Critical Metals - The Future of Lithium Extraction in the UK
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The speaker began by introducing his own background which included exploration, discovery and development of several mines in Western Australia, before returning to London about 14 years ago, during which time he spent about 8 years going down to the Congo and discovered the largest undeveloped phosphate deposit. This project was taken as far as DFS (Definitive Feasibility Study) in which $40 million was spent, but ultimately defeated by perceived sovereign risk. He was one of the founders of European Metals which included a lithium (Li) deposit in the Czech Republic near the border with Germany, in which the Czech Government took 51% of the ownership.

A similarity with the Cornish batholith was proposed by his son and so they travelled to Cornwall, took a sample from a roadside outcrop near St Austell. A sample was taken and sent to their laboratory in Perth, Australia, and it was essentially an ore grade Li deposit! The surprise therefore was that so little work had been done in UK on potential Li deposits, but a decade ago it was a very small market with a low price. Further investigation showed that BGS had taken a lot of samples in 1979 in places that were no longer available, but no assays had been made.

Fortunately, BGS donated 40 of these samples to the for assaying, which was especially valuable because access to these localities was no longer possible. However, it seemed that there was no point in exploring further, because there was no known method of processing such granite for Li. Consequently, an outline scheme for processing it was tested in Perth over a 6-month period, and negotiations with landowners provided exclusivity for mineral rights in both Devon and Cornwall, which were narrowed down to a specific site. They had estimated that there were about 500 million tonnes of stent, which is the rock left after water cannons had removed the clay, and 400 million tonnes of sands and 300 million tonnes of mica left after extracting the kaolin.

They digitised a lot of early OS maps and compared these with modern Lidar data, but there were almost no records of what had been put where, or where it had been sourced from! Additionally, it is almost impossible to get assays from tailings dumps is very hard because you don't have any lithology or continuity, so they turned their attention to the hard rocks instead, aided by the fact that there was a great deal of outcrop left after all the kaolin mining. In 2018 some holes were drilled, the first time anyone had drilled for Li in the UK. The first hole was drilled to 353 m and with other cores, and a low grade very disseminated deposit identified with polylithionite micas. However, there has never been a method of production from these micas and so a lot of work has gone into developing a new production process, aided by several Govt. grants, and the team has lodged seven patent applications.

The first part of the process is to concentrate the mica out of the whole rock, however this is not straightforward; DMS (Dense Media Separation) and froth flotation are not effective for mica and all the minerals have a similar density, so a form of chemical treatment had to be worked out with calcining and leaching, rather than acid treatment, given the high rainfall and environment in Cornwall. Clearly the quartz and feldspar have to be removed with as coarse a particle size as possible to reduce energy use, so the earlier idea of processing wastes from previous mining had to be dropped. All this preparatory work indicated the need for a pilot plant to prove the technology and this was built last year, able to handle 100 kg per hour and have already produced 99% pure lithium carbonate (Li CO3), which is battery grade. What is the future of Li batteries? There is a lot of battery research going but as yet there is no standard for Li grade material although the BSI has a committee to develop a document which will eventually be an ISO standard.

The Govt has of course developed a paper on critical minerals which British Lithium contributed to, including Li, Cobalt (Co), Nickel (Ni), Manganese (Mn) and the rare earth elements (REE), all of which are subject to serious geopolitical risk. Battery research seeks to reduce use of Co to about 10% (because that comes almost entirely from the DRC and Russia), but they still have four critical materials in them – Li, Mn, Ni & Co which are 'volatile' i.e. subject to geopolitical risk. In effect, we are trying to build and industry on four critical minerals. The batteries in an electric vehicle (EV) represents half of its cost and 40-50% of the weight.

An alternative type of battery is a lithium ferroan phosphate, of which the only critical element is Li, since both iron (Fe) and phosphate (PO4), abbreviated to LFP, are plentiful and cheap, but that chemistry is only available in China which has worldwide patents for this technology, albeit they expire this year. It is expected that there will be rapid move to LiFePO4 battery development; while they have a lower energy density, they do not suffer a fire risk, and have more charge cycles before being degraded. This field is one of great volatility, recent predictions of the price and availability of LiCO3 compared to lithium hydroxide (LiOH) have proved to be comprehensively wrong and the price of these two has actually inverted this year so that carbonate is now more valuable that hydroxide, because LFP batteries use the carbonate. Predicting where the market is going has proved to be very difficult therefore.

Recent events have impacted on the energy market; the fundamental policy driver for energy was environmental impact of emissions, but recent events have probably changed that more towards energy security. Then there is consumer demand for EVs; the biggest selling EV both in UK and USA is the same car – a Tesla 3, which is significant because the Govt mandate is still a long way off – 2030 here and 2035 in the EU, so this is purely consumer demand.

And we have seen the price of Li going from $6,000 per kg at the end of 2020 to $70,000 now, which if it stays at this price might even make EV cars unaffordable. The UK needs to secure its position since we are at enormous risk because we have in effect outlawed the biggest industry we have – car production. We make 1.3m combustion cars a year, of which 1.2m are exported, representing £84bn of GDP, employing 26,000 people, and yet in only 8 years, that industry will not exist! Changing our emphasis EVs, will require billions of £ investment and Govt grants, and we think the availability of raw materials will assist in this transition, and making it more likely that battery manufacturers will base themselves in the UK. But we are off to a bad start - we only produce one EV at the moment, the Nissan Leaf, which the only luxury EV is the Jaguar Ipace which is built in Austria, and the batteries for it come from Poland. The new Landrover Discovery is made in Slovakia from a new plant capable of producing 250,000 cars a year, so unless the Govt really tackles is and the community gets behind the supply of critical raw materials, there remains a huge threat to UK manufacturing industry.

Discussion

Q. Could you summarise the key battery types?
A. Two main ones: NMC batteries (Li Ni Mn Co oxide) which were developed with the highest energy density. The NMC 811 for example has 80% Ni, 10% Mn, and 10% Co. The LFP (Lithium Ferroan Phosphate) is a lithium ion phosphate cathode. There is a lot of proprietary tweaking between them. Lithium producers sell to material makers, not to battery producers, and the Govt understands this very well, but there is no LFP manufacturer in UK. The cost of Li ion batteries has been falling for many years and there is an inflection point of about $100/Kwh, such that the cost of an EV is close to the cost of a conventional car. However, with many market disruptions in the past year, the cost of raw materials has gone up again and the cost of LFP batteries has become much higher. However, LFP batteries have only one critical raw material.

Q. Are we likely to find Co elsewhere than the DRC?
A. Not sure, but one of the aspects of a raw material to a given country is the industrial need for the economy and the threats to supply. The UK imports all of them and often the price is inelastic because it is produced as a co-product, e.g. Co in the DRC is a co-product of large Cu mines, so while the price of Co might go up, no more Co can be produced because it is dependent upon the capacity of the copper (Cu) mine in the first place.

Q. Is there any Co in W Australia?
A. Some, but the average grade of Cu ores has been declining for many years.

Q. Back to Cornwall, where the kaolin has already been separated from the waste dumps, can you clarify why it was not possible to use the mica from that source?
A. All the mica dams now have solar farms with 99-year leases on them; others have been rehabilitated and grass covered, but there is no record at all of what has gone in them, so it's not possible to determine the source of the material. Also, it is very difficult to drill them because of circulation and hole stability issues, and with no lithological control, the density of drilling required would be enormous. The in-situ granite, by contrast, is relatively soft and the ground cost is fairly low, with no need to grind up silica or reduce the natural particle size. Using up waste material would be no doubt be supported, but it is already being recycled (by simple screening) to produce sand for the building industry and replenishing beaches.

Q. Is K extractable from the mica by hydrolysis?
A. Once you have mica separated from the crushed (relatively soft) granite, there are two ways of producing Li, one is by acid and the other is to heat it. Acid of course dissolves everything and this gives a problem with F (as in hydrofluoric acid). BL uses heat instead in a calcining process. Mica is also not amenable to simple screening because of size, shape and flexibility.

Q. Do all micas have Li?
A. No, it depends on granite's original geochemistry, post-emplacement cooling history and fluid mobilisation etc. A hand held XRF (X-ray Fluorescence) is quite useful in guiding prospectivity on site.

Q. What is the
A. The scaled-up project is planned to be up to 20,800 tonnes p.a. of $LiCO_3$, from 2 million tonnes of ore, which is a quarry rather than a big mine.

Q. And how many cars can be produced from that output?
A. A Tesla model S has about 65kg of Li in it, so our output might be able to meet about one third of UK demand, which is estimated about 70,000 tonnes p.a.

Q. What is the next step?
A. More drilling; a 10,000m from 50 holes to establish continuity to a higher level.

Q. Is your process very energy or emissions intensive?
A. We established a database of scores of existing hard rock mines and many proposed ones around the world including transport energy use/emissions, and an independent consultant did a benchmarking exercise per tonne of Li, the estimate was almost half that of other hard rock mines. There is negligible comminution work or transport and renewable power on site.

Q. What support does Govt. provide for critical raw materials?
A. Actually quite a lot from BAIS (Business and Energy Industrial Strategy) and DIS (Dept of International Trade) both of whom have critical raw materials staff working for them. It was BAIS that wrote the Critical Materials Strategy document last year which is an impressive document. And there has been a lot of grants provided and they seem to understand the issues, and the fact that the EV production is the biggest threat to industrial production since the second world war!

Q. Why does Britain not yet have a giga battery manufacturer?
A. The cathode active material makers sell to the giga manufacturers, the cell makers and battery assemblers, but there isn't one in the UK. Additionally, car batteries typically weigh two tonnes and they need to be made where cars are made for obvious reasons, but always because if transported separately otherwise would be regarded as dangerous goods. And there aren't many in Europe, only Germany, Poland and Sweden. The battery technology is very complex and so it is not easy to get into. Johnson Matthey for example invested £350 million but was unsuccessful but finally gave up. Then there is the question of tariff trade in the EU, whereby the car has to have 75% made in the UK to qualify. If the cells and cars are not made here, they will not qualify as tariff free.

John Bennett