Grand Excursion 2017
Australia

03 – 24 March 2017

Final Report

Institute of Mining

Clausthal University of Technology

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Grand Excursion 2017

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Grand Excursion 2017

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“People travel because it teaches them things they could learn no other way.”

(Lance Morrow)

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Foreword

Clausthal goes OZ

Field trips are important in a Mining Engineering Curriculum. The Mining Institute of Clausthal University of Technology performs these events since decades every three years with destinations all over the world. Certainly, a must is a country with several interesting mine sites. Doubtlessly, Australia is such a destination. This country or better continent is so big, that you cannot visit all areas or all important mines in one journey. Therefore, we had to limit it to New South Wales, South Australia and Victoria. The journey is described in detail in the available book as follows.

We are deeply grateful for the support we got from industry and other donators. That puts us in a comfortable position to offer the journey to the students for an acceptable fee. In the name of all students, I thank all donators for their kind contribution. All their names are listed on page 2.

Australia is far away from Europe – by the way, Australia is far away from every destination – you need more than 20 flight hours to get there. But it will be worth the effort because it is a great country with beautiful landscapes, great people, coloured cities and of course interesting mining operations.

We have to thank also all these nice and friendly people in the country who helped us to manage some problems and hosted our group in industry at universities or at their home as my dear colleague Prof. Bruce Hebblewhite did for example.

For all of us, this trip was a great experience and I want to thank especially Alexander Hutwalker for his busy job to plan and manage this tour.

Glückauf

Prof. Dr.-Ing. Oliver Langefeld

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THANK YOU

Facts about Australia: Size

Australia is

- the biggest island
- the smallest continent
- the sixth largest country
- holding 5% of the world's land area

The length of the Australian Coastline is 25,760km, which represents 64% of the equator.

The highest point is the Mount Kosciuszko in New South Wales with a height of 2,229 m a.s.l.

The lowest point is the Lake Eyre in South with a height of -17 m a.s.l.

The distance between the points is ca.1300 km.

Source: http://www.ga.gov.au/scientific-topics/national-location-information/dimensions

List of Participants

1	Prof. Dr. Oliver Langefeld	9	Jacob Mai
2	Angela Binder	10	Lisa Rabe
3	Alexander Hutwalker	11	Felix Rohkamm
4	Christain Heinrich Dörner	12	Nachinzorig Saruulbayar
5	Matthias Gericke	13	Tina Waldow
6	Anja Kehr-Ritz	14	Constantin Weigel
7	Sebastian Leonhard	15	David Zelienka
8	Heinrich Lux	16	Lydia Ziemer

Itinerary

Friday, 03.03.2017

Departure from Clausthal, Bus and Train ride to Frankfurt am Main

Saturday, 04.03.2017

Flight from Frankfurt to Hongkong

Sunday, 05.03.2017

Arrival in Hongkong, Flight to Sydney, Arrival in Sydney

Monday, 06.03.2017

Visit of University of New South Wales (pg. 27), BBQ with Prof. Bruce Hebblewhite

Tuesday, 07.03.2017

Individual day in Sydney

Wednesday, 08.03.2017

Visit of Bloomfield Colliery (pg. 35), Drive to Newcastle

Thursday, 09.03.2017

Visit of Warkworth Mine (pg. 42), Drive to Sydney, PPE pickup

Friday, 10.03.2017

Visit of Appin East Mine, Appin West Mine and Dendrobium Mine (pg. 47)

Saturday, 11.03.2017

Flight to Adelaide

Sunday, 12.03.2017

Drive to Coober Pedy (pg. 52)

Monday, 13.03.2017

Visit at Tom's Working Mine and Josephine's Gallery & Kangaroo Orphanage

Tuesday, 14.03.2017

Visit at Prominent Hill (pg. 61), Drive to Andamooka (pg. 69)

Wednesday, 15.03.2017

Andamooka Opal Fields

Thursday, 16.03.2017

Drive to Adelaide

Friday, 17.03.2017

Visit of University of Adelaide (pg. 32)

Saturday, 18.03.2017

Individual day in Adelaide

Sunday, 19.03.2017

Drive to Ballarat

Monday, 20.03.2017

Visit to Ballarat Gold Mine (pg. 78), Drive to Traralgon

Tuesday, 21.03.2017

Visit to Yallourn Open Cut (pg. 82), Drive to Melbourne

Wednesday, 22.03.2017

Individual day in Melbourne

Thursday, 23.03.2017

Flight from Melbourne to Hongkong

Friday, 24.03.2017

Flight from Hongkong to Frankfurt, Train and Bus Ride to Clausthal


Newcastle
Sydney
Melbourne
Ballarat
Adelaide
Andamooka
Coober Pedy
N
O
S
W
kilometers traveled
10000
1000
100
10
1
Ferry
20
Bus
66
Train
800
Car
3765
Airplane
35528

Σ 40 179 km

Mining in New South Wales

Heinrich Lux

History of Mining in New South Wales

In the 1790s, so over 200 years ago,coal mining started near Nobbys Head in Newcastle and mining was a part of New South Wales ever since. The first coal shipment – Australia´s first commodity export in general - left Newcastle in 1799 and established the basis for Newcastle being the world´s largest coal export port today. Newcastle and Wollongong drove the New South Wales economy from the late 1800s onwards due to their busy ports and New South Wales played the most important role in the history of Australian mining.

With the availability of high grade coking coal deposits the Illawarra, just south of Sydney, flourished and started to support all major industries such as steel production and manufacturing simultaneously with the start of the first mining operation in 1848. Till today the Illawarra is a leading producer in the steel market for the South East Asian region regarding steel itself but also steel products, having Port Kembla to handle steel and coal exports.

Nowadays, coal is the major player in the industry but in the mining history of New South Wales gold had a large influence on the events. The discovery of gold near Orange sparked a gold rush in 1851 and the gold and copper mining at Cadia Hill started in 1870, now hosting one of the largest gold mines in Australia.

A lot of the regional centers across New South Wales were established and continue to thrive through mining, including Newcastle, Broken Hill, Wollongong, Cessnock, Muswellbrook, Lithgow, Orange, Gunnedah and Cobar. The largest service town regarding the Hunter Valley these days, Singleton, for example was first settled in the 1820s but did not take off until the first mine opened in 1860. All due to mining there are hundreds of businesses nowadays supporting the local economy by supplying the mining industry and eventually depending on it.

Through the decades, mining evolved to a strategically important industry in New South Wales and it did not only take a major part in creating todays affluence in the past but will create further wealth in the future as well.

Today's Mining Industry

One of the key factors in our modern way of life are all sorts of minerals. There would not be any steel or cement necessary for construction and manufacturing without coking coal. The supply of homes with electricity to keep on the lights, enable to prepare food and to heat or cool the houses is based on the power generation from thermal coal. All the modern electronic devices not only need electricity to operate but also are made of several resources such as copper, steel, zinc, platinum and lead. Only to mention a few.

All those much needed minerals occur often in New South Wales. Not only a strong coal deposit but also deposits of metallic minerals (silver, gold, zinc, copper, mineral sand) are part of the natural resources of New South Wales.

It is not only that the extraction enables a use of these minerals for energy and production but also ensures the employment of many and hence delivers a substantial yield to the state. The wages payed to and then spent by the miners and all other investments and payments by the mining companies stimulate the state economy. Additionally, the license fees payed to the New South Wales Government ensure essential services and infrastructure such as nurses, teachers and police, trains, bridges and roads.

The New South Wales mining industry´s direct contribution to Commonwealth and State Government revenue is estimated to have been at least $3.7 billion in 2012-13 and growing. This is equivalent to 30 per cent of industry value added. This is comprised predominantly of company tax, minerals royalties and personal income taxes paid on wages (in that order). If the mining industry were to contract this would be expected to negatively impact other sectors and would indirectly reduce government taxation collection.

Coal

Coal is a mineral with the major components of carbon, hydrogen and oxygen formed when gathered plant material is covered by layers of soil, decays and by that is subjected to high temperatures and pressure over millions of years. Coal beds and seams which are formed during that process are made up of several layers of

coal and are scattered with other sedimentary material such as shale and sandstone. Those can vary in size from less than one millimeter to several meters thick. The main types of coal are brown coal (lignite) and black coal.

Black coal has a higher energy value than brown coal due to its lower content of moisture. It also emits less greenhouse gases compared to lignite. Brown coal on the other hand is fairly soft and has a lower carbon as well as a higher water content towards black coal. Its only Victoria where lignite is mined.

In New South Wales the black coal plays a fundamental role in the power generation. 84 % of the electricity of New South Wales originates from coal fired power plants which are operated with coal mined in New South Wales. Black coal that is utilized for the production of electricity is often named thermal or steaming coal and the main part comes from mines in the Hunter Valley. Some of it is used in the close by power plants such as Eraring, Bayswater or Liddell power station but the major part is exported. Mainly to Asian countries to satisfy their increase in the demand for energy sources due to the strong economic growth. By that providing an important export revenue for the national economy.

For 2007-08 the generated value of mining output summed up to $13.9 billion and 66 % of that where contributed by coal with a total amount of 135 Mt.

Some of the coal mined in the Southern coalfield in New South Wales is processed in coke-making that is needed for steel production in blast furnaces. Also known by the name coking coal it can be used to fabricate cement.

Metallic Minerals

The major part of the gold mined shows a concentration of under 5 grams in each ton of rock produced. It is not only used for currency and jewelry but also to manufacture medical equipment, for the production of all sorts of electronic devices and space satellites. Due to the major production at the mine sites near Parkes, West Wyalong and Oranges from the south to the central west of the state (Cadia Valley Operations which is located there is one of the largest gold mines in Australia) New South Wales is Australia´s second largest gold producing state.

Third to iron and aluminum, copper is one of the most consumed metals worldwide which is needed for power generation and transmission and all sorts of electronical equipment. The main copper mines of New South Wales can be found all along the major gold mines around West Wyalong, Cobar and so on as normally the copper is mined from the same deposits as gold. Further minerals and their deposits are listed in Figure 1.

Mining Methods

There has been a transformation in the mining techniques over the centuries. Technological advances improved efficiency, health and safety for the people and minimized the environmental impact of the operations. The mines visited during the time spent in New South Wales are all coal mines and are highlighted red in Figure 1. Bloomfield Collieries and Warkworth Mine being both open-cut mines and Appin Mine being a longwall underground mine.

Open-Cut Mining

A type of mining that generally takes place if the mineral deposit is up high and not far away from the surface. To get to

the deposit surface layers of soil and rock are removed. As soon as the mineral seam turns accessible it gets fractured and is extracted for processing. Open-pit mining tends to be more effective than underground methods regarding the degree of recovery which usually is at about 90%. Around 65% of the raw coal extraction in New South Wales is gained through it. Quite a few copper and gold deposits in New South Wales are mined open-cut style as well and BHP Billiton's Mt Arthur Coal mine (Top10 largest coal mines in Australia) is set in the Hunter Valley.

Underground Mining

In underground mining the mineral seams are reached through drifts coming down from the surface. Those seams can be up to a 1000m deep down below the ground. The drifts/tunnels are necessary to transport the mineral up to the surface and all the material needed for production down to the seam. Even though it makes up 60% of the world coal production is is not that popular in New South Wales where it only accounts for 35% of production. This is due to many shallow coal beds. Not only coal is mined underground but also copper and gold deposits. It is mainly longwall and bord-and-pillar technique that is used in New South Wales.

Bord and Pillar

Using a grid of tunnels and leaving behind supportive pillars whilst gradually trimming coal around those pillars, bord-and-pillar has been the typical way to mine in New South Wales for decades. As it tends to be outrun by more efficient methods its usage constantly declines but it can still be found in a few mines all across the state (Yancoal`s Tasman Mine near Newcastle).

Longwall Mining

Starting in 1960 longwall mining is not only a much safer but also a more cost effective method for coal production. Also quite efficient in a large-scale type extraction. The top of the mine is held up by a hydraulic-powered support that moves towards the mined coal seam and lets the top of the mine collapse behind it. The collapsing can lead to subsidence. Production itself is run by several mechanical

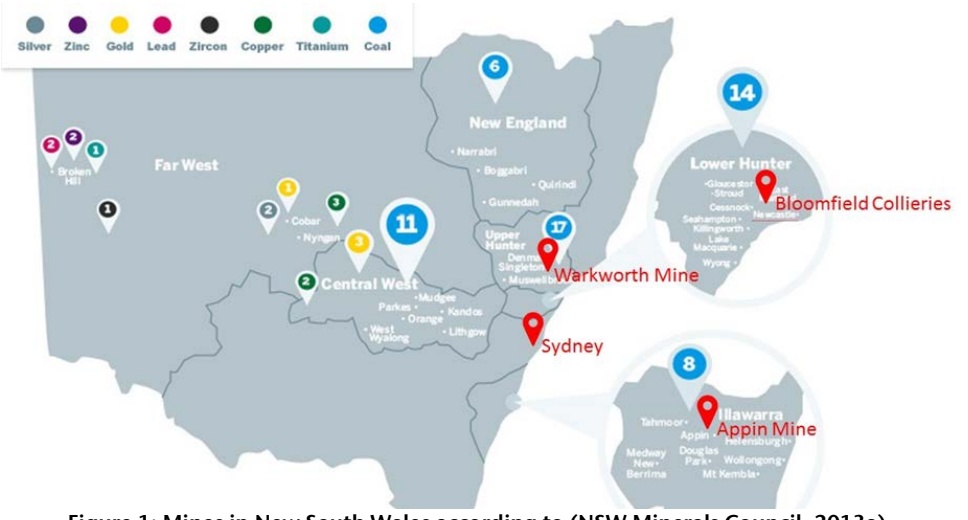

Figure 1: Mines in New South Wales according to (NSW Minerals Council, 2013a)

shearers which trim away the coal not leaving any pillars behind. One example of a longwall mine is the Appin Mine we visited.

Block Caving

Block-caving can be called a rather modern technique which uses the weight of the mineral deposit to let it collapse and hence enable the extraction of e.g. gold and copper. The first mine in Australia using this technique is set in Central West New South Wales and opened in 1997. Rio Tinto operates it in their "Mine of the Future" program trying to increase efficiency and safety by a higher grade of automation and remote operation.

Coal Preparation and Mineral Processing

Several different impurities such as dirt diminish the profitability of the resource. Therefore washing and other treatment in a coal processing plant are used to increase its quality. By that not only the value of the product itself increases but only transport cost decrease due to the removed waist which no longer needs to be handled.

The processing of a mineral starts at exploration already and can be found in all different steps along the value chain. For New South Wales it is possible to be the leader in mineral processing in Australia due to an advanced cement and aluminum production, an extensive infrastructure and furthermore involved in the production of several materials.

There are two aluminum smelters in the region both located northwest of Newcastle. One is the Tomago smelter and the other one is the Kurri Kurri smelter. Tomago smelter produces around 520000 tons of aluminum each year and Kurri Kurri, a minor one regarding international standards, around 170000 tons of aluminum per year.

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Mining in South Australia

Christian Dörner

Australia belongs to the Commonwealth and South Australia is one of the six federated Australian states. It is an area of 984,000 square kilometers, which is about 13 percent, the fourth largest land area in Australia. It contributes approximately 10 percent to the total population of the entire population in Australia. Nowadays 1,706,500 people live in South Australia with a population density of 1.74 ppl / km².

Less than 30 percent of South Australia lies between sea level and 300 meters. The highest elevation with 1,435 m is Mount Woodroffe in the Musgrave Range. South Australia is dominated by wide plains, large salt or clay encrusted lakes and low elevations. The areas farther away from the seawater are dry and therefore the lakes mostly contain little or no water. Most of the precipitation falls in the winter half of the year and mostly near the ocean and the coast-like hills that cross the country in a north-south direction. Only nineteen percent get more than 250 mm of rain and only eight percent of the area gets more than 400 mm. In the interior of South Australia the precipitation is rather irregular. Overall, the rainfall in South Australia is at a low level and is the lowest in Australia. On the southern coasts there is a Mediterranean climate with mild and rainy winters and very hot and dry summers.

Economically, life in South Australia is determined by agriculture and mining. These markets are highly export oriented

Figure 1: Map of South Australia (Encyclopædia Britannica, 2017)

and on the other hand the local processing industry is heavily dependent on imported goods.

1. History

The first human life in South Australia can be proven to 21,000 years before the Christian Era and has so ancient origin. Archaeologists found evidence for this at the Nullarbor Plain.

The first Europeans who entered South Australia were the crew of an exploration vessel, Guilden Zeepaard, financed of the East India Company commanded by Captain Francois Thyssen. This expedition sailed as far west until they reached Fowlers Bay. The result sent to Europe was sobering, and so it was that not until two hundred years later the next Europeans set foot on South Australia's soil. This time, there were two expeditions in the

same mission that had the mission to explore and map the South Australian coast. Both expeditions met in Encounter Bay. One of the two expeditions directed by Matthew Flinders, published a complete cartography in the Investigator in 1802. Only a little later appeared an article in the Le Geographe by the counterparty, written by navigator Nicolas Baudin. Reports of Charles Sturt over the entire length of the Murray River lead to the final basis for a British colonization of South Australia.

Edward Gibbon Wakefield designed an experimental and novel form of colonization, which was applied in South Australia for the first time. His theory of a systematic colonization designed in 1829 included the sale of land at a fixed price and both the creation of work, as well as introduction of capital were coordinated. South Australia should not be a colony, but a settlement which is more like a province of the motherland. The establishment of British citizens and free Australians was facilitated and supported. Since this was the only conceptual settlement of this kind in Australia, a local pride and a special patriotism developed in South Australia. The first settlers landed on Kangoroo Island and Glenelg on 28th December 1836 and officially founded the first settlement in South Australia.

In 1854 the first construction of a railway line began on the Australian continent in South Australia. This was fueled by the discovery of a rich copper deposit in Burra, which ten years before the construction of the railway line, triggered a mining boom in this area. The area around Adelaide was very good for arable farming and after some time the initial cattle farms were pushed further into the dry parts of the country.

The metropolitan area around Adelaide had a great attraction and already in 1921 most people lived in this. Only 12 percent of the population was employed in agriculture.

In the present time, South Asia is particularly known for its good wines and its many festivals. The financial sector is becoming increasingly important, but most people are still engaged in the mining, agricultural and manufacturing industries.

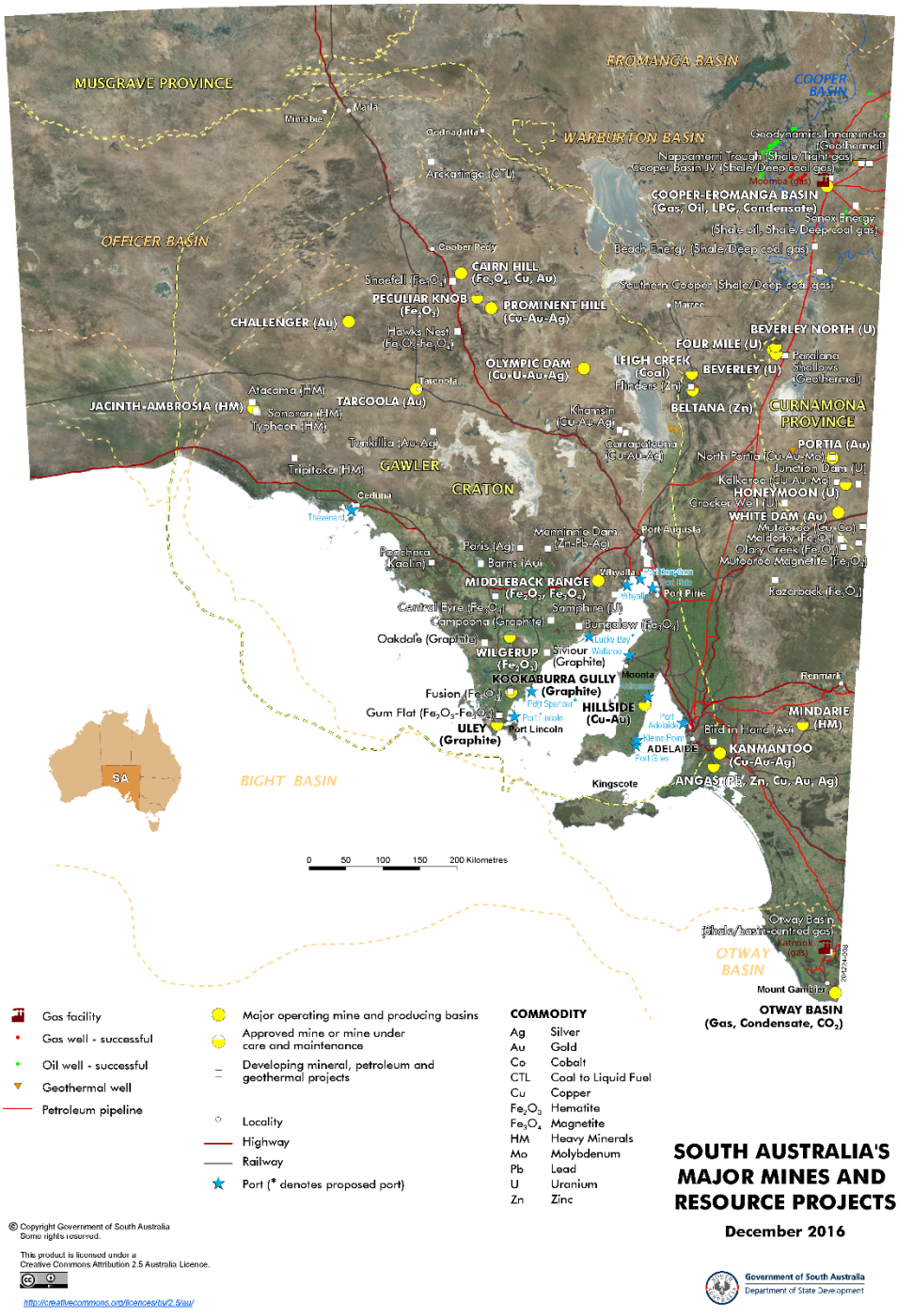
2. Mining in the past and today

The cradle of the mining industry in South Australia was laid in the hills around Adelaide in 1841. There was a small lead-silver mine. The Wheal Gawler Mine is the first commercial mine in Australia. Between 1842 and 1861 further discoveries of copper deposits in Kadina, Moonta, Kaounda and Burra fueled the mining in South Australia. These led to the soon being spoken of by the Copper Kingdom of Southern Asturias. As a positive side-effect of the boom in the mining sector, a near-state split could be averted.

In the Middleback Ranges, west of Whyalla, further high grade iron ore reserves were found towards the end of the nineteenth century. However, these could not be smelted locally and had to be shipped to New South Wales. First was the destination Newcastle and later Port Kembla. It was not until 1941 that the first iron mill in South Australia opened and its own iron production was able to refine the raw materials to pig iron. In 1958 the groundbreaking was followed by an iron and steel plant. South Australia is also known for its large opal deposits. Eighty percent of the world's opals come from this state. They are hunted in Coober Pedy, Andamooka and Mintabie. Salt and gypsum, mostly in coastal areas, are also mined.

The energy supply was initially covered by coal reserves. These are located far from any population centers. There are significant coal deposits, however, which are limited by their contamination in their use. It is mainly low grade subbituminous brown coal. Since 1954, there are large brown ostrich farms in the region at Leigh Creek. These supply power stations in Port Augusta, which produce the electricity with this coal. In the remote northeast, large gas and oil deposits were discovered in the Cooper Basin in the 1960s. These were subsequently dismantled and played a major role in the energy supply of the country. Since it was produced on demand, pipelines were built in the direction of Adelaide and Sydney. The Torrens Island power plant is the first of its kind on the entire continent that used natural gas. A recycling plant in Port Bonython prepares the LPG to a condensate intended for export to other parts of Australia, New Zealand or Japan.

West of Lake Torrens, one of the largest deposits of copper-gold-uranium mineralization was found in the seventies, which has been commercially dismantled since 1988. This new type of deposit was named iron oxide-copper-gold deposit (IOCG). Following this other deposits were found and mines like Prominent Hill by Oz Minerals were established. OZ Minerals is undertaking a new drilling program north-west of their Carrapateena project. The Intercept Hill project is targeting iron oxide-copper-gold mineralization similar to that seen at OZ Minerals' Carrapateena copper project and existing mines in Prominent Hill and BHP Billiton's Olympic Dam. They speculate gravity anomalies due to reprocessing of old geophysical data which could have been



overseen by previous explorers. First test drills started in early 2017. They will initially drill four holes testing four separate targets as part of 'Stage 1' with the initial funding of circa $1.2 million. If the results are satisfying OZ Minerals can elect to spend a further $2.8 million on exploration as part of 'Stage 2'.

As mentioned above, the mining industry is one of the main employers in South Australia, mainly mining raw materials such as iron ore, copper, gold, silver, uranium, zinc, graphite and zirconium. Of the total exports of this country, raw materials contribute for a total of forty per cent. With Olympic Dam is the deepest mine of the continent in South Australia. It is the largest uranium deposit in the world. It is also home to 80 percent of the Australian uranium reserves and 25 percent of the world's reserves. This makes South Australia the largest uranium producer in Australia. Amongst others, Olympic Dam is still the fifth largest gold deposit in the world and the fourth largest copper deposit worldwide. 68 per cent of the known copper resources of Australia are lying in South Australia, contributing one third to the total production of copper in Australia.

In 2003, the Plan of Accelerated Exploration (PACE2020) was introduced by the government. This led to a significant increase in exploration spending from annually $ 41 million to hundreds of millions nowadays. Thanks to the policies of the various current and recent State Governments, the recognition of raw materials in South Australia increased and led to an increase in investment in this sector.

The exploration in South Australia targets mostly copper deposits followed by iron ore, other base metals, gold and uranium. The Gawler Craton is an area with world-class copper deposits and thus most explorations take place in this area, 62 percent in number.

Iron ore is the most explored and produced mineral after copper. Expenditure on exploration rose significantly according to the expenses in copper. Thus, in 2000, one million US dollars were spent and these days it is between 50 and 70 million US dollars. Also, the production rose from three million tons per year to eleven million tons.

As a result of the expansion of raw material production and the significant increase in expenditures for exploration, expenditure on research and innovation projects in cooperation with higher education institutions also rose. This has led to a closer link between companies and universities in the country, which is a positive side effect and contributes to the optimization of today's technologies.

There is no doubt that South Australia will continue to play an important role in the mining industry, the number of active mines in 2000 rose from four to 21 in 2014.

3. Acts and Regulations according to (Government of South Australia, 2017a)

"Mining in South Australia cannot be undertaken on Crown or private land unless in accordance with the provisions of the following acts and regulations:

- Mining Act 1971 and Mining Regulations 2011 made under the Act
- Offshore Minerals Act 2000
- Opal Mining Act 1995 and Opal Mining Regulations 2012 made under the Act [...]

3.1. Mining Act 1971

The Mining Act and Regulations made under the Act:

- Provide that all minerals are the property of the Crown
- Provide for the issue of mineral tenements that give rights with respect to mineral exploration and production
- Establish landholder and licensee rights regarding access to land and provide for compensation for any resulting damage
- Provide for the regulation of operations within tenements
- Provide for the collection of royalties on production; plus a range of fees for required approvals, annual tenement fees and penalties for breaches of the legislation
- Provide for the appointment of inspectors and authorized persons to have access to tenements
- Provide specific definitions of minerals, prospecting, exploration and mining"

4. IOCG deposits

Magmatic-hydrothermal iron oxide-copper-gold (IOCG) deposits were proposed as a new class of deposits after the discovery of the spectacular copper-uranium deposit at Olympic Dam in south Australia in 1976. The defining difference to other copper sulphide deposits (e.g. porphyries) is the large fraction of iron oxides in the ore. Exploration for copper in southern Australia was based on the expectation of ore deposits of Keweenawan (Michigan) or Copper Belt type (Central Africa) in the geologically similar Gawler craton of South Australia. Drilling high amplitude Bouguer gravity and magnetic aerogeophysical anomalies soon located ore of a wholly unexpected nature.

The Olympic Dam deposit occurs within an anorogenic oxidized potassic granite (dated to ~1590 Ma), which is set within a Paleo-/ Mesoproterozoic graben and is covered by 350 m of younger, unmineralized sedimentary rocks. Host rocks are coarse haematite-rich granite breccias of explosive volcanic and phreatomagmatic origin. The breccia ore contains copper

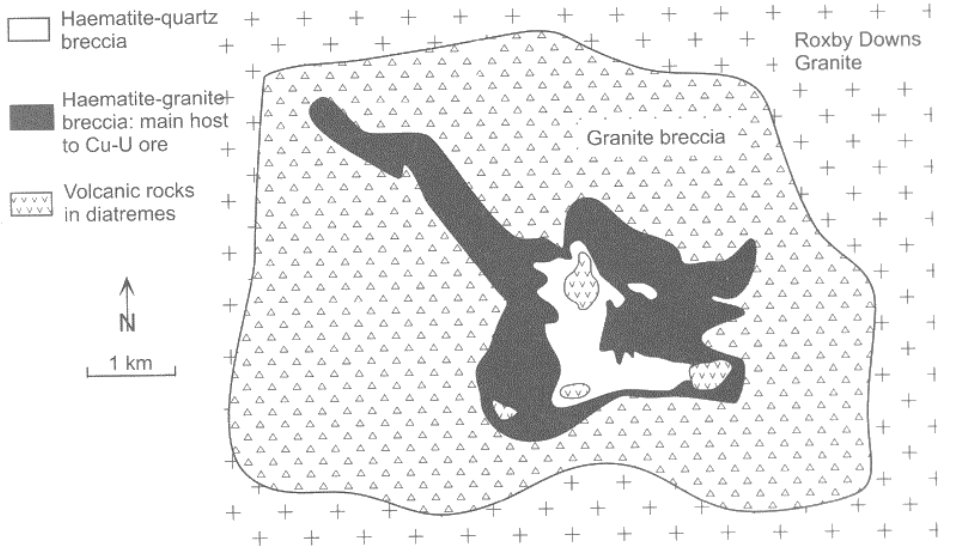


Figure 2: Geological Structure of the Olympic Dam Deposits (Pohl and Petrascheck, 2011)

sulphide and by-product grades of rare earth elements, uranium, gold and silver. Total resources are estimated to ~7700 Mt of ore with 0.9% Cu, 0.3 kg/t U3O8, 0.3 g/t Au and 1.6 g/t Ag. The mineralization appears to be the product of mixing of ascending hot magmatic brines with shallow highly oxidized haematite-forming groundwater leaching uranium and LREE (light rare earth elements). The source of copper and gold can hardly have been the host granite. Mingling of mafic and silicic melt, deep crust and fertile mantle enriched by prior subduction may have contributed to the metal endowment. This setting is very different from the Central African Copper Belt. Olympic Dam is a textbook case of highly successful exploration that was based on the "wrong" geological model. .

The Olympic Dam deposit is supposed to have resources of 107 MOz of Gold but roughly only 30 percent of the deposit has been touched by the engineers so far. Once, Rio Tinto wanted to invest some 30 billion US dollars in the expansion of Olympic Dam to form one of the largest underground mines in the world into the largest opencast mine on the planet. But these plans were a victim of falling commodity prices in 2012.

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Mining in Victoria

Anja Kehr-Ritz

Introduction to the State of Victoria

Victoria is one of the six federal states which form the commonwealth of Australia. It is the smallest state on the Australian mainland and has South Australia and New South Wales as direct neighbours. While there is a straight border to South Australia in the state's west, the northern border to New South Wales is mostly along the Murray River. South of Victoria lays the Bass Strait and the Island of Tasmania.

Victoria offers a variety of different climatic conditions especially in contrast to states with dry and arid climate like Western Australia or more tropical states like Queensland. Even snow can be experienced in the Victorian Alpine areas, with Mount Bogong (1968m) as highest mountain. The north-western part of Victoria experiences semi-arid climate with hot summers, whereas close to the cost and along the mountain areas the climate is much cooler. The Victorian Alpines belong to the Great Dividing Range, a mountain system which extends east-west through central Victoria and continues toward New South Wales (Victoria (Australia)).

Victoria is the most densely populated state with a population of 5.62 million in 2012. Predictions assume that the population will increase to 7.3 million by 2031 (Minerals Council of Australia, 2013b) The population of Victoria is distributed on around 227 600 square kilometres, round about the size of the British Isles (Visit Victoria, 2017). But the clear majority is living in the greater urban area of Melbourne, the state's capital. Other significantly populated areas are the regions around Ballarat, Bendigo and the Latrobe Valley, all of them traditional mining areas.

Figure 1: Map of Victoria (Unknown, N/A)

Victoria is the most densely populated state with a population of 5.62 million in 2012. Predictions assume that the population will increase to 7.3 million by 2031 (Minerals Council of Australia, 2013b) The population of Victoria is distributed on around 227 600 square kilometres, round about the size of the British Isles (Visit Victoria, 2017). But the clear majority is living in the greater urban area of Melbourne, the state's capital. Other significantly populated areas are the regions around Ballarat, Bendigo and the Latrobe Valley, all of them traditional mining areas.

As diverse as it's landscape is the Victorian economy. The business and industry sector includes the finance and insurances

sector, the manufacturing sector, the hospitality and tourism industry, the agriculture sector and the food industry (Victoria State Government). The mining industry however has a relatively small size and is therefore a small employer compared to other industries in Victoria (Minerals Council of Australia, 2013b, p. 12).

History of Mining in Victoria

As the other Australian colonies, except South Australia, Victoria was founded as a colony to transport convicts from the overcrowded prisons of the British Empire. The first explorations of gold were therefore treaded warily. In 1844 gold was found in New South Wales by a geologist named W.B. Clarke who showed the nugget to the governor Sir George Gipps. It is said that the governor exclaimed 'Put it away Mr Clarke, or we shall all have our throats cut!'. The governor feared that the news of gold would cause an uprise of violence and mayhem in the colony. Another concern was that convicts and farm labourers would abandon their badly paid jobs to rush for gold and fortune. Nevertheless the government was forced to encourage gold mining in Australia as people started to head towards the gold fields of California at the end of the 1840s. The Australian gold rush began in the 1851 in New South Wales.

Due to the rivalry between the young colonies the government of Victoria offered a reward for the first gold discovery in the state and the gold rush took its course in Victoria as well. Gold was soon discovered near Ballarat and Bendigo and allured people from all over the world to come to Victoria. In the next decade the population increased heavily from 80 000 to 500 000. In 1853 gold was the number one ex-

Fun facts about Australia: Melbourne

When founded in March 1837 it was called **Batmania** for a short time, named after John Batman (*1801, † 1839), a farmer from Tasmania who "bought" the land from the aboriginal people.

Australias first **traffic lights** were installed in Melbourne (in 1912). In March 2017 Melbourne began to install "Female traffic lights".

Melbourne's most famous shot is "**wet pussy**" (vodka and peach schnapps), which is served in almost every bar.

Nearly 40% of the people of Melbourne are born overseas (UK, Italy, China, Vietman, Greece ...). Melbourne's **Chinatown** was founded 1851, which makes it the world's oldest Chinese settlement outside China.

In 1922, **Vegemite** was invented in Melbourne by Dr. Cyril P. Callister

Statue of John Batman in Melbourne, Collins Street
Source: Biatch, Wikimedia Commons

port commodity of Victoria. The upcoming mining industry had a great impact not only on the economic and demographic structure of the time. In 1854 the Ballarat Reform League was founded. Their members demanded social rights and political involvement for diggers. For the government the members of this group where plainly rebels. They chose a flag with the Southern Cross for their cause which remains a national symbol until today.

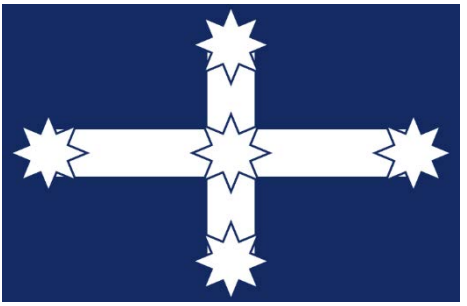

Figure 2: The Eureka Flag (Australian Eureka Flag, 2013)

The rebellion escalated in the so called Eureka Stockade which was beaten down bloodily by the government. Nonetheless the government lowered the royalties, diggers were granted more rights and finally the question of land distribution in general was discussed.

But the gold rush ignited significant racial problems as well. Numerous Chinese fortune hunters came to the gold fields of Victoria in the 1850s. The lived in separated communities but were opposed to enviousness and pure hate by the white diggers. Armed hostilities and violent riots against the Chinese were the consequences. This development led among others to the so called White Australia Policy. Immigration to Australia became strictly restricted. Furthermore the idol of white Australians in contrast to inferior races like the Asians as well as the native Aborigines was preached. This national and racial development continued until the 1960s (Hagemann, 2004, pp. 65–73).

The gold rush of 1851 changed and shaped the state of Victoria in many ways. The small colonial town of Melbourne became known as Marvellous Melbourne a growing and vibrant city. On the gold fields the alluvial deposits were slowly exhausted and consequently more capital was needed to reach the deeper deposits. The single handed diggers were therefore replaced by the first mining companies. The capital was raised by selling company's shares and local stock exchanges opened in many mining towns in Victoria. A new kind of gambling was introduced to Australia. People were investing the money from the gold fields and started to speculate in the stock-markets and especially in property and land speculations. The country as a whole was enthusiastic and the economic bubble grew as much as the cities of Melbourne and Sydney (Hickey, 2013).

In 1890 though, the crash consequently hit Australia. In 1893 two thirds of the banks had to close down. Unemployment increased and the situation was tightened by a severe drought period. The economic crisis that followed in the years after enforced the wish of an Australian federation. It was believed that the varies social and economic problems could be better faced with one united nation instead of quarrelling separated colonies which led to the establishment of the Commonwealth of Australia in 1901 (Hagemann, 2004, pp. 71–72).

The volatile cycle of boom and bust in the mining industry repeated itself throughout the history of colonised Australia. While Victoria sank into depression in 1890 people started to leave the eastern coast and move towards Western Australia. Newly explored mining areas and

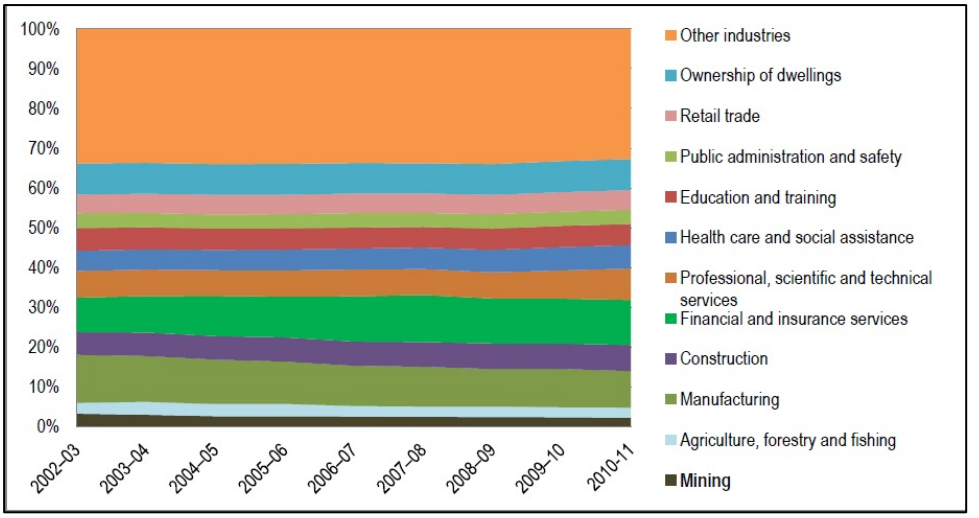

Figure 3: Victorian Economy by Industry (Minerals Council of Australia, 2013b)

the promise of gold to be found in Kalgoorlie set of the next mining boom (Hickey, 2013).

Victoria slowly recovered from the depression but never became a major mining state again.

The current Victorian Mining Industry

As mentioned above the mining industry in Victoria is comparatively small. In 2010/11 the state of Victoria had a Gross State Product (GSP) of $328, 6 billion which would account approximately for 22% of the overall Australian Gross Domestic Product (GDP). The mining industry contributed only 2.3% to the Victorian GSP. Regarding the GSP the Victorian economy is very variate. The strongest contributors are mainly the finance and insurance services (11, 3%), the manufacturing sector (9, 2%), the professional, scientific and technical services (7, 9%), the real estate sector (7, 8%) and the construction sector (6, 6%) (Minerals Council of Australia, Victorian Division, 2013, S. 11–12). Because the mining industry is relatively small in Victoria it is also a small employer compared to national standards. In fact, in 2010/11 only 5% of all the people working in the minerals industry in Australia have been working in Victoria. Employees working in the minerals industry in Victoria make up 0, 65% of the overall workforce in Victoria (Minerals Council of Australia, 2013b, p. 14).

By law, the mineral resources in the ground belong to the State and therefore royalties have to be paid to the state government of Victoria for extracting minerals. From 2002/03 to 2010/11 the income gained by the state through royalties has increased significantly. However, the Victorian government hasn't been able to focus on encouraging mining activities. For one thing the national focus is pointed towards the bulk commodities in Western Australia and Queensland. Not matching the superlative size of these deposits and operations, the world class deposits in Victoria for mineral sands and gold are easily underestimated. Furthermore the mineral industry is facing barriers for staring operations in Victoria that prevent an increase in the mining activity of the state. At the same time Victoria is the

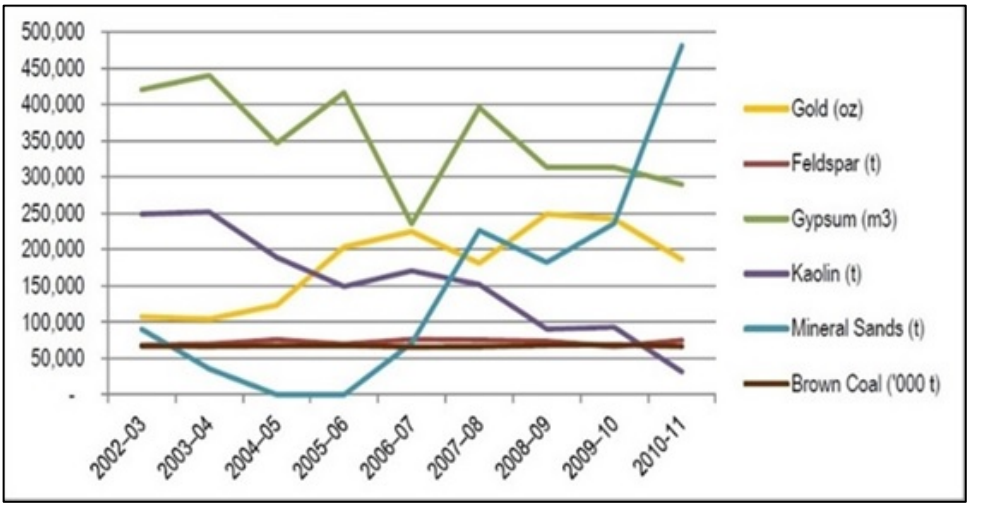

Figure 4: Victorian Mineral Production (Minerals Council of Australia, 2013b)

home of one of the major international mining capitals. The headquarters of notable mining companies are located in Melbourne and with them the support and service sector as well. In addition Melbourne accommodates international companies working in insurance, finance, technical services, engineering and equipment and materials manufacturing (Minerals Council of Australia, 2013b, p. 15).

Besides profiting from these assets Victoria has to encourage and increase exploration activities. Otherwise the known deposits will be exhausted and the future of the mining industry in Victoria will be threatened. Since 2007/08 brownfield as well as greenfield exploration has decreased with the cost per meter drilled increasing up to 350$ nationally (Minerals Council of Australia, 2013b, p. 17).

The Victorian mineral industry can be differed in two different sectors with the coal sector one the one hand and the metalliferous sector on the other hand which includes metals, gold and mineral sands as most important resources.

Brown Coal

While gold provided the capital and wealth to turn the provincial town of Melbourne into a metropole, it was the brown coal that provided the energy for the developing city and economy likewise. Prior to the discovery of gold the first coal deposits were located in Victoria but the serious usage of brown coal started in 1921 with the foundation of the State Electricity Commission of Victoria. The first power plant was opened in 1924 and provided Melbourne with power generated from brown coal mined in the Latrobe Valley. Today there are three brown coal mines operating in the Latrobe Valley: Loy Yang, Hazelwood and Yallourn. 90% of the state's power is generated by six power stations. 430 billion tonnes of brown coal are estimated within Victoria including 33 billion tonnes in the Latrobe Valley (Minerals Council of Australia, N/A a).

Gold

Since 1851, 80 million ounces of gold have been exploited in Victoria. With today's gold price these 80 million ounces would be worth $150 billion. Even

though the alluvial and shallow deposits are exhausted, Victoria is still considered a major gold province with considerable resources yet to be explored. The recent yearly production rate is 200 000 ounces coming from the gold mines at Stawell, Fosterville and Ballarat (Minerals Council of Australia, N/A b).

Mineral Sands

While gold has been mined in Victoria since 1851, mineral sands are an upcoming mineral resource in Victoria. Mineral sands are deposited ancient beach sands that contain valuable minerals such as rutile, ilmenite, zircon, monazite and other rare earth elements. Estimations state that there are eight million tonnes of rutile and six million tonnes of zircon to be found in Victoria's mineral sands deposits. The mining activity is focused on the Murray Basin in the state's west. These minerals are used in modern technology like computers and smart phones. Therefore an increasing demand for such minerals can be expected in the future (Minerals Council of Australia, 2013a).

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Facts about Australia: Kangaroos

Kangaroos (Roos) are balancing with their tails

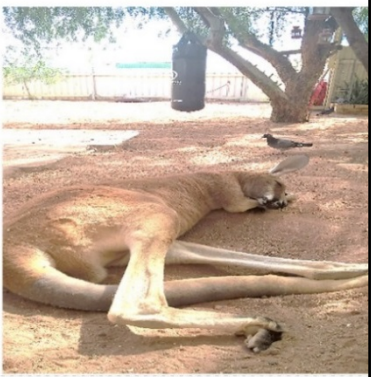
The young Roos is born at a immature stage. Then it weighs only a gram and is with about 2 cm as big as a sugarcube.

It leaves the mothers pouch completely in an age of seven to ten month.

The activity rhyth of Roos is irregular. In General, they are active at night, dusk and dawn.

Biting, kicking and boxing is the fight language of male roos.

Their maximum speed is 55 km/h.



Source: https://www.britannica.com/animal/kangaroo

University of New South Wales

Lisa Rabe

The University of New South Wales (UNSW) in Sydney is one of the leading Australian universities with nine faculties and over 50000 students from more than 128 countries. Established in 1949, the university holds a strong focus on the scientific, technological and professional disciplines and has a strong tradition of pioneering research and sustained innovation. The main campus is located seven kilometres from the centre of Sydney on a 38-hectare site at Kensington. (UNSW Sydney, 2017b)

Figure 1: Logo UNSW (*UNSW Sydney at a glance - UNSW Sydney)*

School of Mining Engineering

The School of Mining Engineering at the UNSW is Australia's leading mining engineering educational institution and one of the largest mining schools in the English-speaking world. It offers Undergraduate, Postgraduate and Research programs.

The research focus is on mining geomechanics, sustainable mining practices, mining systems and mineral processing. (UNSW Sydney Mining school, 2017)

Mining Geomechanics

The research group für mining geomechanics focuses on improving mine safety through fundamental rock mechanics research as well as applying their findings to issues facing the industry. This contains

- Developing and improving ground support technologies;
- Ground control – i.e. pillar design, ground support design, rock mass classification, rock burst, coal burst, and advanced risk based designs in underground and open cut mines;
- Advanced visualisation – i.e. the use of virtual reality technology as a tool for a systems approach to understanding seismicity;
- Mine subsidence behaviour and prediction; and
- Numerical modelling.

The current main research projects deal with fundamental coal burst research, avoiding premature cable bolt failure, investigating cable bolt performance under a range of geotechnical conditions, mine subsidence behaviour and prediction, highwall mining pillar design, estimating rock mass strength from laboratory properties and probabilistic analysis of slope stability. (UNSW School of Engineering, 2017)

Sustainable Mining Practice

Many research projects that concern sustainable mining practices are executed by the Australian Centre for Sustainable

Mining Practices (ACSMP). These projects span

- Mine site water, groundwater and seepage barriers;
- Remote sensing to detect environmental impacts, subsidence and illegal mining; and
- Climate change adaptation and mining, and carbon management.

The current research concerning this field deals with an evaluation of geotechnical mechanisms in valley subsidence and closure. (UNSW Sydney Mining Engineering, 2017)

Mining systems and mineral processing

The research groups for mining systems and mineral processing focus on improving efficiencies in mining systems and mineral processing through novel techniques, technology developments and new approaches. These areas include:

- Froth flotation as a mineral separation technique;
- Longwall top coal caving;
- Block cave mining; and
- Off-Earth Mining on asteroids, Mars and the Moon.

The current research projects being undertaken include flotation froth behaviour and bubble stability, and the development of an integrated economics model for in-situ resource use to support a colony on Mars. (UNSW Sydney, 2017a)

ACSMP

A major strength of the mining school is the Australian Centre for Sustainable Mining Practices (ACSMP). It was introduced in 2009 and is accepted by both government and industry in Australia and internationally as a leading authority on sustainable mining practices. The centre provides and develops innovative educational resources across both tertiary and professional development sectors as well as it is an actice research organisation focused on new mining practices, and development and application of technologies and systems for sustainable mining projects.

Figure 2: Logo ACSMP (ACSMP UNSW Sydney 2017)

The ACSMP is actively researching and working with industry and government in the following mining areas:

- Sustainability impacts of unplanned mine closures
- Mine safety
- Community engagement
- Mining legislation and policy
- Biodiversity offsets and mining
- Carbon mitigation at mine sites
- Climate change adaptation and mining
- Environmental and social impact assessment
- Implementing sustainable mining practices in India and China
- Remote sensing and imaging the mining environment
- Mine water, coal seam gasification (CSG), seepage barriers, water quality, virtual water gender issues in mining
- Mining laws and policies
- Sustainability in mining education

Furthermore, the school's academic engage in a wide range of short-term consulting roles with industry and government agencies, both in Australia and internationally, on topics including safety and productivity investigations as well as mine planning, economic evaluation and mineral economics. They also deal with topics like mine management practices, problem-solving in a range of technical areas including blasting and rock breakage, mine ventilation, rock mechanics and roof control, and minerals processing. The school has worked with organisations such as BHP Billiton, Rio Tinto Iron Ore and Douglas Partners. (ACSMP UNSW Sydney, 2017)

Figure 3: Students use the virtual reality simulator (UNSW Sydney Engineering, 2017)

Virtual Reality Simulator

The abovementioned research fields and groups include among others the use of virtual reality. Located within the School of Mining Engineering, the VR Suite was developed in conjunction with industry partners of the school. This cavernous dome provides a virtual setting for students to explore an underground mine and undertake training with the system in detecting hazards. Students have the opportunity to be immersed in straggeringly realistic underground mine and scenarios through the VR Simulator. This facility – also referred to as the Advanced Visualisation and Interaction Environment (AVIE) – casts 360-degree 3D images against the dark surrounds with cinematic clarity on floor-to-ceiling screens.

In the VR Simulator, students learn to assess the feasibility of a mining project while considering issues around risk, economics, ore-body characteristics, equipment selection, health and safety, and staffing. Alternatively, students can go above ground and manage the development of a greenfield site. These are great learning experience beyond the theoretical lectures and prepare the students for

Industrial trainings during their undergraduate degree courses.

Apart from the advantages for students, industry partners of the school benefit from using the 3D simulation. Different modules have been developed by industry professionals to simulate various mine environments. Thus, they can experience potential hazards safely, test evacuation procedures and consolidate feasibility studies, from open-cut to underground.

The current used modules are:

• Self-escape: students are presented with an emergency situation within a 3D-representaton of a longwall mine and various transport roadways. Split-second decisions need to be made while a team of miners is evacuated.

• Mining in a Global Environment: this module transports students to the vast blue-skies of Kakadu National Park (where they can walk through 360-degree panoramas of the Ranger Mine and its local environment) to undertake feasibility testing and to take a hands-on approach to project planning.

• Outburst management: this module presents a detailed virtual reproduction of an often-fatal outburst event, allowing students to safely enter this 'worst-case scenario', trace the events that led to the outburst, and then manage their teams through the aftermath.

• 3D terrain exploration: students are in the driving seat for this module. They choose possible surface environments that might exist near a mineral deposit. Then an ore-body is placed underneath the selected terrain-scenario to instantly reveal the depth, orientation, dip and rock characteristics.

• ViMINE: The ViMINE Module 1 scenario activity is on mining methods selection for both 1st and 3rd Year students. Currently the students learn how to select mining methods through several separate activities, without the benefit of an integrated simulation. At the end of the course, the students are assessed in the form of a written report and/or presentation and in a final exam, in which they are expected to demonstrate an integrated understanding of the selection process and its potential outcomes. (UNSW Sydney Engineering, 2017)

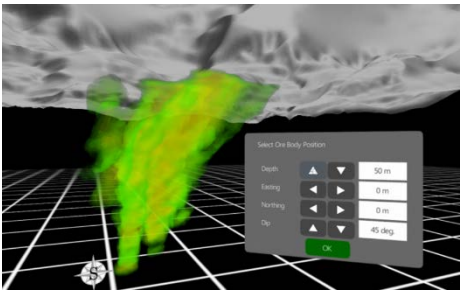


Figure 4: ViMINE (UNSW School of Mining Engineering, 2017)

ViMINE

ViMINE is a tool to get to know various aspects of a mining operation working together, integrating several types of simulations into one environment. Due to scenario-based learning activities run through the ViMINE environment, students get the chance to access information from multiple simulations and make decisions throughout the whole lifespan of a virtual mine. This ranges from initial exploration to final site rehabilitation. That gives students the opportunity to experiment with a fully "operational" mine. (UNSW School of Mining Engineering, 2017)

Laboratories

Apart from the mentioned VR Simulator and ViMINE, the School of Mining Engineering has a computer laboratory, a rock mechanics laboratory and a ventilation laboratory, where the students design and

develop mining case studies and use customized equipment for fundamental and applied research into mining issues and water research. (UNSW Mining Engineering, 2017)

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The University of Adelaide

Nachinzorig Saruulbayar

Figure 1: Skyline of Adelaide (City of Adelaide, 2017)

Adelaide is the capital city of the state of South Australia. It is located 654 km northwest from Melbourne and 1161 km west from Sydney. The coastal city is the fifth most populous city of Australia with over 1,3 million residents. Adelaide is known for its many events and festivals, wine fields and its long beachfronts. Defense and manufacturing sectors are quite developed there as well. The city is well and cleanly planned and attracts many students. Adelaide city has 3 universities - one of those is the University of Adelaide.

The University of Adelaide is a public university, that was founded in 1874 by philanthropist and copper miner, Walter Watson Hughes. It was the 3rd University in Australia after University of Sydney and University of Melbourne by the time it was built. In 2017, the university was listed 142nd in the World University Rankings (Times Higher Education) and has been consistently ranking in the top 1% of the world's universities. They also belong to the Group of Eight (Go8), which comprises of Australia's eight leading research Universities. Australia has been awarded with 15 Nobel Prizes. The university claims associations with five Nobel laureates.

Figure 2: Logo of the University of Adelaide (The University of Adelaide, N/A)

There are five academic faculties at the university, each divided into several schools and disciplines:

- Faculty of Arts,
- Faculty of Engineering,
- Computer and Mathematical Sciences,
- Faculty of Health and Medical Sciences,
- Faculty of Professions and Faculty of Sciences.

Currently, 21396 students (5678 international students) are enrolled in different areas, as shown in the chart below.

The university provides comfortable environment for its students with four campuses located throughout South Australia and an education center in Singapore. Noteworthy to that was the 24/7 open students' hub with library, which we visited during campus tour. As part of our field trip, we have visited the School of Civil, Environmental and Mining Engineering (CEME) at the campus North Terrace. The School of CEME has around 500 to 600 students with 10-15% international students. 60-70 students are enrolled each year. In the Mining Engineering course are currently studying ca. 120 students. The school includes a department for Petroleum Engineering as well.

After returning to Adelaide from our visit to the opal fields and Prominent Hill in South Australia, our next destination was the university. The group has arrived at the University of Adelaide on March 17th, 2017. We were welcomed by Prof. Peter Dowd, the executive director of the school and the Professor of Mining Engineering. Prof. Peter Dowd has been active in the academic field for more than 40 years. Besides research and teaching administration, he also consulted the industry. He has published over 200 papers and sections of books. His specialized fields are geostatistics and stochastics modelling. Further researches include computer-aided designing of mine layout, mine development, financial and economic aspects of mining and even development of software. Later, we were also introduced to associate Professor Dr. Murat Karakus, who guided us on the laboratory tour. He specializes in rock mechanics and numerical modelling in geotechnical engineering. After a brief conversation with Prof. Dowd, Dr. Karakus and other doctoral students, we went on a tour around the school's laboratory. The school's laboratory was divided into 5 sections. These include the laboratories for rock mechanics, soil mechanics, mineral processing, civil engineering (material testing etc.) and for water systems engineering. We had a brief tour in the geomechanical laboratory, which had 3 TC chambers, instrument for acoustic measurements (measuring of acoustic sounds from rock cracking), instrument for rock hardness, ventilation duct and etc:

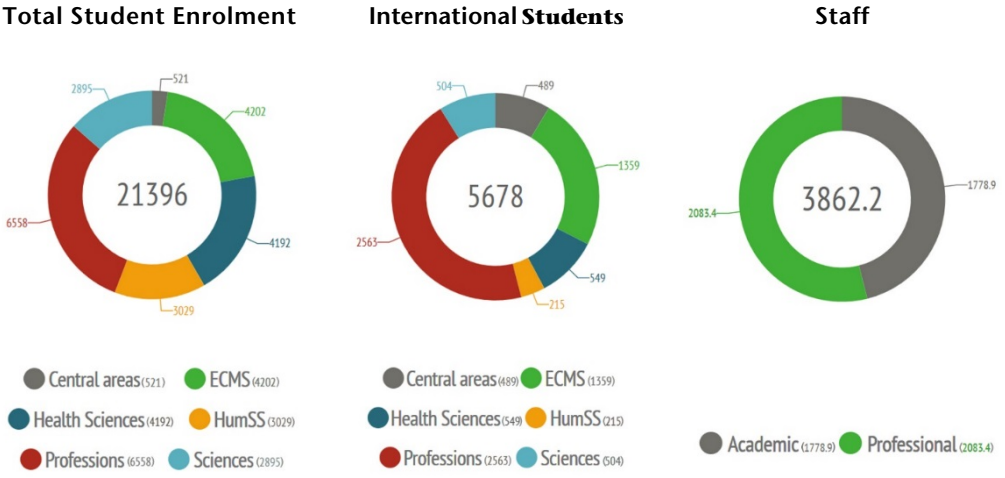

Figure 3: Students and Staff Numbers (The University of Adelaide, 2017)

- Geostatistics
- Rock fracture modelling – Geothermics, stress distribution around rock excavation, coal seam gas extraction
- Geomechanics - Rock fracture, rock failure
- Geotechnical Engineering – Consolidated/unconsolidates rock mass stability
- Mining operations research – Mine planning and simulation

Furthermore, the research projects in partnership with the Deep Exploration Technologies CRC were highlighted on the website. The "Mining and Geotechnical Engineering Research Group" is currently contributing to five of the eight CRC projects. As the demand of commodities increase, the prospective mines will have to go deeper. To ensure the future of extractive industry and the demand of raw materials, new technologies to explore and mine at greater depths and at sea have to be developed. For this significant work, the research fund sums up to around $112M.

As for education in Mining, the university offers several courses in bachelor and master as well as double degree courses. In fact, Mining Engineering as a separate study was first introduced in 1903. By 1913, the Bachelor and Master degrees were established. The Bachelor degree lasts for 4 years with a total of 120 CP, whereas the Master's program takes 2 years with 48 CP. The degree structure is developed by the Mining Education Australia, a collaborative venture of certain Australian universities. In comparison to the bachelor's program of TU Clausthal, the courses such as Electrical Engineering (Elektrotechnik), Experimental Physics and Chemistry (not for Petroleum) are not included in the program. But Rock Mechanics and Soil Mechanics are studied into more details across 6 or 7 separate courses. Master's degree structure is seemingly similar to ours in terms of offered courses. But they mainly focus on project planning, project management and project research and study.

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The Bloomfields Collieries

Constantin Weigel

Figure 1: Logo Bloomfield Collieries (Bloomfield Group, 2016b)

The first mine visit of our group was on the 7th of March, three days after arrival to Australia. For the mine visit, we travelled from Sydney into the Hunters valley. The Hunters Valley is a region north of Sydney, which is famous for its wine and its coal mines. Our destination was the Bloomfield Colliery open-cut hard-coal mine owned by the Bloomfield Group ltd. We arrived at site at 9 am and were kindly welcomed by the mine manager, who told us in an introductionary meeting about the company, the mine-site, the processing and about health and safety procedures. Bloomfield Colliery is located in the Hunters Valley in New South Wales:

The Bloomfield Group ltd. is an Australian owned and operated group of private companies with interests in mining and engineering in the Hunter Valley. It operates two mining operations: The Rix's Creek mining operation (located in Singleton) and the Bloomfield Colliery (located in East Maitland) mining operation, which both are open-cut coal mining operations. The Bloomfield group employs around 500 employees and had in 2013 a mining capacity of 2 million metric tons of hard coal per year.

Mining commenced at East Maitland (Four Mile Creek) in 1937. The coal was mined by underground methods until 1992. The open-cut mining commenced

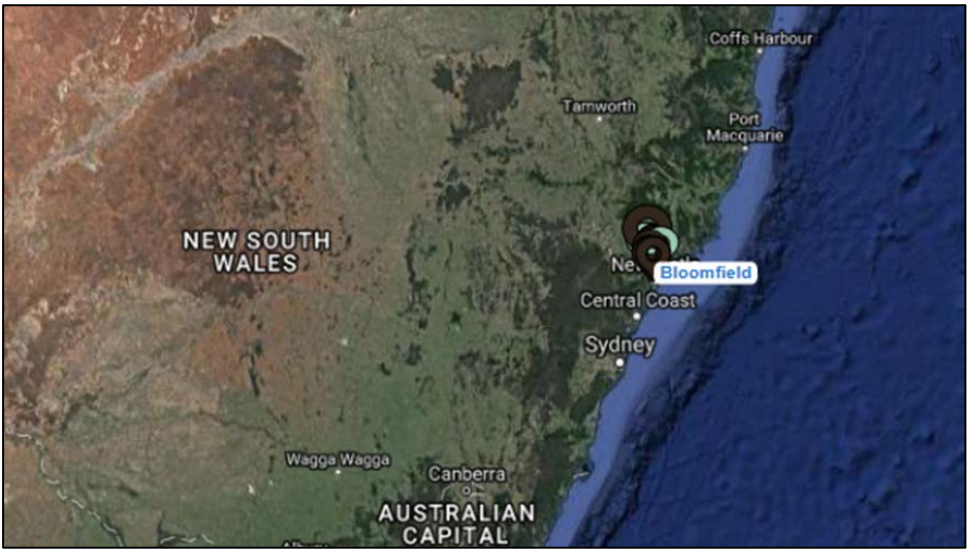

Figure 2: Location of Bloomfield Mines in New South Mapes based on Google Maps

in 1964 and continues till today. The company has consistently produced steaming and coking coal for exports market since 1958 and is exporting its coal mainly to the Asian market. Next to coal mining, Bloomfield Group ltd deals with contract coal washing and bulk handling, the manufacture and sale of underground mining equipment and the maintenance and component repair of diesel equipment.

The Bloomfield (Four Mile Creek) deposit, which we visited, holds in situ resources of 37.7 Mt of which 21 Mt are recoverable and 12.6 Mt are marketable. The mine produces between 500,000 t and 600,000 t of saleable coal per year (around 1 Mt coal before processing) and moves around 13.25 Mt of overburden annually. In total 97 employees are employed at Bloomfield.

The deposit consists out of 13 seams or splits of hard-coal, which are mined simultaneously. These coal seams are imbedded in sandstone. Bloomfield faces relatively high stripping ratios around 10:1. The average stripping ratio in the Hunters valley is between 6:1 and 7:1. The high stripping ratio demands a high efficiency mining operation at Bloomfield. The open-cut production started in 1964 using bulldozers and tractor scrapers. Nowadays, Hitachi EX 5500 excavators and 170 t rear dump trucks as well as a range of dozers, front end loaders and highway type trucks are utilized for a multi seam, multi bench mining. A 500 t hydraulic backhoe and 240t rear dump trucks remove the overburden. For the mining operation 2361 t of explosives and 7128 t of fuel are consumed per year. The mined coal is delivered the coal to the on-site coal preparation plant.

Figure 3: Coal Washing Plant

Due to bad weather conditions in the prior days, the coal preparation plant was made the primary objective of the mine visit as the pit was to wet for mining operation that morning. We were guided through the washing plant by two employees of the Bloomfield group, who showed us the plant and explained its components.

In the coal preparation plant, or washery, up to 1000 t of raw coal can be processed per hour. Prior to processing, crushing takes place for primary size reduction after extraction. After crushing the material is screened and divided into two processing cycles. The coarse coal (50 mm x 1 mm) is washed by two stages, dense media cyclones, which use magnetite to control the density. The magnetite is reclaimed after the process for further usage. The fine coal is processed in a reflux classifier and a Jameson cell. A Jameson cell is a floatation machine developed by an Australian mining professor at the University of Newcastle, which is the biggest city in the Hunters Valley.

The coal washery as shown in has the capacity to wash 6Mt of coal per year, producing around 4 Mt of saleable product. It employs a 1000 t/h feed hopper, wet screens, a rotary breaker, dense media cyclones, fine coal spirals, ultra-fine coal floatation equipment and a 1000 t raw coal bin. The product coal is stacked under gantries at the washing plant where it waits to be delivered to the train loader by conveyor belts. The product-coal stockpile has a capacity of approximately 400,000 t and is managed between the Bloomfield and contract operations. The Rail Load-out Facility can be used to transport up to 3,500 t per hour. The coal is conveyed to Newcastle. At Newcastle, the coal is stored awaiting shipment at the Port Waratah Coal Services coal terminal. The Port Waratah Coal Services coal terminal is owned by the Bloomfield Group.

Figure 4: EX5500 Excavator

After the tour through the processing plant we were invited for lunch and awaited the weather to improve, which it did. The better weather and drier soil allowed for the mining operation to continue and our mine visit to continue. For the second part of the mine visit our group divided into for four smaller groups. Each of these groups were assigned to a car and a guide, which took us through the mine. The guide explained us the mining method at Bloomfield:

The mining method is a truck and shovel open-cut method. The truck and shovel mining method is better suited for smaller, geological complex deposits, such as the Bloomfield Collieries, due to its high flexibility. In addition to flexibility, lower capital costs (as for dragline operations) are an advantage of this mining method. Anyhow, this method goes with higher operating costs than the dragline operated strip mining. The mining activity starts at one end of the deposit and advances in strips along the strike direction. Overburden is initially dumped outside of the pit and later inside of the pit, when sufficient dump room is available. The pit is excavated as a series of horizontal benches, on which coal and waste are exposed. The mining method is refered to as "Haulback Mining" as the waste is hauled and dumped back into previously excavated areas.

After explaining us the way of operation we drove through the mine visiting different parts of it. We first stopped to see one of the bucket excavators, which was located on the top of the pit.

The EX5500 excavator weighs 550 t and is presented in Figure 4. In operation, it consumes 390 l fuel per hour and is equipped with a fuel tank of 10,400 l. With its 29 m^3 bucket the bucket excavator can handle

Figure 5: Electric Shovel

1800 m³/h. After seeing the bucket excavator, we continued the tour to see the electric shovel, which was located one level deeper in the pit.

The electric P&H 5700 shovel is powered by an 11 kV electric current and displayed in Figure 5. It weighs 1800 t and is able to lift 1900 m³/h with its 36 m³ bucket. After seeing the shovel we went to the bottom of the pit were we could take a look at the geology of the deposit.

Figure 6: Bloomfield´s Coal Seams and complex Geology

Figure 7: CAT 793 Dump Truck

Specially to see the multiple coal seams and the amount of overburden was impressive, as it illustrated the complexity of the geology and the selectivity and flexibility that is needed for the mining operation. A representative highwall is shown in Figure 6. The next step of our tour was the dumping station, where the trucks dumped the overburden.

The CAT 793 Dump trucks can weigh when loaded up to 385 t. An example is shown in Figure 7. They are equipped with a 2,160 HP diesel engine, consuming up to 125l/h unloaded and 425 l/h when loaded. The trucks are 12.86 m long, 7.4 m wide and 5.9 m high. The can reach a top speed of 56 km/h and are equipped with four tyres, costing 51,100 $ each and having a tyre life of 9,860 h.

The last step of our mine visit was to see the tailing dam and already rehabilitated land.

Rehabilitation included to shape the land into a final even landform, as well as the top soiling, cultivation, seeding and fertilization. The seeds were either a mix of improved pasture species (Couch, Clover, Rye, Lucerne Kikuyu) or a native vegetation mix. Nowadays already 449 ha have been rehabilitated.

During the trip, we learnt a lot about a rather small truck & shovel, multi seam open-cut haulback operation, which was especially interesting due to the challenging geological situation. Than we continued to Newcastle.

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Facts about Australia: Koalas

Koala carry their babies in a pouch making them marsupials and not bears.

Koalas are born naked with ears and eyes closed in the size of a jellybean.

At the front paws, Koalas have two thumbs for better climbing, hanging in the tree and grabbing food.

Koala eat only special kinds of eucalypts. Adults eat up to 1 kg each night.

For marking his territory, male Koalas have a dark scent gland on their chest, which they rub on trees.

Source: https://www.savethekoala.com/about-koalas/fascinating-facts

Mount Thorley Warkworth Mine

David Zelienka

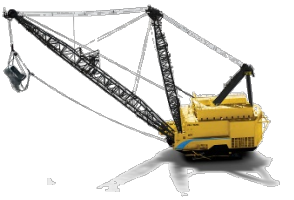

Figure 1: O&H 9020C (Komatsu Mining Corp. 2017)

Introduction

Mount Thorley Warkworth (MTW) is an integrated operation of two open cut coal mines, Mount Thorley and Warkworth, located adjacent to each other. (Rio Tinto, 2014) Warkworth Mine commenced mining operations in April 1981 in a mining lease which comprises 4200 hectares of land. Commencement of Mount Thorley's mining operations was in the same year with a mining lease that encompasses approximately 1992 hectares of land. (Halfpenny, 2012)

The integration of both mines occurred in 2004.

The mine complex is located 15 kilometers south-west of Singleton in the Hunter Valley region of New South Wales and was the workplace for about 1350 - 1650 employees in 2016 (Rio Tinto, 2017a). Furthermore, in 2015, Mount Thorley Warkworth mine supplied international and Australian markets with 11.7 million tons of semi-soft coking coal and thermal coal. Coal & Allied Industries Limited, a wholly-owned Australian subsidiary of Rio Tinto, is managing the MTW mine as operator on behalf of the joint venture partners. (Rio Tinto, 2014) In 2017, Rio Tinto agreed on the sale of Coal & Allied Industries Limited to Yancoal Australia Limited, a company 78 % owned by Yanzhou Coal Mining (Rio Tinto, 2017b).

Concerning safety, MTW operates with a LTIFR (Lost time injury frequency rate) of approximately 0,33 per 200,000 hours

Figure 2: A dragline is removing overburden at Mount Thorley Warkworth (Chakraborty, 2017)

worked and an AIFR (All injury frequency rate) of about 0,59 per 200,000 hours worked. In 2014, the energy use per ton of material moved was approximately 4,44 kWh (Rio Tinto, 2015) while in 2016 the average costs per mined ton of coal were about 46 AUS$. The ridge-to-bottom depth of the Warkworth pit was about 260 meters in March 2017.

Geology and Resources

In the Hunter Valley region in NSW almost all open cut coal mines have to deal with a complex multiple seam geology, which makes it necessary to design a suitable extraction method for up to 50 coal seams. The coal seams in this region have their origin in the late Permian (~ 255 to 251 Ma) and the strata dip to the west and the south west generally between 4 and 6 degrees (Coal & Allied, 2002).

The Warkworth and Mount Thorley leases contain significant resources of thermal, soft and semi-soft coking coal. After revised interpretations of the coal seams structure, yield and quality in 2016, the total resources of Mount Thorley Operations are 322 Mt thermal and coking coal, comprising 39 Mt of measured resources, 226 Mt of indicated resources and 57 Mt of inferred resources. The total Warkworth resources are 966 Mt of thermal and coking coal, comprising 141 Mt of measured resources, 307 Mt of indicated resources and 517 Mt of inferred resources (Rio Tinto, 2017a).

Mining and Machinery

Mount Thorley Warkworth mine is an open cut coal mine, using a dragline, truck and shovel method to mine the coal. The main equipment fleet employed to carry out mining operations at MTW comprises about 150 machines, which are operating in 12 hour shifts, 24 hours a day, 7 days a week. (Halfpenny, 2012)

The whole mining process can be divided in four parts:

- Vegetation clearing and topsoil stripping
- Overburden and interburden removal
- Coal removal
- Progressive rehabilitation

During the first step, a pre-clearing survey is undertaken to identify habitat trees and other plants. After this survey, all vegetation will be removed, trees suitable for timber will selectively marked and removed, and topsoil will be removed by dozers (Cat D11T, Cat D11R, Cat D10). The topsoil is stockpiled or directly used for rehabilitation in mined-out areas.

The overburden removal at MTW is based on dragline stripping and shovel pre-

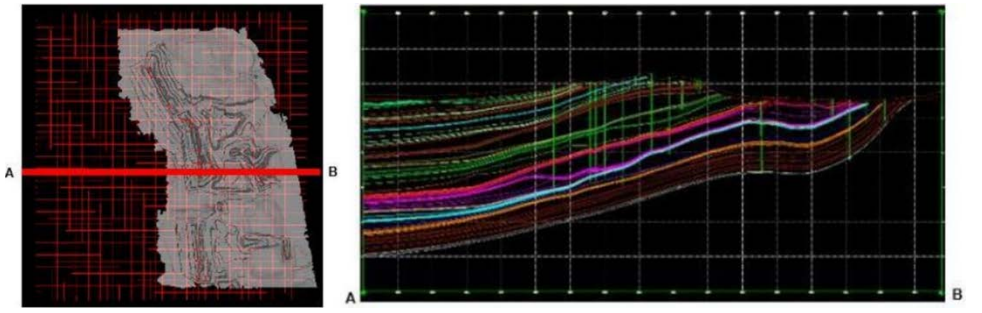

Figure 3: Crosssection A to B (West to East) (Rio Tinto, 2017a)

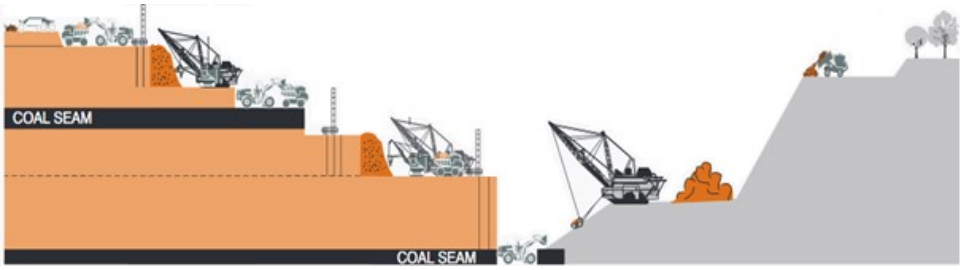

Figure 4: Open cut Mining Methodology, Rio Tinto

stripping methods. To expose shallower coal seams in the pit, multiple benches are created by trucks and shovels to provide a working platform for further interburden removal by dragline operations. The combination of trucks, shovels and draglines enables the mining of the relatively complex multiple seam geology (Onargan, 2012).

MTW mine is operated three different draglines: a Marion 8200 Dragline with a bucket capability of 46 to 61 m³, a BE 1370WB Dragline and P&H 9020 Dragline with a bucket capacity range from 55 to 93 m³. Furthermore, several excavators like Hitachi EX3600, Hitachi EX5500, P&H 2800XP and P&H 5700XPA as well as a fleet of 76 haul trucks, including Komatsu 830E 240T and different Caterpillar models, are operating in MTW. Almost all overburden and interburden requires blasting. The material is transported from its source to overburden dumps in mined-out areas and is used for reshaping the original landscape for rehabilitation.

In MTW mine, multiple coal seams are mined simultaneously to enable the production of coal of different qualities. The mean stripping ratio is about 1:10. The thickness of seams varies between 0.5 and about 2 meters. Seams thicker than 2 meters are drilled and blasted, while seams thinner than 2 meters are ripped by dozers. Mined coal is loaded into trucks by front-end loaders or excavators and delivered to the ROM coal stockpile facility at either the Warkworth or Mount Thorley coal handling and preparation plant.

During the last step, the dumped overburden material is reshaped to form the original surface. Previously removed topsoil will be placed above the overburden material to enable the growth of new vegetation (Coal & Allied, 2008).

Coal Handling and Preparation Plant (CHPP)

Mount Thorley Warkworth mine's saleable production in 2016 was approximately 12 Mt of coal, approximately one-third coking coal and two-thirds thermal coal. MTW is operating two washing plants which are separating about 70 % coal from 30 % waste material by using cyclone circuits, spiral processes, flotation and centrifugal techniques (Halfpenny, 2012). Saleable coal is dispatched by train to Newcastle harbor. Most of the saleable production is almost entirely sold to companies which are registered in Japan, Taiwan, China or other Asian countries.

Conclusion

The visit at the MTW mine site was a personal highlight for me. The opportunity to get a brief overview of black coal open cut mine of this dimension was unique, especially because of the lack of comparable open cut mines in Germany/Europe.

Furthermore, the effort that is undertaken to monitor parameters like air quality, surface water quality, groundwater quality, operational noises, cultural heritage and the flora and fauna, was impressive.

Another highlight was to catch a glimpse of the operating P&H 9020 Dragline because of the rarity of draglines in Europe. Not less impressive than the dragline was the good structured pit and the condition of the ramps and driveways, compared to other open cut mines that we have visited during our field trip.

Moreover, I had the opportunity to improve my knowledge by visiting my first mine which is using a truck, shovel and dragline combination for mining.

Unfortunately, we could not take a closer look at the CHPP and it was forbidden to take any pictures of the mine or equipment, nonetheless I think I will keep a lot of positive impressions.

Finally, I would like to thank Coal & Allied for supporting our Field Trip to Australia and for the very well organized mine tour.

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Facts about Australia: Iconic Food

According to the Australian Geographic the most iconic Australian foods are

1. Pavlova *(we had two perfectly made by Sue Hebblewhite)*
2. Chiko Roll
3. Meat pie *(the easiest choice at the gas station)*
4. Splice
5. Lamingtons *(perfect food during drives)*
6. Vegemite *(a must-eat at breakfast for some of us)*
7. Sausage sanger *(getting familiar with it at BBQ at UNSW trying at our one in Adelaide)*
8. Weet-Bix
9. Anzac biscuit *(see 5.)*
10. Neenish tart

Typical Australian Barby,
Photo: O.Langefeld

Source: http://www.australiangeographic.com.au/topics/history-culture/2015/01/10-iconic-australian-foods-and-their-history

The Appin Mine

Felix Rohkamm

During the first week in Australia we visited the Appin Mine which is located in the New South Wales Illawarra region, around 25 kilometres north-west of Woolongong and 75 kilometres south-west of Sydney. The Illawarra region lies south of Sydney and has large coal deposits as well as deposits of metallic minerals like gold, silver, copper, lead and zinc. There are also some industrial mineral deposits in New South Wales, like limestone, clay and sands. (Minerals Council of Australia, N/A c)

In the history, the Appin Mine consisted of the Appin and the Tower collieries (located at Douglas Park) which is today known as the Appin West mine. The Appin colliery started its first operation in 1962 and first longwall mining was introduced in 1969. The Tower colliery started its first operation in 1978 and in 1988 the first longwall operation started at the Tower colliery. The Tower colliery finished the extraction of 20 longwall blocks

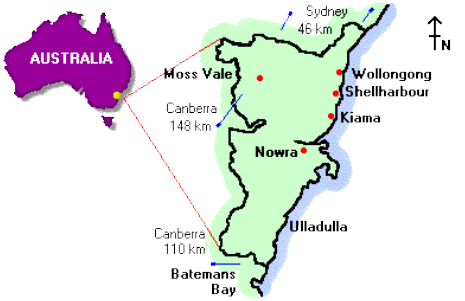

Figure 1: Illawarra region in NSW (Illarwarra Coal 2015b)

in 2002. Afterwards the mine was redeveloped to continue mining in the current longwall 7 area. In 2003 all the underground infrastructure, e.g. roads, conveyors and ventilation were merged together to become the Appin Mine. Today the Appin Mine consist of the Appin East, the Appin West mines. The Appin Mine is owned and operated by Endeavour Coal P/L, a subsidiary of Illawarra Coal Pty Ltd which is 100% owned by South32. (Gregory, 2016, p. 7) The Appin Mine is located in the New South Wales southern coalfield, where a bulli seam of late permian

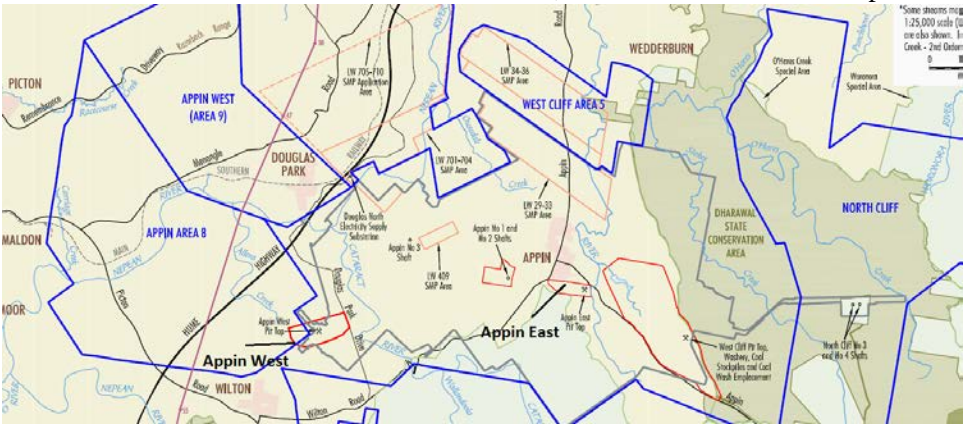

Figure 2: The Appin Mine (Illarwarra Coal and bhp biliton, 2009)

Figure 3: The Appin and Tower project (Energy Developments, 2011)

period coal can be found in place. Within the southern coalfield there is also another coal seam which is called wongawilli seam, but within the Appin Mine only the bulli seam is in an economical range of extraction. (Gregory, 2016, p. 13) At the Dendrobium mine, which is in the neighborhood of the Appin Mine, the wongawilli coal seam is mined. In the area of coal mining, the bulli seam has a thickness of around 2,9 up to 3,2 meters in a depth below the surface of around 300 metres in the south-east and up to 850 meters in the north-west. The coal at the Appin Mine is mined by longwall mining technology, which allows an efficient production at low operation costs. Above the bulli seam there can be found different sequences of sandstone, claystone and shale. Whereas there are diverse types of sandstone in the strata, which often cause challenges during the mining process and sometimes lead to aggressive ground conditions. Since the first longwall mining started in 1969 a massive mine development, exploration and mine extension took place at the Appin Mine to develop further longwall panels and to extend the life of the mine.

Miners and material access to the underground operations via main drifts and shafts. They are located each at the Appin East and Appin West pit tops. To shorten the conveyor transportation of coal, additional drifts were installed during the development of the mine as it is necessary and possible.

In certain areas of the mine the roof is setting down, therefor steel arches or so called roof bolts were brought into the

roof, to support the roof and prevent a collapse of the roof. After the arches or bolts were set into the roof, they were filled with cement under pressure. Depending on the roof conditions, there is also steel cable roof support installed within the mine. The type of roof support is chosen according to the underground requirements. To support the roof nearby the longwall operations, so called standing roof supports which consists of wooden bars were installed. They are built as it is necessary according to the roof conditions and the roof movements. This type of roof support is also called as “Hercules crib” or “Link-N-Lock crib” and is characterized by its simple, easy and fast construction. By monitoring the movement of the wooden standing roof support, the engineers are able to evaluate the direction of the occurring forces in the roof and to decide about further necessary actions. Within the whole mine, the roof monitoring is done manually by checking each measuring device in a regular time sequence. In a depth of around 500 meters below the surface there is a stress of approximately 21 MPa, the stress within the bulli coal seam is around 10 - 11 MPa.

Inside the mine in certain areas stone powder is sprayed onto the coalface to prevent coal dust. Furthermore, bags filled with stone powder were installed at the roof in certain areas, to collapse during explosions and to prevent the expansion of the explosion. In July 1979, there was tragic accident caused by a methane gas explosion around 500 metres underground, which caused the death of 14 miners. (Illarwarra Coal, 2015a)

Around 300 metres below the surface there is a groundwater aquifer within the mining area, which leads to a certain amount of water that floats into the mine and that needs to be removed from the mine. Therefor an effective water management system need to be in place, to make sure there is not too much water in the underground infrastructure and that the production and the mine safety is not affected. It is also necessary to install water treatment facilities within the surface area to handle the water that is pumped out from underground. It is also necessary to meet the given regulations on the waste water. For the Appin East mine and the Appin West mine, there are water treatment facilities like, ponds, lagoons, dams, filters, dosing plants and other water treatment facilities installed. The treated water is then supplied to the underground mining operations for further use. (Gregory, 2016, p. 60)

Longwall Mining

Longwall mining technology belongs to the so-called secondary extraction methods which starts after the development of the longwall panel. The development is usually done by continuous miners and shuttle cars. Longwall mining is used to mine out coal from big underground coal seams. The so-called longwall panel is up to 4 km long and the coalface that is mined out is up to 400 m wide. The individual size depends on the underground and the seam conditions of each mine. Within the whole width of the longwall panel, hydraulic jacks were installed. They were also called roof support. The hydraulic jacks support the roof of the mined-out area of the coal seam and prevent the collapse of the roof by progressively moving along the mined-out area. (Underground Coal, n.d.) The coal is cut by a shearer that is moved along the entire length of the coalface. An armored face conveyor or AFC removes the coal from the coalface and transports the coal to the main gate of the longwall. There the coal is often crushed, to reduce its size and

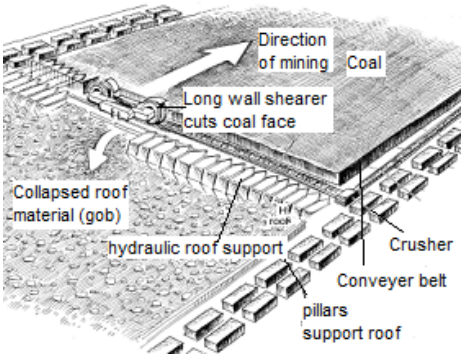

Figure 4: Longwall Mining (Larson, N/A)

then loaded on a conveyor belt that transports the coal to further handling or transport equipment.

As the shearer cuts the coal, the armored face conveyor and the roof support move forward into the newly created cavity. Behind the longwall, the mined-out area is allowed to collapse, which means the area becomes a goaf. Longwall mining is a safe and efficient way to mine underground coal seams. The longwall mining technology mines out the whole coal seam, that means that no pillars were left in the mined-out area. The resource recovery is much higher compared to the room and pillar mining method. It is also less manual handling necessary and the miner's safety is enhanced because they work under the hydraulic roof support. (Underground Coal, N/A)

During our flied trip, we were able to visit the Appin Mine. Because of the group size of 16 people, we divided the group to three smaller groups. One group visited the Appin East mine, another group visited the Appin West mine and the last group visited the Dendrobium mine. On behalf of all group members, I would like to thank all employees of the Appin Mine which made this underground tour possible and especially our underground guides, for our great and interesting underground tours. During our tours, all group members learned a lot about the Appin Mine and the longwall operation. We would also like to thank you for your great hospitality and all your efforts. For some of our group members it was the first time they went underground.

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Fun facts about Australia: Sydney

Sydney has the **world's largest natural harbour**. It has an average volume of about 500 Gl (gigalitre)

When talking about litres: The initial 3 coats of paint on the **harbour bridge** (built 1923 – 1932) took 272,000 l of paint, which is 0.000272 Gl

The building costs for **Sydney Opera House** ended up at AUD 102 million instead of an original estimate of AUD 7 million

Sydney has the largest **fish market** in the southern hemisphere (3rd in the world)

Manly Beach was named after the founder of the city was impressed by the indigenous inhabitants' "manly behaviour"

Sydney receives **10 million visitors** each year, and we were part of them!

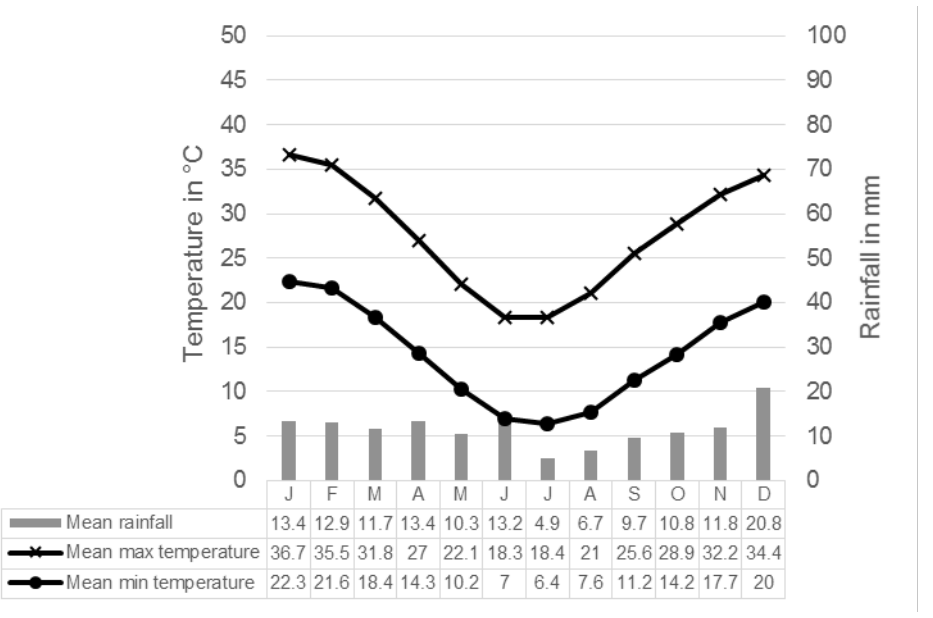
Sydney fish market
Photo: A. Binder

Coober Pedy Opal Fields

Lydia Ziemer, Angela Binder

In the Far North of South Australia, the town of Coober Pedy is located. Due worlds largest opal fields situated around Coober Pedy, it's called "the opal capital of the world. The fields measure 4954 km², which is approximately twice the area of the Saarland, and were discovered in 1915 making them the first discovered fields in South Australia. The location is shown in Figure 2. Coober Pedy can be reached driving on the Stuart Highway 550 km from Port Augusta. Besides opal miners, tourists visited the city not only to see the opal mining but also to stop on their way to Alice Springs, which is located 687 km northwards. The city can also be reached daily by plane from Adelaide. The landscape which is flat and barren in this region of Australia has been reshaped by Opal Mining. Coming closer to Coober Pedy, the number of characterists heaps increases. (Bradtke, 2017) (Government of South Australia, 2017b)

Located in the Australian Outback 225 m above sealevel, the climate is arid, as shown in Figure 1. Since 1994, the highest temperature measures was on the 1st of January 2014 47.4 °C. On the 22nd of July 1997, the lowest temperature has been recorded, which was -0.4 °C. Rainfall occurs normally seldom with an annual mean rainfall of 140.4 mm. (Commonwealth of Australia , Bureau of Meteorology, 2017b)



	J	F	M	A	M	J	J	A	S	O	N	D
Mean rainfall	13.4	12.9	11.7	13.4	10.3	13.2	4.9	6.7	9.7	10.8	11.8	20.8
Mean max temperature	36.7	35.5	31.8	27	22.1	18.3	18.4	21	25.6	28.9	32.2	34.4
Mean min temperature	22.3	21.6	18.4	14.3	10.2	7	6.4	7.6	11.2	14.2	17.7	20

Figure 1: Climatograph of Coober Pedy according to (Commonwealth of Australia , Bureau of Meteorology, 2017b)

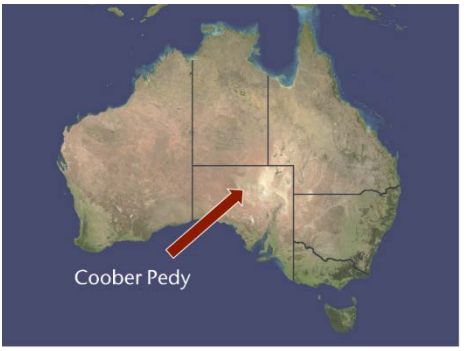


Figure 2: Location of Coober Pedy in Australia according to (Harpagon, 2008)

The region has been inhabited by Aboriginal people for more than thousand years, who lived in a nomadic lifestyle as gatherers and hunters on a constant travel to find food, water and to attend in traditional ceremonies. The establishement of a town started in 1915, when three guys from the New Colorado Prospecting Syndicate found a piece of Opal on the 1st of February. Digging started just eight days later, when the first claim was pegged. During the early times the areas was known as Stuart Range Opal Field named after the Scottish explorer John McDouall Stuart, who also established the name of Andamooka, but in 1920 it was renamed to Coober Pedy. It is an Anglicism of the words which described in the Miners in the Aboriginal language. “Kupa piti” means white man in a hole. (District Council of Coober Pedy, 2017b)

After the discovery of the first opal, more man came to find their gemstones. The movement was triggered due to the completion of the Trans Continental Railway in 1917, which was a huge infrastructure boost for South Australia and released a number of construction worker who were looking for a new money making activity . Furthermore soldiers who fought in World War I followed the workers. In the middle of the desert living conditions were hard and people lived in underground dugouts which provide a sufficient climate in the contrast to the surface conditions. Another big challenge was the water supply, which is still an issues in nowadays town. Today water is tranfered 24 km from a underground water source and treated afterwards making a great drinkable water quality. (District Council of Coober Pedy, 2017b)

In the 1930s and 1940s, the production was affected by the consequences of the great depression which dramatically lowered the opal prices leading to an slump of production. A new rush started in 1946 when Tottie Bryant, an Aboriginal women, found at the Eight Mile field a sensational opal. New people exspecially coming from the war-torn Europe tried to make money winning or loosing everything. In the 1960s and 1970s Coober Pedy developed to a modern mining town, which was mainly an attraction pole for European migrants. In the 1980s the town became also touristic. In 1981, the first hotel was established by Umberto Coro. (District Council of Coober Pedy, 2017b) (Ilya, 2017)

Figure 3: The town's landmark (Ward, 2015)

The population of Coober Pedy consists of 1,762 persons in 2016. 302 of them, making of a share of 17.1 % are Aboriginal and/or Torres Strait Islander People. Men come in superior number making a share

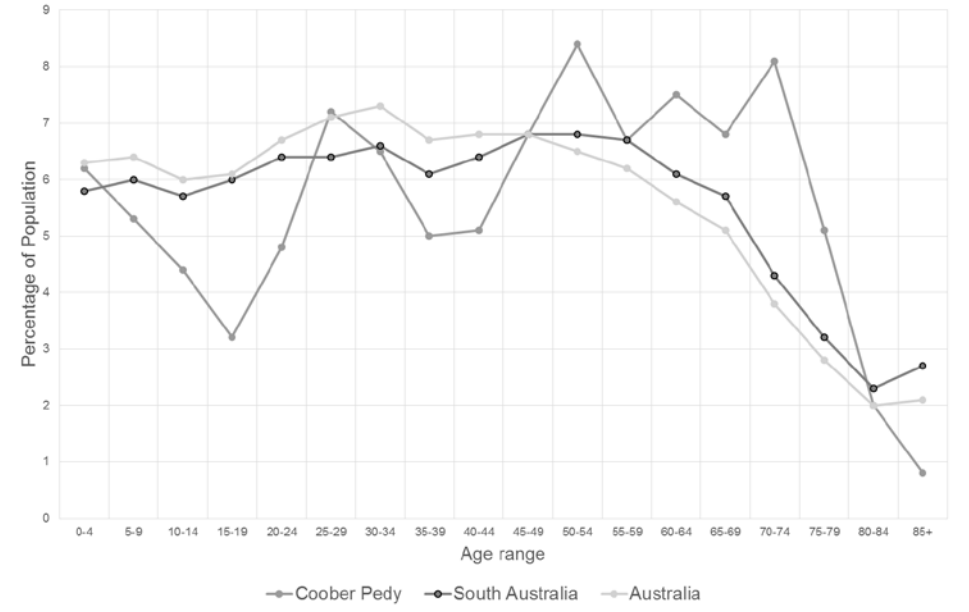


Figure 4: Age structure of the population of Coober Pedy according to (Australian Bureau of Statistics, 2017b)

of 54.6 %. 45.4 % of the inhabitants are female. Figure 4 shows the age structure in comparison with South Australia resp. Australia. It can be seen that the amount of older people is bigger in Coober Pedy. This is also represented by the meadian age of inhabitants of 46, which is six resp. eight years older than in South Australia resp. Australia. In comparison with Andamooka, which is also based on opal mining and introduced starting from pg. 69, the people of Coober Pedy are younger. A difference can be seen in the amount of people in the age span from 20 – 39. These persons are a approx. quarter of the inhabitants in Coober Pedy but just 14 % in Andamooka. Aboringal and Torres Strait Islander people are much young than the average. The median age is 25 , which is two years older than the Australian average in this group

Opal

The occurance of Opal in the areas led to the development of the town. Hence, Opal is introduced in the following section.

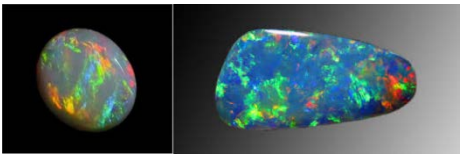


Figure 5: Opals (Ward, 2015)

Opal, as shown in Figure 5, is an amorphous form of silica which contains a variable amount of water. The formular is SiO_2*n H_2O. The atoms are arranged not in a crystal lattice but more or less chaotic. Opals are distinguished in amorphous opals (A-Opal) and slightly crystalline opals, in which structures are arranged in a local lattice (C-Opal). A-Opals are formed in condition of less than 50 °C while C-Opals formation condition are above 190 °C. On the Mohs-Scale, the

hardsness of Opal is 5.5 – 6.5 and they have a conchoidal fracture.In Coober pedy precious opal is mined, which show a colorful shimmer. The common opal has no shimmering. Other forms are the hyalite, fire opal and the geyserite. The shimmering is based on the composition of small spheres. The body of the precious opals can be grey, blue, white or black. The precious opal is found mainly in sediments. 95 % of the world production is coming from the Australian Outback. (Neukirchen, 2012, pp. 172–175)

Opal have no industrial usage and are used for creating jewellery. Therefore, Opals are judged based on different criteria. Of course the size measured in carat is important but also the background color, the dominating color and the combinations of colors. Besides, the treatment of cutting and polishing increases the value of an Opal. Three kinds of gemstone are distinguished: Solid, doublet and triplet opals. A solid opal is a massive gemstone, which has no underlayer. A doublet is made by cutting an opal and putting it mainly on an dark underground to increase its optical effect. A triplet consists of three layers. It is a doublet with an extra layer of glas above, which also protects the stone. (Schmid et al.)

Geology of Opal

The formation of precious is still discussed. Some theories explain the development and occurrence. A theory refers the alteration processes, another on points out that the occurances is often related to tectonic movements which could be an explanation. Water from Artesian wells is another explanation. Maybe, bacteria have an important role in the formation. (Neukirchen, 2012, p. 175)

Australian opal is found in altered sediments from the Cretaceous period close to the surface. In this periode the sea level was higher and parts of the Australian basin were flooded. As a coast area, it was effected by water movement and clay sediments settled. When the sea lowered the sediments were exposed to intense chemical alteration by organic acids which reached approx.. 100 m. Silica grains and clay minerals remained. During middle tertiary, this mixture was exposed to alkaline groundwater, which could resolve more silica due to its pH level. 24 Ma ago, tectonic movements took place in Australia, which could have led to the precipitation of Silica and formation of Opal preferred in areas of low permeability such as clay horizons. (Neukirchen, 2012, pp. 175–176)

In Coober Pedy, opals are found in the massively weathered Bulldog Shale, which has a white to mauve color, forming the host rock. Weathering areas such as vault and other discontinuities form horizontal or vertical levels, which can be found within a depth of maximum 25 m below surface. The distribution is uneven, making it the discovery of opal unpredictable. Figure 6 shows the map of Coober Pedy's Opal fields. (Opals Down Under, 2017)

Mining Opal

For prospecting and mining of opal in South Australia, a Precious Stones Propecting Permit is required, which is a special Mining permit for opal. Application must be made in a Opal Mining Registrar, which are located in Adelaide, Andamooka, Coober Pedy and Marla. The permit is not tranferable, valid for a year and must be requested personally. On the base of the permit, tenement can be pegged. Small tenements sides are less

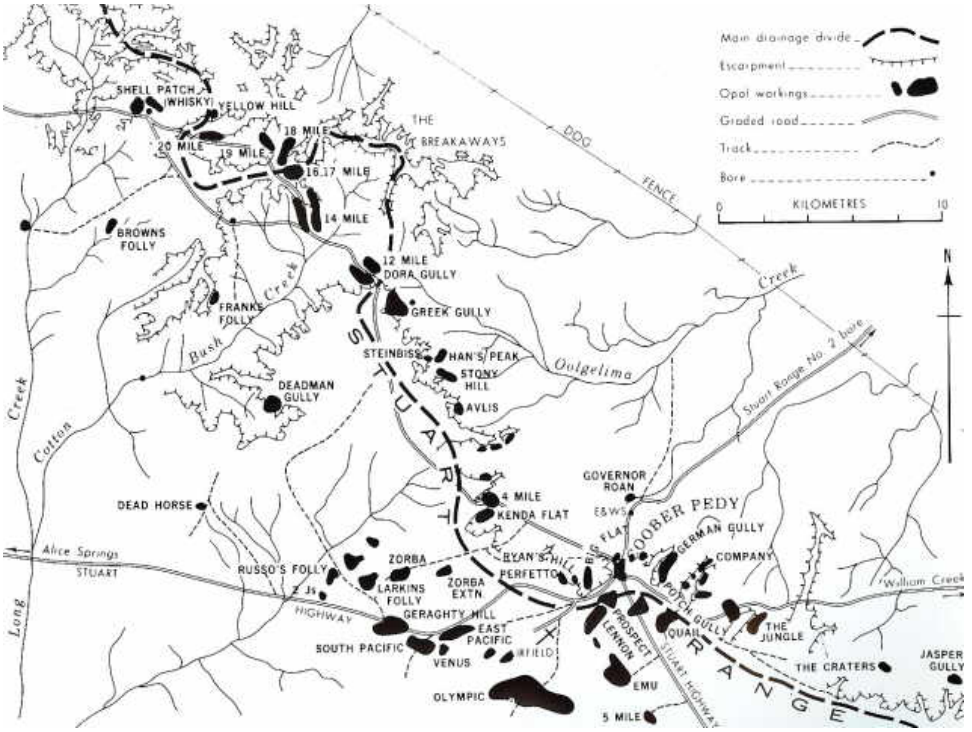


Figure 6: Map of Coober Pedy Opal Fields (Opals Information, 2009)

than or equal to 50 m. Large tenements have a maximum area of 5000 m² while on latitude is not longer than 50 m and latitude is not longer than 100 m. Outside of major working areas extra large claims can be pegged (100 m x 200 m) in Andamooka, Coober Pedy, Mintabie and Stuart Creek. For prospecting, areas of 200 m x 200 m can be claimed but only once for three months. Beyond proclaimed precious stone field, other regulations are relevant. (Government of South Australia, 2017b) (Government of South Australia, 2014)

Due to a higher amount of overburden, surface mining for opal is not common in Coober Pedy as it is in Andamooka. After the first opal has been found in 1915, pick and shovel were used for mining. Shafts were digged and tunneling and driving was carried out with those universal miners tools. In the level, extraction of the traces were conducted by screwdrivers and handpicks. The material was hauled by hand hoist and later on by power winches or automatic bucket tippers. (District Council of Coober Pedy, 2017a)

With technical progess, the mechanization in opal mining raised but is limited due to the special financial situation of the miners. Unlike mining companies, the financial resources of opal miners, who work often as a one man company, are restricted. Hence, large investments don't take place and equipment is improvised, self-built or modified regular gear. Shaft with a diameter of about one meter are usually drilled by Calweld-type drills combinaed with auger buckets. The shafts have a depth of up to 30 m. The conveying of the material is done by truck-mounted blowers, which pneumatically extract the material to the surface. An example is used in Coober Pedy's landmark

shown in Figure 3. The method is also presented by Figure 7. Bigger machines have been introduced since the 1970s. Small tunneling machines equipped with revolving cutting heads as well as LHDs here called boggers were used in extraction. Besides underground mining, an interesting type of surface mining has been practiced combing bigger machines and manual labour. In this method, bulldozers remove the overburden to uncover the level of Opal. Following spotters look for seams of opal and handpick in the prepared area. (District Council of Coober Pedy, 2017a)

Noodling

Another way to find opals is called Noodling. It is a unconventional secondary mining extraction method. The goal is to find opals in the heaps which were missed by the miners. Opal miners look primarly for opal which are thick enough to be cut en cabochon. Hence smaller gems can be found on heaps. The method is popular by tourists and locals, who make their living off the returns. To noodle on a heap, permission of the claim owner is needed. Heaps excavated by bulldozer which crushed the sediments combined with negligent operators increase the likelihood of success. An optical separation supported by ulta violet lights is undertaken by the seeker. For this small conveyor belt are used, which are running under utra violet lights. Alternatively, seekers equipped with ultra violet torches seek at heaps at night. In general but especially in this action, the numerous open shafts,

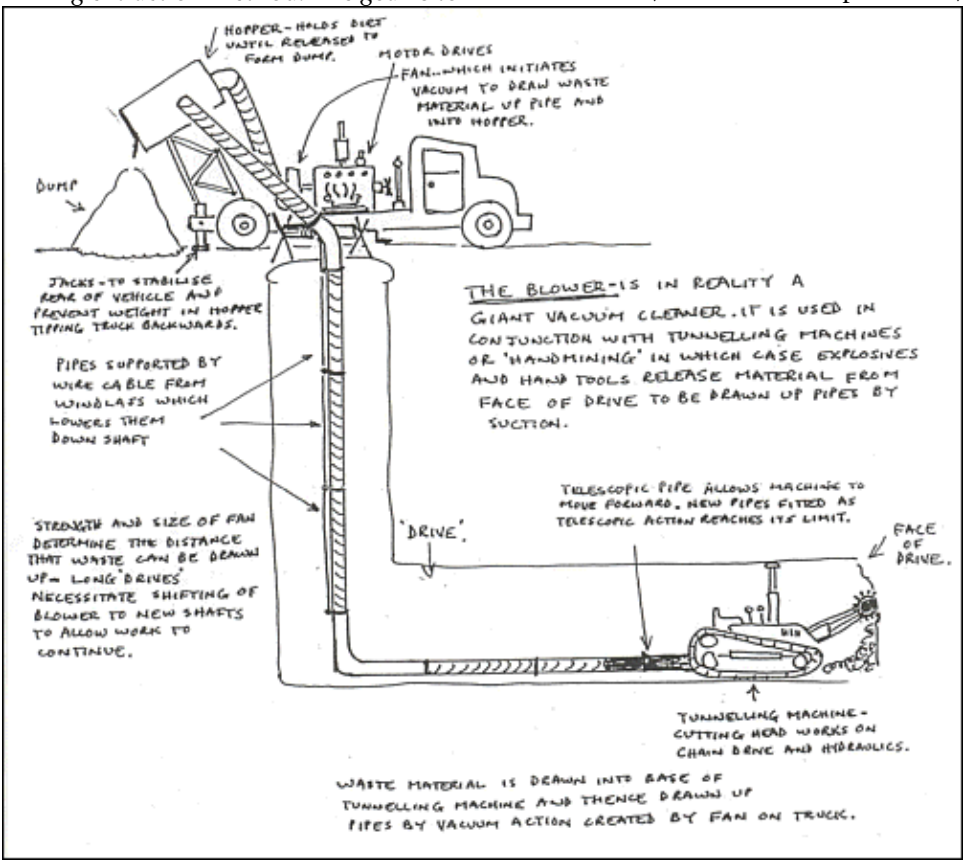


Figure 7: Demonstration of opal Mining (District Council of Coober Pedy, 2017a)

which are not fenced, represent a hazard. (District Council of Coober Pedy, 2017a)

Tom's Working Opal Mine

At the edge of Coober Pedy, Tom's Working Opal Mine is located directly at the Stuart Highway. It comprises both an open mine and a museum showing visitors the underground extraction of Opal. The facility which started in 1988 has a surface Noodling area, where used machines as Blowers are presented. In the underground area guided tours are provided as well as interactive walks through the mine.

Figure 8: The loop

Figure 9: Presentation board for explosives (right)

In the front room, visitors are informed about the genesis, occurrence and properties of Opal as well as about the regulative framework of Opal Mining. At the guided tour, which we took as a group, the mine is explained by an opal miner. The tour takes you across the shaft, where the miner can get in and out with a small seat loop, the handling with explosives, the machines, the excavator as a blower and the handling with the opal. Each one can try to find opal with the jackhammer.

Figure 10: Example for dugout(left) and the jackhammer(right)

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Facts about Australia: Aboringinal and Torres Strait Islander Peoples

Today, 3% of the Australian population are Indigenous people. The number is expected to increase to 4% in 2031. 34.8% live in major cities, 43.8% in regional areas and 21,4% un remote and very remote areas.

In 2010-12, Aboriginal and Torres Strait Islander People had in average 10.6 years less life expectency than non-Indigenous Australian.

In 1788, over 250 languages and dialects were spoken, today less than 145 are in use. Less than 20 are considered to be spoken by all generations.

Archipelago is at least twice as old as the Pyramids of Egypt.

Source: https://www.humanrights.gov.au/education/face-facts/face-facts-aboriginal-and-torres-strait-islander-peoples

Prominent Hill Mine

Jacob Mai, Angela Binder

General

The Prominent Hill mine is located in 800 km north of Adelaide in the state of South Australia, as shown in Figure 1. The Mine can be reached with either a set of wheels over a 45 km dirt road connecting it to Stuart Highway, as our group did, or directly by airplane, which is favoured by most of the workforce.

The Mine, which main commodities are Copper and Gold, is owned by the Australian Mining Company OZ Minerals Limited and operated in cooperation with Thiess Pty Ltd. The deposit was discovered by Minotaur Exploration Limited in 2001, which was owned from 2005 by Oxiana Limited after the formation of a joint venture in 2003. The milesstones until 2009, when the first concentrate was exported from Port Darwin, is shown in Figure 2. (Barns et al., 2009)

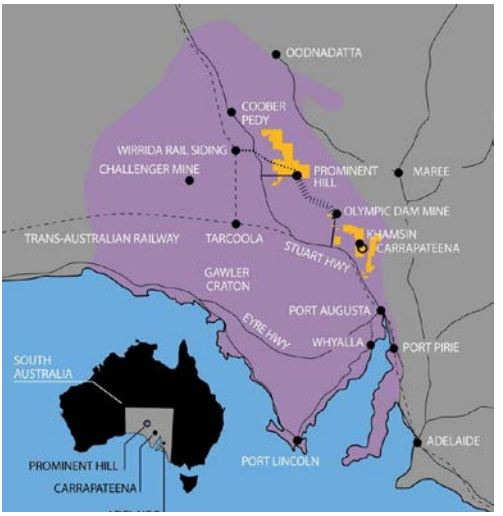

Figure 1: Location of the Prominent Hill Mine (Robinson, 2016)

Nowadays, the extraction is conducted in the Malu Open Pit and in the Ankata Underground Mine, which was started with a decline in 2013 and achieved first production in October 2014. The facilities, as

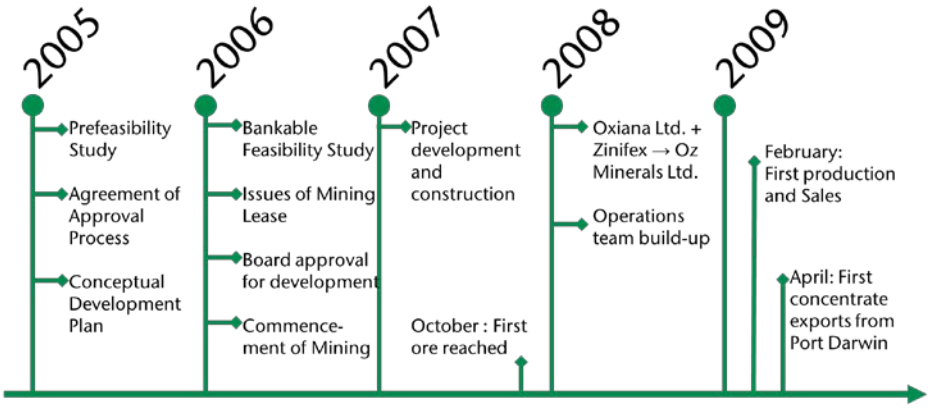

Figure 2: Project Milesstone in 2005 – 2009 according to (Barns et al., 2009)

shown in Figure 3, are the stockpiles for extracted ore, the processing plant and tailings facility. Additionally, there are the Airport and the Camp site with leisure facilities for the personnel which is predominantly flown in on site. A total of 1200 employees and contractors is working either on a 14-7 or an 8-6 roaster at a 12 h shift schedule. The electrical energy is provided by the Olympic dam, whereas the fuel is hauled from Adelaide by trucks. All domestic and industrial used water is pumped from a well, located 200 km south, albeit has to be treated due to its high salinity.

After processing the concentrate of copper and gold is transported to Port Adelaide and then further shipped to smelters around the world.

Geology of the Prominent Hill Deposit

The deposit is located in the Gawler Craton, which is undercovering around 600,000 km² in Southern Australia. It hosts also the Olympic Dam Deposit and other Mineralisation, which are defined as Iron-Oxide-Copper-Gold (IOCG) deposits, a type of hydrothermal ore deposits. Most of these deposits refer to the Gawler Range Volcanic Hiltaba magmetiv event, which led to the formation of the deposit 1,600 – 1580 Million years ago. Similarities between the Olympic Dam and Prominent Hill deposit are the field of geological setting, the mineralogy, the breccia styles and the alteration. (Belperio and Freeman, 2004)

Main differences between the deposits are related to the host rocks. The Prominent Hill Mineralisation is hosted in complex of haematite matrix hydrothermal breccias, which were altered extensive and overprinted. Hence the hydrothermal iron is associated with gold, copper, fluorine, barium, uranium, lanthanum and cerium. The deposits is flanked by volcanic complexes on the northern and southern side and strikes in east-west direction, dipping at 70 % north. The deposit is forming two lenses. (Belperio and Freeman, 2004)

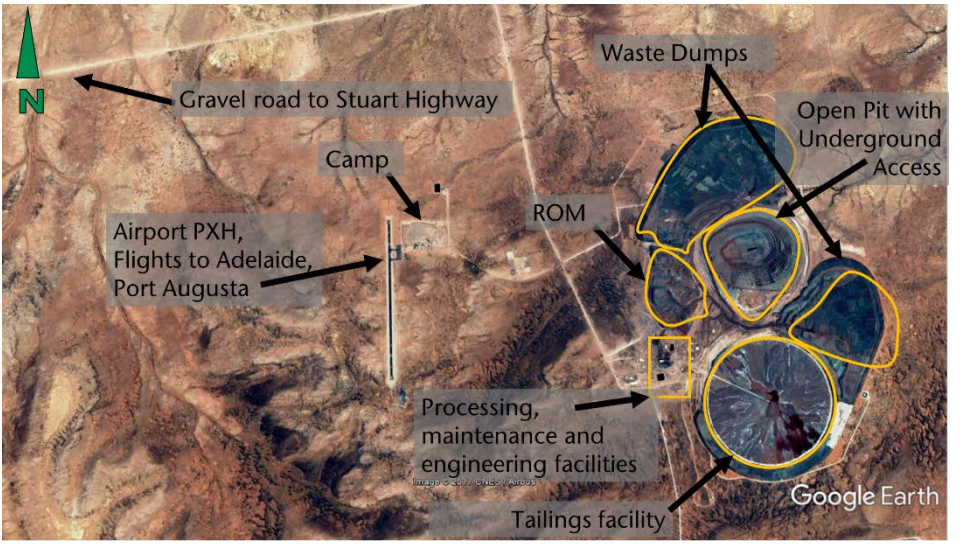

Figure 3: Overview on Promint Hill Mine and related facilities on base of Google Earth

Originally, the resources were estimated as 152.8 Mt with 1.18 % of Copper, 0.48 g/t of Gold and 2.92 g/t of Silver. (PIRSA - Minerals and Energy Resources, 2009) The content of uranium is less than 150 ppm and therefore economically infeasible, but demanding for additional operational measures to hit international standards. Despite, the ore consists mainly of Hematite, no iron is recovered. The most important copper minerals are Pyrite, Chalcocite (Cu_2S), Bornite (Cu_5FeS_4) and Chalcopyrite ($CuFeS_2$). (Belperio et al., 2007)

In 2016, the mine life was extended at least until 2028 based on the resource and reserve estimation shown in Table 1.

Table 1: Summary of Prominent Hill Resource and Reserve Estimation as at 01.07.16 (Robinson, 2016)

Resources*

	Classification	Tonnes Mt	Cu %	Au g/t	Ag g/t	Cu kt	Au Koz	Ag Moz
Copper Mineral Resource	Measured	46	1.4	0.5	3.5	640	690	5.2
	Indicated	37	1.1	0.7	2.7	410	790	3.2
	Inferred	64	1.1	0.6	2.5	700	1,170	5.2
	Total	**148**	**1.2**	**0.6**	**2.9**	**1750**	**2,640**	**13.6**
Gold Mineral Resource	Measured	13	0.1	0.1	2.3	14	320	1.0
	Indicated	4	0.0	0.7	1.1	2	240	0.2
	Inferred	7	0.0	1.8	0.6	3	460	0.1
	Total	**25**	**0.1**	**2.0**	**1.6**	**19**	**1,020**	**1.3**

Reserves*

All Ore Reserves	Proved	49	1.0	0.5	3.2	490	840	5.0
	Probable	25	1.0	0.7	2.6	250	580	2.1
	Total	**75**	**1.0**	**0.6**	**3.0**	**740**	**1,400**	**7.1**

* Table subject to rounding errors.

For further exploration of the deposit surface and underground drill holes are used as well as reverse circulation (RC) drill holes on surfaces. The majority of data is referring to 2,084 diamand core drilling, while 79 holes are drilled with RC technology. In total more than 400 km are drilled with average costs of 1.7 $/m. The cores are treated at the on-side Core Shed, where X-ray fluorescence (XRF) and radiometric analysis are taking plase. With costs of 60 – 70 $ per sample the costs for sampling in external labs is higher. Therefore, the number of samples is kept low. (Robinson, 2016)

Mining

The Mining Operation started with the exploitation using an open cut approach, which was the best way to mine the deposit having a larger extension to depth and being slightly covered with young sediments. Nowadays, production happens underground and on surface, resulting in three production areas: the Malu open pit, the Ankata Underground Mining Areas and the Malu underground Mining Area, as shown in Figure 4. The total annual production of 12 million tons of ore is resulting in 105,000 t of Copper and 105,000 oz of Gold. More than 80 % of the annual production comes from the open pit.

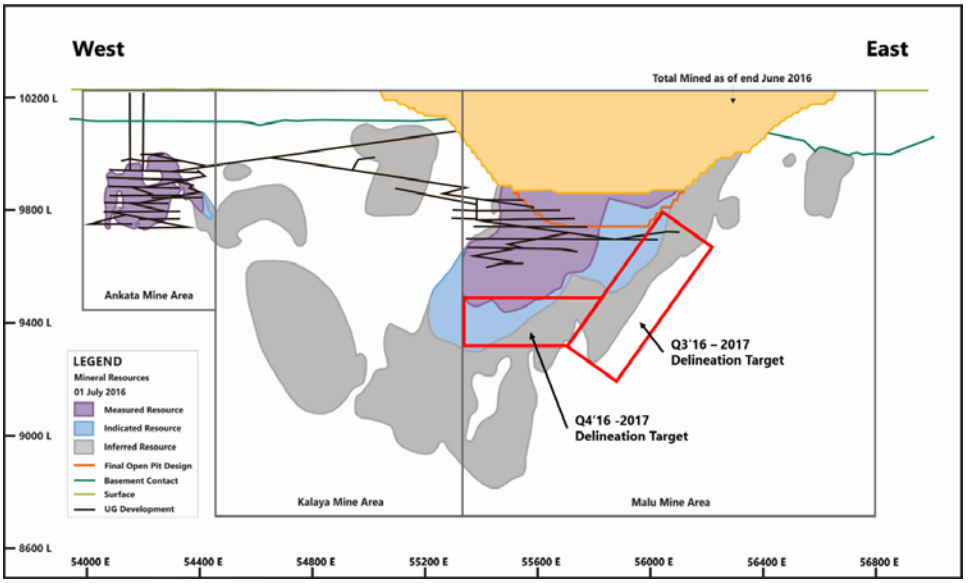

Figure 4: Mining areas, as of July 2016 (Robinson, 2016)

Surface Mining Operation

The surface mine production, which started in 2006 with the first ton moved, will end in 2018, when the total production will be happen in Underground. The pit focuses on the upper part of the Malu Mine Area. After the end of the surface extraction, the processing planed will be fed with ore from the stockpiles for five years before the production is realized just from the underground mining areas. The final pit will have a depth of 470 m.

The open pit operation is based on loosening the ore by drilling and blasting. The material is transferred by two shovels of the type Liebherr 996, which work parallel, to 17 CAT 793 Miningtrucks, which haul each 240 t per term to the Run-Out-Mine (ROM) area. The dispatching system is supported by GPS as well as HGPS. (OZ Minerals, 2014)

The slope are designed differently one the northern and southern wall. While the bench height is 12 m at the north wall, it doubles on the south side. The overall slope angle is 35° in the north and 43° in the south. Rather unstable zones, which are treated separtly, are the first 100 m containing soft rock as well as a unstable bulldog shell at the 4th bench. Therefore, the slope angle is 70° at the first 100 m and 80° in the lower section. Slope stability is monitored using a radar system based on two points. (Robinson, 2016)

Underground Mining Operation

The extraction in underground represents the future of Mining activities at Prominent hill. Nowadays, the production is about 20 % of the total production, but this share will raise until 2023 to 100 %. The mine has a maximum depth of 700 m and a width of 1.6 km. It is operated with six loaders and 12 trucks. At the time of our visit, the access was trough the open pit using the Ankata decline. In the future a second entry on the north side is planned, using one way traffic to increase productivity. For ventilation two additional ventilation shafts are existing. Both have a depth of 286 m and a diameter of 5 m. (OZ Minerals, 2014)

The chosen Mining method for Underground extraction is sub-level open stoping. The applied range is 30 m x 30 m x 60 m. The deposit divided into 50 stopes, of which six to seven are extracted simultaneously. The ore is loosened by drilling and blasting. Blasting is conducted every 12 h. At the beginning of extraction of a stope the opening is created by either using a central loaded hole with seven surrounding drill holes or raise boring, as shown in Figure 5. Afterwards the expansion is realized by blasting. The blasted ore is loaded by front loaders which are elevated 2 – 4 m to increase the performance. The loaders haul the ore to the trucks. The maximal distance is 150 m and one truck is filled by three loading cycles. The ore is transferred to the ROM.

The support is realize using mesh, shotcrete modified with polymers and bolts. After stope extraction backfill is used in order to stabilize the area and allow a higher recovery of the deposit. Alternatively to common use of the mining method, the stope is half refill before blasting the next overlaying sector. The backfill is pumped to the cavities. It consists of tailings mixed with cement as a binder. Additionally, coarser material separated by cyclones and slimes are disposed. In the primary stopes, the backfill is enriched of binder. Secondary stopes can left open and filled with waste rock. The paste backfill must gain a minimum strength of 850 kPa.

The ventilation demand of the mine amounts 10,000 m³/s. The air is moved using two primary fans on surface, which move 440 m³/s and two fans underground as well as a number of auxialiary fans and ducts. As the water intake of the surface mine can be managed with horizontal drains, the underground mine requires a pumping capacity of 40 – 60 l/s to lift the mine water.

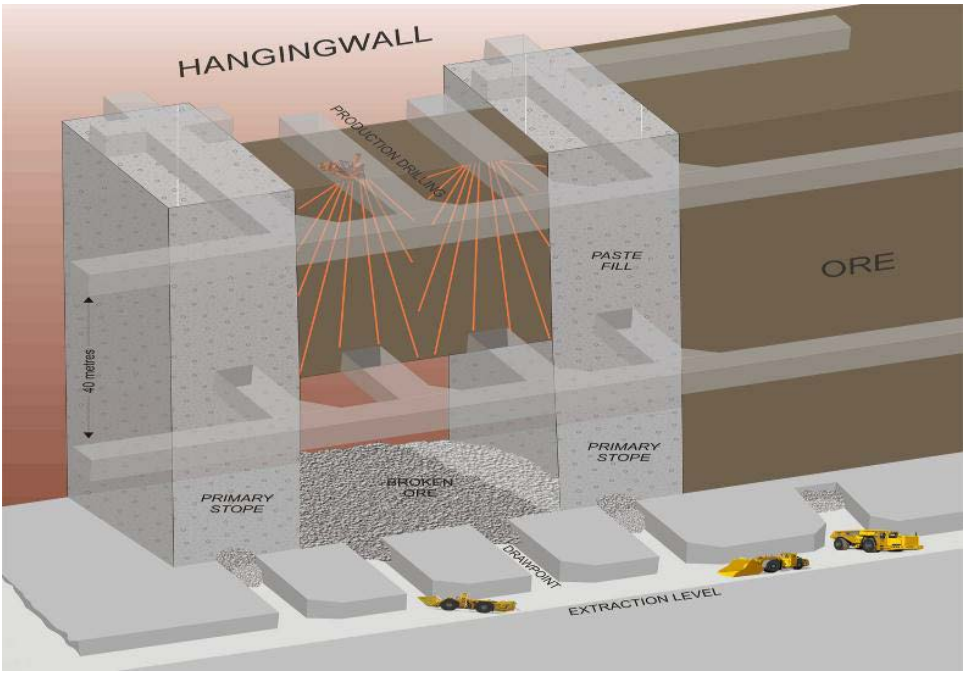

Figure 5: Long hole open stoping method (OZ Minerals, 2014)

Blending and Processing

The gain one of the highest copper concentrates in the world, the ores from surface and underground extraction need to be blended before processing to serve the demand of the smelters. The truckloads discharge the ore to the ROM. Based on the grades the material is loaded, hauled and dumped at the primary crusher. 10 – 15 % is hauled directly from the mine to the crusher. The gyratory crusher has a capacity of 3600 t/h and hands the material, which has been crushed down to 110 mm, over to the stockpile, from which the processing plant is fed. The stockpile holds a capacity of 120,000 t representing the daily production of three days.

The material is tranfered to the processing plant using a belt conveyor. It is crushed to 1 mm in a Semi-Autogenous Grinding (SAG) mill with a power of 12 MW, which has a diameter of 10.4 m and a length of 4.7 m. The material is screened and either tracked back into the SAG or to the Primary Cyclone, which feeds the ball mill with the coarse and the Flotation with the fine material. The ball mill grinds the material with 60 mm balls to run the flotation subsequently. The mills has a diameter of 7.3 m and a lengeth if 10.4 m and is equipped with 12 MW power. The balls for both mills are lifted with a bucket conveyor belt allowing a better process control and higher working safety. The flotation is separated in a rougher and clean floatation, which are connected by classification and grinding stages and a Jameson Cell B 5400. The Jamesson cell is used for washed froth cleaning. The cleaner floatation itself has three stage

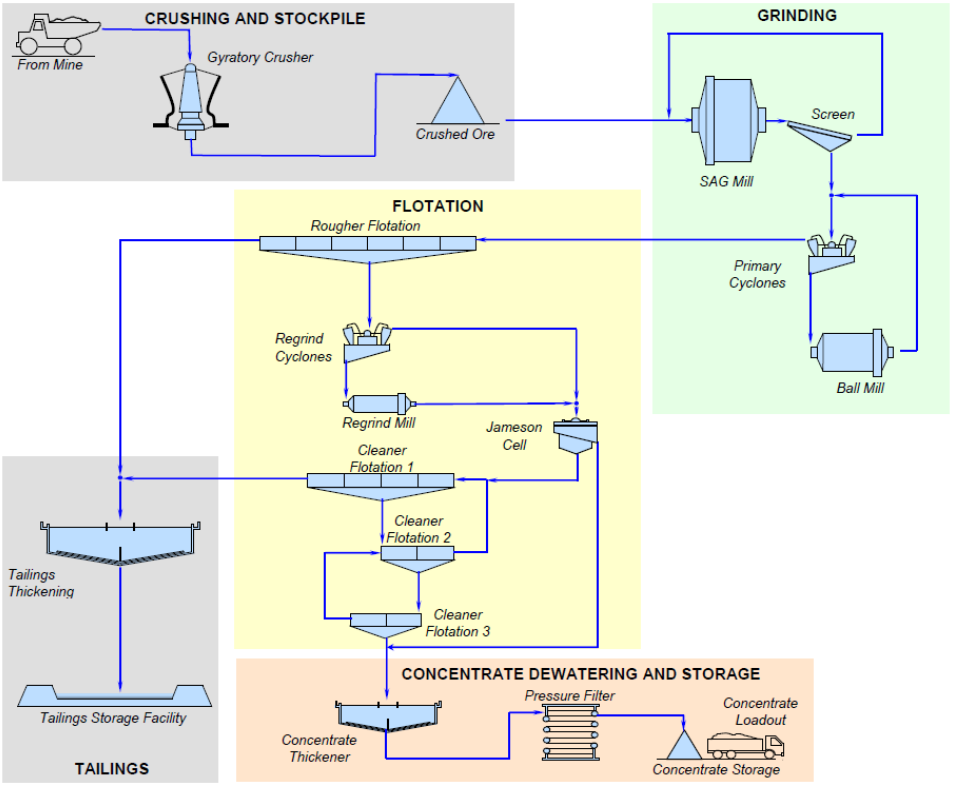

Figure 6: Processing flow sheet (OZ Minerals, 2014)

with a total volume of 14,000 m³, while there are six rougher cells with each a volume of 150 m³. Ethyl Xanthates and thionocarbamates are used as collectors. The flotation is done with six cells and Xanthatite as Collector. The separated concentrate is dried in two stages: first using a thickener and secondly by pressure filters. It has a grade of 48 – 50 % of Copper and 300 g/t of Gold, while the hematite and uranium content are lowered to a insignigicant level. The tailings are collected from both flotation stages, thickened and transferred to the storage facilities. The process is reprensented in the flowsheet in Figure 6. (OZ Minerals, 2014) (Barns et al., 2009)

70 % of the used water gets recycled, which has even a higher importance due to the fact that the water must be tranfered 50 km from the supplying borehole.

Tailings Facilities

The tailings, which make 10 Mt/a, are stored in the circular tailings facility, which can be spotted in Figure 3, if they are not used as backfill material. Due to the flat landscape the circular design was chosen, because no natural structures such as valleys could be used as boundary. The facility, which has a diameter of ~850 m has a high proximity to the open pit – 2 km middle to middle distance, which leads to merits and demerits. The haulage distance is smaller but the stability of the dam becomes even more important. The arid climate with less rain favors the stability and also the evaporation leading to a better consolidation, a higher density and higher stability.

The circular dam has been constructured in the primal stages in preparation for usage with heights of 5 – 9 m. Each three years the dam must be lifted another 5 m to create the needed capacity. In March 2017 the dam was lifted two times having a thickness 16 m, which directly relates to the pit volume.

The material is pumped to the facility and discharged from two neighboring spigots, which are placed every 129 m around the dam. The spigots are changed circulating each shift to create even beaches of material. In the middle as many water as possible is colleted to return it to the processing plant. Annualy 600 – 700 Ml are recovered, which represents 1.5 month of milling water. Due to water restriction and long transportation of water it is important to minimize the footprint. On the other hand, the arid climat with less rain falls enhances the evaporation and lowering the amount of collected water.

The tailings are sampled on a yearly bas to get the confirmation that the processes of consolidation and drying are running as assumed for the stability calculations. The recent investigations showed a better performance than designed with a higher density of the material.

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Andamooka

Matthias Gericke, Angela Binder

Andamooka is located in Southern Australia in the region Far North, which represents as well as the least populated and largest region of the state. According to (Australian Bureau of Statistics, 2010) the population density is 0.96 persons/m², which is half of density of Mongolia being the less dense populated country on earth. The location is shown in Figure 1. The town can be reached by wheeled vehicles using the Stuart Highway and leaving it in Pimba going 85 km North to Roxby downs on the B 97 and than taking the Andamooka Road for another 29 km. The closest airport is the Olympic Dam Airport, where public planes leaving to Adelaide 600 km away from Andamooka. Just four out of hundreds road of the town are sealed, making up 20 km, so 4-wheel-

Figure 1: Location of Andamooka in Australia (Davis, 2017)

cars are preferable. After Andamooka the sealed roads end. To reach the Lake Torrens, which is the second biggest salt lake in Australia, 15 km of gravel road need to be driven. (The Andamooka Progress and Opal Miners Association, 2017) (S. Fischer Verlag, 2016)

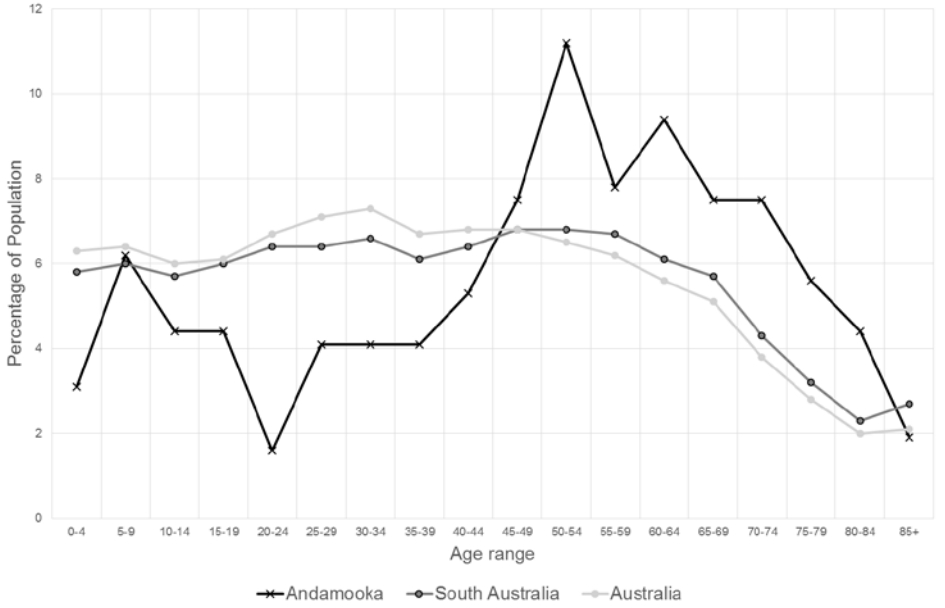


Figure 2: Age structure of People living in Andamooka according to (Australian Bureau of Statistics, 2017a)

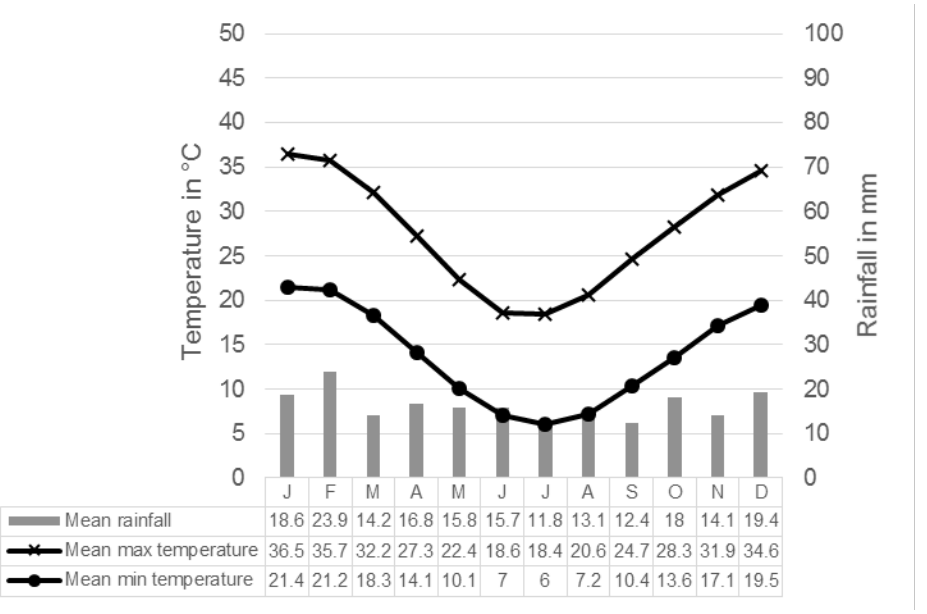
In 2016 the population of Andamooka consists of 316 persons. 54.4 % were male and 45.6 %. 4.1 % of the populatopn were Aboriginal and/or Torres Strait Islander People. In comparison with South Australia and Australia people in Andamooka are older, as shown in Figure 2. The median age in Andamooka is 53, which is 13 years more than in South Australia and 15 years more than in Australia. (Australian Bureau of Statistics, 2017a)

Located at a height of 76 m above sealevel, the climate in Andamooka as show in Figure 3 is arid. The lowest temperature has been recorded on the 17th December 1991 with 48.3 °C, while at the 20th of July 1976 the lowest temperature was measured with -1.6 °C. In the last 47 years 39 % of the days per year had a higher temperature than 30 °C. (Commonwealth of Australia , Bureau of Meteorology, 2017a)

History of Andamooka

The name of the town is explained in different ways by different authors. Two common stories are the origin in the Kuyani language and the naming by a Scottich Explorer. In the local Aborignal language of Kuyani the word Ardndoo means powerful and moka means bone, making together Andamooka, a place where wisdom but also punishment were shared. In June 1858 the Scottish John McDouall named a waterhole in the area like that. (The Andamooka Progress and Opal Miners Association, 2017)

A pastoral station was established in 1872, which was used for sheeps first and is a cattle station nowadays. The first opal was found in the 1930 by Sam Brooks and Roy Shephard, who worked as boundary riders at the Andamooka station and checked the outer perimeter of the station. In a story told, they were caught in a thunderstorm at a place which is called Treloar's



	J	F	M	A	M	J	J	A	S	O	N	D
Mean rainfall	18.6	23.9	14.2	16.8	15.8	15.7	11.8	13.1	12.4	18	14.1	19.4
Mean max temperature	36.5	35.7	32.2	27.3	22.4	18.6	18.4	20.6	24.7	28.3	31.9	34.6
Mean min temperature	21.4	21.2	18.3	14.1	10.1	7	6	7.2	10.4	13.6	17.1	19.5

Figure 3: Climate diagram according to (Commonwealth of Australia , Bureau of Meteorology, 2017a)

Hill today, when they spotted a coloured rock underneath a tree. They took the rock and it was later identified as Opal. Trying to keep it a secret failed and the found triggered a Miner's rush heading for Andamooka in the following years. (The Andamooka Progress and Opal Miners Association, 2017)

In this times the Outback lifestyle of acting free without government represented an attraction for people, who were mainly coming from Europe, where they escaped from the circumstances of war. Everyone tried to make the best out of his/her situation resulting in practical living condition during the first half of the 1930s, when Australia also suffered from the Great depression. Materials and local condition were used to create living spaces, which are the semi-dugout homes. Due to its unique appearance and importance in the historical development some of them are listed as a Heritage place in the South Australian Heritage Register. The Andamooka Historic Precinct including Bob Cutzow's Dugout, Mrs.Perry's Kitchen, Tom Brady's Dugout, Andy Absalom's House and Frank Albertoni's house were listed in 1986. Dick Clark's Residence also shows the characteric layout of the domestic structure in the early years.Various materials are used in a very good intergrity without major alterations of the structured. It consists of a semi-dugout living room, a workroom and two detached sleep-outs. Therefore is was registered in 2008 as a heritage place. The underground homes driven in a side of a hill provided a better climate compared to th extreme outside temperatures. (The Andamooka Progress and Opal Miners Association, 2017) (The Government of South Australia, 2017a) (The Government of South Australia, 2017b) (Unknown, 2013)

Fun facts about Australia: Drop bears

Drop bears (*Thylarctos plummetus*) are one of Australia's most dangerous predators, which are also known to prey on humans. The name is derived from it's hunting strategy: It climbs trees and drops on it's prey.

Adult drop bears measure up to 130 cm and weight up to 120 kg.[1]

Drop bears are carnivorous marsupials, related to the koala. They live in the forests of eastern Australia and in the Outback in central Australia.[2]

During summer usually one baby, or joey, is born each year. After six months in the pouch, the joey is gradually weaned from milk.

Feeding of orphaned drop bear cub with cattle blood.
Credit: K. Nilsson, Brisbane

[1] https://australianmuseum.net.au/drop-bear
[2] Janssen, Volker (2012). „Indirect Tracking of Drop Bears Using GNSS Technology". *Australian Geographer.* **43** (4): 445-452

Also after the 1930s, Andamooka remains a magnet for international opal miners, which still creates an environment which is multi-cultural and unique due to circumstances. Opal miners came to Andamooka and some of them stayed for longer. In the 1970s the population increased to 1200 – 1500 persons living in Andamooka. But the situation of no surveyance and occupation which was defined as Miners' Right lead to situation which scared investors and a continuous decline of the town. Citizens formed a progress association which is still in place organizing the necessary activities related to supply, electricity generation and maintenance of the airstrip which was used by the Flying Doctor Service. A dry creek bed formed the main street while other roads consisted of unsealed track. The governmental presence was very low until 1966, when the first police station was opened. Before, the town was visited once a week by police men from the Woomera station, so there was a self-policing system. The Tuckerbox which is still in place was the social hub. (The Andamooka Progress and Opal Miners Association, 2017) (Griffiths, 2012) (Unknown, 2013)

Unless some decreases and increase, the population declined over the years. In 2012 BHP Biliton announced an expansion of the Olympic Dam Mine situated 30 km away. Due to this the population decreased from 1,100 to 450 in few years, because many families and mainly single man left to work there and live in Roxby Downs which is closer to the mine. In the last years the decrease continued to 316 inhabitants today. Low commodity prices and related job losses also caused this effect. Due to a developed strong liability on the Mining Operations at Olympic Dam, the economic situation is the worst ever happened in Andamooka with most business closed and minor social life left. The left Opal Miners are older than ever before and the Opal production were also decreasing all over Australia with high cost. The remaining miners keep their Mining activities ongoing with hope to find a big gem one day. (Donnellan, 2015) (Brown, 2015)

Opal Mining

Surrounding Andamooka, there are 263 km² of Opal fields making it the second largest area in South Australia. For mining, a Precious Stones Prospecting Permit (PSPP) must be hold. Further on Opal can be found starting at pg. 52. (Government of South Australia, 2017b)

Geology of the Andamooka Opal Fields

Two geological campaigns have been undertaken in Andamooka. In the 1970s, (Carr et al., 1979) described the general formation. During another Govermental granted, another drilling campaign had been undertaken between 2008 and 2011 for a better exploration of the area. Results are presented by (Morris, 2015). The Opal ist hosted in the Bulldog Shale, which is deeply weathered with an shallow-marine origin from the Cretaceous age. Underneath either the pre-mesozoic basement or the Algebuckina Sandstone is situtated. The weathering of the Shale show well-developed profiles, which are a zone highly weathered, bleached and kaolinised of slighty sandy, aminly white clay. The zone had been 30 m thick before erosion now measuring 10 m. The horizon is named *kopi*. Below a light yellow, grey or light brown claystone is found, also called *mud*. The zone with a thickness of 4 m consists dominantly of montmorillonite clay mineral is impermeable. Underneath, the so called *bulldust* is situated consisting of red to yellow and brown silt and making up to 4 m. In the kopi-mud

interface Opal can be found normally as avoid filling, replacement or cement and also as a replacement of bones and shells. (Morris, 2015)

Mining

Mining started with pick and shovel, equipment nowadays still being a Miners trademark and often found on the local cemeteries. In the 1970s bulldozers arrived, which were used to form long scratches to a lower level, in which Opals could be found. Those represent the introduced kopi-mud interface. In this level horizontal drifts were extracted following the level. As the levels are more shallow than in other opal field like Coober Pedy, it needs less effort to reach the respective levels, representing an advantage for smaller prospectors who have a more limited capital. Due to the easy access to the deposits, Opals were mainly exploited in Andamooka in the 1970s, before other fields were mined. Drifts are created by using explosives. In the fields of Andamooka, remarkable gems have been found. On of them is the Andamooka Opal. Nowadays trucks and shovels are used mainly by fewer remaining miners as we learned at our visit. (Schmid et al.)

Famous Andamooka Opal

On of the finest Opals ever discovered in Andamooka is the Andamooka Opal which also named the "Queen's Opal" shown in Figure 4. After it was found in 1949, it was cutted and polished by John Altmaan. The opal features outstanding intense colors and a superior size of 203 carats. The Wendts Limited Company from Adelaide framed it in an palladium necklace with diamonds. In March 1954 it was presented to Queen Elisabeth II during her post-cronation travelling through Australia on behalf of the people of South Australia with matching earrings in Adelaide. After being worn during the travel, it became part of the todays crown jewels. (Order of Splendor, 2013)

Figure 4: Andamooka Opal (Order of Splendor, 2013)

Our visit to Andamooka

Our stay in Andamooka lasted from the 14th to the 16th of March. We arrived in the evening and were welcomed by Margot Duke, who's running the only hotel of Andamooka. She showed us our rooms and habe a short overview on the place. She continued explaining about the town and its history when we took our dinner at the nearby Restaurant Tuckerbox.

Peter Taubers took us on a tour on the Opal fields on the next day after we had lunch at the hotel. He introduced us to the Mining at Andamooka and showed us different types of Opal mines and described how to find it. Figure 5 shows impressions from the visit of the surface mining places.

This claim is operated by one man only. He bought and rented his equipment to

Figure 5: Open Pit Mine

Figure 6: Underground Mine

dig down in hoping to find the area which contains the opal. It looks more like an adventure than a professional mining. But for one man, he reached to move a lot of ground.

Afterwards we went to a former underground mine which was started 40 years ago as shown in Figure 6. Today the site is used for parties but the cavities are still stable.

Outside the mine, Peter showed us some dumps where we started to seek for some opal pieces. We walked along the area and some tried to dig a bit but most of us where without luck. Peter told us stories about people who looked for days and found nothing and some lucky people who looked only one time and found pieces which were very valuable. Peter and one member of our group had fortune and found some pieces, but the rest of us got nothing.

Later, Peter told us, fortune is the most importand thing needed, if we wish to find opal. Surely we need good equipment and time, but without fortune we can dig as long as we like and find nothing. Many years ago more than 1500 people lived in Andamooka and tried to get rich with finding opal. Today, most people prefer to work for a company and to get monthly there payment instead of hoping to find there fortune.

Later, back at the motel, Peter and Margot showed us the Opal shop and their opal showroom in the cellar, which is shown in Figure 7. Peter showed us the different types of opal from all around the world in his showroom. Also he polished the piece of opal of our lucky group member and finally told him that his small piece is around 250 Dollars in worth.

The rest of the day we had leisure time. Most of us explored the area for themselfs, bought some nice pieces of Opal from Margot or tried to find some Opal once again, but without fortune. At our last day we had again a nice breakfast made by Margot and Peter. Before we left we thanked them for the nice time and their hospitality. They offered much more than someone could expect from a normal motel. If you wish to visit them too, look at their webpage at andamookaopal.com.

Figure 7: Opal showroom and Peter Taubers

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Ballarat Goldfields

Tina Waldow

About Ballarat

Ballarat is a city in Victoria, Australia, in the goldfields region of Victoria about 120 kilometers northwest by road from Melbourne. It used to be a gold rush boomtown and was known as one of the richest goldfields in the world.

The possesses sites and landscapes reflect the whole period of gold mining in Australia, and have particularly important large areas relating to the early phase of the great Aus-tralian gold rushes. In this regard, the goldfield is a very rare entity. (Campbell, 2005)

Management

Underground mining at Ballarat is operated by changing managing directors. The successful mining at the Ballarat goldfields was owned by the following companies:

- Ballarat Goldfields [1983 – 2007]
- Lihir Gold [2007 – 2010]
- Col.Goldfields Limited (C.G.F.Limited) [2010 – 2012]
- Liongold [2012 – present]

Liongold Corp.

The Ballarat Gold Mine is located in the Bendigo Zone of Victoria Gold Fields. The sole shareholder of the Liongold Corp. is Castlemaine Goldfields PTY LTY (CGT).

CGT has 154 employees, 79% of them are based in Ballarat and 81 FTE are contractors.

The production average per annum is 40-50,000 oz since 2011. In 2016 there were 6 t of gold. The total mining amounts to approximately 600 t, which is more than 64 million oz Gold. CGT planned a total development of 42 km and reached 20 km in the middle of April 2017.

The following facilities are located at the ground surface: portal, waste dump, workshop, core shed, warehouse, batch plant, mill, rom pad, tailings storage facility and Gekko Lab.

Figure 1: Left: A drukk core with gold content; right: Quarz rock with gold content

Figure 2: Mine truck(left) and shovel (right)

Geology

The Mineralisation occurs in free gold grains, which contain general 70 – 90 % of the gold in the deposit. The grains are located in fine quartz veins, which can be found along or adjacent the major thrust faults. (LionGold Corp., N/A) At the Ballarat Goldfields, rocks with a gold content from 5 g to 82 g gold/t are extracted (Figure 1). Along with gold, quartz, ore, breinstone, granite, sandstone, shale and some radon are also excavated in the Ballarat region.

The Victorian Mineralisation has a strong characteristic: The Nugget effect occurs very high due to the coarse gold, which is distributed in the vein. This makes is unpredictable even using modern drilling and mining. (Figure 2) (LionGold Corp., N/A).

Mining process

In the Ballarat goldfields about 30 to 35 employees work underground in the day shift and 18 to 22 employees in the night shift. The shape of the underground mine resembles a U. The deepest sole is close to 800m below the surface.

The removal of the rock of two lodes takes place over two ramps (one is also used for supply air, one for exhaust). Over all five loads, five trucks, two jumbo, twin boom drills and 43 ancillory equipment are used (see Figure 2 and Figure 3). Dangerous and unsecured areas are reached with externally controlled machines.

The underground operation is performed in the following order: stope design – drilling design – drilling – blasting – review.

Figure 3: Jumbo twin boom drill

Figure 4: Impact mills/ centrifugal mills(left) and Classification (right)

Currently treating 250.000 t excavation material per annum production. Five month of mine production are still planned, resource is 30,000 oz gold.

The production drilling creates a speed of 1,5 m/min and up to 100 m/day. The route reached 50 km underground drilling per annum.

Processing

The processing plant was constructed in 2005.

The order of processing is divided into four steps. The first step is liberation, which breaks the coarse dismantling materials into smaller pieces. This is followed by the separation, whereby the broken material is sorted by its density according to gold-containing and gold-free material. Thirdly, the gold-containing rock is purified and the flotation separates 70% of the gold from the rock. Lastly, the leaching takes place during which the remaining 30% gold is extracted.

The individual paths of the rock are explained in more detail in the following section.

After excavation, the rock is fed to the processing plant via Loads. First, the material passes through the coarse crusher and then through the fine crusher. After two impact mills / centrifugal mills, a classification of the rock takes place. The grain size is sorted over sieves. After excavation, the rock is conveyed to the processing plant via loads. First, the material passes through the coarse crusher and then through the fine crusher. After two im-

Figure 5: Flotation (left) and Tailings (right)

pact mills / centrifugal mills, a classification of the rock takes place. The grain size is sorted over sieves. The larger grains must be comminuted again. The fine grains are transferred to the dense sorting. In this step the particles, which are too light and can not contain gold because of the low density, are sorted out. In the next step, the remaining material is cleaned and treated with chemical separators. During this flotation most of the gold separates from the rock material. The remaining gold-containing material passes through the leaching. The remaining gold is dissolved and flows through plastic tubes, so that the gold deposits on those tubes.

The chemical solutions from the flotation and the leaching are partly recycled. A second part is transported to a tailings dam, which is completed in Ballarat after two years.

Further Information

The operation is a significant contribution to the local and state economy. All the managers involved have great environmental responsibility.

Because of their location, they work under constant cooperation with local residents. Dust, vibration and further environmental impacts of the company are minimized. For example, the coarse crusher runs only at fixed working times. Since the rock can be pre-breached at night, the coarse crusher is not required at night and does not produce any noise. As a further example, non-active areas are recultivated and backfilled.

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Yallourn Mine

Sebastian Leonhard

Figure 1: Logo Energy Australia (EnergyAustralia, 2017)

The Yallourn Mine was our last mine visit. We arrived early at the 21st of March. The night before we stayed in Morwell just a few kilometers away. The mine is located in Victoria's Latrobe Valley, around 150 km east of Melbourne.

After we arrived at the entrance we had to go through a mandatory security check from where we where picked up by Ron Methen the Manager of Mining. Before we could enter the mine we got a short induction. From there we drove to the mine site. Mining started 1915 at this area and was done by the State Electricity Commission of Victoria.

Between 1920 and 1950 the company has built the town of Yallourn to accommodate the miners and their families. At its peak the town had 5000 inhabitants. In 1978 the town of Yallourn was removed in order to access new coalfields.

Since the beginning over 293 Mm3 of overburden and 1,005 Mm3 tonne of coal have been mined (up to April 2015). Over the time several different coalfields where mined.

The current operation takes place in the Maryvale field. The area is owned by Energy Australia, which is doing the planning and oversees the mining operation.

The mining itself is contracted since 2002 to RTL Mining and Earthworks Pty Ltd, which is a joint venture of Roche Mining, Thiess and Linfox.

Energy Australia is one of the biggest electricity and natural gas suppliers in Australia and has next to the Yallourn Power Station two more in South Australia.

The Yallourn Power Station is located directly next to the open cut and was build 1975. It has four separate units, 2 x 360 MW and 4 x 380 MW, which produce 22% of the electricity in Victoria.

Figure 2: Yallourn Power Station, Photo by O. Langefeld

Figure 3: Channeled Latrobe River, Photo by S. Leonhard

The mine is connected to the power station over a central steel cord belt, which is 1400 mm wide and runs with 6,8 m/s.

In order to operate at full capacity with all 4 units the power station needs a supply of 2400 tonnes per hour. Between the mine a power station is a raw coalbunker with a capacity of max. 35.000 tonnes. It can supply the power station for roughly 12 hours any kind of problem inside the mine or on the conveyor, which would cause a longer delay in supply would directly affect the electricity production.

Behind the bunker we crossed the Latrobe River, which had to be redirected. The diversion was commenced 2001 and was completed 2005 on time and budget. The total costs for this project where 120 million $. The river was enclosed with dams on both sides. For the dams 13 million m3 of clay and sand overburden material was used. The river was channeled 3,5 km trough the mine.

Normally the river would only fill the middle part of the channel called the low flow riverbed. This part of the riverbed has woody debris in it as fish, bugs and slug habitat. It is sufficient for 1 in 2 year flood event.

The whole channel itself was designed for a 1 in 10.000 year flood event. It is a 70m wide trapezoidal and 10m deep. Over its length the dams are covered with grass in order to control erosion. In the area of the channel instruments monitor pressures, movements and the water height.

A major failure occurred in the Latrobe River dam on 6 June 2012 and a part of the mine was flooded. The river was contained and the mine back to service on 27 October 2013.

From the top of the dam we drove in the mine.

From 1956 the mine used Dredger to remove the overburden and mine the coal. Some of them where produced in Germany. Till 2002 five of these machines where used four with a bucket wheel and one with a ladder chain. Today only the youngest of them, which started operating 1978, is still in use to remove overburden. Another dredger is backup for coal

Figure 5: Author in comparison to the Dozer Blade, Photo by J. Mai

production, but was not used when we where there.

The coal seam has a thickness of up to 80m and lies below only 20m of overburden.

At the current system the seam it divided into two banks. The banks operate separately to be more flexible and reliable, at each bank are two Feeder Breaker.

Figure 4: Dozer, Photo by O.Langefeld

The new push mining system is based around a fleet of highly modified Caterpillar D11 Dozers pushing to high volume throughput Feeder Breakers that feed coal onto a face conveyor system. The Dozer push coal from a fan shaped area in the Feeder. These fans have capacities between 160.000 -200.000 tonnes. Every 5-7 days the Feeder are moved along the face of the seam. After 3-4 mounts the Feeder and Conveyor move towards the advancing coalface.

The D11 Dozers are fitted with a 94 cubic meter coal blade believed to be the biggest such blade in the world. At 3.63m high the special purpose blade is capable of moving 70 tonnes of brown coal per push. The dozers are fitted with GPS guidance and on board survey capability, which helps the driver to operate efficient.

We made a stop at one of the Dozers, which was standing on top of the seam. We could go close to machine and have a

look at it. Especially the blade was impressive and we used the opportunity for some pictures.

Afterwards we drove to one of the lower Feeder at the bottom of the mine. We had the massive 80m seam in front of us and could climb on one of the Feeder Breaker Stations. There we could feel the enormous power of the Dozer, while one of them was pushing enormous amounts of coal towards us.

An interesting fact about the Dozer is, that with a single push, they move 70 tonnes of coal. From this coal around 47 MWH of electricity are generated, which is enough to power 7 average Victorian houses for a whole year.

Before we left the mine we made at short detour to the backside of the open cut. Once the overburden is stripped it get transported via a 6 km long conveyor to the backside and is dropped from a Tripper Stacker. The Stacker was made by a German company called Weserhütte and began to work at the mine 1978.

The machine can stack the loose material 8-10m high at the topside and up to 20m high at the bottom side. The material is sloppy and can start to flow, therefore dump stability is a continual issue. Since 1973 the mine moved in average 4,2 million m3 of overburden per year.

At this point our guide showed us the side of the mine, where 5/6 June 2013 a major slope failure happened. At this day 6 million m3 sledded into the mine, which causes an break in of the Morwell River. In the following months more then 70 Gl of water where pumped out of the mine and the same amount pumped from on point in the river to a point behind the breach.

Figure 6: Dozer and Feeder Station, Photo by S. Leonhard

At its peak there were 80 pumps the size of a D10 bulldozer, using 80.000 liters diesel fuel per day. The largest of the pumps alone consumed 5500 liter per day. We were told that almost the complete pit was flooded and the water where covered with countless boats on which the pumps where mounted. Despite the massive use of pumps it took until the 25 of March 2013 to complete the dewatering.

In order to prevent further failures there are measure points spread over the whole the mine area. Periodically mine surveyors use GPS to detect the slightest ground movements. Additionally there are dozens of PVC tubes 200-400m deep in some slopes to reduce the water pressure inside. The imbalance is about 20m at some points and the drainage increases the slope stability significantly.

After we left the mine we drove around the Power Plant, additional to the information we already got our guide told us, that despite the fact that the power station has 4 units it only has 3 cooling towers, because the planners wanted to save money at the time it was build.

Additional to safety measures against water the mine has a network of pipes that can supply water to fire extinguish nozzles all over the mine. This system shall prevent bush fires to ignite the coal seam. Usually these fires do only very limited damage due to the extensive extinguishing system. The water comes from a pond that is 150m above the mine. The difference in altitude supplies the necessary pleasure. At the bottom of the mine the nozzles can spray the water up to 80m far.

Once the tour was finished we drove back to the office building where we started.

There we got a lunch and had some time to chat with our guides. There was also a presentation from one of the employees about the history of this mine and the region. He spent a lot of time to collect old pictures and gather information from almost a century.

After the lunch one of us held a presentation as well, his topic was the Renaturation of German soft coal mines. The team of Energy Australia was very interested in that topic, because they are developing a plan for the Yallourn mine closure at the moment. They told us that flooding is at the moment their preferred option for the final pit. But they have a lot of work to do, to convince the local authorities.

The flooding of the final would take estimated 80 year, if the inflow would be only ground water. Should they get the permit to use water from the surrounding rivers, it could be done in around 2 years.

At the end we said good by to our guides went back to our cars. From Yallourn we headed to Melbourne for our last two days in Australia.

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The Journey from a non-technical perspective

Angela Binder

Great events are often foreshadowed.

Begin of November in Clausthal – the hercynian weather of rain, fog and incedrible humidity gets interrupted by some warm shafts of sunlight rising from an E-Mail. A long discussed field trip to Australia is announced. Three warm and sunny weeks in a famous mining country are distracting students from the reality in the small university and mining town of Clausthal-Zellerfeld.

27th of November 2016: Just in time of the deadline, the Institute of Mining is flooded by applications to participate in the field trip. Some good swimmers and divers are needed to struggle through the candidates and pick the right one forming the ideal group. But the challenge can be met and at noon of the 29th 13 students receive a joyful message.

This messages acts as starter for personal and group preparation, while the organizational work had started months ago. The entire group with little exceptions met for the first time on the 14th of December to learn and discuss relevant basics, especially what to do before. The discussion about beer prices closed the meeting.

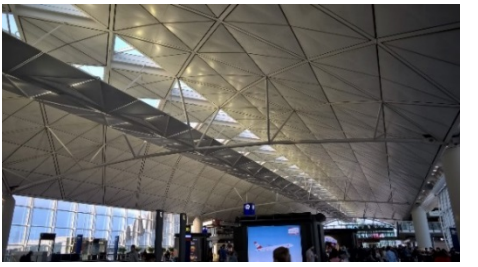
While concentrating on exams in the beginning of the year, passports, visas, and international driver's license are purchased with more or less effort needed. The appearance of the license sheet turns back time to the last century. As more and more preparations are completed, it's time to focus on teambuilding. Three significant actions have been undertaken in Clausthal to enhance the group performance: On the 20th of February a majority met at the house of the BuH-Verein to celebrate the end of the lecture period, three days later a meeting at the Anno Tobak was held to clear question and talk about the final preparation. The WhatsAppGroup "Clausthal Goes OZ" was founded to simplify further arrangements. Some enjoyed the last beer in Clausthal on the 02nd of March at Querschlag.

The Journey Begins

The 3rd of March was the begin of the journey lasting for 21 days. The group assembled on the way, finalizing at the Check-in Counter at the airport. But let's tell it one by one: On a Friday afternoon at the Marktkirche in Clausthal, where the bus to Goslar is taking off, it's totally normal to meet more than ten students with some extra luggage. For these students, it was the beginning of a long journey. We enjoyed during the extra long ride via Hahnenklee the

Hills and Curves of the Harz Mountains the last time for three weeks, before we took the RB 14126. A smart person had decided that a longer trip is better than to change trains, so we spend more than one hour to go to Göttingen, where to took the direct ICE 771 to Frankfurt Airport Station. Some used the time to get a little sleep, which was missing from packing luggage (or maybe forgotten at Querschlag), while others practiced proactively their abilities to drink beer in the Bord-Bistro. At the airport we explored the path to the hotel, where we stayed overnight. After checking-in and getting our things stored, we met our fellow student Andreas Pahl in front of the hotel, who was visiting his parents nearby. After a short refreshment from his trunk, we set out for Frankfurt downtown to first get a Schnitzel with green Sauce with traditional cider and afterwards some others drinks – the best preparation for a long flight.

Hence, it wasn't easy to walk the 1.5 km to the Terminal, where we met the rest of the group. Planned and arrived in the manner "Five minutes before the time, it's a miners punctuality", we had plenty of time at the airport, which were mostly used for a second breakfast and refreshing after the hike to the airport, which felt like climbing a summit for some, who enjoyed the night before too much. At 12:50, our Cathay Pacific flight CX 288 left Terminal 2 starting the challenge of sitting in limited space for eleven hours. The time went by and we were entertained by the videos, sleep, food or by watching our fellow travelers ~~impressing the crew with their bodies~~.keeping the blood flowing by some exercises. With Asian food served during the flight, the preparation for Australian city food started and we enjoyed noddle snacks.



Arriving in Hongkong stretching legs and arms was a huge pleasure. But we had just one hour and fifty minutes to enjoy more space until our next flight started. In the meantime, the alcoholic offering at the airport was checked, but most of us decided to not buy any booze. One guy did and suffered by the regulations which prohibits any bigger amount of liquid in the plane. The next flight CX 139 took us from Hong Kong to Sydney, which means another nine hours of limited space. We arrived at 20:45 in Sydney, where immigration went smoothly for almost everyone. Just our Mongolian fellow traveler Nachnaa needed some extra-care. Due to German soil on his shoes, Heinrich used the possibility to get his shoes cleaned by the Australian officials. But we made it and took two group shuttles to the Avoca Logde, our home for the next days. To move after a long time sitting almost all of us took a little nightwalk to Congee beach, where we couldn't find any place to have a beer, because it was just to late on a Sunday evening. But having the feet

in the Australian ocean for the first time compensed the travelling stress. The rain was just a little disturbing, because it was warm rain and we had arrived in Australia.

A shell-shaped Opera, a bridge: This must be Sydney

Monday Morning: We had a meeting at UNSW (read on more on pg. 27) and we became familiar with classic Aussie Barby and Sausage Sangers with onions as well as BBQ-Sauce. It provided the opportunity for some chats with students and faculty members, establishing new contacts and fostering old networks.

In the evening, we were invited by Prof. Hebblewhite for another BBQ at his house in Manly. It taught us an important lessons regarding Australia: It's always Barby time. So we had to travel from UNSW located close to the Royal Randwick Race Course to Manly. Time for getting in touch with our beloved Opal Cards, which are used for paying the public transport. Except of moving out of the bus to early, which cost us 20 extra minutes at a not very enjoyable bus stop, our trip went well. We arrived at the Circular Quay, where we took the ferry and saw the Sydney Opera House and Harbour Bridge for the first time. This amazing experience let us forgot about all troubles before and we enjoyed the ferry ride to Manly.

At the harbour, Prof. Hebblewhite already waited for us to guide us to his house. We were overwhelmed and impressed by the hospitality of Sue and Bruce Hebblewhite, and loved their house, the food, the view, everything, which made the end of our first day so special. On our way back, we enjoyed approaching the skyline by night and had some drinks with a view on the Harbour Bridge, before driving back to the Avoca Lodge.

The next day was free, so we explored the big city in small groups. Some went to Bondi Beach for Fish'n'Ships, some visited the botanic garden, some watch old ladies playing sports, some had a sunburned face afterwards, some explored the city center, some headed to visit downtown, the fishmarket and Darling harbour.

When the groups met afterwards, there was a lot to tell. In the afternoon, the drivers for the next days - Prof. Langefeld, Alexander, Christian, Sebastian, Jacob and Angela – met at the Hertz station to get our first rentals, which were equipped afterwards with the basics (water, chips, chocolate, toilet paper and maybe beer). The evening was used to taste some Australian beers in a sports bar nearby.

Heading north – the neat harbour town of Newcastle

The next morning started relatively early. The cars were packed with all luggage and the squad started. The intended motorcade lasted until we passed the third traffic light. The communication wasn't preferred by all cars and the distance between the cars raised. Hence, every car went on its own and we met after more than two hours in front of the office of Bloomfield Colliery.

Due to heavy rain the days before, they were not sure if we could go to the open pit. Therefore, we got an introduction to the mine first and went through the plant afterwards. For more information on the Bloomfield Collieries start at page 35. It was possible for us to see the open pit in the afternoon. In the meantime we were invited for lunch and again overwhelmed by the Australian hospitality. After an amazing pit tour and some final question, we thanked our guides and headed to Newcastle. Our hotel consisted of containers, which was just obvious from the outside. We explored the city and the coastline. Some grabbed a beer, some walked down to the lighthouse. At the promenade we ended the day with beer and Schnitzel.

At the next morning, some of us took the chance and jumped into the ocean for a morning refreshment. We went to the Warkworth mine, also located in the Hunter Valley, which is famous for it's coal mining (see pg. 42). After the mine visit we stopped at the Cockfighter Creek tavern nearby and shocked the owner by an order of 16 steaks, burgers and some drinks. As he didn't trust us fully, we had to pay with in advance, but he made the deal of the month. At the gas station next to the pub, we filled our gas tanks and maybe our beer deposit. Heading back to Sydney, someone decided to take the longer but scenic drive through the Blue Mountains. So we waited for a scenic lookout, which could not be found. After three hours, we arrived in Sydney, organized some gear needed for the next mine visit and prepared for the early departure the next morning with some sleep.

The last days in New South Wales

Friday, 10th of March, was the day on which we had the opportunity to see Underground Coal Mining using the Longwall Mining. Due to internal structures the group was divided into three subgroups and we headed South to the Appin Mines (West and East) and to the Dendrobium Mine, which are all located close to Wollongong, see more information at pg. 47. The rubber boots we borrowed from the department of Mining of UNSW were totally needed due to the amount of water underground. The groups experienced different mine tours, which offered a topic to talk about in the evening, which we spent in Sydney. As it represented our last night in NSW, we spent the night out and enjoyed some last views on the harbour with New South Wallisian beers. Some new stories were shared about the lastest facial hair styles which someone was forced to explore according to the safety regulations. While discussing about the unnecessity of fluid in the shaving process a photo series of amazing beard styles amused us very well.

The morning after we had to leave early because our plane to Adelaide left at 09:30. Bags were packed and stored in the

vans, before we started our way to the airport, on which 66 % of the cars missed an important stop on the road and therefore had to drive an extra round after dropping their passengers at the airport terminal. The ride from the international terminal, where the rental station is located, to the domestic terminal, where our flight left, proved the expensiveness of the Sydney airport is true. Ridiculously, the price for a bus and train ride between the terminals is 6 $, which is a) more expensive than taking a ferry from Circular Quay to Manly and b) not supporting the traffic relief of the streets surrounding the airport. We took the train, checked in and waited for the Tigerair plane to departure bringing us to the sun of South Australia.

Welcome to Adelaide

Stepping out of the Airport at Adelaide, we experienced first the warmth heat of South Australia and instantly enjoyed the feeling after warm but unsettled weathers in Sydney. Although we were after one week in Australia used to the lazy Australian ey laid-back, relaxed, stress free lifestyle (#noworriesmate), our patience strained by extremely slow working employees of Europcar, who made us waiting for half an our because our vans had to be cleaned. When got our four superficially cleaned cars, we started to go to the Jackson Motor Inn, where we spent our night in Adelaide. After all cars had arrived, everyone did what need to be done. Some organized a diving trip for the next week, did their laundry, bought beer and wine, did sports

Fun facts about Australia: Adelaide

Founded in 1836, the town was named after queen consort **Adelaide of Saxe-Meiningen** (Adelheid von Sachsen-Meiningen)

Adelaide is the **driest** of the Australian capital cities

Adelaide is Australia‘s capital of **adult entertainment shops** per capita with 5.22 shops / 100,000 people, according to the Yellow Pages (Hobart has the lowest with 1.89)

Adelaide was the first Australian town to legalize **nude swimming**

The **biggest glasshouses** of the southern hemisphere are located in Adelaide’s Botanic Garden

Australia’s only professional **astronaut**, Andy Thomas (4 spaceflights), was born in Adelaide and studied Mechanical Engineering at Adelaide University (BEng in 1973, PhD 1978)

Adelaide of Saxe-Meiningen
Portrait by Sir W. Beechey, 1831

or explored the city. The cars were equipped for the trip to the outback starting on Sunday. As the hotel had a pool with a BBQ place, we decided to relax at the pool and have burgers from the barby for dinner. The personalized travels mugs worked well for cold South Australian white wine. Calming down and chill at the pool was a perfect decision after the busy.

The red heart of Australia – Exploring the Outback

On the next day we started early again and left the city at daybreak. The daily portion of road time was the biggest share we had on the whole trip with a distance of 850 km from Adelaide to Coober Pedy. Fearing kangaroos on the road without having a roobar, we decided to go early and have some buffer time for breaks. The caravan was established from four SUV: two white and one silver Toyota RAV-4s as well as one red Mitsubishi Outlander. Communication was better than in Sydney, but still some cars refused to participate in our communication. The Silver Surfer tried to open the game of car names, which wasn't enjoyed so much by the rest of the group. Quickly after leaving the motel drive control was activated and with 110 km/h we rushed through the slowly changing landscape.

We stopped in Port Augusta for a lunchbreak, discovering the small cities Sunday noon atmosphere. Spliting up the group, some enjoyed their lunch at a diner, while other bought some goods at the local store and sat close to the water. Refreshed and not hungry anymore, cars equipped with new cool water and iced coffee, the journey continued northwards and the harbourside was the last bigger collection of water we saw for some times. We entered the Stuart Highway, which is connecting Port Augusta and Darwin via Alice Springs. As we entered the Outback now, we were looking for Kangaroos, which were in our dreams jumping parallel to the road. But not a single one could be found alive! Just some dead ones were spotted at the edge of the road.

After 175 km, we stopped by in Woomera located 6 km north from the Highway. The area around, which has nearly the size of England, was a permitted area until 1982 for military purpose as it was a large testing area for air defense system. The Woomera Heritage Centre shows a collection of missiles and rockets. We enjoyed our time there and wandered around the exhibits. A part of the group, equipped with some car keys, the opening hours of

the local animal centre leaving the rest of the group to joyfully wait in the heat.

It was closed. The Silver Surfer including its crew explored also the local sports ground, which seemed quite strange with its green gras in the dry middle of nowhere. Highlight of this mission was to see a kangaroo jumping around next by. After we refuelled the cars at Spud's Roadhouse heading north continued. After missing water collections for the last kilometres, were stoked to reach the blue coloured lakes shown on our way by Google Maps. Huge salt lakes bordered the way through the outback. With more than 300 km still to do driving was at this point (if not before) boring. Some stops for peeing and taking pictures of the red, flat and dry landscape taught us to appreciate the cars´ AC. Nasty outback flies taught us the outback dance.

Finally we arrived in Coober Pedy in daylight. You can read more about it starting at pg. 52. We checked in into the underground hostels which is kind of amazing but special indeed. As the possibilities in the Opal town of Coober Pedy are way less spread than in Sydney, we went to John's Pizza Bar and Restaurant together and had a good evening with Pizza, Steak and some drinks, which we continued in front of the hostel, while someone was looking for snakes in the dark getting nearly arrested.

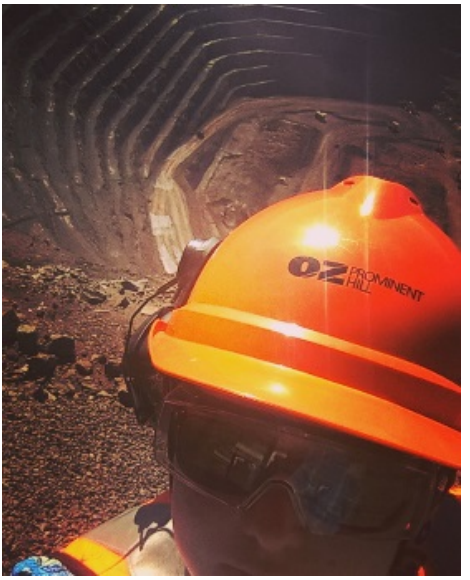
Coober Pedy and Prominent Hill – Mineral Extraction in the Outback

On the next day, which was a public holiday due to the Adelaide Cup, Tom's Working Mine was on schedule. We got the mine tour as well as the the opportunity to test our opal digging abilities. Jackhammering in thongs was fun for the group members so we spend some time underground looking for Opal. Afterwards we checked the huge entertainment opportunities offered by Coober Pedy and made an appointment at Josephine Kangaroo Orphanage to see the animal feeding in the afternoon. In the meantime we explored the city and found beautiful lookouts, bought new beer and learned about special regulations in the Coober Pedy.

Finally a big part of the group ended up in the public swimming pool, which was the perfect refreshment fighting against flies and high temperature. At the orphanage we learnt about the fate of small kangaroo orphanage rescued from the leave of its mothers which were killed in car accidents.

Overwhelmed by cuteness of a little kangaroo we went back to the hostel. In the afternoon, we decided to eat pizza again and had a great outback group evening. As it was announced that there will be no electricity in the next morning, we had to prepare in the evening, because we need to start at 04:00 to reach Prominent Hill mine on time. No light, when it's dark outside and you're living underground is not a good idea, to sum this morning up.

On the 14th we left Coober Pedy at 04:00. We had "just" 136 km to go, but after 88 km we left the Stuart Highway and continued on a gravel road for another 45 km to reach the mine site. As we didn't have the needed radio frequency with our walkie-talkies, we needed to be accompanied by a car from the mine on the dust road. In the dawn of day we got to the camps parking lot. To get in order with our schedule we needed to speed up everything, which was quite unusual for Australian. We went to the canteen and had to grasp some lunch and breakfast. The variety was huge and having a quick breakfast some of us dreamt about working there without having seen the mine but the breakfast. For the rest of the mine tour, the group split up.



Ten persons went for an underground tour, while the rest visited the open pit, the processing and tailings facilities. You can read more on pg. 61 about the mine. After the great visit, when every question was answered and discussed, we hit the road again and drove 440 km to Andamooka, where we arrived some minutes after the sun set.

Andamooka – how the Outback Atmosphere feels like

When the navigation devices told us we've arrived at our destination, we wondered about the darkness. Without sun or street lights, we could just assume buildings. After a turn we saw an open bar next to our "hotel". As it had not enough rooms for all of us, parts of the group settled in holiday houses nearby, while the rest stayed in the Andamooka Dukes Bottlehouse Motel. It is a single-story complex including the owners' home, the post-station with a small shop and a opal showroom as well as the name-giving bottlehouse, which is a circular room made of glass bottles in the better days of Andamooka. Next to the Motel the Tuckerbox is located, a outback pub, where our host Margot Duke organized us some late night food (at a time, which even in Germany we would not call late). We became acquainted with Margot and she enjoyed speaking German with us. Her parents came from Germany and she was totally into Opal Mining. Tired from the long day some people went to bed early while other chatted with the locals drinking some beers.

In contrast to the day before the next morning started slow and late. Breakfast was served in a neat dining room specially made for everyone as personally desired. During breakfast we got to know Margot a bit better and she told us about Andamooka and its history. You can read more about it on pg. 69. The motel was founded in 1967 by her parents Rudi and Inge Duke. On the question what to explore in Andamooka she gave us some advice. Strangely, she recommended visiting the cementry as well as the second-hand-store, what some of us did afterwards. The graves are often personalized and as Andamooka is almost completely inhabited by opal miners the graves show often shovels and picks – the classic miners tools. The calmness of Andamooka was also used to sit down and read under the porch watching some emus crossing the street. A big reason for this atmosphere was the absence of internet, which was only available in the public library using a computer and speed reminding on surfing in the late 90s.

At noon we met with Margot's partner Peter Tauber who has been a miner, cutter and jeweller for more than 40 years and knows best about noodling, opals and the region. He has seen lot of people coming to Andamooka, digging for opal, getting rich or poor, leaving or passing away. He

has a lot of stories to tell. We went to the claim of an active miner, who was digging on surface and explained us his strategy. Afterwards we went to a place where a miner's pub has been in more successful times. In the waste rock piles we looked more or less motivated and successful for some opals and enjoyed the empty landscape and thought about Andamooka's golden times.

On some heaps we saw some chilling black kangaroos. Meanwhile, we did the Outback dance except of those who joined the surface tour at Prominent Hill, where they got fly nets. Than we went to an old underground mining place where nowadays parties are held without disturbing anyone. The rest of the day was used to explore the various attractions of the town. Some also went to Roxby Down to refresh in the pool. In the evening the tuckerbox was visited for food, drinks and communicative times. When we found the flipper with a hunting theme some dollar coins were spent for lucky times connected to childhood memories.

On the next day we saddled our cars in the late morning and started our trip back to Adelaide. At first we went to Woomera again, because the animal park was open,

which was a bit disappointing just hosting birds, but they were lovely. 500 km still to go to Adelaide, the feeling was known and each car crew arranged in their own way. With constant 110 km/h, AC and cruise control activated, we got closer to Adelaide. Some ice cream, refuelling and peeing breaks brightened the journey as well as listening to stories about Schnapspralinen. When we finally arrived, we were happy to leave the cars and been brought back to civilization. We stayed at the same Motel as before, so we decided to use the BBQ option again and shopped for some burgers and drinks.

Adelaide – big city life South Australia Style

In the City Center of Adelaide, the University of Adelaide is located, which was our goal on the 17th of March. Compared to our bus driving experiences in Sydney everything went perfectly and we met Prof Peter Dowd in front of the Bonython Hall, a gothic building opened in 1936, which is used for graduations ceremonies, expositions and meetings with large audience at the University of Adelaide. As we compared what we saw in Australia with our Clausthalian standard, we appreciated the building very much, but in comparison our Aula Academica might be a bit nicer.

We got a tour around the campus and the buildings by the mining department and were again overwhelmed by the hospitality. You can learn more about the University of Adelaide starting at pg. 32.

Having a sandwich we got to know faculty members and students and chatted about the university and the city as well as the differences in mining and culture between Germany and Australia. As we heard there is a campus bar, we had to have a beer there. In the afternoon, the group split up and smaller subgroups discovered the city: CBD, with its free public transportation, China town, the botanic garden and the Fringe festival were places to see.

After checking out downtown, the next day was used to explored the surrounding area. A group spent time scuba diving in the ocean, while another group visited a wild life centre to pet some roos and feed emus. Afterwards the cliché German village of Hahndorf was shortly visited, but left quickly for a wine tasting in a typical vinery. In the afternoon, the beaches were visited for swimming and chilling in the sun. The diving boys also did their vinery

stop and we all met back in the motel for cosy evening. The next morning, we had our a breakfast in the motel. The hosts did their best to make us feel comfortable. They even served breakfast at 05:00, when we left early to go to Coober Pedy. But there's a little thing weakening the experience: The breakfast room is the Korean BBQ Restaurant and it smells like burning charcoal.

Ballarat – Town of gold rushes

On Sunday morning we started the 613 km drive to Ballarat. After three hours we left South Australia and entered Victoria including a short stop for fuel and ice cream . 300 km later one of the cars decided that it's time for another wine tasting. Due to late communication (100 m before leaving the highway) the remaining three cars stayed on the planned path. At the Begonia City Motor Inn, it's totally clear that a Sunday afternoon must be spend at the hotel pool. Ice cream and drinks were bought and pool time was totally enjoyed. In the evening we visited a local recommended restaurant nearby to feed the hungry mouths. Somehow the remaining guests wondered about the big group of young folks. After multiply times of group ordering at the bar, as it is common in Australia, we used our optimized ordering system and it worked well. The evening was finished with some beers in front of our beautiful and big apartments, which we sadly had to leave the next morning.

Relaxed and refreshed after the cosy Sunday of driving and pool and everyone was excited to see the Ballarat gold mine on Monday morning, which is described at starting pg. 78 After an interesting introduction to the mine site, its history and the production and processing system, the group was split up again. Antipodal to the setting at Prominent Hill, six persons went underground while the rest visited the surface facilities.

After the great visit, lunch was taken in Ballarat city by the crew of three cars. The condition of the silver surfer had become worse with every kilometre and the trunk could just be opened from the inside. Advanced packing had to be practiced. Due to the upcoming two hotel changes we decided to get the car repaired or changed to avoid displeasing times of packing and unpacking. So the silver surfers went on his trip to a rental station. The nice lady there couldn't help us with a new car or fixing the old one but told us to see a station in Melbourne, which was on our way to Traralgon, where we stayed the next night. She found out that the station, which is most likely to have a fitting car for us, is at the airport, where we had to leave our beloved silver surfer and

changed to the third white RAV-4, which was called the snow king, to make it different to the other two snowflakes. Bringing them together at the Motel in Traralgon, we realized that we just needed 30 extra minutes for our trip.

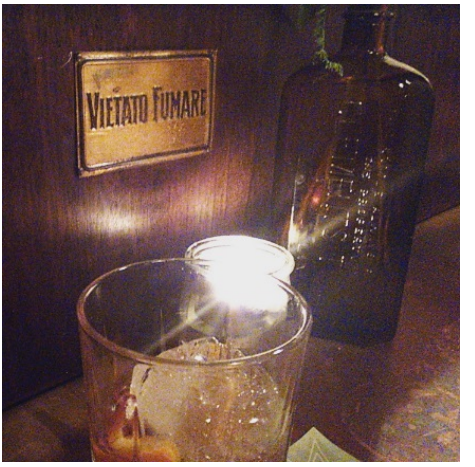
The small town Traralgon offered us not a huge variety and due to our relatively late appearance (after 7 pm) it was even smaller. We decided to go together to a schnitzel place. Overall we realized that schnitzel is even more common than steak and a popular way to serve meat. In our time in Australia we ate more schnitzel than in three normal weeks in Germany. At the restaurant, where most of us ordered schnitzelburger, we weren't allowed to have a third beer so the evening ended quicker than we thought.

Doozermania

Yallourn, a large lignite open pit, was the last mine we visited. Closely located to the hotel, we had to drive just half an hour to get there. So we had time to enjoy the continental breakfast made of toast and cereals. After a short ride, we had to go through a registration to enter Doozermania. The open cut, as described from pg 82, uses almost exclusively doozers to move material.We were impressed by those dimensions and had good discussion also about the differences of lignite mining while having lunch with the staff from Energy Australia. This ended the technical part of the excursion, but we had almost two days left, which we spent in Melbourne. The two hours to reach the capital of Victoria seemed almost ridiculous short in comparison to the long drives we had in the weeks before.

Melbourne – enjoying the last days in Australia

We reached our last stop of the trip, the city of Melbourne. Different to our stays in Sydney and Adelaide, our hotel was located very centrally in the CBD. This led to advantages as well as disadvantages. First, we explored the disadvantage of unloading cars and parking in a city, but we got along. So we could enjoy the advantages and started a foray to discover Melbourne downtown. The huge variety of food offerings led the group split but Chinatown was a place where all of us ate.



Afterwards the nightlife of Melbourne was tested and we visited bars with happy hours, rooftop bars, which are not as high as we thought, small bars but also had to learn that after midnight it's hard to find a new place. But two very special places were found for late drinking: the Workers Club at Brunswick street, where the owner

of the bar locked the door from the inside to have some drinks with his new German friends and the Bar Americano, where a German bar tender served us classic cocktails in a standing only room located at the end of a narrow street. It was a night to remember.

The next day was an individual day and the last full day in Australia. So most of us spent time exploring the city and shop the last souvenirs. The city offered a lot of possibilities and everyone made their own way. A lot of kilometres were walked to see the skylines, stadium, the cathedrale and museums. Due to free public transport in CBD getting around was easy and when the feet hurt we could sit down in the historic light rail which is driving in circle around the CBD and shows the historic locations for free. In the early evening a lot of people met at the Queen Victoria Market, because it was the last night market of the season. Different types of food were served and live music was played. As we all knew that bars are closing early, a large group visitied the Workers Club again for some beers. But the evening was also used to pack the bags ready for the upcoming flight. Well trained by short stays at the different places, it was easier than in Germany but took us some time, especially figuring out a good configuration for all helmets we had to bring. The next morning some last-minute-shopping, and packing was performed and we left the hotel in the late morning to go to the airport. The cars were refuelled for the last time and finally we had say goodbye to our reliable vehicles. At the airport, time was spend with random actions such as searching the postbox, which is located as far away from the terminal as possible. It was finally the time to say good bye. Our Cathay Pacific flight CX 139 left at 15:25 and after just nine hours, we arrived in Hongkong. This time shopping was a bit more extensive, but the time was used to sleep by many of our fellows. Deep at night, local time, our flight CS 289 to Frankfurt left, which was also very sleepy. A medical case of emergency appeared, which left us all thoughtful, when we left the plane after waiting more than 30 minutes. As the group was formed on the way, the same thing happened going back. After three week, everyone came home savely and managed the jetlag on his/her own.

Visual impressions and highlights

Welcome to Australia, it's Sydney calling Photo by A. Hutwalker

Characteristic feature of a field trip car? Photo by C. H. Dörner

The Hard Had Collection

Size does matter! (in Mining) Photo by A. Hutwalker

Experts at work – Part 1 Photo by A. Binder

Sydney´s magnificent skyline Photo by A. Binder

The Coat Hanger Photo by C. H. Dörner

A different perspective of the Sydney Harbour Bridge Photo by A. Binder

It´s a long way to ... everywhere in Australia! Photo by A. Hutwalker

Watch Out! Miner´s Country! Photo by O. Langefeld

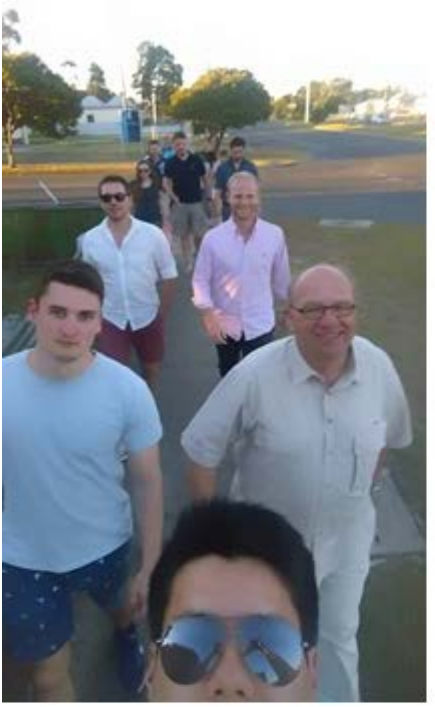
Underground group at Prominent Hill Photo by Prominent Hill Mine

Roadtrip Classics Photo by O. Langefeld

Big Hole – Australian style Photo by Prominent Hill Mine

Experts at work! – Part 2 Photo by Ballarat Gold Mine

Best Group Photo in 2017 Photo by Ballarat Gold Mine



Walk to the next Billabong
Photo by N. Saruulbayar

Cheers Mate! Cheers, Mate!
Or: For a hard earned thirst.
Photo by A. Hutwalker

First contact with the natives
Photo by A. Binder

How a stop on the road to Coober Pedy looks like

Tailing facility in the middle of nowhere

We love big machines

All Panaroma Photos by A. Binder

Surface group at Prominent Hill Mine

Overburden removal level at the Yallourn Mine

Top View: Australian one-man-open-pit-operation Photo by O. Langefeld

Worm's-eye view: Australian one-man-open-pit-operation Photo by A. Binder

Best Pub in town (supposedly) Photo by C. H. Dörner

Clausthaler Gold (Opal) Rush Photo by O. Langefeld

Romantic Roadtrip Photo by A. Binder

Loving Big Machines Photo by A. Binder

Enjoying culinary specialities Photo by C. H. Dörner

Skyline of Melbourn arranged with grey sky Photo by C. H. Dörner


TimTam
drop bear
Down Under
experiential
meat
gold and coal
long rides
#noWorries
outback
VB
cheers mate
mining land
Opal fields
platypus
SaftyFirst
beer
BBQ
roo
mining
Huntwalker
wide landscapes
supersize
hi-vis
diving
kangaroos
high contrasty
amazing
dowsing rod
quality time
G'day
Golden Gaytime
sunburn
diversity
Black Stump
roadtrip
Korean BBQ
#ClaustralCoesOz