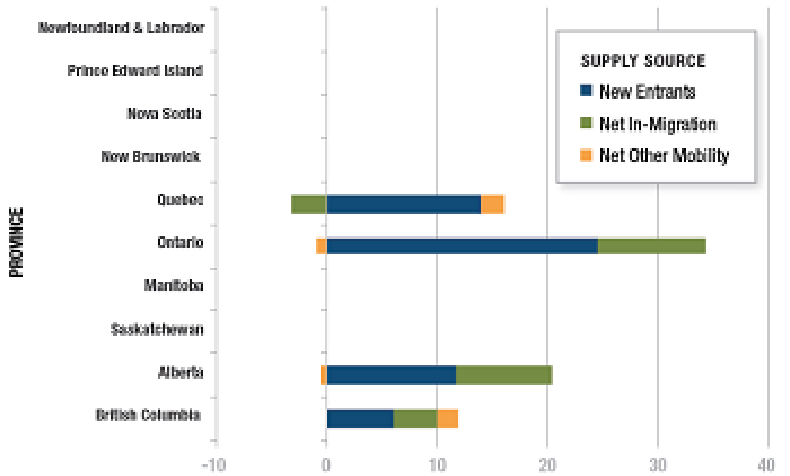
*Table 7: Metallurgical Graduates in Canada by Province (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).*

| | Average age of Metallurgical and Materials Engineers (2015-2025) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
| British Columbia | 45 | 44 | 44 | 44 | 43 | 43 | 43 | 44 | 44 | 44 | 44 |
| Alberta | 45 | 45 | 45 | 45 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| Ontario | 45 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43 |
| Quebec | 42 | 42 | 43 | 43 | 43 | 43 | 44 | 44 | 44 | 45 | 45 |

*Table 8: Average age of Metallurgical and Materials Engineers (2015-2025) (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).*




Demand for Metallurgic
and Materials Engineers
(Annual average 2015-
2025)
The main demand is
replacement of existing
staff due to retirement
(?) or people leaving the
industry for other
reasons. A proportion of
these posts are howeve
for expansion; this is
assuming the industry
maintains a steady
condition with little
growth.




Sources of Supply of
Metallurgical and Metal
Engineers (Annual
Average 2015-2025)
As new graduate
numbers will not full all
the demand, there is
anticipated new
participants due to in
ward migration and othe
inward net mobility.

*Table 9: Sources and demand for graduate Metallurgical and Materials Engineers by Province (2015-2025) (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).*

This interpretation is supported by the reasons given by employers for appointment of graduates, predominantly citing replacement of those who are leaving the industry (retiring etc.) rather than posts which are expanding the business (***Table 9***).

The data from Engineers Canada's 2014 Enrolment and Degrees Awarded Report, suggests that although the number of Metallurgical and Materials Engineers graduating is steady, it is insufficient given the large number of people expected to leave the industry. The new entrants from university will be filling existing posts rather than new ones. This assumes that the demand and level of production will stay consistent with little or no growth. There is still a risk to the industry and a shortage of graduates with this particular expertise.

#### 3.1.3.2 Mining Engineering

***Table 10*** shows the number of mining engineering graduates as a five year average between 2000-2004, and between 2005-2009, with data for each year between 2010-2013. The number of graduates from Ontario and Quebec has more than doubled since 2009, and the total number of graduates each year more than doubles from 2009 to 2013. Females account for 17% of Mining Engineering graduates from 2009-2013.

| | Degrees granted, Mining Engineering (2000-2013) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Enrolment and degrees awarded 2014 report | | | | | | |
| | Average (2000-2004) | Average (2005-2009) | 2010 | 2011 | 2012 | 2013 | Total (2000-2013) |
| British Columbia | 18 | 19 | 34 | 32 | 39 | 34 | 324 |
| Alberta | 16 | 17 | 39 | 43 | 34 | 32 | 313 |
| Ontario | 40 | 44 | 78 | 103 | 101 | 101 | 803 |
| Quebec | 25 | 16 | 40 | 23 | 46 | 40 | 354 |
| Nova Scotia | 10 | 13 | 18 | 21 | 17 | 13 | 184 |
| Total for each year | 109 | 109 | 209 | 222 | 237 | 220 | 1978 |
| Total for the period | 545 | 545 | | | | | |
| Total graduate numbers from 2000-2013 | 1978 | | | | | | |

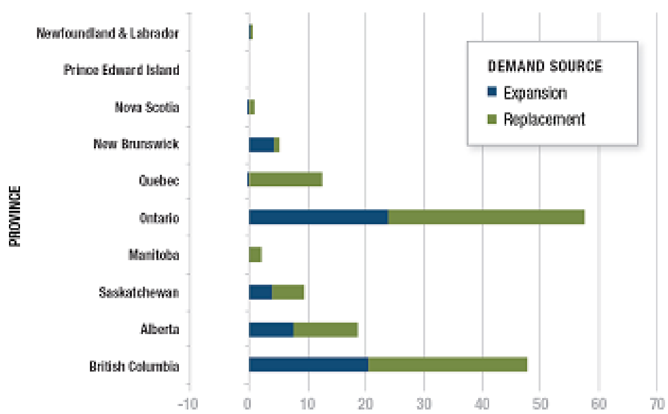
*Table 10: Mining Engineering Graduates in Canada by Province (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).*

| | Average age of Mining Engineers (2015-2025) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
| British Columbia | 43 | 43 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| Alberta | 40 | 40 | 40 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 |
| Saskatchewan | 38 | 38 | 38 | 39 | 39 | 40 | 40 | 40 | 40 | 40 | 41 |
| Manitoba | 42 | 43 | 43 | 43 | 43 | 43 | 44 | 44 | 44 | 44 | 44 |
| Ontario | 45 | 44 | 44 | 43 | 43 | 42 | 42 | 42 | 42 | 42 | 42 |
| Quebec | 45 | 45 | 45 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| New Brunswick | 35 | 36 | 37 | 38 | 38 | 38 | 39 | 40 | 39 | 40 | 40 |
| Nova Scotia | 39 | 39 | 40 | 40 | 40 | 40 | 41 | 41 | 41 | 42 | 42 |
| Newfoundland & Labrador | 33 | 34 | 35 | 35 | 35 | 36 | 37 | 38 | 38 | 39 | 40 |

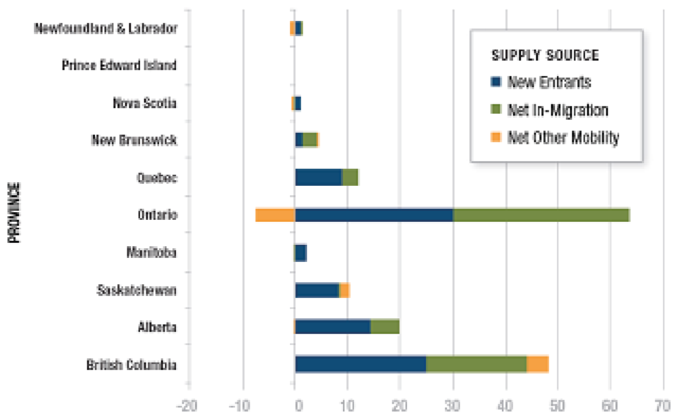
*Table 11: Average age of Mining Engineers (2015-2025) (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).*

The total number of Mining Engineering graduates from 2000-2013 is 1,978, which is a modest number given the scale and importance of the mining industry to the Canadian economy. In the current economic climate however, the number of graduates from Quebec and Ontario exceeded the demand (job availability) for those provinces. These graduates may have moved to other provinces to fill demand (e.g. British Columbia) or remained in further education or are still seeking opportunities. The mismatch between training provision and skills shortage amongst the provinces mean that graduates would need to move for work opportunities, but given their years of study and initial interest in mining they would be expected to be mobile.

It is not surprising that most mining engineering graduates go on to work in the mining industry. Ontario and British Columbia have the largest demand for mining engineering graduates.




Sources of Demand for Mining Engineers (Annual Average 2015-2025)
The majority of demand is driven by replacement with some significant expansion in Ontario, British Columbia and New Brunswick




Source of Supply for Mining Engineers (Annual Average 2015-2025)
The industry is dependent on external sources to fill the skills gap.

*Table 12: Sources and demand for graduate Mining Engineers by Province (2015-2025) (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).*

The average age of mining engineers is still high but lower overall than for Metallurgical and Materials Engineers (***Table 11***). There is very little change in the demographics expected over the next 10 years. British Columbia (BC), Ontario and Quebec all predict a slight decrease in the average age, suggesting more young people coming in to replace older mining engineers. The average age of mining engineers is set to slightly increase in all the other provinces.

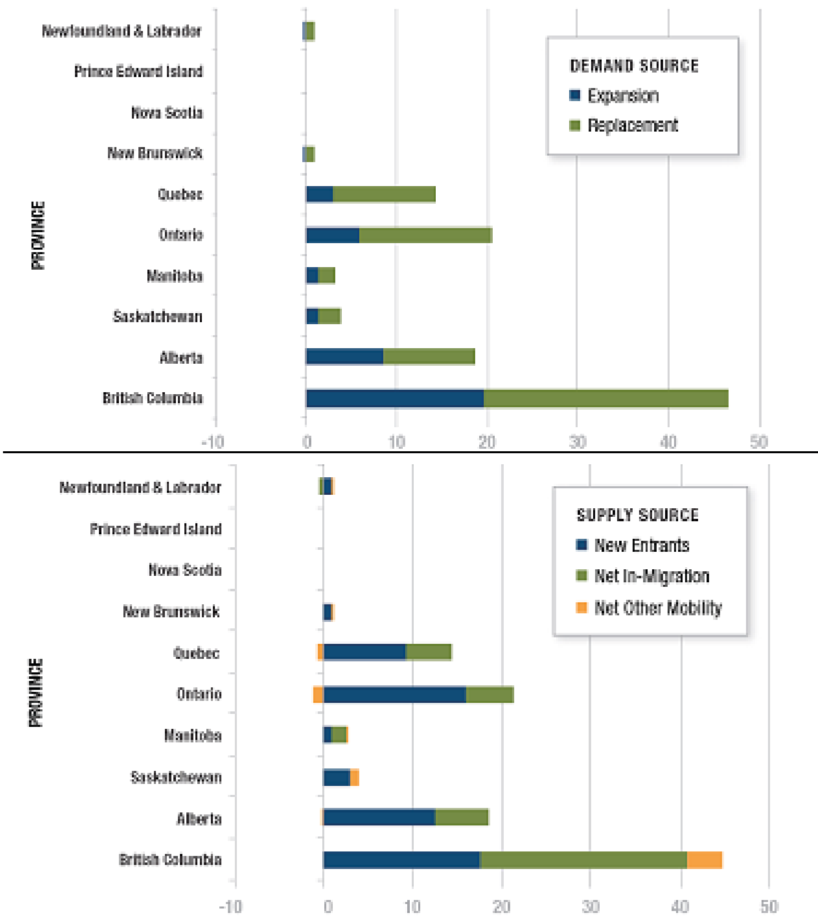
British Columbia and Ontario will have the most job openings through both

| | Degrees granted, Geological Engineering (2000-2013) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Enrolment and degrees awarded 2014 report | | | | | | |
| | Average (2000-2004) | Average (2005-2009) | 2010 | 2011 | 2012 | 2013 | Total (2000-2013) |
| British Columbia | 17 | 20 | 29 | 38 | 26 | 28 | 306 |
| Alberta | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Saskatchewan | 12 | 13 | 19 | 16 | 23 | 27 | 210 |
| Manitoba | 1 | 0 | 0 | 0 | 0 | 0 | 5 |
| Ontario | 24 | 34 | 35 | 34 | 47 | 65 | 471 |
| Quebec | 39 | 22 | 38 | 37 | 20 | 37 | 437 |
| New Brunswick | 7 | 4 | 6 | 3 | 5 | 7 | 76 |
| Total for each year | 100 | 93 | 127 | 128 | 121 | 164 | |
| Total for the period | 500 | 465 | | | | | |
| Total number of graduates 2000-2013 | 1505 | | | | | | |

*Table 13: Geological Engineering Graduates in Canada by Province (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).*

| | Average age of Geological Engineers (2015-2025) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
| British Columbia | 49 | 48 | 47 | 46 | 46 | 45 | 45 | 45 | 44 | 44 | 44 |
| Alberta | 40 | 40 | 40 | 40 | 40 | 41 | 41 | 41 | 41 | 41 | 41 |
| Saskatchewan | 43 | 42 | 42 | 42 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Manitoba | 47 | 46 | 45 | 44 | 44 | 43 | 43 | 43 | 43 | 43 | 43 |
| Ontario | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| Quebec | 45 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| New Brunswick | 48 | 47 | 47 | 46 | 45 | 45 | 45 | 44 | 44 | 43 | 43 |
| Newfoundland & Labrador | 39 | 39 | 40 | 40 | 40 | 41 | 41 | 41 | 41 | 41 | 41 |

*Table 14: Average age of Geological Engineers (2015-2025) (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).*




Source of Demand for Geological Engineers (Annual Average 2015-2025)

Replacement is the main demand, BC has significant expansion when compared to other provinces, but expansion is small in comparison to replacement.

Source of Supply for Geological Engineers (Annual Average 2015-2025)

BC dependency on both Net in-migration and new entrants. Other provinces less dependent on Net in-migration.

*Table 15: Sources and demand for graduate Geological Engineers by Province (2015-2025) (Engineers Canada, 2015, Engineering Labour Market in Canada: Projections to 2025).*

replacement and expansion from 2015-2019 (***Table 12***). The supply of mining engineers is highly dependent on net inward migration of mining engineers to replace those leaving the industry with more needed to fill expansion roles.

### *3.1.3.3 Geological engineers*

Over the next 5 years the Canadian mining industry will require 135 geological engineers annually, with demand decreasing to 85 per year thereafter (***Table 13***). The reduction is due to less expansion and more replacement posts.

A combination of new entrants and net in-migration will be required to meet the skills demand. Nearly all the geological degrees are granted by universities in Ontario, Quebec, Saskatchewan and BC. The number of women granted degrees in Geological Engineering increased from 49 in 2000 to 58 in 2013.

The average age is highest in BC, closely followed by New Brunswick and Manitoba (Table 14). The forecast average ages are not reduced significantly over the 10 year period and the demographic gap will persist and remain a risk to expansion of projects and knowledge transfer to the next generation of professionals.

Supply is dependent on both new entrants and net in-migration; from 2015-2019 the dependency on net in-migration is much greater than on new entrants. From 2020-2025 new entrants are the major source in all but one province, BC, which remains reliant on net in-migration.

#### *3.1.3.4 Masters Courses in Mining Engineering (and related courses)*

Programmes are offered at five of the major universities (***Table 16***).

| University | Masters in Mining Engineering | PhD in Mining Engineering | Other related |
|---|---|---|---|
| Alberta | MSc (MEng routes currently suspended) | Yes | MEng route MSc and MBA joint |
| University of British Columbia | MEng (course based & MASc (Master of Applied Science) (Coursework and thesis) | Yes | Major Edumine online course structure for distance learning leading to the Certificate in Mining Studies |
| Queens, Ontario | MEng (course based & MASc (Master of Applied Science) (Coursework and thesis) | Yes | |
| McGill, Quebec | 1. Master of Engineering (M.Eng.) - Thesis option<br>2. Master of Engineering (M.Eng.) - Project option<br>3. Master of Science (M.Sc.) | Yes | Graduate Diploma |
| Laurentian, Sudbury | MSc and MEng In Natural Resource Management largely focussed on mine automation | PhD in Mineral Deposits and Precambrian Geology<br>PhD in Natural Resource Management | Applied MSc in Mineral Exploration<br>'Executive Program' of CPD mini modules |
| Dalhousie, Nova Scotia | MEng (course based & MASc (Master of Applied Science) (Coursework and thesis) in Mineral Resource Engineering | PhD in Mineral Resource Engineering | |
| Laval, Quebec | MSc in Mining Engineering | Yes | |
| Ecole Polytechnique Montreal | MSc Mineral Engineering | Yes | |

| | | | |
|---|---|---|---|
| Toronto–Lassonde Institute | MEng (course based & MASc (Master of Applied Science) (Coursework and thesis) but in other departments - no specific course titles | Yes | |

*Table 16: Canadian University offering graduate programmes in Mining Engineering.*

| UBC data | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Applications | 30 | 34 | 32 | 43 | 44 |
| Offers | 10 | 13 | 8 | 19 | 11 |
| New Registrations | 7 | 12 | 7 | 17 | 9 |
| Total enrolment | 28 | 35 | 30 | 34 | 42 |

*Table 17: Enrolment Data MSc Mining Engineering at UBC (https://www.grad.ubc.ca/prospective-students/graduate-degree-programs/master-of-applied-science-mining-engineering).*

Numbers of students enrolled on these programmes has been difficult to ascertain but generally there are less than 10 new registrants each year on any such programme. The best data available is from the MSc Mining Engineering Programme at the University of British Columbia (***Table 17***), which is one of the biggest programmes:

*"This program has a graduation rate of 86% based on 22 students admitted between 2005 - 2008. Based on 28 graduations between 2011 - 2014 the minimum time to completion is 1.32 years and the maximum time is 5.00 years with an average of 2.58 years of study. All calculations exclude leave times."*(https://www.grad.ubc.ca/prospective-students/graduate-degree-programs/master-of-applied-science-mining-engineering).

The flexibility in duration of postgraduate study makes it very difficult to know how many students complete their Masters each year. The number of new registrations is low compared to the number of applicants. This low conversion rate could be due to funding/scholarship availability or limited places due to staffing at the institution.

#### *3.1.3.5 College Courses*

Over 25 community colleges offer training programmes, including apprenticeships in mining related trades across Canada. These range from generic trade apprentices to college industry partnerships.

As Canada is dependent on net inward migration to fill skills gaps, there are language courses specifically designed for mining related professions and trades. These courses not only ensure language skills but that these language courses address the language and terminology used in mining. This improves job prospects and making the individuals ready for work and also increases the pool of people available. (http://www.acareerinmining.ca/en/careers/training.asp)

Courses at college level include:

- Blasting techniques;
- Earth Resource Technician;
- Mining Engineering Technician;
- Mining Engineering Technology;
- Mining Techniques;
- Resource Drilling and Blasting;
- In addition to more traditional trades training courses such as:
  - Electrical technicians;
  - Heavy equipment technicians;
  - Welding and Fabrication.

The number of students taking college level courses in mining related programmes is low. Cambrian College, in Sudbury, Ontario offers 2 & 3 year courses in Mining Engineering Technician and Mining Engineering Technology respectively, with a total of 28 student graduating in 2012-2013 (in 2011-2012 30 graduates for these courses) (http://cambriancollege.ca/Programs/Documents/GraduateReport.pdf).

The general overview of college education shows a surprisingly low number of applicants to mining related college programmes, however those who do start courses in mining related courses have a very high completion rate and good employment levels.

The Mine Training Society (MTS) is a partnership involving the aboriginal community, the Government of the Northwest Territories (GNWT) and industry representatives. The role of MTS is to screen, select, train and place people into mining jobs. This partnership relies upon the Department of Education, Culture and Employment, the teaching resource and expertise from Aurora College, and the occupation/skills requirements of the mining industry.

### *3.1.4 Canadian Training and Education Financing*

For full time Canadian students, the cost of tuition to study an undergraduate Engineering degree averages C$7,151 per year but varies depending on the Province between C$10,460 in Ontario to C$2,550 in Newfoundland and Labrador. This also varies depending on the Engineering degree itself (Mining, Civil, Mechanical, etc.). There are numerous awards and scholarships but these tend to vary depending on the institution.

Masters level courses in Mining Engineering (and related Geotechnics, etc.) cost in the region of C$5000 per year, for the 2 year programme. Numerous scholarships, sponsorships and funding opportunities are available, especially to those working in industry and wishing to purse Masters level studies. These opportunities vary depending on province and institution.

Funding for college level training is normally through government (e.g., Mine Training Society) and industry. For example partners include:

- Boart Longyear and MTS trained 6 diamond drillers, with a total investment $216,168 of which $112,222 was contributed by the partner (2010).
- Rio Tinto Diavik Diamond Mines, funded 5 underground traineeships, with a total investment $468,371, of which $267,491 was contributed by the partner (2010).

The training programmes are very specific and often linked to individual companies. They involve traineeships at mines and with industry mentors. In general these are small numbers doing very specialist training to fill required skills.

### *3.1.5 Canadian Government-Industry Initiatives*

A range of initiatives are co-funded by the government in the area of mining skills development.

#### *3.1.5.1 Skills Canada*

This organisation is dedicated to promoting career opportunities available in the skilled trades and technology sectors to young people. This is achieved through skills competitions, workshops and engagement with industry professionals. This is a national programme.

#### *3.1.5.2 Mining Matters*

This national charitable organization works with students, educators and the public to increase awareness about Canada's geology and mineral resource potential. The charitable organisation provides current information about minerals, metals and mining, and the careers available in the minerals sector. In addition Mining Matters provide teaching resources for classrooms which are aligned with the education curriculum in many provinces and territories. These resources are developed by educators and Earth Science experts and are excellent for educators and students.

#### *3.1.5.3 Mining Industry Human Resource Council (MiHR)*

MiHR is a national human resources (HR ) council working exclusively with the Canadian minerals and metals industry, and is probably the foremost organisation in terms of setting the national training agenda. MiHR works to assess industry needs and collaborate with stakeholders to develop solutions which aim to meet the current and future human resources needs in the mineral industry. They also provide outreach and education initiatives and resources to attract young people into mining.

### 3.1.5.4 EdGEO

Since the 1970s, this national organization has been supporting Earth science education and development workshops for teachers. The Canadian Geoscience Education Network of the Canadian Federation of Earth Sciences (CFES) coordinates EdGEO activities. The workshops are designed to enhance knowledge, increase confidence of education providers and provide educational resources to use in the classroom. Each year EdGEO supports and encourages over 160 teachers across Canada.

### 3.1.5.5 The Canadian Geoscience Education Network (CGEN)

CGEN is the education arm of the Canadian Federation of Earth Sciences. This national organization is an association of stakeholders interested in all levels of geoscience education and outreach. They work with educators and Earth science professionals from government, industry and academia. Undertaking national and regional education and outreach activities, CGEN serves to actively encourage geoscience awareness and serves as a forum to discuss matters related to geoscience education across the country.

### 3.1.5.6 Earth Sciences Canada

Earth Sciences Canada is the homepage of the Canadian Federation of Earth Sciences (CFES), the mouthpiece for Earth Sciences in Canada. The homepage hosts links to websites of participating organizations and partners, including those featuring education resources. The education websites include CGEN, Earth Links, a repository of teaching resources, and the 'Explore a Career in Earth Sciences 'website. This includes videos and earth science careers profiles, providing an opportunity for students to learn about relevant careers (www.earthsciencescanada.com).

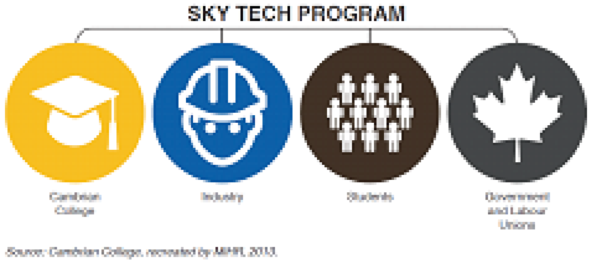
### 3.1.5.7 Mine Training Society (MTS)

Formed in 2004, MTS is Canada's most successful collaborative training initiative. Working with Aurora College, Aboriginal Communities, and Aboriginal Skills, mining companies (De Beers, Rio Tinto, Boart Longyear and others), to assess the needs and jointly fund training and enabling access to work opportunities in the mining industry.

### 3.1.5.8 SkyTech

SkyTech is an example of how industry and education providers can form successful partnerships in order to make sure that education programmes meet industry needs (***Figure 22***). This ensures that organisations have access to skilled human capital which fits their needs and workforce plans. This programme is currently under review.

Education and industry partnerships are an essential part of workforce planning and, ensuring the education is relevant to the needs of the industry. Partnerships can also be used to mitigate the cyclical nature of the industry through workforce plans and joint training initiatives. (MiHR, 2013).




The SkyTech board consist of several mining companies: Glencore, Vale, in addition to unions and Cambrian College. SkyTech provides funding for training equipment, operational costs, and the opportunity for stakeholders to work together in filling the skills gap.

*Figure 22: SkyTech Program (MiHR, 2013).*

## 3.2 USA

### *3.2.1 U.S. National Workforce Plans*

The mining and minerals workforce comprises less than 0.25% of the total workforce, yet its value-added contributions are worth approximately $14.5 trillion to the U.S. economy (NMA, 2014). The U.S. raw materials workforce is older than the rest of the general U.S. workforce: one third of the workforce is baby boomers due to retire in large numbers by 2020. The number employed in mining fluctuates unevenly with the global minerals economy, and modern job roles require higher competencies in STEM (science, technology, engineering and mathematics) skills (Freeman, 2015). Near the height of the recent boom there was a shortage of qualified minerals professionals. But in the last two years, there has been an excess supply, other than in a few niche occupations, and therefore cost indices suggest a 3-4% annual drop in labour costs.

The US has an open market approach to labour. There is no national workforce planning in the United States, although the Bureau of Labour Statistics (BLS), Mine Health and Safety Administration (MSHA), Energy Information Administration (EIA) and various other agencies are involved in data collection and dissemination. The federal government exercises a very limited role in directing growth in certain economic sectors, and although state governments occasionally pass special tax incentives for industry, it's rarely sustained.

The Society for Mining, Metallurgy and Exploration (SME) and National Mining Association (NMA) are key stakeholders in U.S. raw materials education and workforce development. Various reporting and occupation classifications make it difficult to understand employment figures. For example, the BLS classifies the mining and mining services sector into over 330 different occupations, many which blend into several related industries such as oil and gas or civil engineering. A good approximation is that 200,000 are directly employed, with another 290,000 classified as "support activities for mining". The general accepted estimate of the total mining workforce by industry associations is approximately 400,000.

State governments with a significant mining industry sometimes work with trade organizations in developing limited workforce plans, although there is little evidence of sustained funding of workforce development. The Alaska Miners Association (AMA) is one example of an industry group taking initiative. There is a mining-related workforce of around 4,600 individuals in Alaska. The high attrition rate there combined with growing mineral development suggests likely shortages in the years ahead (AMA, 2015). Looking more closely, the key occupational shortages can be contrasted by one group of 'priority occupations' and another category of more highly-trained, and highly-paid staff whose recruitment is difficult, although a far fewer number are required ***(Table 18)***.

In Nevada, the state with the largest mining industry, local communities do not have an adequately skilled workforce to meet the needs of industry, and shortages are most likely experienced in the maintenance field. The "boom and bust" perception of mining, and the problems of career-livelihood balance impact recruitment. Nevada's list of the highest demand occupational categories and

| Priority Occupations | Difficult to Recruit Occupations |
|---|---|
| Underground Miners | Electrical/Instrumentation Technicians |
| Mill Operators | Mining Engineers |
| Drillers and Blasters | Mechanical Engineers |
| Mechanical Maintenance (Mill, Diesel) | Geologists |
| Haul Truck Drivers | Metallurgists/Metallurgical Technicians |
| Equipment Operators | Permitting Specialists |
| | Health and Safety Specialists |

*Table 18: Staff shortages identified in Alaska.*

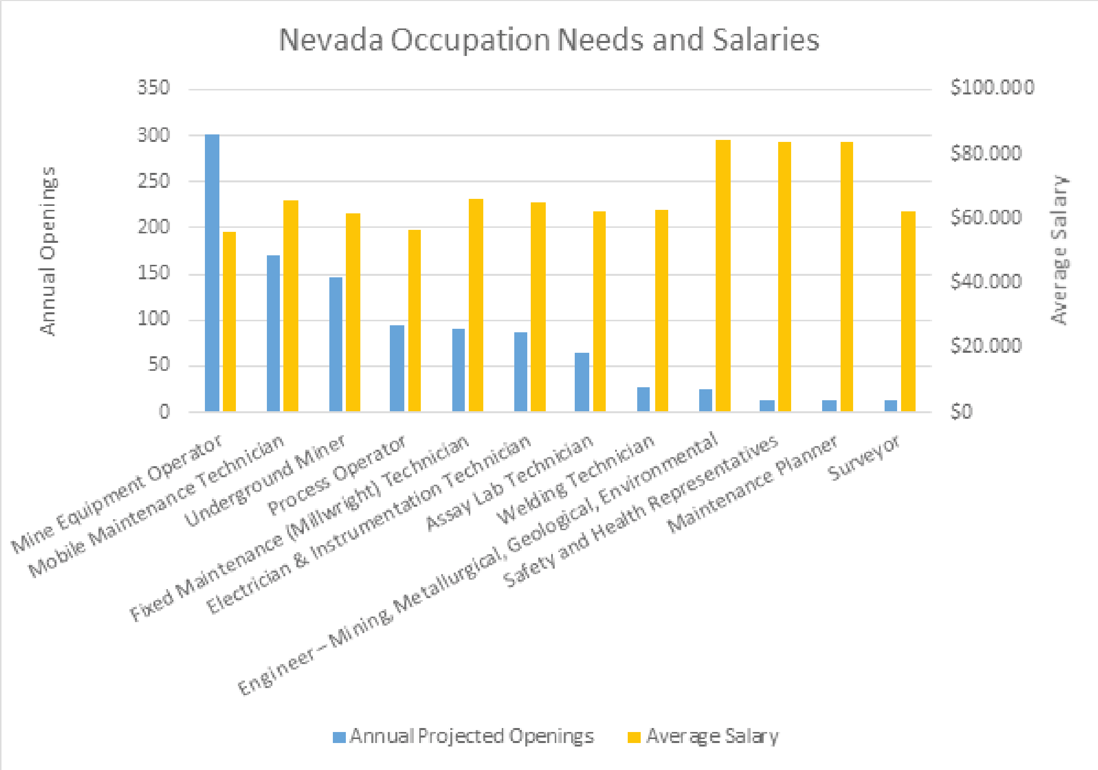



*Figure 23: Nevada State Mining Occupation Needs and Salaries.*

salaries for 2014 are shown in ***Figure 23*** (NVDETR, 2015).

It is clear that the highest need is in the lower paid and lower skilled job categories like equipment operators and maintenance technicians, while there are very few openings for engineers, geologists, and other highly paid careers; however this also reflects the small number of professional specialist roles in typical mining operations (***Figure 23***).

In 2013, the National Academy of Sciences (NAS) (expert advisers on science and engineering education and research) issued a study on workforce trends in the industry. Some key findings include:

- Mining workforce demographics are older, male-centric, and less diverse; this is in contrast to general population trends in the U.S.;
- Key occupational demand increases expected during 2010 – 2020 are boilermakers, geoscientists (except hydrologists and geographers), electrical power-line installers/ repairers, and geological technicians;
- Shortages predicted in: geological technicians and occupational health and safety specialists;
- Data systems likely undercount mining employment.

The NAS did not forecast a general shortage of labour. In contrast, a study by the SME (Society for Mining, Metallurgy and Exploration) using similar data sources highlighting predicted shortages across the mining workforce due to an ageing, retiring workforce.

Their estimates include a 128,000-person shortfall in 2019, growing to 221,000 people in 2029, due to more than half the 2008 workforce retiring (***Figure 24***). It's unclear what assumptions SME used and how extrapolations were made. The American Geological Institute (AGI) forecast an overall geoscience deficit of 35,000 people by 2021.

Similar reports in the SME journal have warned of skills shortages and educational failures (Moudgil et al., 2012; McCarter, 2007; Daemen, 2004; McDaniel & Moss; 2014, Hustrulid, 2004). In 1982 a total of 25 universities had mining and mineral engineering programs, which fell to 14 in 2014. Alongside there was a decline in faculty from ~120 in 1984 to ~70 in 2014. According to one source, the number of graduating mining engineers has fallen from a high of 700 in 1982 to approximately 180

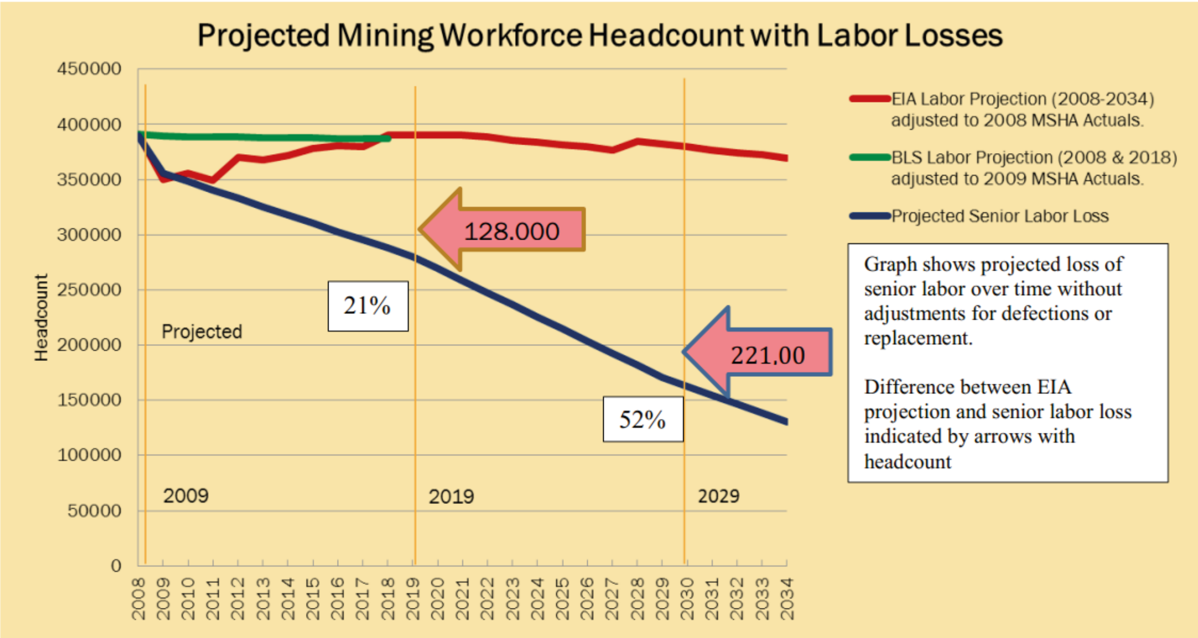



*Figure 24: Projected U.S. Mining Workforce Labour Losses (SME 2015).*

in 2011 (Adams, 2012). The SME Education Forum estimated in 2007 that the growing demand for mining engineers would be 300 for at least ten years, in order to address replacements and industry growth (SME 2013). Despite sustained growth, this target has not yet been reached.

### *3.2.1.1 Employment of mining engineers*

According to 2014 Bureau of Labour Statistics, the median annual wage for mining engineers is US $90,160, which is higher than the $88,720 average engineer salary, and far exceeding the average of all occupations, $35,540. The median age of the mining labour force is 47.2, compa-

2004 RETENTION OF 4-YEAR DEGREED MINING GRADUATES THAT MATRICULATED FROM 1976-1996

| EDUCATION | INDUSTRY SECTOR | GRADUATE PLACEMENT (FIRST JOB) 1976 - 1996* | 30% Attrition | RETENTION AS OF 2004** |
|---|---|---|---|---|
| **4 YEAR PROGRAM** | **PRODUCTION** | **70%** | | **35%** |
| | Coal | 35% | | 15% |
| 30% Attrition? | Precious Metals | 10% | | 5% |
| | Base Metals | 10% | | 5% |
| | Sand and Gravel + Stone | 10% | | 5% |
| | Industrial Minerals | 6% | | 5% |
| | **SERVICES and SUPPLIES** | **15%** | | **35%** |
| | Consulting | 5% | | 20% |
| | Equipment | 5% | | 5% |
| | Supplies | 5% | | 10% |
| | **NON-TRADITIONAL** | **13%** | | **20%** |
| | Production in Other Industries | 5% | | 5% |
| | Construction | 5% | | 5% |
| | Other | 3% | | 10% |
| | **GOVERNMENT** | **2%** | | **9%** |
| | Federal | 1% | | 4% |
| | State | 1% | | 5% |

* Percentages based on 20 years worth of graduate information from accredited programs.

** From BLS occupation statistics compiled for 2004

*Figure 25: Retention of U.S. Mining Graduates (Brandon, 2005).*

red to the average age in US labour of 40.7 (SME, 2014). The ageing workforce, along with retention, are key issues identified by SME and NMA.

The overall attrition rate for mining graduates is an estimated 30%, with a large number of engineering graduates leaving production roles. A typical career path sees engineers start in mines (only 20% start in metalliferous mining), then transition into consulting roles. After several decades, 35% of mining engineering graduates remain in production (about half in coal). An equal number work in consulting, one fifth in civil and other industries, and 10% in government ***(Figure 25*** reproduced from the Brandon, 2005).

### 3.2.2 U.S. Educational Provision

The United States has a robust, but expensive, education system, from primary to tertiary. In 2015, there were 18,900,000 students enrolled in approximately 4,100 colleges and universities (National Student Clearinghouse Research Centre, 2016).

As of December 2015, there were fifteen (15) universities offering mining engineering degrees (there are nearly 900 colleges and universities that offer geoscience related programs) (***Table 19***).

Mining and geological engineering programs are accredited by the Accreditation Board for Engineering and Technology (ABET). ABET is a federation of 30 professional and technical societies such as SME which shares curricular responsibilities for accreditation. In 2014, 18 programs were accredited (17 undergraduate Bachelor of Science 4-year programs) based on faculty, curriculum, and facilities, etc. This is up from 13 accredited programs in 2008. The first Masters of Science Mining Engineering program was accredited in 2014 at the University of Missouri Science and Technology.

To become a registered mining engineer in the U.S., licensure is required over the course of several years, including a passing score on the Fundamentals of Engineering (FE) exam, at least 4 years of relevant work experience, and a passing score on the Professional Engineering (PE) exam. Each state administers their own licensure and registration, which usually includes continuing education credits for upkeep. Employment in 2014 was 8,300 and projected to grow to 8,800 over the next ten years. This 6% growth is in line with other occupations, although geographically it is concentrated in the Western States such as Nevada, Arizona, Colorado, Alaska, Utah, Montana, Wyoming and the Appalachian coal mining

| |
|---|
| University of Alaska Fairbanks, College of Engineering and Mines |
| The University of Arizona, Department of Mining and Geological Engineering |
| Colorado School of Mines |
| Southern Illinois University Carbondale, Department of Mining Engineering |
| University of Kentucky, Department of Mining Engineering |
| Michigan Technological University, Department of Geological, Mining Engineering and Sciences |
| University of Missouri S&T, Department of Mining and Nuclear Engineering |
| Montana Tech of the University of Montana, Department of Mining Engineering |
| Mackay School of Mines, University of Nevada, Reno, School of Earth Sciences and Engineering |
| New Mexico Institute of Mining and Technology, Department of Mineral Engineering |
| The Pennsylvania State University, College of Earth and Mineral Sciences |
| South Dakota School of Mines and Technology |
| The University of Utah, College of Mines and Earth Sciences |
| Virginia Polytechnic Institute and State University, College of Engineering |
| West Virginia University |

*Table 19: List of US Universities that offer mining engineering degree courses.*

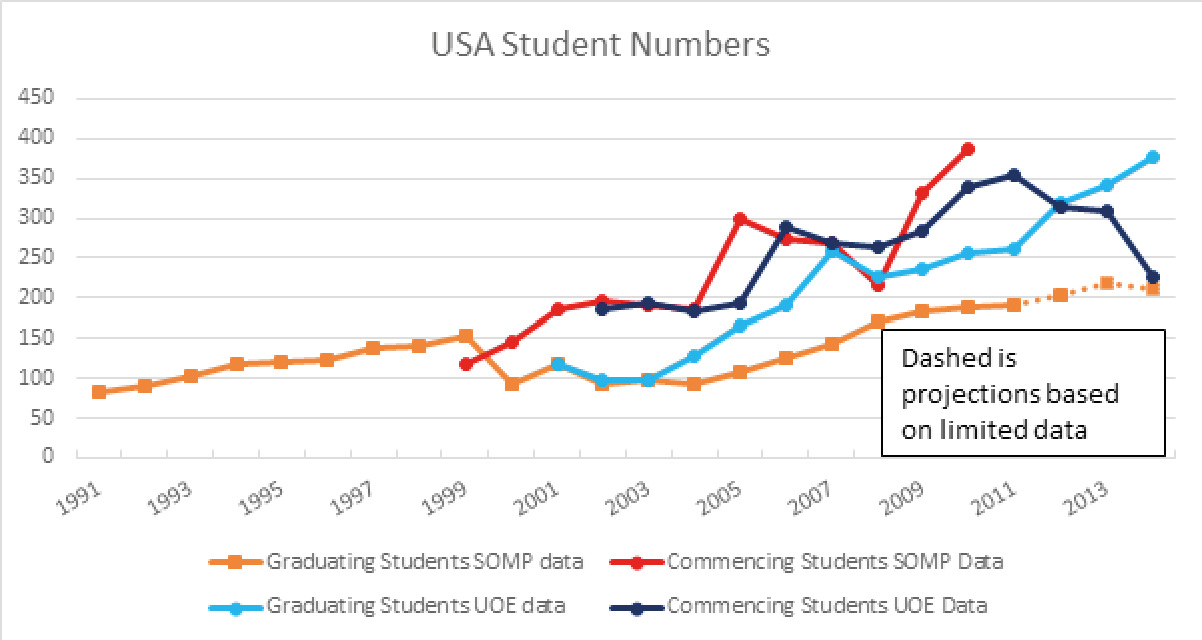


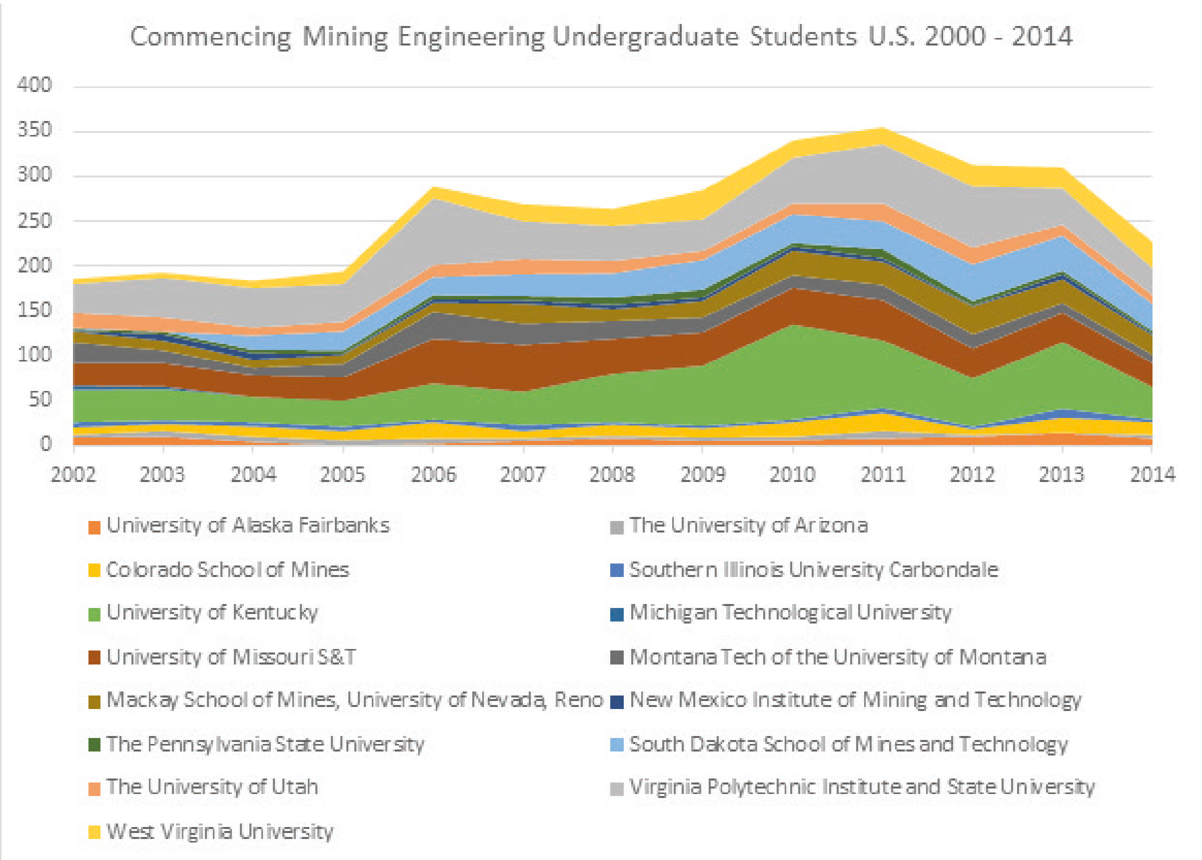

*Figure 26: U.S. Graduating and Commencing Student Numbers.*

region of Kentucky and West Virginia (U.S. Bureau of Labour Statistics, 2015).

Key shortages of mining staff were identified in 2014 by SME President John Marsden as first in the trade skills within mechanical, electrical, instrumentation and process control areas. Acute shortages of mid-career professionals are also found in mine planning engineers, metallurgical and chemical engineers, mineralogists and environmental engineers (Marsden, 2014).

#### *3.2.2.1 Data*

Data on U.S. mining engineering programs are patchy, as not all institutions report each year, and standards and defi-



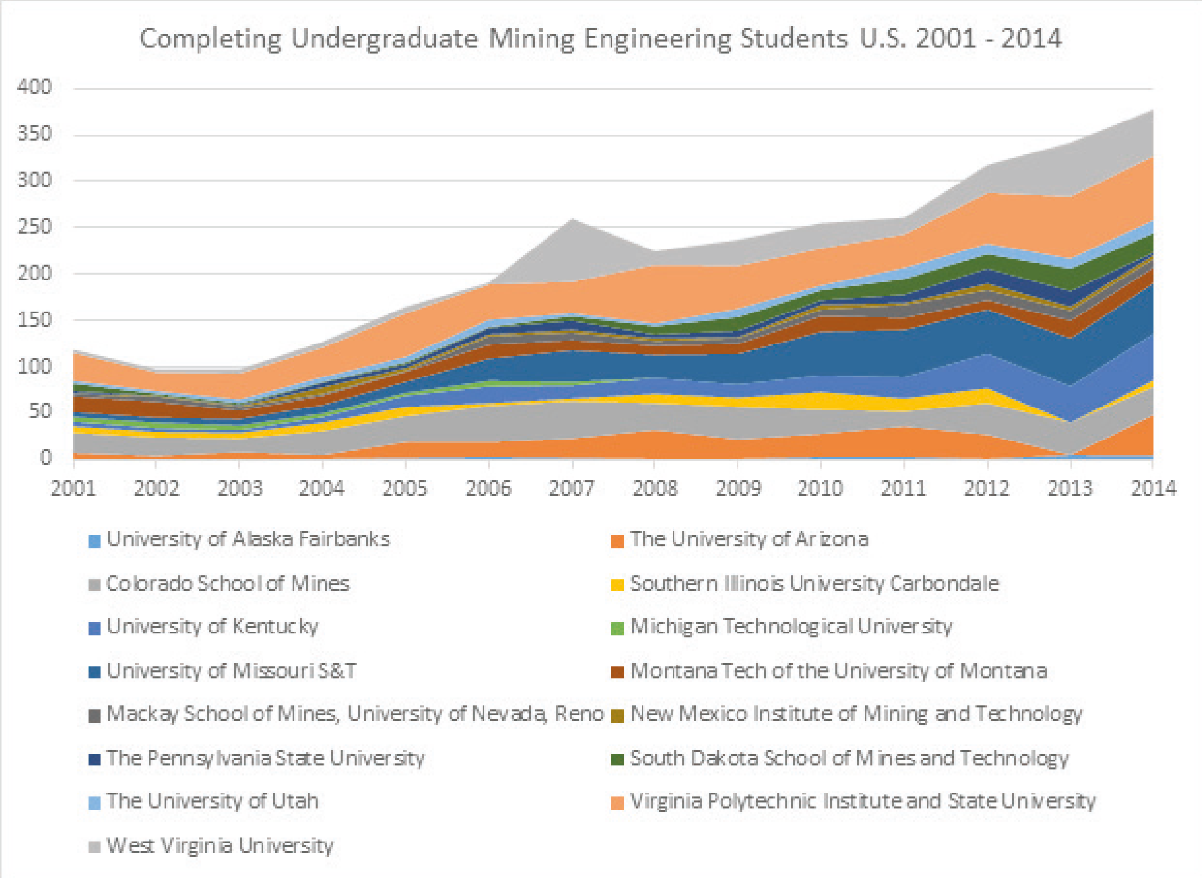



*Figure 27: Commencing and completing Mining Engineering students on US Programmes.*

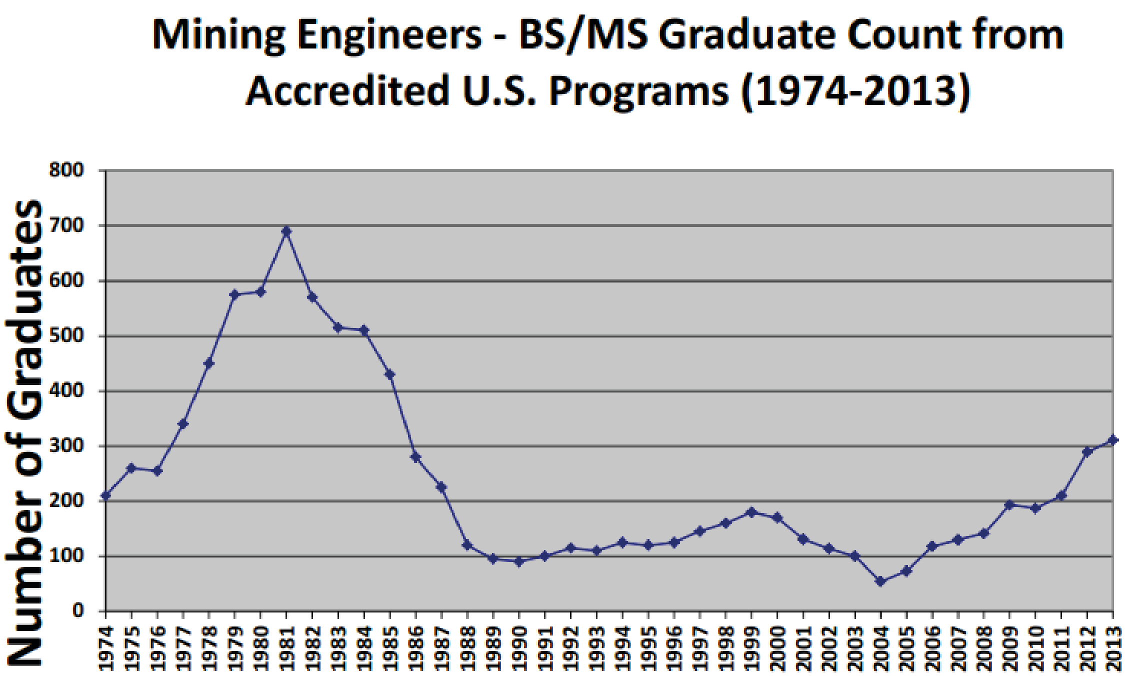



*Figure 28: Decline in Number of Mining Engineering Graduates.*

nitions differ making comparisons difficult. Nevertheless, a fairly complete count of graduating mining engineers is shown in the two graphs below (***Figure 26 and 27***).

The number of students generally matches commodity market fluctuations, with a general rise associated with the 2004-2012 mining boom and a drop in commencing students in recent years.

It's clear by looking at the scale of each institution, that some programs are much larger than others and some have shrunk or grown over the last decade (***Figure 27***). In the case of Michigan Tech, their program was eliminated in 2003, but is set to begin again in 2016.

The programs in Virginia Tech, West Virginia and Kentucky have remained fairly well subscribed and expanded considerably during the recent era of high coal prices, but have also suffered the most from recent coal market declines.

Put into perspective, the number of mining engineering graduates from 1975 – 1985 ranged from ~250 per year up to a peak of 700 in 1981 (SME, 2013) (***Figure 28***).

Several reasons for the decline have been offered, paraphrased from R. Bishop's white paper for the House Committee on Natural Resources (2015):

- **Elimination of US Bureau of Mines (USBM) in 1996 -** $100 million and 1,000 employees ceased, ending research, information gathering, policy analysis and other strategic education and outreach functions;
- **Decline in Federal Research Funding** – following USBM closure, funding was curtailed by over $50 million. Faculty at large universities are expected to bring in $150,000 - $200,000 each year and primary federal research funding from the major organizations has fallen;
- **Industry Cycles and Low Enrolment:**
  - 1950's and 1960's → 800 – 1,200
  - 1970's energy crisis peak → 3,000
  - 1980's and 1990's → 500
  - 2012 gradual rising → 1,600 (commodities boom)
  - 2014 falling (mineral price falls)
- **University Economics** – small size nature of mining programs fail in metric-centric productivity assessments using criteria such as: faculty-student ratio, department size (students and faculty), degree cost, cost per student, and total research funding. This leads to reactionary closures during industry downturns;
- **Reduction in State Support** – general funding for higher education fell 7.6% from 2011 – 2012. State cutbacks have been ongoing for 15 years, and in some cases is down 90% (AGI, personal communication, January 28, 2016). Some mining programs receive no monetary support from state governments;
- **ABET Accreditation Loss** – when not enough courses are taught and too few faculty exist, accreditation is lost, enrolment drops and the program is closed;
- **Faculty Retirements** – 2010 survey showed that over half of faculty would be eligible to retire within ten years, and only 10 members across the entire US were under 40 years old. In February 2013, 18 faculty positions were open including 5 departmental head vacancies;
- **Weak PhD Supply** – Whilst the number of graduates has remained steady at 15 per year, there has been a

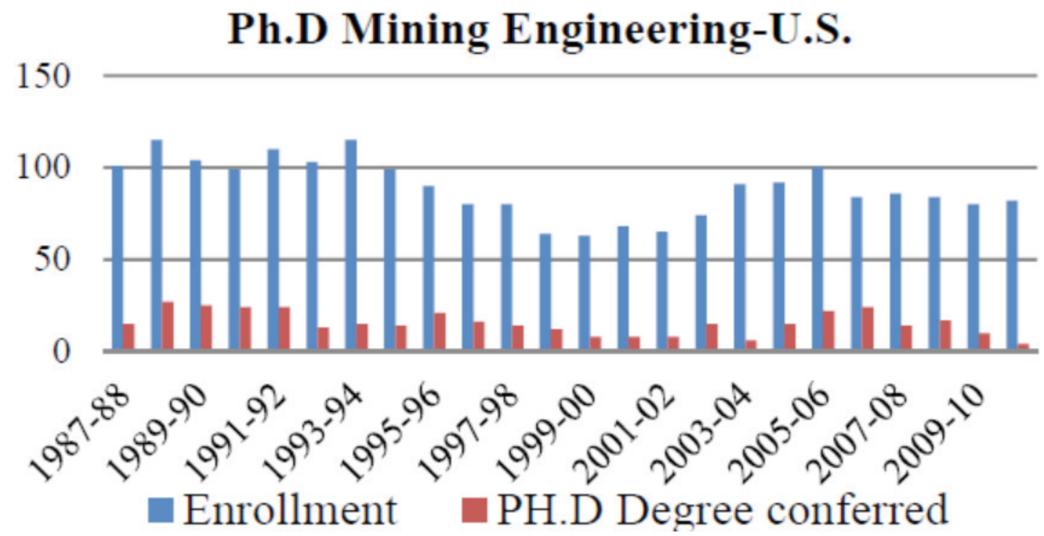



*Figure 29: Decline in Number of Mining Engineering Graduates.*

recent fall and there is a high attrition rate among PhD and new faculty members (***Figure 29***). A 2010 survey of PhD candidates found only 25% were interested in a university career (Poulton, 2012);

These organisations include; National Institute for Occupational Safety and Health (NIOSH), United States Geological Survey (USGS), Department of Energy(DoE), Mine Safety and Health Administration (MSHA), Office of Surface Mining Reclamation and Enforcement (OSM), National Sciences Foundation (NSF), and Department of Defence (DoD).

- **Tenure Process** – the long, formidable evaluation is a disincentive and often causes burn out. The current process lasts 5 to 7 years after starting and examines teaching quality, number of master's and PhD students graduated, number of peer-reviewed publications, service (to university and industry) and most importantly the amount of research funding brought-in.

Analysts have cited other reasons for the demise of US mining engineering programs. The use of contractors has been on the rise in the U.S. mining industry, and technological developments has reduced the need for as many mining engineers. The mining boom in Australia and Canada has also lured many U.S. graduates abroad to seek higher salaries.

In general, the number of female students has been increasing, but there are not good statistics available. A good estimation is that between 15 – 20% of students are female in mining engineering programs. Within geoscience graduates however, the number is approximately 43% for undergraduate studies, rising to 52% among PhD students (AGI, 2015).

The average number of staff at each university is 8, although this ranges from 3 at Montana Tech to 27 at Missouri. One problem with these data is calculating how many staff which share teaching loads with other departments (engineering or geoscience) should be included in the overall attribution.

The age of academic staff is evenly distributed with 65% between 30 and 59 years and between 20-30% over the age of 60 (***Figure 30***). The main explanation is the recruitment of foreign staff from India, China, and other developing countries with large mining engineering university departments. Academic staff in the U.S. have a higher percentage of professors (34%) and associate professors (28%) among the mining department staff than in other parts of the world (***Figure 31***), although this tenure system is not shared by other countries and the comparison

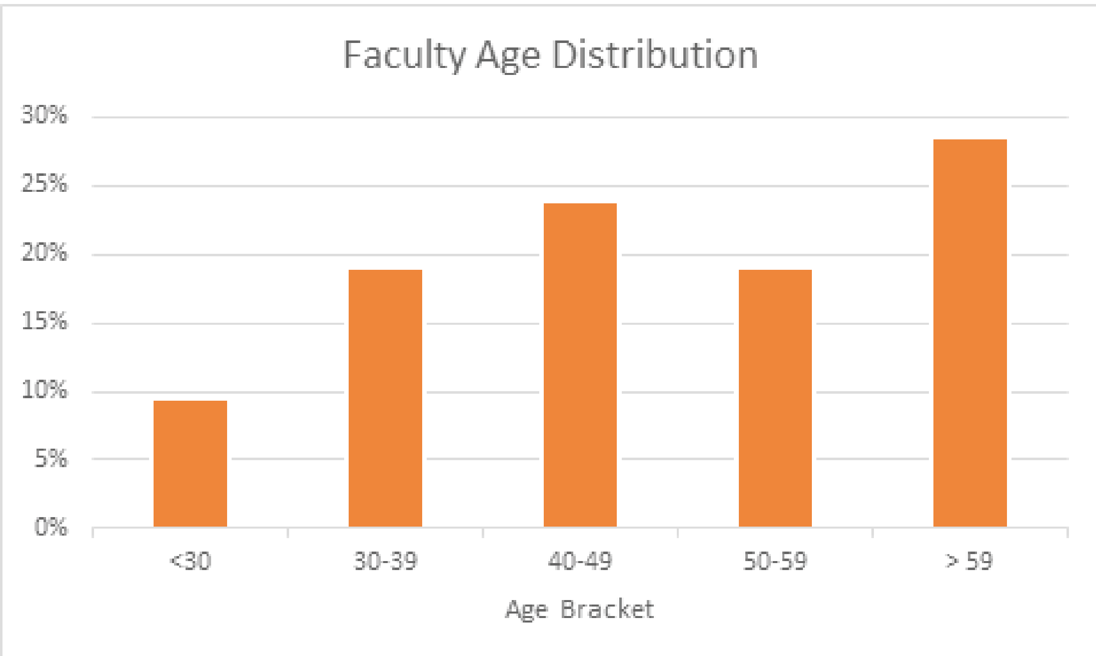



*Figure 30: Age Distribution of U.S. Mining Faculty.*

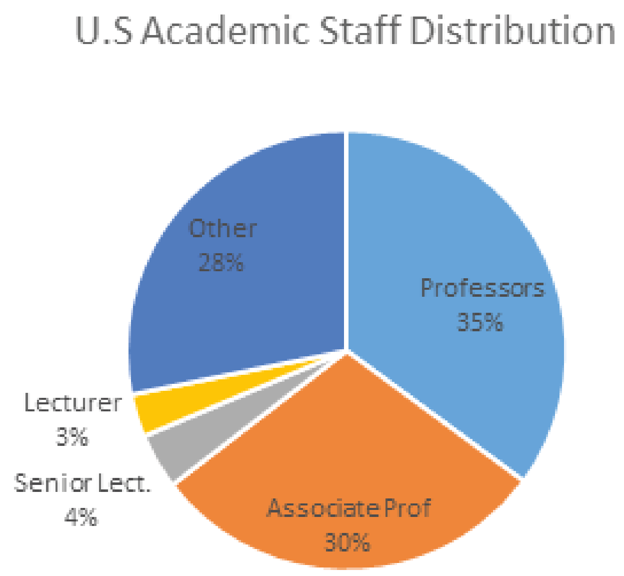



*Figure 31: Experience Distribution of U.S. Mining Academic Staff.*

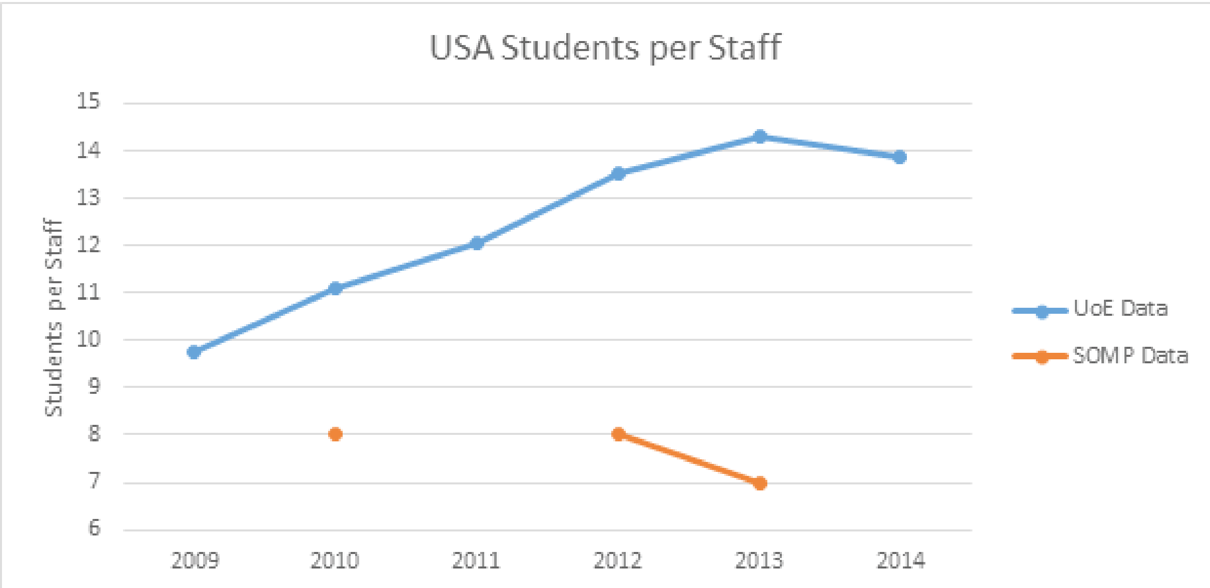



*Figure 32: Students per Staff.*

requires further scrutiny. The number of female staff on average is 12%.

The number of students per staff (***Figure 32***) is relatively high in the U.S. compared to other reference countries, likely due to the problem of attracting and retaining staff, and recent growth in enrolments at mining schools.

The completion/commencing ratio is problematic to calculate and beset with data inconsistencies from the schools, SME and SOMP data (***Figure 33***). One reason is that many students do not declare their major until their third year, which inflates the effective completion rate when reported. The completion rate over four years is uncertain, but possibly around 50 or 60% among U.S. schools, and fluctuates with the mining industry. During boom years it may be above 90%. SOMP data calculates based upon single-year enrolment and graduation rates, which are biased when student numbers fluctuate. It has been suggested that most STEM disciplines measured over full 4-year undergraduate cycles reveal a completion rate closer to 30%. This figure matches more closely with year-to-year fluctuations among enrolments where many students do not progress. Most students

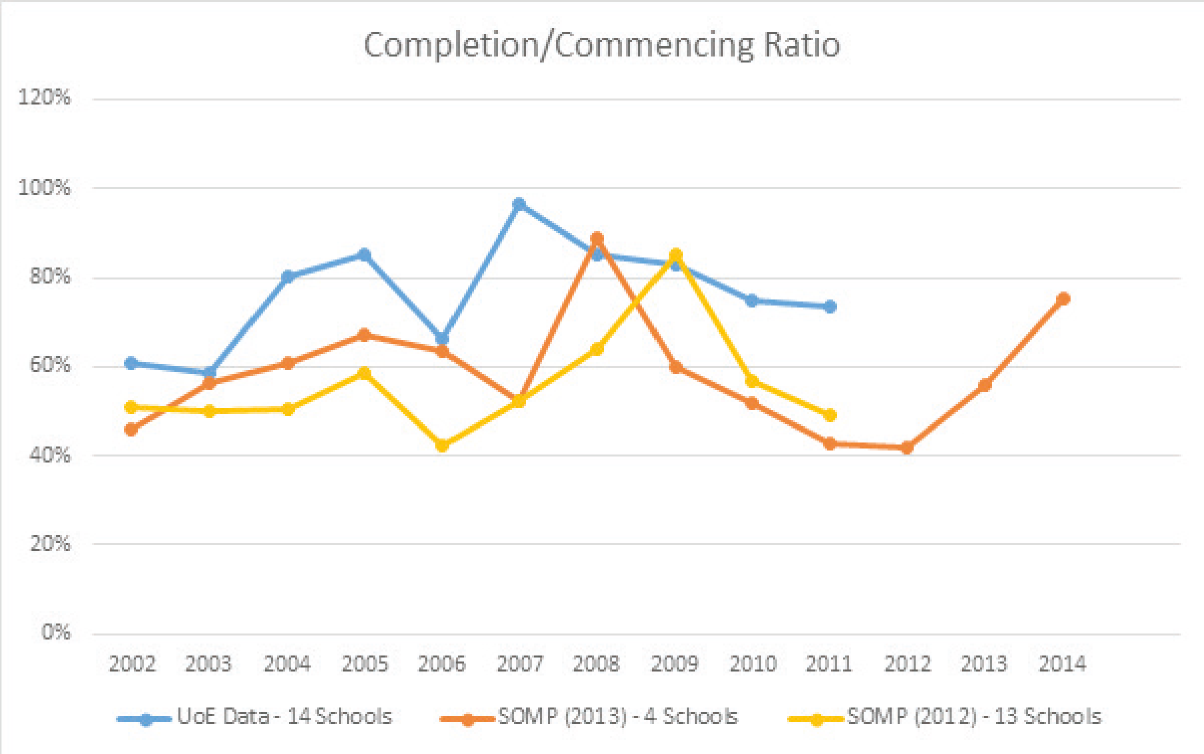



*Figure 33: Completion/Commencing Ratio.*

receive scholarships from mining companies and benefit from ample summer internships, good networking opportunities at SME events, and good career prospects.

Retention, as previously discussed, is relatively low for mining engineers at production roles. Although 70% of graduates start at operating mines, at least half leave during their careers, mostly into consulting. Most mines are drive-in drive-out (DIDO) in contrast to the FIFO (fly-in fly-out) models at many Australian and Canadian mines. Despite this general advantage of location closer to towns, the problems of family life in these communities (often poor) is a deterrent for many potential employees.

#### 3.2.2.2 Geoscience

There are close to 900 colleges and universities in the U.S. offering geoscience, geology, earth science, mining and related programs (AGI, 2015b).The American Geosciences Institute produces an annual survey of the geoscience workforce and graduates in the U.S. In 2014, one finding from its graduate survey was a difficulty finding employment in the minerals field, although overall geoscience graduates have ample employment opportunities. Combined with the fact that over half of students do not participate in internships or obtain work experience during their studies suggests a lack of job preparedness (AGI, 2015b). The 2015 survey had responses from 692 students representing 210 schools. Most students were from California and Texas, followed by Washington, Colorado, Pennsylvania, New York and Illinois. There was about 10% more males than females, although amongst PhDs this was reversed. Among Bachelor graduates, less than 10% were international, versus 19 – 27% amongst PhDs. Slightly less than half took an earth science course during secondary school.

Two thirds of bachelor degrees are in general geology, and among specializations environmental science, geological/geophysical engineering and geophysics/seismology were the top pics. This changes dramatically at Masters and PhD levels. The greatest specializations are in geophysics and seismology, geochemistry, hydrology, palaeontology, petroleum geology and environmental geosciences. There is not a mining or economic geology category, so it's unclear what percentage specialize into fields leading to the minerals industry.

Funding was received by student loans, federal grants, institutional grants and external scholarships. For masters and PhD students, most held research or teaching assistantships. Over half of students participated in a field camp, and many participated in over 6 field excursions during their studies.

Only 11% of graduating Bachelors were employed at the time of the survey, and nearly 40% are not seeking employment in the sector. Employment increases exponentially with education: 40% of Masters' graduates accepted a job at the time of the survey, and nearly 60% of PhD graduates. The industries where students are working were dominated by oil and gas until 2015, when environmental services hired more graduates with a Bachelors. Still, two thirds of employed Masters-level graduates went into oil and gas. For the mining industry, no employed bachelors or PhD graduates reported employment in the field, whereas 4% of employed Masters level graduates did.

The higher the education level of graduates, the less attracted they are to mining employment. Asked what industries they were interested in, most Bachelor and Masters' graduates (over 70%) selected environmental services, followed by oil and gas, government and mining (20% among bachelors, 12% amongst masters). Less than 5% of PhD graduates are interested in mining jobs. Despite these figures, economic geology has consistently been one of the top five Master's thesis topics going back to 1970 and entered the list of top five again for Doctoral dissertations in the period 2000 – 2010 (AGI, 2014b). So although students are interested in studying mining topics, there is not a huge attraction to employment in the sector. This indicates a gap in the understanding of mining career attractiveness amongst students.

#### 3.2.3 U.S. Training and Education Financing

Minerals education financing is largely privatized, although various Federal, State, and Local funding sources are available. Many scholarships, loans and grants are also available. Many of the colleges which supply talent to the mining industry have traditionally been land-grant institutions, which have had strong leanings towards the practical arts and sciences. These "State" schools offer lower tuition fees for students coming from within the state, and a higher fee for those from other states. In addition, the Western Undergraduate Exchange (WUE) reduces tuition for students in Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Utah and other states that wish to study in another Western U.S. college by charging a reduced tuition rate of 150% of the in-state cost.

##### 3.2.3.1 Industry Support

The University of Alaska Fairbanks (UAF) receives support from mining companies operating in the state. Kinross' Fort Knox mine regularly provides a $1 million gift to support research and graduate students, in addition to graduate bursaries. Similarly, Sumitomo's Pogo mine provides $1 million every two or three years to the same UAF Mining Research Endowment fund.

The University of Arizona receives support from the local SME chapter and alumni such as David Lowell. The Lowell Institute for Mineral Resources was established and sustained by numerous generous endowments starting in 2009, and since has delivered over 100 research projects with involvement from over 250 staff or students and over 350 industry participants. 1,300 students have enrolled on professional courses, 20,000 were reached in talks, in addition to 15 short courses and field trips. The new programmes have led to the start-up of 12 new companies. Approximately 19 mining companies also support the Institute, as well as government and university collaborators around the world. Besides the 13 department faculty, the Institute has an additional 10 staff offering graduate studies, professional development courses, field courses and also support primary-secondary outreach support.

The Colorado School of Mines is one of the top ranking engineering schools in the U.S. and receives over 40% of research awards from private industry. In 2015, donors contributed $41 million in gifts and $64 million in research awards were won, half from non-federal sources; an endowment fund of $271 million supports ongoing expenditures and infrastructure upgrades, with a goal of increasing this to $350 million. Of the 4,500 students, approximately 100 are mining engineers. Another 450 are in geosciences or metallurgy

#### *3.2.3.2 Internationalization and Scholarships*

The U.S. is the most favoured country in the world for attracting international students, whose higher fees support the provision of domestic students that are less profitable. The U.S. also has one of the highest amounts of philanthropic support, with a large provision of scholarships. Approximately three quarters of students received some form of financial assistance from the university, State or Federal government.

### *3.2.4 U.S. Government – Industry Initiatives*

Rio Tinto has supported the idea of educational partnerships in North America, following the success of the Australian MEA model (McDaniel & Moss, 2014). In 2014 they reviewed mining schools and asked a group of professors how they would spend a $1,000,000 gift. Below (***Table 20***) is the wish list provided, in no particular order.

Partnerships between universities following the Australian model have been proposed for a number of years. In 2002 it was suggested to have just two national mining schools, one East and one West, following the predicted (Daeman, 2004) demise of over half of mining schools. Ten years on however, rather than the 6 – 8 schools predicted, there are still 15 remaining.

Educating at primary and secondary levels is generally a state or local government-level responsibility. One common initiative is teaching K-12 teachers in mining states about the industry. Various state mining associations fund these programs and the Colorado 'Total Concept School of Mines' program has run for over 45 years. Each year about 30 teachers attend the 4-week course which includes field visits and industry presentations from engineers, scientists and other industry professionals; over 1,800 have completed the course (Witkowsky, 2007).

Virtual reality simulation and online education are some of the novel approaches to workforce development. The University of Missouri-Rolla began a distance course in mining engineering over ten years ago. Lectures are video-recorded and sent to students. In addition, they have been developing augmented reality training systems such as MinerSIM which helps educate underground miners on how to jackleg drill and install rock bolts safely (Nutakor et al., 2007).

In 2015 the SME began providing PhD fellowships for 4-year graduate programmes ($60k/yr) and career grants for new faculty ($100k/yr) (Gardner, 2015). SME is also active lobbying Congress to legislate investment in mining education, including the establishment of NSF grants, minerals scholarships, or re-creation of the Bureau of Mines (SME, 2014). In December 2015, the Subcommittee on Energy and Mine-

| High Cost | Low Cost |
|---|---|
| Dedicated course development (ex: Block Caving) | Student scholarships |
| General staff funding | Summer jobs for students |
| Non-tenure (Practical) professor funding | Mining case studies |
| Laboratory equipment (computers, programs, etc.) | Field trip funding |
| K-12 outreach programs | Graduate student funding (for teaching assistance) |
| Chair-endowed Professorship | Industry mentors, including executive in residence |

*Table 20: Mining education enhancements.*

ral Resources held a field hearing at the Colorado School of Mines Edgar Experimental Mine. In the classroom, 1,000 feet in the mine, testimony was given on the proposed Mining School Enhancement Act, to support new faculty vacancies at mining schools.

#### 3.2.4.1 Outreach

State and Local mining foundations or associations provide funding for all education sectors, such as the Southwest Mining Foundation or Alaska Miner's Association. At the national level, the Minerals Education Coalition (MEC), part of SME, produces primary and secondary education lessons and is supported by mining companies like Newmont, Rio Tinto, and Freeport-McMoRan.

#### 3.2.4.2 Beyond Traditional Models?

The traditional four-year accredited model has been questioned for many years in the U.S., especially following the success of the Bologna distributed education model in Australia and less successful trials in Europe. In the Mining Education Australia (MEA) system, students rotate among participating Universities, alleviating the need for each school to maintain a base of faculty expertise in each part of the required courses (Mougdil et al., 2012).

Industry participation in education is also changing, rather than only providing scholarship and professorship endowments, some companies are participating as visiting professors and running increased student internship programs (McDivitt, 2002).

#### 3.2.4.3 Distance Education and Technology

The University of Missouri S&T has been the leader in the USA of distance education, and has expanded recently into providing certificate courses and also a course in Explosives Engineering. The Masters of Mining Engineering is delivered over the internet via live video streaming, collaborative learning software included WebEx and Blackboard. The University of Mississippi and Penn State have also developed online geology programs, although they currently feed more into the energy sector.

The U.S. National Academy of Engineering has emphasized that not only technology, but the globalized "explosion of knowledge" in increasingly competitive (Asian, South American) markets will drive

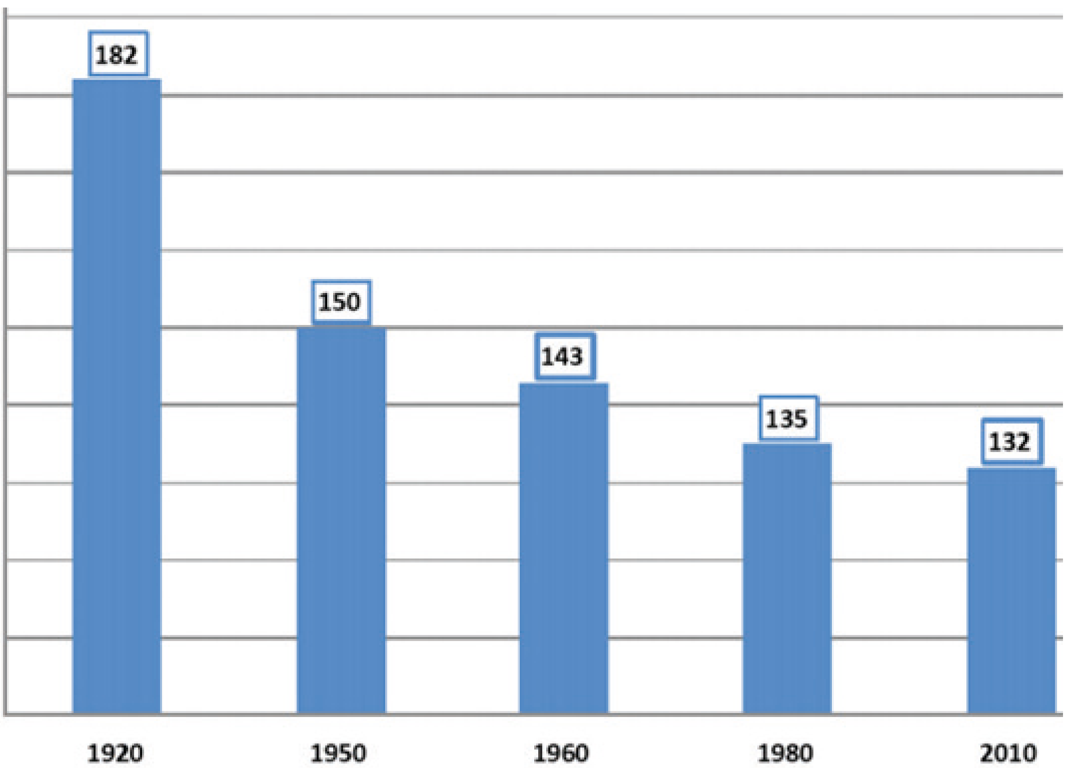



*Figure 34: University of Kentucky degree credit hours (Sevim and Honaker 2012).*

the need for interdisciplinary models, partnerships and system-based approaches to education. The Committee on Engineering Education (CEE) highlight that improving the public understanding of engineers and status of the profession would also improve the recruitment and retention rates (NAE 2005).

#### *3.2.4.4 Curriculum Development*

In a review spanning ninety years, Sevim and Honaker (2012) reviewed mining engineering education and an interesting finding was the significant decline in teaching hours provided to students (see below).

The critique of curriculum highlighted common issues affecting all minerals schools such as poor secondary training in maths and a deficiency in communication skills, and the need for generous industry involvement through scholarships, co-ops, or internships. Curriculum changes in recent decades has highlighted computer applications, management, environmental impacts, and social issues.

In addition to curriculum development, some Universities are revising the metric system to reflect career realities. In 2012, Missouri S&T began using a knowledge-experience-attribute (KEA) metric to gauge the job readiness of graduating engineers. Although broadly correlating with traditional cumulative grade point averages (GPA), the KEA metric provides a more complete picture of student capacities. The experience metric is based on the number of internships and co-ops a student completes during his/her studies, and the attribute metric is composed of six important behaviours evaluated by both academics and industry during mine design presentations: communication, human relations, hard work/ sense of duty, leadership, organization, and passion for industry (Frimpong, 2013).

#### *3.2.4.5 Adult Education*

To address the U.S. "graying workforce" (Mullard et al., 2012) and the influx of new miners and mine managers (both Native English speaking and not) the National Institute for Occupational Health and Safety has been continuously developing adult education models to improve training effectiveness (Kowalski & Vaught, 2012). The instructor-led classroom training method is the predominant method utilized by 70% of workplace education programs, yet adults don't respond well to lecturing according to the study. The method being developed at the Pittsburgh Research Laboratory is based around a system of routine and non-routine worker responsibilities. It uses an experience-based, task-centred approach for underground coal miners. This "socio-technical" systems approach was originally developing in Britain during the 1960s and since implementation in the US during the 90's the rate of fatal roof fall accidents (especially in small mines) declined dramatically (Kowalski & Vaught, 2012).

#### *3.2.4.6 Indigenous Education*

Although the U.S. has two to four times as many indigenous people as Canada, and up to ten times that of Australia, and often located in, or on state lands with significant mineral reserves (Arizona, New Mexico, Alaska, Nevada, etc.) there is generally a lack of education and training opportunities targeted at Native Americans (Harvard, 2014). Despite this lack of government programmes targeted at mining, there are numerous, well-funded educational funding available to Native Americans, who also pursue geology degrees at a higher rate than their proportion of the population (AGI oral communication, 28th January 2016). Many mining companies actively recruit from local villages and offer scholarships. Typically, mining companies critique the lack of STEM skills among tribal citizens as the impediment to increased aboriginal employment, but there are more hidden socio-cultural issues often causing difficulty, such as poor primary education, health problems, and subsistence livelihoods. In addition, especially in the Southwest US, there are legacy issues associated with environmental and social impacts resulting in many negative sentiments from Native American communities. Companies such as Teck who have invested in indigenous workforce development have had more successful, resilient mines (see

**Red Dog Mine Local Indigenous Training Success**

The Red Dog mine in Northwest Alaska is the second largest lead-zinc mine in the world. Located above the Arctic Circle in a remote, harsh environment, the mine depends on local Inupiat participation who traditionally lived a subsistence lifestyle based on hunting and fishing. More than 50% of mine employees are local Inupiat. The mine runs an annual 'School to Work' program for students in surrounding villages and provides extensive scholarships to build professional and technical competencies. In 2009, 99 students received post-secondary scholarships totalling over $120,000. On-site mine training hours (15,400 logged in 2007) are more than 10 times the industry standard. Apprenticeships in heavy-diesel mechanics, electrical work, millwrighting and power generation are offered, as well as in geological, metallurgical and environmental fields. Although only 30% of those trained are retained by the mine, without the partnership and commitment to local indigenous skills development, the mine (the most profitable in Alaska) would not be viable.

*Figure 35: Red Dog Mine, Alaska.*

above).

The University of Arizona Superfund Research Program developed mining educational modules on copper processing and impacts to benefit K-12 and non-technical audiences (Chief et. al. 2014). Although industry and other organisations have addressed the need for primary and public education in this regard, there is still a deficit in the managerial, engineering, and technical knowledge and skills among indigenous people which would allow increased access to mineral resources.

### *3.2.4.7 Centres of Excellence*

In 2011, the Colorado School of Mines established the Centre for Underground Construction and Tunnelling, offering a Master of Science degree in Underground Construction and Tunnelling since 2013. The centre received a $5 million contribution from alumni and construction company Kiewit Corp. Short courses and guest lectures are offered, and the multidisciplinary group leads many industry-focused research projects. Approximately 15 interned graduate students study on the course. The centre has three professors and five assistant professors, as well as post-doc and other research staff.

Three other centres at Colorado include the:

- Advanced Explosives Processing Research Group (AXPRO) – 9 staff and numerous other faculty, industry and government partners;
- Centre for Innovation in Earth Resources Science and Engineering (CIERSE) – established by Newmont Mining Corporation in 2009 with a $1.2 million pledge;
- Excavation Engineering and Earth Mechanics Institute – for over 30 years has been a global leader in tunnelling and excavation technology.

The University of Alaska Fairbanks (UAF) refurbished the Silver Fox mine in 2007 which is used as a field laboratory for mine surveying, rock mechanics, industrial explosives, and mine safety operations. Other laboratories include coal preparation, mineral preparation, rock mechanics, rock drilling and coring, computer and mine design, and mine ventilation, geology, geomaterials, subsurface hydrology and exploration geophysics.

The Lowell Institute for Mineral Resources at the University of Arizona employs 10 staff within 6 research areas:

- Centre for Environmentally Sustainable Mining;
- Centre for Mine Health and Safety;
- Geometallurgy;
- Global Mining Law Centre;
- Lowell Program in Economic Geology;
- Mining and Geological Engineering.

Since 1958 they have also operated the San Xavier Underground Mining Lab, with 4 levels of workings down to a depth of 250 feet. It is the only mining laboratory with a working vertical shaft, in addition to a decline and adit access. Students are required to work one 8-hour shift per week, participating in mine development, maintenance and other operational training activities. The Laboratory is also used for tradesperson training for the construction and tunnelling industry. Since 2000, over 300 miners from 7 states participated in the program.

Michigan Technological University hosts the Computational Research Centre and 'Superior', one of the most powerful supercomputers in the Great Lakes region which can be used by researchers to predict complex processes and build better geological and mining models. In addition, the Remote Sensing lab has both airborne and space-borne platforms, and is one of several labs related to minerals geoscience and engineering applications.

### 3.3 SOUTH AFRICA

Minerals education in South Africa is at a crossroads. Although South Africa produces an increasing number of mining professionals, and has excelled at teaching and research in the past, there is a growing shortage of qualified mining engineers and other key professionals.

Historically, the industry was dominated by a few mining majors who invested large amounts of time and money to develop training programmes to fast track mining professionals to high levels of competency faster than other countries. Further, the country has always ranked relatively well in the Fraser Survey's 'Availability of Labour/Skills' criteria, higher than some regions of Canada or USA.

South Africa produces the majority of mining engineers in the English-speaking world. According to the 'Landelahni Mining Survey 2010' South Africa produced 304 graduates compared with Australia's 130, Canada's 127 and the US's 35. However, in recent years, mining education and skills shortages have become major challenges facing the industry, and are likely set to grow in the future. Main industry issues include: declining commodity prices and ore grades, deeper mining depths, falling profitability, and no major exploration investment or success. One suggestion is that the current focus on revenue generation and productivity (coupled with an oversupply of qualified professionals in the 50 – 60 year age group) has contributed to a lack of training of graduate/junior engineers.

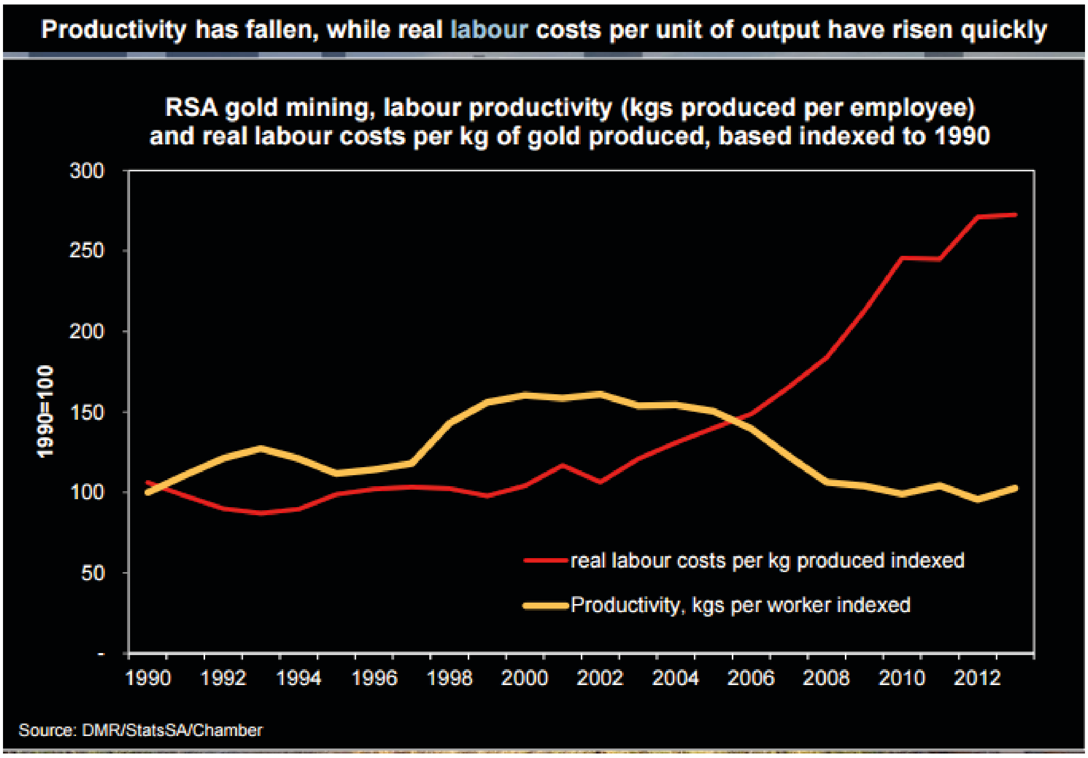



*Figure 36: South African Costs and Productivity - Labour costs increased over 175% over ten years (2002 - 2012) whilst productivity has fallen, reducing profit margins and forcing the closure and restructuring of many mines in recent years (Murray 2014).*

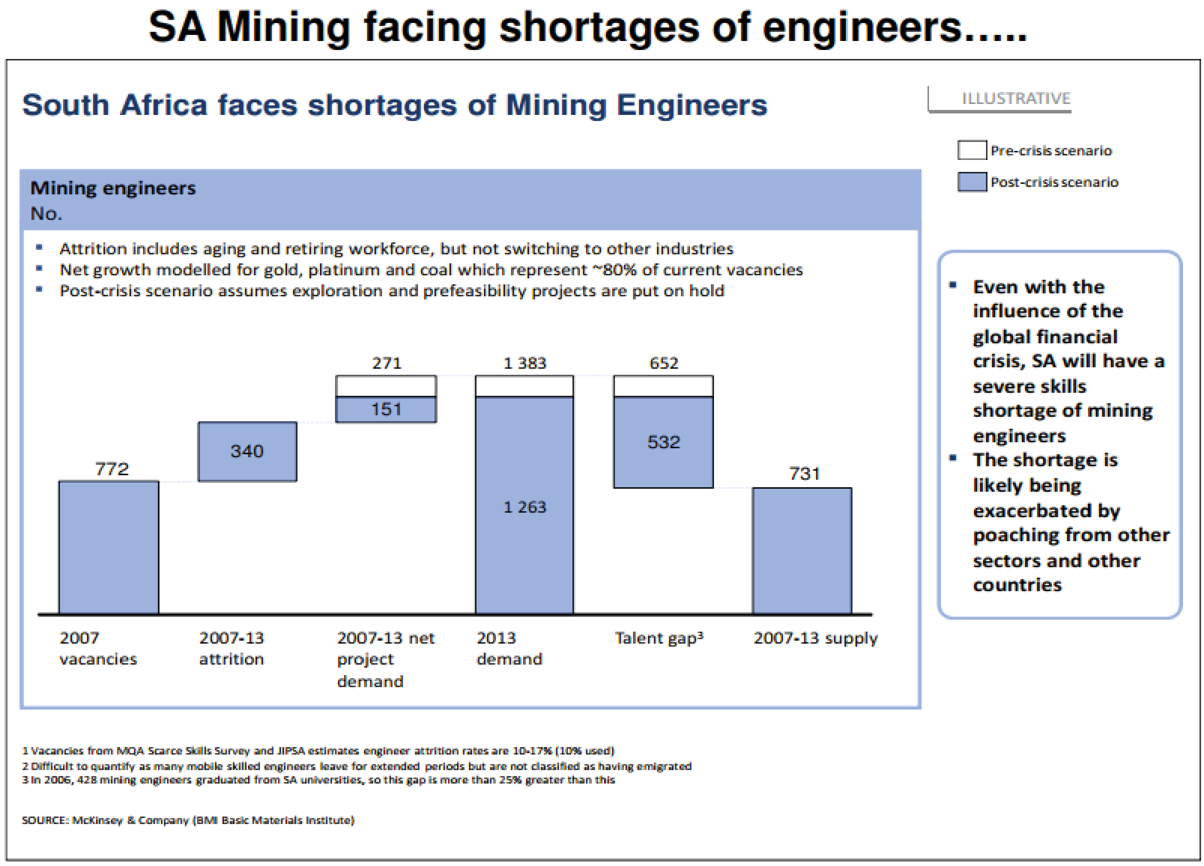



*Figure 37: Chamber of Mines presentation slide on the skills crisis given to Parliament in 2011.*

Productivity has fallen in the majority of underground metalliferous mines, in particular gold mining as shown in ***Figure 36.*** Other constraints such as geological/geotechnical conditions, ageing infrastructure, and depth of operations impedes the introduction of mechanisation in narrow reef deep level gold mines.

Economic, social, and political issues are also important contributors. In recent years, the increase in the representation of historically disadvantaged South African's (HDSA's) has been moderately successful in both employment and education. Salaries for experienced personnel have been competitive compared to Australia, Canada, and the USA; however currency fluctuations have pushed some to seek employment outside. Retention and the "brain drain" is a recurring problem (Kihn, 2012).

The mining skills "brain drain" is a major affliction – only 15% of mining graduates stay in the South African mining industry (Stacey et. al. 2009) – this is compared to 75% for US graduates and 80% in Australia, according to South Africa's former Mineral Resources Minister Susan Shabangu. According to Shabangu, more than 50% of technical graduates leave in their first 5 years of employment to other sectors of the economy; this increases to 70% within 10 years of employment (Kihn 2012). As the global mining boom took many graduates, the skills shortage crisis has been growing (***Figure 37***). CEO of Gold Fields Nick Holland commented in 2010 that South Africa was down to 500 practising mining engineers (Creamer, 2010).

In the largely migrant and multi-lingual mining workforce there is a deficit in basic literacy and numeracy. Improvements have been made in many areas, but the complexities of labour union politics, BEE (Black Economic Empowerment) policy, health issues (HIV/AIDS and respiratory conditions) and financial strain continue to hamper mineral skills development. Operation Phakisa, the latest economic stimulation package, includes task forces in mining (to prevent further retrenchments and possible collapse) and education, spearheading a digital revolution by providing information and communications technology across classrooms all around the country. The Chamber of

Mines has commented that as the skills shortage could become more acute due to retirement pressures with an ageing workforce (although evidence suggests a normal age distribution). In recent years however, the major issue contributing to lack of retention is the availability of higher wages internationally or in other industries, pulling away skilled engineers.

This chapter focuses primarily on tertiary minerals education provision. There are 25 universities in South Africa, four with a mining engineering department. However nearly all (22 of 25) provide geoscience and related degree programs that feed into the raw materials workforce. In addition, there are several routes for the trade skills to enter the labour force via diploma courses, 'artisan' (trade occupations in South Africa are referred to as 'artisan' and have the same meaning, including welders, fitters, electricians, etc. From herein both are used interchangeably) development schemes, apprenticeships and in-house training.

Skills development and mining education is an area of government policy with numerous overlapping public and private stakeholders involved (besides mining companies) including:

- Mining Qualification Authority (MQA)
- National Skills Authority (NSA)
- South African Qualification Authority (SAQA)
- Human Resources Development Council of South Africa (HRDC-SA)
- Chamber of Mines of South Africa Skills Development Unit
- Quality Council for Trades and Occupations (QTCO)
- Council for Higher Education for Universities and Universities of Technology
- Umalusi (Quality Council for Schools)
- Labour Unions:
    - National Union of Mineworkers (NUM)
    - Association of Mineworkers and Construction Union (Amcu)
    - Others: Solidary, Uasa, and NUMSA

| 2014 National Scarce Skills List | |
|---|---|
| NO | OCCUPATION |
| 1 | Electrical Engineer |
| 2 | Civil Engineer |
| 3 | Mechanical Engineer |
| 4 | Quantity Surveyor |
| 5 | Programme/Project Manager |
| 6 | Finance Manager |
| 7 | Physical/Engineering Science Technicians |
| 8 | Industrial/Production Engineers |
| 9 | Electrician |
| 10 | Chemical Engineer |
| 11 | Construction Project Manager |
| 12 | Mining Engineer |
| 13 | Accountant (General) |
| 14 | Energy Engineer |
| 15 | Materials Engineer |
| 16 | Electronics Engineer |
| 17 | Metallurgical Engineer |
| 18 | Medical/Public Health Manager |
| 19 | Telecommunications Engineer |
| 20 | Energy Engineering Technologist |

| Related Occupations | |
|---|---|
| 20-30 | Millwright, Geologist |
| 31-41 | Boiler Maker, Fitter and Turner, Carpenter and Joiner, Welder, Environmental Engineer, SHEQ Practitioner |
| 41-50 | Mechanical Engineering Technologist, Diesel Mechanic |
| 51-60 | Metal Fabricator, Industrial Machinery Mechanic, Draughtsperson |
| 61-70 | Civil Engineering Technologist, Mining Engineering Technologist, Metallurgical Engineering Technologist |
| 71-80 | Chemical Engineering Technologist, Earthmoving and Related Plant Operators |
| 81-90 | Environmental Manager, Production/Operations Manager, Health and Safety Manager |

*Table 21: List of South African National Scarce Skills 2014.*

| Major mining occupation categories (2008-2013) | Average annual growth rate | 2008 Distribution | 2013 Distribution |
|---|---|---|---|
| Elementary occupation | 8.0% | 18% | 23% |
| Plant/machine operators, assemblers | 1.0% | 31% | 26% |
| Craft and related trades workers | 3.4% | 33% | 31% |
| Service workers, shop & market sales | -2.4% | 2% | 2% |
| Clerks | 11.8% | 5% | 8% |
| Technical and associate professionals | 5.0% | 4% | 3% |
| Professionals | 6.9% | 4% | 4% |
| Legislators, senior officials & managers | -11.9% | 3% | 1% |
| Total | 3.6% | | |

*Table 22: Change in industry skills profile 2008- 2013.*

- Business Unity of South Africa
- Mining Industry Growth Development and Employment Task Team (MIGDETT)
- Technical Task Team of the President's Framework Agreement for a Sustainable Mining Industry
- National Economic Development & Labour Council (NEDLAC)
- Operation Phakisa – Employment Relations
- Ministry of Mineral Resources
- Ministry of Higher Education and Training
- Minerals Education Trust Fund

### *3.3.1 South African National Workforce Plans*

The National Scarce Skills list 2014 (published every second year by the Department of Higher Education and Training) makes clear that mining engineering (# 12 of 100) and related minerals science and engineering occupations are a strategic priority for skills development. See the top 20 of 100 scarce skills listed below, in order of highest to lower scarcity (based on vacancies, industry consultations, and government planning research):

Three employment trends have been identified: growing demand for high-skilled engineers, retrenchment of managers and intermediate-level skilled labour, and increased demand for clerks, and manual labourers such as unskilled or semi-skilled technologists. These trends are depicted in ***Table 21*** and support hypotheses of both high-skilling and de-skilling (Wildshut and Meyer 2015).

Skills training and workforce development in South Africa is directed by the Mining Qualifications Authority (MQA), which was established in 1996 under the Mine Health and Safety Act (***Figure 38***). Its mission is to provide "relevant, quality and accessible education, training and development in the mining and minerals sector" (DHET 2014 Annual Report).

MQA core functions:

- Develop and implement a sector skills plan
- Develop unit standards and qualifications for the sector
- Establish, register, administer and promote learnerships and apprenticeships
- Maintain the quality of standards, qualifications and learning provision
- Disburse grants from the Skills Development Levy (The Skills

The **Mining Qualifications Authority (MQA)** is the Sector Education and Training Authority (SETA) responsible for administering skills development programs for the mining and minerals industry in South Africa. It was established in 1996.
http://www.mqa.org.za/

*Figure 38: the Mining Qualifications Authority.*

Development Levy is 1% tax on companies' payrolls as part of the Skills Development Act to train and education employees).

The MQA directs minerals skills development and research programs, generates skills standards and learning programs, and is responsible for the quality of education and training. The MQA has grown considerably in the last ten years. A summary of their 2014/15 payments (R714 million) and funding activities, based on annual receipts of approximately (R900 million) is shown in ***Table 23***.

In 2014 the MQA published a Skills Shortage and Trend Analysis: they estimated the overall shortage of mining and minerals sector skills was approximately 1% of the total employed number (approximately 500,000), or roughly 5,300. The shortages are more pronounced in the professionals group (11%), followed by trade

| Overview | |
|---|---|
| Bursaries | R 120,400,000 |
| Work Experiences & Internships | R 222,825,000 |
| Artisan Development | R 265,505,000 |
| Non-Artisan Learnerships | R 131,523,000 |

| | |
|---|---|
| LECTURER SUPPORT<br>To increase the number of historically disadvantaged South African (HDSAs) lecturers in mining related disciplines at Higher Education & Training (HET) institutions. | 27<br>University lectureships supported |
| BURSARIES<br>To provide bursaries to undergraduates enrolled in MMS disciplines. | 535<br>Undergrad bursaries awarded |
| WORK EXPERIENCE (UNDERGRADUATES)<br>To assist undergraduates with the P1 and P2 work experience in order to attain their undergraduate qualifications. | 822<br>Undergraduates assisted with work place experience |
| WORK EXPERIENCE (GRADUATES)<br>To facilitate access to internships for graduates in MMS skills. | 699<br>Grads with work experience |
| ARTISAN DEVELOPMENT (REGISTRATION)<br>To support the registration of learners on artisan programmes. | 2482<br>Artisan learners registered |
| ARTISAN DEVELOPMENT (COMPLETION)<br>To support learners to successfully complete artisan programmes. | 1703<br>Artisans completed programme |
| ARTISAN AIDE DEVELOPMENT<br>To provide training that will enable currently employed artisan aides/assistants to access qualifications to become fully qualified artisans. | 335<br>Artisan aides qualified |
| SKILLS DEVELOPMENT FACILITATORS<br>To build the capacity of skills development facilitators and skills development committee members in order for them to better understand the MMS skills development environment | 1383<br>Trained facilitators and HR staff |
| MATHS AND SCIENCE<br>To support grades 10, 11 and 12 learners to improve their maths and science grades. | 1037<br>Young learners supported |
| ADULT EDUCATION AND TRAINING<br>To support learners to complete AET programmes to progressively increase levels of literacy in the sector. | 2151<br>Adult programme completions |
| OCCUPATIONAL HEALTH AND SAFETY<br>To support MMS employees to complete training in Occupational<br>Health and Safety (OHS) Representatives programmes. | 10449<br>Employees trained |

| | |
|---|---|
| FOUNDATIONAL LEARNING COMPETENCY TRAINING<br>To support learners to complete the Foundational Learning Competency<br>(FLC) programme to progressively increase levels of literacy in the sector | 257<br>Completed literacy programme |
| TVET SUPPORT (LECTURSHIPS)<br>To support Technical, Vocational Education and Training (TVET) College lecturers to be responsive to sector skills needs and priorities. | 20<br>TVET lecturers exposed |
| TVET SUPPORT (GRADUATES)<br>To Support TVET College learners to be responsive to sector skills needs and priorities. | 89<br>TVET graduates placed |
| DIAMOND AND JEWELLERY MANUFACTURING<br>To facilitate and support skills development activities for diamond and jewellery manufacturing. | 252<br>Learners funded |
| LEARNERSHIPS<br>To develop learners with disabilities in core learnerships for the MMS. | 3264<br>Learners supported |

*Table 23: MQA funding and support activities 2014/5.*

workers (3%) and technicians (2%).

Per occupation, the shortages are for: mining engineers (11%), electrical engineers (15%), metallurgical engineers (12%) and mechanical engineers (6%). Other points noted in MQA's Workplace Skills Plans and Annual Training Report for 2014:

- Employment per subsector is PGMs (platinum group metals) 32%, gold 24%, coal 11%, diamond 2%, other mining 19%, services 6%, and CLAS (cement, lime, aggregates and sand) 2%
- Females represent 12% of the workforce, up from 4.3% in 2002
- There is a normal age distribution and no ageing workforce
- 20% of workers have an educational qualification below National Qualifications Framework Level 1 (basic literacy). In 2004 this was reported as 61% and in 2011 as 30%. Those with NQF Level 4 has increased from 14% to 30%.
- The percentage of employees who received training in 2013/14 was 64%.
- The number of artisans (tradespersons) who qualified in 2013 was 1,827.

#### *3.3.1.1 Gender*

The Mining Charter declares that women should make up 10% of mining company workforces, however it does not specify how women are to be deployed on mine sites. Globally, women make up 11.5% of the senior management and executive roles in the industry (Women in Mining-UK and PricewaterhouseCoopers report) but inflexible arrangements and tough workplace environments are barriers in many of the labourer, operator and trade positions (Vella 2014).

#### *3.3.1.2 Empowerment Charter*

Profound regulatory changes in recent decades have affected education and labour by emphasizing black economic empowerment (BEE), local value addition, and skills development. The 2004 Broad Based Socio-Economic Empowerment Charter for the South African Mining Industry (Mining Charter) and Mineral and Petroleum Resources Development Act (MPRDA) has transformed socioeconomic empowerment in order to redress historic practices that suppressed, blocked and destroyed skills development. The most important of these was a tripling of scholarship provision from 1200 to 5000 by 2005 and the 1% levy based on annual payroll for skills development. Other important features and a scorecard assessment by the Chamber of Mines are summarized in ***Figure 39***.

Until 1981, mining engineering graduates from South African universities

**Mining Charter Key Elements & Scorecard**

- This includes Section 100 (2) MPRDA Provisions and related legislation (Employment Equity Act 1998, Skills Development Act 1998, Preferential Procurement Framework Act 2000). Assessment from PWC/COM 2015

| ELEMENT | DESCRIPTION | 2014 COMPLIANCE TARGET | CHAMBER OF MINES ASSESSMENT |
|---|---|---|---|
| OWNERSHIP | Minimum target for effective HDSA ownership | 26% | 38% overall<br>100% companies achieving target |
| HOUSING & LIVING CONDITIONS | Upgrade/convert hostels to 1 person per room occupancy rate<br>Convert/upgrade hostels into family units | Percentage Reduction into Single Room Occupancies<br>Percentage Conversion of Family Units | 73% compliant<br>63% compliant |
| ENTERPRISE & SUPPLIER DEVELOPMENT | BEE Procurement spend and multinational suppliers contribution to the Social Fund | 40% capital from BEE, 70% services, 50% consumables<br>0.5% Procurement to Fund | Compliance: Capital (72%), Services (63%), Consumables (72%)<br>20% compliant |
| EMPLOYMENT EQUITY | Diversify workplace to reflect South African demographics and identify/fast track talent pool | 40% HDSA Participation<br>10% Female Participation | 41% total HDSA<br>17% total Female |
| HUMAN RESOURCES DEVELOPMENT | Pay levy as percentage of total annual payroll, offer basic literacy/numeracy, develop career paths/development plans and mentor empowerment groups | 5% | 5.5% HRD expenditure |
| MINE COMMUNITY & RURAL DEVELOPMENT | Conduct collaborative ethnographic community consultation to delineate needs and implement projects | Up-to-date reports | 71% compliant |
| SUSTAINABLE DEVELOPMENT & GROWTH | Implement Environmental Management Plans (EMP), improve health and safety, and utilize South African sample analysis facilities | 100% EMP, H&S planning<br>100% Local Lab Utilisation | 91% EMP compliant<br>86% H&S compliant<br>85% Lab compliant |

*Figure 39: Mining Charter Scorecard (Chamber of Mines, 2015; PWC, 2015).*

were exclusively white males. The first black mining engineer ('black' includes African, Coloured, Indian) to graduate was an Indian man who graduated from the University of the Witwatersrand. The first female mining engineer graduated in 1994 (Cruise, 2011, cited by Van der Merwe, 2011). Since then there has been a profound change. In 2010, the proportion of Black graduates at Witwatersrand and Pretoria universities was 100% and 70%, respectively; while females represented 30% of the combined total of the two universities (Van der Merwe, 2011)."

In addition to the Mining Charter, companies are required to maintain Social and Labour Plans which address human resource development, local economic development, and processes to manage downscaling and retrenchment. Part of the skills requirement include employment development plans, career pathways, mentorships, internships and bursaries, and employment equity. In practice, companies have invested in ABET (adult basic education training) certificate courses for numeracy and literacy, short course provision (e.g. mineral processing, health and safety, front end loader training), portable skills training (e.g. computer IT, first aid, hand tool, welding, rigging) and learnerships / internships (e.g. fitters, boilermakers, electrical/mining engineer).

### 3.3.2 South African Educational Provision

#### 3.3.2.1 Primary and Secondary Education

The quality of general education is a concern for the minerals industry. Primary and secondary education standards have been deteriorating in South Africa. The World Economic Forum's 2015-16 Competitiveness report ranks South African education quality as 120th of 140 countries; for math and science education it was ranked 140th of 140 (WEF 2015).

According to the 2014 White Paper on Post School Education (Department of Higher Education 2014) skills development provision is not meeting demand and is still not sufficiently diverse. Education quality is low, with high repetition and high dropout rates. The low standard has been identified as one of six threats to the sustainability of South African minerals by a former head of the University of Witwatersrand mining engineering department (Cawood 2011). One third of students do not proceed past primary school. Poor statistics are confirmed in several global reports such as the Global Competitiveness Index, World Development Indicators and Human Development Report. According to Cawood, "The whole education system needs an overhaul. Too many learners drop out, and the quality of education is too low."

#### 3.3.2.2 Further Education

According to the Department of Education, there are weak linkages between educational institutions and workplaces with insufficient employer involvement in training and weak data systems. Under new education investment proposals, headcount enrolments are planned to expand (***Table 24***).

Technical and Vocational Education and Training (TVET) Colleges are relied upon to provide young apprentices to the industry, but the quality and pass rate has fallen over the last decade (Baxter 2015). The mining industry however, has become active within College Councils and is providing lecturer development in recent years. Adult Basic Education and Training (ABET) whose historic performance is not well received, is now being taken up within the TVET Colleges in order to provide basic literacy and numeracy skills.

| | 2014 | In 2030 |
|---|---|---|
| Public Universities | 940,000 | 1,600,000 |
| TVET Colleges | 650,000 | 2,500,000 |
| Community Colleges | 265,000 | 1,000,000 |
| Private Institutions | Unknown | 500,000 |

*Table 24: Projected increase in educational enrolment.*

| Certificates issued 2010 – 2014 | # | % | Certificates issued 2010 – 2014 | # | % |
|---|---|---|---|---|---|
| Advanced Mine Surveying | 305 | 6% | Mine Environmental Control | 143 | 3% |
| Advanced Mine Valuation | 372 | 7% | Radiation Protection Monitoring Screening | 745 | 15% |
| Advanced Rock Engineering | 22 | <1% | Rock Mechanics | 98 | 2% |
| Basic Mine Sampling | 765 | 15% | Strata Control | 343 | 7% |
| Basic Mine Surveying | 725 | 15% | Intermediate Mine Environmental Control | 236 | 5% |
| Elementary Mine Sampling | 453 | 9% | Mine Survey Draughting | 149 | 3% |
| Elementary Mine Surveying | 623 | 13% | Practical Mine/Environmental Control | 3 | <1% |
| Total: 4982 | | | | | |

*Table 25: Chamber of Mines Certification 2010-14.*

The Chamber of Mines administers certificate examinations in fourteen mining skill areas. Each year about 1,000 certificates are issued, summarized in ***Table 25*** (Baxter 2015).

As the skills and training authority, the MQA also provides numerous Certificates of Competency for mine managers, surveyors, ventilation technicians, engineers, overseers and rock engineers. They have been criticised in recent years for low pass rates that ranged between 10 – 16% in 2013; this improved to 30% in 2011. The reasons for low pass rates identified were "poorly prepared candidates, lack of suitable or any learning materials, ill-defined or no syllabus, quality of training courses, lack of suitable mentors and support from managers" (Baxter 2015).

Other companies and organization provide skills training such as Xtract who is accredited with the MQA and provides short courses, workshops/seminars, operator training and assessment/coaching mainly to the quarrying and aggregates sector.

#### *3.3.2.3 Tertiary Education*

South Africa has 25 Universities. Of these, 11 are 'traditional Universities' such as the University of Witwatersrand and the University of Pretoria. Traditional universities' are those that offer a theoretically-oriented university degree and have often long established histories; universities of technology, or "technikons", offer vocational oriented diplomas and degrees; whilst "comprehensive universities" offer a combination of both types of qualifications. There are eight former 'Universities of Technology', or 'technikons'. Some of the former traditional Universities merged with technikons to become 'comprehensives' such as the University of Johannesburg and the University of South Africa. Fees range from R 25,000 to R 50,000, although these are not directly comparable globally and should be normalised to the cost of living (Grant 2015).

A mining engineering academic qualification is obtained via a minimum 4-year full-time university or university of technology (previously Technikon) course, leading to various degree awards and diplomas outlined below. Non-traditional routes via accredited training centres and workplace skills development programs also exist at mining companies and Technical and Vocational Education and Training (TVET) Colleges.

Historically, the development of mineral resources had a profound effect in establishing higher education in South Africa. Although the universities in Cape Town and Stellenbosch were established decades earlier, the mining rush in Kimberley in 1866 prompted the establishment of a vocation-based School of Mines. This was to provide high level manpower to the diamond industry. Later, discovery of gold in Witwatersrand helped establish the three central institutions in the Gauteng area: the University of Witwatersrand, the University of Pretoria, and the University of Johannesburg (Knottenbelt 2007).

There are four major higher education universities in South Africa preparing mining professionals:

- University of Witwatersrand, School of Mining Engineering (aka Wits)
- University of Pretoria, Department of Mining Engineering (aka Tuks)
- University of Johannesburg (Technikon), School of Mining, Metallurgy & Chemical Engineering (UJ)
- University of South Africa, Department of Mining Engineering (UNISA)

Wits, Tuks and UJ are contact institutions whereas UNISA is a distance learning university. The University of Venda plans to offer mining engineering in 2017.

The system of National Diplomas and BTechs is undergoing revision currently, and a new National Quality Framework will soon better distinguish between education levels.

As described in the South African Mine Health and Safety Act, to be qualified as a mine manager one must hold a permanent blasting certificate, have a minimum two years working experience and pass a written examination. There are four types of qualifications in South Africa that are recognized:

- Bachelor of Engineering – issued by the University of Pretoria;
- Bachelor of Science in Engineering– issued by the University of Witwatersrand;

- Bachelor of Technology – issued by the University of Johannesburg
- National Diploma – issued by the University of South Africa and University of Johannesburg.

In addition to the National Diploma, a minimum of five years mining experience is required.

Accreditation for formal mining engineering qualifications is the responsibility of the Engineering Council of South Africa (ECSA). Their Certificated Engineers Accreditation Committee (CERTAC) advises the Commissioner of Examiners for the Government Certificate of Competency (GCC). A mining engineering exam can then be taken to attain a Certificates of Competency (CoC).

In addition to the mining schools, there are approximately 22 institutions providing geoscience, geology, earth science and related tuition. Besides the four mining schools, other universities of relevance providing geoscience professionals, related engineering or metallurgy programs, and regarded by the South African Institute of Mining and Metallurgy (SAIMM) include:

- Central University of Technology
- Durban Institute of Technology
- North West University
- Stellenbosch University
- University of Cape Town
- University of Limpopo
- University of Western Cape
- Walter Sisulu University
- Nelson Mandela Metro University
- Rhodes University
- Tshwane University of Technology
- University of Fort Hare
- University of KwaZulu-Natal
- University of the Free State
- Vaal University of Technology
- University of Venda

#### *3.3.2.4 Tertiary Education Data*

The number of completing, graduating students in undergraduate mining engineering programs is shown in ***Figure 40*** based on data gathered from University reports, SOMP (Society of Mining Professors) surveys, and published literature.

In 2014 a total of 190 students graduated in mining engineering, up from 61 ten years previously, but slightly below the peak in 2010 of 228 graduates. The Universities of Witwatersrand and Johannesburg have seen the greatest growth in recent years. This data shows undergraduates only; similar growth trends have been experienced in postgraduate courses, heavily supported by industry sponsorships. For example, the MSc mining engineering course at Witwatersrand has grown from 42 students in 2012 to 176 in 2015 (Wits, 2015).

The University of Witwatersrand (Wits) is the largest mining engineering school and combined has a student population of 844 in 2015, almost double the size ten years ago, due to the growth in undergraduate numbers (***Figure 41***). The number of postgraduates has declined over the last

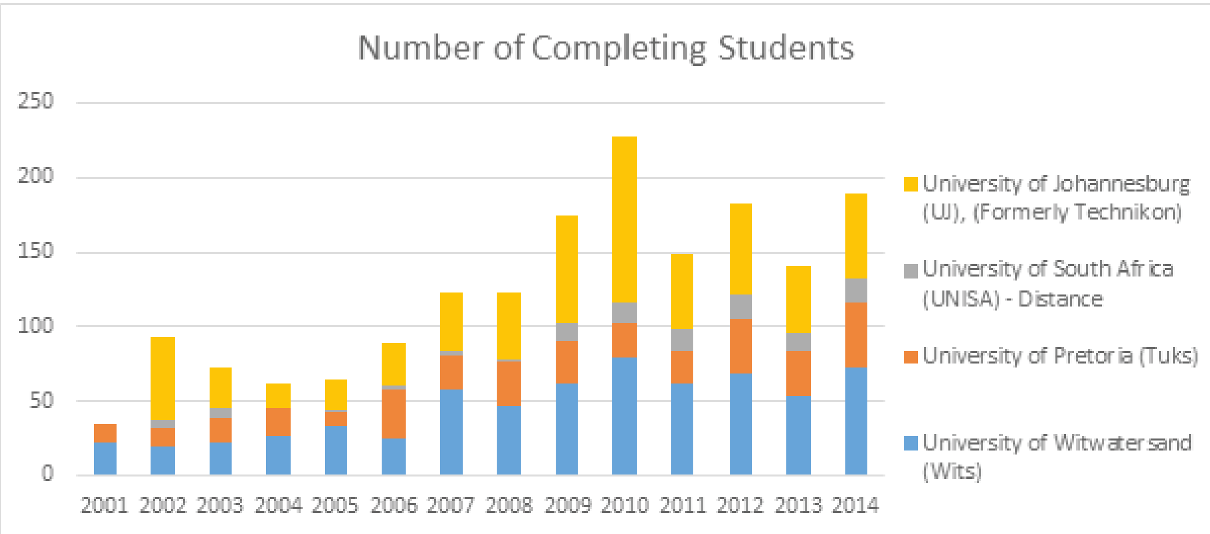



*Figure 40: Number of Completing Mining Engineering Students in South Africa.*

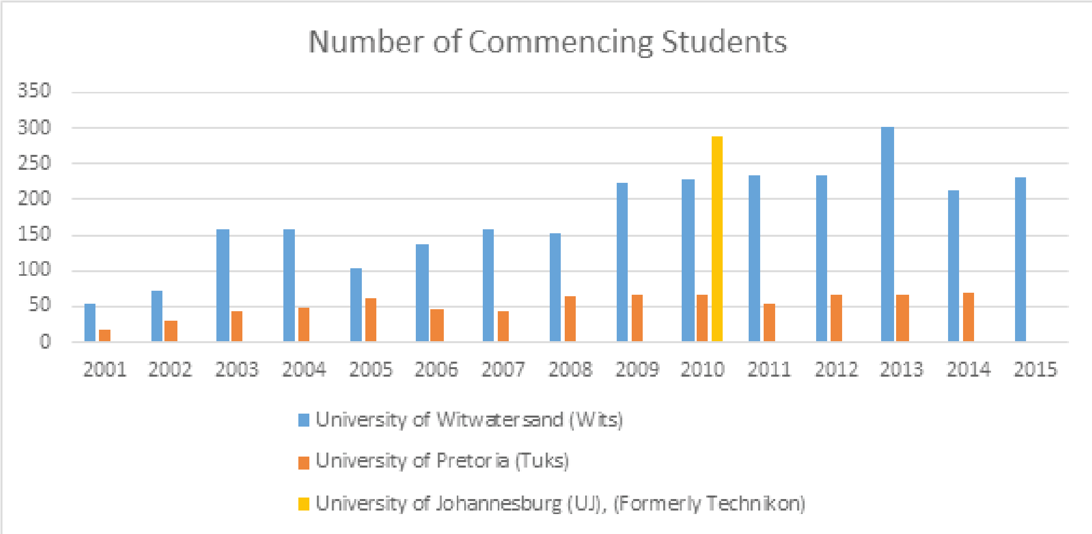



*Figure 41: Number of Commencing Mining Engineering Students in South Africa (data not available for UJ in missing years).*

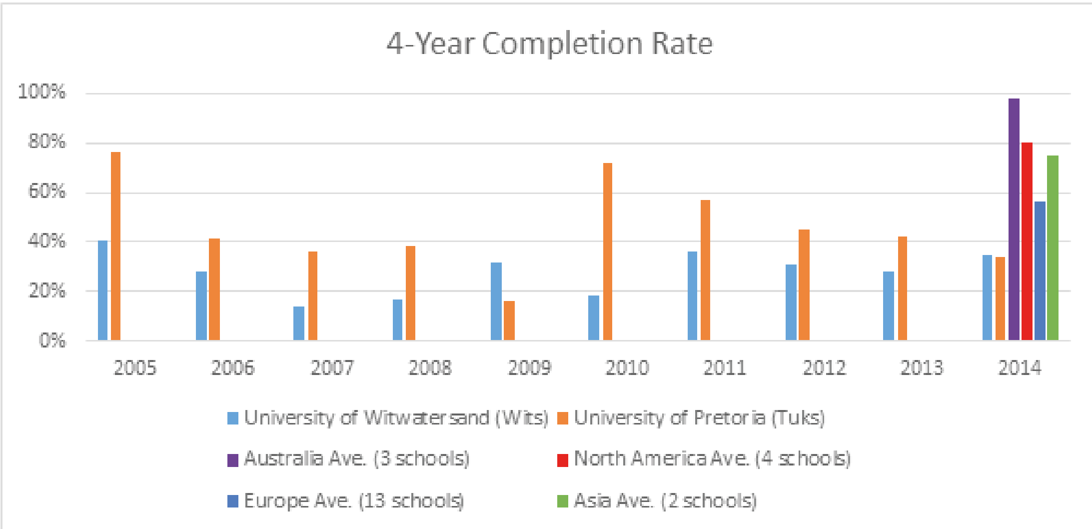



*Figure 42: Four-Year Mining Engineering Completion Rate in South Africa (global comparison data only available for 2014).*

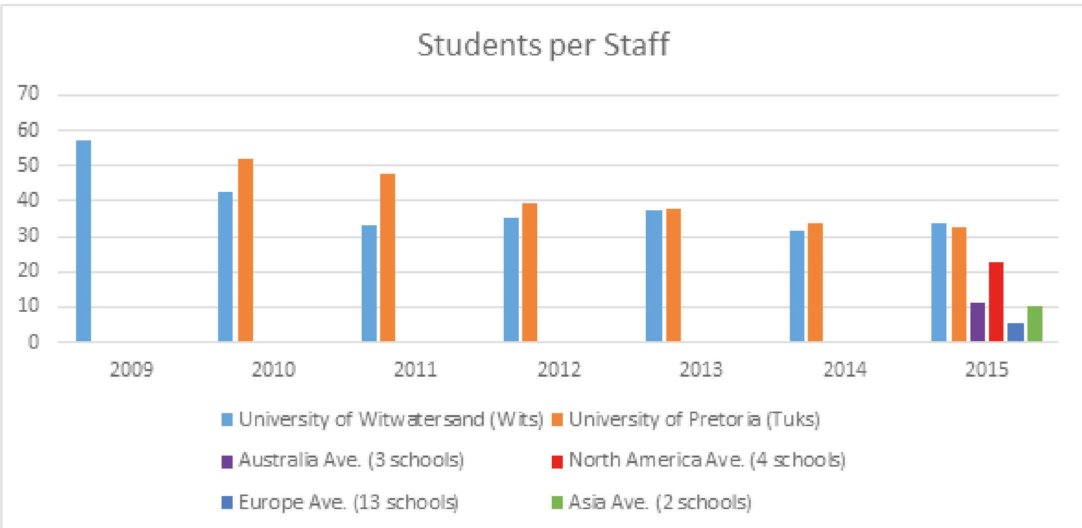



*Figure 43: Number of Mining Engineering Students per academic/teaching Staff Member.*

15 years, but in 2014 enrolment onto new MSc Mining Engineering courses grew rapidly, up to 176 students in 2015.

Completion rates at South African institutions is below the global average of 77% over four years, averaging 34% in 2014 (only a limited number of schools are reported, so this average may not be accurate, and only represents reporting schools) (***Figure 42***). This average has fallen over the last five years. The completion rate for the two South African universities is based on the percentage of students in each year completing and progressing to the next, although full details on re-takes, transfers and dropouts are not considered. Other data is taken from the SOMP 2015 survey.

The number of students per staff member has been falling, but is still far above the global average of 12 (***Figure 43***). A major reason is staffing problems in South Africa (***Table 26 and Figure 44***).

The data in these graphs in ***Figure 44*** are from the year 2015; however that from Pretoria is from 2013-2014 and might be somewhat misleading as the situation changed in 2014. It should be noted that

| Institution | Education Staff |
|---|---|
| University of Witwatersand (Wits) | 25 |
| University of Pretoria (Tuks) | 16 |
| University of Johannesburg (UJ) | 6 + 18 Part-Time Industry |
| University of South Africa (UNISA) | 8 |

*Table 26: Number of Educational staff in each University (2015).*

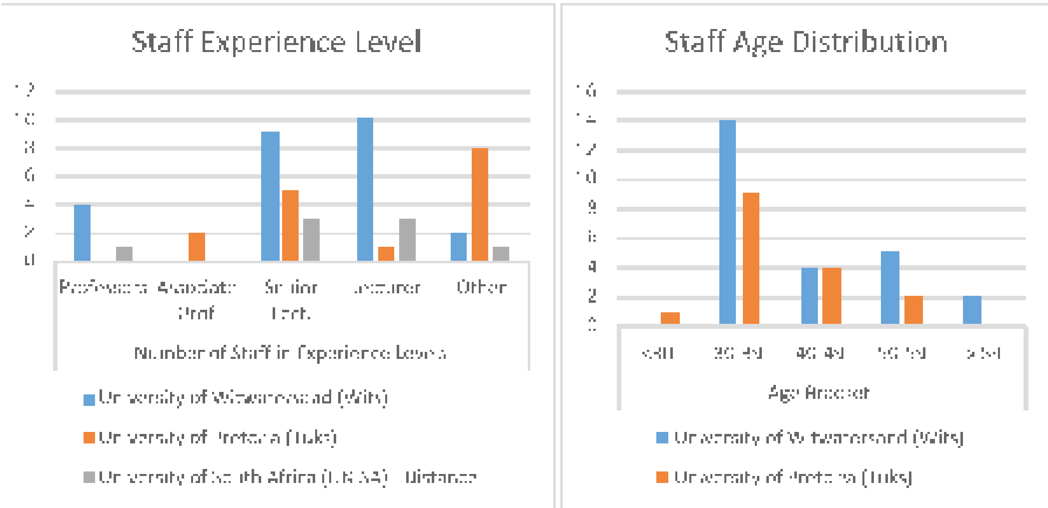



*Figure 44: Mining Engineering Staff Experience Levels and Age Distribution in South Africa (2015).*

| Academic Staff | | Support Staff | | Projects/Postgrad/Chairsummary | |
|---|---|---|---|---|---|
| 1 | Associate Professor | 8 | FT PhD Students | 3 | Extra ordinary Professors |
| 5 | Senior Lecturers | 1 | Education Councillor | 1 | Honorary Professor |
| 1 | Junior Lecturer | 1 | PhD Admin | 2 | PhD Contracted Lecturers |
| 1 | Sasol Chair (Ass. Prof.) | 1 | Personal Assistant | 1 | FT PhD Student |
| 1 | Harmony Chair | 1 | English Instructor | 10 | Contracted Industry Risk Lecturers |
| 1 | | | | 1 | Kumba VR Centre Manager |
| MRRI Project Manager | | | | | |

*Table 27: Mining Engineering Staff profile at University of Pretoria.*

as of June 2014, the University of Pretoria staff show an increase of 53% to their mining staff aged below 30 years old as a result of new recruitment. A summary of Pretoria staff is shown in ***Table 27*** (Pretoria SOMP 2014).

There has also been recruitment success at the University of Witwatersrand in recent years, supported mainly by mining companies and the MQA. This has transformed the age, gender, and racial demographic profile significantly. Still, there is a shortage of qualified, experienced staff. Poaching is the most often cited cause, as remuneration is more attractive in Australia, the United States, Canada or Europe.

The number of female students commencing and completing degrees in mining engineering in South Africa (***Figure 45 & 46***) is high compared to the global average of 11% and 14% respectively. In this aspect, South Africa leads the world in gender parity, although the percentage of women working at mining schools (14% of staff are female) is slightly below the global average of 18%.

The percentage of black students has also changed dramatically in the past fifteen years, becoming more reflective of the demographics of South Africa (***Figure 47***). Data was unavailable at Wits for 2000-2008 but it would show a similar black enrolment trend as Tuks.

Tertiary mining education is conducted in English at these universities, however

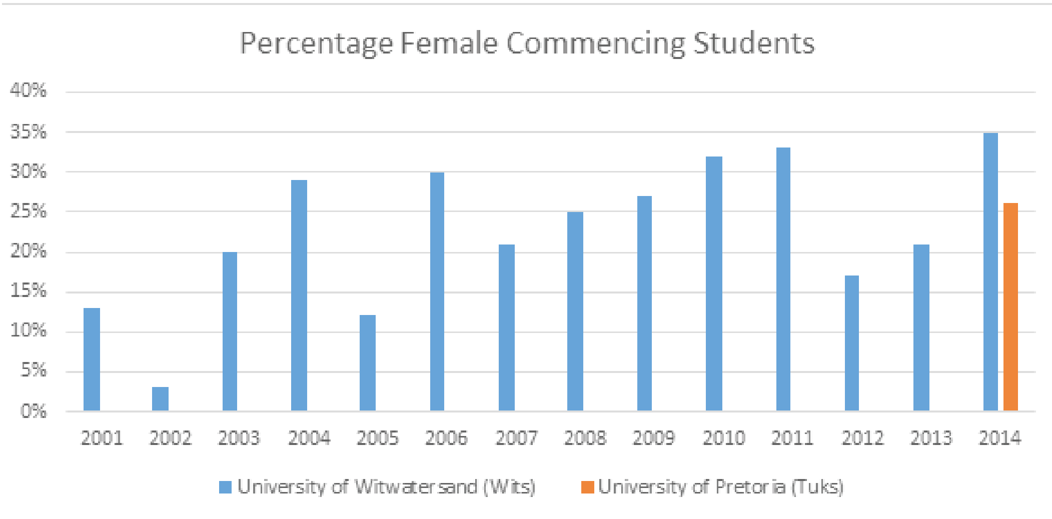



*Figure 45: Percentage Female Mining Engineering Commencing Students in South Africa (no data available for UJ).*

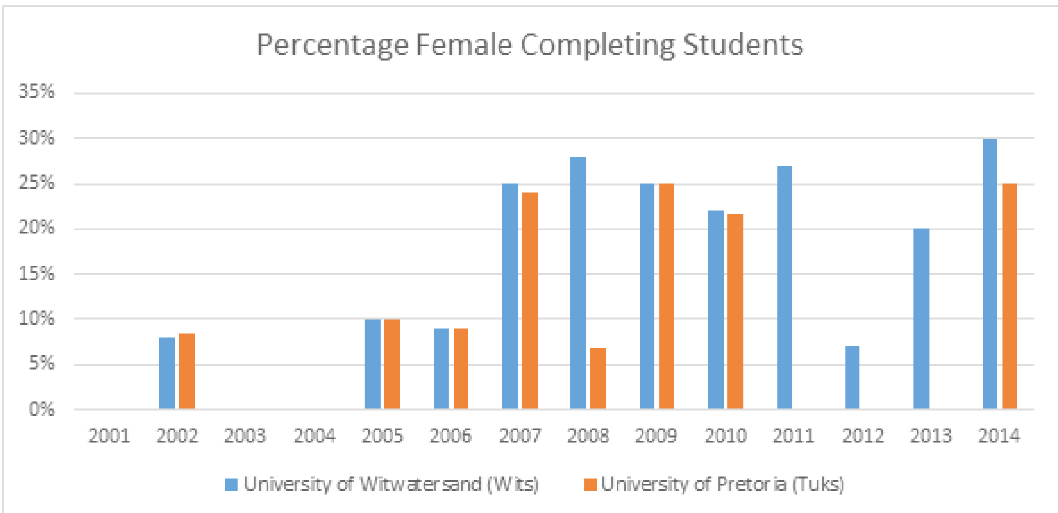



*Figure 46: Percentage Female Mining Engineering Completing Students in South Africa (years with no data represent 0% female completing students).*

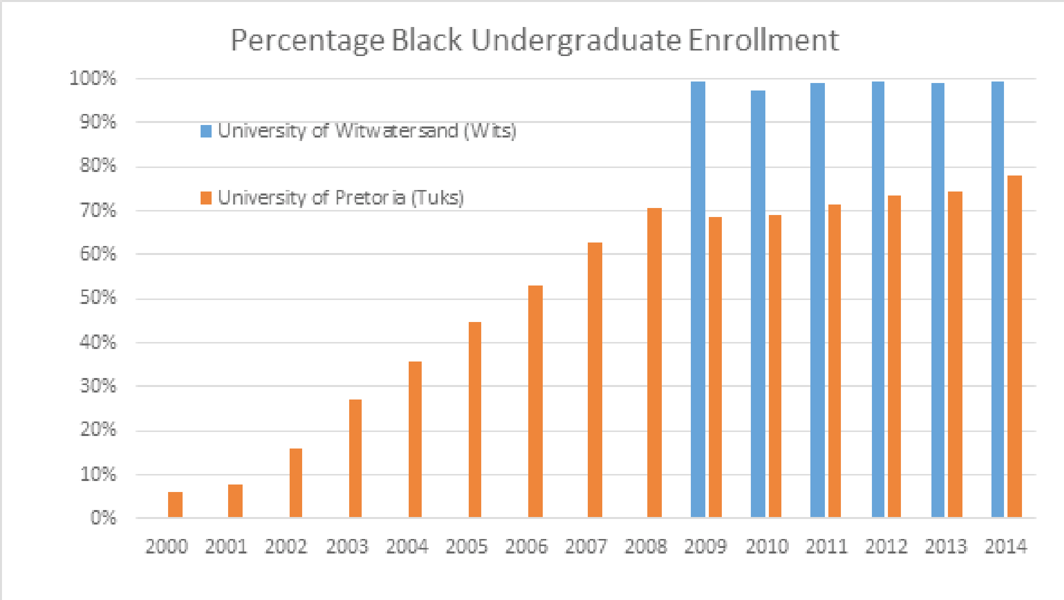



*Figure 47: Percentage Black Mining Engineering Undergraduate Enrolment.*

one problem is English proficiency, as the first language of most students is not English. From Pretoria, the distribution in 2014 was 19% Afrikaans, 17% Sepedi, 12% Isizulu, 10% Setswana, 8% Sesotho, 7% Tshivenda, and others 20%. Only 7% of students spoke English as their first language.

While there is good tertiary mining engineering teaching provision, there is an inadequate research provision. During the 1970s and 80s it is estimated that some 600 full-time researchers were employed, which together with universities and companies probably rose to 800 in total. In 2009, the figure was less than 80 (SAIMM 2014).

### 3.3.3 South African Training and Education Financing

#### 3.3.3.1 Bursaries, Learnerships and Scholarships

Bursaries and scholarships are an important source of education financing for the minerals industry, mainly provided by the Chamber of Mining company members. Over the past 10 years, Chamber members have annually supported approximately 10,000 students through bursaries at tertiary institutions. This focus on opportunities for youth means that one third of mining professionals today are below the age of 35, with similar figures for clerical, support, and artisan workers (Chamber Mines Media Release Oct. 2015).

The Department of Higher Education and Training produces an annual list of funding avenues for higher education, including bursaries, scholarships and study loan providers. Besides the National Student Financial Aid Scheme (NSFAS), industry bursaries are provided by: Afrisam, Anglo-Kumba Iron Ore, Anglo-Platinum, Anglo-Thermal Coal, Barloworld, CareerWise, Exxaro, Foskor, Harmony, Impala Platinum, MQA, and Murray & Roberts.

The annual nvesting in African Mining Indaba also provides bursaries – in 2015 four were provided at a cost of R350, 000 for students at Witwatersrand and Johannesburg. In 2009, of the 328 postgraduate students at Wits, 290 - 88% - were sponsored by industry employers. (Stacey et al. 2009).

The Department of Mineral Resources provides 2 – 5 bursaries each year to develop trained mine inspectors and provides extensive in-house training, with dozens enrolled onto Wits short courses in various technical fields, predominantly around health and safety.

Another important driver of talent development is the Technology and Human Resources for Industry Programme (THRIP), which supports an average of 235 projects each year. Financed by the Department of Trade and Industry, and the National Research Foundation, THRIP is a public-private partnership that supports student development for industry-driven/co-sponsored projects. Government funding totals around R 150 million per year, which is matched by approximately R 240 million from industry.

#### 3.3.3.2 MQA

As previously stated, MQA provides approximately R 700 million per year. For example, in 2014, Wits received R20 million for lectureships and hundreds of student bursaries (Mining Magazine 2014 April).

The MQA provides education support in many ways from skilled artisans and basic adult education to undergraduate work placements, bursaries and university lectureships. One example, which has evolved over the years is the Graduate Development Programme (GDP). The GDP was established in 2004 to increase the number of technical graduates and provided a structured two – year industry workplace experience to unemployed HDSA graduates. An amount of R165, 000 per candidate per year was provided to cover training and allowances and approximately 115 candidates per year were supported. Over the years, the MQA has funded hundreds of university students each year in the form of bursaries, and thousands of learnerships annually to upskill artisans.

#### 3.3.3.3 Industry

According to the Chamber of Mines, during 2014 a total of R5 billion was invested in skills development and education projects by member companies.

The Minerals Education Trust Fund (METF) is a voluntary industry initiative established in 1999. Since then, its 29 members have pooled over R295 million. Each year approximately R35 million is distributed to 9 universities as support for academic staff salaries in the disciplines of Mining, Metallurgy/Chemical Engineering and Geology. Funded institutions include:

- University of the Witwatersrand
    - School of Mining Engineering
    - School of Chemical and Metallurgical Engineering
    - School of Geosciences
- University of Pretoria
    - Department of Geology
    - Department of Mining Engineering
    - Department of Materials Science and Metallurgical Engineering
- University of Johannesburg
    - Department of Geological Sciences
    - Department of Extractive Metallurgy
    - Department of Mining Engineering
- UNISA, University of South Africa
    - Department of Electrical and Mining Engineering
- University of Stellenbosch
    - Department of Process Engineering
    - Department of Earth Sciences
    - University of Cape Town
    - Department of Geological Sciences
    - Department of Chemical Engineering
- University of KwaZulu Natal
    - School of Geological Sciences
    - University of the Free State
    - Department of Geology
    - North West University
    - School of Chemical and Minerals Engineering

### 3.3.4 South African Government – Industry Initiatives

#### 3.3.4.1 Improved Standards

The Chamber of Mines learning material project has been developing learning and assessment guides for MQA accredited training providers. As of 2015, material for 1,710 unit standards has been created, and are now being developed into practical modules for occupational qualifications through the QCTO in fields such as: mines rescue service workers, strata control, ventilation, sampling and surveying.

#### 3.3.4.2 Health & Safety

Mine health and safety is a major focus area of education, as historically South Africa has struggled with high fatality rates. Two recent initiatives of the South African Mining industry to work towards the 'zero harm' goal include a Chamber of Mines MOSH (Mining Industry Occupational Safety and Health) Learning Hub (http://www.mosh.co.za/) and the Mine

Health and Safety Council Centre of Excellence (CoE) (http://mhsc.org.za/). The learning hub fund pilot projects demonstrating best practice in dust, noise, ground control, and transport/machinery safety and provide practical teaching and learning activities. The CoE is researching new technology and new ways of training people to transform and strengthen a risk averse culture (Mining Magazine December 2014). CoE partners included the University of Pretoria and Wits University, CSIR, National Institute of Occupational Health and other stakeholders. Completed projects in 2014 included rock mass assessment toolkit development, dust monitoring and suppression automated systems, diesel particulate matter measurement and control, and a missing person locator system.

Also, the Mine Health and Safety Council in Mines, a tripartite board represented by State, Employer and Labour members under the Chief Inspector of Mines, is active in many multi-stakeholder research programmes in topics such as: behaviour safety, occupational disease, and rock bursts. The Council arranges a summit every two years to review occupational health and safety and works with the MQA and other organizations towards "zero harm".

#### *3.3.4.3 Professional Networks and Conferences*

The Southern African Institute of Mining and Metallurgy has a membership of approximately 5,000 and is the mining technical services professional organization. SAIMM publishes an academic journal and is very active in all education matters. There are branches in 5 South African provinces and regional branches in bordering and nearby countries. In addition to the journal, SAIMM organises symposia and facilitates short courses.

The Association of Mine Managers South Africa (AMMSA) is active in knowledge sharing and collaboration. The AMMSA is the professional organization of mine managers and organises quarterly meetings, an annual general meeting, technical visits and general networking for students and industry staff. The AMMSA also supports universities and other outreach activities.

Other industry bodies and relevant organizations can be found at the "Industry Links" page of the Chamber of Mines website (http://www.chamberofmines.org.za/sa-mining/industry-links).

#### *3.3.4.4 New Programme with International Funding*

The demand for mining graduates has prompted the University of Venda (UNIVEN) to develop a mining engineering programme with support from China, De Beers, and ECSA. In 2012 UNIVEN signed a MOU with the China University of Mining and Technology together with China Coal Technology and Engineering Group to develop teaching programmes. Two bursaries for staff members have been offered to complete a doctorate in China, along with two Masters' degrees (UNIVEN annual report 2012). Bursaries supporting staff and students come from the Department of Mineral Resources, Mining Qualifications Authority and Botswana Consulate General. The mining engineering programme will be delivered starting 2017 (Limpopo News 2014).

#### *3.3.4.5 Direct Industry Funding*

In 2010 Gold Fields invested R 26 million at the Wits University over three years for a 101-seat mine design laboratory and other infrastructure as well as salaries for full-time senior tutors. This is in addition to its' R165 million spend during the previous year across South Africa, including its Gold Fields Academy, on-mine training as well as university bursaries (124), technical learnerships (378) and post-graduate assignments (40) (GF 2010 press release).

The University of Pretoria has invested R 50 million recently in new offices, lecture theatre, student study centre, and mine design lab. The mining engineering department receives major contributions from mining companies Sasol Mining, Kumba, Harmony, African Rainbow Minerals as well as organizations previously mentioned such as MQA, METF and AMMSA (SOMP Presentation 2014). In 2013 Harmony donated over R 4.7 million to Pretoria for a 3 year period to establish a Chair in Rock Engineering and Numerical Modelling. This partnership in research activities will also help establish a postgraduate qualifications to support technological advancements and safety improvements.

#### *3.3.4.6 Distance Education*

UNISA is currently the only distance education provider, with a four year mining engineering course which requires several years of industry placement work to graduate. Some universities are also enrolled into EduMine to access the 130+ short, online minerals courses. Currently, the Universities of Johannesburg and Pretoria are enrolled.

#### *3.3.4.7 Bursaries, Internships (Learnerships) and Apprenticeships*

Mining companies fund more than 3,000 tertiary institution bursaries per annum (Chamber of Mines 2015 December Quarterly Report).

Learnerships (internships) are provided by all major mining companies, as a structured process for either employed or unemployed persons to gain the theoretical knowledge and practical workplace skills leading to a NQF qualification. Learners attend classes and complete on-the-job training, and are generally a 6-months (SETA website). Learnerships count towards BEE requirements and are tax deductible. Some mining companies providing internships and bursaries:

- Anglo American
- ArcelorMittal
- Barloworld
- BHP Billiton
- Cullinan
- De Beers
- Department of Mineral Resources
- Eskom
- Exxaro
- Gold Fields
- Impala
- Lonmin
- Mintek
- Murray and Roberts
- Northam
- Phalaboura
- Royal Bafokeng
- Sandvik
- Sasol
- Sibanye Gold

In 2014, the Department of Mineral Resources and Mining Qualifications Authority initiated a Learner Inspector Programme, where 50 unemployed graduates from previously disadvantaged backgrounds are placed at different mines to undergo a two-year experiential training programme, leading to Government Certificate of Competency (GCC) examinations (DMR 2015 annual report).

Another MQA initiative is fully-funded 6-week practical mine training course to university students at UNISA, Witwatersrand, Pretoria, and Johannesburg to achieve Competency A and B certification.

Many companies have apprenticeship programs. Sandvik provides a 31-month Apprentice Programme to support skills development. During 2003 – 2011 the total intake was 563 persons, producing 417 artisans focused on mechanized mining; 41 (10%) of these were female. The budget amounts to R20 million per annum with approximately 150 apprentices in training at any one time (Marx 2012).

#### *3.3.4.8 In-House Training*

The mining industry invested R3.8 billion in education and training for employees and others in 2014 (Chamber of Mines 2014 Annual Report). Several South African minerals companies have dedicated academies and training centres, sometimes in partnership with universities and sometimes standalone as part of workforce development programs.

Fluor University in Secunda, South Africa has trained over 30,000 individuals during 35 years with accreditation by business and government bodies in various trade skills such as fitters, welders, electricians, pipefitters and other construction trades (Fluor website 2016).

Sasol in 2013 established the Sasol Engineering Leadership Academy (SELA) for an initial 32-student cohort in their final bursary year at the University of Pretoria. This is part of the Sasol Chair in Safety, Health and Environment. The objective was to address the deficiency in leadership experienced by many graduates by improving self-awareness, oral communication and team work skills. The programme's success has spilled over into psychometric testing being implemented for all engineering students starting from year one, although the Harvard model used implements both quantitative and qualitative evaluation processes (Knobbs et al 2014). Sasol also has a Learning Skills Academy with 30 trainers to provide on-the-job skills training.

At Rustenburg, Anglo American Platinum provides underground training and practical instruction at their Platinum School of Mines, pictured below (Anglo American Platinum Annual Report 2013).

*Figure 48: Anglo American Platinum School of Mines underground training facilities in Rustenburg.*

#### *3.3.4.9 Secondary Schools Support*

Large mining companies in South Africa support primary and secondary schools, especially in the subjects of maths and science. Kumba, Impala, De Beers, Lonmin, Rio Tinto, BHP Billiton and Anglo American Platinum annually invest about R100 million in corporate social investments. During 2009 – 2012, Anglo invested R100 million into the Limpopo and North West provinces through service providers, learner programmes (Saturday classes and winter camps), teacher training, infrastructure and facility upgrades. Analysis by the University of Witwatersrand School of Governance concluded that although test scores improved, in general the returns on education and development were small because the company "tried to do too many things in too small doses, thus reducing its chances of making a deep and lasting impact" (Besharati 2014).

### *3.3.5 South African Minerals Research Landscape*

Three organizations across the mining value chain important to the research landscape include the Council for Geoscience (CGS, exploration), the Council for Scientific and Industrial Research (CSIR, extraction), and Mintek (processing). CGS provides geoscience services across a range of areas including geochemistry and geophysics to mineral development, GIS and hydrogeology. Mintek provides services in mineralogy, minerals processing, hydrometallurgy and pyrometallurgy, among others.

The CSIR has been tasked to develop an R&D strategy for mining extraction and this will be further discussed at the Mining Phakisa. There is no overarching minerals sector strategy and therefore no R&D strategy, although the current Mining Phakisa/Mining Lab process could provide new opportunities (The Mining Phakisa is an executive program to enhance activities in strategic areas aligned with the National Growth Plan, mining identified as one key sector). At its peak in 1989 there were approximately 800 full-time researchers in mining, 660 at the Chamber of Mines Research Organization (COMRO). Today, there are less than 50, mostly at CSIR (CSIR 2014), although the organization has over 1500 science, engineering and technology researchers in total.

CSIR is a contract R&D organization partially funded by the government that supports innovation and competitive solutions. Capabilities exist in mechanisation and automation; fatigue, dust and noise management; safety; fires and explosion testing; and post-mining landscapes.

The University of Cape Town established a minerals beneficiation centre of excellence called "Mineral to Metals" in 2006 within the Department of Chemical Engineering. There are fourteen research supervisors (8 professors, 2 assistant professors, and 6 six research officers), seven research associates and twenty three Masters and PhD students. Research concentrations are in:

- Safety
- Mineral Carbonation
- Value from Wastes
- Energy Optimisation
- Process Optimisation
- Community Engagement
- Minerals Beneficiation

The University of Witwatersrand has three centres of excellence, including the Centre for Sustainability in Mining (https://www.wits.ac.za/csmi/), the Centre for Mechanised Mining Systems (http://www.minemech.org.za/), and the latest, Wits Mining Research Institute (https://www.wits.ac.za/wmri/) launched in 2012. Its focus is on safety, narrow reef gold extraction, and geological exploration. However two years on, due to a lack of funding, the centre was planned to be closed. New leadership at Wits would like to focus on mine mechanisation and automation technologies. Gold Fields has provided seed capital for the digital mine initiative.

At Pretoria, the Mining Resilience Research Institute (MRRI) is a multidisciplinary centre focusing on practical solutions to the complex multi-stakeholder problems of the industry. In addition, the University has research strengths in:

- Rock mechanics and underground mine design
- Rock breaking and surface mining
- Management and leadership
- Mine ventilation engineering
- Risk management
- Mineral economics
- Underground surveying (in partnership with CSIR)

In addition, the University of Pretoria hosts the Kumba Virtual Reality Centre for Mine Design, providing a 3-d, 360 degree 'immersive' experience of the mining environment. Research and teaching focuses on scenario building and decision-making, operational risk management and innovations in data visualization.

Most research is practiced in-house with occasional collaborations and SAIMM publishes on a wide set of issues. Coaltech 2020 is a research association with over 30 industry partners engaged since 1999 into competitive, safe and sustainable coal mining techniques. About ten research projects are completed each year in the areas of geology and geophysics, underground mining engineering, coal processing, surface environment, and water.

There has been a cry from academia and industry to restart the Chamber of Mines Research Organization (COMRO) which once led the world in mining technology patents.

## 3.4 AUSTRALIA

### *3.4.1 Introduction*

Australia is a country famous for its mines and natural resources; since the first gold discovery in NSW in 1823 Australia has been a global producer and by the 1850s was producing 40% of the world's gold. At this stage mining was using simple extraction and processing techniques and did not require the skills and training needed today. By 1870-1900 Australia was producing tin, copper, silver, lead, zinc, iron ore and the establishment of the first large-scale operations occurred. From 1900-1950, mining saw a major decline and production ceased at many operations even with the continued rise in the commodity market.

Australia has a well-established geological state survey, which has been in existence in some form since 1900. The (national) Bureau of Minerals Resources was established in 1946 but state surveys pre-date this and are often the best repositories for detailed data and information.

In the early 1960s Australia experienced massive growth in the mining sector, led by development of the Pilbara iron ore region in WA. The availability of information encouraged exploration and this new impetus resulted in numerous discoveries and diversified the commodities being produced particularly, coal, base metals, bauxite, nickel, and tungsten. This soon made Australia a major international exporter of mineral commodities and established a number of areas across Australia as globally recognised mining centres

Today, Australia remains a world leader in mineral resource production. It has many world class operations and as a result it is a major producer of, for example, iron ore, coal, bauxite, gem and industrial quality diamonds. The geological potential of Australia means it's likely to remain a global leader in mineral production for many decades. Companies are actively exploring and significant new discoveries have been made in recent years. Currently mineral exploration activity is however greatly reduced due to commodity process and other factors.

Despite this history of mining activity, only 0.02- 0.05 % of Australia is directly affected by mining activity (Australian atlas of mineral resources, mines & processing - What minerals mean to Australia by the Minerals Council of Australia, http://www.australianminesatlas.gov.au/history/index.html accessed February 2016).

Mining and other resource extraction has been central to the Australian economy for over 200 years, and still dominates Australian exports, generating billions of dollars in revenue. In the year to April 2015, the mining sector (including mining services) contributed around 8.5% to Australia's GDP (total output), and employed around 2% of the workforce (about 220,000 people) (http://theconversation.com/australias-five-pillar-economy-mining-40701 accessed February 2016).

Australia's top 5 exports are:

1. Iron ores (AUD 69,494M) (World's largest exporter of Iron ore)
2. Coal (AUD 39,805M)
3. Education travel services (AUD 15,020M)
4. Natural gas (AUD 14,602M)
5. Gold (AUD 13,897M)

(Australian Government, Department of Foreign Affairs and Trade, 2015).

Mining is not unique to a particular state

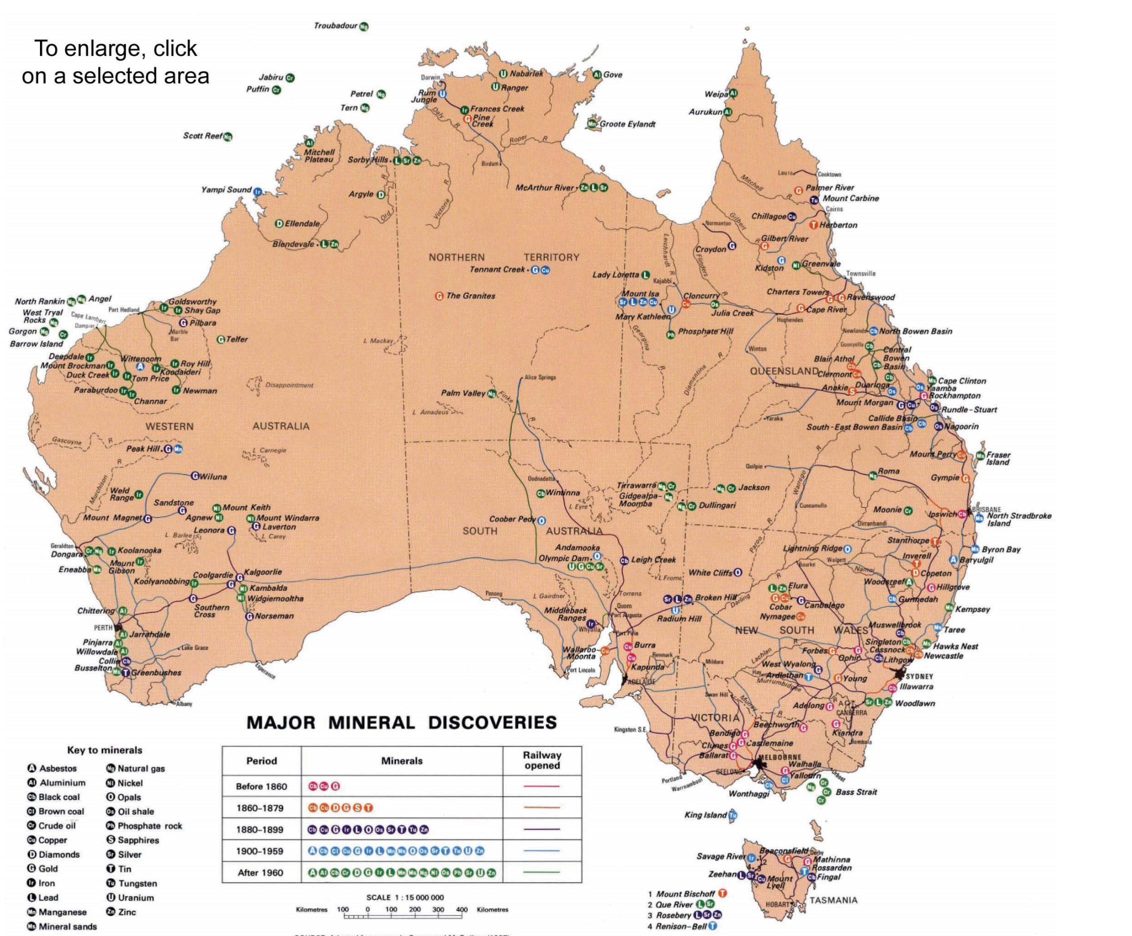



*Figure 49: Major Mineral Discoveries in Australia during last 100 Years (http://www.mininghistory.asn.au/mining-history/).*

or territory of Australia, deposits are found in almost every region, although gold and iron ore are mainly mined in Western Australia. This widespread and diverse range of deposit types creates challenges in terms of expertise and infrastructure but also brings a sense of stability as the sector is less dependent on a single commodity, thus better prepared to manage turbulent mineral prices.

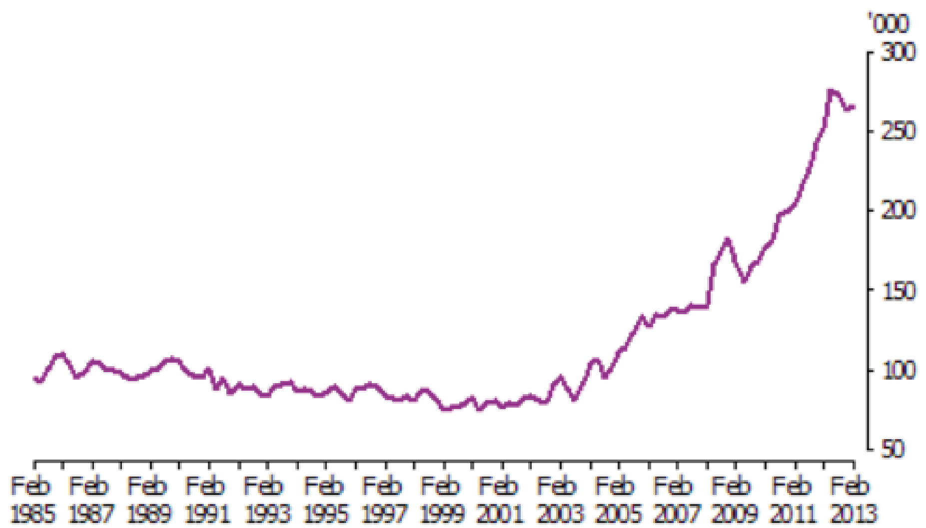
The country is well equipped with regional Geological Surveys, an excellent collection of data to encourage future exploration, good mapping and importantly this information is readily available and easily accessible.

### *3.4.2 Australian National Workforce Plans*

Historically mining has been at the heart of Australian industry and many towns and cities exist today because of their historical link to mining. The sector contributes $121.1 billion to the Australian economy. Having a vibrant modern mining industry, which offers high salaries and good career prospects, many people still aspire to work in the mining industry. In order to monitor employment trends and plan for skills availability and training needs, a series of Workforce Plans on a State, regional or commodity basis have been developed.

The number of people working in the

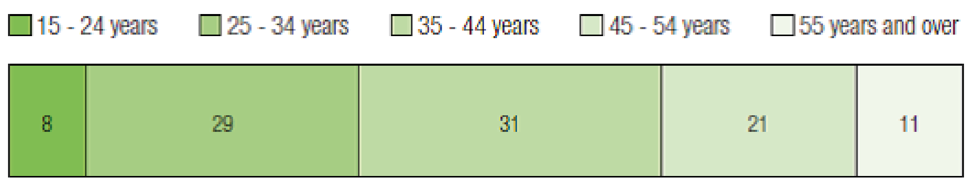
**NUMBER OF PEOPLE EMPLOYED IN THE MINING INDUSTRY**




Source: Labour Force, Australia, Detailed, Quarterly (cat. no. 6291.0.55.003)

*Figure 50: Australian mining workforce trend (Australian Bureau of Statistics).*

**Age Profile**
**Mining (% of industry total)**




*Source: ABS, Labour Force*

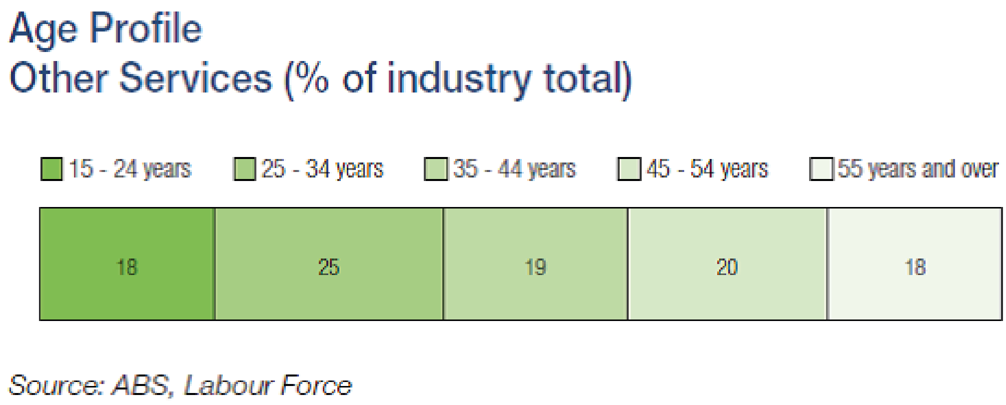



*Figure 51: Australian mining sector and overall industry sector age profiles (Australian Jobs 2015).*

# MINING

| Employment | This industry | All industries |
|---|---|---|
| Employment Nov 2014 | 228,900 | 11,613,900 |
| 1 year change to Nov 2014 | -15.8% | 1.2% |
| 5 year change to Nov 2014 | 37.3% | 7.0% |
| 5 year projected change to Nov 2019 | -17.8% | 10.0% |
| **Employment Profile** | | |
| Working part-time | 3% | 30% |
| Female | 14% | 46% |
| Aged 15 to 24 years | 8% | 15% |
| Aged 45 years or older | 32% | 39% |
| Regional | 55% | 32% |
| **Workforce Educational Profile** | | |
| With a bachelor degree or higher qual | 20% | 29% |
| With a cert III or higher VET qual | 45% | 31% |
| Without a post-school qual | 30% | 34% |
| **Top 5 Occupations** | | |
| Drillers, Miners and Shot Firers | 50,600 | 52,700 |
| Metal Fitters and Machinists | 24,900 | 123,800 |
| Technicians, Other Building and Engineering | 13,000 | 25,000 |
| Drivers, Truck | 12,300 | 189,300 |
| Electricians | 10,900 | 141,700 |

*Table 28: Australian mining industry employment profile (Australian Jobs 2015).*

Australian mining industry has seen a dramatic increase in the last 30 years. As illustrated in ***Figure 50***, between 1985 and 2005 mining industry employment remained around 100,000 with its lowest in 1999 at about 75,000. From 2005 to 2013, the number increased dramatically and, notwithstanding some minor fluctuations, rose to approximately 270,000. With the recent falls in commodity prices and significant retrenchment programmes this has however now fallen back to approximately 200,000 (Jan 2016).

***Table 28 and Figure 51*** show profiles of employees in the Mining industry compared to the Australian industrial sector as a whole, in 2014; as the current downturn was just starting. It reveals that the majority of mining employees are full time, male, based outside the urban centres and have an age profile that is somewhat older than other industry sectors (***Table 28***). There are relatively few part-time jobs or those for young people. While 20% of employees are degree-level trained there are also 30% without post school qualifications. As expected the industry employs the overwhelming majority of miners and drillers, however it also employs 10 - 20% of the available trades and technicians.

The Australian mining industry has only 14% women employees and this major gender gap permeates almost all aspects of the industry but especially in Trades (***Table 29***). One area where inroads are being made is for truck drivers, where there also appears to be evidence that women outperform men in terms of safety and equipment longevity.

The Australian Government has commissioned Workforce Plans at the State rather than national level. Each State is tasked with producing plans to ensure that a lack of available skill does not slow development in particular sectors.

Three of these Plans are briefly discussed below. WA is home to the largest number of mining employees, within which the massive iron mining region of the Pilbara has its own Plan, while SA has experienced the greatest increase in mining employees over the last 5 years (***Table 30***).

**Table 4: Top five occupations in the mining industry**

| Occupation | Total number | Number of females | Number of males | Female % | Male % |
|---|---|---|---|---|---|
| Drillers, miners and shot firers | 39,283 | 2,299 | 36,984 | 5.9 | 94.1 |
| Metal fitters and machinists | 14,575 | 90 | 14,485 | 0.6 | 99.4 |
| Other building and engineering technicians | 8,369 | 766 | 7,603 | 9.2 | 90.8 |
| Truck drivers | 7,305 | 1,488 | 5,817 | 20.4 | 79.6 |
| Electricians | 5,503 | 102 | 5,401 | 1.9 | 98.1 |

Source: This table is based on ABS Census 2011, 'Australia (Statistical Local Area), Occupation by Sex and Industry of Employment', and is not directly comparable with the Agency reporting organisations.

Industry Snapshots: Mining, Workplace Gender Equality Agency, 2012

*Table 29: Australian mining industry gender employment profile, Top five occupations in the mining industry (MCA workforce gender review 2012).*

| | Mining Employment | | | |
|---|---|---|---|---|
| State | Employment Nov 2014 | % of total | 5 year change to Nov 2014 | |
| | '000 | % | '000 | % |
| New South Wales (NSW) | 27.9 | 1 | -4.9 | -15.0 |
| Victoria (VIC) | 11.0 | 0 | -0.5 | -4.2 |
| Queensland (QLD) | 64.7 | 3 | 23.8 | 58.4 |
| South Australia (SA) | 15.8 | 2 | 8.9 | 126.6 |
| Western Australia (WA) | 98.7 | 7 | 31.2 | 46.1 |
| Tasmania (TAS) | 3.3 | 1 | -0.3 | -9.4 |

*Table 30: Australian mining employment by State 2014.*

#### *3.4.2.1 Skilling WA – A Workforce Plan for Western Australia*

First commissioned in 2010, this study made a considerable contribution by working with industry, communities, and government organisations to help build a workforce that addressed the needs of Western Australia. As a result a second report was carried out in 2014.

*'The development of work force plans is to build, attract and retain a skilled workforce that is flexible, diverse and responsive to changes in the labour market, economic or social conditions'*

*(Deputy Premier; Dr Kim Hames, Minister for Training and Workforce Development, 2014).*

The effect of the recent commodities cycle on overall WA employment is easily identified although employment has risen fairly consistently over the last 15 years (***Figure 52***). As a region which is dependent on mining, the global commodities market has a significant effect on the overall employment rates due to the impact on direct supply chains, and the 'multiplier effect' through related goods and services. Although the industry is currently undergoing considerable turmoil linked to global metal prices, mining employment has until recently been maintained and the number of people employed in mining in WA remains at a historically high level (***Figure 52***).

The Skilling WA plan (2014) highlights projections for job growth by qualification (2013-2018) (***Figure 53***).

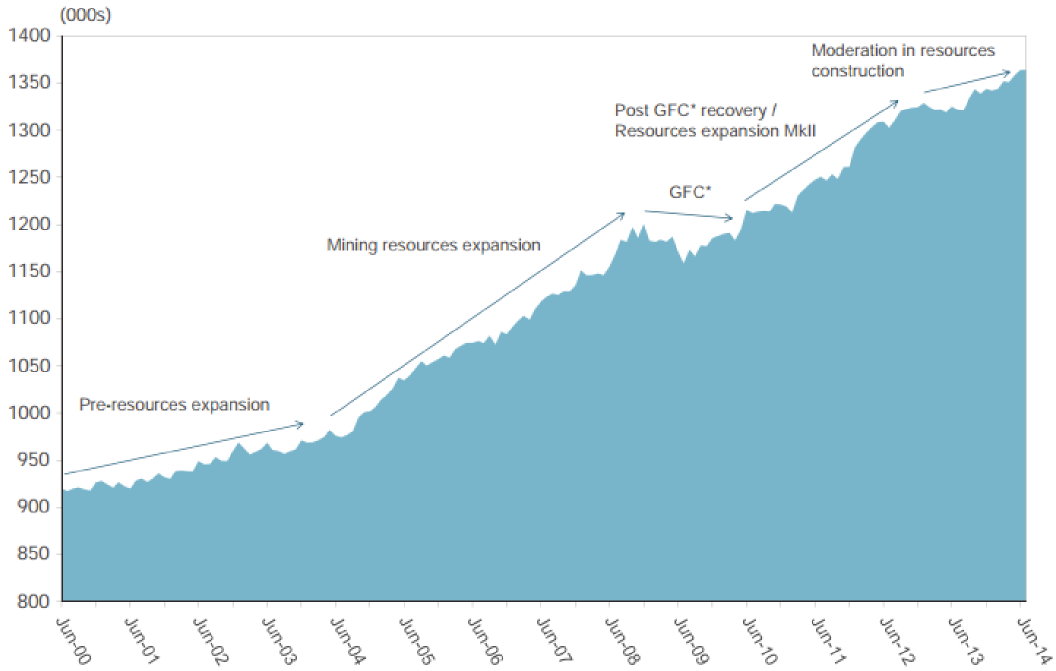



*Figure 52: Western Australian Employment Levels (2000-2014) the numbers are in 000's (GFC-Global Financial Crisis) (http://www.dtwd.wa.gov.au/workforceplanninganddevelopment/skillingWA/Documents/).*

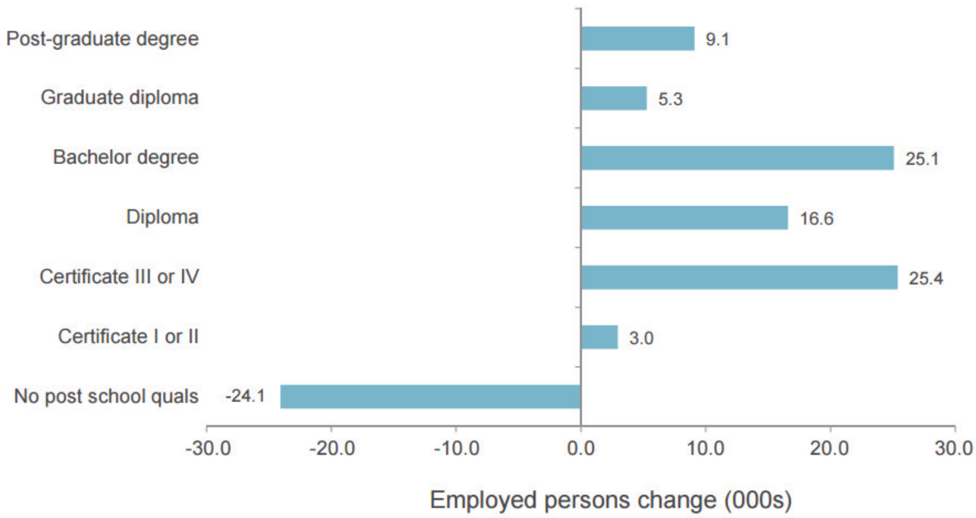



*Figure 53: Job Growth projections 2013-18 by qualification level in Western Australia's 2014 Workforce Plan (Skilling WA- A workforce plan, 2014).*

WA expects the demand for skilled workers to remain moderate for the immediate future but also identified two main challenges:

- Ageing demographic
- High unemployment of young people, suggesting a mismatch between skills and demand

It aims to address this through:

- Engaging with disengaged, unemployed youth, mature workers, aboriginal and other minority groups who are underrepresented in the workforce.
- Skilled Migrants to fill gaps which the local workforce are unable to fill.
- Attract workers to WA from across Australia to fill demand
- Provide education and training opportunities which are flexible, innovative and responsive to the needs of the local industry

At the time of publication this was predicting only a modest growth for the mining sector but still greater than any other sector (***Figure 54***). The growth for the region is dominated by the need for professionals, technical and trade staff (***Figure 55***).

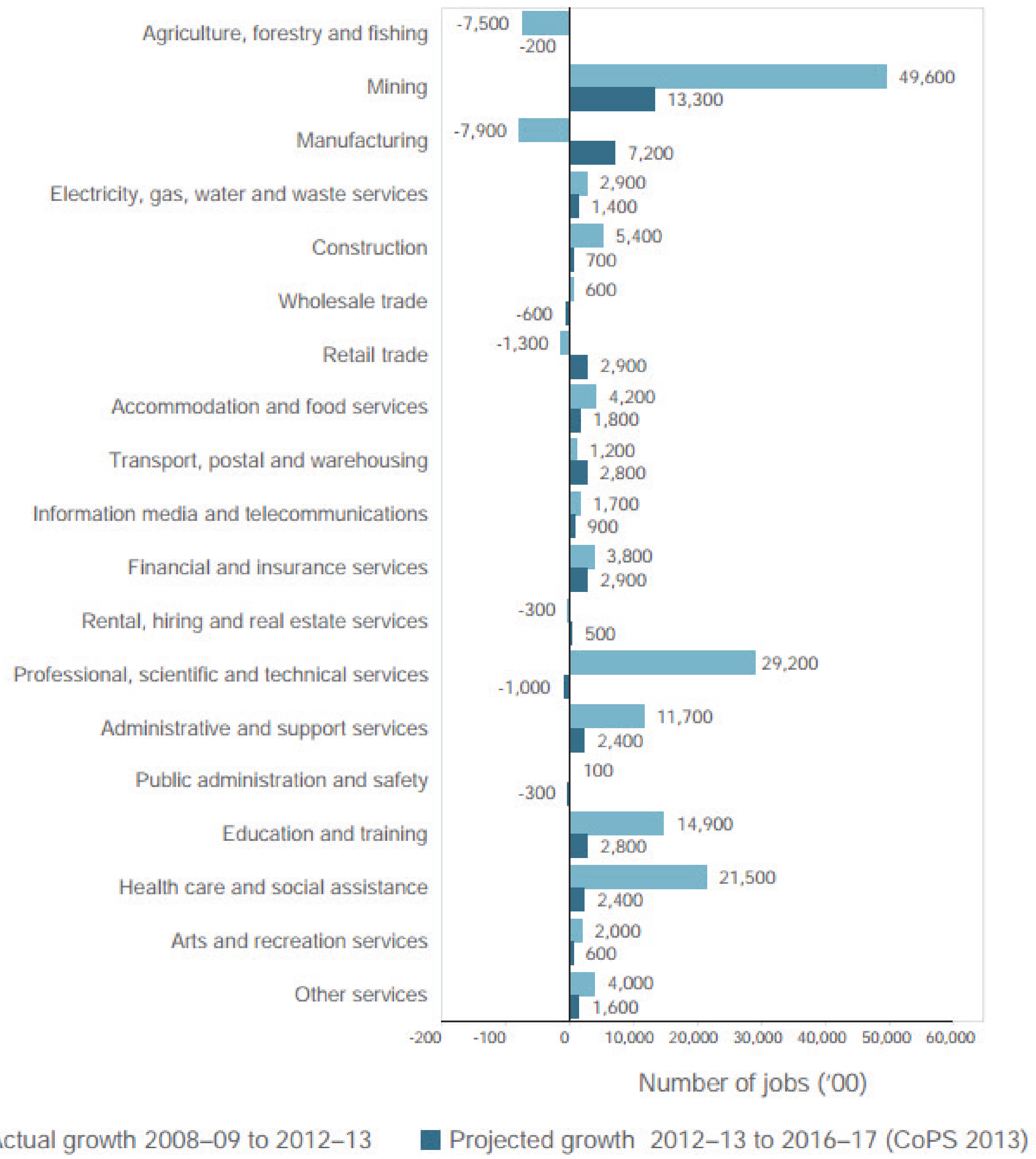



*Figure 54: Employment growth by industry sector 2008-2009 to 2016-2017.*

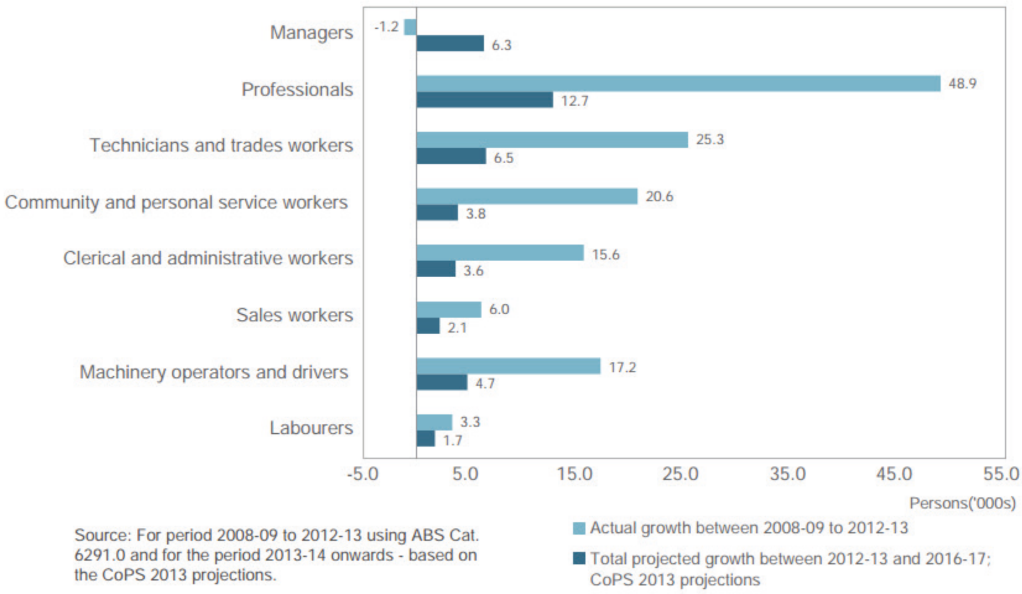



*Figure 55: Employment growth by occupation 2008-2009 to 2016-2017.*

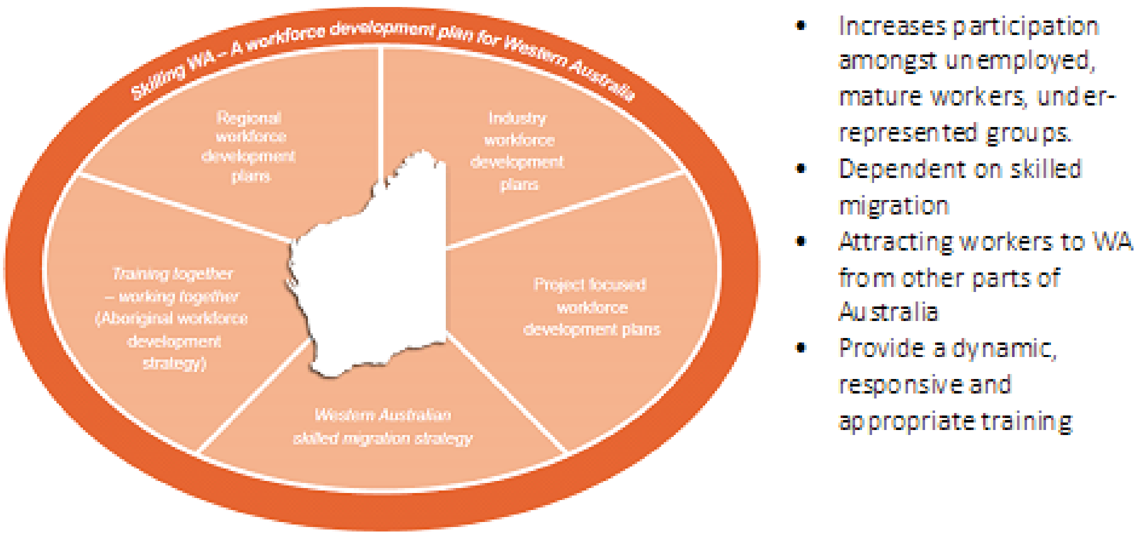



*Figure 56: The outputs from Skilling -WA Workforce Plan2014.*

### 3.4.2.2 Pilbara Workforce Development plan 2013-2016

The Pilbara Workforce Development plan is aligned with Skilling WA, and the aim of this particular regional report is implementation of its strategy (***Figure 56***).

- Increases participation amongst unemployed, mature workers, under-represented groups.
- Dependent on skilled migration
- Attracting workers to WA from other parts of Australia
- Provide a dynamic, responsive and appropriate training

The Pilbara is a major iron ore mining region and since 2006 the mining sector has seen the number of mining employees increase from 5,754 to 11,431 (***Table 31***), accompanied by large increases in construction, professional and technical roles. For the same period the education sector growth was very small, and may not have been sufficient given the mining and mining related workforce trends.

The region's geography and cultural profile makes education a challenging task. This includes the number of remote and isolated communities, lack of mobility and poor education standards at some schools.

| Industry sector | 2006 Persons | 2011 Persons | 2011 % distribution | 2006–11 % growth |
|---|---|---|---|---|
| Mining | 5754 | 11 431 | 35.3% | 98.7% |
| Construction | 2087 | 5303 | 16.4% | 154.1% |
| Accommodation and food services | 990 | 1637 | 5.1% | 65.4% |
| Transport, postal and warehousing | 916 | 1694 | 5.2% | 84.9% |
| Professional, scientific and technical services | 409 | 916 | 2.8% | 124.0% |
| Manufacturing | 835 | 1111 | 3.4% | 33.1% |
| Education and training | 1359 | 1544 | 4.8% | 13.6% |

*Table 31: Employment by industry sector, Pilbara 2006-2011, Australian Bureau of Statistics.*

#### *3.4.2.3 South Australia Government; Resource Industry Workforce Action Plan, 2010-2014*

In order to develop a sector specific plan that responds to industry needs, an extensive consultation took place to identify the challenges which needed to be addressed. These included:

- Skills in demand/labour shortages and gaps
- Attracting, recruiting and retaining
- Education and training
- Skilled migration
- Industry/government partnerships (funded and support)

(Source: skills.sa.gov.au)

The report also made the following findings:

- There is no shortage of inexperienced applicants for semi-skilled positions and companies are inundated with such applicants
- Companies experience challenges in recruiting experienced semi-skilled workers
- Critical shortages in trades trained staff
- The need for professional staff, mining engineers, geologists, is more acute as it requires years of study and this is followed by a number of year of on-the-job experience
- There are also shortages in the following areas; technicians, planners and estimators, draftsperson, technical document specialists, senior project engineers, managers, experienced metallurgists and geoscientists.
- The major demand is during the construction phase of mining projects
- The main demand for trade position is by contractors not mining companies
- Innovative training, accelerated pathways, mature aged apprentices, and attracting trades back to the industry are some of the strategies to address the skills shortage.

Between them these Workforce Plans highlight a wide range of education and training issues, around the overall capacity, means of delivery, particular skills shortages, employer characteristics, demographic and cultural challenges faced by the country during the mining boom as well as potential actions to take. The extent to which these are solved or more likely deferred as a result of the current downturn is unclear.

### *3.4.3 SkillsDMC – a Sector Skills Council*

SkillsDMC is engaged by the Australian Government to provide the function of the Industry Skills Council to the Resources and Infrastructure Industry and are considered global leaders in defining competency standards. In a 2014 submission to the Department of Industry's 'Industry Engagement in Training Package Development – Discussion Paper' an analysis of anticipated skills shortages in the mining industry was presented (***Table 32***). Drillers, miners and shotfirers, fitters / machi-

**Table 2.7: Projected Workforce Gaps – Total Mining**

| Occupation | 2014(e) | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Summary charts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Drillers, Miners and Shot Firers** | | | | | | | | | | | | |
| Labour Demand | 59,889 | 60,784 | 60,729 | 61,129 | 61,638 | 60,360 | 62,174 | 62,390 | 64,444 | 65,407 | 65,517 | |
| Existing Workforce | 59,889 | 58,781 | 57,694 | 56,626 | 55,579 | 54,551 | 53,541 | 52,551 | 51,579 | 50,625 | 49,688 | |
| ***Workforce Gap*** | | *2,003* | *3,035* | *4,503* | *6,059* | *5,809* | *8,632* | *9,839* | *12,865* | *14,782* | *15,829* | |
| **Metal Fitters and Machinists** | | | | | | | | | | | | |
| Labour Demand | 29,319 | 29,817 | 29,670 | 29,846 | 30,113 | 29,548 | 30,440 | 30,554 | 31,567 | 32,052 | 32,123 | |
| Existing Workforce | 29,319 | 28,806 | 28,302 | 27,807 | 27,320 | 26,842 | 26,372 | 25,911 | 25,457 | 25,012 | 24,574 | |
| ***Workforce Gap*** | | *1,011* | *1,368* | *2,040* | *2,793* | *2,706* | *4,068* | *4,643* | *6,110* | *7,040* | *7,549* | |
| **Truck Drivers** | | | | | | | | | | | | |
| Labour Demand | 16,402 | 16,693 | 16,240 | 15,859 | 15,570 | 15,236 | 15,576 | 15,509 | 15,899 | 15,984 | 16,034 | |
| Existing Workforce | 16,402 | 16,082 | 15,768 | 15,461 | 15,159 | 14,864 | 14,574 | 14,289 | 14,011 | 13,738 | 13,470 | |
| ***Workforce Gap*** | | *611* | *472* | *398* | *411* | *372* | *1,002* | *1,220* | *1,888* | *2,246* | *2,565* | |
| **Other Building and Engineering Technicians** | | | | | | | | | | | | |
| Labour Demand | 15,791 | 16,057 | 15,589 | 15,237 | 14,979 | 14,692 | 15,035 | 15,011 | 15,406 | 15,526 | 15,620 | |
| Existing Workforce | 15,791 | 15,491 | 15,196 | 14,908 | 14,624 | 14,346 | 14,074 | 13,806 | 13,544 | 13,287 | 13,034 | |
| ***Workforce Gap*** | | *567* | *392* | *329* | *355* | *345* | *961* | *1,205* | *1,862* | *2,240* | *2,586* | |
| **Electricians** | | | | | | | | | | | | |
| Labour Demand | 9,038 | 9,192 | 9,146 | 9,201 | 9,283 | 9,109 | 9,384 | 9,419 | 9,731 | 9,881 | 9,903 | |
| Existing Workforce | 9,038 | 8,921 | 8,805 | 8,690 | 8,577 | 8,466 | 8,356 | 8,247 | 8,140 | 8,034 | 7,930 | |
| ***Workforce Gap*** | | *271* | *342* | *510* | *706* | *643* | *1,028* | *1,172* | *1,591* | *1,846* | *1,973* | |
| **Production Managers** | | | | | | | | | | | | |
| Labour Demand | 7,918 | 8,058 | 7,840 | 7,656 | 7,516 | 7,355 | 7,519 | 7,487 | 7,675 | 7,716 | 7,741 | |
| Existing Workforce | 7,918 | 7,764 | 7,612 | 7,464 | 7,318 | 7,175 | 7,036 | 6,898 | 6,764 | 6,632 | 6,503 | |
| ***Workforce Gap*** | | *295* | *228* | *192* | *198* | *180* | *484* | *589* | *911* | *1,084* | *1,238* | |
| **Earthmoving Plant Operators** | | | | | | | | | | | | |
| Labour Demand | 7,692 | 7,828 | 7,616 | 7,437 | 7,302 | 7,145 | 7,305 | 7,273 | 7,456 | 7,496 | 7,520 | |
| Existing Workforce | 7,692 | 7,561 | 7,432 | 7,306 | 7,182 | 7,060 | 6,940 | 6,822 | 6,706 | 6,592 | 6,480 | |
| ***Workforce Gap*** | | *267* | *183* | *131* | *120* | *85* | *365* | *451* | *750* | *904* | *1,040* | |
| **Structural Steel and Welding Trades Workers** | | | | | | | | | | | | |
| Labour Demand | 7,331 | 7,455 | 7,238 | 7,074 | 6,955 | 6,821 | 6,980 | 6,969 | 7,153 | 7,209 | 7,252 | |
| Existing Workforce | 7,331 | 7,210 | 7,091 | 6,974 | 6,859 | 6,746 | 6,635 | 6,525 | 6,418 | 6,312 | 6,208 | |
| ***Workforce Gap*** | | *245* | *146* | *100* | *95* | *75* | *346* | *444* | *735* | *897* | *1,045* | |
| **Other Construction and Mining Labourers** | | | | | | | | | | | | |
| Labour Demand | 4,452 | 4,516 | 4,407 | 4,311 | 4,234 | 4,142 | 4,238 | 4,229 | 4,339 | 4,370 | 4,393 | |
| Existing Workforce | 4,452 | 4,392 | 4,333 | 4,275 | 4,217 | 4,160 | 4,104 | 4,048 | 3,994 | 3,940 | 3,887 | |
| ***Workforce Gap*** | | *124* | *74* | *36* | *18* | *-18* | *134* | *181* | *345* | *431* | *507* | |
| **Other Stationary Plant Operators** | | | | | | | | | | | | |
| Labour Demand | 4,298 | 4,375 | 4,256 | 4,156 | 4,080 | 3,993 | 4,082 | 4,064 | 4,167 | 4,189 | 4,202 | |
| Existing Workforce | 4,298 | 4,219 | 4,141 | 4,064 | 3,989 | 3,915 | 3,843 | 3,772 | 3,702 | 3,633 | 3,566 | |
| ***Workforce Gap*** | | *156* | *115* | *92* | *91* | *78* | *239* | *293* | *465* | *555* | *636* | |

e = estimate

Note: Blue represents skills shortage, red respresents skills surpluss.

Source: BIS Shrapnel

*Table 32 Projected workforce skills gap to 2024 (Resources and infrastructure sector stakeholders 2014).*

nists had the largest projected shortfall. It points out that even with a reduction in short term industry demand, major infrastructure projects planned for the next decade will still require these skilled employees. The future mining skills required will also change as efficiency-driven investment in more automated and technological solutions will reduce the need for lower skilled staff and drive demand for high skills levels.

### *3.4.4 Australian Education Provision*

Australia has a population of just over 24 million people and just over 1.3million are enrolled at higher education institutions in 2014 (***Figure 57***); according to 2011 census data 36.6% of 20 year olds are attending university or higher education. This is commensurate with Australia's economic ranking and is similar to the USA, lower than Canada and Japan, but much higher than South Africa. There has been a significant increase in the number of overseas students studying in the country.

#### *3.4.4.1 Mining specific courses*

"The Minerals Tertiary Education Council (MTEC) was set up in 1999 by the Minerals Council of Australia (MCA) to help build a world-class tertiary learning environment. Through MTEC, member companies of MCA support a number of university partners offering undergraduate and pos-

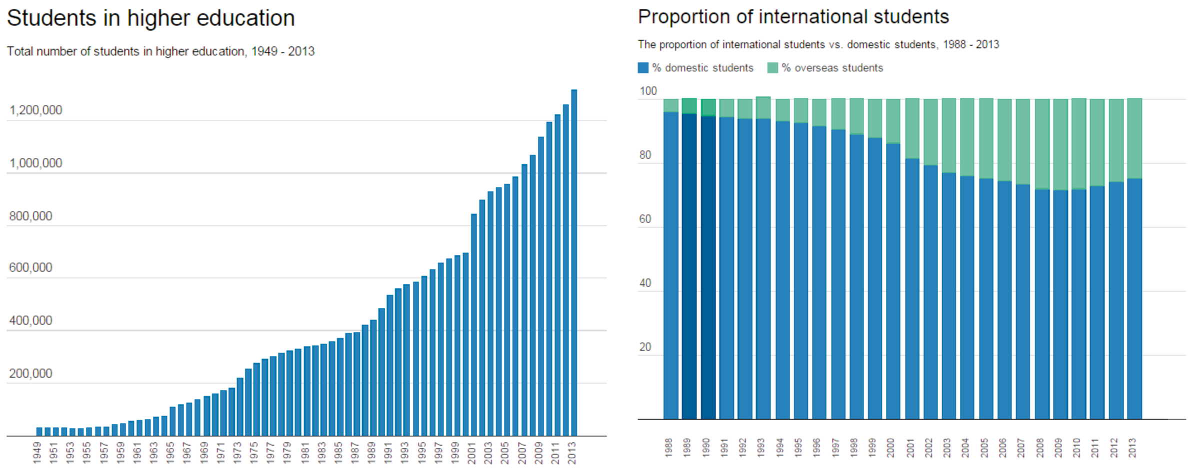



*Figure 57: Growth and Internationalization of Australian Universities (Department of Education and Training) (http://theconversation.com/who-goes-to-university-the-changing-profile-of-our-students-40373).*

| |
|---|
| University of Adelaide |
| University of New South Wales |
| Curtin University |
| Federation University |
| University of Wollongong |
| Monash University , |
| University of Queensland |
| University of Western Australia offers a three-year Bachelor degree followed by a two-year Master of Professional Engineering specialising in Mining Engineering; |
| Mining Education Australia (MEA) is a joint venture of the University of Adelaide, Curtin University, the University of New South Wales and the University of Queensland |

*Table 33: List of Australian Universities that offer Mining Engineering degree courses.*

tgraduate courses in mining industry related disciplines - Earth Science (Minerals Geoscience), Mining Engineering and Metallurgy" (www.minerals.org.au/mca/mtec ).

Australia has globally recognised universities and academics who teach and research in all the major minerals industry specific disciplines (exploration, extraction and processing), and other related disciplines (http://www.minerals.org.au/corporate/about_the_minerals_industry). All undergraduate Mining Engineering degrees in Australia are of four years duration, accredited by the Institution of Engineers Australia and are offered at eight Universities listed in ***Table 33***.

Australia has a unique collaborative university programme in support of the mining industry, in which four of the main universities have joined together to deliver a common curriculum. The University of New South Wales, University of Adelaide, University of Queensland and Curtin University make up Mining Education Australia (MEA). MEA provides:

*"A high quality, comprehensive education to mining engineering students at MEA partner universities; the Australian minerals industry with sufficient graduate mining engineers to meet the majority of its annual graduate requirements; MEA partner universities with financially viable mining programs through shared development and delivery of courses; mining academic staff with a collaborative, supportive peer network; and graduates with desirable attributes as endorsed by industry.*

*What MEA means for students - A comprehensive education program covering all aspects of mining engineering technical, operational and social, community and environmental issues, access to a* *national group of mining academic staff with skills in major areas,….., opportunity to undertake exchange semesters among member universities and graduate with a world-class degree, from an industry supported national program."* (http://www.engineering.unsw.edu.au/mining-engineering/study-with-us/mining-education-australia-mea, accessed December 2015)

MEA students account for 85% of all the Mining Engineering students now educated in Australia. Enrolment data for 2014 is given in ***Table 34***.

In 2014 there was a 48% drop in applications compared with 2013. This is believed to be due to the decline in the mining industry deterring potential applicants.

The trend in the number of Australian mining graduates is positively linked with the metals and minerals price index over the long term (Figure 58). There is however a lag, and peaks in graduation lag the commodity index as students who were enrolled during a mining boom graduate in the following downturn. This is one of the contributing factors to the skills shortages experienced by the industry during the recent boom and the current large numbers of mining graduates (***Figure 59***).

***Figure 59*** shows the number of MEA Mining Engineering graduates from 2006-2014 together with the number of graduates from non-MEA universities (the sum of the two being the total number for Australia). During this period the total number of graduates increased by 210%, whilst the total number of MEA graduates increased by 270%. In 2013 there were 57 registered Postgraduate mining related research students, mainly for PhD but with a few on MPhil study programmes (MEA Annual Report 2014)

A recent development has been the Define Your Discipline project to consult stakeholders and then more accurately define the educational outcomes for mining related programmes, and develop a Graduate Capability Framework for use by all the MEA Consortium members in revitalising their own programme structure and delivery. This is addressing Mining En-

| Enrolment Numbers | Adelaide | UNSW | WASM | UQ | MEA |
|---|---|---|---|---|---|
| First Year students total | 27 | 34 | 50 | 50 | 161 |
| First year international | 8 | 5 | 0 | 5 | 18 |
| First year female | 2 | 5 | 0 | 8 | 15 |
| First year Indigenous | 0 | 0 | 0 | 0 | 0 |
| Second Year students total | 48 | 63 | 120 | 66 | 297 |
| Second year international | 18 | 2 | 68 | 16 | 104 |
| Second year female | 8 | 11 | 14 | 8 | 41 |
| Second year Indigenous | 0 | 0 | 0 | 0 | 0 |
| Third Year student total | 39 | 94 | 68 | 81 | 282 |
| Third year international | 9 | 18 | 41 | 18 | 86 |
| Third year female | 7 | 11 | 10 | 8 | 36 |
| Third year Indigenous | 0 | 1 | 0 | 0 | 1 |
| Fourth Year student total | 40 | 70 | 59 | 87 | 256 |
| Fourth year international | 11 | 19 | 26 | 16 | 72 |
| Fourth year female | 1 | 8 | 7 | 12 | 28 |
| Fourth year Indigenous | 0 | 1 | 0 | 0 | 1 |
| Fifth Year students total (double degree) | 0 | 0 | 0 | 27 | 27 |
| Fifth year international | 0 | 0 | 0 | 2 | 72 |
| Fifth year female | 0 | 0 | 0 | 3 | 28 |
| Fifth year Indigenous | 0 | 0 | 0 | 1 | 1 |
| Totals all students all years | 154 | 261 | 297 | 311 | 1023 |

*Table 34: Enrolment at Mining Education Australia Institutions, MEA annual report 2014.*

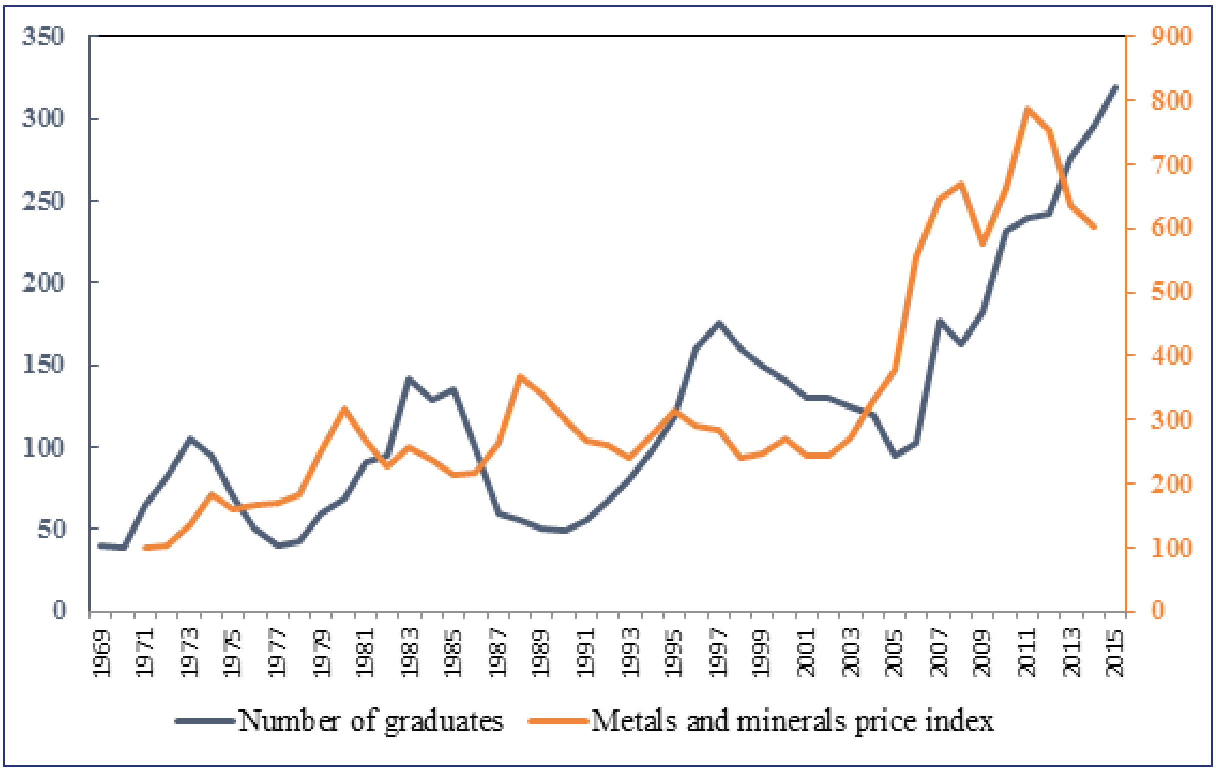



*Figure 58: Lags between Graduate Supply and Mineral Markets, MEA Annual Report 2014 (http://www.mea.edu.au/).*

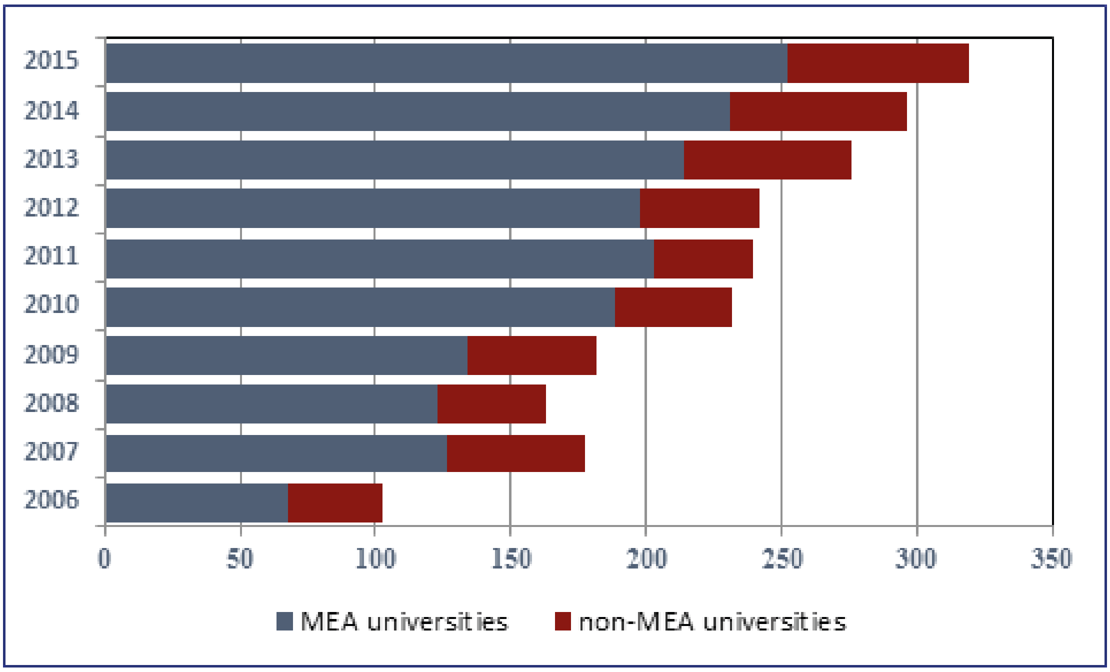



*Figure 58: Lags between Graduate Supply and Mineral Markets, MEA Annual Report 2014 (http://www.mea.edu.au/).*

gineering programmes during 2016 and aims to align students knowledge and skills with employers expectations.

MEA Programmes also involve final year research projects that are reported in the Journal of Research Projects Review and there is also an annual conference where leading students present their findings.

#### *3.4.4.2 Geoscience Programmes*

There are geoscience programmes available throughout the Universities in Australia (***Table 35***). Graduates from these are able to pursue a wide range of careers including the mining industry.

There are however a more limited num-

| |
|---|
| ACT<br>Australian National University, Department of Geology and Research School of Earth Sciences<br>University of Canberra, School of Resource, Environmental & Heritage Sciences |
| NSW<br>Macquarie University, Department of Geology<br>University of New England, Department of Geology<br>University of New South Wales, Earth Sciences<br>University of New South Wales, School of Mines<br>University of Newcastle, Department of Earth Sciences<br>University of Sydney, School of Geosciences<br>University of Wollongong, Department of Geology |
| Queensland<br>James Cook University of North Queensland, School of Earth Sciences<br>University of Queensland, Department of Earth Sciences |
| South Australia<br>University of Adelaide, Department of Geology and Geophysics<br>Flinders University of South Australia, School of Earth Sciences |
| Tasmania<br>University of Tasmania, Department of Geology |
| Victoria<br>Federation University, Department of Geology<br>University of Melbourne, School of Earth Sciences<br>Monash University, Department of Earth Sciences<br>Royal Melbourne Institute of Technology, Geological Engineering and Applied Geology |
| Western Australia<br>Curtin University of Technology, School of Applied Geology<br>Murdoch University, Mineral Science<br>University of Western Australia, Department of Geology and Geophysics<br>Western Australian, School of Mines |

*Table 35: Australia Institutions offering geology degree programmes.*

ber of courses that are closely aligned with the mining industry such as the Applied Geology degree at Curtin and at Masters Level:

- Master of Economic Geology - Tasmania
- Master of Geoscience – WA
- Minerals Geoscience– James Cook
- Mineral Exploration & Mining Geology – Curtin (WASM)
- Master of Mineral Resources - Queensland

Although skills shortages have included geoscientists, there are a much larger number of graduates annually who can be trained to take up mining roles. The main shortages appear to be for experienced exploration and mining geologists with expertise in resource estimation, grade control, specialist modelling software and specific deposit knowledge.

### *3.4.5 Minerals related tertiary education*

It is significantly easier to assess the availability of training at university level, because these formal education routes are in a limited number of institutions, however, the availability of mining related vocational courses, trades, technician training and apprenticeships is more difficult due to the multiple sectors in which they work.

Technical and further education or TAFE institutions provide a full range of mining related vocational tertiary education courses. TAFE colleges award Australian Qualifications Framework (AQF) qualifications accredited through the Vocational Education and Training (VET) sector that award Certificate I, Certificate II, Certificate III, Certificate IV, Diploma, Advanced Diploma, Graduate Certificate and Graduate Diploma qualifications. In some cases TAFE study can contribute credits towards bachelor's degree-level

| |
|---|
| ACT<br>Field Assistant - Dept. of Resources Science, Canberra Institute of Technology<br>Geoscience Diploma - Dept. of Resources Science, Canberra Institute of Technology |
| NSW<br>Coal Mining (Open-Cut Examiner) - Short Course, NSW TAFE<br>Coal Operations - Certificate II, NSW TAFE<br>Geotechnical Field Operations - Certificate II, NSW TAFE<br>Mining Studies - Short Course, NSW TAFE<br>Mining Supervision - Certificate IV (AQF), NSW TAFE<br>NSW TAFE Mining Courses |
| Queensland<br>Queensland Mining School - Mt Isa TAFE<br>Queensland Mining School - Central Queensland TAFE |
| SA<br>Geoscience, Diploma (AKA) - SA TAFE |
| Tasmania<br>Laboratory Practice (Geoscience) - TAFE Tasmania Course |
| Victoria<br>Graduate Certificate of Applied Sciences (Laboratory Technology - Mining Lab, Box Hill TAFE, VIC<br>Vic TAFE Mining Courses - Vic TAFE Web Site |
| Western Australia<br>Certificate III of Drilling Principles - Leederville TAFE, WA<br>Certificate III in Mining Geoscience Practices - Leederville TAFE, WA<br>Certificate II of Geoscience Field Practices - Leederville TAFE, WA<br>Certificate IV in Surface Mining - Leederville TAFE, WA<br>Diploma of Technology (Applied Science) - Geology Stream - Leederville TAFE, WA |

*Table 36: Australia TAFE Colleges offering mining related programmes.*

university programs. Examples of courses available for the mining industry can be seen in ***Table 36***.

The Minerals Industry National Associate Degree (MINAD) programme is a new initiative that seeks out "true partnership between industry, government and academia to reshape minerals education in Australia," and will provide the minerals industry with efficient, appropriately skilled para-professional workers as part of their workforce profile. By moving beyond reactionary initiatives to counter cyclical industry requirements, the MINAD project is a natural extension to the MCA's vision of an uninterrupted sustainable education and training pathway for workforce participation, diversity and skills".

#### *3.4.5.1 Apprentices*

There is a multitude of providers of generic trades training that equip individuals for the construction, mining, engineering and other related sectors.

In Australia apprenticeships and traineeships are defined as:

- Regulated, employment based training with a contract of training
- The training is agreed between, employer, employee and registered training organisation
- The occupation is specified and the training involves paid employment and on the job training, with the formal (off the job) college training leading to a recognised qualification
- Training is provided to an agreed level and in accordance with Australian Qualifications Framework

(Knight, B. 2012, NCVER, Evolution of Apprenticeships and Traineeships in Australia- an unfinished history)

The National Centre for Vocational Education Research (NCVER), is focused on collecting, examining and communicating statistics about vocational education and training (VET) on a national level.

The organisation is independent and made up of state/territory government, commonwealth governments, industry, unions, training authority and NCVER.

The government and the department of industry work with NCVER to examine the needs of the five major industries and the ability of education and training to meet those needs. Education and training must be responsive to the emerging skills demand in these key industries:

- Food and Agriculture
- Biotechnology and Pharmaceuticals
- Advanced manufacturing
- **Mining equipment, technology and services**
- Oil and gas

***Table 37*** shows that the number of apprenticeships has been increasing gradually from 2004- 2012 and then there was a sharp decline in 2013 and again in 2014. This is likely to be due to the slowdown in the Australian economy and the reduced availability of industry funded training as a result of the poor economic climate.

Although general trades are widely used in the mining sector the directly related apprenticeships amount to around 10,500 in 2014.

| | | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 19 years and under | 106.4 | 108.3 | 109.6 | 114.5 | 117.4 | 101.1 | 115.8 | 111.6 | 107.3 | 85.5 | 79.8 |
| | 20 to 24 years | 45.0 | 45.7 | 46.3 | 48.2 | 48.6 | 45.6 | 54.4 | 56.6 | 57.1 | 45.0 | 39.8 |
| | 25 to 44 years | 76.3 | 77.1 | 78.1 | 80.4 | 86.1 | 85.8 | 100.2 | 105.7 | 114.2 | 81.1 | 54.9 |
| | 45 years and over | 29.5 | 31.0 | 32.4 | 32.7 | 36.6 | 39.3 | 44.7 | 46.9 | 52.0 | 34.2 | 17.5 |
| Sex | Male | 152.3 | 154.5 | 156.5 | 162.1 | 166.4 | 152.9 | 180.4 | 180.2 | 187.7 | 151.5 | 119.1 |
| | Female | 104.9 | 107.6 | 109.9 | 113.8 | 122.3 | 118.9 | 134.6 | 140.5 | 142.8 | 94.3 | 72.9 |
| AQF qualification level | Certificate I or II | 51.4 | 48.2 | 44.5 | 42.1 | 42.3 | 36.0 | 35.5 | 26.1 | 19.7 | 15.0 | 14.7 |
| | Certificate III | 178.0 | 185.1 | 187.4 | 196.0 | 199.4 | 177.0 | 204.3 | 207.8 | 212.0 | 173.5 | 145.4 |
| | Certificate IV | 27.1 | 27.9 | 33.4 | 35.1 | 43.2 | 54.6 | 59.4 | 57.0 | 62.5 | 51.0 | 24.7 |
| | Diploma/advanced diploma | 0.7 | 0.9 | 1.1 | 2.6 | 3.8 | 4.2 | 15.9 | 29.9 | 36.2 | 6.4 | 7.2 |
| Full-time status | Full-time | 190.9 | 193.9 | 197.2 | 203.8 | 207.4 | 189.6 | 224.1 | 223.6 | 232.7 | 184.5 | 136.8 |
| | Part-time | 66.4 | 68.2 | 69.2 | 72.0 | 81.3 | 82.3 | 90.9 | 97.2 | 97.8 | 61.3 | 55.2 |
| Existing worker | Existing worker | 66.0 | 67.2 | 69.1 | 71.0 | 78.0 | 88.4 | 103.9 | 113.7 | 129.4 | 80.2 | 35.4 |
| | Newly commencing worker | 191.1 | 194.9 | 197.3 | 204.9 | 210.7 | 183.4 | 211.1 | 207.1 | 201.1 | 165.6 | 156.6 |
| School-based status | School-based | 13.1 | 15.8 | 17.0 | 19.0 | 20.5 | 16.2 | 18.1 | 18.4 | 20.2 | 18.1 | 18.8 |
| | Not school-based | 244.1 | 246.3 | 249.4 | 256.8 | 268.3 | 255.6 | 296.9 | 302.3 | 310.3 | 227.7 | 173.2 |
| Training package coverage | Training package | 248.4 | 255.7 | 261.3 | 270.8 | 284.3 | 269.8 | 314.5 | 320.5 | 330.1 | 245.7 | 191.8 |
| | Non-training package | 8.9 | 6.3 | 5.1 | 5.0 | 4.4 | 2.0 | 0.5 | 0.3 | 0.5 | 0.1 | 0.2 |
| **Total** | | 257.2 | 262.1 | 266.4 | 275.8 | 288.8 | 271.8 | 315.0 | 320.7 | 330.5 | 245.8 | 192.0 |

*Table 37: Australian apprenticeships 2004-2014.*

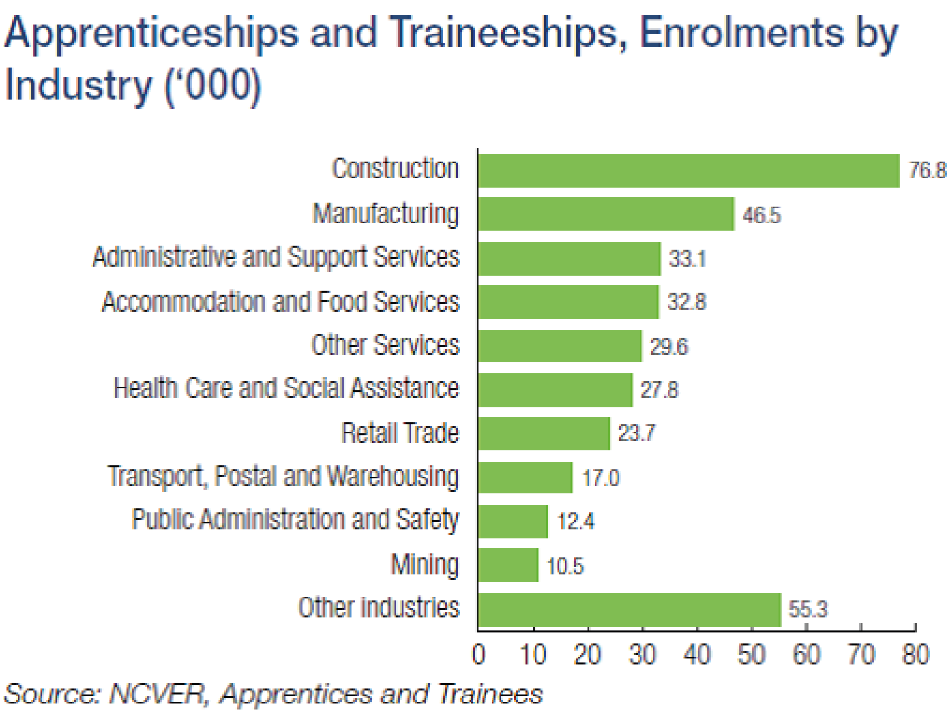



*Figure 60: Mining related apprenticeship enrolments in 2014.*

### *3.4.6 Ageing mining education staff*

The demographic issues in the mining workforce are mirrored in the academic faculty teaching mining or other engineering in Australia. Staff profiles reflect the generally ageing population but are also amplified by age clustering through past recruitment hiatuses and the skills drain into a booming industry offering higher salaries, leading to widespread retirement and skills loss in the next 10 years.

The engineering higher education sector in Australia has a range of staffing issues which include (Hugo 2010):

- Difficulties in recruiting new academics and retaining them at all academic levels. This problem may be particularly critical in some engineering schools with large numbers of academic staff approaching retirement, and in areas, such as mining and resource engineering where academic salaries and professional opportunities are poor, relative to those in the industry;
- The low numbers of female academic staff, particularly at senior levels;
- Employment of academics and tutors with poor language and teaching skills. Anecdotally it appears the mining education sector has followed in a similar way to Canada, of more overseas appointments where communication skills have not always been ideal or from industry where teaching skills were unproven.
- Additional organisational and management complexity in employing and supporting part-time staff in teaching roles;
- The low flow of engineering graduates into research degree studies, and on into academic positions, undermines the future health of the engineering education enterprise.

In their 2010 study which looked at the sustainability of mining education in Australia, Laurence & Hebblewhite illustrated the significant risk of ageing staff in Australian mining engineering departments (***Table 38***).

They also highlighted that between 2003 and 2010 those staff that were recruited were predominantly via overseas recruitment (***Table 38***).

The situation has been improved by some strategic recruitment but with an even bigger demographic gap than the mining industry, and a similar gender imbalance, there is a need for strategic initiatives around widening access and accelerated staff development even with the current industry downturn.

Age profile of Australian mining engineering academic staff.

| School | <30 years old | 30 - 40 | 40 - 50 | 51 - 55 | >55 | Total |
|---|---|---|---|---|---|---|
| UNSW | | 2 | 2 | 1 | 6 | 11 |
| UQ | | 2 | 4 | 1 | | |
| WASM | | | 2 | 2 | 1 | |
| Adelaide | | | 1 | 2 | | |
| Wollongong | | | | 3 | | 3 |
| Ballarat | | | | | 1 | 1 |

Number and nationality of new full-time mining staff since 2003.

| School | Nationality | | | | | |
|---|---|---|---|---|---|---|
| | Australia | Turkey | India | Zambia | Iran | Other |
| UNSW | 1 | 1 | 1 | 0 | 0 | 0 |
| UQ | 1 | 1 | 0 | 0 | 1 | 0 |
| WASM | 0 | 0 | 0 | 1 | 0 | 2 |
| Adelaide | 0 | 0 | 0 | 0 | 0 | 3 |
| Wollongong | 1 | 0 | 0 | 0 | 0 | 0 |
| Ballarat | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 38: Australian mining academic staff age profile and ethnicity 2003-2010.*

### *3.4.7 Outreach*

The Australian Government, Geoscience Australia (http://www.ga.gov.au/education) dedicates resources for schools to use, to get young people at primary school and secondary school age interested in geoscience. They achieve this through providing curriculum linked activities at education centres. The education centres also provide an opportunity for young people to meet geoscience staff, look at specimens, satellite imagery and also learn about the history of geoscience. They also partner with the National Youth Science Forum, which is a twelve day residential for Year 12 students who are passionate about science, technology and engineering. This enables students to learn about the career options available to STEM graduates.

The ConocoPhillips Science experience for year 9 and 10 students, is a fun science experience in which students spend 3 or 4 days at one of over 35 universities and tertiary institutions, allowing the young students to experience the laboratory facilities, lecture theatres, meet academic staff and generally experience what is like to be at university. The fee for this is between $120 and $160 which is payable by the participant or the sponsor. Classroom resources are also available for primary and secondary school levels.

Getting young people to explore career options in geoscience and experience what geoscience and engineering departments at university are like is a powerful tool that helps to encourage those with a genuine interest from a young age. The state/regional geological survey also help in education by providing information to students, particularly in tertiary education. Providing open access to mining documents, maps, and news on mining projects helps to engage students who are preparing to go into the industry and give them an early insight.

Curtin run a 5 day focus on mining residential camp for Year 11 & 12 science and maths school students interested in studying the subject.

Almost all companies undertake local outreach activities, inviting local community visits to sites, school visits, indigenous peoples' programmes, and under-represented group activities (these will be described in more detail in Chapter 4)

### *3.4.8 Australian Training and Education Financing*

In a major report commissioned by the mining industry through the MCA in Australia, partly in response to government criticism over what it perceived to be the lack of spending on industry training, NCVER concluded that "the minerals sector spent just over $1.1 billion on training during the financial year ending 30 June 2012, equivalent to almost 5.5% of total payroll. Almost 98% of this training expenditure is industry-funded, with only 2% coming from government subsidies" (NCVER 2013).

Furthermore nationally, around 80% of total mining employees participated in structured training and almost 80% of companies provided some form of support for structured training. There is a wealth of additional information regarding the relative performance of the gold, iron and coal mining sub-sectors and gender, age, indigenous peoples, roles s apprenticeships used in, company size, salary data etc.

This highlights the difficulty of accessing information on company training and education activities which are rarely fully reported. Any linear study of changes in the industry support would need to find ways to capture the relevant information without continual replication of this comprehensive review methodology.

For university studies fees are often partly government subsidized (***Table 39***) for many Australian students and there are student loan schemes available. Scholarships for university places are generally based on merit and high academic achievement, and for attracting excellent international students. Other scholarships are for those who are going through hardship and need assistance to continue their studies. These tend to be university based and awarded to individuals who can demonstrate they fulfil a certain requirement.

**Table 1 Government-funded student characteristics by state or territory of funding, January–September 2015 ('000)**

| Student characteristics | NSW | Vic. | Qld | SA | WA | Tas. | NT | ACT | Aust. |
|---|---|---|---|---|---|---|---|---|---|
| **Sex** | | | | | | | | | |
| Males | 181.1 | 230.3 | 136.0 | 50.2 | 70.6 | 19.2 | 10.9 | 10.8 | 709.2 |
| Females | 202.1 | 199.3 | 105.6 | 49.6 | 55.7 | 14.8 | 9.0 | 10.4 | 646.6 |
| Not known | 0.2 | 0.9 | 1.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.3 | 2.8 |
| **Age** | | | | | | | | | |
| 14 years and under | 0.7 | 0.8 | 1.1 | 0.1 | 0.6 | 0.0 | 0.4 | 0.0 | 3.8 |
| 15–19 years | 85.1 | 82.7 | 64.9 | 17.2 | 34.3 | 5.5 | 3.7 | 3.9 | 297.4 |
| 20–24 years | 74.0 | 88.6 | 46.7 | 18.7 | 22.3 | 6.3 | 3.3 | 5.2 | 265.0 |
| 25–44 years | 150.3 | 164.4 | 88.5 | 41.4 | 49.7 | 13.3 | 8.7 | 8.8 | 525.3 |
| 45–64 years | 67.4 | 84.2 | 39.6 | 20.5 | 18.4 | 8.3 | 3.7 | 3.4 | 245.7 |
| 65 years and over | 5.3 | 9.7 | 1.7 | 2.0 | 0.9 | 0.5 | 0.1 | 0.1 | 20.3 |
| Not known | 0.6 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 |
| **Indigenous status** | | | | | | | | | |
| Indigenous | 27.6 | 6.7 | 13.8 | 3.8 | 9.8 | 1.6 | 7.7 | 0.8 | 71.7 |
| Non-Indigenous | 351.8 | 417.4 | 206.6 | 94.8 | 104.0 | 32.1 | 11.8 | 18.5 | 1 237.1 |
| Not known | 4.0 | 6.4 | 22.4 | 1.4 | 12.5 | 0.3 | 0.4 | 2.1 | 49.6 |
| **Disability (including impairment or long-term condition)** | | | | | | | | | |
| With a disability | 36.2 | 38.2 | 12.5 | 9.8 | 6.7 | 3.0 | 1.2 | 1.8 | 109.4 |
| Without a disability | 344.1 | 386.0 | 154.9 | 90.2 | 104.5 | 30.3 | 18.0 | 19.6 | 1 147.6 |
| Not known | 3.1 | 6.3 | 75.5 | - | 15.1 | 0.7 | 0.7 | 0.1 | 101.5 |
| **Language (main language spoken at home)** | | | | | | | | | |
| Non-English | 63.2 | 115.1 | 23.4 | 14.5 | 23.0 | 1.9 | 6.4 | 3.7 | 251.2 |
| English | 289.6 | 306.1 | 196.8 | 75.3 | 87.3 | 31.5 | 12.7 | 14.3 | 1 013.5 |
| Not known | 30.6 | 9.4 | 22.7 | 10.1 | 16.0 | 0.6 | 0.7 | 3.5 | 93.7 |
| **Apprentice/trainee status** | | | | | | | | | |
| Apprentices and trainees undertaking off-the-job training | 56.9 | 63.3 | 64.8 | 6.3 | 36.1 | 9.0 | 3.7 | 4.7 | 244.8 |
| Not apprentices and trainees | 326.6 | 367.2 | 178.1 | 93.7 | 90.2 | 25.0 | 16.1 | 16.7 | 1 113.7 |
| **Total students** | 383.4 | 430.5 | 242.9 | 100.0 | 126.3 | 34.0 | 19.9 | 21.5 | 1 358.5 |

*Table 39: Government funded student statistics January –September 2015 (NCVER 2015).*

The resources sector provides significant financial assistance as a contribution to the development of future workers, and to widen participation in the industry, regardless of economic circumstances. There are many scholarship programs offered across all types of tertiary education, from a bursary towards fees and materials to fully-paid tuition and accommodation fees. These scholarships can be offered in conjunction with certain universities, TAFE campuses and training institutions or alternatively can be stand-alone scholarships that do not necessarily have commitments to a particular tertiary institution.

The Language, Literacy and Numeracy (LLN) Practitioner Scholarships Program seeks to assist in addressing skill shortages in the adult LLN field in Australia by increasing the number of qualified LLN practitioners, particularly in regional areas.

Companies and organizations also offer work experience and advanced entry into graduate programs, as well as international exchange opportunities. Examples of awards, scholarships and educational assistance packages:

- Minerals Council scholarship program
- The Awards for Academic Excellence
- The EEF Scholarships (including the Sir Frank Espie/Rio Tinto Leadership Award)
- The Rio Tinto Indigenous Cadetship
- Santos Prize
- Australian Postgraduate Award (APA)
- International Postgraduate Research Scholarships (IPRS)
- University of South Australia Postgraduate Award (USAPA)
- Rural and Isolated Scholarship
- Indigenous Scholarship
- CSIRO Postgraduate Scholarship Program

- Great Artesian Basin
- Playford Trust PhD Scholarship for South Australians
- Thomas Scholarship
- Relocation Scholarship
- AusIMM EEF Scholarship
- Atlas Copco Scholarship
- Bicentennial Gold 88 Endowment
- Maptek Mining Engineering Scholarship
- The Bob Besley Mining Engineering Scholarship
- BHP Billiton Olympic Dam Scholarship Program
- The Parsons Brinckerhoff Scholarship
- Indigenous Cadetship Support
- Santos Scholarship
- John F Kennedy Memorial Scholarship
- The Society of Petroleum Engineers Scholarship
- ConocoPhillips SPIRIT Scholarship

Apprenticeships are supported through a number of channels.

- Trade support loans
- Living away from home allowance
- User choice
- Youth Allowance and ABSTUDY

In addition to this they are usually also paid during their in-work training and availability of apprenticeships is strongly dependent on the health of the mining sector.

Mining companies also provided support in a number of other ways including:

- Employing graduates.
- Mining companies regularly sponsor barbeques at mining schools as part of recruitment campaigns.
- Providing scholarships – the cost of tertiary education is considerable and includes tuition fees; accommodation and living expenses. Many students, particularly those from rural areas, would not be able to access minerals tertiary education if it were not for scholarships.
- Providing equipment – at least one Australian mining school has a computer laboratory equipped by a mining company.
- Providing industrial training – mining is a practical business and industrial training is an essential, and sometimes compulsory, component of the degree.
- Providing access to mine sites for field trips –this again is a vital part of minerals education in a variety of topics e.g. sustainability; rock mechanics; ventilation; mining methods, etc.
- Participating in open days – this provides the credibility and evidence that mining programs are relevant.
- Providing guest lecturers – full-time academic staff cannot be expected to be expert in every part of mining.
- Providing strategic advice – advisory boards, consisting of very senior managers, provide invaluable advice to senior academics on strategic directions.
- Sponsoring continuing professional education for staff either for full degrees/diplomas or one-off short courses.
- Sponsoring industry chairs – there are currently two industry-sponsored chairs at mining schools, one at UNSW and one at the University of Queensland (UQ). These initiatives, however, tend to be ad-hoc and very much dependent on a champion or individual within a company that thinks strategically and for the long-term.

The new government National Innovation and Science Agenda will also be supporting scholarships in strategic mining related areas where the country sees itself as having an advantage primarily around mining equipment and technology.

#### *3.4.9 Australian Government-Industry Initiatives*

Government does provide a range of support for the mining sector, by establishing frameworks in which the industry operates, particularly through licencing of exploration and mining activities. It also for example, invests in and runs research centres and provides scholarships.

Geoscience Australia provides high quality geological data, research and many other services the mining industry relies on. Australia has arguably the best and most accessible online geoscience data provision that is used by industry to de-risk exploration and mining investment decisions.

There is further support for exploration in particular assisting companies by providing proof of concept, seedcorn exploration funds – these have been successful in finding new deposits and consequent job creation. The government is also committed to reducing red tape and speeding up the approvals process to reduce mining project delays and costs. They can help facilitate mine development by critical supporting infrastructure projects.

PACE in South Australia is a world-leading government-industry programme to attract investment in mineral exploration through the provision of pre-competitive exploration data, collaborative research and drilling projects, land access, cultural exchanges and a streamlined permitting as a means to promote the States mineral wealth. This has recently been extended to the new PACE Copper initiative seeking to leverage increased exploration specifically for copper in South Australia.

CSIRO, the Commonwealth Scientific and Industrial Research Organisation, is Australia's national science agency and one of the largest and most diverse research agencies in the world. It has extensive programmes in geoscience and mining technology, as well as undertaking a wide range of outreach activities in the area of mining.

The government is also establishing industry think tanks—known as Industry Growth Centres—which target the growth sectors of the Australian economy. The Mining Equipment, Technology and Services (METS) Growth Centre, METS Ignited, is an industry-led, government-funded initiative, which aims to drive the Australian METS industry to become a trusted partner of the global mining industry, helping to facilitate the mining industry's adoption of cutting edge technology and practices. This has just appointed its Board and will be in operation soon.

In terms of direct educational support government can provide international scholarships for top students to study in Australia or at specific universities and this has been used for mining education but priority areas have changed in the latest programmes. The new Science and Innovation Agenda will also be supporting scholarships in strategic mining related areas where the country sees itself as having an advantage primarily around mining equipment and technology.

In recent years the national government has also removed the mining tax and carbon taxes, and maintained fuel tax concessions to subsidize the industry. These amount to billions of dollars of state assistance to the industry.

### *3.4.10 Centres of Excellence*

There are a wide range of centres of excellence mainly connected with Universities but also some stand-alone research organisations that have industry funding. The following are some of the better known but the list is not comprehensive:

- AMIRA - Australian Mineral Industries Research Association
- ANU Research School of Earth Sciences – Australia
- Centre for Exploration Targeting - UWA, Australia
- CODES - Centre for Ore Deposit Research, University of Tasmania, Australia
- COSSA - CSIRO Office of Space Science, Remote Sensing Research, Australia
- CSIRO Exploration and Mining – Australia
- CSIRO Minerals – Australia
- CSIRO Petroleum - Development of Petroleum Products and Exploration Methods, Australia
- GEMOC - Geochemical Evolution and the Metallogeny of Continents, Macquarie University, Australia
- National Centre for Petroleum Geology and Geophysics - South Australia
- JKMRC - The Julius Kruttschnitt Mineral Research Centre, University of Queensland
- Tectonics Special Research Centre - University of Western Australia
- CEMI - centre for excellence in Mining Innovation
- The Australian Research Council Centre of Excellence for Geotechnical Science and Engineering (CGSE) is pioneering

- new scientific approaches to geotechnical engineering design
- The South Australia Centre of Excellence in Mining and Petroleum Services
- Co-operative Research Centres (CRC): e.g. CRC ORE (CRC for Optimising Resource Extraction), CRC DET (CRC for Deep Exploration Technologies), CRC MINING. These centres of applied research receive federal funding subject to industry match funding, and are run on a collaborative, 'Research Association' model where participating companies pay a membership fee to access the staff and facilities, steer the direction of collaborative research programmes and work with researchers, equipment manufacturers and others to assist in implementation of research solutions. These have been extremely successful in leveraging research around industry priorities.

Rio Tinto has its Processing Excellence Centre and is now opening its Mining Excellence Centre in Brisbane to use real time data from its processing and mining equipment at sites around the world. It will also soon have a Centre of data analytics to support this based in India.

### 3.5 JAPAN

As a country Japan lacks the mineral resources and as a result little mining activity goes on in the country today, but as a consequence of this the technological sector is very advanced and although the country does not have an extractive industry it is globally active in mineral processing technology and has interest in mines in other countries to secure its supply.

Historically it has exploited coal (Figure 61), oil, iron ore, copper and gold deposits. The main commodity exploited was coal, it was mined to meet national demand for energy supply (electric power generation) and with cheaper, better quality imports this declined rapidly in the 1980's resulting the closure of the majority of the active coal mines.

Mining in Japan has a negative historical legacy, often associated with environmental disasters and socially unacceptable working conditions. In the late 19th century and early 20th century, the Ashio Copper Mine incident resulted in pollution of river water and the destruction of the local fishing industry. As a result the government passed legislation in 1911 to address environmental pollution. It can be argued that Japan was very advanced in understanding the environmental impacts of mining.

The lack of significant ore deposits and the more affordable supply of coal from overseas effectively rendered the mining industry in Japan unviable. Known deposits are too small and financially uneconomic to work and this led to an economy based on technology and other industries.


*Figure 61: Hashima Island, Japan (also known as Battleship Island) formed a base for the undersea coal mine and at its peak was home to over 5000 workers. Today it is a tourist attraction and UNESCO World Heritage Site (http://toppixgallery.com/hashima-island-mine/).*

### *3.5.1 Mining in Japan today*

Hishikari Mine, one of few notable operation in Japan, is a gold mine which is operated by Sumitomo Metal Mining and is the only metal mine operating at a significant commercial scale. It has an average gold grade of 40 grams/tonne and has been in operation since 1985.

The main focus for Japan is however mineral processing technology, recycling (urban mining) and research into mineral substitution. In addition Japan has secured mineral supplies by holding interests in mines in other countries through shares and government partnerships.

An industrialised country with relatively poor metallic resource availability, Japan is dominated by production which relies on metal supply from overseas. During the 1960's and 1970's Japan grew to become the worlds largest steel producer but has since then been eclipsed by the growth in both steel production and consumption in China. In 2012 Japan was still the world's second largest producer of steel. Japan is also one of the worlds largest smelters of copper and other base metals primarily due to the international financing of mines and investment in mining companies that Japanese companies have made over the last 30 years.

### *3.5.2 Japanese National Workforce Plans*

Workforce planning ensures that the human capital required for the success of the industry is available; having the right people, at the right location, with the required skills, and at a competitive cost (***Figure 62***) (Mercer, 2009). In a country with the demographic challenge of an ageing population and a decreasing birth rate, human capital is in short supply and so planning for future needs is essential. Finding well qualified people is challenging even during slow economic growth and the education/skills of new industry staff is a critical issue (CEO Challenge, 2008).

Given the lack of active operations there is no real requirement for a workforce plan for Japan's mining sector. However if one existed it would likely include attracting foreign students to maintain numbers required to entre industry and sending Japanese students overseas to give them international exposure.

Japan has a well-established steel industry, and the main focus in the minerals industry is processing technology, recycling and substitution. These areas are very much looked at from an academic and research perspective and japan is dedicating academic effort into these areas.

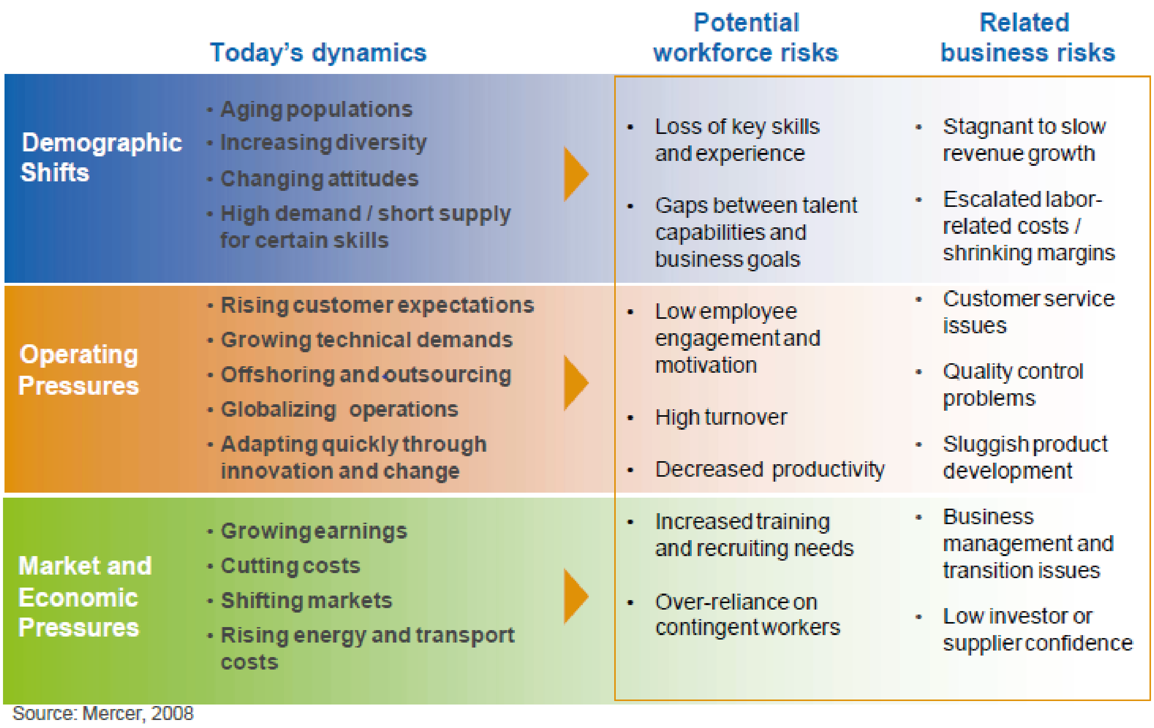



*Figure 62: Workforce risks (Mercer, 2008).*

Given the small size of this sector, a workforce plan is not necessary and the academic institutions have developed a strategy to internationalise, increase student numbers to ensure that research at this high level is maintained.

Japan is a highly skilled nation, technologically advanced with a large focus on downstream mining activities (processing, recycling and substitution).

The important stakeholders in the mining industry are described below:

**JMIA** – Japan Mining Industry Association – represents the copper, zinc, nickel, lead, gold and silver mining and smelting industry (http://www.kogyo-kyokai.gr.jp/)

**JOGMEC** – Japan Oil, Gas and Metals National Corporation – the state exploration and mining company is involved not only with investment, but also technology development into exploration, mining, smelting, refining, recycling, and deep-sea mining. Their remit is the stable supply of natural resource. A Metals Technology Centre compliments their units of mineral strategy/exploration, metal and coal financial and environmental, and stockpile units (http://www.jogmec.go.jp/english/metal/index.html).

**MMIJ** – Mining and Materials Processing Institute of Japan – professional research association with 2,000 members and 64 corporations/organizations publishing in a journal, numerous books and hosting two annual conferences. With Nippon Mining Association the MMIJ funds over £30,000 to UG and PG students annually. Other research is funded on a case by case basis. Different speciality groups within MMIJ include: earth-resources, process & materials, and environmental recycling (http://www.mmij.or.jp/about/)

**NMA** – Nippon Mining Association is part of JX Nippon Mining and Metals, one of Japan's largest non-ferrous mining, smelting, refining, manufacturing and recycling companies.

Major mining companies in Japan are Dowa, Mitsubishi, Mitsui, JX Nippon, Sumitomo, Nittestsu and Furukawa. Their joint venture projects are predominantly located around the Pacific Ring of Fire, although many new ventures are being developed in Africa (***Figure 63***).

There are numerous other organizations focused on single metals such as JCBA (Japan Copper and Brass Association), JCMA (Institute of Japanese Electric Wire and Cable Makers Association), JCDA (Japan Copper Centre), JSNA (Japan Society of Newer Metals), Japan Institute of Metals (JIM), Iron and Steel Institute of Japan (ISIJ) and various others for cera-

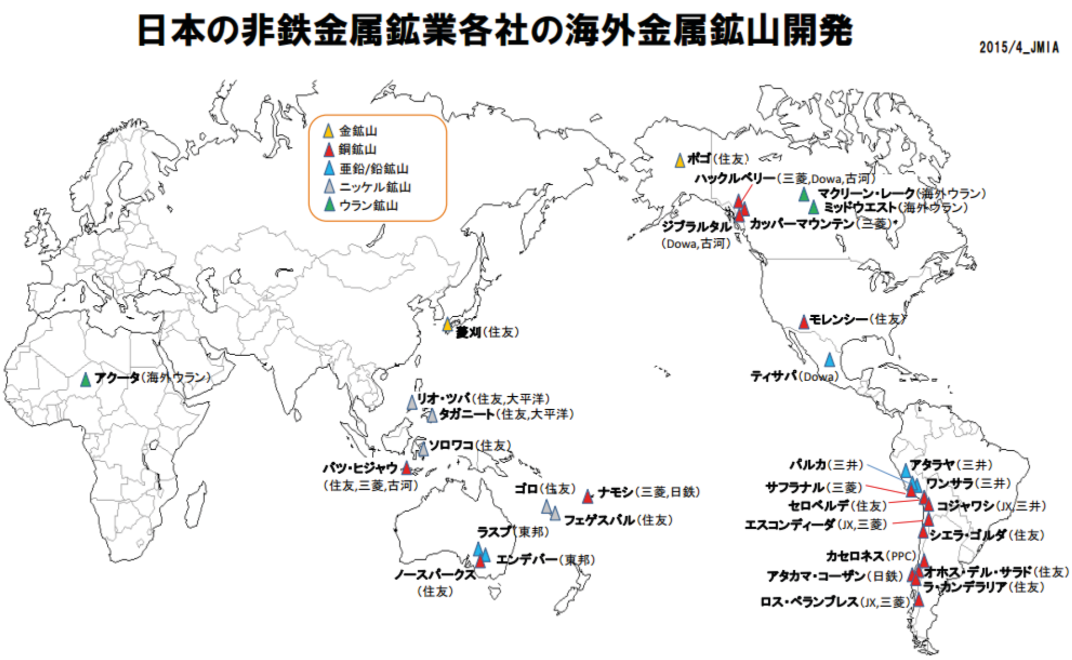



*Figure 63: JMIA Map Showing Location of Active Japanese Extraction Projects in Gold (yellow), Copper (red), Silver (blue), Nickel and Zinc (http://www.kogyo-kyokai.gr.jp/image/pdf).*

mics and other industrial minerals.

Other related organizations include the Geological Survey, Society of Resource Geology, Centre for Eco Mining, and the Japan Research and Development Centre for Metals (JRCM) which conducts R&D in metallic material manufacturing (http://www.jrcm.or.jp/en/).

The New Energy and Industrial Technology Development Organization (NEDO) addresses energy and industrial technology. The 150 billion yen budget in 2015 address raw materials in the following areas: clean coal technology; environment and resource conservation; new energy; energy systems; materials; and crossover and peripheral fields (http://www.nedo.go.jp/english/introducing_pja.html).

### *3.5.3 Japanese Education Provision*

Traditionally Japan places a high value on education and as a result the percentage of Japanese adults with a tertiary education is one of the highest among OECD countries. Japan has a highly skilled workforce, coupled with an ageing population and a declining birth rate. The main trends in University education in Japan are Internationalisation (***Figure 64***) and a change in the university system.

Attracting more international students to study in Japan has two benefits, firstly in a country with declining population this is additional human resource and secondly, and more importantly, Japanese students learn alongside overseas students thus becoming more international in their thinking and also better at competing internationally. It is anticipated that this will also encourage Japanese students to go and study overseas and gain international experience, making them more competitive on a global level.

Taken from a University of Tsukuba presentation in 2008, ***Figure 65*** illustrates Japan's success at attracting foreign students and also the number of Japanese students studying overseas.

The majority of overseas student studying in Japan (over 70%) are from Asia (China, Korea) with less than 20% from Africa, Europe. Middle East, North and South America. With a decreasing 18 year old population, Japan must attract young people to study and carry on the research and development at higher education institutions.

As of May 2015, Akita University had 12 students from African countries, on mining related courses; often in countries where Japanese companies operate or finance

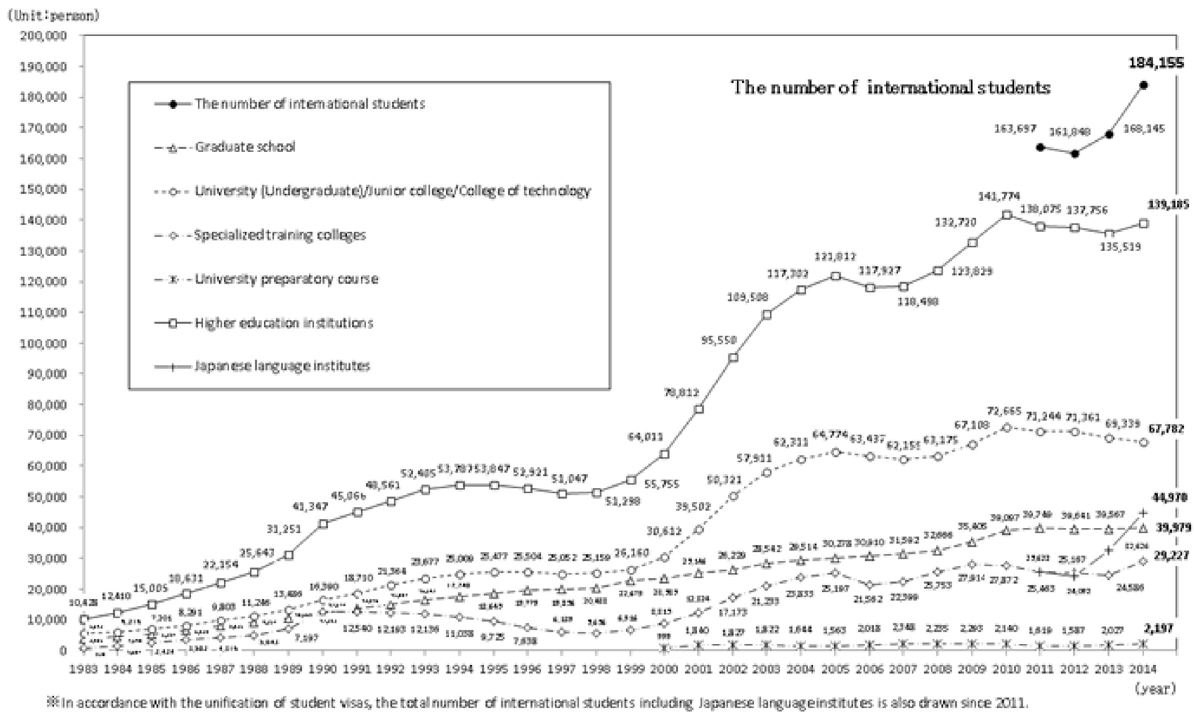



*Figure 64: Rise in International Students in Japan (http://www.jasso.go.jp/statistics/intl_student/data14_g_e.html).*

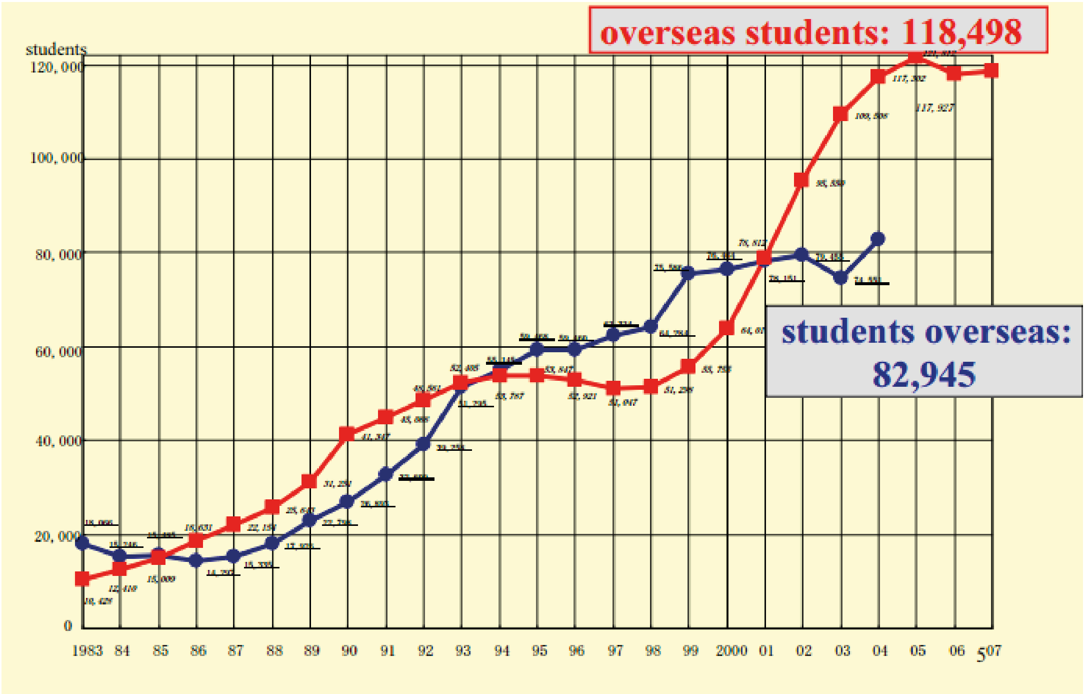



*Figure 65: Rising Overseas Students and Students Studying Overseas (University of Tsukuba, 2008).*

| Institution | Main research focus (minerals related) | Number of staff | Undergraduate | Postgraduate (MSc and PhD) |
|---|---|---|---|---|
| Akita University, Department of Earth Science and Technology<br>ICREMER- International Centre for Research and Education on Mineral and Energy Resources. | Ore deposit exploration<br>Recycling<br>Mineral resource development<br>Smelting- Materials<br>Environmental evaluation and preservation<br>Mineral economics and evaluation | 8 Professor/ Associate Professors | | |
| Kagoshima University, Department of Earth and Environmental Science | Mainly focused on geological sciences, volcanology and seismology. Not mining focused. | | | |
| Waseda Unviersity, Department of Resources and Environmental Engineering | | | | |
| Kyoto University, Department of Civil and Earth Resources Engineering | Mainly focused on Geotechnics and hazard mitigation, geomechanics, Earth crust engineering (hydrothermal), none mining related | | | |
| Kyoto University, Department Materials Science and Engineering | Metallic material design, Aqueous Processing of materials, Advance Smelthing, Titanium smelting process, | 7 | 15 | 3 |

| | | | | |
|---|---|---|---|---|
| Hokkaido University, Graduate School of Engineering | Advanced Mineral Science | 3 (according to webpage accessed January 2016) | 7 | 16 |
| University of Tokyo, Department of Materials Science and Metallurgy | Material design and processing<br>Research on: steel making, recycling and high temperature materials processing. | | | |
| Kyushu University, Department of Earth Resources and Engineering<br>Well established with 4000 alumni since 1914. | Economic Geology, Exploration Geophysics, Geothermic, Resource production and safety engineering, Rock engineering and Mining Machinery<br>Mineral processing, Recycling and Environmental Remediation. | 18 (Professors and Associate Professors) | | |

*Table 40: Japanese mineral education institutions.*

mineral extraction and normally related to partnerships with specific universities such as in South Africa (Wits), Zambia, Botswana, and Mozambique.

In order to maintain a highly skilled economy requiring well educated graduates, Japan offers university programmes at Undergraduate level, Postgraduate level (MSc) and PhD in areas related to mining.

Japan mainly has interest in the downstream mining activities and as such there is a major research focus on downstream activities such as processing technology, material science and substitution. The number of students is generally smaller than for other disciplines as indicated in ***Table 40***.

A snapshot of some of these universities is provided above.

### *3.5.3.1 Akita University, International Resource Sciences*

Akita University (***Figure 66***) was established in 1910 as the Akita Mining College Department of Mining Engineering and continues to provide education and research in applied earth sciences (geochemistry, energy geology, geophysics) and geo-engineering (rock engineering, mine design, mineral transport system technology). After several re-brandings, in 2014 the Department was re-organized into the Faculty of International Resource Sciences and the Faculty of Engineering Science. Their conception of resource science education demonstrates Japan's unique geography and resource policy perspective:

As of 2014, their Graduate School of Engineering and Resource Science (http://www.eng.akita-u.ac.jp/eng/gp/dd/ggme.html) has 3 Departments:

1. Resource Policy and Management (global resource policy, economics, law) with 30 students/yr and 12 faculty members;
2. Earth Resource Science (incl. resource geology) with 35 students/year, 13 faculty;
3. Earth Resource Engineering and Environmental Science (including mineral processing, chemical/materials engineering, energy


*Figure 66: Akita University Mission Statement.*

resources) with 50 students/year and 12 academic staff.

Akita's International Centre for Research and Education on Mineral and Energy Resources (ICREMER) is a post-graduate research organization with English-based instruction within the Graduate School of Engineering and Resource Science and active in several fields (staff number in brackets) (http://www.akita-u.ac.jp/icremer/eng/program.html):

- Ore deposit exploration (3);
- Environmental evaluation and preservation (1);
- Energy resources (2);
- Recycling (2);
- Smelting (2);
- Mineral Economics and Evaluation (1).

ICREMER has partnerships with mining/minerals universities in every country around world including: Lulea, Frieberg, East Kazakhstan, Mongolia U. S&T, Curtin, Tasmania, Montana Tech, Newfoundland, Ottowa, and Santiago. In addition, the university has extensive domestic cooperation with other universities and companies such as Dowa, Mitsubishi, JX, Sumitomo, and government through JOGMEC and others.

Their latest course offering is a 5-year doctorate course called the "New Frontier Leader Program for Rare Metals and Resources". It combines 22 professors from Akita, 8 others from five other Japanese universities, and another 8 from overseas institutions. The program combines laboratory, research and overseas internships/field experience and is split between two courses: earth science and technology; and resource development and processing.

#### *3.5.3.2 Waseda Department of Resources and Environmental Engineering*

Waseda is another school with a long history in raw material supply and was also established in 1910 as the Mining Department. The name changed in 1988 following the changing environmental ethics within the country. Waseda offers majors in four areas: science and engineering of the environment; resources and materials; earth sciences; and resources and environmental engineering. Many students are generously supported by industry and there are high employment rates upon graduation. Approximately two thirds of graduates advanced to Graduate School. Following this, the main employers are engineering firms and oil and gas companies although mining companies are also significant including Sumitomo, Dowa, Taiheiyo Cement, Yoshizawa Coal Industries, Mitsui, and Mitsubishi (***Figure 67***).

There are five research divisions at Waseda:

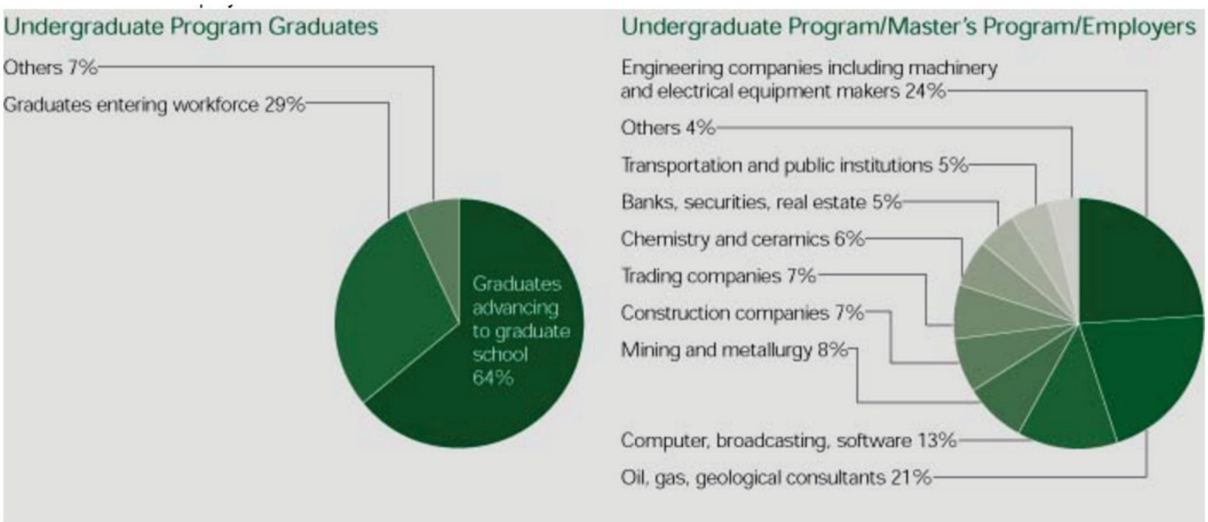



*Figure 67: Waseda University Engineering Graduate Destinations.*

1. Mineral Resources– mineral deposit petrology, mineralogy, exploration, development and processing;
2. Exploration – geophysics, imaging techniques, hydrogeology, fluid behaviour and rock strata stability (petroleum, geothermal focus);
3. Resources Recycling – separation, recovery and recycling of materials;
4. Environmental Safety – hazard measurement, evaluation and treatment methods; water pollution and recycling;
5. Geology – general earth science, structural geology, palaeontology, petrology.

#### *3.5.3.3 University of Tokyo, School of Engineering, Department of Systems Innovation*

One of the oldest and most highly regarded engineering schools, the University of Tokyo is involved in several raw materials education programmes and applied research; but it is understood within a broader 'geosystems' concept of mineral use in society. For example, three staff specialize in "geosystems engineering" and recycling technology, whilst two others are within more conventional earth systems and resource engineering positions. Raw materials education and researched is integrated across several departments including applied chemistry, materials engineering and geography.

An example of the fundamentally different conceptualization of minerals education can be understood in their research speciality "Global Circulation System", described as:

*"Dealing with a global circulation system consisting of circulation of resources, energy, humans and products, information, value, services and others, we will present education and research on a global and high added-value circulation system that ensures symbiosis among nature, human, society and human-made objects. Our education and research will serve to comprehend all these factors involved in circulation with multilateral and panoramic viewpoints."*

The research areas revolve around terms such as: recycle; reuse; reduce; zero emission; global design and production system; logistic and transportation system; energy system; environment and energy policy; waste processing; conservation and purification; earth monitoring; use of outer space and marine; resource circulation; hydrological circulation" (http://www.sys.t.u-tokyo.ac.jp/en/research/).

### *3.5.4 Japanese Training and Education Financing*

JOGMEC, the Nippon Foundation, and mining companies support education, which includes support for domestic students. However the majority of educational financing is spent on students in those countries where Japanese companies operate.

In addition to general social developing funding of local primary and secondary schools in their areas of operation, Dowa Group has a generous internal training program for young engineers. In 2012, there were several dozen enrolled onto programs for business leadership, management, proactive leadership training, cognitive reasoning, presentation skills, and career training. In addition, Dowa operates an exchange program with Tohoku University supporting 20 students annually research materials technology.

Mitsubishi funds scholarships around the world in partnership with other mining companies, such as BHP. Their joint support in Australia, the BMA Indigenous Scholarship Program, provides 10 AUS $20,000 4-year scholarships for local aboriginal students and other Australian citizens. They also offer a Rural Scholarship in Mining Engineering at the University of New South Wales in Australia, as well as funding special lectures. They are one of the many contributors to the U.S. Copper Club Educational Grant Program.

(https://www.cqu.edu.au/coursesandprograms/scholarships/offerings/bma-community-scholarship-program).

Mitsui also has scholarship programs in partnership with both BHP and Anglo American related to coal projects in Australia, and in addition funds a study tour of Japan for Australian students. Sumitomo is one of the largest Japanese mining companies active in Australia, U.S.A., Canada and further afield with both secondary education grants and scholarship programs in each country. In Arizona, Sumitomo funds tertiary education grants to students in related industrial technology fields at the trade skills and polytechnic level. In Asia, the Sumitomo Scholarship is established in many countries. In Alaska, where Sumitomo operates a gold mine, they fund US $1 million every other year to the local mining department at the University of Alaska Fairbanks.

For international students, especially in Sub-Saharan Africa, the Japanese International Cooperation Agency (JICA) funds scholarships for geoscience and minerals engineering students to study in Japan, via university partnerships in South Africa, Botswana, Mozambique and Zambia, among others. In this way, it helps to address the minerals skills shortages experienced in these developing countries.

#### *3.5.5 Japanese Government-Industry Initiatives*

The government along with academic institutions have formed partnerships strategically with mining (and non-mining) countries (see above). Japan holds an interest in many mines and mining companies around the world to ensure that it has a secure supply of minerals for its technological and manufacturing industries.

The resource development policy of Japan is focused on secure, stable, overseas resources which translates into investing around the Pacific Ring of Fire, Asia and Africa, as well as stockpiling of rare metals for the hi-tech manufacturing sector. JOGMEC, the state mining investment company, has activities in four areas, as described in the Ministry of Economy, Trade and Industry (METI) 2009 policy document: Strategy for Ensuring Stable Supplies of Rare Metals:

- **Secure Overseas Resources** – promote grassroots exploration and fund advanced exploration (bases metals, rare metals and uranium; e.g. a 50% stake in Ytterby REE project Newfoundland or Strange Lake HREE deposit) and financing: Ivanplats Platreef PGM-Ni, Lynas Mt Weld REE, Endako molybdenum, lithium brine projects in the USA, Chile and Bolivia;
- **Recycle** – develop technologies;
- **Develop Alternative Materials**;
- **Stockpile**.

JOGMEC began stockpiling rare metals in 1983, to ensure a stable domestic supply for manufacturers, inside a 37,000m2 warehouse. Rare metals include: chromium, cobalt, manganese, molybdenum, nickel, tungsten and vanadium. (http://www.acq.osd.mil/mibp/docs/nds_reconfiguration_report_to_congress.pdf). The national stockpile has public and private stockpile. The national stockpile is 42 days of reference consumption, and private use estimated at 18 days for a total of 60 days of total short-term buffer capacity. In addition to the rare, low tonnage metals such as REEs, niobium and phosphate; Japan also stockpiles steel, copper, lead and zinc. Japan also has a high scrap steel stockpiling rate and encourages recycling (http://www.kogyo-kyokai.gr.jp/category/1850706.html).

### *3.5.6 Japanese Minerals Research Landscape*

Japan has only two active metal mines in the country, and these small tonnage, high-grade and high-tech mines along with the large mineral processing industry (chemicals, fabricated metals, industrial mineral products, iron and steel) are reflected in the provision of research funding. The main focus is downstream activity into mineral processing, minerals technology, steel manufacturing, geothermal energy, seabed mining, recycling and urban mining.

In 2011 JOGMEC was investing over USD $300 million into deep-sea robotic mining technology and assessing deposits around the waters of Japan and Southern Asia.

The Nippon General Foundation Mining Promotion Association provides research grants into metalliferous mining and holds an annual review meeting each November. They also publish a journal.

# 4. Strategic issues

Several fundamental factors control the way mining is developing. The depletion of near surface high grade deposits from hundreds of years of mining have led to our reduced success rate during exploration, more advanced exploration needing to be undertaken and exploiting larger lower grade deposits which are being worked using the economics of scale. The mines are therefore getting larger and more mechanised and their development is more expensive and capital intensive. While on a global scale the informal artisanal sector still employs the most people, global mine production in most commodities comes from medium to large scale formal mining sector operations. There are a range of strategic level issues that occur on a global basis that influence the need for education, training and outreach for the mining industry. These are a function of the nature of international mining sector and are manifest in different ways within the INTRAW reference countries.

#### *4.1.1.1 Mining Skills through the life of a mine and a mining cycle*

The need for mining skills differs through the life cycle of an individual mining operation (***Figure 68***). During the exploration and evaluation stages exploration managers, geoscientists, field staff, drillers, and an evaluation team are central requirements. These are often supplemented by a wide variety of consultants undertaking work related to environmental impact assessments that are essential for regulatory approval. This builds to a comprehensive multi-disciplinary team including financing and legal staff ahead of any decision to build a mine. It is however at the construction stage that the largest number of company staff and contractors are needed, covering the full breadth of planning, design, engineering and construction functions, as well as the mining and metallurgical fields.

Historically the end of this 2-5 year construction period would see a reversion back to a core complement of company staff who would manage and run the mining and processing operations, however increasingly mines contract out significant production activities such as drilling, blasting, haulage, crushing, mobile plant maintenance, etc. This is for reasons of capital or operating efficiency and to maintain flexibility in the cyclical mining sector. This trend, especially in major mining countries like Chile which have some of the world's largest mines, results in mining and processing facilities being populated by two major types of workers - direct employees and contractors who typically perform different roles, have separate employers and often have different terms and conditions. Contract and project management skills are therefore increasingly required by company staff to avoid major cost and industrial relations issues.

The mine construction contractors and engineers, and contract mining suppliers, therefore also require skilled mining personnel and have to recruit alongside the main mining companies. They work on a global basis and include companies such as Barminco, Bechtel, Fluor, Redpath, Cementation, Thyssen Mining, Dumas, Harrison Western and SNC-Lavalin. Skills shortages therefore affect not just mining company but also the contractors who mining companies use to manage staff demand using the contracting process.

During the operational life of the mine the professional skills sets required are dictated by the technical and administrative processes of mining, processing and allied activities. Mines that extract and sell metal concentrates as their primary product naturally require mining geologists, mining engineers and mineral processors with a team of administrators to cover the aspects of safety, HR, finance, logistics, accommodation etc. More vertically integrated companies with added value operations that use these intermediate materials to make higher value products necessarily require extractive

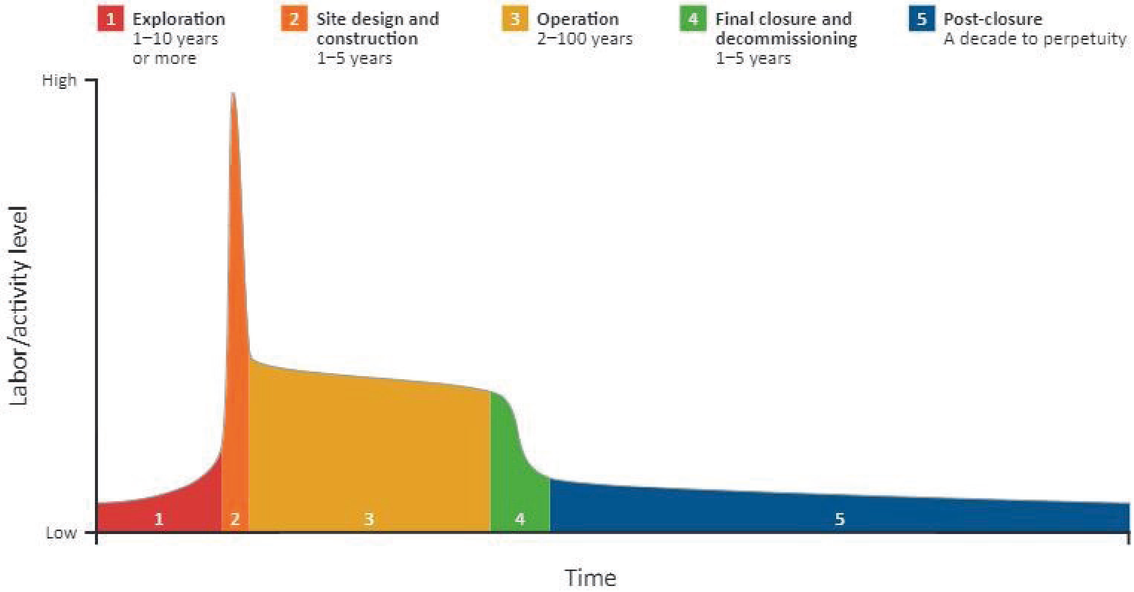



*Figure 68: Stages of a mine with indicative labour/activity levels.*

metallurgists, pyrometallurgists, furnace operators, heavy engineers, chemists, and more specialist materials scientists. They may also require sales and marketing teams to sell their products.

During the cyclical changes in commodity prices and demand for mined products, activities such as exploration and mine investment also fluctuate. This, for example, drives the demand for exploration staff as commodity prices rise, and in downturns metallurgical staff are frequently in demand as companies seek new processing options to reduce costs and maximise product recovery. The link is even clearer at present with mine building and expansion activity subdued, and the demand for construction staff considerably lowered.

#### *4.1.1.2 Trends in Mining Skills*

There are many other industry and societal trends that have changed the skills requirements for mining companies. Most profound have been the exponential increase in environmental legislation and regulatory oversight. This has increased the need for environmental monitoring, continuous reclamation, remediation, aftercare, environmental reporting, and new specialised activities e.g. animal relocation and habitat re-creation. Critical infrastructure such as tailings facilities and waste tips, as well as water treatment and discharge facilities are now designed and monitored by specialist engineers to avoid the major pollution incidents that have, and occasionally still do, give the industry a poor reputation for environmental responsibility.

The industry has also fully embraced the issue of safety and occupational health leading to greater demand for safety specialists that have driven down the prevalence of accidents and fatalities across the mining industry over the last decade. This is usually the company's highest priority and the increased safety culture pervades every aspect of the company's activities with risk assessment and risk management a core staff requirement.

The issue of sustainability as applied to mining has also created demand for specialists in what is a very broad area of a company's activities. Understanding the need for companies to secure not just the legal rights to operate a mine but the 'social licence to operate' from governments, communities, and other stakeholders has become a driver in terms of different skills required. The core mining and processing skills remain but increased engagement with and investment in communities, maximising local employment, increased CSR programmes, better communications or improved environmental management - all have increased the demand for staff with relevant skills that cover both technical aspects of mining but also ability to engage, communicate, and negotiate with a wider set of stakeholders. Community workers, government liaison officers, communication teams, environmental technicians, and CSR programme developers are now essential parts of the mining complement to ensure that a company maintains the best possible relationships where it is operating and avoids costly and reputation-damaging stakeholder conflict.

#### *4.1.1.3 Skills profiles for different scales of mines*

Mining education and training requirements in support of a national mining sector or an individual company depend significantly on the scale of the operations, level of mechanisation and automation, ownership, national regulatory environment and the existing pool of skills.

Major companies generally develop world-class 'Tier1' i.e. large-scale, long-life deposits which require major capital investment, bulk mining techniques, involve significant automation, and typically operate to international best practice standards. Their mines are therefore not built to reflect local or national technology and engineering levels but use world leading technology wherever the mine is located. As such the jobs available require the ability to handle this technology and in some mining locations this represents a huge challenge where the local education system does not prepare people for this type of work.

Where the mining industry is working smaller scale deposits, by less sophisticated methods with simpler technology, the technical skills may be more easily available or acquired by local people and employment routes into the mining company are more straightforward.

Although not a major part of the European mining sector, artisanal operations are usually operated by unskilled or semi-skilled labour and training for them is often provided by NGO's and international outreach programmes - e.g. the United Nations Environment Programme (UNEP) who provide training materials and support artisanal mining communities on simple technology, and avoiding dangers in, for example, the use of mercury in gold recovery.

#### *4.1.1.4 Demographic gap and skills*

During the major boom in commodity prices and mining stocks, between approximately 2003 and 2011, there was a wave of mine expansions, new mine development, infrastructure projects, and in countries such as Australia, a parallel public and private sector construction boom. During this period the demand for technical mining skills, trades, and technicians outstripped supply.

This situation was partly inherited from the last downturn during the 1990's when mining companies stopped recruiting professional mining staff. This has led to a demographic gap in most companies with a small number of now senior staff who were retained through that period and then only junior staff who were recruited during the recent boom. The 10-20 year gap created by this have made 20+ year experienced staff both scarce and hugely expensive. As a result during the boom many deferred retirement, were headhunted at high salaries, and could move to locations of their choice.

During the same period people from other technical backgrounds came in to mining attracted by the high wages and some companies had to rely on partially or incompletely trained staff. Come the recent cyclical downturn however there has been major retrenchment programmes in the industry. Some staff have left for allied businesses, the older generation are retiring and companies are again not recruiting younger staff. There is a very real danger of re-creating the skills shortages for the next upturn. In some companies relatively inexperienced staff are now starting to run major technical functions in their mines. There is an urgent need to capture depleting experience and corporate knowledge, and to de-silo and add practical skills to the new graduate employees.

Despite the reduced demand for staff at present, Canada for example, still anticipates major skills shortages compounded by their ageing population and 'baby boomer' retirements, such that even in the current downturn a major recruitment programme is required.

This highlights the major challenge of managing skills availability through global commodity cycles. The industry has failed to predict demand 'through the cycle', believing its own PR (public relations) of the 'commodity supercycle' and continual growth in China. The major new projects constructed during the boom have now come on stream at the same time as the metal demand has declined. Skills shortages may therefore have been deferred but they have not gone away. There are however other regional, local and specific skills issues at work.

#### *4.1.1.5 Resource nationalism / producer power*

The major producing countries, particularly in the developing world, see mining as a vehicle for not only generating government income (royalties and tax revenues) and foreign exchange, but as a vehicle for economic growth through employment of their own people. The employment model of experienced expatriates working and running mines is a major political issue particularly in southern Africa, and most producer countries are limiting multi-national companies' ability to recruit beyond their citizens. If skills are not available the companies must invest in training and development both as good corporate citizens and for their own needs. This can be extremely difficult for mining companies where basic education levels and quality are poor, and in some regions mining companies are expected to effectively pull up the whole education system to try and secure the skills required. Mining companies are however not in the business of running primary, secondary and tertiary education systems nor indeed are they best equipped to do it. The private sector are therefore often enlisted to help and this risks two–tier schooling and mining education provision. It can also be a divisive issue as mining companies expect governments to use their major receipts from mining to improve the education provision while governments often seek this as additional investment from companies as part of their corporate and social responsibility (CSR), community or strategic national investment. Companies typically resolve this by investing in local schools, scholarships for local people to gain skills for working in mining, and through strategic donations to improve the equipment base and facilities at relevant training centres and universities.

Governments also influence overall employment levels through initial licensing approvals and periodic renegotiation requirements for a range of licences required to stay in operation. The record of employment of nationals is often taken in to account and in this way they influence employment rates, and staff demand. In many mining countries governments also seek or demand partial ownership and exercise this through seats on the Board to promote their employment agenda. It should therefore be remembered that employment rates as exercised even by multi nationals in countries such as Zambia are strongly influenced by government and political control. This is becoming a major issue at present as companies seek to retrench staff to stay in business against governments stated political demands. Resource nationalism means that, even if world skills supply are sufficient, withholding visa's for non-citizens means that national shortages can still occur despite international oversupply.

#### *4.1.1.6 Economics of scale and technology introduction*

With centuries of mining perhaps the majority of near surface, high grade deposits of most metals have been found and worked. The mining industries answer to decreasing ore grades and difficulty of replacing reserves and finding high-grade deposits has been to move towards larger, low grade deposits – an example being the very large copper porphyry open pit mines in Chile. To be economic these must have high outputs and working at this scale requires large mechanised operations. As a result the operational staff needed must be able to operate expensive high capital cost plant with a commensurately smaller workforce. This however contradicts the governmental ambitions of maximum employment and creates a tension with producer country governments, unions and existing staff when companies seek to invest in new, more efficient technology at the expense of employment.

Over the mining boom capital and labour productivity in the mining industry has declined. Companies achieved higher production by high wage agreements, through expensive new capital investment, and partly due to the requirement to maximise employment by producer countries and the desire for companies to be seen as good partners to the producer government. With a downturn in demand there is a need to roll back staffing levels & restrictive work practices as maintaining high cost labour is making some mines uneconomic. In Australia this is now recognised and international competitiveness of the mining industry is under scrutiny.

#### *4.1.1.7 Temporary national shortages*

There are national variations regarding skills availability based on both the national mining project pipeline and other world-class engineering projects. In Australia the construction of the LNG ports and oil and gas facilities in the northwest also happened at same time as the mining boom, and together caused a building boom for new domestic housing. The new Panama Canal Expansion project which is due to be completed shortly has employed virtually all Panamanian engineers at a time that mining companies are also seeking to recruit such staff.

The dual issues of reducing availabilities of visa's to expatriates and with low quality training of national citizens combine to cause not a lack of people, but a lack of appropriate skills in some countries. Many companies reporting a lack of available mining skills are highlighting the skills level rather than number of potential employees.

#### *4.1.1.8 Educational skills shortages*

Skills shortages also operate in education and training for the mining sector. There are equally few industry experienced educational staff available to teach trades, practical mining skills and specialist mining subjects at higher education levels. This has occurred for the same reason that there are relatively few such individuals but exacerbated by the lower salaries in the education sector as opposed to industry, and the demise of many such training and education programmes during the mining doldrums of the 1990's.

As a result new graduates and trainees frequently lack 'mining ready' practical skills and there is a dislocation between the training delivered and the needs of the mining industry. Another challenge facing higher education institutions in all the reference countries is the need for their staff and departments to focus on highly-rated research publications, usually in areas of 'blue skies' research, that will be ranked of international importance in research assessment exercises. League tables, national and international rankings of individual academics and departments have made this an imperative for continued employment in most cases. As a consequence the emphasis on mining industry aligned higher education has been greatly diminished over the last decade. South Africa perhaps was more balanced than elsewhere in this regard with a continued healthy regard for industry involvement and collaboration.

Fortunately during the mining boom Departments could attract research income from industry and in many cases were the recipients of very generous donations and investment from companies operating in these countries. Significant investment has occurred in all the reference countries other than Japan through such industry donations, although the Japanese have themselves been donors in countries in in which they operate. In addition in Australia and Canada strategic government investment was given to develop centres for international mining education initiatives in developing mining countries, ostensibly as an aid exercise but also to promote the Australia's mining education sector to governments and local education providers.

The future challenge is that with industry less able to help invest in Universities, and many governments cutting back on mining relevant research grant provision, academic staff will have to look much harder at maintaining industry involvement and will switch to less applied research activities and associated publications upon which their performance will be judged.

#### *4.1.1.9 Joined up educational provision*

One of the key challenges in developing mining countries is to meet the aspirations of government and communities for the maximum employment of local people in the mining operations. Companies, international training providers and national education institutions can all help with this issue. However, in practice, a common problem is the low academic level of existing schooling and attainment levels of individuals who wish to enter the industry. The specific training for mining careers is therefore ineffective until basic skills levels can be elevated and this usually requires long-term engagement with education providers, education Ministries and even with accrediting bodies around a suitable education and qualification framework in which to operate.

The ability for talented young people in producer countries to pass through a joined up education system that effectively prepares then for employment in a world class mining operation and, better still, to realistically aspire to senior levels in that organisation, are critical factors in sustainability of mining, the social licence to operate and strongly influence the type of educational provision required.

In the reference countries basic educational levels are generally high and the main issues are around appropriate curricula for entry into the industry. In South Africa there are strict qualifications frameworks but access to high quality schooling is still patchy and leads to youth frustration. The Universities teaching mining are also of high quality and have benefitted from industry investment but non-completion rates are sometimes extremely high primarily due to low literacy and numeracy skills.

The importance of 'joined–up ' education provision that can lead students of more practical aptitude into mining related trades and technician roles, and more academically adept students into industry relevant and recognised higher education courses, cannot be overstated.

While traditional education is widely used there are a range of 'experiential mine training facilities' run by companies or part of university facilities, were students or employees can gain practical mining skills while studying for their mining qualifications.

Examples include:

- TU Bergakademie Freiberg
- Montanununiversitat Leoban
- TU Clausthal
- University of Miskolc
- TU Delft
- University of Exeter Camborne School of Mines
- Colorado School of Mines
- University of Arizona
- University of Alaska Fairbanks

Mining companies are also using old mines or areas in operational mines for training and research especially linked to programmes around best practice and future mining technology and practices.

#### *4.1.1.10 Educational themes*

During the 1990's the received wisdom in many countries was that mining was a sunset industry; or twilight industry, and in irreversible decline. It was perceived as having poor environmental credentials and was mainly a manual occupation without the excitement of the new high tech industries that were emerging. Mining was rarely part of the school curriculum and re-cycling was proposed as the solution to almost all raw material supply issues. In this context a whole generation of young people were taught at school that mining was at best an unpromising career and at worst an unethical and morally questionable pursuit. This manifests itself in a lack of public appreciation for the industry and a lack of enthusiasm for young people to train for the industry. This is being slowly reversed by outreach activities, curriculum development, schools engagement, and high-profile role models but there is much still to do.

There is clear evidence that because

of the 3-6 year timescale for training professional mining staff educational activity lags business performance and skills needs. Student recruitment peaks at or after the industry high point in the cycle and by the time they graduate the industry is seeing or well into a downturn. Equally as it is growing and requiring more skilled staff the student recruitment decline through the downturn means that the graduating numbers are insufficient. This is happening now as the numbers graduating in Mining Engineering after many years of stagnation are at a high point but the industry is not in a position to absorb these staff, except those that meet the national interest of certain producing countries.

#### *4.1.1.11 Changing generational attitudes*

Both in developed and developing countries there have been issues regarding whether graduates or trades staff are prepared to work in remote mining locations as compared to other opportunities in urban centres. In such countries the growing well-educated, urban middle-class do not always wish to work at remote mining operations on rosters or with shift patterns that mean they spend significant time away from their families. In some developing mining countries, particularly with multinational mining company operators, the relatively high wages counteract these trends.

A further challenge to recruiting new graduate mining staff is that in many developed mining countries there is a perception that the mining industry is a difficult place to build a career. Companies have eroded trust by boom and bust employment–retrenchment cycles, and this is being seen by potential graduate entrants as a reason to seek other career routes. Many mining graduates indicate they would prefer consultancy more than direct mining employment.

Even more fundamental is the changing nature of younger generations in terms of their aspirations of work and the conditions they would expect to encounter. There is a much reduced concept of lifelong careers with single companies, and especially with the industry attempting to attract more women into mining there needs to be radical thinking around what appears to be a still rather macho culture in favour of a more family friendly working environment.

#### *4.1.1.12 Unionisation and labour costs*

While the negotiation of appropriate salaries and conditions is greatly facilitated by representative labour organisations these have also been cited as major contributors to the rising costs in many mining countries. In order to avoid labour disputes and disruptions during the recent commodity boom wage settlements and working practices have been agreed at levels which are seen as increasingly unsupportable with lower commodity process. This is of course challenged by labour organisations who are seeking the best conditions for their members and a share in the profits of the mines activities. Growing unionisation in countries such as South Africa and Chile is seen as a growing risk for mining investment. These problems of high or increasing costs are hard to reverse in down cycles and so particular countries become unattractive to mining investment. Australia has been highlighted as an example of reduced competitiveness and an excessively expensive location for mining to operate, while South Africa has been seen as a problem for labour disruption. Investment in more productive mining equipment has been actively resisted in such countries where it might impact jobs. The trend of larger-scale mining, more automated equipment, and higher technology drives the need for different types of skilled employees and training. Companies seek locations with flexible, well-trained labour and a well-regulated labour environment in which to operate.

#### *4.1.1.13 The current mining industry downturn*

The current decline in metal prices has led to a sharp correction in supply by the mining industry and aggressive cost reduction to stay in business. This has involved major job losses across the world involving all sections of the mining workforce.

Recent announcements are highlighted

below:

*"Anglo American to slash workforce by 85,000 amid commodity slump … and is selling or closing up to 35 mines. The company is reducing its assets by 60%. In a presentation to investors, Anglo American said it would sell or close up to 35 mines, leaving it with about 20 sites and cutting employee and contractor numbers from 135,000 to fewer than 50,000 after 2017.*

*Anglo American's shares, which have lost almost three-quarters of their value this year, fell more than 12% to a new all-time low of 323p".*

*The Guardian.Tuesday 8 December 2015 12.20 GMT*

*"About 30,000 fresh job cuts, more mine closures expected in Australia. The Australian mining industry is bracing for more job losses and mine closures next year as coal and iron ore prices remain depressed. Almost 80% of mining leaders are reducing capital expenditure, up from 44% last year, the latest annual report by Newport Consulting shows.*

*'We will maintain controls on spending, capital expenditure is at a minimum and we have made redundant thousands of people. We don't believe we can cut more. If the market does not improve, we will close mines and put them on a care and maintenance regimen.'*

*The survey also suggested that the pain is spreading from the miners themselves to ports that service them and the rail contracts that get product to the wharves.*

*'Supply chains are suffering, employment is suffering, and mines that cannot be run profitably are being closed and there are a lot more redundancies coming,' Newport Consulting managing director, David Hand, said in a statement.*

*He added that he expected more mines to close and there could be as many as 30,000 jobs lost across Australia over the coming year, especially in the coal states of New South Wales and Queensland."*

*Infomine - Cecilia Jamasmie | July 29, 2015*

Some of these are unprecedented in scale but reflect the massive increase in staffing associated with the boom years of the 2000's. It is clear therefore that at this stage near the bottom of the commodity cycle there are a wide range of mining staff and employees available for potential mining operations to hire. However this has always been the case during cyclical downturns and to some extent the extremes of the boom and subsequent slump have further highlighted the problem of the mining sector employment model needing sufficient staff available at a reasonable cost for the periods of maximum demand that can be dispensed with when the industry does not need them.

This is effectively similar to 'seasonal work' in many locations where people have to make sufficient income during the good times to sit out the bad, or have more than one occupation they can revert to as needed.

Of course this also relies on mobility of staff, both their being prepared to move to where mining jobs may be available or, as discussed under resource nationalism, whether they are permitted to take up such jobs even if they were available.

#### *4.1.1.14 Addressing minority groups, communities living near mining activities and other disadvantaged sectors of society*

A major recent issue relates to skills availability from local communities and mining education occurs because of both native peoples land rights and indigenous peoples preparedness for work in the mining sector.

In Alaska, for example, the settlement of mineral ownership of large tracts of land to native corporations has established partners for development that directly benefit indigenous peoples through annual dividends for local people. In South Africa the historical inequalities have led to Black Economic Empowerment legislation and accompanied by strong unionisation and political involvement make a complex environment in which mining labour operates. The traditional use of migrant labour often grouped and housed on tribal, national or religious grounds has also been a source of conflict.

However challenging most mining companies will be keen to engage with local communities, and disadvantaged sectors with a view to facilitating their involvement where possible and helping distribute the benefits of the mining activities into those communities. This is often based around new models of culturally sensitive education and training for the industry.

**Examples in Canada**

In terms of employment, the mining sector has become, proportionally, the largest private sector employer of Aboriginal people in Canada. Given the proximity of many Aboriginal communities to current and potential mining operations, as well as the large number of Aboriginal youth, employment in well-paying, skilled mining jobs is poised to increase. http://mining.ca/our-focus/aboriginal-affairs

Each year, the association donates to Indspire, whose programs have been effective in improving high school graduation rates, and supporting Aboriginal students through post-secondary scholarships and bursaries. MAC is also a large supporter of the Mining Industry Human Resources Council, which offers resources on mining careers and a work readiness program geared to Aboriginal job-seekers.

*Mining Essentials: A Work Readiness Training Program for Aboriginal Peoples*

This program is a pre-employment training program for Aboriginal peoples who are interested in exploring their career options in mining. The program teaches both the essential skills and work readiness skills that the mining industry requires to be considered for an entry-level position.

http://www.mihr.ca//en/news/resources/AMEFOutcomesReportFinal.pdf

**Examples in Australia**

*http://www.miningoilgasjobs.com.au/mining/your-mining-lifestyle-guide/indigenous.aspx*

*Indigenous Employment and Aboriginal Jobs in WA*

Figure 69: Aboriginal Jobs Recruitment in Australian Minerals Industry.

*"Most of the major employers in Western Australia, with support from the WA State Government, have introduced dedicated indigenous training, education and employment programs to help alleviate the skills shortage as well as provide much-needed economic and employment benefits to disadvantaged local communities.*

*Other similar programs have already been launched (see below), with further programs in the planning stages by major employer groups as well as the WA and Federal Government."*

Posted on June 10, 2011 by Mark Read
Figure 69: Aboriginal Jobs Recruitment in Australian Minerals Industry.

*WA State Government Indigenous Employment Initiatives*

The WA State Government's Department of Commerce has implemented a variety of labour relations initiatives to assist indigenous employers and employees in understanding their workplace rights and obligations. The key aims are to assist indigenous workers to:

- Access relevant employment information
- Have a better understanding of their employment rights
- Develop confidence in applying for paid work

- Build and maintain positive employment relationships

*Fortescue Metals Group's Indigenous Employment Initiatives*

*FMG's Vocational Training and Employment Centre (VTEC)*

Fortescue's Vocational Training and Employment Centre is a doorway towards employment opportunities for Aboriginal people. The centre runs a program designed to equip local indigenous people with the skills to gain employment in the mining sector. VTEC was established in 2006 and is based at Pundulmurra TAFE College in South Hedland. VTEC works by identifying employment opportunities for Aboriginal people. Training is provided to develop and equip people with the necessary skills for those jobs. VTEC has trained and employed approximately 200 Aboriginal people over the past 3 years.

Summit 300 is the next step under Fortescue's original VTEC program, and will use training programs to prepare 300 people for employment within Fortescue over the next 24 months. Aboriginal people who belong to the native title groups with which Fortescue has formal agreements will be the primary target of the 300 jobs. Fortescue has recognized their desire to secure good jobs in exchange for supporting Fortescue's mining operations on their land.

*BHP's Sustainable Indigenous Relationships Program*

**Community Partnership Programs**

BHP Billiton has implemented a range of partnership projects that seek to improve the wellbeing of the Pilbara's regional Indigenous communities by providing leadership for building capacity in the areas of employment, health and education. Programs address issues such as improved life skills and, high school retention and reduction in diabetes. Ongoing community partnership commitments include:

- Benchmark enrichment programs for Indigenous students in Port Hedland and Newman that provide literacy training and enable graduating students to pursue tertiary and vocational training
- Additional investments in primary school education in Newman, and scholarships for educational support provided in partnership with The Smith Family

*Rio Tinto and Indigenous Employment*

Rio Tinto believes that local communities can provide an important pool of skills and employment candidates. Where appropriate, Rio Tinto's Iron Ore group seeks to employ locally and develop capacity within local Aboriginal communities wherever it operates.

In Western Australia, Rio Tinto runs programs in partnership with Aboriginal groups to better prepare people for employment with Rio Tinto and other businesses in the region. The training team offers education programmes, pre-employment training programs, scholarship and cadetship programmes designed to support self-determination and community capacity building. These programs increase the pool of candidates for positions and also increase the broader skill base.

*The Federal Government's Indigenous Employment Programs*

The success of current indigenous employment programs in WA has demonstrated that through targeted programs, many employers are successfully training and employing indigenous people. The Federal Government's Indigenous Employment Program has a goal to halve the employment gap between indigenous and non-indigenous Australians over the next decade, through direct assistance to businesses and organisations looking to employ indigenous Australians. These programs involve working with job service providers to provide pre-employment training and on-the-job support including mentoring and coaching.

**Examples in South Africa**

*The Mining Charter*

The vision behind the country's mining charter was to achieve a globally competitive mining industry that can benefit all South Africans. It is an important development in a sector historically dominated by white capital and profiting off the cheap labour provided by a disempowered black majority. The stated goal of the charter is to «create an industry that will proudly reflect the promise of a non-racial South Africa». One of its key objectives is to achieve 26% ownership of mining companies by previously disadvantaged people within the next 10 years. The charter provides a framework to help mining companies comply with the Mineral & Petroleum Resources Development Act, which obliges mining companies to promote black economic empowerment when applying for new mineral rights or converting current rights. A key component of the charter is the mining scorecard, which provides a framework for measuring the BEE process in the sector. The scorecard has three core elements: direct empowerment through ownership and control of enterprises and assets; human resource development and employment equity; and indirect empowerment through preferential procurement and enterprise development.

- *Mining sector charter*
- *Mining scorecard*
- *Overview of main points*
- *Mineral & Petroleum Resources Development Act*

*(http://www.southafrica.info/business/trends/empowerment/charters.htm#.VokwVmdyZgU#ixzz3wBxBlcxN)*

#### *4.1.1.15 Gender issues*

The global industry has historically had a poor gender balance. On an international basis women still only make up around 5-10 % of the mining work force. Industry initiatives and the recent mining boom has led to some improvement.

http://www.internationalresourcejournal.com/mining/mining_mar14/why_more_women_need_to_break_through_into_mining_s-upper_ranks.html

Australia now has 13-16 % women largely graduates in full time professional roles but the trades remain a stubbornly male dominated sector. Some of the reasons may be societal, while others to do with education, lack of role models, and access to training. In some countries there have also been legal impediments to women's participation in the mining workplace.

All the major companies have programmes promoting opportunities for women and have stated aims to increase the proportion of women employees. There are a range of workplace culture, location, childcare, as well as perceptual issues that need to be addressed and Women in Mining is an organisation that helps promote this issue within the industry.

#### *4.1.1.16 Company specific approaches*

There are many different approaches being taken by individual companies to educate and train staff to meet their needs. In many countries when the mining sector was nationalised or controlled by single large companies, mining training was also a central provision and led to the development of major training centres (e.g. Zambia). These often suffered from underinvestment and on subsequent privatisation were replaced by individual company, less centralised, training arrangements.

Companies such as Vale have developed extensive in house training. This is partly historical as the company, was traditionally centred around a major national cluster in Brazil, while other multinational had more diverse geographic coverage.

Companies will undertake essential Health and Safety training, mining inductions and reporting protocols to ensure its statutory responsibilities are being met, although these may be delivered by external training bodies or contractors. Internal training of specialist technical functions are also widely undertaken as part of the normal career development / talent management processes. In-house training may also covers standard business skills such as finance, project management, administrative skills, and generic management but use of contracted services is also common.

General technical training and MBA's however have largely been through external providers such as colleges and Universities particularly as these have certificating authority allowing the participants to achieve internationally recognised qualifications.  These are important for personal development, but are also often required as part of the proof of competency for certain job roles, especially those with significant safety impact and covered by relevant national mining regulation.

Historically entry to the industry involved relatively low educational attainment levels and progression was based on the display of individual competence and experience accrued in the workplace. Senior staff were typically time-served practical people who had added commercial, managerial and leadership skills. The technical specialists were often developed through apprenticeships and experience. Increasingly however graduate level entry is used for management as well as specialist roles, and graduate schemes that rotate staff internationally are used to 'retrofit' the experience that such roles would historically have already gained.

Mentoring and unstructured development is still a significant route to develop skills and of courses experience in the mining industry. This is sometimes recorded in professional diaries for appraisal and personal development, or validation of experience, accreditation and professional recognition.

Most of the major companies run graduate programmes, with numbers fluctuating with demand. The graduates are sometimes recruited on national requirement but are typically trained to be mobile within the international Group. Specialist roles in the companies are internally recruited from these graduate programmes as well as via direct recruitment.

Staff coming in via the general employee and trades routes typically undertake training in the company's own training centres, for example training diesel mechanics or electricians, but may also attend local colleges via secondments, day or block release as access allows. These training centres for the trades are important and in some cases this is where major company investment has gone in due to the critical shortages of such staff. They are often run by national training agencies, local training centres or colleges and may provide joint provision for several companies with their courses / qualifications accredited by professional trade bodies. They are frequently established and supported as part of the companies CSR strategies and community development initiatives.

A more recent innovation has been the use of distance learning with Edumine operated by UBC in Canada as the de facto on-line resource for professional mining staff. This is used either alone or by local education providers in support of their activities. There are however a range of blended learning programmes for more advanced training with specific universities including for example:

- Mining MBA at the University of Santiago;
- Mining Professional Programme at the Camborne School of Mines, UK.
- Mining Engineering Technician course at Northern College (NORTEC);
- Batchelor of Mining Engineering - bespoke APL format; Atlantic International University;
- Graduate Diploma in Extractive Metallurgy by Open Universities Australia;
- Master of Engineering in Mining Engineering at Missouri S&T.

Some companies are introducing lower level internal 'intranet' or web based resources for staff development, sometimes in parallel with Edumine resources, as 'company universities' so that staff can access training at multiple mining sites. These also incorporate the more generic management training components and regulatory / legally required training provision centre – the First Quantum Minerals University is one such system in development.

The extent of industry training of its staff has always been hard to gauge as it is rarely captured by companies or reported externally in a way to allow international comparisons. This is also a political issue as in some countries government have sought to introduce additional taxation justified by the need to use the revenues for training that it believes the industry should be doing. Such an argument has occurred in Australia and Zambia in recent years.

In Australia this led to an industry wide initiative to record the extent and value of such training and concluded that:

*"The minerals sector spent just over $1.1 billion on training during the financial year ending 30 June 2012, equivalent to almost 5.5% of total payroll. Almost 98% of this training expenditure is industry-funded."* (NCVER 2013).

This would suggest that the external provision of training is only the tip of the iceberg in terms of total industry training and that that external provision itself is largely industry funded as opposed to self-funded individual career development activities. This may also however be a sign of the times as 2012 was the height of the recent mining boom where training of individuals from diverse technical backgrounds was needed and such training was also a means of staff retention.

#### *4.1.1.17 Pay and Conditions*

Of course one way to avoid skills shortages for an individual company or indeed the mining sector is to poach staff with the necessary skills. During the recent boom this meant many mining staff moved from roles frequently securing better salaries and packages leading to massive escalation of costs in the industry.

As a sector mining has done the same with the trades, enticing construction and engineering staff from the construction, heavy engineering and military to meet the demand, and presumably many will be returning to these sectors if possible in the current downturn.

In some cases this has led to whole countries being seen as expensive to operate in, Australia being a good example, and this acts as a deterrent to future mining investment despite its many other advantages.

(http://www.news.com.au/finance/business/australia-is-too-expensive-for-business-rinehart/story-fnda1bsz-1226465315817)

#### *4.1.1.18 Exporting mining not just minerals!*

Developing mining countries initially seek to promote mining investment then make a drive to maximise the mining sectors role in economic development. This includes strategies around added value addition in-country (sometimes termed beneficiation) and development of local chains including equipment manufacturers and suppliers, consultants, goods and service providers to support the industry. Beneficiation incorporates: upstream (equipment suppliers and construction); sidestream (goods and services to support production e.g. legal, financial, clerical, transport, catering); and downstream (metal refining, metal or other mineral products, and consumer products). The aim is to keep the maximum proportion of the wealth generated by the mineral products in the country stimulating wider economic development.

Most producer governments are however increasingly seeking to not only export the concentrates or added value products but also to export mining as a whole (e.g. Australia, Chile) through exporting the resultant mining equipment products, consultancy and expertise, mining services, finance and legal services etc. Such producer country aspirations bring with it very different education & skills requirements.

#### *4.1.1.19 Conclusion*

The type of mining skills and employee needed by the industry are gradually changing as technology, scale of operations and safety considerations increase. Mining occurs in areas where these skills are not always available and the demands of producer governments increasingly add nationality to the recruitment criteria. The sector is competing for many trade skills with other sectors such as construction and where jobs are located in more amenable areas. The enticement of staff to work in remote areas have made these skills costly. The legacy of a reduction in recruitment in the 90's caused skills shortages in the recent boom and the current downturn could recreate similar skills shortages again during the next upturn. The current downturn has made the issue slightly less immediate but it has not been fully addressed. The downturn has however helped 'crystallize' the issues around staffing shortages, and it is important to differentiate between an absolute labour shortage that occurred at the height of the boom particularly where the industry was less mechanised and automated, as opposed to a skills shortage which today still persists to a significant extent as the increasing skills requirements being created by efficiency-driven technologically investment outstrips the supply of experienced, technically competent and skilled mining staff.

Skills shortages are a local and national issue rather than global, but also have generational and gender issues still to address. The industry needs to find an employment model offering a more attractive and less cyclical career path if it is to retain staff and avoid the periodic scramble for skills. Australia, USA and Canada have excellent work force planning at national or State level, while South Africa is more complex in its use of labour, has lower deployment of mining technology, and has unionisation issues that represents risk to mining companies. Investment in its university sector however is producing high quality graduates for the industry. Japan relies on its high basic skills levels for limited mineral industry roles but is much more focussed on mineral processing, recovery and re-use, trading, international mineral diplomacy, and a potential future use of unconventional offshore mineral resources.

# 5. Benchmark metrics

An initial list of possible measurable metrics to benchmark and compare EU countries against, and forming the basis for Action Plans in Work Package 3 include:

### 5.1 RESEARCH AND INNOVATION

- The number of NERC/NSF mining programs and amount of funding
- Amount of government funding
- The number and financial amounts of large bequests/donations/ endowments)
- Staff demographics
- Number of publications, staff, and research quality/impact ratings
- Global university rankings with mining/minerals geoscience courses
- Number of patents, and commercialisation special units or spin-offs
- Number of industry schemes – academic connections, and quality
- Scholarship availability and placements/internship rates

### 5.2 EDUCATION AND OUTREACH

- Number of universities teaching mining/minerals geoscience
- Length of programs and quality of curriculum (including staff: student ratio)
- Number of students and demographics
- Amount of mining/minerals geoscience in secondary school curriculum
- Number of mining education organizations and membership
- Training data and workforce shortages
- Qualification requirements
- Others from MiHR, SOMP and Workforce Planning Reports

### 5.3 INDUSTRY AND TRADE

- Mineral endowment and potential:
  - Number of mines
  - Production history
  - Commodity range
- Profitability of operations
- Mineral exports as a percentage of GDP
- Size of workforce
- Amount of tax benefits and other economic indicators
- Global production ranking (%) per commodity and supply dependence
- Number of companies registered
- Number of top 100 mining companies headquartered
- Number of service/supply companies and demand
- Number and amounts mining investment institutions, funds, etc.
- Degree of vertical integration and downstream investment
- Amount of exploration/tax/ development incentives?
- These are suggestions that will be examined along with other ideas in WP 2 of the INTRAW project

# 6. Report conclusions

Review of the reference countries has revealed a number of themes around mining skills availability and especially how this was exposed during the recent mining boom. During the last decade skills shortages have been arguably the mining industry's most significant problem.

- Shortages may be local, regional, national or international and government policies can cause, reduce or exacerbate these.
- Skills shortages are different to labour shortages and there is increasing recognition in many countries, especially in a down turn, that we have sufficient access to people but their skills levels are too low.
- There is under-utilisation of women, disadvantaged communities, native peoples and young people in the industry – and industry have programmes in most countries to address these but at a modest scale
- The cyclicity of the industry is a major challenge to predicting staffing needs and skills demand.
- Workforce plans are generally good but suffer from the same lack of data.
- Employers need to consider funding, retaining and upskilling staff through the downturns and this may need new models of employment
- That said the reference countries all have established infrastructure of training, education and skills development.
- Real-time skills and employment data are not easily accessible and new methods are needed if prediction through the cycle are to be realistic.
- There appear to be few absolute skills shortages, perhaps in mining engineering and mineral processing but not critically so.
- Criticality is caused by timing of availability as the training duration lag time re-enforces the skills shortage as the upturn develops and compounds the oversupply at the next downturn.
- Training needs to be more aligned with industry cycles – evidence of good practice is there but there is a need for more creative solutions to in-work education and industry-education partnership arrangements.
- Education and training is too slow and not able to respond when needed. If possible it should be speeded up but also cyclicity in education and training institutional income needs to be evened out to avoid capacity loses in downturns.
- Industry and educational sector staff performance metrics need closer alignment - current academia preoccupation on research outputs creates disincentives for industry-education engagement.
- Trades availability is more difficult to assess due to their 'sectorial permeability', and superimposition of mining, infrastructure and housing booms in some countries.
- Mining investment in efficiency, mechanisation and automisation will push up the required skills levels and reduce the opportunities for low skill jobs.
- Mining needs to attract skills not on pay but other career features and, dispel by its actions, the 'hire and fire' reputation of the industry, which drives the high wages sought by people entering what they believe to be a temporary job while a mining upturn lasts
- South Africa needs to retain its newly trained mining staff, address its brain drain, confront labour unrest and cost escalation. It is becoming inefficient and expensive and many mines are only working now due to the currency weakening.
- South Africa needs to improve the basic education required to facilitate mining training and improve university retention and completion rates. It

has recently been the beneficiary of much investment so needs to consolidate on this.
- Canada needs to continue recruitment to avoid another demographically driven skills crisis Canada has a major and persisting demographic and skills issue that even the downturn has not solved and needs strategic actions.
- Australia needs to regain efficiency and address its high labour costs to avoid under investment in the next decade. Australia has to return to competitiveness, avoid the problems of boom economics and societal expectations, and gear up for a recovery.
- The US will continue to face Mining School closures and major hierarchical divisions of quality minerals education, and must recognize the success of the MEA joined-up model in Australia
- Japan is operating an interesting alternative model of a trade driven raw material strategy, mineral diplomacy and some targeted high technology support for new partners.
- Japan focuses on lifecycle history through products and novel techniques for processing, recovery and re-use.
- Japan's strategy is centred on bi-lateral and multi-lateral, high level international engagement.
- Outreach is relatively minor, and needs hearts and minds education to attract the best staff into the industry in competition with other industries.
- In the past commodity booms and busts were frequently local, national and regional – now they are more interconnected and global as a result of trade, multinational companies, investor expectations, higher capital intensity, and investor prerequisites – effectively there is always more at stake and with higher risks yet on a national basis this is not always appreciated. Risk management in mining companies is done by the Treasury function to mitigate price and exchange rate volatility – it would be interesting to explore whether mining countries could develop a similar attitude to risk management for skills and staffing through a mining cycle.

Overall it is about strategically managing through constant change: long term trends, commodity cycles, changing politics, and changing human aspirations – indeed a company analysis, insight, and management of these may be considered a strategic advantage as well as being of value in EU policy development.

The next stage of INTRAW is to see how these lessons need to be developed into strategies that would mark the EU out as a place where mining could thrive and the industry would therefore invest. These should aim to create conditions where raw material supply would be a holistically coherent exercise covering physical raw material handling i.e. mining and recycling, but also the diplomatic, legal, and the human resources to undertake these.

# 7. Country summaries

## 7.1 CANADA

Canada is a world class mining country with high education levels, and home to world class education and training centres for the mining industry that have the capacity to train the next generation of mining staff. It is home to Edumine, an internationally recognised leader in online mining education.

Canada however has a persisting issue around skills shortages due to the workforce demographics and still modest level of graduate training and recruitment. Despite the recent downturn in the number of staff required Canada needs to maintain its recruitment to address the skills gap. There is however still underrepresentation of native peoples in the industry and programmes to address this are being funded by industry and government. There are signs that skills are being retained in downturn due to difficulty of recruitment. The training of trades and graduates demonstrates a classic lag bringing them onto the job market during mining downturns rather than when industry demand is high. Planning for these issues through the mining lifecycle has been identified as crucial to the accuracy of the national workforce planning process.

Meeting the mining skills demand currently relies on cross-Canada migration from the training rich areas of Ontario and Quebec to employment centres in BC. The mining education sector has recruited internationally to try and meet the demand for technical staff.

## 7.2 USA

The general education standard in the U.S. is one of the highest in the world, and at the tertiary level the U.S. has many large and high quality institutions and excels in many geoscience and minerals engineering related fields. However, during the general decline of the mining industry and most importantly, the disbanding of the federal U.S. Bureau of Mines in 1996, there has been a major downwards shift in minerals-related education. Enrolment dropped, funding ceased, schools closed and faculty retired. Since the minerals boom there has been steady increases since 2006 and similarly decline in 2013 – 2015 related to commodity price softening.

The U.S. minerals education sector has adapted to changes by recruiting more foreign staff, but still faces shortages both in the mining workforce and within universities. The mining industry is a large supporter of schools, and there is a three-tier hierarchy of larger, more successful mining engineering departments with high student numbers or sustainable research funding versus smaller departments at risk of closure. The large ones include the Colorado School of Mines, The University of Arizona, University of Missouri S&T, Virginia Polytechnic Institute and State University, University of Kentucky and West Virginia University. The smaller ones are Montana Tech, University of Nevada, South Dakota and University of Utah. Programs at risk of closure or with very low numbers (<10 completing students/year) include the University of Alaska Fairbanks, Southern Illinois, Michigan Tech (closed since 2007, reopening in 2016), New Mexico Institute of Mining and Technology and Pennsylvania State University. Distance education has been developed at Missouri and has been a successful program for about a decade. Another proposal is to adopt the distributed education model to reduce the number of mining departments and operate similarly to MEA in Australia.

Nevertheless, the number of completing U.S. mining engineering graduates is meeting the needed supply. The mining workforce is "graying" and on average is several years older than other occupations, although there is unclear picture of the mining trade skills market (welders, maintenance technicians, etc.). It's likely that there will be a constant imbalance due to market cycles. Many organizations including the Society for Mining, Metallurgy and Exploration (SME) are actively involved in primary and secondary minerals education outreach, but socio-political changes in the U.S. in general are slowly moving away from domestic raw materials production and becoming more reliant on trade relationships.

### 7.3 SOUTH AFRICA

South Africa minerals education is an enigma because there is a severe shortage of mining professionals. Although the country is probably the most highly endowed with large ore deposits and some years produces more mining engineering graduates per year than any other English-speaking nation, the retention rate is the poorest globally. Political, social and economic issues has driven an increasing number of qualified mining staff towards Australia, Canada and elsewhere. There are four major mining schools, and several more geoscience departments of high regard. The University of Witwatersrand and University of Pretoria are two mining departments of high global repute.

A major reason that mineral occupations rank so highly on the National Scare Skills List each year is because South Africa has poor education standards at basic level, and performs the worst among the reference countries globally in the ranking of science, engineering, technology and mathematics primary-secondary educational quality. The nature of most mining in South Africa (very deep, low tonnage, manual-labour intensive, highly sensitive to market prices) has resulted in a bipolar skills distribution. Much of the industry is still at risk of collapse due to international market forces, disputes between industry and labour, and the complex black economic empowerment transformation process. Education is similarly undergoing significant changes. The Mining Qualifications Authority is the government institution responsible for skills and training distributes over R700 million per year for bursaries, internships, trade sills development, and scholarships, financed by a 1% levy on mining companies' payroll budgets. There is reduced research occurring in South Africa, most of which has shifted in-house. Despite this, the industry is closely linked to the two leading universities which will likely continue to lead minerals education.

### 7.4 AUSTRALIA

Australia is one of the world leading mining countries and minerals dominate it exports. Despite its 8.5% contribution to GDP mining only employs around 2% of the workforce, but this is twice the levels seen in previous decades. It has become a high salary, high skills mining location, but employs relatively few young people, women and those from aboriginal or other minority groups.

The industry spends around AUD 1.1 billion per year on training and there are numerous programmes to facilitate underrepresented groups entering the industry and address related literacy and numeracy challenges. Companies also facilitate widespread support for students, schools, teachers, and others to gain a better understanding of the industry.

Skills shortages in the trades during the recent commodity cycle were exacerbated by simultaneous housing and infrastructure booms. The country however has a set of high quality Universities that are in a unique collaboration around mining education through the MEA Programme which delivers 85% of country's mining engineering graduates. Universities host may Centres of Excellence particularly in geosciences and mineral processing undertaking world-class research. Graduate and apprentice availability has increased through the recent mining booms but demonstrated a lag on commodity cycles creating graduate oversupply during downturns and shortages during the peaks. The mining workforce are generally older than comparative industries and faculty in the universities show an even greater demographic challenge. The country has introduced a strategic programme to address its recent lack of international competitiveness.

### 7.5 JAPAN

Japan is not a major mining country but is a major consumer of raw materials and exporter of manufactured products. It has few mines. Japanese culture places a value on education and one of the highest levels of participation in higher education. The country has a skilled but ageing workforce due to the low birth rates. Educational and training capacity is based around a life-cycle concept that highlights recycling, mineral and material processing, metallurgy and materials science. The country however is currently not a high growth economy and this lack of indigenous raw materials has made it vulnerable to the international commodities markets. Government initiatives are therefore around 'mineral diplomacy', with the negotiation of bi-lateral agreement with major mineral producing countries especially in South America as a means to ensure raw material supply. Mining technology collaborations especially around potential sea floor metal extraction, and the support for increased recruitment of international students has been part of this process. The use of strategic stockpiles to de-risk critical raw material supply has also been introduced. Strategic financial investments in project financing of major new mines has also been part of the strategy. JOGMEC is a new single state body to ensure a stable supply of the raw materials for the country.

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