Welcome to MTD summer newsletter 2019. This year seems to be flying past, already its July. We have lots to report in our newsletter this time, but I want to tell you all about the IOM3 launching a sustainability initiative “Resources Strategy Group” (RSG), headed by Jeremy Ramsden. This group encompasses all IOM3 divisions. However since the Institute has a diverse membership, MTD is forming a sub-committee to look at sustainability in mining and how it can be applied. So to kick start our discussion Laurence has written the first article. See page 5.

Further newsletter contributions include celebrations of the James Watt Bicentenary, a synopsis of the MTD 150 years booklet and much more. MTD also pays respect to Albert Wheeler, who died earlier this year.

MTD would be interested in your comments on the newsletter contents and please do contribute to the sustainability debate, MTD have lots of plans to make this a hot topic.

Christine Blackmore
IOM3 MTD Chairman

IN THIS ISSUE......

• Tailings Dams;
• Synthesis of 150 years;
• Mining sustainability;
• Albert Wheeler;
• Symposium on Decarbonisation in Dnipro - MTD board member speaking on coal;
• James Watt Bicentenary; and
• Local society focus

See our webpage: www.iom3.org/mining-technology-division for full article details

The Mining Technology Division is a technical community within the Institute of Materials, Minerals and Mining (IOM3), Registered Charity Number 269275, based at 297 Euston Road, London NW1 3AD Tel: 020 7451 7300 www.iom3.org
Tailings Dams: How to Mitigate Public Concern

Poor waste disposal management has been a major contributor to the public’s opposition to mining. In January this year, an iron ore tailings dam burst at the Brumadinho mine in Brazil, killing at least 166 people. It follows another Brazilian dam disaster in 2015, where a mine dam at Bento Rodrigues collapsed, killing 19 workers. The Brazilian government is considering banning upstream tailings dams, one of the most common kinds of the estimated 3,500 tails dams world-wide.

Tailings dams are often large-scale embankments designed to contain by-products from mine processing plants, and are used in almost all types of mines from gold to coal. In metalliferous mines the ore is crushed to finely ground rock, and once the metal is extracted the slurry is deposited together with residual chemicals from the extraction process. For a medium-sized gold mine treating 8,000 tonnes of ore per day, 8,000 tonnes of waste minus a few grams of gold are deposited. Over a year it will amount to nearly three million tonnes or over one million cubic metres. Hence tails dams continue to grow during the life of the mine, and can eventually become very large. Although on mine closure the tailings should be made safe, they are expected to remain for millennia.

Overflow from the Brumadinho dam

The stability of dams depends largely on the site chosen, the construction materials, the method of construction, quality assurance and control, and operating practice.

Until very recently, the most common type of dam was the upstream type. An earth or rock embankment a few metres in height is built across a valley and the slurry from the plant allowed to build up behind it. The supernatant liquid or water on top of the slurry is pushed away from the embankment by depositing more material against the face. The slurry solidifies as it dries out. For the next embankment lift the solid tailings themselves are used, either excavated by backhoe or placed by classifiers or hydrocyclones. The latter separates out the finer faction with most of the water, and piles up the thicker coarser material on the embankment and on the drier tailings below. As a result, the embankment moves upstream.

The upstream method using tailings is cheap and simple, can defer development capital costs, and is still widely used in developing countries. However, unless carefully managed throughout the mine life, the dam can be destabilised by leaks through the embankment and/or contaminate groundwater.

Much more expensive to build are the downstream dam types that use earth, rock or even roller compacted concrete for each lift. The upper stages depend on widening the lower embankments to maintain the design crest width. More stringent government regulations and environmental standards may even require the upstream face and the body of the tailings to be lined by geomembrane and to have an underdrain system in place. It is more likely where there is a risk of acid rock drainage (ARD) and groundwater contamination.
The operations plan – for the life of the facility (called the TSF or tailings storage facility) – usually consists of the following activities:

1. Minimise water in the dam – by a robust water balance that returns excess water to the plant and allows for precipitation, run-off and extreme weather event.
3. Recruit competent staff and thoroughly train local people.
4. Thickening the tailings by thickeners or filters.
5. Widen the dam crest.
7. Careful reclamation after closure.

Naturally, technology moves on. Filtered or dry-stack tailings have considerable advantages over expensive downstream dams that require liners and underdrains, and are much preferred by environmental authorities. A filter press or deawatering device is attached on to the process plant and produces either filtered wet or dry unsaturated cake. It cannot be pumped and piped conventionally like slurry and needs to be trucked or conveyed to the dump site. It is then deposited, spread by grader and compacted by roller. It may be covered by rock waste or incorporated into the waste rock dump.

However, it places a burden on the mining operations. It will require significant number of extra trucks or an additional conveying system, but it does avoid dam failure and groundwater contamination.

Another huge public concern is cyanide in tailings dams, used principally in gold processing. Cyanide does eventually break down under natural conditions and the long term risk is negligible. There have been few human deaths but there is understandable concern on the risks to birds and mammals which drink from tails and process settling ponds. Cyanide is treated in the plant by chemical oxidants such as hydrogen peroxide, sulphites and atmospheric oxygen, called the SO2/air process. In tailings dams that use the process, cyanide exists at negligible levels.

PIRRATO
References
Time to Talk about Tailings Dams, Molly Lempriere, 27 March 2019, Mining Technology
www.industrial-union.org/why_you_need_to_know_about_tailings_dams
The Economist, 28 January, 2019
www.911metallurgist.com
SME Mining Engineering Handbook, SME, 2011
Cyanide Management in the Gold Industry, Chris A Fleming, SGS Minerals Services, 2010
www.tailings.info/disposal/drystack
Innovations Through History

This booklet has been put together by a group of members of the Mining Technology Division (MTD) of the Institute of Materials Minerals and Mining (IOM3) as part of the celebrations to mark the 150th Anniversary of the formation of the Iron and Steel Institute in 1869, one of the original forerunners of IOM3. The collection of articles in the booklet describes a number of mining inventions and the lives their inventors. All of these innovations made major contributions to the safety and efficiency of mining and, on occasions, to the impact mining has had on the wider public. The mid-nineteenth century was a period that witnessed the acceleration of the Industrial Revolution in the UK and also the formation of a number of learned bodies to serve the technical development of the mining industry. Some pre-dated the Iron and Steel Institute and some formed soon after that year. Many of these have survived and exist today as Local Societies affiliated to IOM3.

It is no surprise that the booklet is largely based on developments that began in the UK and which are, therefore, dominated by UK practice in coal mining. However, although coal mining techniques and technology were largely shaped by the mining industries of northern Europe, the authors have not made it exclusively coal mining based. The booklet includes articles that describe 22 specific innovations and their innovators from 17 contributors, all who have a background in the mining industry, as well as a Foreword and Introduction. This selection is not exhaustive, but as there have been many other key contributions to the safety and economics of mining, some will inevitably have been omitted. However, this leaves the possibility of a further edition of this booklet at a later date.

Underground mining of minerals is an activity that brings with it engineering challenges that require innovative solutions. This is true of all mining activity although underground coal mining operations bring with them significant additional challenges. These challenges include: Water, High temperatures underground, Harmful and Explosive Dust, Flammable and Noxious Gases, No natural light, Breakage and Transport of minerals, Noise, Working in Confined Spaces, Support of the roof, Difficulty of access to deposits at depth, Communications, Disposal of Waste and other Environmental issues. This booklet describes how many of these challenges were overcome by the work of some remarkable individuals.

The content of this booklet is laid out in an entirely random manner. This approach was chosen because the most obvious approach, listing by chronological order, would not work. Whilst it was found that some specific dates identified the threshold of a key innovation, other contributions describe engineering development that covered a much longer period of time, often up to the present day. Also, the editors did not wish to give priority in the order to a particular innovation thus creating a league table of ‘importance’. A more detailed review of the booklet content can be found in the May 2019 issue of Materials World.

As those who have studied the history of mining innovations will readily recognise, change and invention do not always come from the need to solve technical problems to improve efficiency of operations. Tragically, on occasions, innovation and the introduction of significant Health and Safety legislation has been driven by loss of life and disastrous events. The safety lamp is a prime example here, averting the risk of explosion in mines, but also, you will find in this booklet, details of the Aberfan tip disaster of 1966, when colliery waste formed a massive landslide inundating a village school leading to the loss of 146 lives, including 118 children. This event led directly to major changes in how mine tips were planned and managed, and, ultimately, to the introduction of the Health and Safety at Work etc Act of 1974 (HASWA). The book also refers to the impact of the Universal Colliery explosion at Sengenhydd, also in South Wales in 1913, where 439 men and boys perished in a methane gas explosion most probably caused by open sparking in electrical signalling equipment. Another example not specifically covered in this booklet was the deaths of 204 men and boys at Hartley Colliery in Northumberland, that occurred in 1862 when the beam of the mine’s pumping engine broke and fell down the shaft, trapping the men below. The disaster prompted a change in UK law to require all mines to have at least two means of egress. Sadly there have been many other similarly tragic events that populate the history of mining, far too many to describe in detail in a booklet of this size, but all proving drivers to innovation.

Another interesting feature of this booklet is the diversity of backgrounds (and education) of the personnel that made these key innovations. Richard Trevithick, the designer and builder of High Pressure steam engines is reported as performing poorly at school, yet he went to work for his father at a Cornish mine “where he showed an exceptional ability”. Thomas Newcomen was a Baptist, “a persona non-grata in the days of Church of England dominated society, which meant he was effectively self-taught”. William Coulson is described as “a self-made man... not formally educated”. But others such as Sir Humphrey Davy were already eminent scientists with a high position in Society. The booklet describes the rivalry that took place between Davy and George Stephenson and the view in the technical community “that Stephenson, an ‘illiterate’ practical artisan could compete with an eminent scientist like Davy... was deemed unacceptable”. Yet quite a significant number of the innovators described were honoured by society for their work. Swan, Davy and Garforth received knighthoods, Anderton was made CBE. Haldane became a Fellow of the Royal Society, as was Davy. Nobel gave his name to the famous international prizes.

Rod Stace
MTD Board Member
Sustainability in Mining

There are many meanings of ‘sustainability’ and it has become synonymous with ‘environmentalism’. Nonetheless, at its core there must be continuity, preserving the natural environment for future generations. The issue is whether we would preserve the current degraded natural environment, or work for a better version, and to what extent?

The current and very topical climate debate should be seen as a major element of ‘sustainability’ along with other issues: water scarcity, overfishing, degradation of farmland, endangered species and atmospheric pollution - and many more.

Mining sustainability is a contradiction. Mines have beginnings, middles and ends, and every mine will eventually close, leaving at best a diminished resource for future generations. The best hope is leaving the original land in the same or in better condition, which could mean turning the open-pit into wetlands or a boating lake, the waste dumps into flat agricultural land, and so on.

Other than rehabilitation, sustainability in mining has many meanings. The Guardian newspaper quotes ‘stewardship’ and stresses socio-economic factors; Transparency International of Canada discusses corruption; while other authors consider, inter alia, energy efficiency, climate change and water scarcity. Nonetheless, in this article, I have narrowed it down to the technical aspects that are within the control of mining operations such as energy usage, equipment efficiency, water scarcity and rehabilitation.

DIAVIK Diamond Mine from Wind Farm

Nonetheless, the ‘elephant in the room’ is climate change. I have no intention of wading into the hot and deeply divisive politics of anthropomorphic global warming, nor take sides on to what extent human activity is contributing to warming. Nonetheless as good corporate citizens it behoves miners to reduce atmospheric emissions and reduce our carbon footprint for many reasons such as clean air, preserve diminishing petroleum resources, planting forests, as well as mitigating climate change.

Electrical Power

A problem faced in many mines is to obtain enough power. Requirements can vary enormously from a few to several hundred megawatts. Getting power from a country’s national grid can be difficult through grid capacity, remoteness, terrain, environmental and social permitting, and extremely expensive. Many mines instead rely on diesel generators or in the case of Cobre Panama, a build your own 300 MW coal-fired power station.

Some mines are looking at sustainable power such as B2Gold’s 7 MW solar power plant at Otjikoto in Namibia. The Diavik diamond mine in Canada’s North-West Territories has installed a wind farm producing 9.2 MW. However, these are somewhat isolated examples and more needs to be done to encourage sustainable energy in the sector.

B2Gold, 7MW Solar Farm at Otjikoto, Namibia

The Harvard Review points out that solar costs have dropped by 80% over the past decade and that the cost of battery storage is making electric vehicles more competitive. Given the environmental pressures on building long-distance powerlines, it can be expected that the mining industry, generally shy of new technology, will consider solar and wind farms as solutions for their power-hungry requirements.

Mine Trucks

All the major countries have strict vehicle emission standards and it would be suicidal for an OEM (original equipment manufacturer) not to meet those standards. They are cognizant that most major mining regulatory authorities insist on measuring and reporting emission standards. Meeting those standards assumes the equipment is kept in good condition by efficient and OEM-supported preventative and predictive maintenance programs.

READ THE FULL ARTICLE ON MTD WEBPAGE
www.iom3.org/mining-technology-division

Laurance Morris
MTD Board Member
Born in Edinburgh, Bert Wheeler joined the coal industry in 1952 in the Lothians Coalfield and studied at Heriot-Watt University to gain a BSc in Mining in 1956. He then became a management trainee with the National Coal Board (NCB) for two years and subsequently held underground management posts in the Lothians Area, NCB. Bert rose to become Deputy Manager at Lady Victoria Colliery, Lothians Area in 1964.

In 1965 he moved to North Derbyshire to become Deputy Manager at Williamthorpe Colliery. He moved on to become Manager at High Moor Colliery (1966), at Westhorpe Colliery (1966) and Manager of the combined Williamthorpe/Grassmoor Colliery in 1967. In 1969, he was appointed as Production Manager in the North Derbyshire Area and in 1971 he became Deputy Chief Mining Engineer, then Deputy Director (Mining) in 1973. In August 1980, he was appointed Director of the NCB's Scottish Area, taking over the additional responsibilities for opencast mining in the Area in 1984. In early 1985, he was appointed Director of the South Nottinghamshire Area and Director (Designate) for the combined North and South Notts Areas. The merger took place in August of that year.

Bert Wheeler took up the position of Director of Group Operations, British Coal in July 1988. In August the same year he spearheaded a major re-organisation in British Coal's central coalfields. He then moved on to become Regional Director (Midlands and South) with British Coal. On 1 April 1991 he became a full-time Corporation Member and Operations Director. His final appointment with British Coal was as Deputy Chairman from 1 April 1992 and he retired from that position in June 1995. In addition, he was a Director of British Coal International Limited and Deputy Chairman, Coal Industry Social Welfare Organisation. After his long career with the NCB/British Coal, he became Chairman, Mines Rescue Service Limited.

In 1965 he moved to North Derbyshire to become Deputy Manager at Williamthorpe Colliery. He moved on to become Manager at High Moor Colliery (1966), at Westhorpe Colliery (1966) and Manager of the combined Williamthorpe/Grassmoor Colliery in 1967. In 1969, he was appointed as Production Manager in the North Derbyshire Area and in 1971 he became Deputy Chief Mining Engineer, then Deputy Director (Mining) in 1973. In August 1980, he was appointed Director of the NCB's Scottish Area, taking over the additional responsibilities for opencast mining in the Area in 1984. In early 1985, he was appointed Director of the South Nottinghamshire Area and Director (Designate) for the combined North and South Notts Areas. The merger took place in August of that year.

Joining the Institution of Mining Engineers in 1956, he became a Member in 1962 and a Fellow in 1974. Eventually, he was elected President of the Institution of Mining Engineers for 1991-1992. Throughout his mining career he was a strong supporter of the local societies and was elected President of The Mining Institute of Scotland for 1982-1983.

Away from work, Bert had a lifelong interest in rugby and was an ardent supporter of Rangers football club. His other interests included walking, foreign holidays, cruising and exploring new places. He was appointed a CBE in the 1991 New Year Honours List.

Bert died on 3 May 2019 and will be sadly missed by his wife Eileen and family, as well as by his many friends and colleagues from the industry. He had long been a supporter of the Institute and took a special interest in the careers of Younger Members. His loss will be felt by many members of the Mining Technology Division and the wider IOM3 community.

David Seath CEng FIMMM
Dnipro, Ukraine
Speaking on Decarbonisation

I attended a Symposium on Decarbonisation in Dnipro, Ukraine, in June. Like Poland there is great internal support for the coal mining industry in Ukraine as it currently forms the mainstay of its power generation. At the conference EU representatives were pushing decarbonisation and the funding available to support regeneration of closing coal mining areas, however the cities and towns in Ukraine actually affected by mine closures, were not really sure what they could do to offset their major employer disappearing. It is OK to fund good projects but what projects? The UK and other countries have been through similar events and many areas are still suffering the consequences some 30 years later.

The Ukrainians like many other countries are attempting to determine what mines are profitable, what mines could become profitable if enough money was invested, and what mines will never be profitable. However, the strategy, whilst laudable, is flawed. In order to look at which mines could be profitable, the future market for the coal must be looked at. That market is determined by any future Ukrainian energy policy. If they are going to decarbonise as a policy, with all the social issues that that will bring with it, they need to determine over what period that will take place to minimise such issues and what will be the energy generating policy in the future.

If, on the other hand, they decide that decarbonisation is all about keeping the mines going but capturing and storing the carbon, using CCS or other techniques, then they need to start developing those techniques now.

Will coal be replaced or will coal still be used and clean technologies developed to be able to meet emission targets? Either way a strategy will be required to justify the high cost of either. Once the strategy is determined they can then see how many coal mines will be needed, over what period to ensure an orderly change to the new reality.

Obviously, these are sensitive political decisions, not taken lightly, but without that strategy no effective assessment of the mines can take place. It does not matter how profitable the mines are now, if their market disappears, as it surely will as the clamour for decarbonisation increases, then the mines will have to close anyway.

I found myself wondering whether we ever learn the lessons of history. One of the positive papers at the symposium described the redevelopment of the Limburg mining area in Belgium, which showed it now ‘might be’ succeeding. It was not pointed out this is some 27 years after the last mine closed in 1992!

Robin Dean

Focus on the Local Societies:
Western Institute of Mining and Minerals

Formed as the North Staffordshire Institute of Mining Engineers in 1872, the Institute has evolved and changed with the times and is now the Western Institute of Mining and Minerals (WIMM), a local society within the IoM3. We are an active society and hold a series of monthly lectures on a broad range of topics generally with some mining or geosciences content. We welcome any visitors to our meetings, no pre-registration required. Attendees are a broad range of people from practitioners and consultants in the mining and minerals industries to academics, students, geologists, engineers, inspectors, a strong cohort of retired professionals to people with general interest in particular topics. During the year, we aim to hold one or two site visits to operating mines and quarries or historic sites, these by virtue of the visits are generally only open to small groups.

We have a close association with the Earth Sciences Department at Keele University and hold our meetings there at the William Smith Building. Meetings are held 7pm on the first Monday of the month between October and April (except January) and are attended by some 25 to 40 people. Each meeting is followed by a free to attend buffet to give people the opportunity to network and renew acquaintances.

Annually we award the Wynne Student Prize for a Keele University undergraduate or masters’ dissertation and co-sponsor a joint essay prize. Over the years we have nominated a number of Outstanding Contribution Awards within the IOM3 and are former winners of the Local Society of the Year.

We open to anyone attending any meetings and are particularly interested to hear from anyone who is interested in giving a presentation at some point. Our lectures for each season are published on the WIMM microsite: www.iom3.org/western-institute-mining-minerals/about-western-institute-mining-minerals

Dr Richard White (President), James Carter (Secretary), John Weston (Treasurer) on behalf of the Council of the WIMM
**James Watt Bicentenary**

2019 marks the 200th anniversary of the death of James Watt (1736-1819), one of the most important historical engineers.

Born in Greenock in Scotland in 1736, Watt moved to Birmingham in 1774 to enter into partnership with Matthew Boulton (1728-1809) to manufacture an improved steam engine that incorporated his innovation of the separate condenser. The Boulton & Watt engine was to become, quite literally, one of the drivers of the Industrial Revolution in Britain and around the world.

In addition to his steam engine work, Watt was a man of many other talents – scientific instrument maker, civil engineer, chemist, inventor and member of the renowned Lunar Society.

During his lifetime he was famous, and after he died, he was elevated to the status of a national hero. In the last thirty years, however, awareness of Watt has diminished and so the 2019 Bicentenary provides an opportunity to revisit and review his achievements.

Lots of great events are taking place this year to celebrate the life and work of James Watt – in the UK and beyond. In England, the bicentenary programme (James Watt 2019) is delivered by a host of heritage partners and coordinated by the Lunar Society. For more information on the James Watt 2019 visit www.jameswatt2019.org where information on a multitude of events (www.jameswatt2019.org/upcoming-events) is set out.

In Scotland, a parallel programme has been organised and events can be found at www.jameswatt.scot/events

A key objective of James Watt 2019 is to inspire young learners to discover the life and legacy of one of Britain’s foremost inventors, innovators and engineers. The Mining Technology Division also applied such an objective through the publication earlier this year of Mining Inventors and Innovations through history as a means of celebrating 150 years of IOM3.

David Seath
MTD Board Member

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**Selective Mining**

It is generally understood that mining thin ore veins produces excessive ore dilution and is uneconomic. Many mines have been unable to mine veins effectively because of poor mining methods: one gold mine in Mexico was ‘strip mining’ a bench by taking a 4 to 5 metre cut along the face, sending waste as well as ore to the plant. The veins at around 4 grams/tonne (g/t) were reporting a head grade of 0.4 g/t.

This is an extreme example of at least 150% dilution, and although dilution is more normally 20 to 40%, it can be reduced to around 5% by good mining practice. Each gram equivalent of gold saved by reducing dilution can raise as much as 0.4M USD on 8,000 tonnes/day throughput (see the Conclusion).

Full article in MTD Autumn newsletter.

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**CONFERENCES – ONES TO WATCH**

**SDC 2019 4th International Conference on Shaft Design and Construction**

**Toronto, Canada : 18 – 20 November 2019**

This global shaft conference is being held for only the fourth time since its inception in 1959, and for the first time in North America. It is a conference for shaft designers, constructors, equipment suppliers, and mine owners carrying out or contemplating shaft projects. The SDC2019 provides a unique opportunity for delegates and presenters to share knowledge, best practices, lessons learned, and to exchange ideas and network with mine owners.