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Lithium

From Exploration to End-user

9-10 April 2018

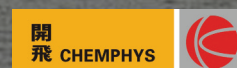
The Geological Society of London, Burlington House

ABSTRACT BOOK

Convenors:

Sarah Gordon (Satarla / The Geological Society)
Daniel Smith (The University of Leicester / MDSG)
Julian Aldridge (Wood plc / IOM3)
Jeremy Wrathall (Cornish Lithium)
Ali Dai (Chengdu Chemphys Chemical Industry)

Event Partners:



Energy Materials Group
of the Institute of Materials, Minerals and Mining



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CONFERENCE PROGRAMME

| Monday 9 April 2018 | |
|-----------------------|--|
| 09.00 | Registration & tea, coffee |
| 09.30 | Welcome Address |
| 09.40 | KEYNOTE: Demand – How, why and where do we use Lithium? Alison Dai, Chengdu Chemphys |
| 10.20 | KEYNOTE : Supply – How do we find, mine, process it? Jeremy Wrathall, Cornish Lithium |
| 11.00 | Tea & coffee break |
| 11.30 | Lithium Brine Projects Development: Challenges and Lessons Learned Pablo Cortegoso, SRK Consulting |
| 11.55 | FAME: Helping to Valorise European Lithium Resources Chris Broadbent, Wardell Armstrong |
| 12.20 | Bottlenecks in the lithium supply chain, avoidable or inevitable? David Merriman, Roskill Information Services |
| 12.45 | Lunch |
| 13.45 | BREAKOUT SESSION: What are the gaps / assumptions in our Lithium value chain? How will this affect the future of Lithium |
| 14.55 | Feedback from breakouts |
| 15.30 | Tea & coffee break |
| 15.50 | A lithium inventory for silicic magmas Ben Ellis, ETH Zurich |
| 16.15 | Lithium resources in lacustrine sediments Lisa Stillings, U.S. Geological Survey |
| 16.40 | Exploration for and Evaluation of pegmatitic Lithium Deposit in Ontario, Canada Stephen Peters, DMT Group |
| 17.05 | Hard Rock Lithium Sources: Particular Considerations for their Exploration and Mineral Resource Estimation Laura Donegan, SRK Consulting |
| 17.30 | Drinks Reception |
| Tuesday 10 April 2018 | |
| 09.00 | Tea, coffee |
| 09.30 | Welcome Address |
| 09.40 | Lithium in Mexico Peter Seker, Bacanora |
| 10.20 | International Lithium Corporation John Wisbey, International Lithium Corporation |
| 11.00 | Tea & coffee break |
| 11.30 | Lithium in Argentina José Gustavo de Castro Ale, NRG |

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| 11.55 | A review of lithium occurrences in Africa Paul Nex, University of the Witwatersrand |
| 12.20 | The challenges of Li determination in minerals: A comparison of stoichiometrically determined Li by EPMA with direct measurement by LA-ICP-MS and handheld LIBS Robin Armstrong, Natural History Museum |
| 12.45 | Lunch |
| 13.45 | Lithium Market Analysis Toby Green, CRU Group |
| 14.10 | Assessing new and emerging develop projects from an investment perspective Brock Salier, Sprott |
| 14.35 | Cobalt: perspectives on the currently essential ingredient for high-performance Li-ion batteries Richard Herrington, Natural History Museum |
| 15.00 | BREAKOUT SESSION: What are the gaps / assumptions in our Lithium value chain? How will this affect the future of Lithium |
| 15.45 | Tea & coffee break |
| 16.15 | Feedback from breakouts |
| 16.50 | Panel Session |
| 17.15 | Conference Closes |

ABSTRACTS
(in programme order)

Lithium markets: demand & supply

Alison Dai

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Chemphys has been involved in the lithium industry for 20 years and has witnessed significant changes to the lithium market over this time. With this experience, we try to better understand the current market demand and supply dynamics. There has been intense speculation following the release of Morgan Stanley's latest lithium market forecast which predicts lithium prices could fall by 45% by 2021. Every commodity goes through cycles where growing demand triggers a supply response which is often excessive for a period of time. Prices then fall, investment in new projects stall and the cycle repeats. It's difficult to see why lithium will be different from other commodities that have experienced a similar cycle. However, the industry is increasingly divided as to whether the supply surplus will be quickly absorbed by increasing demand or will flood the market and drive down prices over a longer period of time.

The presentation will provide a brief overview of Chemphys' position in the lithium supply chain, followed by Chemphys' perspective of key factors impacting lithium demand and supply.

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Lithium Supply – How do we find, mine, process it?

Jeremy Wrathall

Cornish Lithium

Lithium is rapidly becoming a metal of crucial importance to our modern world given the imperative to move to a low carbon economy. There is currently no commercial alternative to the lithium-ion battery which is taking centre stage in the revolutionary move towards electric cars and power storage batteries. Whilst lithium is technically an abundant element it is difficult to extract on an economically viable basis and this is expected to generate an ever-widening search for new sources and new processing techniques.

In this presentation the current sources of lithium will be reviewed as will existing methods of extraction. This will be followed by a review of exploration for new sources and a review of the rapid advances that are being made in lithium extraction methods. The presentation will also review Cornish Lithium's own efforts to establish a commercial lithium extraction industry based on lithium brines that were first identified in the County in 1864.

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Lithium Brine Projects Development: Challenges and Lessons Learned

Pablo Cortegoso & Julien Declercq, Rob Bowell, Camilo de los Hoyos, Terry Braun

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Brine extraction for surface process and recovery of potash, lithium, boron and industrial salt requires the application of traditional hydrogeological-hydrogeochemical theories to hyper-saline solutions. Such brines present additional technical challenges in comparison to fresh water due to density effects, salinity, density driven multichemical composition flow on a large scale, and interaction between brines and fresh water over the course of the production period. Surface production facilities require estimation of brine composition over time. Therefore, the specialists (hydrogeologist, geologists, geochemists, etc.) are tasked to incorporate this features in all the project steps, including exploration and sampling plans, balancing extraction rates from multiple production wells, locating the production wells in space (and time), predicting chemical composition of the pre-pumping and extracted brines and monitoring depletion of a “dynamic” resource. Predictions requires both accurate site information and an in-depth understanding of the limitations of the tools used. Each of these parameters can have a significant impact on project economics. The parameters such as effective porosity, permeability, anisotropy, aquifer configuration (extent, thickness and heterogeneity), and wellfield efficiency are key in the estimation of resources and reserves for a brine extraction project. During the stages of prefeasibility and feasibility, an accurately built numerical groundwater model is required in order to develop a production plan and accurately predicting the brine composition is key to a sustainable operation.

This presentation examines the technical aspects of conducting a proper evaluation from exploration to exploitation that will feed the precise parameters to the numerical groundwater model and therefore define a production plan and estimate extractable brine resources and reserves.

This presentation will also discuss the challenges and lessons learned from lithium brine projects in development around the world, from early exploration to production.

NOTES

FAME: Helping to valorise European lithium resources

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⁴*GEOS*

The demand for lithium is currently ca. 180,000tpa lithium carbonate equivalent (LCE) and this is anticipated to grow significantly such that by 2030 the forecast is currently at >2 million tonnes LCE per year. This increase is driven by the electrification of transport and, in particular, growth in electric cars.

Lithium is not a particularly rare element in the Earth's crust and is the 33rd most abundant element. Putting this in context, it is slightly less abundant than cobalt but slightly more abundant than lead. However, significant expansion in production of lithium (and other metals) will be required to satisfy the anticipated increase in the electrification of vehicles. Much of the lithium will be used in lithium-ion battery manufacturer, especially for the car industry. Most major European manufacturers have published ambitious targets for the replacement of conventional (diesel/petrol) cars by electric vehicles in the short to mid-term. As this is significant to European economies, strategic European lithium deposits will become ever increasingly important.

Lithium is produced from two distinct sources, brines with production concentrated in Chile and from hard rock minerals with current production centred on Australia. Europe currently supplies around 1% of global lithium (mostly from Portugal) although there are a number of deposits rich in lithium and exploration for lithium brines is active in Cornwall, UK. There is potential in Europe to increase significantly the proportion of world lithium supply produced from European resources.

FAME is an R&I Mineral Processing Project funded by the EU as part of H2020; FAME (Flexible and Mobile Economic Processing) investigates innovative mineral processing solutions relevant to the processing of skarn, greisen and pegmatite ores in Europe. Testwork has been carried out on 6 Reference ores (two of each ore type) and 3 of the Reference Ores contain significant quantities of lithium bearing minerals (either lithium micas or spodumene). Novel concepts are being tested in FAME to enhance conventional mineral processing technologies to produce concentrates of lithium minerals as well as more innovative bio-leaching studies to examine the potential for bio-leaching of Li-ores. Further test work is underway to examine optimum chemical processing routes to produce higher Lithium grade intermediary products that could be used by battery manufactures.

Keliber, a FAME Partner, is planning to mine spodumene bearing pegmatite ore bodies in Finland with production starting in late 2019 current mine plans indicate that after ramp up this mine has the potential to produce 10% of current world production. Portuguese FAME Partner LNEG has worked closely with mineral producer Felmica to identify the potential to produce commercially viable lithium mica concentrates by froth flotation from the Gonçalo pegmatite, Portugal.

This presentation examines potential European lithium resources from hard rock minerals, outlining the important mineral processing factors, key to producing viable lithium mineral

concentrates and the sub-sequent chemical processing options to enable upgrading of the lithium from 6-8% in a mineral concentrate to $\geq 35\%$ in Lithium Carbonate.

NOTES

Bottlenecks in the lithium supply chain, avoidable or inevitable?

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The lithium industry has expanded significantly over recent years and looks set to continue on this trend as demand from industrial and lithium-ion battery applications are forecast to exhibit strong growth over the next decade. Even when applying conservative forecasts of demand growth, the supply of raw materials consumed in lithium-ion batteries are expected to be places under significant strain, with lithium being amongst the raw material affected. The supply chain of lithium raw materials to battery component manufactures is complex, with multiple stages of processing and purification, providing multiple opportunities for bottlenecks to form. What methods could the lithium industry introduce to mitigate the formation of bottlenecks throughout the supply chain, or does growth provide too large a technical and financial challenge for the industry to expand in line with lithium demand.

NOTES

A lithium inventory for silicic magmas

Ben Ellis¹, Julia Neukampf¹, Olivier Bachmann¹ & Tomas Magna²

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²Czech Geological Survey, Prague, Czech Republic,

With the increased global demand for lithium comes the requirement to understand the geological reservoirs in which lithium is found. From a magmatic perspective, lithium is a moderately incompatible element in almost all rock suites, meaning that it remains primarily in the melt rather than being incorporated into growing crystal phases. As magmas evolve predominantly via crystal fractionation, the abundance of lithium in the melt progressively increases such that the most evolved magmas on Earth typically have the highest lithium contents. This behaviour is confirmed by the relationship between silicic magmas and economic lithium deposits. Despite this link, little is known in detail about where lithium resides in evolved magmatic systems. In an attempt to remedy this, we have studied numerous rhyolitic deposits from the Yellowstone hotspot track to try and constrain the pre- and post-eruptive processes affecting the lithium inventory.

Prior to eruption, rapid crystal growth traps small parcels of melt within the crystal, allowing the lithium content of the melt at the time of crystallisation to be determined. In the Mesa Falls Tuff (the 1.3 Ma ‘super-eruption’ from Yellowstone) that we focus on here, the melt inclusions contain up to an order of magnitude more lithium than the groundmass glass (36-55 ppm) indicating that lithium is volatile and leaves the magma during pre / syn-eruptive degassing.

However, unlike most elements, the rapid diffusivity of lithium means that it may remain mobile into the post-eruptive realm. The result of this is that the cooling history of a volcanic deposit has a profound effect on where lithium is hosted. In quickly cooled, glassy deposits the lithium predominantly resides in the glass (typical values for the Yellowstone rhyolites are 40-60 ppm in glass). By contrast, where the deposits have undergone slow cooling following the eruption and exhibit microcrystalline groundmass textures, most of the lithium is hosted within phenocryst phases. We interpret this as reflecting the continued incompatibility of lithium in the groundmass mineralogy of rhyolites (sanidine, plagioclase, and quartz) causing the last remaining liquids to be enriched in lithium (up to 250 ppm). The post-eruptive cooling history therefore controls the physical properties of the material hosting the majority of the lithium and thus the ease with which it can be mobilised from the volcanic deposit.

NOTES

Lithium resources in lacustrine sediments

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[1] Asher-Bolinder, Sigrid. 1982. *Lithium-rich Clays*. In: Erickson, Ralph L., ed. *Characteristics of Mineral Deposit Occurrences*, U.S. Geological Survey Open File Report 82-795, pp. 225-228, <https://pubs.er.usgs.gov/publication/ofr82795>

There is renewed interest in lacustrine deposits that host lithium bearing sediments. In the southwestern United States (US), there are several deposits of lithium-bearing clay found in Miocene- to Pliocene-aged sediments from saline lakes formed in evaporative, closed basins. Lithium-bearing clays are also found in sediments from a Miocene-aged caldera lake. Other international examples of lithium deposits hosted in lacustrine sediments include Bacanora, in Sonora, Mexico, where lithium bearing clays are found in lacustrine sediments deposited in half-grabens; Jadar, in Serbia, where jadarite, a new lithium-borate mineral, was discovered in an intramontane lacustrine sedimentary basin; and Macusani Plateau, Peru, where lithium has been discovered in water-lain, felsic, ash fall tuffs.

We have conducted geochemical and mineralogical analysis of samples from closed-basin, saline lakes in the US from Lyles, Arizona; Franklin Mills, and Hector, California; Fish Lake Valley, and Clayton Valley, Nevada; and from the caldera lake at McDermitt, Nevada. Geochemical analyses were conducted by X-Ray Fluorescence (XRF) for major elements, and a combination of Inductively Coupled Plasma Spectroscopy Atomic Emission/Mass Spectrometry (ICP-AES/MS) for lithium and trace elements. Mineralogical analysis consisted of powder X-Ray Diffraction (XRD) using random-packed and oriented (air-dried and glycolated) samples.

All samples are dominated by magnesium- and fluoride-rich clays. Most are smectite (hectorite), although illite was identified at McDermitt, and mixed-layer smectite-illites were identified in the Esmeralda Formation of Clayton Valley, Nevada. Lithium content ranges from 0.05 – 0.71 % in bulk sediments, and 0.12 – 1.24% in clay separates.

Data are analyzed for a link between lithium concentration, clay mineralogy, and the environment of deposition. A conceptual deposit model for lithium-rich clays [1] suggests the environments of deposition commonly include the following characteristics: a) closed-basin deposition of ash-derived smectites, b) hydrothermal activity in the basin or on its margins, c) evaporative concentration of lithium-enriched fluids within the basin, and d) co-occurrence of accessory elements such as uranium, beryllium, boron, and fluorine.

The suitability of clay as a lithium resource is dependent upon both the concentration of lithium and the position of lithium in the crystal structure of the clay, which dictates the cost of lithium recovery. In the smectite and illite clays of our sample suite, lithium is found in the octahedral structural layer, whereas in the mixed-layer smectite-illite clays, lithium is found as an exchangeable cation in the interlayer. We argue that the mixed-layer smectite-illite clay may be more suitable as a lithium resource because lithium may be more easily extracted from the interlayer than from the octahedral structural layer.

NOTES

Exploration for and Evaluation of pegmatitic Lithium Deposit in Ontario, Canada

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Ontario's spodumene-bearing pegmatites are known since 1952 [1]. Since then the pegmatite bodies have been explored in three campaigns. During the years 1955 until 1957 the first drill holes were drilled and a shaft was sunk. During the years 2008 until 2011 a second exploration campaign tested mineralization with more drilling. The last exploration campaign started in 2017 and it will lead to a new resource evaluation. The resource update will incorporate additional drill holes, channel samples and assay data. A new 3D model is under construction and first mining options are under investigation. In addition, to the resource definition work, a bulk sample has been taken and first processing investigations have been completed.

The strike length of individual pegmatites at surface ranges from 50 to 1800 m. The thickness varies from 1 to 10 m. The majority of the pegmatites is hosted by meta-sediments and/or biotite granite. Spodumene is the dominant Li-bearing mineral in all pegmatites. The pegmatite dykes show internal zonation with the development of a granitic or aplitic marginal zone and a spodumene, albite and quartz central zone.

Mineralisation comprises coarse-grained, fresh and pale green spodumene crystals oriented perpendicular to the strike of the pegmatite dyke. In the field, spodumene minerals are often in the size of a finger. In some areas, the length of these crystals is up to 1 m with a corresponding diameter of up to 12 cm.

Up to date investigations focused in the northern areas of the licences, where several spodumene-bearing pegmatites occur at the surface relatively close to each other. In total five 5 pegmatite bodies have been modelled in 3D. Currently, the deepest intersection is 300 m below surface. Drill spacing is less than 50 m. More than 200 drill holes have been completed. Lithium oxide contents of samples vary, but may reach up to 2.7 % (Li₂O). The new NI 43 101 resource statement is in preparation [2].

Next steps will include a pit optimisation study together with more detailed geotechnical investigations. In addition, the environmental and water situation is also under investigation. The project will be shown in the actual situation and the newest exploration results will be displayed.

[1] Pye, E.G. (1965): Georgia Lake Area, Ontario Department of Mines, Geological Report No. 31.

[2] S. Peters, T. Gorka, R. Schlüter, E.B. Teigler (2010): The Evaluation of Ore Deposits in View of the Requirements of Western Stock Markets. – Aachen International Mining Symposia, Third International Symposia "Mineral Resources and Mine Development", 26.-27.05.2010, Aachen

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Hard Rock Lithium Sources: Particular Considerations for their Exploration and Mineral Resource Estimation

Laura Donegan, Ben Lepley, Martin Pittuck, Robert Bowell

SRK Consulting (UK) Ltd

Hard rock sources of lithium include pegmatites, volcanic tuffs and lacustrine deposits containing volcanoclastic clays and/or evaporites. About half the world's lithium supply currently comes from pegmatites and the other half from brines; a handful of lacustrine deposits are currently undergoing feasibility studies.

Pegmatites either occur in swarms around a source intrusion or may be isolated if evolved from a partial melt. Lithium-rich rare metal pegmatite melts migrate several kilometres along pathways and into trap sites, both of which may be difficult to predict or trace.

Geophysical exploration is challenging due to low contrast between the pegmatites and country rock by most methods, however aerial image interpretation, good mapping and wide area trace element litho-geochemistry may be considered as useful exploration tools. An effective exploration strategy should seek to determine predictable trends in mineralogy and bulk chemistry across the pegmatite swarm.

Pegmatites may be lensoid sills, anastomosing dykes or may mould into trap sites such as refractive openings in shear zones and folded strata; They may have complex or ordered internal zoning of mineral content and texture; geological modelling of such zones is key to establishing resource estimation domains. Pegmatites often contain large crystals which can make it difficult to ensure drill core or channel samples are representative. Lacustrine deposits, on the other hand, often comprise laterally extensive basin fill with relatively constant lithium grades.

It is important to record proportions of mineral species in each sample to understand which minerals may contribute to a saleable product. The more common pegmatite ore minerals are spodumene, lepidolite and petalite which can be separated and concentrated on site. Concentrates can be roasted and/or chemically leached to release a pure lithium salt or used directly by specialised ceramics manufacturers. However, there are more than 150 known minerals that can host lithium as a major component, not all of which can be considered as having ore potential.

Drilling can be hampered by alternating soft and hard rock inside pegmatites. It is also important to choose suitable assaying methods for the accurate determination of lithium grade; some trace element methods add lithium borate and therefore do not report lithium; direct analysis by XRF is not possible due to the low atomic number of the element. In lacustrine sediments, presence of organic matter can complicate ICP analysis.

Some lithium bearing lacustrine volcanoclastic deposits in which lithium occurs within clay minerals such as hectorite or jaderite are under evaluation. A challenge with these is the relatively low concentration of lithium in the clay minerals resulting in relatively large volume low grade deposits.

Resource classification requires statistically defensible domains to be modelled with demonstrable continuity and with defensible geometry. Good confidence may require relatively dense drilling coverage in pegmatites to deal with multiple internal zones, irregular contact geometry, large crystal effects and rapid changes in thickness. Conversely, lacustrine deposits can have relatively predictable geometry and grade requiring less onerous drilling.

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Lithium in Mexico

Peter Secker

Bacanora

Bacanora Lithium is an AIM listed company focused on developing the world's next major lithium project in Mexico. The Company is rapidly commercialising the world class Sonora Lithium Project in Mexico which benefits from a large, scalable and high grade lithium resource with an NI 43-101 Measured plus Indicated Resource of over 5mt LCE. A Feasibility Study ('FS') has been completed, and results confirm the positive economics and favourable operating costs of a 35,000 tonnes per annum ('tpa') battery grade Li₂CO₃ operation. The FS estimates a pre-tax project Net Present Value ('NPV') of US\$1.253 billion at an 8% discount rate; an Internal Rate of Return ('IRR') of 26.1%, and Life of Mine ('LOM') operating costs of US\$3,910/t of lithium carbonate ('Li₂CO₃').

Over CAD\$20 million has been invested to date on exploration, studies and development of a lithium pilot plant near Hermosillo, which has produced high quality battery grade (>99.5%) lithium carbonate during ongoing testwork conducted over a 24 month period. This is a key differentiator and positions the Company favourably in comparison to its peers.

Bacanora boasts a highly experienced Board and management team, led by CEO Peter Secker who has built and operated over 5 greenfields mining projects over the past 35 years.

NOTES

Lithium in Argentina

José Gustavo de Castro Ale

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Complete Business & Project approach strategy of a Junior Company at Lithium Triangle, specifically Argentina based on the unique experience of designing, engineering starting up and operating 2 projects of lithium products production.

Main reasons because production is delaying against forecasting and possibilities to change and become a production facility in short term. Risks analyses of a Lithium Project in Argentina, mainly focus in Technological challenges, communities affairs, political relationship, suppliers/client influences and financial markets and shareholders. Why NRG is the right business model for advancing in Lithium production.

NOTES

A review of lithium occurrences in Africa

Nex, P.A.M.¹, Goodenough, K.M.², Shaw, R.A.³, Kinnaird, J.A.K.¹

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Lithium deposits worldwide are typically divided into two types; those derived from continental brines and those sourced from granitic rocks particularly pegmatites. In Africa there are no known resources, nor significant occurrences of continental brines containing economic quantities of lithium, which could be extracted using evaporation such as practiced elsewhere. Conversely there are many occurrences and several deposits of lithium minerals within pegmatites that are, or have been mined and may provide resources for the future.

Pegmatite-hosted lithium is typically found in LCT (Lithium-Caesium-Tantalum) pegmatites that are associated with the waning stages of continent-collision and orogenic collapse. From pegmatites, lithium is typically extracted from spodumene ($\text{LiAlSi}_2\text{O}_6$), and petalite ($\text{LiAlSi}_4\text{O}_{10}$), although lithium-bearing micas such as lepidolite and zinnwaldite may also be an important source.

In Africa, LCT-type pegmatites are most commonly associated with the construction of the Proterozoic super-continent Rodinia and Palaeozoic Gondwana, although some significant pegmatites of Archaean age are known.

In Zimbabwe, the Archaean Bikita pegmatite has been Africa's largest lithium mine from a single pegmatite. It has been mined for lithium since the 1950s and has also produced beryl, tantalite and caesium from pollucite. There are several active exploration projects in Zimbabwe evaluating other Li-bearing pegmatites including those near Harare, Fort Rixon, Benson and Kamativi. Other Archaean Li-bearing pegmatites include albite-spodumene pegmatites in the northern part of the Barberton Greenstone Belt and a minor occurrence in the Vredefort impact structure. LCT pegmatites of Archaean age, some enriched in Li, are known from greenstone belts in the West African craton, but are little-studied.

Proterozoic LCT pegmatites are known from Central Africa in the DRC and also from the Namaqua-Natal metamorphic belt in South Africa. The Manomo-Kitolo pegmatite swarm in the DRC contains spodumene, cassiterite and columbite-tantalite-bearing pegmatites that can be traced over a strike length of more than 15 km.

Pegmatites associated with orogenic belts formed during the end-stages of the amalgamation of Gondwana, during the Pan-African (c.650-500 Ma), occur in many African countries. In particular the Rubicon and Helikon pegmatites in Namibia are past producers of lithium from petalite and in the Alto Ligonha area of Mozambique lithium minerals have also been mined from the Morrua and Marropino pegmatites.

NOTES

The challenges of Li determination in minerals: A comparison of stoichiometrically determined Li by EPMA with direct measurement by LA-ICP-MS and handheld LIBS

Robin Armstrong¹, John Spratt¹, Yannick Buret¹, Andrew Somers² and the FAME WP2 team

¹ The Natural History Museum

² SciAps, Inc

The reconciliation of the mineralogical residence of Li with whole rock assays is important both in the estimation of resource and the design of mineral processing flow sheets for 'Hard rock' lithium deposits. The accurate determination of Li in minerals is challenging because of its low atomic mass meaning that it cannot be directly measured by standard electron beam techniques. Previous works have developed routines for the reduction of EPMA data to give stoichiometric estimates of Li content in several key Li-bearing phases such as spodumene and the Li-micas. These methods encounter a number of problems due the presence of other elements which cannot be determined directly by EPMA (O, H, B, and Be). Despite these limitations it is possible demonstrate the heterogeneous distribution of Li in key lithium-bearing phase such as the Li-micas.

Here we will present new data from a range of Li-bearing mineral phases from the Natural History Museums mineral collection, collected using EPMA, LA-ICP-MS and the Sci Apps handheld Laser Induced Breakdown Spectroscopy. This work compares and contrasts the results and may present a cost effective method for the direct determination of Li contents in minerals for the more accurate determination of Li residence in potential Li ores.

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Lithium market analysis

Toby Green

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CRU is a global analysis firm focused on mining, metals and fertilisers, and was one of the first commodity research firms to develop a robust and customizable model for forecasting electric vehicle (EV) demand, and its associated impacts on global commodities. At the Geological Society conference, we examine two of the key pillars of Lithium market analysis – Supply and Demand.

On the supply side, we shall explain how CRU estimates the quantity of metal that is likely to come to market in the coming years, and which nations are expected to be the global winners and losers in this race – what are tantalite tailings reprocessing plants, will China develop its resources and what should we make of Chilean mining policy? We will also unpack some of the bottlenecks in the supply chain – spodumene, Lithium Carbonate and Lithium Hydroxide processing facilities – and the impacts these have on the ultimate availability of battery-grade materials, as well as where the stockpiles will likely build up.

Our core focus in this presentation will be on demand. Firstly, we shall show how overall 2018 Lithium demand of 300ktpa rises to over 700ktpa by 2025, before focusing in on the key demand driver of EV batteries. The importance of this sector for Lithium is profound, and accurate forecasts can make or break a potential project in the pipeline. We demonstrate the complexity of modelling this sector and explore how this transformation will develop with respect to technological decision-making from battery-manufacturers, consumer patterns of behaviour, total vehicular costs of operating, threats from alternatives and various governmental policies around the globe. We will also touch on some scenarios of possible trajectories in this ever-developing market and provide our base case view for the next ten years.

We look forward to having you with us and welcome any questions you may have on the future of Lithium and electric vehicles.

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Assessing new and emerging develop projects from an investment perspective

Brock Salier

Sprott

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Sprott is active in the lithium space as investment banker, lender and principal investor. Our focus is on finding and supporting new discoveries and emerging development projects globally, and we are active across hard rock and brine as well as alternative lithium sources. Our presentation focusses on the key subtleties required for a successful development project, as well as a commercial comparison of brine to hard rock assets, and is based on detailed financial and technical reviews, both desktop and site based, of projects globally.

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Cobalt: perspectives on the currently essential ingredient for high-performance Li-ion batteries

Richard Herrington¹ & The CoG³ Research team²

¹*The Natural History Museum*

² <http://www.nhm.ac.uk/our-science/our-work/sustainability/cog3-cobalt-project.html>

The background to this talk is that battery industry currently uses 42 percent of global cobalt production, a critical metal for Lithium-ion cells. Although cobalt is not the only metal that can be used in Li-ion cells, NMC, NCA and LCO batteries provide the highest energy density and they all require cobalt. LCO is the battery of choice for Tesla, committed to production of 500,000 vehicles a year using Li-Co battery technology.

More than 95 percent of the world's primary cobalt comes as a by-product of nickel or copper mining with up to 60% of that production located in the DRC, some of which is linked to unethical mining practices. The recent price hike for cobalt suggests that we are already witnessing an increased scarcity of cobalt supply. An added problem may be that the price of copper and nickel has been dropping to current six-year lows, making some of the mines traditionally supplying by-product cobalt uneconomic.

In the short term at least, with a growing cobalt market, new resources are needed to secure the supply. There is no absolute shortage of cobalt resources to be found in the ground, in a range of environments away from Central Africa, some of these under our noses in Europe.

Our currently active research project, CoG³ is funded through the NERC SoS Minerals programme and is focused on the geology, geomicrobiology and geometallurgy of cobalt deposits with the aim of increasing recovery of cobalt from the diversity of natural deposits <http://www.nhm.ac.uk/our-science/our-work/sustainability/cog3-cobalt-project.html>. This talk will focus on the results emerging from this research where we have found that in some cases, simple changes to processing methods could extract more cobalt currently lost at existing or dormant operations. For other scenarios with more complex ores, implementation of innovative technology is the game-changer that will be needed to diversify the supply of mined cobalt for the battery industry.

NOTES

Geological Society

Fire Safety Information

If you hear the Alarm

Alarm Bells are situated throughout the building and will ring continuously for an evacuation.

Do not stop to collect your personal belongings.

Leave the building via the nearest and safest exit or the exit that you are advised to by the Fire Marshall on that floor.

Fire Exits from the Geological Society Conference Rooms

Lower Library:

Exit via main reception onto Piccadilly, or via staff entrance onto the courtyard.

Lecture Theatre

Exit at front of theatre (by screen) onto Courtyard or via side door out to Piccadilly entrance or via the doors that link to the Lower Library and to the staff entrance.

Main Piccadilly Entrance

Straight out door and walk around to the Courtyard.

Close the doors when leaving a room. **DO NOT SWITCH OFF THE LIGHTS.**

Assemble in the Courtyard in front of the Royal Academy, outside the Royal Astronomical Society.

Please do not re-enter the building except when you are advised that it is safe to do so by the Fire Brigade.

First Aid

All accidents should be reported to Reception and First Aid assistance will be provided if necessary.

Facilities

The ladies toilets are situated in the basement at the bottom of the staircase outside the Lecture Theatre.

The Gents toilets are situated on the ground floor in the corridor leading to the Arthur Holmes Room.

The cloakroom is located along the corridor to the Arthur Holmes Room.

Ground Floor Plan of The Geological Society

