



# Sustainability

## Abstracts

# Index

An alternative approach to predict acid neutralisation potential effectively and routinely during mining .....	1
Application of Life Cycle Assessment (LCA) in supporting the right decision in the mining and metals industries decarbonisation endeavours.....	2
Reducing the Carbon Footprint of Copper Melting Operations .....	3
MinSus Project (BGR/GIZ) on Sustainable Mining in the Andes .....	4
Los Bronces Afforestation Program. ....	5
Las Tortolas tailings dam Ornithofauna Program. ....	6
Biodiversity Management Plan (BMP) Los Bronces operation, study case. ....	7
Coexistence between carnivorous mammals and mining activities; Los Bronces operation study case.....	8
Rural Water Programme .....	9
COVID-19 management as an accelerator of health digitalization in Anglo American Chile....	10
A vision for the future of the Mining in Latin American countries.....	11
Sustainable semi-finished copper production – On the way to climate neutrality using continuous strip casting-rolling technology .....	12
The arsenic challenge: new technologies for the removal of arsenic into environmentally stable residues .....	13
Resource and climate paradox: How climate changes restricts resources for the energy transition .....	14
Sustainable operations at Atlantic Copper: staying one step ahead .....	15
The world needs more copper mines: can we build them? .....	16
The Environmental, Social, Governance (ESG) strategy from a fabricator perspective & implications for the industry.....	17
ADAS (Advances Driving Assistant System), the state-of-the-art technology for improving safety in mining transportation and operations. Not only technology, also a cultural change...	18
An industry leading approach to risk management of smelting operations .....	19
Long Term Evaluation for Great Copper Ores Resources.....	21
Future Directions of Copper Industry as Indicated by Sustainability Analysis.....	22
Monitores Ambientales: An Experience of Mining-Community Engagement and Participation	23
Management of Risks Associated with Operating Tailings Facilities in a Changing Environment. ....	24
The Copper Mark and Responsibly Produced Copper .....	25

## **An alternative approach to predict acid neutralisation potential effectively and routinely during mining**

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**Paul Weber, Mine Waste Management, New Zealand.**

**George Levay, Levay & Co Environmental Services, Australia.**

**Rosalind Green, Mike Hutton-Ashkenny, Rio Tinto, Australia.**

### **Abstract**

*Typically mining operations use total C measurements for assessment of carbonate neutralisation potential in the block and mining model. The objective of this study was to develop a low cost, rapid, industry-applicable, thermal decomposition methodology for quantification of carbonate mineral Acid Neutralisation Capacity (RapT ANC) to aid in the prediction and remediation of acid mine drainage waste rock, tailings, and other mined materials. Standard titration-based methods for ANC can be compromised due to contributions from silicate minerals, ion exchange, Fe-rich carbonates, and other transition metal carbonates. The methodology developed consists of decomposition of non-neutralising carbonate minerals in an N<sub>2</sub> atmosphere at 500°C followed by carbon assay of the residue. RapT ANC (kg H<sub>2</sub>SO<sub>4</sub> t<sup>-1</sup>) is then calculated as C (wt%)×81.8. This method provides an effective means to cheaply analyse for carbonate neutralisation potential with assignment of potentially acid forming and non-acid forming blocks to waste rock cells.*

## **Application of Life Cycle Assessment (LCA) in supporting the right decision in the mining and metals industries decarbonisation endeavours.**

**Dr. Johannes Gediga, Director Sustainability Consulting Metal & Mining, Sphera Solutions GmbH, Germany.**

**Peter Chigada, Senior Consultant Metal & Mining, Sphera Solutions GmbH, Germany.**

### **Abstract**

*Increasing stakeholder awareness and pressure is leading mining and metals processing companies to address the topical decarbonisation challenge through adoption of various innovative sustainable technologies. Some of these technologies include mine electrification, use of hydrogen in mining vehicles powertrain or utilisation of hydrogen as an alternative reductant for carbon-based reductants. These decarbonisation efforts are in alignment with the Sustainable Development Goals (SDG 3, 9, 12 and 13).*

*It is therefore imperative to apply life cycle assessment (LCA) methodologies to evaluate the benefits of adopting these electrified powertrains and hydrogen-based technologies in the mining and metals industries. Life Cycle Assessment (LCA) is a valuable tool that can be used to understand the environmental impacts across a product value chain from cradle to grave. It can be utilised to support achievement of carbon neutral operations through identification and avoidance of environmental burdens shifting within a value chain or impact categories.*

*Currently, battery vehicles are the preferred technology due to cost and overall efficiency compared to fuel cells. However, for some applications of batteries and fuel cell drivetrains (trucks, busses, etc.), a number of LCA studies have demonstrated that batteries are not always the optimal solutions for addressing the decarbonization challenge. This study demonstrates the importance of understanding primary greenhouse gas emissions as well as use-phase related emissions such as nitrogen oxides and carbon monoxide along the value chain when adopting powertrain based on battery and fuel cell technologies in the mining sector.*

*The assessment benchmarked different technologies and assessed the influencing parameters thereby facilitating attainment of the overall objective of reducing greenhouse gas emissions by ensuring environmental burdens were not just shifted across the life cycle stages. The main influencing factor over the life cycle for greenhouse gas emissions is the source of electricity for charging the battery or production of hydrogen via electrolysis. Additionally, results demonstrating decarbonisation benefits of utilising bio-reductants including sustainable plantations in metallurgical reduction processes will also be presented.*

# Reducing the Carbon Footprint of Copper Melting Operations

**John Hugens, Hugens Combustion and Metallurgy, United States**

## **Abstract**

An accounting of the carbon output of copper melting, casting and forming operations includes carbon from combustion, from refractory consumption, protective covers, belt coatings, mold linings, lubricants and emulsions. It also includes the carbon released in the generation of the power necessary to transform the copper. The net output of carbon in combustion off gasses from the power generation, melting, holding and liquid metal transfer processes far exceeds the contributions made by the other parts of the plant on a tons/emitted per tons copper transformed. Therefore operators achieve a significant reduction in the absolute size of this net carbon footprint with the use of incremental savings in power and combustion supply strategies. Such strategies include green power supply, oxygen in combustion, combustion ratio settings, fuel modifications, production scheduling, changes in operating equipment, fuels and operator training. This study shows potential examples of the net carbon footprint reduction achieved under various operating regimes for copper melting casting and forming installations.

## **MinSus Project (BGR/GIZ) on Sustainable Mining in the Andes**

**Achim Constantin, BGR, Chile**  
**Nicolas Maennling, BGR, Chile**

### **Abstract**

*The mining industry as one of the most important economic sectors of many Andean countries has the potential to contribute significantly to its growth and social development, desirably in line with the Sustainable Development Goals (SDGs) of the UN Agenda 2030. While the sector faces challenges of environmental damage, high economic expenses and social impacts, its continuous development is crucial in order to meet the goals of the Paris Climate Agreement, considering that renewable energy technologies, electric vehicles and battery storage require high volumes of raw materials, such as copper and lithium that are largely produced in the Andean region.*

*In this context, the German Federal Ministry for Economic Cooperation and Development (BMZ) has commissioned the German Agency for International Cooperation (GIZ) and the Federal Institute for Geoscience and Natural Resources (BGR) to jointly carry out the MinSus Programme in cooperation with its regional counterpart, the United Nations Economic Commission for Latin America and the Caribbean (ECLAC).*

*In line with the SDGs, the current phase promotes regional cooperation for a more sustainable management of mining resources in the Andean region, focusing on the establishment of international sustainability standards and best practices as well as the transparent integration into global supply and value chains.*

*The poster aims to illustrate the achievements of the MinSus programme and provides an outlook towards future activities.*

## Los Bronces Afforestation Program.

**Ariel Villarroel, Anglo American Chile**

**Rafael Ascanio, Anglo American Chile**

### **Abstract**

*Anglo American, Los Bronces, currently has 13 Afforestation Plans. These plans cover approximately 240 Ha, containing more than 122,000 planted specimens belonging to 20 different species and are located in an altitude gradient ranging from 600 to 2,300 meters.*

*Despite this great variability of conditions, geographical altitude, species, as well as climate change and the great drought that is affecting Chile (especially the central area), the general survival percentage is close to 90%. This result has been possible through the implementation of scientific studies, plans and activities such as Water efficiency study developed by University of Chile (Faculty of Forest Sciences) professionals; Genetic study of endangered species; Remote irrigation system (SIRECOR) implementation; Continuous maintenance and improvement irrigation systems plans; Nurseries Selection with local quality specimens; Study of Guayacanes (*Porlieria chilensis*) plantations; The survival of the specimens over time has been complex, so we are developing a study that evaluates different alternatives (planting, substrate, irrigation, maintenance) that allow improving their establishment.*

## Las Tortolas tailings dam Ornithofauna Program.

Rafael Ascanio, Anglo American Chile  
Ariel Villarroel, Anglo American Chile

### Abstract

*To avoid the possible impact of birds in the Las Tórtolas tailings dam, Anglo American Los Bronces has been implementing an ornithofauna Management Program since 2008. The program presents significant information to help protecting the fauna surrounding tailing dams. Across the 13 years of the program's existence, a huge amount of data has been collected, with nearly 110,000 specimens recorded and approximately 5,000 specimens recovered and released.*

*The positive evaluation of the program is sustained on its four components: chasing, rescue, recovery, and release of birds. As chase away measures the company has implemented electronic devices and the use of drones, among others. For rescues, we use a motorized boat drive by specialized personnel. When they see a sick or in poor condition specimen, it is captured and taken to a Rescue Center. Once there, they receive veterinary treatment until their full recovery, then they are released together with the Agricultural Livestock Service in a protected area.*

*In addition, the program is presented as dynamic, in the sense that because of the passage of time, climate change and the great drought that is affecting central Chile, an adaptive management of the program has been implemented.*



## **Biodiversity Management Plan (BMP) Los Bronces operation, study case.**

**Gustavo Girón, Biota Gestión y Consultorías Ambientales Ltda., Chile**  
**Aira Faúndez, Biota Gestión y Consultorías Ambientales Ltda., Chile**  
**Rafael Urbina, Biota Gestión y Consultorías Ambientales Ltda., Chile**  
**Rafael Ascanio, Anglo American Chile**  
**Ariel Villarroel, Anglo American Chile**

### **Abstract**

*A Biodiversity Management Plan (BMP) sets as objective to avoid, minimize, restore, or offset the negative impacts of Los Bronces Operations on local biodiversity through the identification, prioritization, managements and tracking of the risks involved in all sectors and activities related to the operation, to accomplish a net positive effect on it.*

*The BMP consists in the implementation of Los Bronces's Biodiversity information system; planning and implementation of a biodiversity accounting system; incorporation of an environmental risks analysis in every engineering stage of the projects or activities not affected by Environmental Assessment; and implementation of a strategic plan of the restoration of degraded environments.*

*As a result of an adequate implementation of the BMP, it has been possible the systematization of the biodiversity data generated by Los Bronces Operation allowing technical and scientific papers serve as a guidance to preserve Biodiversity. As consequence, 9 animal and 6 plant species endangered or near threatened were identified, 2 terrestrial ecosystems are classified as endangered ecosystems, and 6 are identified as ecosystem services related to biodiversity.*

## Coexistence between carnivorous mammals and mining activities; Los Bronces operation study case.

**Gabriel Lobos, Ecodiversidad Consultores, Chile**

**Rafael Ascanio, Anglo American Chile**

**Gianina Tapia, Ecodiversidad Consultores, Chile**

**Alejandra Alzamora, Ecodiversidad Consultores, Chile**

**Nicolás Rebolledo, Ecodiversidad Consultores, Chile**

**Hugo Salinas, Ecodiversidad Consultores, Chile**

**Juan Carlos Trujillos, Ecodiversidad Consultores, Chile**

**Gustavo Girón, Biota Gestión y Consultorías Ambientales Ltda., Chile**

**Ariel Villarroel, Anglo American Chile**

### Abstract

Carnivorous mammals are located at the top of trophic pyramids, which makes them rare, not very abundant with large home range, that is known as the “large carnivore problem”. Various authors have proposed them as flagship species for ecosystems health. Los Bronces by Anglo American is located in the central Chilean mountain range, in a Mediterranean environment of high biodiversity. The general objective of this study was to obtain population antecedents of carnivores near the extended area of influence of Los Bronces. For two years (2019-2020) trap cameras were installed and transects carried out to study these mammals in the area of influence. Following the protocol of Kelly et al. (2008) and Negrões et al. (2010), 33 traps were installed 5 km apart. 35 transects were carried out per seasonal campaign. Abundance was determined by species and by season. The results, novel for the scientific community and the authorities indicate the presence of 6 native species: two felines (*Puma concolor* and *Leopardus colocola*), two canids (*Lycalopex culpaeus* and *Lycalopex griseus*), one mustelids (*Galictis cuja*) and one Mephitidae (*Conepatus chinga*). Additionally, there are two feral species: domestic cat (*Felis silvestris catus*) and dog (*Canis lupus familiaris*). These findings, represent a major achievement for conservancy of the species, and an example of private public partnership for sustainability, as the results will help the Chilean conservancy agency to develop a plan for the area.

## Rural Water Programme

**Gonzalo Jaramillo, Anglo American Foundation Chile**

### **Abstract**

*In Chile, where most of the country has been affected by severe drought for the last decade, we are acutely aware of the very real challenges faced when water is in scarce supply. In rural areas of the country, almost two million people are reliant on the Rural Drinking Water Systems, most of which do not have the necessary infrastructure or technology to efficiently manage the supply. The team of Anglo American's Rural Water Programme has been working to develop innovative solutions, so they can ensure a sustainable water supply for the communities around our sites in Chile. The program relies on boosting rural potable water supply wells with equipment and technology.*

*The program has 3 fundamental pillars: technology, support and autonomy. Technology: considers data management through telemetry, with sensors, monitoring and efficiency in data reportability. It also considers the operation, through device management, valve control, control room and automation. Accompaniment: carrying out a technology transfer to those who operate the APR systems, conducting training and advising during the process. Autonomy: the last phase considers achieving the operational excellence of the systems, generating a new work perspective, through innovative solutions.*

*To date, the Program has been implemented in 64 Rural Water systems, which are operated by the own community, in four provinces of the Metropolitan and Valparaíso Regions, operating 152 plants and benefiting more than 100,000 people.*

## **COVID-19 management as an accelerator of health digitalization in Anglo American Chile.**

**Jose Ignacio Mendez MD,  
Marcela Rodriguez Aldana,  
Pablo Otelo Benavente,  
Alejandra Cabezas Verdugo,  
Marta Cabrera Contreras MD,  
Milagros Altuna Sotomayor.  
Anglo American, Chile.**

### **Abstract**

*COVID-19 pandemic pushed the mining industry to an unprecedented limit and required innovative and integrative approaches to this health risk. Anglo American decided since the beginning to support its COVID management approach with a dynamic and strong digital strategy, along with a robust protocol system, which were a key factor for success in protecting our workers lives. Putting our people in the center of everything we do, allowed us to make this possible. Some of these initiatives were the following: a virtual medical command center with a self-designed health platform that gathered all the workers´ data (symptoms, test results, contact tracing, vaccine doses, etc.); a virtual health assistant (chat and voice bots); an epidemiologic data-driven PCR random testing system; online COVID tests scheduling and result collection; contact tracing using wearable devices (smartwatches) among others. All these digital knowledge and skills are today a great opportunity for general health management at workplace, offering several possibilities in other areas like hygiene, ergonomics and health promotion at work, allowing us to develop a “Health-hub” that will integrate all this information, triggering unprecedented opportunities for workers health improvement.*

## A vision for the future of the Mining in Latin American countries

Jorge Pedrals, Pedrals & Cía., Chile

### Abstract

*While in Chile is being discussed the necessity to produce Green Copper, the country is going down in its share in the world copper production from 37% to 27%. At the same time, people are asking to add value in the copper production chain and the world is showing that the copper requirement will growth 30% up to 2030.*

*Responding to these challenges, this paper puts in perspective the contributions that mining has made to the countries, and two dimensions to face the future, taking into consideration the just transition mechanism.*

*The first one, related to an increasingly complex and interconnected world, where exploration companies, producers and venture capital funds are key players. The field of that game are those countries that have promising geologies. In this dimension, the rules of the game are already defined (market and policy ones) and the main actors are already playing and showing results, some related to fatigue and others to sustained growth.*

*The other dimension is related to Canada, whom define themselves as “the center of the world mining”, with a large number, diversity and variety of companies participating in the mining activity. In this country, since a time when it was required to inject strong subsidies to gold mining, they have managed a virtuous dynamic that it has spread to the entire world, connecting mining activity and the society as a whole. This is an example that must be considered in a proper way by the Latin American countries.*

## **Sustainable semi-finished copper production – On the way to climate neutrality using continuous strip casting-rolling technology**

**Peter Böhlke, KME Germany GmbH, Germany**  
**Hendrik Busch, KME Mansfeld GmbH, Germany**  
**Olaf Schwedler, KME Mansfeld GmbH, Germany**

### **Abstract**

*The use of intelligent production processes in the manufacture of copper strips significantly shortens the usual processes and is therefore faster and more cost-efficient. KME already operates production facilities in Germany with the highest energy efficiency. For example, the Conti-M® at the Hettstedt site operates according to a globally unique casting-rolling technology. The Conti-M® process skips the conventional step of hot rolling the slabs and thus covers the first part of the process chain in a sustainable, innovative way. With a maximum casting width of 1.290 mm and a melting capacity up to 70 t/ h different copper qualities can be continuously produced via a continuous casting and rolling technology in one casting period. These milled copper coils produced by this technology are made not only with shorter lead times of about 2 hours, but also with higher energy efficiency compared to conventional strip technology. This technology is thus already the benchmark for the production of high-purity copper strip. Further improvements to the ecological footprint focus locally on the application-specific use of renewable energies and the shift away from fossil fuels, for example through partial smelting with hydrogen. An important aspect for improving the overall global energy balance in copper strip production is the preliminary stage of cathode production. The future use of CO<sub>2</sub>-free cathodes is a decisive factor in advancing the production of climate-neutral copper strip.*

## The arsenic challenge: new technologies for the removal of arsenic into environmentally stable residues

Ricardo Pezoa, EcoMetales Limited, Chile  
Claudia Urbina, EcoMetales Limited, Chile  
Nicolás Pereira, EcoMetales Limited, Chile  
Guillermo Cornejo, EcoMetales Limited, Chile  
Quentin Graaff, EcoMetales Limited, Chile  
Marcelo Acuña, EcoMetales Limited, Chile

### Abstract

*Since ore deposits are becoming older the presence of deleterious elements in copper concentrates is increasing. Arsenic is among the most challenging elements for the copper industry which poses several environmental and operational problems. Most of the arsenic released from smelters is removed in the form of calcium arsenite, which is considered a hazardous residue. In spite, for years EcoMetales has operated an industrial plant for the removal of arsenic in the form of scorodite and is continuously developing new technologies for the abatement of arsenic in a stable residue. In this work we introduce different processes by which arsenical effluents are treated for obtaining arsenical residues that are environmentally stable in terms of the amount of arsenic released in total characteristic leaching procedure (TCLP). We have developed different methods for precipitating arsenic essentially removing oxidation and/or temperature steps using different precipitating agents. The residues are characterized using different analytical techniques such as XRD, SEM among others for providing scientific based explanations of our observations. The results presented in this work contribute for providing new technologies that aim for transforming the way arsenic is disposed at smelter facilities within the next few years.*

## Resource and climate paradox: How climate changes restricts resources for the energy transition

Paulina Fernández, Department of Mining Engineering, University of Chile, Chile.

Luis Felipe Orellana, Department of Mining Engineering, University of Chile, Chile. Advanced Mining Technology Center (AMTC), University of Chile, Chile. Solar Energy Research Center (SERC), University of Chile, Chile.

Emilio Castillo, Department of Mining Engineering, University of Chile, Chile.

### Abstract

*Climate change is one of the most important challenges, with direct hazards to the economic growth and development of modern global society. Among the strategic productive sectors being affected, mining is of relevance since the production of metals and minerals is key to the energy transition goals. Mining in Chile represents 50% of total exports in value, being the first worldwide producer of copper and the second of lithium. Copper and lithium companies concentrate the largest number of operations and production in the north of Chile, whose areas are prone to the negative impacts that climate change brings and therefore increasing supply chain risks. However, the risk level resulting from climate change to produce these resources has not been quantified in Chile. Using the Chilean copper and lithium industry as a case study, this work offers a methodology for evaluating the effects of climate change on resource availability. In doing so, we study areas with a higher probability of risk of the occurrence of an event generated by climate change and we investigate the coincidence of climate change related events to the production of metals and minerals, and how it affects the supply chain of raw materials. Main research goals consist of improving the understanding on how climate change can affect production of mineral resources, quantifying the disruption of mineral supply due to adverse climate events, and discussing adaptation measures for resilience.*



## **Sustainable operations at Atlantic Copper: staying one step ahead**

**Esther Alonso, Atlantic Copper SLU, Spain**  
**Pablo García, Atlantic Copper SLU, Spain**  
**Guillermo Rios, Atlantic Copper SLU, Spain**

### **Abstract**

*Atlantic Copper Metallurgical Complex in Huelva (Spain) was commissioned in 1970 with a capacity of 40,000 tpy of copper cathodes from concentrate. During the last 50 years, through several expansions and technical modifications, the production has increased up to 290,000 tpy of cathodes, while ensuring the environmental sustainability of its operations. This paper describes the projects carried out at Atlantic Copper in the last ten years, which have led to a reduction of 59 % in dust emissions, 34% in SO<sub>2</sub> emissions and 30 % in CO<sub>2</sub> emissions, as well as an 88 % reduction of the metals contained in the smelter treated effluents. Moreover, this paper outlines the new on-going projects, which will allow Atlantic Copper to keep one step ahead of the environmental challenge.*

## The world needs more copper mines: can we build them?

Dr. Jocelyn Fraser, University of British Columbia

### Abstract

*Copper is one of the most important metals for society's transition to a low-carbon economy. It is needed for power grids, wind energy infrastructure, batteries and charging stations for electric vehicles, and copper's electrical and thermal conductivity is vital for the collection, storage and distribution of solar energy. These applications, plus strong growth in emerging economies, means demand for copper is increasing. Approximately 35 percent of copper is recycled annually, yet this will not be sufficient to meet demand. New mines will be required.*

*Can we build them?*

*The scrutiny applied to the mining industry on environmental, social and governance (ESG) performance is intensifying. Disagreement about land use, conflict with communities, Indigenous rights and reconciliation, and competition for scarce resources such as water are a few of the issues that can stall or derail mine development projects. In addition, pressure is growing from downstream users such as car manufacturers including BMW and Tesla, and information technology giants Apple and Microsoft calling for transparency within the mine supply chain.*

*As companies grapple with increasing calls for mining projects to deliver social profitability as well as shareholder returns, there is risk to be managed and opportunity to be seized. This presentation will consider how best to mitigate ESG risk and identify opportunities for copper mining to play a role in our transition to a low-carbon economy.*

## **The Environmental, Social, Governance (ESG) strategy from a fabricator perspective & implications for the industry.**

**Pia Theresa Dürschnabel, Wieland Group, Germany**

**Uwe Hofmann, Wieland Group, Germany**

**Nathalie Kutter, Wieland Group, Germany**

**Benjamin Schwarz, Wieland Group, Germany**

**Andreas Torka, Wieland Group, Germany**

### **Abstract**

*The next ten years are crucial to fight climate change. To foster Sustainability, Wieland applies global frameworks (GRI, ESG) and target-setting approaches (Science Based Targets initiative). Science imposes a reduction of the global GHG-emissions by ~50% until 2030. Wieland will meet this requirement based on SBTi. About 5% of Wieland's emissions are direct emissions, i.e., Scope 1. In FY 18/19 they made up ~100kt CO<sub>2</sub>e. In one of our biggest plants in Vöhringen (Germany) e.g., 15% of them are due to heating of buildings, 85% are used for annealing and pre-heating. Introducing alternative heating and replacing natural gas will ultimately reduce Scope 1 emissions. Still, 95% of Wieland's emissions are created indirectly, Scope 2 (~25% or ~500kt CO<sub>2</sub>e). Scope 3 covers new metal which makes up about 70% or 1200kt CO<sub>2</sub>e. Recycling is one major lever to reduce Scope 3 emissions. Besides Decarbonization Wieland selected 5 more strategic focus areas in accordance with the ESG framework: Environment: Circular Economy, Eco-friendly product portfolio; Social: Health & Safety, Diversity & Inclusion, and Governance: Responsibility in the Supply Chain.*

## **ADAS (Advances Driving Assistant System), the state-of-the-art technology for improving safety in mining transportation and operations. Not only technology, also a cultural change**

**Cristian Jensen Montt, Anglo American, Chile**

**Claudio Hurtado Guzmán, Anglo American, Chile**

### **Abstract**

*One of the highest risks in mining business is transportation. A significant number of incidents occurred in mine operations including fatal are related to mobile equipment and commuting. Back in 2019 Anglo American decided to increase the transportation safety by introducing as mandatory to all business units ADAS (Advanced Driver Assistance Systems), a driving assistance technology. ADAS is an ecosystem based on a behavioral change over the drivers who are supported by a set of integrated technological devices to alert them so they can correct their behavior "in situ". It is a complete monitoring system to register the alerts, manage them in the short term and finally integrate all the data for trend analysis, evaluate the risks and make decisions when a risk indicator trespass the defined threshold.*

*ADAS begun with 600 vehicles, the riskier ones. Phase I was finished mid-2020 and phase II by the end of 2020, completing 1200 monitored vehicles. Today ADAS monitors more than 2500 vehicles and more than 6000 drivers (own employees and contractors) for all sort of working, transport and commuting vehicles like light trucks, road trucks, buses, minibuses. The system is raising daily about 4000 alerts of all kinds over 12 categories, meaning significant available data for decision-making.*

*We will show how ADAS works, how was the implementation process and learning, what are the main challenges for consolidation of the cultural change and how useful it has been in saving lives.*

## An industry leading approach to risk management of smelting operations

Elisheba Radke, BHP Olympic Dam, Australia

Michael Hill, BHP Olympic Dam, Australia

### Abstract

*Olympic Dam Operations is a fully integrated processing facility from ore to metal producing copper, gold, silver, and uranium. The smelter flow sheet at Olympic Dam includes a Direct to Blister Flash Furnace, Electric Slag Cleaning Furnace, two Anode Furnaces and two Casting Wheels. Copper smelting and operation of furnaces requires substantial technical understanding for safe operation. Despite the accumulation of years of smelting knowledge, there was still an opportunity to proactively drive understanding of failure modes beyond routinely encountered hazards, to manage low-frequency high-catastrophic potential risks.*

*At Olympic Dam, an industry leading approach to risk identification, assessment and management has been implemented. The approach uses a semi-quantitative bowtie risk assessment methodology to manage and visualise process safety risks associated with plant areas or activities. The methodology leverages best practices from the petroleum industry and is a first for both BHP and the minerals industry.*

*The bowties are developed through a systematic review of design and operational information and workshopped with a diverse team of subject matter experts and frontline personnel. Through this process, all operational knowledge and lessons learned are documented for the plant area/activity, and improvement plans are developed to reduce the risk. This rigorous yet pragmatic approach enables prioritisation and justification of risk reduction projects and actions, allowing efficient use of organisational resources. The bowties, which are kept live, also enable efficient and effective day-to-day risk management, and provide a tool to educate frontline personnel of the risks in their area and how they contribute to safe operations.*

*Through 2019-2021, Olympic Dam assessed the process safety risks associated with the processing plant. Specifically for the smelter, 26 bowtie risk assessments were completed covering all hazards that can cause serious harm to personnel, including molten metal, steam explosions and other smelter hazards such as SO<sub>2</sub> gas and strong acid releases. Over 250 risk reduction actions were identified, mostly associated with strengthening control performance.*

*The bowties have provided far greater granularity and personnel understanding compared with existing qualitative risk assessments. As an example, for blister tapping scenarios, credible harm due to steam explosion or self-tap is now detailed across 11 unique scenarios. These scenarios included previously unexplored steam explosion mechanisms, such as:*

- Build-up on blister taphole collection box (skull) causes blister to flow back towards the tapping block causing a molten metal steam explosion*
- A frozen ledge behind the slag taphole results in tapping a slug of blister leading to slag launder failure causing a molten metal steam explosion*

*The bowtie risk assessments have been integrated into BHP's risk management processes and systems. Alongside the bowties, robust performance requirements and assurance processes for controls have been defined and implemented to ensure they are operating as designed. Overall, this leading practice approach has provided a far greater understanding of operating risks and enabled the improvement of controls, ultimately delivering a more reliable operation long term.*

## Long Term Evaluation for Great Copper Ores Resources

**Gonzalo Araujo, Caserones, Chile**

**Juan Rayo, JRI, Chile**

### **Abstract**

*Chile has more than ten large-scale copper mines in operation or prospect, which should work in a long-term schedule, typically above 60 years and in some cases above 100 years. They were designed to operate from 20 to 25 years, with a maximum NPV and a discount rate between 6% and 10%. All these projects undergo several expansions along with their operation, achieving 5 to 10 times the initial ore throughput. Unfortunately, the initial designs normally don't consider a strategy for future expansions. Consequently, it could prompt higher costs for new sections, more complex operations, higher OPEX, and reduced metallurgical recovery. Chilean authorities promote long-term projects with high environmental and social standards because they positively impact the economy and profits for the Chilean state. This situation suggests that long-term evaluation of large ore deposits requires a different view. To reduce the cash costs with high recovery, it proposes evaluating long-term projects for large ore resources, considering the transition from pit to underground mines, future expansions, ore grade, water and power supply, tailings deposits, closure plans, etc. Additionally, greenfield projects require an intensive evaluation of resources, technology, and processes for primary and secondary products, and reduce environmental impacts and residues. The proposal must be supported with innovation practices suggestions for a long-term design of large-scale copper mines and greenfield projects.*

## **Future Directions of Copper Industry as Indicated by Sustainability Analysis.**

**Kai Tatemoto, JX Nippon Mining & Metals Corporation, Japan**

**Tomohisa Takeuchi, JX Nippon Mining & Metals Corporation, Japan**

**Yutaka Yasuda, JX Nippon Mining & Metals Corporation, Japan**

### **Abstract**

*The copper business is currently facing a period of major change. Copper demand is expected to grow significantly owing to the rapid commercialization of electric vehicles and progress in the development of digital transformation. In contrast, the forecast growth of minable copper reserves is limited, which is cause for future supply concerns. When a manufacturing user evaluates the environmental impact of a material, including its carbon footprint, and stability of future supply, copper materials do not meet user criteria and are being increasingly substituted. To dispel such supply concerns, effective and stable utilization of copper resources and promotion of recycling are required. To date, there has been insufficient cooperation between the resource development businesses and recycling businesses, and user supply anxiety remains. For the copper business to fulfill its responsibility with respect to stable supply of material to the market, appropriate sustainability assessments should be conducted throughout the supply chain. Transparency of the evaluation methods and results should be available to the market, and it is necessary for the operators of each sector to work together. This paper considers the environmental impact of copper and a method for evaluating its sustainability. The future direction of the industry is discussed in this context.*



## Monitores Ambientales: An Experience of Mining-Community Engagement and Participation

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### Abstract

*In Andacollo an open pit mine operates very close to the town, and there are historic abandoned tailing deposits in the urban radi. Mining activity had faced increasing opposition from part of the community, especially due to environmental issues, and in 2009 the area was declared saturated for atmospheric pollution (PM10). In this context, Teck Carmen de Andacollo (Teck CDA) contacted the Mining Eng. Dept. of the U. of La Serena to develop a training activity on mining-environmental problems. The main idea was to confront both workers from different areas and hierarchical levels of the Company, and members of the community, including detractors of the company's presence, with the problems and its possible solutions. The program aimed to train "Environmental Monitors" focused on the activities in Teck CDA's operations. It considered 6 one month-modules (e.g., Environmental Impacts; Waste, Residues and Mining Effluents), each one with 2 hours of class/week at the University, for 4 weeks, and 4 hours at Teck CDA facilities afterwards. The program, developed both in 2012 and 2013, was successful, because in addition to the technical topics covered, and the training given, it provided a neutral environment (the University) for the analysis and discussion of various environmental issues. A remarkable result was the open, dedicated and frankly attitude of most of the participants and their collaboration to look for constructive solutions to some of the existing problems.*

## Management of Risks Associated with Operating Tailings Facilities in a Changing Environment.

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### Abstract

*The last catastrophic dam failure in South Africa occurred back in 22 February 1994, since then a lot of initiatives were introduced and implemented in the South African tailings management field to prevent such failures happening again. The initiatives included introduction of new standards, new legislation and continual research and training of tailings dam designers, dam owners and operators. These initiatives covered all aspects of the tailings dam life cycle, and it is believed that these have promoted good risk. In the recent past there has been many changes in the South African tailings industry, including the loss of crucial skills to overseas countries, introduction of new tailings consulting and contractors to the market, new legislative requirements etc. This paper will briefly discuss these changes and their possible impacts on the overall risk management of the operating dams.*

## The Copper Mark and Responsibly Produced Copper

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### **Abstract**

*The Copper Mark is an assurance framework designed to promote responsible production in the copper supply chain as we look to support the green transition and wider sustainable development in the communities within which the copper industry operates.*

*As part of this commitment, the Copper Mark works with companies and organisations throughout the copper industry to enable them to better understand and meet the increasing demands for independently verified responsible production practices, which mitigate environmental degradation while promoting positive community engagement and development.*

### **Promoting transparency in the copper value chain**

*The Copper Mark is built on a genuine commitment of the International Copper Association (ICA) to responsible production, based on the understanding that practices needed to be externally verified and managed by an independent organisation in a transparent way. It has a unique role to play in bringing the sector and its stakeholders together to ensure sustainable production standards are implemented across the industry.*

*With a view to promoting transparency at the local level, sites are independently verified to have responsible production practices – based on over 40 existing, leading, sustainability standards – through a rigorous site-level assessment process. The results of the assessment are published in a summary report, highlighting both strengths and areas for improvement, as well as linking to other publicly available information.*

*The Copper Mark recognises that core expectations and regulatory requirements evolve over time and become more demanding. To ensure that its own criteria remain relevant and can be clearly communicated across time, the Copper Mark revises these criteria every three years to make sure they continue to meet the core expectations of stakeholders and regulators.*

*By assessing sites through its comprehensive assurance framework, the Copper Mark acts as an up-to-date and credible source of information on responsible practices for companies using copper in their products and technologies. It supports the growing demand for responsible production practices throughout the supply chain and provides clarity for both upstream producers and downstream users. This allows the Copper Mark to promote transparency across the copper value chain, from mines all the way through to the end user.*

### ***Expanding the reach of the Copper Mark's assurance framework***

*The Copper Mark's assurance framework currently includes 31 participating sites from across the mining, smelting and refining parts of the supply chain. Our aim is to cover all parts of the supply chain that lead to the production of some form of copper product. These efforts are supported by downstream partners who send the demand signal by giving preference to Copper Mark sites in their sourcing practices.*

*We are currently working on downstream expansion and are looking towards the mid-stream supply chain – up to and including fabricators – to promote transparency on standards and practices through the entire copper value chain. To this end, the Copper Mark has announced that it is piloting the implementation of its assurance framework for semis-fabricators in 2021/22, ahead of the official launch of the assurance framework for semis-fabricators in 2023.*

*The Copper Mark is on a strong growth trajectory and expects its number of participants to increase in 2022 as more producers and copper users focus on the sustainability of their supply chains.*