

# COBALT NEWS

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# COBALT NEWS

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### THE COBALT DEVELOPMENT INSTITUTE

18 Jeffries Passage, Guildford, GU1 4AP, UK

Tel: (0)1483 578877 Fax: (0)1483 567042

email: [info@thecdi.com](mailto:info@thecdi.com) web: [www.thecdi.com](http://www.thecdi.com)

Editor: D. Weight – Production: I. Porri

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## COMMENT

In May we had a hugely successful Cobalt Conference in Marrakech and the excitement around the cobalt market was palpable. Delegates enjoyed keynote presentations on supply and demand together with seminars on sustainability and responsible sourcing to aid strategic decision making for forward planning. The fundamentals for cobalt are probably the strongest they have ever been, largely as a result of the developments within the Li-ion rechargeable battery market – but other sectors, such as aerospace, are also buoyant.

In 2018 the CDI Cobalt Conference will be in Las Vegas on 23/24 May.

As mentioned in previous editions, Cobalt remains under the scrutiny of regulators and legislators where it is receiving disproportionate attention. Concurrently we are having to deal with the Dutch CLH proposal for Co metal; possible Restriction for Co Salts; scrutiny of cobalt in association with tungsten in hard metals (by the Dutch) and an unwarranted attempt to place our most benign substance, tricobalt tetraoxide, on the candidate list through its minimal association with an impurity, which itself is not a SVHC. These four concurrent procedures demonstrate a complete lack of consideration of the implications in some cases, of coordination and of proportionality from Regulators. To move forward safely, effectively and prudently a collaborative approach between Industry and Regulators would be the answer. Regulators should be able to recognize that it is industry who has the intimate practical experience of cobalt and is the leading expert in the development of cobalt science

Good progress is being made on the Cobalt Industry Risk Assessment Framework for our Responsible Sourcing programme and we should be reporting more formally in the next edition of the Cobalt News.

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# ***THE Cobalt Conference 2017***

## **Marrakech, Morocco**

On 17–18 May this year, the CDI held its 24<sup>th</sup> Annual Cobalt Conference at the Mövenpick Hotel Mansour Eddahbi, Marrakech. This annual event is put on by the CDI as an industry centre piece. It is the only purely cobalt conference and is not designed as a profit-making venture so we are able to offer very good value compared to other metals conferences. The Conference itself attracts the great and the good from our industry and provides a forum for networking, business development and getting up to date with what is happening in the sector. This year there were many new faces, all keen to find out more about what drives the cobalt market and what the future may hold.

Since last year the cobalt price had increased almost 150% and we were aware that there was much more interest in our very special, technology enabling metal this year. We enjoyed a buoyant level of registrations from a broad range of interested parties from commercial business and consultancy through academia, end-users, investors, R&D, service providers and new projects.

The programme was designed to cover important aspects of cobalt, from market reports to end-use, new projects, sustainable development, responsible sourcing and more, to examine what drives the cobalt market, what challenges there are or may be expected and other important aspects that impact our market.

In association with the CDI Cobalt Conference, the Natural History Museum of London put on a workshop on the day before our Conference to look at “**The Geology, Geomicrobiology and Geometallurgy of Cobalt Resources Leading to New Product Streams**” – the so called COG3 project. At the end of our Conference Roskill Information Services then held a **Round Table Discussion on Battery Supply Chain bottlenecks**. Both workshops were very well attended, particularly as they looked at two major areas being considered for cobalt – where is cobalt to come from to meet the expected future demand for rechargeable batteries!

### **CDI Conference – Day 1**

**Président Directeur Général of Managem Mr Imad Toumi** welcomed all the delegates to Marrakech and outlined the work of this international group whose focus was on creating value from minerals. He explained that Managem is an international mining group specialising in the extraction, production and recovery of many metals: copper, zinc, lead, fluorite, cobalt, gold and silver. With over 85 years of experience in Morocco, Managem is a leading player in the mining sector in Africa.

**CDI Chairman David Elliott** opened the proceedings by commenting on the challenges that cobalt faced and emphasising the strong value proposition of the Institute in helping to meet and address these challenges. He explained that the CDI needed to deal with a broad range of different issues on behalf of its Members, and the industry as a whole, in order to protect market access for cobalt.

**CDI President David Weight** provided an outline of the **Institute’s Value Proposition**, emphasising that our trade association was part of the solution to reducing Members costs and getting important results for the industry. He highlighted the main areas of interest for the CDI and its Members:

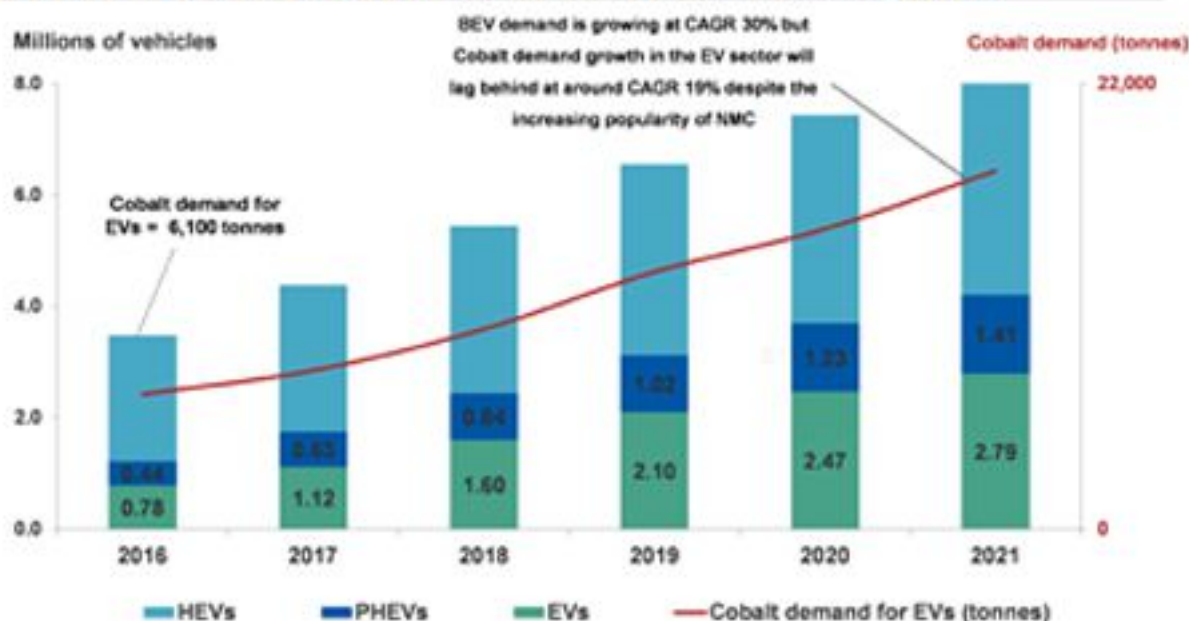
- **Human Health Classification**
- **Global Regulation**
- **Responsible Sourcing**
- **Sustainability**
- **Safe Use of Cobalt – HS&E**
- **Cobalt as a Critical/Strategic Raw Material**

David emphasised the disproportionate level of scrutiny being put on the classification of cobalt through poorly considered science by EU Regulators, the impact of developments for responsible

sourcing and the growing need for more data on the sustainable profile of cobalt. The CDI is addressing all these issues as we seek to promote this technology enabling, bioessential and critically important element!

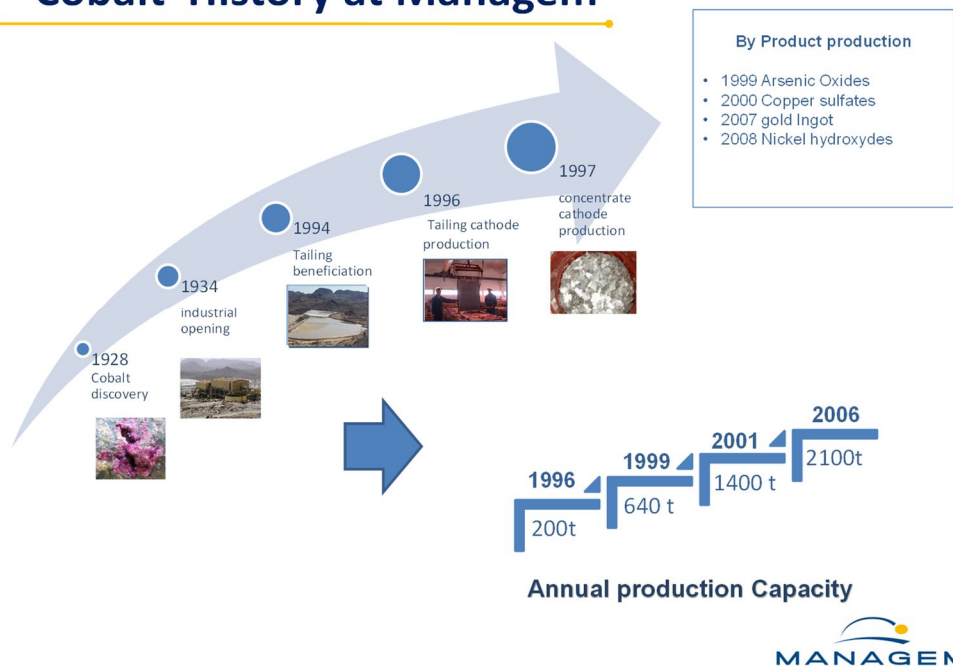
The CRU once again provided the first keynote presentation of the Conference and **Dr Ed Spencer, Senior Consultant – Nickel, Stainless Steel and Special Alloys**, spoke on **Cobalt Supply and Demand: A Global Perspective**. He looked in detail into the global supply and demand in both the chemical and metal sectors and concluded that the market will remain tight over the next five years and prices will remain strong to the end of the decade. Significant growth in demand for rechargeable batteries will be the main driver

### EVs, PHEVs and HEVs will drive mid-term demand growth

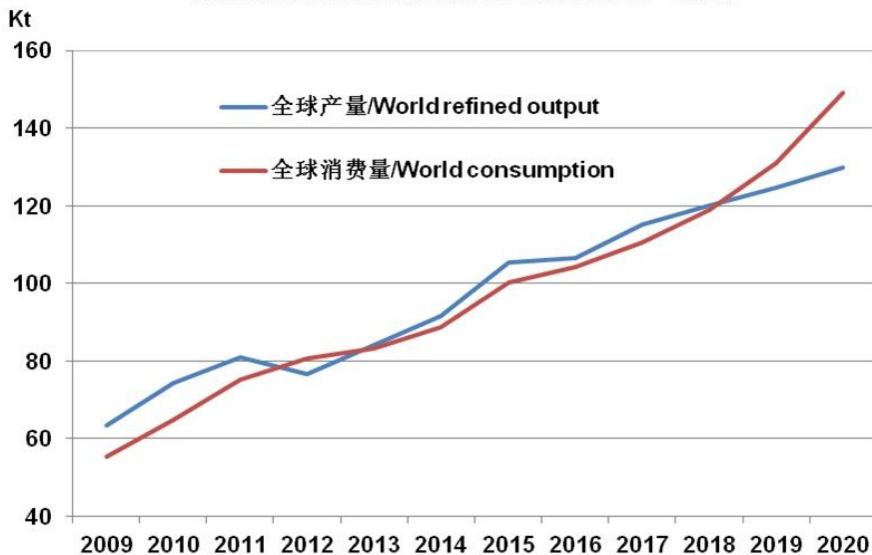


The Conference was then delighted to welcome **Dr Intissar Benzakour, Scientific Director of the Managem Group** who gave a presentation entitled **Moroccan Cobalt – A Captivating Story for a Strategic Metal**. This was an intriguing story of the 85-year history of their Moroccan mining operations (and overseas operations), showing how the group is focused on innovation, responsibility & performance for sustainable operations.

### Cobalt History at Managem



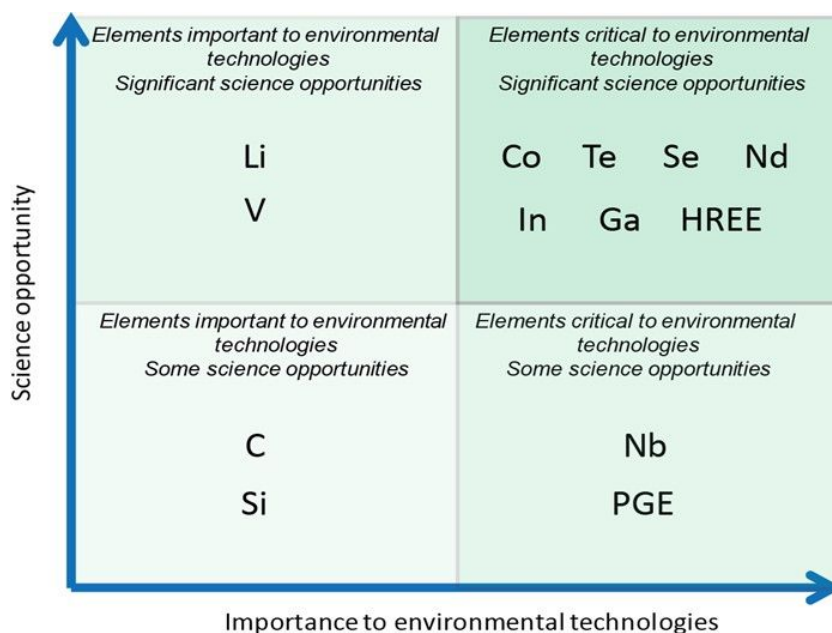
World refined cobalt SD balance ~2020



Source: Antaie

The next keynote presentation was from **Mrs Xu Aidong, Chief Analyst from the Beijing Antaie Information Development Co**, who presented a paper on the **China Cobalt Industry Review**. This is always eagerly awaited because the Chinese market is a dominant player with respect to cobalt. She looked in great detail at the manner in which rechargeable batteries were affecting the demand for cobalt and examined the development of various technologies in China. She too

commented on the continued strong demand and possible future constrained supply.



Science opportunities and importance to environmental technologies related to "E-tech" elements (Natural Environment Research Council, UK, Expert Group)

Cobalt is identified as being a 'critical' mineral in the EU and strategically important in the USA. This would also apply to other developed economies and so sourcing this metal is vitally important for technological development. The **Natural History Museum of London** is running a project to look at novel ways of extracting cobalt and **Professor David Barrie Johnson** of the College of Natural Sciences at Bangor University presented a paper on **Bioprocessing options for extracting and recovering cobalt from primary ores and mineral wastes**. He explained that the 'COG<sup>3</sup>' project was focused

on biomining for cobalt and other technologically important metals that are vitally important for industry. Improving the availability of cobalt through innovative means is considered of major interest and hence has financial support from Natural Environment Research Council (NERC) in the UK.

## Session on Cobalt Sustainability

This year the Cobalt Conference included two new seminars put on by the CDI. The first seminar was looking at developing the **sustainable profile for cobalt** and was organised by **Ms Carol Pettit, REACH and Sustainability Manager** at the CDI. She introduced the session outlining the key sectors and value chains for cobalt, outlining the new work the CDI is conducting to look more closely at environmental effects (life cycle assessment) and socioeconomic benefits, for highlighting the "sustainability attributes" of cobalt substances in various applications (rechargeable batteries, catalysts, surface engineering, etc.), and emphasising the importance of the 'circular economy' model.



## Cobalt LCA Programme of Work

- Considers both primary production routes: co-product from nickel and copper production
- Represents both pyro- and hydrometallurgy production processes
- Accounts for cradle-to-gate production



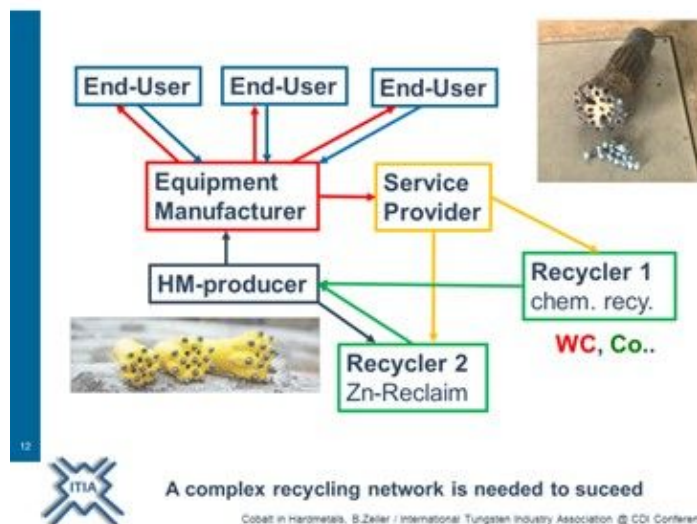
- Base year is 2012 production
- Based on data from eight CDI members
  - representing 30% of global production and 64% of CDI members
- Conducted in accordance with ISO standards on LCA and
- Consistent with the harmonisation document for metal LCAs

8  
The business of sustainability



**Jonna Meyhoff Fry, Senior Consultant with ERM** outlined the life cycle assessment (LCA) study that ERM completed for the CDI. This 'cradle to gate' LCA project served to remove the confusion that had reigned previously in the market, by providing the first industry led LCA dataset for refined cobalt. This key information can be used for informed decision making when considering the sustainability of products in the market and for improvements in production processes.

**Burghard Zeigler** the **Secretary-General of ITIA** (the Tungsten Association), then outlined the importance of cobalt in hard metals, describing its technical benefits, and today's situation concerning recycling and recovery of cobalt from hard metal application; emphasising that cobalt and tungsten carbide are a great "couple" with unique properties.



A complex recycling network is needed to succeed

Cobalt in Hardmetals, B. Zeigler / International Tungsten Industry Association @ CDI Conference, Mannheim, May 2017

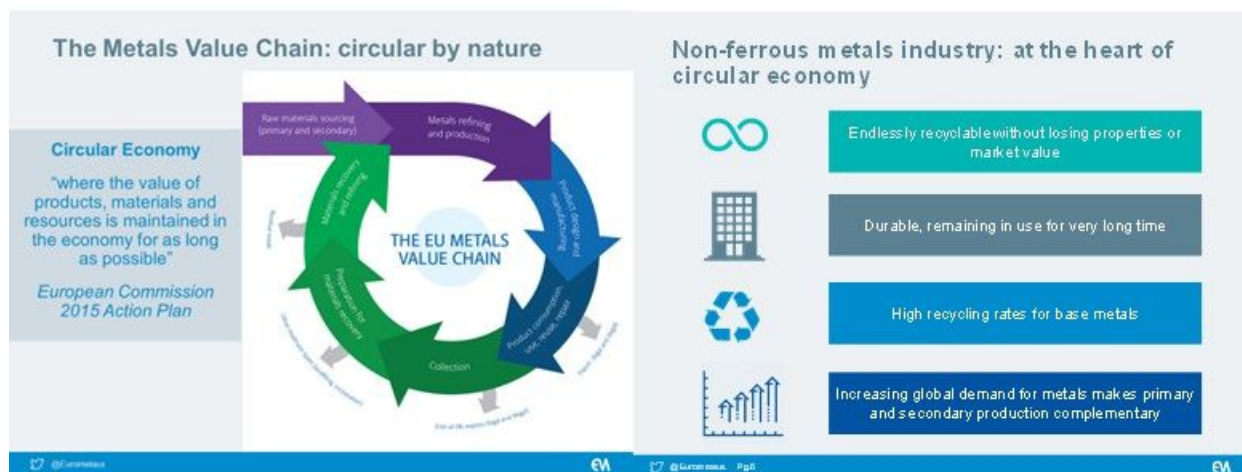


## The World is moving....



This was followed by a summary of the battery sector prepared by **Claude Chanson, General Manager of ReCharge** (the rechargeable batteries association) and delivered by **Carol Pettit**. The emphasis of this presentation was on the **Product Environmental Footprint (PEF)** project in the EU, to which the CDI participates and has provided cobalt LCA data. The PEF project is designed to assess the environmental impacts of products, in this case rechargeable batteries – an important contributor to a future green global economy.

To put all this into a global context, **Guy Thiran, Secretary General of Eurometaux** outlined the critical importance of metals in the **Circular Economy**, and he emphasised that these were at the heart of the model:



**Simon Aumonier, Principal Partner at ERM** then explained the importance of **'whole life costing'** to be able to fully understand the life cycle of a raw material such as cobalt. Such measures are being adopted by industry to help specify eco-efficiency or environmental cost-effectiveness of decisions. The sustainability session concluded with an expert panel discussion, outlining the need for new data collection for input towards further development of the sustainability profile for cobalt. So, for next year's conference, the CDI is planning a similar session to focus on the recycling/recovery aspects of the key sectors (alloys, batteries, catalysts, etc.).

### Seminar on Responsible Sourcing

There then followed a Seminar on **Responsible Sourcing** introduced by **Brigitte Amoruso, Advocacy and PR Manager** with the CDI. This is an important subject for the cobalt industry and the seminar examined the issue in detail, explaining how the large scale mining industry was addressing responsible sourcing. Indeed, Brigitte announced that the CDI, in conjunction with **RCS Global**, would be developing a Cobalt Industry Risk Assessment Framework which the industry could work with to establish effective responsible sourcing.

**Jack Lowe, Marketing Director** representing the **Ambatovy Mine** in Madagascar outlined how this large nickel mining and refining facility recognised human rights and worked with the local communities to protect children's rights; A good example of how CDI Members approach this fundamentally important issue.

**Ambatovy's Commitment to Sustainability**

- Acting Responsibly through Respect, Integrity, Transparency and Ethical Standards
- Sustainability Performance
  - Social License to Operate
  - Environmental Stewardship
  - Governance Accountability
  - Social & Community Involvement

Ambatovy



## Drivers

This was followed by **Dr John Atherton, Director - Health, Safety & Product Stewardship of ICMM** who outlined the considerable upstream activities relating to responsible sourcing within the large scale mining sector as well as the technical, economic and cultural issues that arise in creating a 100% traceable supply chain.

- Conflict minerals – legislation / guidelines



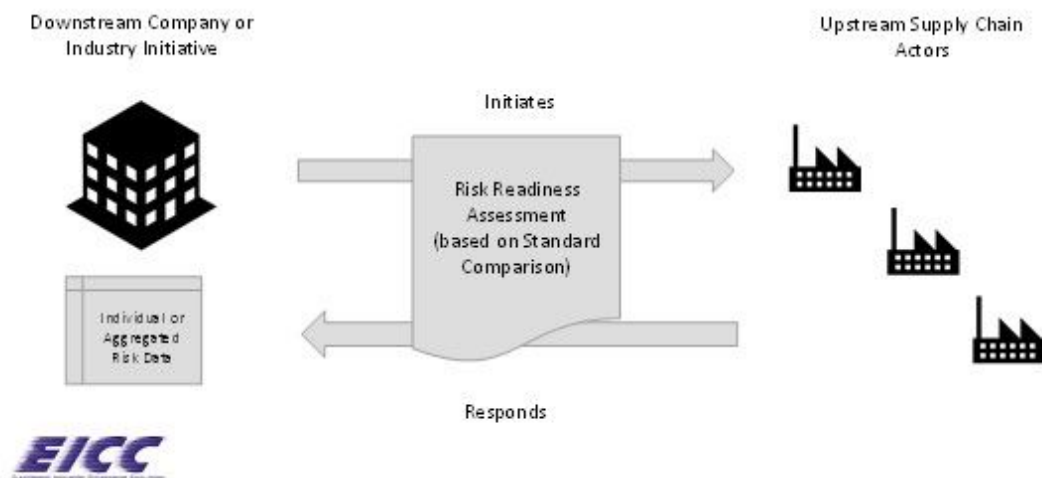
- Supply chain sustainability – good business

- Being seen as a responsible producer - response



**Michelle Bruelhart, Technical Director of the EICC** then explained how downstream industries were organising themselves for establishing processes that ensured their members received responsibly sourced material to go into their products.

## Creating an “Upstream” Risk Assessment for Responsible Mining



To close off the session **Edward Lauer, Head of Portfolio Optimisation at ERG**, chaired a panel session that gave the speakers an opportunity to discuss how the cobalt industry was addressing responsible sourcing and what the potential outcomes could be.

This ended a full first day and the delegates were provided with a comprehensive look at the market from a factual, strategic, commercial and ethical points of view.

## CDI Conference – DAY 2

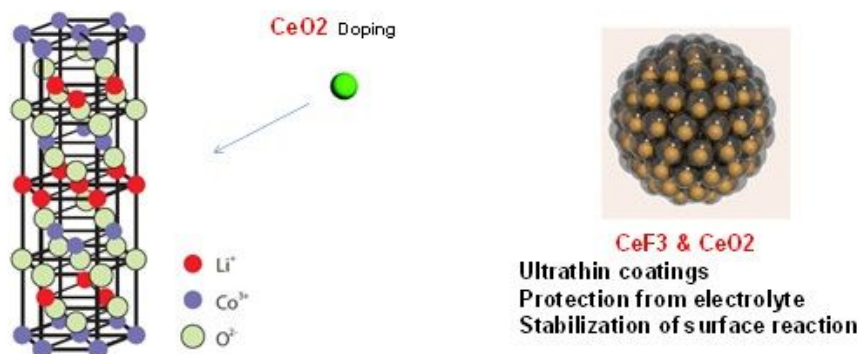
To open DAY 2 of the cobalt conference **Dr Hakim Faqir - Deputy Director of the Research Activity in REMINEX Research Centre** presented a paper on **Improving Safety Characteristics and Energy Storage Performances of LiCoO<sub>2</sub> Cathode Materials** where he was able to demonstrate the considerable technical prowess of REMINEX.



## Our Approach



Innovation can occur via **new materials development**, or by better engineering



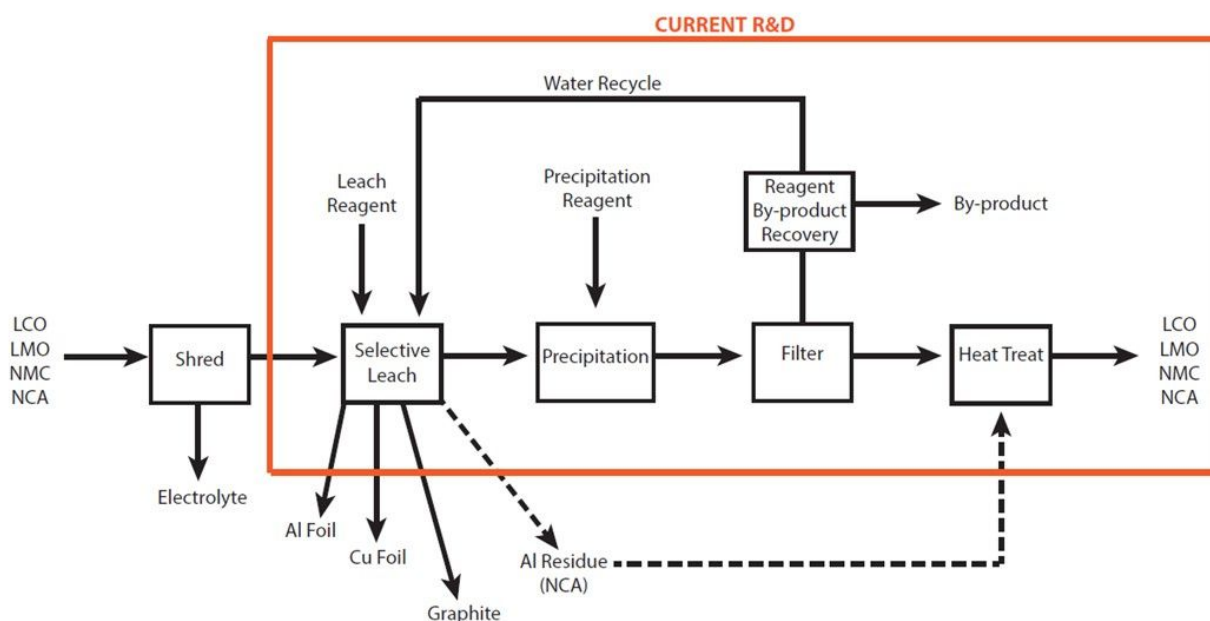
The introduction of an oxygen reservoir « CeO2 » into the structure of LiCoO2 can improve Safety & Charge Capacity of LiCoO2 cathode

REMINEX have created a  $\text{CeF}_3$  coated  $\text{LiCoO}_2$  molecule that affords protection from electrolyte and provides stabilization of surface reaction which translated to significantly improved thermal properties. This is a particularly important for safe operation of these types of cells.



Going back to the market theme, **Andrew Miller** an **Analyst with Benchmark Mineral Intelligence** gave a presentation on the **Outlook for Lithium-ion Batteries**. He explained that their research suggested a forward CAGR of 11% pa for Li-ion battery demand, that the cobalt tonnage involved would increase 2.5 times by 2025 and that after 2020 rechargeable batteries would account for ~60% of the total demand for cobalt.

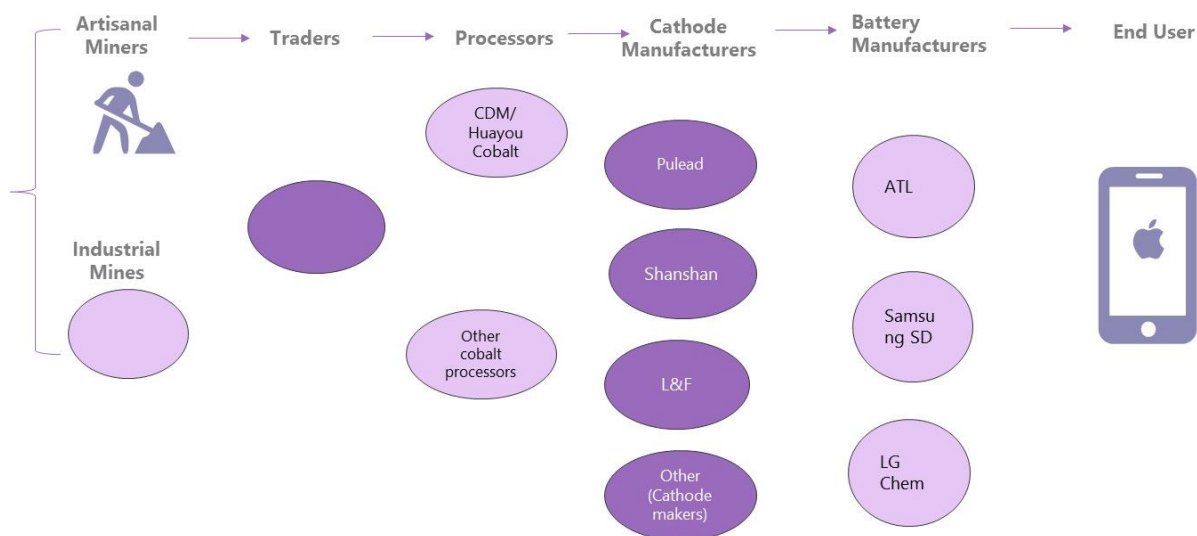
The recurring theme was concern about whether cobalt supply could keep pace with demand, and one way to help ameliorate this would be through recycling. **Larry Reaugh, CEO of American Manganese Inc** in collaboration with **Norman Chow, President of Kemetco Research Inc** highlighted their innovative and cost-effective re-cycling process which took old batteries and selectively extracted key battery ingredients such as cobalt. Proof of concept for this patent pending process has already been achieved and could create tremendous value for the upcycling industry for spent batteries – a potentially major source of high purity raw material for Li-ion battery manufacture.



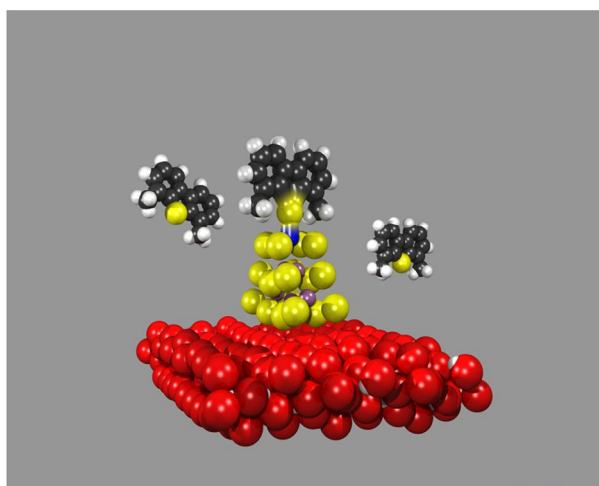
Provisional Patent Application Filed. More Intellectual Property in the Works  
Proprietary Operations Not Shown

The conference highlighted what was being done by the large scale mining industry to ensure responsible sourcing, but another major challenge of this theme is traceability in the supply chain. **Lara Smith, Managing Director of Core Consultants**, gave a presentation on **Cobalt Supply Chain Transparency, Auditability and Trust**. The cobalt supply chain is complex, but she demonstrated that the use of 'blockchain' digital technology may help consumers and producers alike to positively respond to the pressure for change in the current system. The strength of the blockchain is that the information is immutable and the data base supporting it is decentralised. Therefore, this technique delivers transparency, auditability and TRUST. However, Lara warned that Blockchain is not a panacea to all the various problems that exist in the current supply chain, most notably with artisanal mining, which by its very nature was hugely diverse and lacked proper regulation.

## Cobalt Supply Chain Journey



## Hydroprocessing cuts out sulfur



ALBEMARLE

The final paper was from **Professor Eelco Vogt of Albemarle** who presented a keynote paper on the importance of cobalt in catalysts, entitled **Cobalt in Catalysis: the Goldilocks Principle**. In a most interesting and highly entertaining paper Professor Vogt showed how the use of cobalt had evolved over years of research and as a constituent in catalysis for refining solutions it was considered 'just right' – hence the Goldilocks association. It was explained that there were no realistic alternatives to cobalt in a broad range of functions, notably for producing

clean fuels, and that without it the environment could be driven back to the acid rains of the 1970s.

This was the final presentation of the 2017 Cobalt Conference and in summarising the wealth of information from the high quality and interesting presentations over two days, David Weight commented that in all his 37-years in the cobalt industry he had never seen such robust fundamentals in the market and so many potentially exciting developments for cobalt. It was shown that demand for cobalt remains strong, mainly as a result of continued growth in Li-ion battery applications, notably

EV/PHEVs, but that other sectors were also growing. The question was how all this extra cobalt demand could be accommodated from known supplies. This would be a challenge but that a focus on improving the product life cycle and developing novel extraction techniques could provide some answers. From the Conference it could be seen that there was a recognition by governments that cobalt was critically and strategically important to technological advancement for industry and some had promoted projects to address this issue, such as the Natural History Museums COG<sup>3</sup> project. However, recycling could also provide significant volumes of sustainably recovered cobalt if a suitable technique could be industrialised, and we saw that Kemetco in conjunction with American Manganese were possibly moving in the right direction. It was essential however that cobalt is produced ethically and responsibly and there is a need for all elements of the supply chain to work together in this respect. The issue however, is not just about child labour as many more elements of responsible sourcing needed to be brought into the equation if any initiative is to be truly sustainable. As highlighted at the beginning of the Conference there is a significant threat from 'over' regulation of the cobalt market, particularly with regard to classification and the CDI sincerely hopes that Regulators and policy makers will follow legitimate scientific arguments to ensure appropriate, measured and fair regulation of metals.

**With that the 24<sup>th</sup> CDI Cobalt Conference closed and all were reminded that next year would be in Las Vegas on 23/24 May 2018**

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# ***THE Cobalt Conference***

***Planet Hollywood Resort & Casino, Las Vegas, USA  
23/24 May 2018***

***The Cobalt Development Institute will hold its annual Cobalt Conference in Las Vegas, USA in May 2018.***

***The programme will include:***

- *Detailed cobalt market reviews*
- *Review of global cobalt trade flows*
- *Regulatory matters and updates*
- *Supply chain sustainability*
- *Presentations on major cobalt related projects and mining operations*
- *Latest on sector developments and applications such as GTL, Superalloys, Batteries, Chemicals*

***If you have a paper which you feel would be of interest, there is still time to include it in the programme. Please contact David Weight at the CDI.***

# A boost for permanent magnets: Scientists analyse structure and behaviour on atomic level

Scientists at TU Darmstadt explored on an atomic level how changes in iron content influence the micro-structure of samarium-cobalt based permanent magnets. Their results were published in "Nature Communications." In the long run they could contribute to the development of permanent magnets with improved magnetic performance. These magnets can be found in microwave tubes, gyroscopes and satellite controls, for instance.

Although samarium cobalt magnets (Sm<sub>2</sub>Co<sub>17</sub> magnets), a type of rare earth permanent magnets, were developed in the early 1960's the underlying domain wall pinning mechanism has remained unknown. Scientists at TU Darmstadt showed that the iron content controls the formation of a diamond-shaped cellular structure that dominates the density and strength of the domain wall pinning sites and thus the coercivity, in other words the resistance the magnet puts up against demagnetization. By using an atomic-resolution aberration-corrected (scanning) transmission electron microscope in combination with micromagnetic simulations the authors could reveal for the first time the atomic structure of the single phases present and establish a direct correlation to the macroscopic magnetic properties. With further development, this knowledge can be applied to produce samarium cobalt permanent magnets with improved magnetic performance.

Pinning-controlled permanent magnets operating at elevated temperatures above 100° Celsius boost device performances of magnet-based industrial applications. These include microwave tubes, gyroscopes and accelerometers, reaction and momentum wheels to control and stabilize satellites, magnetic bearings, sensors and actuators. Sm<sub>2</sub>(Co,Fe,Cu,Zr)<sub>17</sub> is an important industrially used material system since it has both a high Curie temperature and a high magnetocrystalline anisotropy. Unlike nucleation-controlled Nd-Fe-B-based permanent magnets, the Sm<sub>2</sub>Co<sub>17</sub>-type maintains its excellent magnetic properties at elevated temperatures.

In order to obtain such high magnetic performances it is necessary to gain precise control of the synthesis parameters during the manufacturing process of a magnet and to thoroughly understand the atomic-scale structure and behaviour of the involved phases.

A higher saturation magnetization obtained by increased iron content is essential for yielding larger energy products in these rare-earth Sm<sub>2</sub>Co<sub>17</sub>-type pinning controlled permanent magnets. The scientists at TU Darmstadt developed model magnets with an increased iron content based on a

unique nanostructure and a chemical modification adding iron, copper and zirconium. Dr. Leopoldo Molina-Luna, who was the corresponding author of the publication, presented the results at the "Nature Conference on Electron Microscopy for Materials -- The Next Ten Years" celebrated at Zhejiang University in Hangzhou, China (May 24-May 27). This conference brought together leading experts in the field of electron microscopy for materials science.

## Follow-up research to boost magnetic performance

Further investigations planned at the TU Darmstadt on this material system include temperature dependent studies using a recently acquired DENSsolutions microelectromechanical systems (MEMS) chip-based in situ TEM holder. By implementing this state-of-the-art setup in combination with advanced simulation techniques the TU Darmstadt scientists envision to further investigate the mechanisms that lead to improved magnetic performances in samarium-cobalt-based and related permanent magnets systems. This would represent a major breakthrough in the field. Furthermore, site-specific electron energy-loss magnetic chiral dichroism (EMCD) measurements are planned for a quantitative local magnetic structure determination in collaboration with colleagues from the Beijing National Center for Electron Microscopy.

The results published in *Nature Communications* were obtained under the framework of the LOEWE research cluster RESPONSE (Resource-Efficient Permanent Magnets by Optimised Use of Rare Earths) that is coordinated by Prof. Dr. Oliver Gutfleisch. The research cluster includes the Departments of Materials and Earth Sciences, Chemistry and Mechanical Engineering and aims to optimise the use of rare earth permanent magnets.

## Reference:

1. M. Duerrschnabel, M. Yi, K. Uestuener, M. Liesegang, M. Katter, H.-J. Kleebe, B. Xu, O. Gutfleisch, L. Molina-Luna. **Atomic structure and domain wall pinning in samarium-cobalt-based permanent magnets.** *Nature Communications*, 2017; 8 (1) DOI: 10.1038/s41467-017-00059-9

Source: Technische Universität Darmstadt. "A boost for permanent magnets: Scientists analyze structure and behaviour on atomic level." *ScienceDaily*. *ScienceDaily*, 5 July 2017. [www.sciencedaily.com/releases/2017/07/170705113305.htm](http://www.sciencedaily.com/releases/2017/07/170705113305.htm)