AUSTRALIAN EARTH SCIENCE EDUCATION

Mining Impact and Rehabilitation

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Effect of mining on Aboriginal Cultural Sites

- Cultural heritage sites are protected by the *National Parks and Wildlife Act 1974*
- Mining companies work with traditional owners to identify key sites before mining
- Companies that damage sites can be prosecuted and fined

Aboriginal stone axe quarry in Victoria
(J Stevens 2008; Wikimedia Creative Commons)

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Before commencement of mining, Aboriginal cultural sites must be identified in consultation with local Aboriginal stakeholders.
In 2011 MCG Quarries in Queensland was fined $80,000 plus costs for damage to a culturally significant Aboriginal quarry.
In 2013 OM Manganese was fined $150,000 for desecrating the Two Women Sitting Down site near Tennant Creek. The company knew about the site, but continued with blasting that caused damage. This was the first contested case of desecration in Australia.

Overview of the mining rehabilitation process

- Before mining
  - Environmental survey
  - Identify and consult with stakeholders
  - Plan post-mining land use with stakeholders
  - Pay rehabilitation security bond
  - Plan for protection of species and habitat
  - Clear land, collecting topsoil for later rehabilitation

Site of the Agnew Nickel mine in Leinster WA before open-pit mining began
(R Hill, CSIRO Science Image)

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Mining rehabilitation was not a consideration in the early days of mining, but is now a major focus at all stages.
Before mining, the company must conduct an environmental survey to determine whether there are significant animals, plants or ecosystems present in the area. If so, mining may need to proceed differently or offsite areas may be identified for rehabilitation and habitat creation to maintain biodiversity.
Mines must consult with all stakeholders (local government, land owners, traditional owners) before mining about land use and rehabilitation options
A security bond is required that will cover the cost of rehabilitation if the company goes out of business.
The initial land clearing for mining is vital, as topsoil must be carefully stored and native seeds may be collected for use in revegetation during and after mining.

Overview of the mining rehabilitation process

- During mining
  - Progressive rehabilitation where practical
  - Annual reporting on progress
  - Waste rock placed in stable design for final landforms
  - Saved soil placed on landform and appropriate plants/seeds added

The Polkemmet coal mine in North Lanarkshire Great Britain is being contoured during mining.
(R Webb 2009, Wikimedia Creative Commons)

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Rehabilitation requirements are specified in mining approvals and rehabilitation is undertaken during mining, whenever practical.
Companies are usually required to report on rehabilitation progress on a yearly basis.
Waste rock is piled as indicated by the final landform design. Rock needs to be stable and allow water to drain freely. The final void (hole) is often allowed to fill with water for recreational use after rehabilitation.
Saved topsoil is placed over the shaped landform and plants are chosen based on future land use. This may be for grazing, crops, recreation or biodiversity.

Overview of the mining rehabilitation process

- After mining
  - Topsoil capping and revegetation continue
  - Native animals may be reintroduced or return naturally
  - Areas are monitored to ensure success
  - When objectives are met, companies sign-off land and relinquish to local or government control

Megathyruss maximus (Petrie Green Panic) is pasture grass sown in mine rehabilitation sites in the Hunter region of NSW
(H Rose 2016, Wikimedia Creative Commons)

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Mine waste and areas that were not rehabilitated during the mining process must be capped and revegetated after mining is finished.
Native animals may be introduced if necessary, or may return naturally from nearby environmental offset areas.
The areas must be monitored to ensure that there is no acid drainage, instability or other problems. If monitoring indicates successful rehabilitation, the land will be signed off and returned to landholders, traditional owners or government management and use as appropriate.

Environmental Hazards

- Noise
- Dust
- Chemical contamination
- Salinisation

Blasting at this open cut coal mine near Newcastle causes both noise and dust.
(2000, CSIRO Science Image)

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Blasting is used in both open cut and underground mining to break up rock for removal and processing. This produces large amounts of noise and dust. Blasting is generally limited to fixed times of day to minimise community disturbance.
Dust is a great problem that led to the black lung disease of early coal miners. It remains a problem in coal mining areas such as the Hunter Valley north of Sydney. Lead-containing dust poses a great risk to children in areas such as Broken Hill, thus acting as both a physical and chemical contaminant.
Chemical contamination may be by acid mine drainage or through dust containing lead and other toxic elements. Groundwater may be contaminated by gases and chemicals used in onshore drilling.
Salinisation is a risk at open pit mines due to the large amount of land clearing required.

Mining

- Open cut
  - Ore deposit relatively close to surface
  - Dug downwards in intervals (= benches)

Open cut mining at Paddington Gold Mine near Kalgoorlie
(1998, CSIRO Science Image)

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Open cut mines have a large void (pit) and are dug in steps to access ore. Mines often have a large surface area with an even larger cleared area for waste and processing. These features shape the rehabilitation possibilities.

Rehabilitation – Challenges and solutions

- Challenge: large void
- Solutions
  - Backfill with waste rock and tailings
  - Allow to fill with water for a lake
  - Use for landfill

An abandoned mine in Illinois, USA, is used for crude landfill, which is covered with clay (US National Archives and Records Administration, 1973, Public domain)

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Filling with waste rock and tailings is an uncommon rehabilitation option, as most open pit mines are too large for this to be feasible. Backfilling also delays rehabilitation, as the waste rock could have been contoured and planted years before the end of mining.

The large hole (void) left after mining may be allowed to fill naturally with water and become a lake.

Mines can also become engineered landfill sites (unlike the simple landfill in the photo). The Woodlawn mine near Goulburn was converted into a major landfill for metropolitan Sydney. Smaller brick pits and quarries in the Sydney area have been used for landfill and then converted into recreational spaces such as sports ovals.

Rehabilitation – Challenges and solutions

- Challenge: loose waste and tailings
- Solutions
  - Contour piles of waste
  - Cap with clay if sulfur-containing minerals present
  - Cover with soil
  - Revegetate

The former Jackpile-Paguate uranium Mine in New Mexico USA has been backfilled and contoured. (M Gant, National Institute of Environmental Health Sciences 2013, Public Domain)

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Loose waste and tailings present the risk of erosion and landslides. These must be contoured to a gentle slope that is stable enough for capping and revegetation.

Rehabilitation – Challenges and solutions

- Challenge: acid mine drainage
- Solutions
  - Clay capping of waste piles
  - Passive neutralisation of acidic water

Acid mine drainage in Ohio, USA, is treated through limestone dams and channels that neurtalise pH (Wayne National Forest 2010, Wikimedia Creative Commons)

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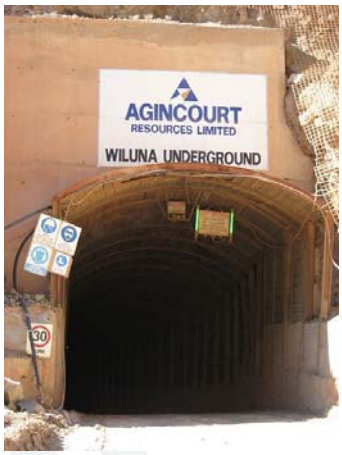
Sulfur-containing minerals in waste rock and tailings react with oxygen and water to form sulfuric acid. The acidic water then dissolves toxic metals and metalloids such as lead, copper and arsenic. Vulnerable waste is capped with compacted clay to keep water and oxygen from reaching the sulfides.
If acidic runoff is generated despite capping, this may be treated with passive systems such as limestone-lined channels and dams. These progressively neutralise the water. As the pH rises, toxic metals are no longer soluble and precipitate out. At the end of the treatment channels, the water can be returned to the environment.

Mining

- Underground
  - Ore deep underground (often in pockets)
  - Accessed through tunnels and shafts



Entry to Wiluna Underground Gold Mine, Wiluna WA
(2009, Wikimedia Creative Commons)

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Although the surface may appear unscathed by underground mines, the mining process leaves dangers due to the shafts and tunnels. These may be a danger to people and animals, but often provide habitat for insect-eating bats.

Rehabilitation – Challenges and solutions

- Challenge: shafts and adits
- Solutions
  - Backfill with waste rock and tailings
  - Block access

Shaft entry blocked for safety at Barranco de Badajoz mine in Tenerife
(2019, Wikimedia Creative Commons)

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As with open pit mining, backfilling is a rare option. Waste is generally left at the surface and contoured into new landforms.
Shaft entry needs to be blocked, but old mines can provide valuable roosting areas for bats. Many barriers are designed to allow bats to fly through, but prevent humans and larger animals from accessing the site.

Rehabilitation – Challenges and solutions

- Challenge: subsidence
- Solutions
  - Reinforce and backfill during mining process
  - Fence subsidence area and allow collapse

Subsidence near Corndon Hill, Mid Wales, UK, caused by an old underground mine collapse
(D Croker 2008, Wikimedia Creative Commons)

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The removal of large amounts of underground rock can lead to collapse of tunnels and subsidence of the land above. Reinforcement and backfilling during mining should prevent this, but sometimes there are still collapses.
Mines may plan for subsidence and fence off the area above the mine to prevent entry of livestock and humans. The collapse is allowed to occur and this area is permanently fenced. Between 2009 and 2014, mine subsidence claims cost NSW $8.7 million.

Mining

- Drilling
  - Onshore – petroleum or coal seam gas (fracking)
  - Offshore – fixed platorms or ships

Oil and gas drilling platform
(CSIRO Science Image)

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Drilling has a relatively small footprint. The greatest risk for onshore drilling is groundwater contamination through unpredictable rock fracture and fugitive methane emissions from gas extraction. In 2014, the CSIRO estimated that fugitive emissions accounted for 2.5% of Australia's greenhouse gas emissions.
The risk of oil spills from offshore drilling affects the entire sea bed. One example is the Deepwater Horizon event in the Gulf of Mexico (2012) which had long lasting and devastating effects on the environment and humans.

Rehabilitation – Challenges and solutions

- Challenge: drill pad and hole (onshore)
- Solutions
  - Plug drill hole
  - Rip compacted soil
  - Revegetate

Capped exploration drill hole in Cape Ranges WA (S Filan 2019)

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All drilling requires plugging of the drill hole. This is generally done by cutting the pipe below the surface on land, plugging the pipe and then backfilling over the area. The photo above is an old oil exploration pipe that was capped and fenced in the 1950s. The compacted soil around the drill hole is ripped to loosen it and then revegetated.

Rehabilitation – Challenges and solutions

- Challenge: drill rig and hole (offshore)
- Solutions
  - Plug drill hole
  - Remove rig
  - Option for rig to reef

Fish at an oil platform (G Boland & US Bureau of Ocean Energy Management 2006, Public domain)

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Plugging the drill hole is a relatively simple process, but the fate of the oil rig is more difficult. Oil rigs quickly become encrusted with organisms and can provide valuable habitat by forming an artificial reef. Options for rig to reef include:

- Cutting the rig well below the level of any passing ship and leaving the top portion on the sea floor beside it.
- Toppling the rig sideways to lie on the sea floor.
- Re-purposing rig components to make a designer reef.

The first rig to reef project in Australia was the King Reef in the Exmouth Gulf (WA). The rig was altered to make 58 modules that were then arranged into an artificial reef area.

References

- Photo sources cited with each image.
- Minerals Council of Australia (2018). Mine rehabilitation: rehabilitation, closure planning and regulation. Accessed 23 March 2020 from: https://minerals.org.au/sites/default/files/Mine%20rehabilitation_Update%20AUG%202018_FINAL.PDF


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