COBALT NEWS MAGAZINE

July 2018
SPECIAL EDITION

THE COBALT CONFERENCE 2018
23-24 MAY, LAS VEGAS

Promoting the responsible use of cobalt in all forms
We just came back from our Cobalt Conference in Las Vegas and are delighted to share with you its huge success. There is no doubt cobalt is the metal of the moment, primarily because of the development of lithium-ion battery technologies and the growth of the EVs, HEVs and PHEVs market but also due to its use in a wide range of technological applications from smartphones to tablets and laptops enabling easy and fast wireless connection and facilitating work and life in the 21st century. However, it is not just about batteries as cobalt has many critical and essential uses in a broad range of industrial applications.

Delegates attending the Conference received first-hand information on cobalt and the cobalt industry through presentations and seminars which addressed some of the key and ‘hottest’ issues of the moment including recycling and recovering of battery materials and responsible sourcing of cobalt. In this regard, the Cobalt Institute (CI) was pleased to announce the advancement of the Cobalt Industry Responsible Assessment Framework (CIRAF) which has been developed during the past 18 months to support the CI goal of promoting the sustainable and responsible use of cobalt in all forms.

The Conference sessions emphasised the important role of cobalt in the industrial sector, showed in depth market reports, demonstrated the pursuit of sustainable and responsible mining through innovation in technology, highlighted the major challenges being faced by industry and stakeholders and outlined the ways to overcome them.

On the 15-16 May 2019 The Cobalt Conference will take place in Hong Kong, we are looking forward to repeating the success of this year and so look forward to your attendance at this key industry event!
THE COBALT CONFERENCE 2018

A SUCCESS FROM THE BEGINNING
The 2018 Cobalt Institute (CI) Annual Conference took place at the Planet Hollywood Resort and Casino Hotel in Las Vegas, USA, from 23 to 24 May. It is the only industry event solely focused on cobalt which has, as we all know, become the most sought after metal of the moment, with a more than three-fold price increase over the last year. This was the CI’s 25th Cobalt Conference and has triggered immense interest among the cobalt industry sector with participation increasing by 50% comparing to last year, ranging from producers, manufacturers and end-use companies to recyclers, traders, analysts, investment companies, consulting firms and researchers.

The considerable attention surrounding the Conference this year allowed the CI to construct an interesting and topical programme which included market reports, recycling opportunities within the wider cobalt industry, technological innovations, new project developments, the continued grow of lithium-ion battery Megafactories as well as responsible sourcing and sustainable supply of battery materials.

With regard to this last topic, at the end of the conference the CI, together with RSC Global consulting firm, held a seminar which introduced the advancement of the Cobalt Institute Responsible Assessment Framework (CIRAF) initiative which is designed towards achieving responsible and sustainable production of cobalt.

CONFERENCE DAY 1 (MAY 23)

CI President David Weight welcomed all the delegates to the 25th Cobalt Institute Conference in Las Vegas stressing that cobalt has undoubtedly become the metal of the moment, being critical, strategic and essential for enabling technological innovations and solutions.

He also emphasised the continuing work of the Cobalt Institute to protect market access for cobalt and linked this to our aim of promoting the sustainable and responsible use of cobalt in all forms. He also highlighted the CI key role in the development of the CIRAF, the CI initiative focused on responsible sourcing of cobalt that will help members and stakeholders identify material risks within the cobalt sector and providing a good-practice based guide on how to respond to those risks.

The new CI Chairman, Guy Ethier, Senior Vice President Supply Chain Sustainability at Umicore, then officially open the Conference commenting on the challenges and opportunities that have lately arisen within this industry sector. On the following day he made a presentation of his company’s experience in sustainably procuring cobalt during the last 15 years.
THE YEAR OF COBALT: ANALYSING THE DISCONNECT BETWEEN MARKET FUNDAMENTALS AND COBALT PRICES

The first presentation of the conference was delivered by George Heppel, Senior Consultant (Cobalt and Molybdenum) at CRU.

He looked into the recent steep rise in price of cobalt to conclude that there is not a general cobalt shortage as it could seem, but a metal shortage on which the cobalt price is set due to a reduced output of this refined material, the closure or reduced output of many metal refineries in recent years and a lack of investment in the metal sector; whilst on the contrary, the chemical sector is currently well supplied.
Charlotte Radford, the Battery Raw Materials Team Leader and Senior Pricing Reporter at Metal Bulletin presented at the Conference to go through the history of the company and the functioning of prices, speaking about the review of its cobalt price specifications and its methodological approach; she also addressed the next change of names for its in-warehouse cobalt prices to ‘standard-grade’ and ‘alloy-grade’ from June 2018.

RECYCLING SUPERALLOYS CONTAINING NICKEL AND COBALT

Recycling cobalt containing superalloys, widely used in a broad range of industrial applications, brings benefits both for generators and melters including revenue streams maximized, more competitiveness, cheaper energy costs and a lower carbon footprint, among others. Daniele Sedge, Product Manager at ELG Utica Alloys, delivered this presentation focused on one of the current hot topics within the cobalt sector.
NICO ETHICALLY PRODUCED COBALT FROM CANADA

Cobalt & Rechargeable Batteries

- Demand growth in portable electronic devices, electric vehicles (EVs) & stationary cells for grid storage
- Cobalt Lithium-Ion batteries deliver superior energy density, performance & charge Life with safety
  - Lithium-Cobalt Oxide (LCO)
  - Lithium-Nickel-Manganese-Cobalt Oxide (NMC)
  - Lithium-Nickel-Cobalt-Aluminum-Oxide (NCA)
- Major companies confirm cobalt-based batteries will remain the standard for the foreseeable future
- Typical smartphone contains 5-20 grams (g) of cobalt vs 4,000 to 30,000 g (9-66 lbs) per EV
- Supply issues driving efforts to reduce cobalt
  - NMC 111 → 532, 622 & 811 & low Co NCA
  - Cost vs. performance & safety tradeoff
Cobalt plays an essential role in lithium-ion batteries chemistry and there is not substitute at the moment to match its high thermal and safety performance. Robin Goad, President and CEO at Fortune Minerals Limited, introduced the Fortunes Minerals’ NICO Project in Canada which main objective is to position the company as a leading producer in cobalt used in batteries whilst addressing the increasing concerns about cobalt production’s concentration in the high risk DRC, refinery concentration in China and its production as a by-product of both copper and nickel. He also highlighted that Fortune Minerals will account for supply chain transparency and control of ethical cobalt all the way through the production of cobalt sulphate heptahydrate used in lithium-ion batteries.

SUPPLY-SIDE CHANGES IN THE COBALT MARKET

Jack Bedder, Manager at Roskill, outlined that in order to meet the increasing demand for cobalt, new sources of this metal will be needed in the coming future. The paper also addressed the development of the cobalt supply and refined capacity over the next decade.

Outlook for demand: EV batteries will drive the boom

- Roskill expects the market to grow at 10%py to 2027 with demand from batteries growing at an even higher rate
- Battery demand could reach 240kt in 2027 according to Roskill’s base case. Low case scenario currently assumes <190kt
- It should be noted that there are lots of uncertainties with regard to forecasting and various caveats should be considered
- Some substitution possible in more niche applications but most non-battery end-use sectors will require increased levels of cobalt over the forecast period

Source: Roskill
This presentation, delivered by Laurent Cohen, Global Marketing Manager at Solvay, focused on the economics of various cobalt refining processes as well as on the optimisation of extraction technology. He concluded that there is a need for more cost-effective production processes as well as opportunities for new technological innovations.

NEW COBALT DISCOVERIES IN ONTARIO

Dr Ian Pringle, Technical Director at Battery Mineral Resources gave a comprehensive overview on the company and its current cobalt projects focusing on the exploration and assessment in Ontario (Canada) and Idaho (USA) mining areas.
HIGHLIGHTS SUMMARY

✚ Growing market driven by EVs & a global shift to lower carbon emissions.
✚ Multi-commodity portfolio delivering critical mass to most cathode chemistry & anode material end users.
✚ Consistent supply of quality raw materials from a single-source supplier.
  — Ten Canadian cobalt projects containing the highest-grade cobalt outside the DRC.
  — Quality portfolio of lithium assets strategically located in California & Nevada.
  — Advanced high quality flake graphite projects in South Korea, the world’s second largest battery market.
✚ Multi-channel marketing & development strategy provides a presence in up- & down-stream battery material markets.
✚ Mine development in stable jurisdictions & quick path to production.
✚ Diversified & strong board & management team.
✚ Capital markets strategy culminating in TSX listing.

EFFICIENT, SUSTAINABLE AND ETHICAL PRODUCTION OF BATTERY GRADE COBALT USING CHEMISTRY AND GREEN ENGINEERING MOLECULAR RECOGNITION TECHNOLOGY PROCESSES

SuperLig® MRT: Essential to Management of Scale

• Efficient: Rapid production of pure products with > 99% recovery
• Sustainable: Minimal energy and water use, zero greenhouse gas emissions, low metal inventory (working capital)
• Green Chemistry and Engineering: No organic solvents; high metal selectivity in single stage separations eliminates labor, time, chemicals, space, safety, and processing costs associated with multiple separation stages; minimal waste
Steven Izatt from IBC Advanced Technologies presented a paper on how this company together with Minera y Metalúrgica del Boleo are using Molecular Recognition Technology (MRT) to obtain battery grade cobalt while minimizing the use of energy, water and chemicals and the production of waste. He also emphasized the decisive role of green engineering and chemistry to meet future cobalt production requirements including recycling.

CONFERENCE DAY 2 (MAY 24)

COBALT AND THE RISE OF THE LITHIUM ION BATTERY MEGAFactories

Caspar Rawls, Analyst from Benchmark Mineral Intelligence, open the second day of the Cobalt Conference with a presentation that highlighted the rise of the lithium-ion battery mega-factories in recent years to fulfil the anticipated demand of electric vehicles.

The Megafactories are coming – 2015 Prediction

<table>
<thead>
<tr>
<th>Company</th>
<th>Capacity</th>
<th>Investment</th>
<th>Location</th>
<th>Technology</th>
<th>Year</th>
</tr>
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<tbody>
<tr>
<td>Panasonic</td>
<td>35GWh</td>
<td>$5bn</td>
<td>Nevada, USA</td>
<td>Lithium-ion</td>
<td>2016</td>
</tr>
<tr>
<td>LG Chem</td>
<td>7GWh*</td>
<td>$500m*</td>
<td>Nanjing, China</td>
<td>Lithium-ion</td>
<td>2015</td>
</tr>
<tr>
<td>FOXCONN</td>
<td>15GWh*</td>
<td>$810m*</td>
<td>Anhui, China</td>
<td>Lithium-ion</td>
<td>2016</td>
</tr>
</tbody>
</table>

*Benchmark Estimates, not disclosed by company

Source: Benchmark Mineral Intelligence
Ahmad Mayyas from the National Renewable Energy Laboratory (NREL) outlined the significance of recycling at the end of the batteries life cycle both from an environmental point of view and as a way of recovering materials such as cobalt that can then be used to cost-effectively manufacture new batteries. He also said that these savings could reach up to 43% of the cost of cathodes.

**SELECTIVE AQUEOUS EXTRACTION OF COBALT FROM WASTE SOURCES**

Increasing demand of cobalt combined with the current risks inherent to its supply chain had led many firms to research on new ways and processes of recycling battery materials. Dr Michael Wyrsta, CEO at Lixivia gave a detailed explanation on the method developed by the company to extract cobalt from waste batteries through selective metal extraction chemistries and processes using aqueous based lixiviants.
SUSTAINABLE SUPPLY OF Li-ION NEW BATTERY MATERIALS

Cobalt | Step 2 - Identify and assess risks in the supply chain

- **Cobalt supply chain mapping**
  - **Large Scale Mining (LSM)**
  - **Artisanal Small Scale Mining (ASM)**
  - **Crude Refiner CDM**
  - **Fine Refiner HY**
  - **Large Scale Mining (LSM)**
  - **Other Traders**

Where is the original (mine site)?
How do you control risks (WFCL)?
How can we trace the cobalt?

**Tier 1**
**Tier 2/+**
Bryce Lee, Director CSR at Huayou Cobalt Co, put an emphasis on the need to achieve a responsible cobalt supply chain management, to meet the expectations of stakeholders regarding the use of cobalt particularly within the lithium-ion batteries industry, one of its lately biggest application areas.

COBALT ON THE LME

The following presentation was addressed by Matthew Chamberlain, CEO of the London Metal Exchange and Member of the Management Committee of HKEX Group. In his speech, he provided delegates with an update on LME and talked about the development of the LME cobalt contract, the responsible sourcing of the LME cobalt and the introduction of a cash-settle cobalt contract.

LME’s roadmap for EV metals
Work with industry to serve the growing market’s needs

- Formation of Advisory Group and discussion with existing Cobalt Committee
  - Bring together key participants across the value chain to acknowledge the shared goals and challenges
  - Discuss the rapid growth of electric vehicles and the impact on the development cycle of the commodities involved
- Discuss key questions for battery complex pricing
  - Gather feedback from the industry regarding the pricing methodology currently adopted
  - Assess need for risk management per battery ingredient
  - Develop understanding of the structure and specificities of the markets in the scope of the analysis
- Identify and refine best-practice pricing methodology
  - Identify, support and endorse the leading index providers
  - Work with the industrial community to encourage industry wide adoption of index linked pricing
  - Work with index providers to ensure compliance with appropriate regulations
- Launch risk management tools
  - Use LME’s know-how of price risk management to assess the needs of the battery materials market
  - Launch effective, transparent, regulated and secure tools for price risk management
  - Work with the industry to promote education, market participation and liquidity

RESPONSIBLE SOURCING SEMINAR: AN INTRODUCTION TO THE COBALT INDUSTRY RISK ASSESSMENT FRAMEWORK

This year, the second day of the Cobalt Conference included a seminar organized by the CI to introduce the Cobalt Industry Responsible Assessment Framework (CIRAF), an initiative aimed to enable member companies, and the cobalt industry more generally, to conduct enhanced risk management in line with industry good practice and global standards focused on the responsible sourcing of minerals.
The ultimate goal of this project is to allow for continued and coordinated progress towards the sustainable production of cobalt.

CIRAF is being developed together with the consulting firm RSC Global whose Director, Harrison Mitchel, conducted the seminar.

The objectives of CIRAF

One of the major objectives of the CI is to promote the responsible production and use of cobalt in all forms.

Building on this commitment, the Responsible Sourcing Task Group of the CI has been working since May 2017 with its members on developing the Cobalt Industry Responsible Assessment Framework (CIRAF).

<table>
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<th>The CIRAF project seeks to:</th>
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<td>1</td>
<td>Identify material risks within the cobalt sector from CI members, as well as their customers</td>
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<td>2</td>
<td>Provide a good practice based framework that will provide guidance to members on how to respond to core risks and report on existing responses with a degree of flexibility that is most appropriate for their operations</td>
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<td>3</td>
<td>Ensure the framework is credible, well-managed and accepted by stakeholders.</td>
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The purpose of this webinar is to outline the CIRAF structure, its provisions, and the expected approach CI members will take in utilising the new framework.

UMICORE’S EXPERIENCE IN PROCURING SUSTAINABLE COBALT

FOR OVER 15-YEARS

The final presentation was from Guy Ethier, Senior Vice President Supply Chain Sustainability of Umicore and Chairman of the Cobalt Institute, who detailed how Umicore has addressed the risks inherent to cobalt supply and operations during its more than 15 years of experience in providing sustainable cobalt.
Cobalt: An Essential Element for E-mobility

Cobalt has specific and beneficial characteristics, creating an essential contribution to the performance of the cathode materials for lithium-ion batteries: Improving its life and safety performance.

With this last presentation the 2018 Cobalt Institute Annual Conference closed its most successful event in the recent years. The large number of delegates confirmed the increasing interest of stakeholders in keeping up to date with the latest insights, technology innovations and projects which are being developed within the cobalt industry sector. This enthusiasm is greatly based on the exponential growth of cobalt price during the last years and linked to the buoyant EV market and the technological developments accompanying the lithium-ion battery field. All this has also led to increase concerns over cobalt demand and supply and, consequently, over the need for a well managed and coordinated responsible sourcing of cobalt which takes into account issues such as human rights, sustainability markers, environment and occupational health and safety. This is probably one of the main challenges facing this industry sector as demonstrated by the content of the conference’s presentations, many of them focused on lithium-ion battery materials recycling, sustainable new recovering processes, advanced green technologies and responsible sourcing of cobalt. We at the Cobalt Institute are absolutely convinced that this is the only way forward to a fully sustainable, ethical and responsibly sourced technology enabling product.

The CI gratefully thanks all the delegates for their participation in this 25th Cobalt Conference and looks forward to seeing all stakeholders at the next Conference which will take place in **Hong Kong from 15 to 16 May 2019!**
GREEN CHEMISTRY SEPARATIONS:
KEY TO MEETING 21ST CENTURY COBALT DEMAND

Cobalt Demand Increasing at Astonishing Rate: Rapidly increasing amounts of high purity battery-grade cobalt are required for the growing number of products in the ‘green revolution’ that is sweeping the globe. Cobalt use in rechargeable batteries for electric vehicles (EVs) of all types, hybrid EVs, stationary power supplies, renewable power generation, and clean energy production is increasing at a rapid rate, representing more than half of the 2018 use of this metal.

Spectacular Global EV Growth: Global sales of lithium-ion batteries (LiBs) totaled nearly 12 billion US$ in 2013. This market is anticipated to reach about 24 billion US$ by 2020, driven by demand for LiBs in EVs, HEVs, and many other applications. The compound annual growth rate for LiBs was 22.8% from 2003 to 2013. (Christmann, P., et al., 2015, Chapter 1. In Chagnes, A., Swiatowska, J., (Eds), Lithium Process Chemistry, Elsevier, Amsterdam.) Projections place the number of electric cars in circulation by 2030 at 56 million, 28 times the 2016 stock. (International Energy Agency, Global EV Outlook 2017, p. 23: Two Million and Counting, <https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf> Accessed April 30, 2018.) A result of this spectacular growth in EV production is that demand for cobalt for use in LiBs is projected to exceed supply by the early 2020s.
**Where will Needed Cobalt come from?** Present production rates of cobalt fall far short of meeting expected demand by 2030. One large source of cobalt is that irretrievably lost through inefficient processing of primary mined ore and scrap using legacy separation technologies, such as solvent extraction, ion exchange, and precipitation (Legacy Separation Technologies).

**Recycling:** Largely untapped sources of cobalt lie in spent rechargeable batteries and other secondary sources. Present recycling rates for cobalt from these sources is low, <5%. Without adequate recycling, millions of tons of rechargeable battery waste could be discarded annually in future years, with irretrievable loss of cobalt. More efficient green chemistry-based processes for separation and recovery of cobalt from primary and secondary sources could markedly increase cobalt supply.

**High Purity Cobalt Required for High Technology Applications:** Achieving highly pure battery grade cobalt requires either selectively separating and recovering cobalt at high purity from complex matrices, as in nickel or copper ore beneficiation, or controlling concentrations of impurity metals, such as cadmium or copper, in cobalt electrolyte solutions at specified levels leaving highly purified cobalt in solution. Metal impurities can have a dramatic negative effect on cobalt function in high technology products.

**Inadequacies of Legacy Separation Technologies:** Cobalt separation from complex matrices and control of metal impurities in cobalt electrolyte solutions are expensive, inefficient, time-consuming and generate appreciable waste using Legacy Separation Technologies that employ solvents and harsh chemicals, have low metal recovery rates, have low metal selectivity, and are profligate in use of energy, water, chemicals, labor, space, and time.

**Meeting Projected Cobalt Demand Requires Major Changes:** Projected 21st century demand for high purity cobalt in the quantities needed requires paradigm shifts away from present Legacy Separation Technologies. These shifts include changes from (1) organic solvent to aqueous chemistry usage, (2) high complexity to simplicity in system design, (3) low to high cobalt selectivity, (4) low to high cobalt recovery rates, (5) high to minimal generation of waste, (6) and high to minimal discard of waste into the environment.
SuperLig® MRT has the Capability to Meet Future Cobalt Demand: SuperLig® Molecular Recognition Technology (MRT) is a commercially proven green engineering, green chemistry simplified separation process that achieves these paradigm shifts. MRT processes use SuperLig® products consisting of a highly metal-selective organic ligand bound to a substrate bead, such as silica gel, by a tether in packed column format. The target metal is selectively removed from a feed solution by the SuperLig® product, the column is washed, and the metal is recovered by elution with a small amount of eluent (usually dilute mineral acid) producing a concentrated solution from which the pure metal is easily recovered. The column is easily regenerated for reuse, a process that can be repeated hundreds to thousands of times making the SuperLig® MRT process economically attractive.

Green Engineering Simplicity: The simplified column separation system used in the SuperLig® MRT process has zero carbon footprint and small space, materials, chemicals, labor, energy and water requirements that provide markedly lower capital and operating expenses when compared to Legacy Separation Technologies. The SuperLig® MRT process can be incorporated into operational flow sheets eliminating time-consuming and expensive batch operations.
Green Chemistry Benefits: SuperLig® MRT features high selectivity for cobalt and impurity metals leading to single stage separations; rapid metal-binding and metal-release kinetics; small metal inventory times (lowering working capital and enhancing cash flow); complete removal of cobalt or impurity metal by the SuperLig® product eliminating need for repetitive processes downstream to polish residual metal; concentration of cobalt or the impurity metal in the eluent making its recovery more efficient; replacement of organic solvents and expensive one-use organic extractants by an all-aqueous system using mild chemicals; effective metal recovery at low feed concentration levels (mg L\(^{-1}\) or lower); and metal control in the feed solution eliminating waste generation that results in negative environmental and health issues. The efficiency of SuperLig® MRT systems results in much lower capital, operating, and life-cycle costs than those of Legacy Separation Technologies.

SuperLig® MRT Systems Provide Favorable Economics for Cobalt Separation, Recovery, and Purification: Economics for separation, recovery and purification of either cobalt from ore matrices, of metal impurities from cobalt electrolyte solutions, or of cobalt from secondary sources can be much less for SuperLig® MRT systems than for Legacy Separation Technologies because of simplification and highly selective separation processes that eliminate the need for many capital and operating expenditures. Effective recovery for reuse of cobalt from these sources reduces dependence on mined ore, contributes to global metal sustainability, prevents significant environmental damage and wastage of a valuable resource, and provides a reliable source of cobalt for the burgeoning market for rechargeable batteries and other high technology products.

THE COBALT CONFERENCE 2019

COBALT INSTITUTE ANNUAL CONFERENCE
15-16 MAY, HONG KONG

More information available soon on www.cobaltinstitute.org

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Membership of the CI is open to those engaged or interested in the industry, subject to and acceptance by the Board.

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