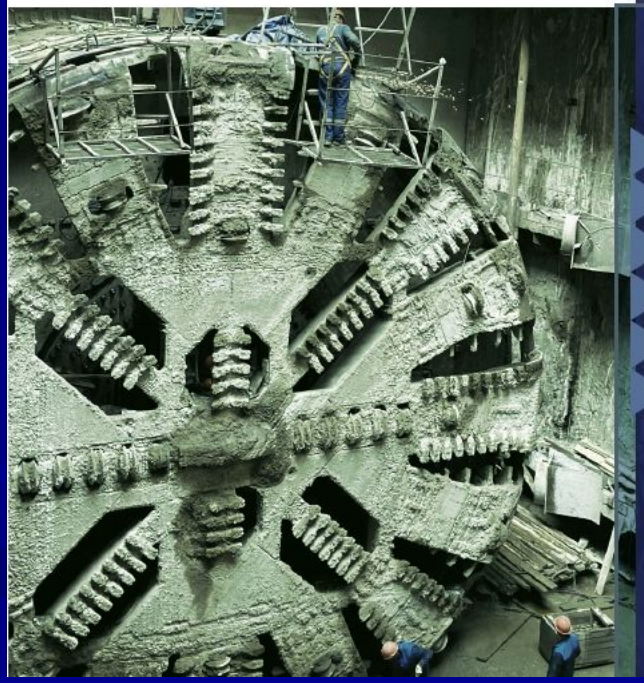
South African National
Committee on Tunnelling

SANCOT SYMPOSIUM 2026

13-14 APRIL 2026
SOUTHERN SUN ROSEBANK,
JOHANNESBURG



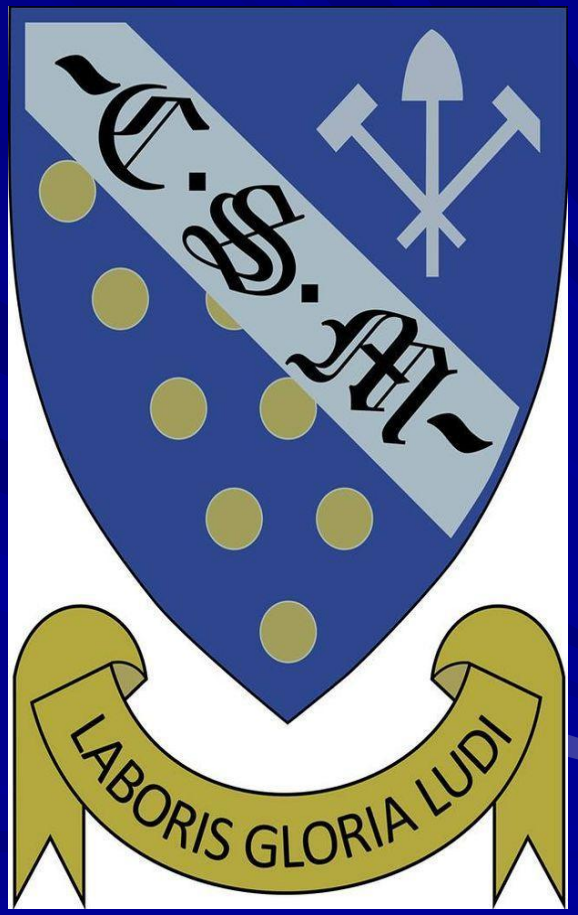
Unlocking Africa's Potential: Advances in Tunnelling in Civil Engineering and Mining

What has the mining industry done for underground civil construction and what is the civil construction industry doing in return?

Dr David Lees

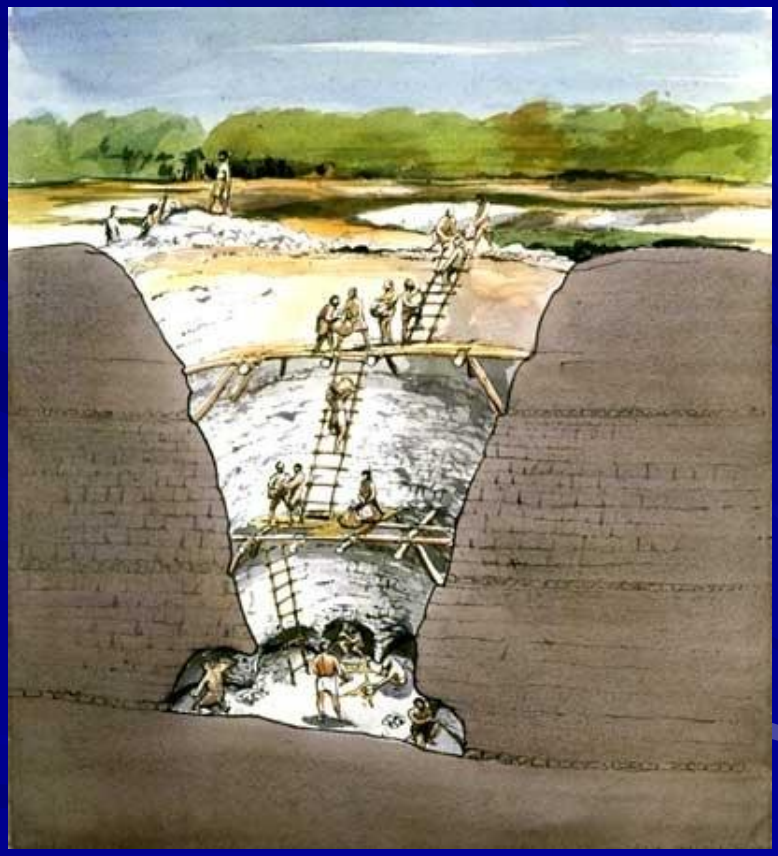
Mining Engineers

- Mining Engineers have well rounded education in electrical and mechanical engineering, structural engineering, geology and geotechnical engineering



Oldest mine

- The oldest known mine is the "Lion Cave" in Swaziland, 43,000 years old.
- Neolthic man mined for flints between about 3000 -1900 BC

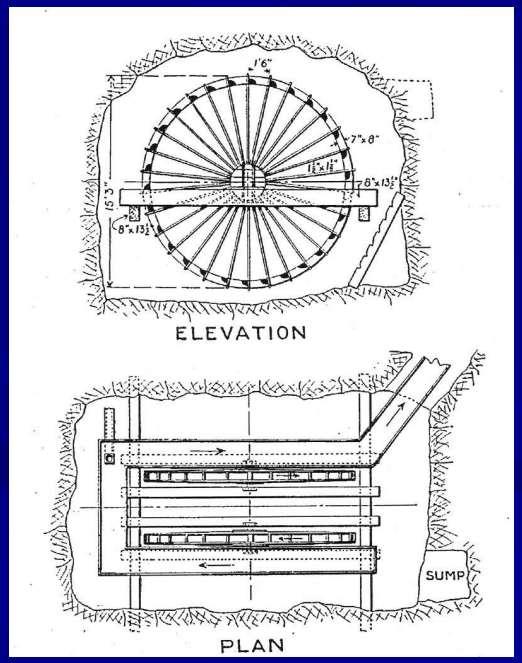


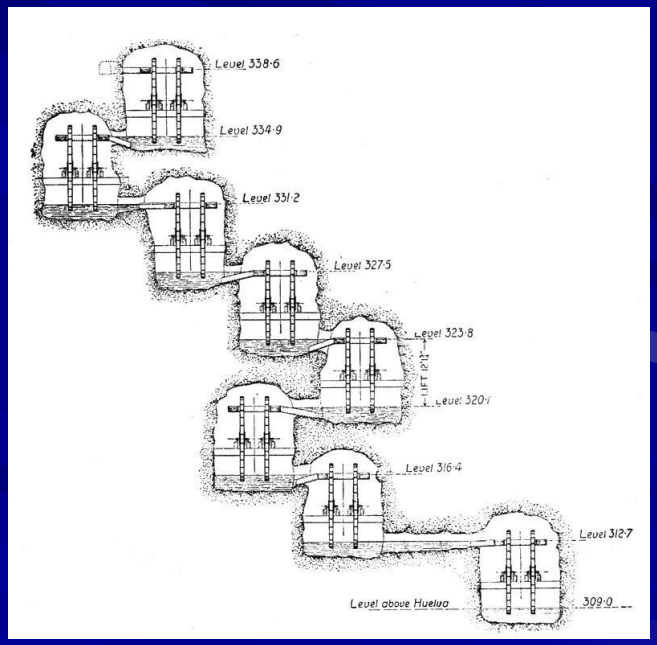
Oldest underground dwellings

- **Cappadocia subterranean city in Turkey dates back 5,000 years**

Roman mining

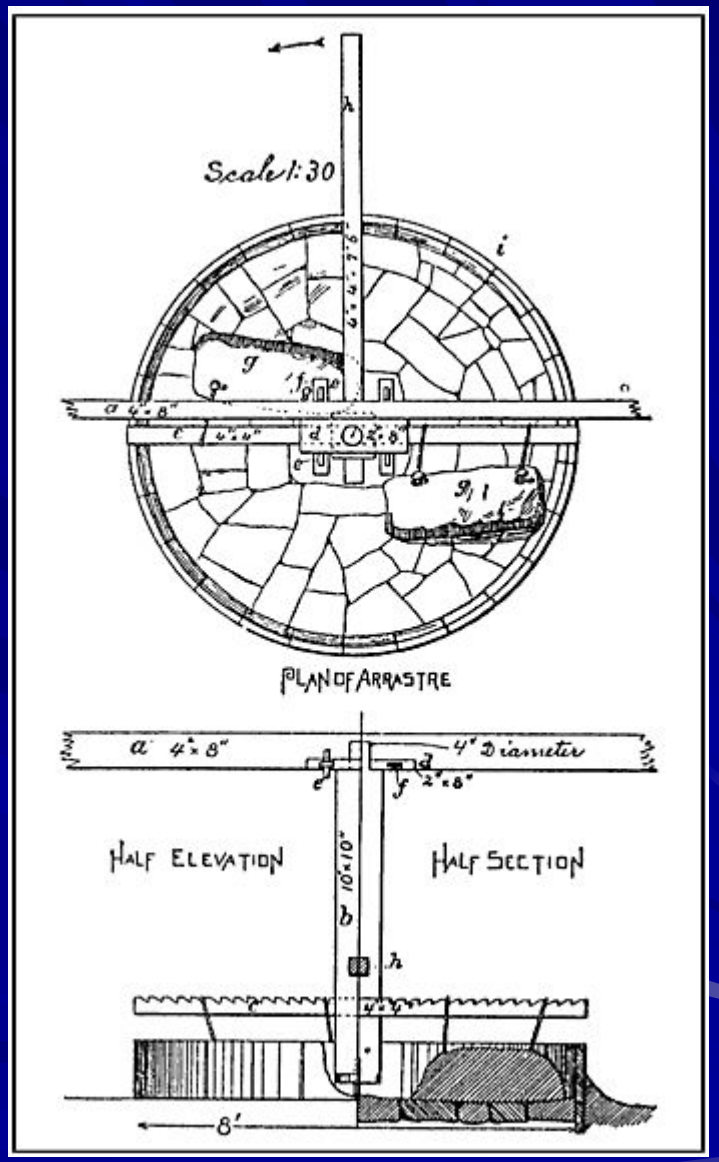
- Firesetting and hydraulic mining
- Drainage and ventilation adits
- Drainage wheels for dewatering





Medieval Europe

- As miners dug deeper to access new veins, mechanical and animal driven pumps.
- Ventilation galleries by powering giant bellows.
- Arrastra used by the Spanish to pulverize ore



Black powder

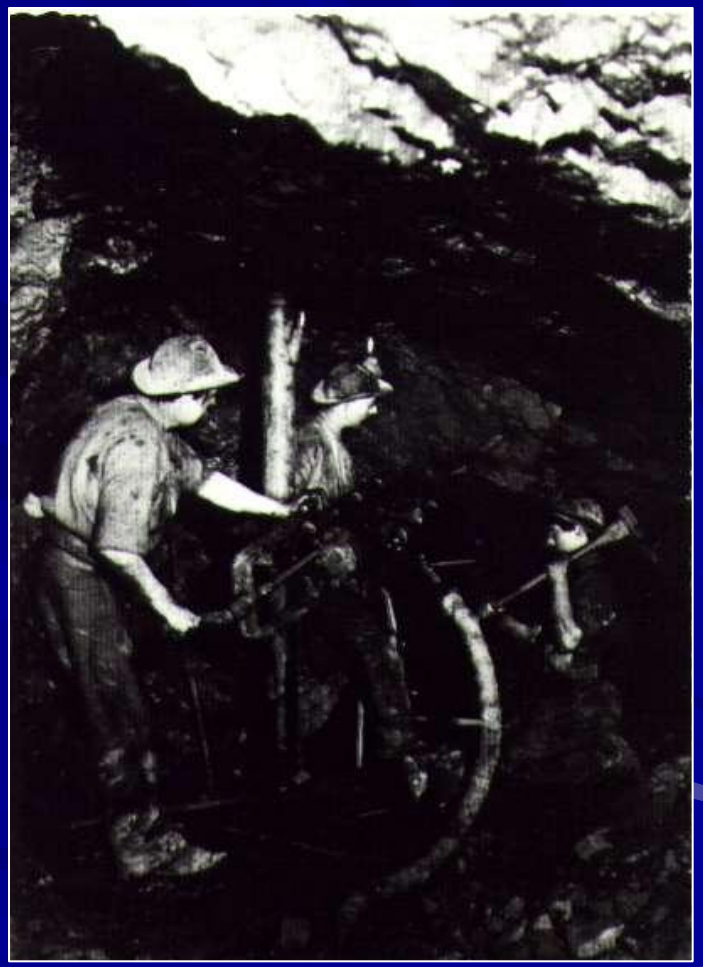
- The invention of gunpowder produced a need to bore holes in rock and ‘Drill and Blast’ was born

Industrial Revolution

- Steam pumping Engines

Mechanised rock drilling

- The American Ingersoll and Rand rock drills from 1870 had very few moving parts.
- Many new inventions were associated with new projects such as Mokean's rock drill for the St Gothard Tunnel
- The Sach's rock drill had a screw feed as compared to the conventional winch handle or wheel but had less durable moving parts.
- The Schram rock drill had just four moving parts. The whole construction of the machine is simple and strong.
- John Darlington had an even simpler idea to base his design on just two parts, the cylinder and the piston



Mechanised rock drilling

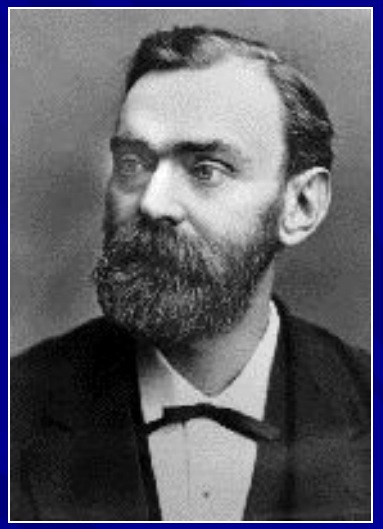
- In 1905 a merger to form the Ingersoll Rand Company marked a new generation in the development of the rock drill including down-the-hole hammers and tungsten carbide tips
- Increased penetration meant more dust which meant more deaths from Silicosis
- In South Africa water was thrown from a puddle with a tin to reduce dust, but this was unclean.
- In 1902 it became official that water should be used to dowse the dust.

The Dust Allayer

- 1935 Major Hibbert and Charles Wetherhill tried prevent the dust by projecting a fog against the face.
- Castor Oil was used to reduce the surface tension of the water
- Miner's did not like it so did not use it.

- In 1897 Leyner designed a drill on which today's drills are still based. The steel was held loosely in a chuck attached to the cylinder itself and the piston reciprocated and struck the blunt end of the drill steel. The most important improvement was his method of introducing air down through the drill steel to keep the drill holes clear of rock. This raised a lot of dust, so he introduced water along the drill with the air; this novel design soon dominated the World market.

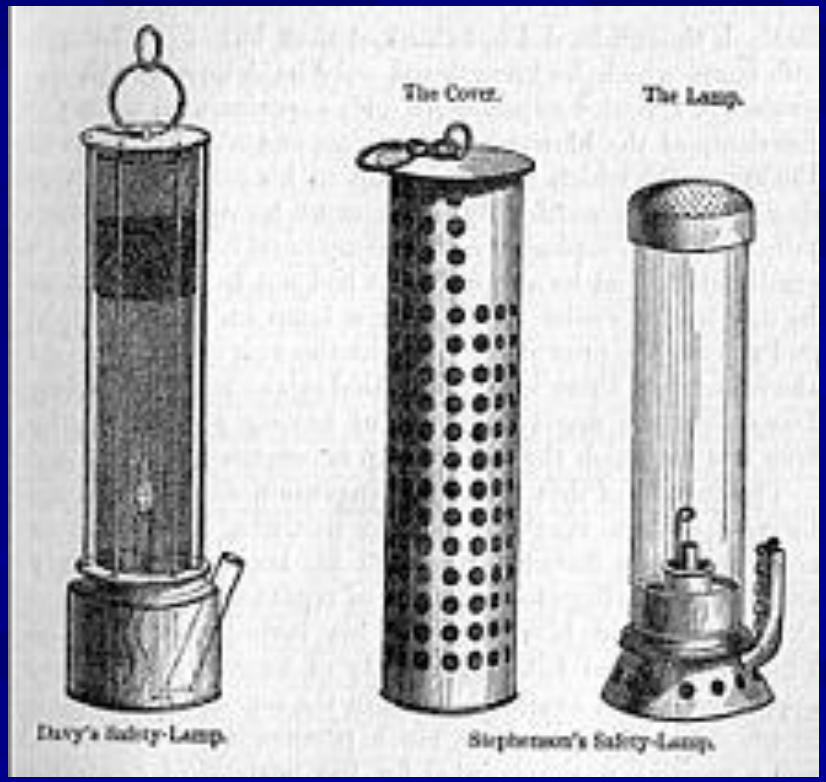
Dynamite



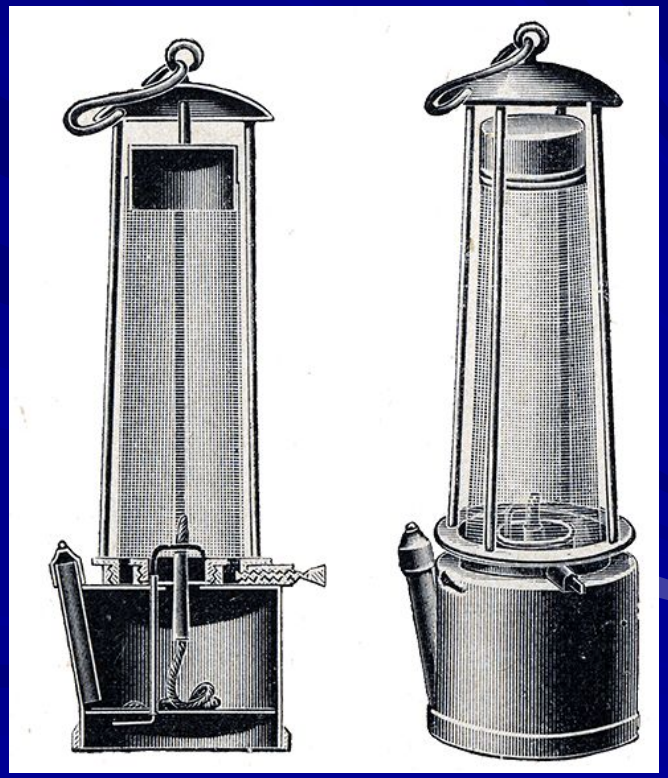
- In 1852 Alfred Nobel found that mixing nitroglycerine with silica would turn the liquid into a paste which could be shaped into rods of a size and form suitable for insertion into drilling holes
- In 1867 he patented this material under the name of dynamite.

The Geordie lamp and the miners safety lamp

- Geordie Lamp



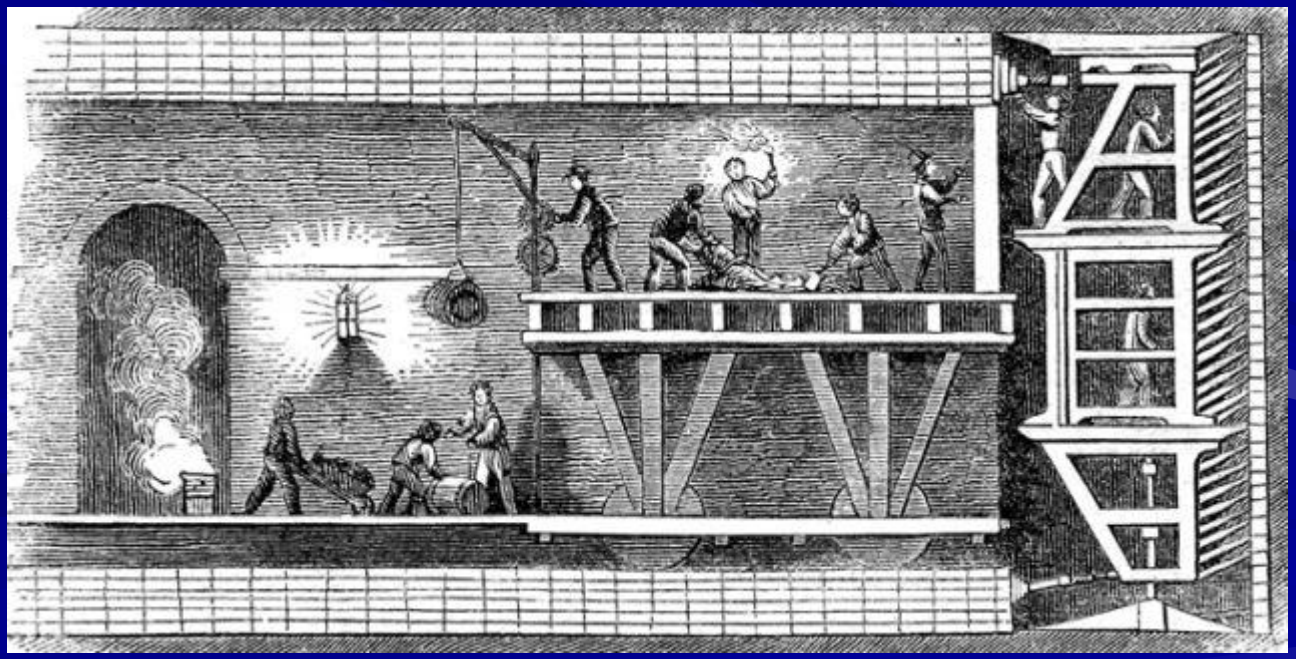
- Davey Lamp



1815

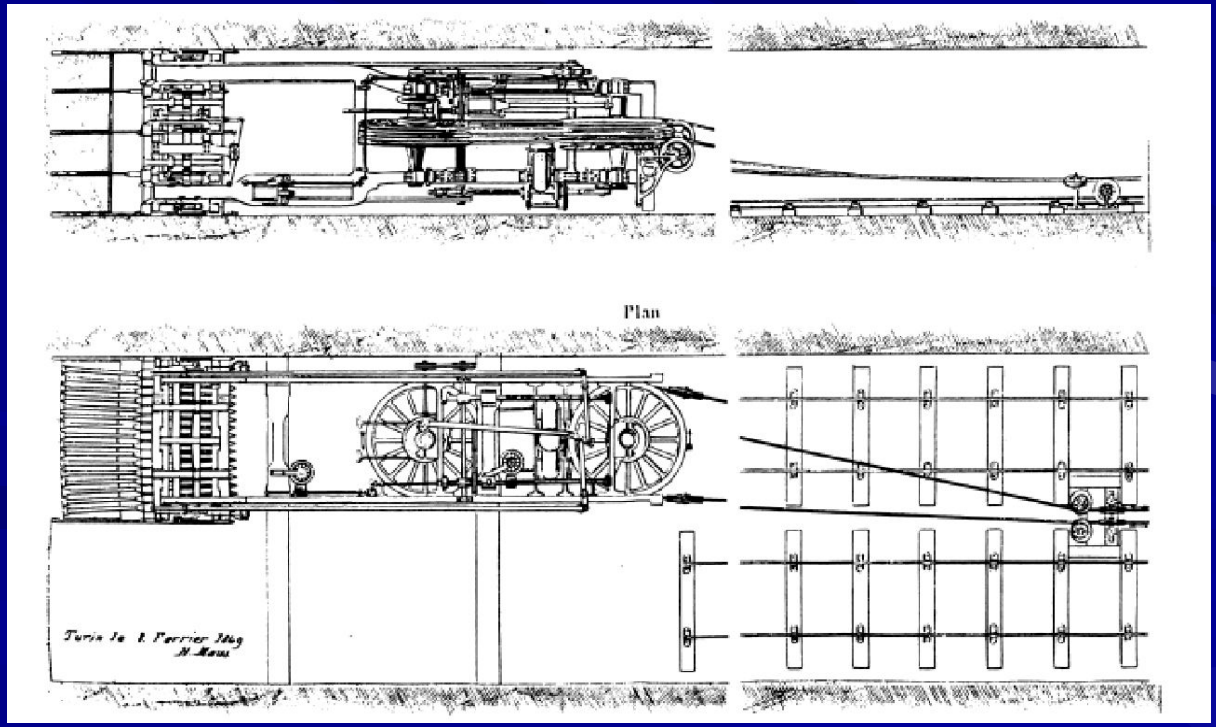
The tunnelling shield

- In 1825 Brunel commenced the first subaqueous tunnel under the river Thames in London



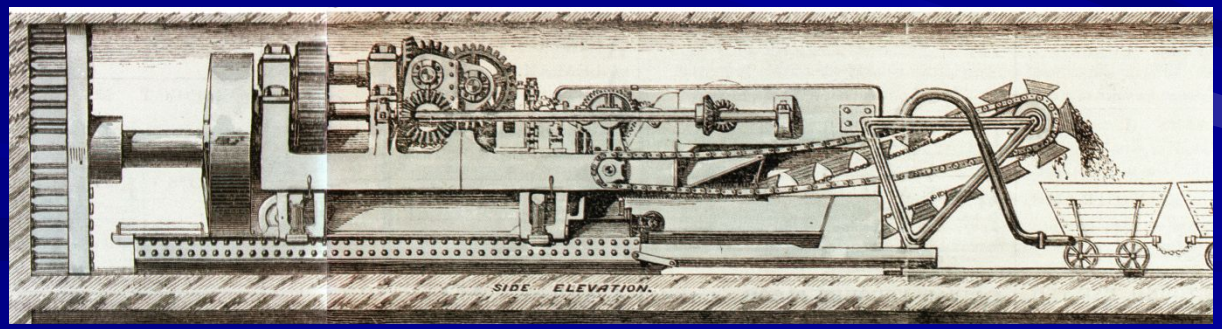
First tunnel boring machines

- 1st TBM was developed by Henri-Joseph Maus for the King of Sardinia to tunnel through the Alps in 1845



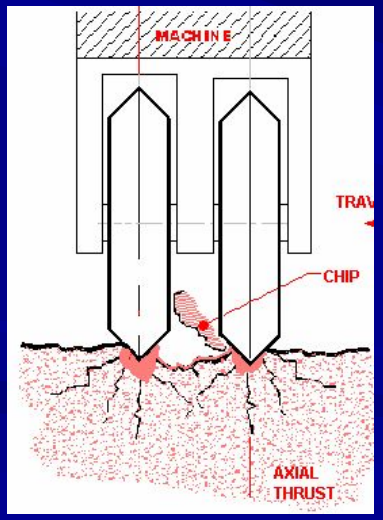
Beaumont's TBM

- The first TBM that tunnelled a substantial distance was invented in 1863
- British Army officer Major Frederick Edward Blackett Beaumont to excavate a tunnel under the English Channel



Hard Rock TBMs

- First hard rock TBM developed with disc cutters by James Robbins in 1950
- Hard rock TBM grips the side wall of the tunnel and pushes forward using hydraulic rams whilst large motors turn the head.
- The rock breaks in tension on either side of the discs as the roll over the rock

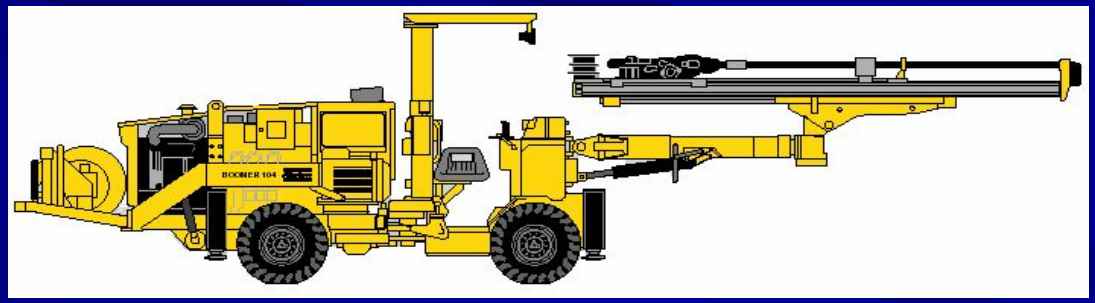


Todays TBMs

- In August 2014 Robbins Dual Mode EPB/Rock TBM was successfully rolled out from the first of two access tunnels at Grosvenor Mine in Queensland.

Modern drill and blast

- Today most drill and blast tunnels and large scale underground mining projects utilise multi-boom hydraulic drill rigs and haulage trucks or load haul dump (LHD) machines.



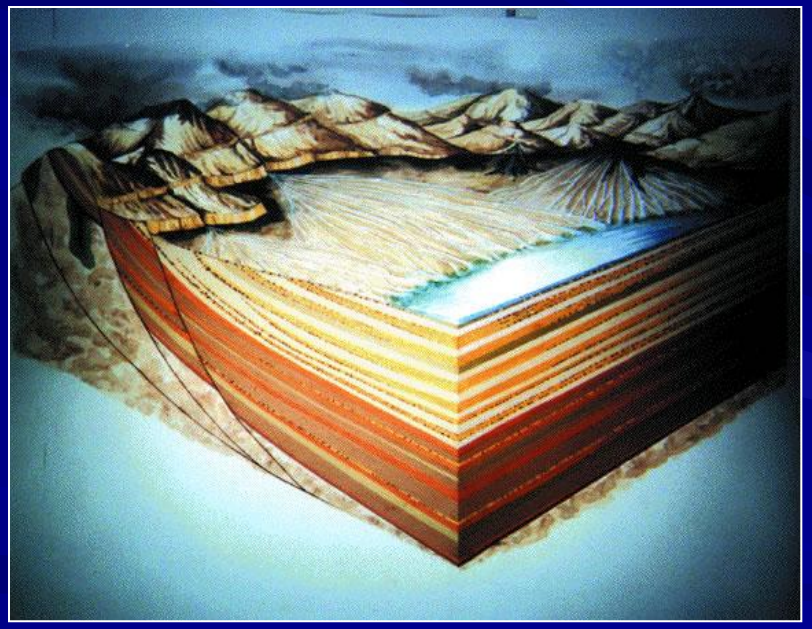
- Remote controlled equipment enables safer and better productivity.

South African Gold Mining

- In the early 1980's the South African Gold Mines started to develop from narrow stopes into trackless mechanised mines

South Deep Project

- South Deep Project Westonaria – 35m stoping height 2000m below surface



Amonium Nitrate

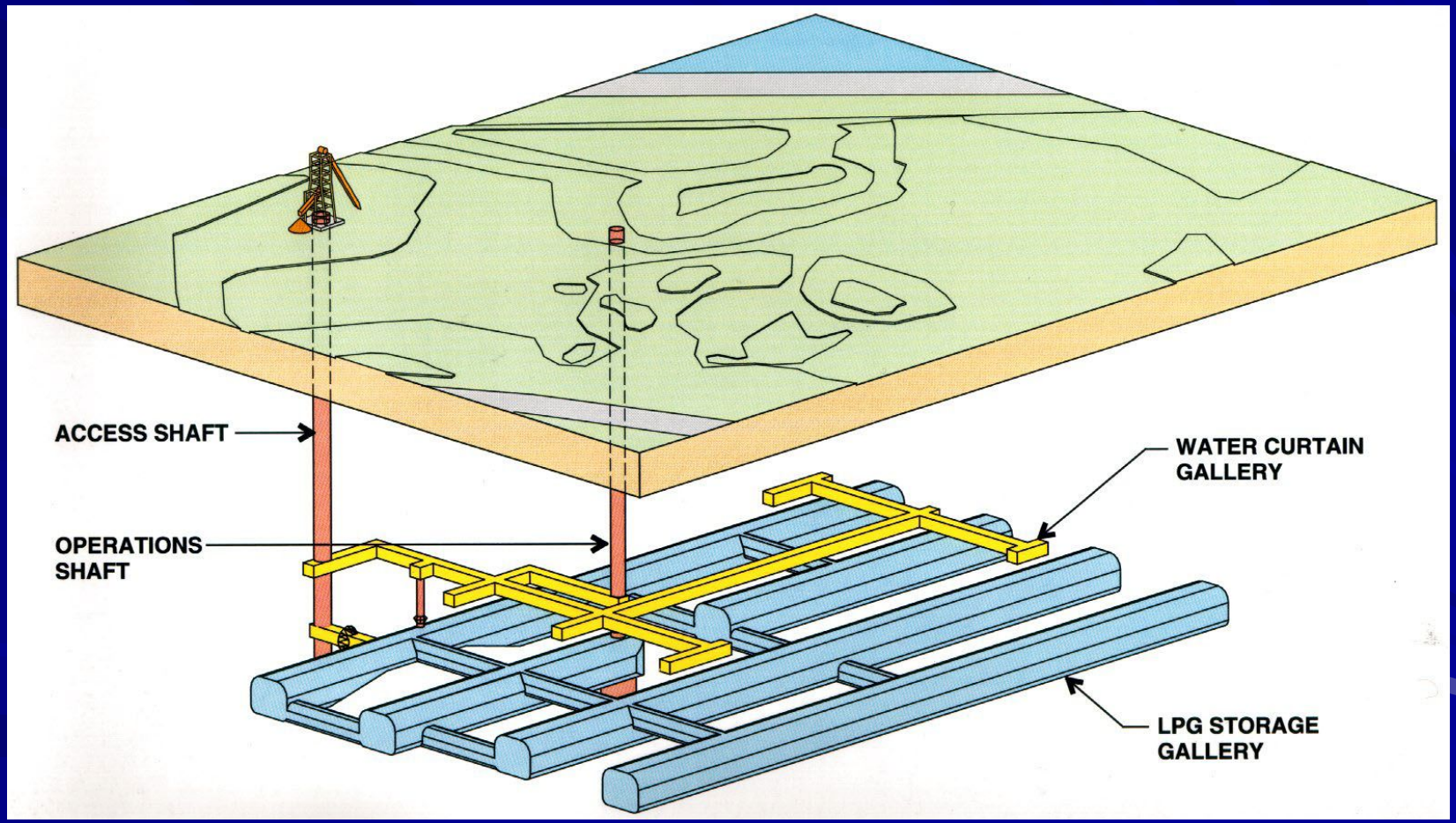
- 1955, marked the beginning of the most revolutionary change in the explosives industry since dynamite with the development of ammonium nitrate–fuel oil mixtures (ANFO) and ammonium nitrate-base water gels, which together now account for at least 70% of the high explosives consumption.

Pumpable emulsion

- In recent years the trend for high volume blasting trackless vehicles delivering pumpable emulsion

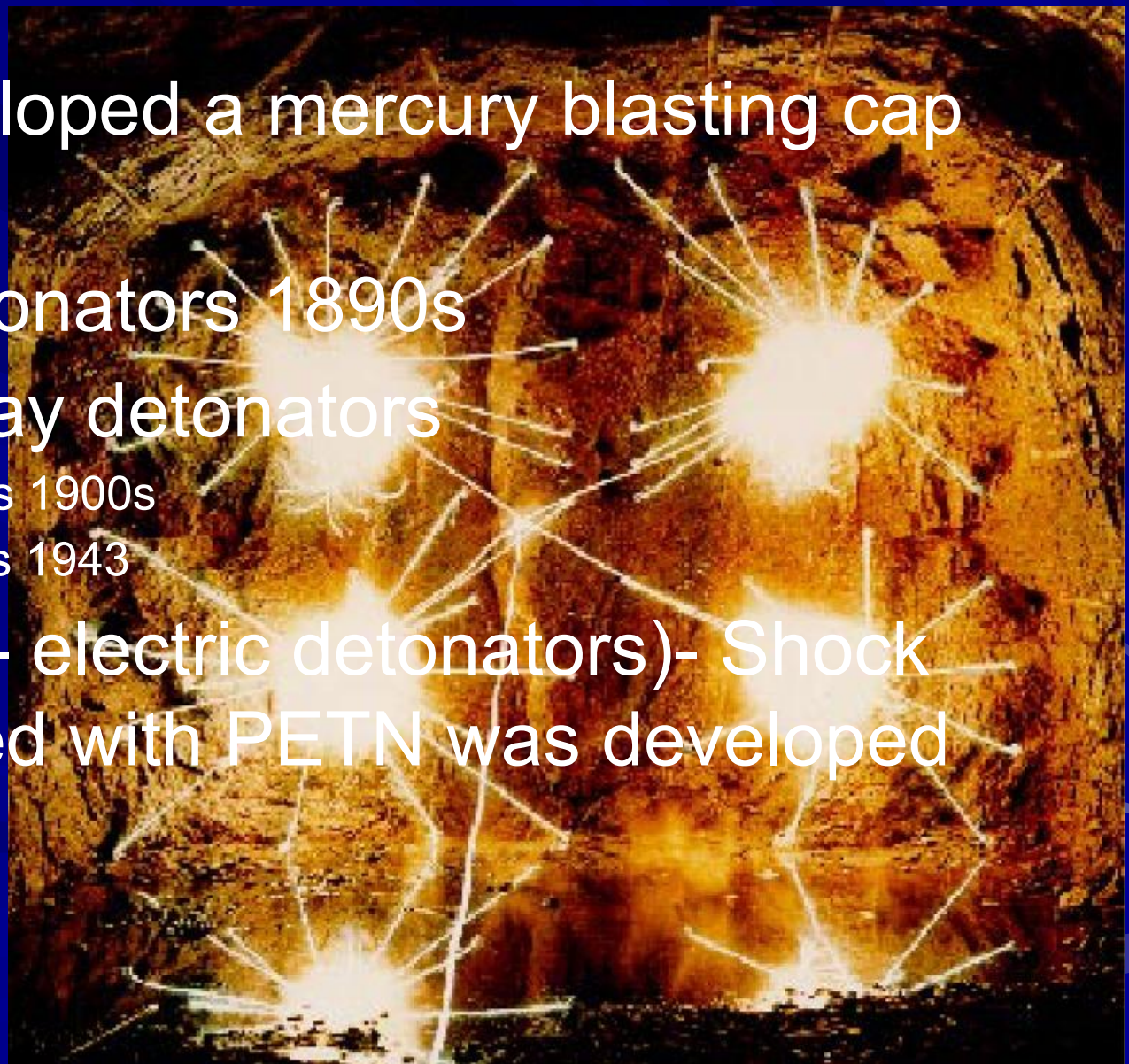
- First use of pumpable emulsion in civil engineering was the Sydney LPG Cavern

Sydney LPG Cavern



Detonators

- Nobel developed a mercury blasting cap in 1865
- Electric detonators 1890s
- Electric delay detonators
  - Half second delays 1900s
  - millisecond delays 1943
- Nonel (non- electric detonators)- Shock tubes coated with PETN was developed in 1960s



Next generation detonators

- **Electronic Detonator can be programmed up to 30,000 ms by 1 ms increases.**

Rockbolts and shotcrete

- The first major application for underground support was in the late 1950's for the Snowy Mountain Hydro-electric Scheme. The Snowy Mountains Hydro-electric scheme is considered one of the engineering wonders of the world with over 126km of tunnels, 8 dams, 5 powers station (three of which are underground).

The Snowy experience

- The Snowy mountains hydro electric project pioneered the use of shotcrete and rock bolts with many kilometres of tunnel remaining “unlined”.

- Laing (1961) developed a set of design rules for pattern rock bolting that related rock bolt length and spacing to block size.
- The rock engineering expertise developed in the Snowy Mountains Hydro-electric scheme was soon transferred into the Australian mining industry and elsewhere around the world

NATM

- Shotcrete became an integral part of the New Austrian Tunnelling Method in the 1960s by which excavation is controlled by continuous monitoring of ground movements.

Steel fibres

- The introduction of steel fibres in 1971 and its application by the Norwegian tunnelling industry in the late 1970's has also had a major impact on mining.

Cadia East Mine

- The Cadia East Project will become the largest underground mine in Australia and one of the largest underground gold mines in the world
- Fibre-reinforced shotcrete has been essential for the safe development of this world-class project.
- Cadia East has an approved mine life of 21 years

Shotcrete industry

- Today more than 800,000 m3 of shotcrete is sprayed in Australia annually with 70% underground.
- Shotcrete application is now a huge global industry expected to be worth more than $10 billion

Grouting and ground treatment

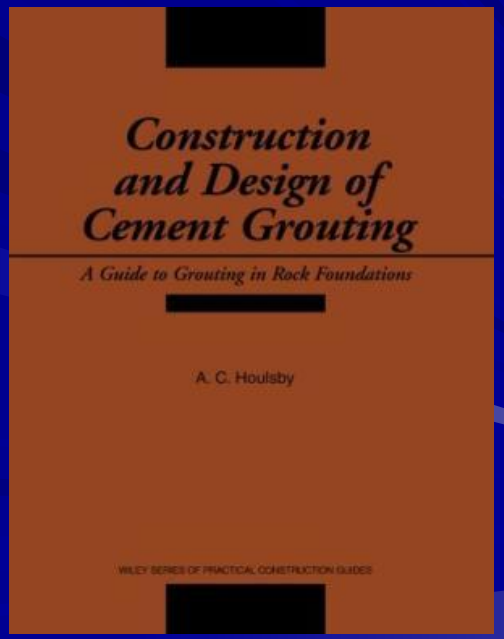
- The first recorded application of grout injection to stabilise civil structures is by Charles Berigny in 1802 for the Port of Dieppe in France
- The first recorded example of using cement to seal off water ingress in mining was in Germany in 1864 when a brick lined tunnel near Hamburg was sealed by “running in milk of cement from the surface by means of a hand pump”.

Tunnel grouting

- The first recorded use of cement grouting in a rock tunnel was in 1880 at Maret in France
- At the turn of the 20th Century cement grouting was used extensively as a remedial measure to deal with water ingress in the coalfields in Europe and for sealing tunnels associated with dams in the USA and beneath the Hudson and Harlem Rivers in New York

Lugeon

- In 1933 Maurice Lugeon published borehole watertightness criteria which is still the basis of our grouting definitions today
- Australian guru Clive Houlsby greatly improved the interpretation of the multi-pressure Lugeon tests in the 1970s



Better cement grouts

- With the invention of the strain viscometer and the Marsh cone in 1931 engineers were able to determine better the flow characteristics of grouts to permeate fracture in rocks or soil pores
- The invention of the colloidal mixer, manufactured by Colcrete in England from 1937 was a major result for grouting.

Chemical Grouts

- Silicate and chemical grouts were introduced at the turn of the 19th Century
- Sodium silicate grouting developed in the 1950‘s

- By the 1960‘s grouting of alluvium was accepted worldwide and included construction of the new Blackwall Tunnel in **London**

Chemical Grouts

- In the 1970‘s concern over health and environmental pollution led to a ban on many chemical grouts particularly in Japan CIRA produced guidelines on the safe use of chemical grouts in the UK in 1981.

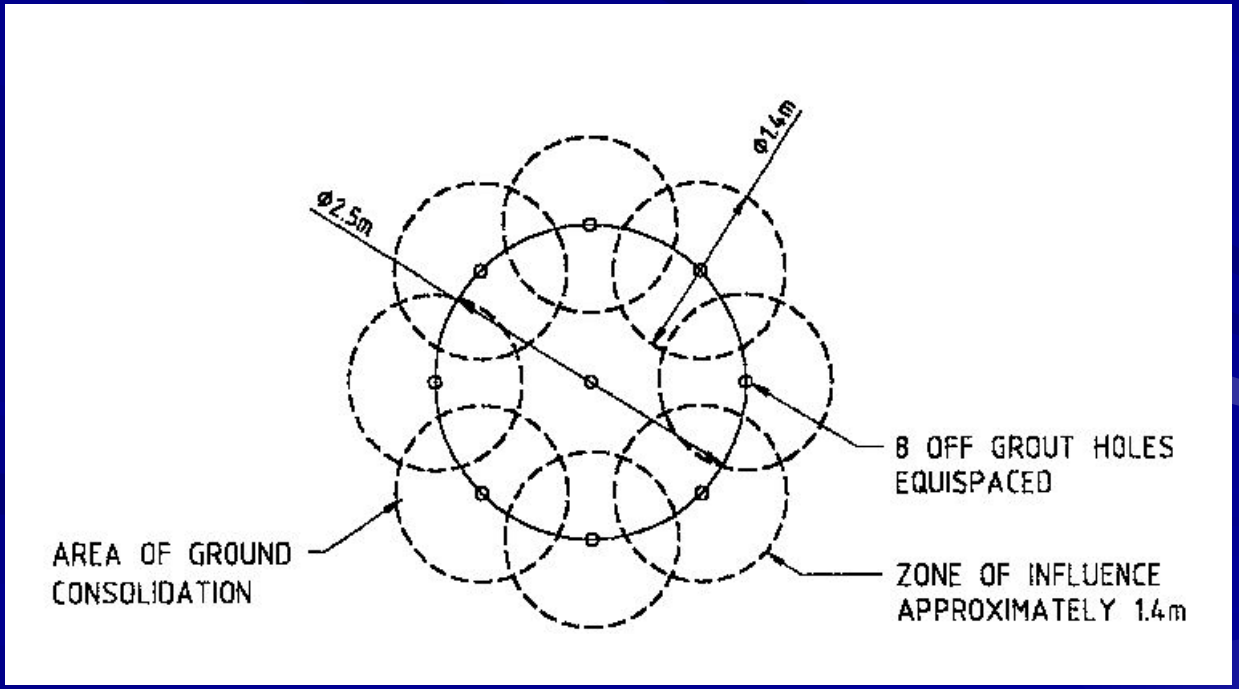
Rhoca-Gil at Hallandsas Tunnel was linked to the death of nearby livestock.

Jet Grouting

- Jet grouting emerged as an alternative to chemical grouting in the 1970‘s with major application for the Singapore Metro

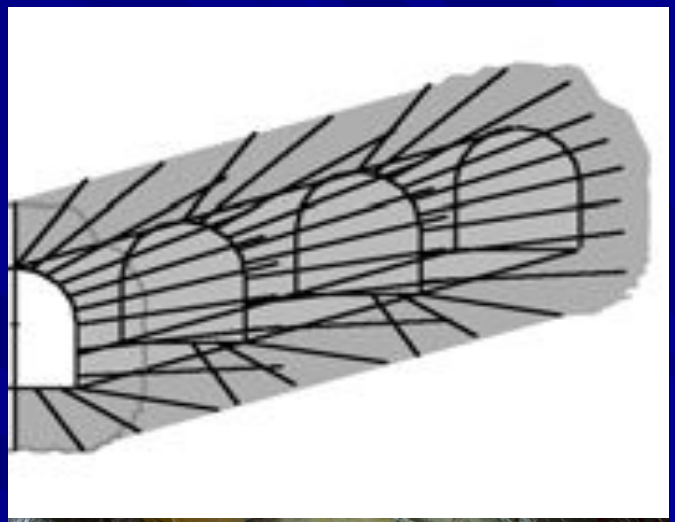
Jet Grouting

- December 1996 GFWA conducted high pressure jet grout mixing to depths of 80m at the Cannington mine



Microfine cement

- According to Norwegian Tunnelling Society - modern grouting technology has now developed to such an extent that grouting should be considered as a third principle tunnelling process alongside excavation and rock support



LiDAR and Drones

- Drones equipped with high resolution cameras and LiDAR sensors are reshaping how modern mining operations are planned, executed, and managed.

Rishikesh to Karanprayag Railway

- LiDAR reduced the time necessary for the route survey through remote Himalayan mountain landscape from several months to a few weeks.

Mining Today

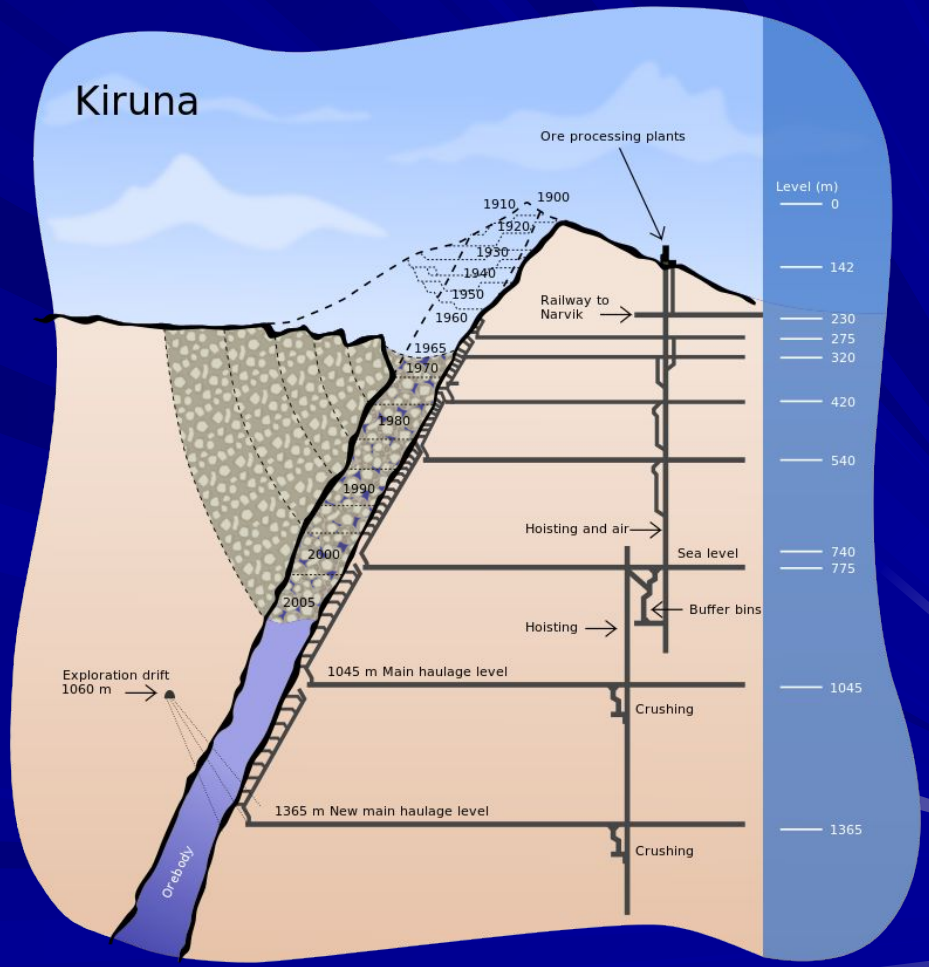
- More underground excavation carried out in the world in mining than in civil engineering.

Mining Today

- The deepest mine in the world is TauTona in Carletonville, South Africa or Western Deeps No 3 shaft at 4km deep.

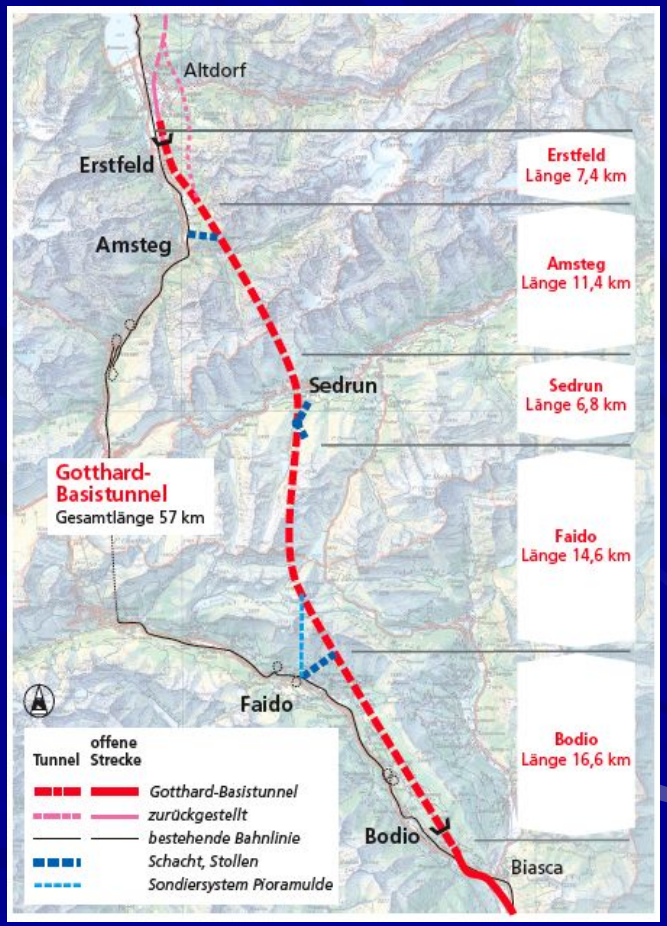
Mining Today

- The largest underground mine is Kiirunavaara Mine in Kiruna, Sweden with 450 km of roads, 40 million tonnes of ore produced yearly, and a depth of 1,270 m, it is also one of the most modern underground mines



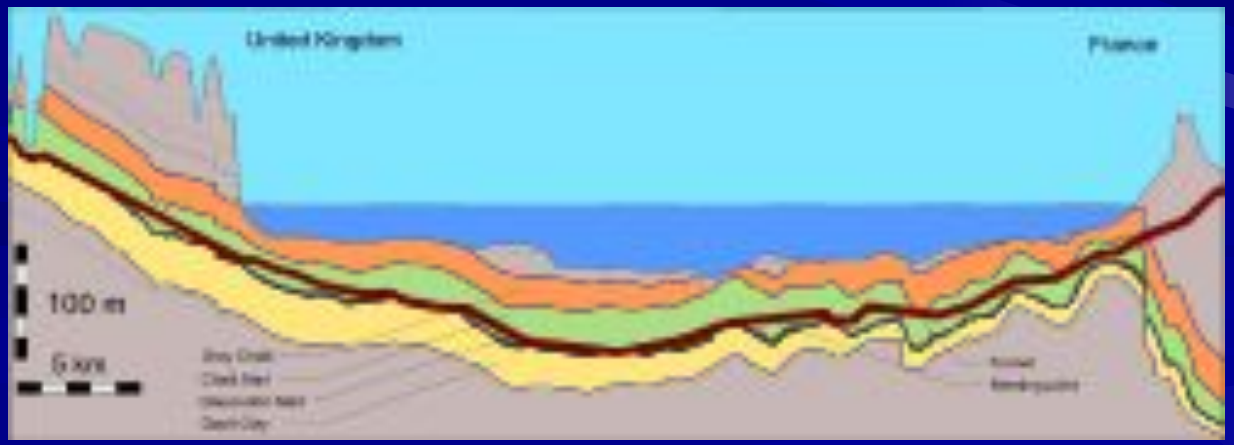
Tunnelling Today

- Gothard Base Tunnel in Switzerland has a route length of 57.09 km and a total of 151.84 km of tunnels, shafts and passages, it is the world's longest and deepest traffic tunnel with a maximum overburden of 2,300 m.



Tunnelling Today

- Longest underwater tunnel in the world is the Seikan Tunnel - 53.85 km (but only 23.3 km under the seabed – 100m deep)
- Channel Tunnel - 50.5-km has a longer undersea portion of 37.9 km and at its lowest point it is 75 m deep.



Crossing Bohai Strait

- China is moving forward with one of the world's most ambitious infrastructure projects: a 120 km undersea tunnel across the Bohai Strait. About 90 km of the 120 km tunnel will run underwater, making it the world's longest sub-sea tunnel.

Gluck auf

- Mining engineers will continue to find opportunities in underground civil engineering projects
- Developments from civil engineering underground construction will continue to find application in underground mining.
- The two industries are inter-related and we must continue to work together.