What will Tesla Motors’ battery super plant mean for critical mineral demand?

Today, North American graphite miners are seen as the go-to suppliers for Tesla Motors’ planned lithium ion battery manufacturing facility – the Gigafactory.

Tesla’s move to an environmentally sustainable, secure source is seen as a win-win for the industry and for investors. Demand will rise for clean technology solutions while the world’s No. 1 supplier, China, diverts graphite exports to its domestic market.

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Contents

4 Profiles
The Industrial Minerals Data team

6 Tesla’s ambition
Building a battery super-plant in south-west US

7 An EV lithium-ion battery
How is it made and where are minerals used?

9 Conceived in the US, Made in China
US turns to Tesla to bring manufacturing back for the 21st century

11 Where do EV battery raw materials come from?
Graphite, rare earths, cobalt and lithium: how secure are these global supply chains?

14 Sourcing graphite
Does Elon Musk know where Tesla’s battery-grade graphite comes from?

17 Tesla’s demand for critical minerals
How many tonnes of critical minerals will Tesla need?

20 What critical minerals are on Tesla’s doorstep?
A look at emerging projects and the next generation of mines in North America

26 Global critical minerals hotspots
From Chile to Russia to Australia: a new generation of critical mineral mines are being developed to western standards across the world

33 A matter of national security
US government now seeing critical mineral supply as a matter of national security

IM Data | Graphite
Graphite prices from Africa, Austria, China, Europe, India and Sri Lanka
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• Full access to data from 1988 onwards

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Profile | Industrial Minerals Data

The Team

CLICK ICONS TO CONNECT

Simon Moores, Manager (London)
- Manages a team of analysts in the UK and China who specialise in the collection of sensitive industry data and provide detailed analysis on niche, private mineral industries.
- Established Industrial Minerals Data as the first major new business launched by the company since its inception in 1967.
- Experience in niche, critical and industrial mineral industries joined Industrial Minerals in 2006 with a specialist focus on battery raw materials, particularly for EV applications, including graphite and lithium.
- Education in Geology with Geography BSc from the University of Birmingham, UK.

Andy Miller, Analyst (London)
- Focus on primary data collection and analysis for the graphite and fluor spar industries by maintaining a global portfolio of private contacts.
- Joined Industrial Minerals Data in 2012 from investment management company Invesco Perpetual where he tracked and analysed the performance of different funds.
- Education in Economics with a first-class honours degree from the University of East Anglia, UK.

Shruti Salwan, Analyst (London)
- Focus on primary data collection and data analysis for graphite and fluor spar.
- Joined Industrial Minerals Data in 2012 after more than seven years’ experience as an industry analyst in the metals, plastics, and packaging sectors.
- Educated in English literature with a post-graduate degree in mass communication from Delhi University, India. She also gained an MBA from IMT Ghaziabad (India) specialising in finance.

Albert Li, Analyst (Shanghai)
- Manages all the data collection and analysis from China with a focus on, but not restricted to, graphite and fluor spar.
- Joined Industrial Minerals Data in 2012 after previous experience as a trader of titanium minerals (ilmenite, rutile) and zircon for Astron Limited, where he was responsible for selling minerals nationwide in China.
- Educated in foreign languages from Shandong University of Architecture, Jinan City, China.

Benjamin Ash, Advertising (London)
- Responsible for advertising and product sponsorship sales across the whole of the Industrial Minerals Group.
- Joined Industrial Minerals in 2012 with a specialist focus on critical minerals such as graphite and lithium.

Industrial Minerals Data is an online price service for the non-metallic minerals industry specialising in graphite and fluor spar. Through online portals, Industrial Minerals Data offers market pricing insight and regular analysis on niche mineral markets.
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Telsa’s ambition: the equivalent of today’s global battery production in one plant

Gigafactory process flow

Plan: to build the world’s biggest electric vehicle (EV) battery production facility in south-west USA
Goal: to ramp up to a 35GWh annual capacity, reduce the cost of the battery packs, make EVs more affordable and spark mass market uptake
Cost: Up to $5bn
2020 Vehicle Volume: 500,000/yr
2020 Gigafactory Cell Output: 35 GWh/yr
2020 Gigafactory Pack Output: 50 GWh/yr
Minerals needed: graphite, lithium, cobalt, copper, bauxite, nickel
Plant footprint: 10m ft²
Total Land Area: 500-1,000 acres
Employees: 6,500

From raw materials to electric vehicles: Tesla’s production flow

GLOBAL PRODUCTION OF MINERALS IN 2013 (NOT TESLA’S SOURCE COUNTRIES)

Lithium
- China 54%
- Australia 25%
- Argentina 11%
- Other 10%
Total: 125,000 tonnes
*Cathode Manufacturing

Cobalt
- DR Congo 55%
- China 6%
- Canada 6%
- Russia 5%
- Australia 4%
- Other 24%
Total: 110,000 tonnes
*Cathode Electrode

Bauxite
- Australia 28%
- China 18%
- Brazil 13%
- Canada 11%
- Indonesia 11%
- Other 30%
Total: 263m tonnes
*Aluminium foil

Copper
- China 31%
- USA 13%
- China 9%
- Peru 7%
- Brazil 6%
- Russia 4%
- Other 36%
Total: 17m tonnes
*Copper foil

Graphite
- China 60%
- India 25%
- Brazil 11%
- Canada 6%
- Other 3%
Total: 375,000 tonnes (flake)
*Cathode Electrode

Various raw materials
*Separator Manufacturing

Anode Manufacturing

Anode Electrode

Electrolyte manufacturing

Can & cap

Separator

Winding

Cell assembly

Module

Cell

Module

Cell

Module

Vehicle assembly (Fremont, CA)

Battery pack recycling

Battery pack lifetime usage

Pack enclosure

New Local Renewables Solar and Wind

GLOBAL PRODUCTION OF MINERALS IN 2013 (NOT TESLA’S SOURCE COUNTRIES)
The EV lithium-ion battery: How is it made and where are minerals used?

1 Cell production
- **Minerals used**
  - **Anode**
    - Flake graphite
    - Synthetic graphite
  - **Cathode**
    - Lithium chemicals
    - Cobalt
    - Nickel
    - Aluminium
  - **Electrolyte**
    - Lithium chemicals

2 Module production
- **Minerals used**
  - **Magnets**
  - Rare earths*

3 Battery pack production
- **Minerals used**
  - **Magnets**
  - Rare earths*

4 Installation
- *Tesla’s cars do not use rare earths

General schematic, Tesla uses a cylindrical design

A Nissan leaf pack

Tesla’s assembly line in California

*Telsa’s cars do not use rare earths
Developing the largest Lithium-Tantalum Deposit in the world

Strong project economics: NPV 8 at $488MM & IRR 33% pre-tax\(^{(1)}\)

Annual Production Forecast: 26,600 tons of battery grade lithium carbonate and 206,000 pounds of Tantalum\(^{(1)}\)

99.9% pure Li\(_2\)CO\(_3\)\(^{(2)}\) & Low iron content spodumene concentrate for the ceramic & glass market\(^{(3)}\)

All infrastructures on site: power line, roads, airport & camp

REFERENCES:
\(^{(1)}\) PEA Press release 21/11/2011
\(^{(2)}\) Press release 25/04/2012
\(^{(3)}\) Press release 05/09/2013
Conceived in the US, Made in China

Simon Moores

When Tesla Motors Inc. announced its ambition to build the world’s largest electric vehicle (EV) battery plant in February, it was a strong rallying call for the return of modern, industrial manufacturing in the US.

Many have felt in the last two decades that ‘made in the US’ has in reality become ‘conceived in the US, made in China’ – but Tesla’s plan has the ambition and scale to return the world’s largest economy to its manufacturing heyday.

The loss of manufacturing jobs to lower cost regions like China is something that grates in the US. This is certainly true of the country’s flagship company, Apple Inc. which creates its ideas in California but manufactures its products in China.

It was only on 25 February, one day before Tesla revealed its grand plans, that the White House issued the following statement:

"Keeping America at the cutting edge of technology and innovation is what is going to ensure a steady stream of good jobs into the 21st century. And that's why we're here today – to take new action to put America at the forefront of 21st century manufacturing."

The Obama Administration outlined the goal of bringing back the manufacturing boom of the 1940s and 1950s and explained that just because the world has changed, this does not mean large-scale manufacturing, which employs an army of people, cannot be achieved. This is of course true, however, manufacturing has a different face in the 21st century.

The revolution the US hopes for is likely to start with advanced materials – lightweight metals that are manufactured in Germany and Japan at present. These then create the base for an array of industrial products such as cars, helicopters, and aeroplanes.

Batteries also play a crucial role in this, which is why Tesla’s ‘Gigafactory’ announcement was so timely.

The discussion, however, is quickly moving to where the country will source the critical minerals and metals that will fuel this manufacturing revolution.

The US has been stung once with China’s rare earths blockade on Japan in 2010 over a fishing vessel dispute. It was the first time niche minerals were used as a political tool and put the critical mineral situation on the map. As a result of the blockade, prices spiked to all-time highs, specialist manufacturers suffered, and the world is now more aware of what their products are made of and where their minerals come from.

To avoid another rare earths situation in the future, supply chains will have to be carefully reviewed to assure security and sustainability otherwise any manufacturing revolution will be fundamentally flawed.
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Where do EV battery raw materials come from?

Simon Moores

Many minerals and metals go into making a modern EV battery. Assuming Tesla is to use today’s lithium-ion battery design, and assuming no major sourcing changes for these raw materials occur in the next six years – which is highly unlikely considering how long it takes to develop, fund, and build a mine – the majority of these battery minerals would have to be sourced from higher risk countries.

It is important to note that Tesla does not use rare earths in its EV batteries and that its cobalt is not sourced from the Congo.

China has a strong grip on the global supply of flake graphite producing between 60-70% of output over the last 25 years.

 Flake graphite is the starting raw material for the battery anode component and is mined in northeast and central east China.

The technology to turn flake graphite into battery-grade, spherical graphite is also only commercially used in China with Japan adding the finishing coating before it is turned into an anode material.

While the industry has had an exploration boom over the last three years, no new flake graphite mines have been established outside of China for a generation.

Graphite from China

Leading supplier: China
Percentage of global supply: 60% (flake)
Active US supply: none
Lithium-ion battery use: anode

Global graphite production 2013

- China 60%
- Brazil 23%
- India 7%
- Canada 4%
- Other 6%
Total: 375,000 tonnes (flake)

Canada is home to the world’s “newest” non-Chinese graphite mine which opened in the 1980s, but the USA has no active graphite mines at present and only two exploration projects compared to the abundance of juniors based in Canada.

Other sources include: Brazil, India and Mozambique.

Lithium produced in Salar de Atacama, Chile
China’s grip on rare earths has been well publicised. Until recently, one mine in Inner Mongolia produced 95% of total global rare earth element supply (110,000 tonnes), a situation that was used as political currency with Japan in 2010 over the arrest of a Chinese fishing boat captain in disputed waters.

When China decided to enact a rare earths blockade on Japan, niche minerals shot into the limelight.

The situation highlighted the fragility of the speciality minerals and metals supply chain. For decades the world’s most developed economies had abandoned supply security in favour of low cost imports. The rare earths stand-off changed this.

Since 2012, China’s supply grip has loosened a little to 86% of global supply. There has been minimal new supply since the 2010 crisis despite mines coming on stream in Australia and the USA. Both mines are producing the rare earth element neodymium, a key component of permanent magnets used in an EV electric motor.

It will take some time for both mines to reach their combined operating capacity of 40,000 tpa. They will also not supply all of the critical light and heavy rare earths the US requires. Nonetheless, attempts to diversify supply chains signifies a step in the right direction for the country’s critical mineral security.

The world’s only major supplier of cobalt is the Democratic Republic of Congo, one of the highest risk countries in the world. Other smaller sources include: Canada, China, Russia and Zambia. The central African nation produces 55% of the world’s 120,000 tpa of cobalt, with the next largest supplier being China with 6%.

Despite this supply dependence on a war-torn region, cobalt was not specifically cited by the USA’s Dodd-Frank Act which, much like conflict diamond legislation, named conflict minerals used as currency to fund wars in Africa.

The idea behind the Act was to force companies sourcing the materials such as tin, tantalum, gold and tungsten from Africa to disclose their dealings, in order to limit funding to rebel groups which keep the area in perpetual conflict.

Although cobalt met these qualifications, fears of destabilising the market discouraged the US government from including it under the Act. While this has prevented market disruption, with few other viable alternative sources, supply insecurity remains.

85% of cobalt supply comes as a by-product of nickel (50%) and copper (35%) production, with only 15% of supply from dedicated cobalt mines. China and the USA are the leading consuming nations of cobalt accounting for 18% and 35%, respectively.
Lithium from Chile

Leading supplier: Chile
Percentage of global supply: 54%
Active US supply: Silver Peak, Nevada (Rockwood Lithium)
Lithium-ion battery use: cathode

Global lithium production 2013

- Chile 54%
- Australia 22%
- Argentina 11%
- China 10%
- Other 3%
Total: 125,000 tonnes

Lithium carbonate and hydroxide is used as the starting raw material for cathodes in lithium-ion batteries. Chile is the world’s leading lithium chemicals producer from the Salar de Atacama in the country’s north.

Underground brine resources are the world’s primary and lowest cost source of lithium. The only other commercial source of lithium is through mined hard rock, spodumene, the largest source of which is in Australia.

The US produces small amounts of lithium compounds at its only brine operation in Nevada, which specialises in hydroxide. The USA also has spodumene resources which have been mothballed.

Since the Atacama resource began its commercial operation in 1996, Chile has been a steady, stable source of low cost lithium for global use.

While there are few doubts over the future of operations in Chile, should any supply crisis hit the country, the US would not be able to source all of its lithium domestically. Other major active sources include Argentina, which is operated by an American company, and Australia, which is owned by the Chinese.

Flake graphite concentrate being unloaded in central China

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Does Elon Musk really know where Tesla Motors’ battery grade graphite comes from?

The chances are no, and neither do the sellers as the spotlight intensifies on the sourcing of critical minerals and metals that will fuel the new age battery economy

Simon Moores

Tesla Motors’ CEO Elon Musk was forced to defend the company’s sourcing of graphite used in its electric vehicle (EV) batteries following a Bloomberg article linking the company to controversial graphite mining in China.

The link between Tesla - the US’ most high profile EV manufacturer - and environmentally damaging practices as far upstream as the mine seems harsh but is becoming unavoidable for large public companies.

In reaction to the story, Musk took to Twitter to explain that the company’s graphite was sourced in Japan and was mined on a “clean way”. But that didn’t really tell the whole story.

In fact, Japan does not operate any graphite mines. It sources all of it’s product from China.

Japan has huge trading houses that scour the world for raw material to fuel its economy. These trading houses are generally ahead of the curve in terms of sourcing specific products and spotting emerging market trends for demand and it’s certainly true for graphite and batteries.

After all, Japan is the world’s leading producer of batteries and China the world’s leading supplier of graphite.

The establishment of large trading houses is a counter balance to the fact the country has very little domestic mining but a huge demand for minerals as one of the world’s leading economies.

Tesla will buy batteries. The battery manufacturer will buy graphite from one of these traders. The traders will buy graphite from a supplier in China.

So the question is whether Japan will know which mines Tesla’s battery grade graphite comes from? Because if Japan is not 100% sure, then neither can be end users like Tesla.

Japan will of course know the detail of it’s suppliers. But many major graphite producers in China don’t mine from around the immediate area where they operate.

For example, Shandong province is China’s second largest graphite producing region. The mines in the area have become low grade and costly to mine in recent times. This has led to many companies stopping the mining in their local mines in favour for cheaper graphite produced in the number one province, Heilongjiang. So while you may buy from a Shandong based company, the likelihood is that the graphite won’t be sourced from there.

Heilongjiang is a vast province which mines coal and graphite across a large area. It is mining on a mass scale.

It is the lowest cost region in the world for graphite production. And it is also under the media spotlight for graphite dust and resource efficiency issues.

Luobei and Jixi are the two main areas where mining takes place, each with numerous small mines feeding into local processing plants. This product is then either exported direct or transported by rail throughout China direct to end users or to graphite processors which blend different raw materials.

The number of people the product can go through before it is even bagged and sold to Japan is more likely to be multiple and less likely to...
be one. But the scale and the complexity of graphite being transported around China means sourcing the specific mine that it comes from is very difficult, near impossible.

This is an increasing challenge for companies like Tesla in a world which is quickly becoming more transparent. The point is that Tesla or any other company using a basic industrial product like graphite shouldn’t even have to think or worry about how it’s mined.

Why is it the company’s responsibility? After all Tesla is not a mining company.

But supply chain responsibility and transparency is one of the most important emerging trends for niche minerals and metals. Particularly, if these raw materials are being used in green technology.

After all if you based your whole ethos on green, clean technology, use this as a commercial hook, then supply chain transparency is the price to pay.

A perfect example of this is the new conflict minerals legislation in the US which forced companies like Apple to declare where their minerals and metals that make their iPhones and iPads come from.

The idea behind it is if they were forced to declare the provenance of their raw materials, it may shame the company into switching to more ethical sources.

The Dodd-Frank legislation was designed to stop minerals being used as currency in central Africa to fuel the perpetual war on the region, a modern version of the conflict diamonds situation. If they can stifle the revenue the area gets from mining, the war may stop.

But consequences of this critical minerals legislation which came into effect last year could be far reaching.

Consumer awareness about these issues has increased to a level never seen before (with thanks to social media). High profile, public companies in the US in particular are under an intensifying spotlight.

In an EV battery, graphite and rare earths will come from China, cobalt from Africa, and lithium from Chile.

A rare earths blockade by China - which controls 95% of the world’s supply - for political reasons has already badly impacted US consumers in 2010. What is to say trade tensions between the US (or Japan) and China won’t lead to a similar situation? How comfortable are the US in sourcing the majority of cobalt from the Congo?

The risk for the US is that the conflict minerals legislation could be used as a basis for other trade restrictions on other niche minerals and metals, industries which are generally inflexible and heavily reliant on a single-source country.

Battery supply chains are still quite immature considering the speed the industry is developing at.

A lot can change in seven years when Tesla plans to hit capacity, but the risks to any active producers of batteries today are clear.

Most probably clearer than where Tesla’s graphite comes from today.
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- CLOSE TO SURFACE DEPOSIT -
- GRAPHITE CONCENTRATE OVER 94% TGC -
- GRAPHITE RECOVERIES OVER 96% -
- LARGE FLAKES -
Tesla’s demand for critical minerals

Simon Moores

Tesla plans to produce 500,000 EVs at capacity by 2020. The following critical minerals demand projections are based on:

- Tesla chooses lithium-ion battery technology to power its EVs
- The minerals analysed are applied in Tesla’s chosen lithium-ion battery technology
- These minerals continue to be required at current lithium-ion battery utilisation rates
- Tesla’s production reaches targeted capacity by 2020

Graphite

Demand from Tesla plant*: 126,000 tpa
Spherical graphite demand: 50,000 tpa
Total flake graphite supply 2013: 375,000 tonnes
% increase on today’s battery demand: 152%
% increase on today’s total flake graphite demand: 34%

*Tesla will be purchasing battery-grade graphite, not flake graphite

Graphite is the largest input battery raw material by volume but batteries are still quite an immature market for the industry which is why the industry is looking at the sector for the future.

The Tesla plant offers the most significant demand increases, in volume terms for graphite, of all critical minerals. At full capacity, Tesla could be consuming 126,000 tpa of flake graphite alone in a bullish scenario and 83,000 tpa in a conservative case.

The bullish numbers are 152% more than today’s volume consumed in batteries worldwide. For flake graphite demand as a whole, this is still a huge 34% increase from today.

The company will not be buying flake graphite direct but the processed battery-grade material, spherical graphite. It takes 2.5 tonnes of flake graphite on average to make one tonne of spherical.

Therefore, Tesla could be purchasing anything between 33,000 and 50,000 tonnes of spherical graphite.

Should production efficiencies improve, the demand for flake graphite should fall to between 50,000 tpa and 75,000 tpa.

The company could also choose to use synthetic graphite, like it does today which could lead to similar increases in synthetic graphite demand. Synthetic product is generally higher cost to produce than its naturally mined counterpart. Today about 60% of battery-grade graphite used is natural versus 40% synthetic.
London-based Roskill Information Services estimates that the battery market for cobalt, assuming no market shift, away from NCA cathode materials, can increase by 20% or close to 7,000 tpa with a Tesla plant at full capacity.

The battery market is today the leading consuming sector for cobalt accounting for 38% of total demand or 41,000 tonnes.

Cobalt, like lithium, has benefited greatly from the expansion in battery demand from mobile technology and as a result has experienced rapid growth, particularly since 2010, growing on average 9% a year.

Of all critical minerals, lithium has seen the most impressive growth from the battery market over the last two decades. Owing to the advent of the rechargeable lithium-ion battery in mobile technology, the battery market has grown from a niche market to the major demand driver for the industry.

The two charts adjacent outline the significance of battery demand for lithium suppliers from 7% in 1992 to 41% in 2013.

Demand from Tesla’s plant operating at capacity alone could increase battery-grade lithium demand by 50% or 25,000 tpa and overall lithium chemicals demand by 20%. This figure, in a bullish scenario, could be as high as 38,000 tpa.

**Cobalt**

<table>
<thead>
<tr>
<th>Demand from Tesla plant:</th>
<th>7,000 tpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cobalt supply 2013:</td>
<td>110,000 tonnes</td>
</tr>
<tr>
<td>% increase on today’s battery demand:</td>
<td>17%</td>
</tr>
<tr>
<td>% increase on today’s total demand:</td>
<td>6%</td>
</tr>
</tbody>
</table>

**Lithium**

<table>
<thead>
<tr>
<th>Demand from Tesla plant:</th>
<th>25,000 tpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lithium supply 2013:</td>
<td>125,000 tonnes</td>
</tr>
<tr>
<td>% increase on today’s battery demand:</td>
<td>50%</td>
</tr>
<tr>
<td>% increase on today’s total demand:</td>
<td>20%</td>
</tr>
</tbody>
</table>

Shift from industrial to technological demand for lithium

- **Lithium1992**
  - Glass and ceramics: 38%
  - Pharmaceuticals: 13%
  - Chemical manufacturing: 13%
  - Lubricants: 11%
  - Batteries: 7%
  - Air conditioning: 4%
  - Others: 14%

- **Lithium 2012**
  - Batteries: 41%
  - Pharmaceuticals: 2%
  - Lubricants: 11%
  - Continuous casting: 2%
  - Frits (glazes): 6%
  - Air conditioning: 5%
  - Glass: 6%
  - Aluminium: 2%
  - Other: 25%

Source: IM Data, USGS, SQM

**Potential critical mineral growth from Tesla’s battery sector plant**

- Flake graphite: 154%
- Lithium: 50%
- Cobalt: 17%
In the very near future, a new generation of renewable energy sources spawned by Graphene will begin to change the world forever.

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Change begins in the infrastructural and automotive sectors. It ends with power-generation for nations.

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What critical minerals are on Tesla’s doorstep?

Simon Moores

Over the last five years an exploration boom for niche, critical minerals has engulfed North America. The search for battery minerals in particular has intensified since 2011 and uncovered significant volumes of quality resources of key minerals such as graphite, lithium, rare earths, and cobalt.

While many of these future mines will need funding to start operations, the opportunity to diversify from today’s leading suppliers such as China and the Congo is there for the taking. It is proof that there is no shortage of critical mineral resources in the ground, but getting battery-grade product onto the market is a different story.

Here is a summary of the key regions, in alphabetical order by state or province that have led the North American mineral boom and some of the companies that have driven it. This list is not exhaustive, but serves to highlight the wide range of minerals available in North America compared to the minimal mining that takes place today.

US

Alabama
The southern US state hosts one of only two graphite development projects in the USA (also see Alaska). Alabama Graphite Co is seeking to return the Coosa Graphite Project to production for the first time since the 1960s.

The company, which is the closest flake graphite project to Tesla’s proposed battery plant, is relatively new on the graphite scene and has recently completed a preliminary exploration survey as it prepares to progress to drilling.

Alaska
Graphite One Resources is one of the leading graphite exploration projects in the industry with a flake graphite resource on the Seward Peninsula in Alaska. It is also the largest graphite resource in the USA and one of only two projects in the country (see Alabama).

The USA’s only lithium producer at Silver Peak, Nevada
The project is only one of a handful of NI 43-101 resources compliant to Canadian regulations and measures 284.71 million tonnes (inferred) at 4.5% C.

Ucore Rare Metals is developing two rare earths projects in Alaska, Bokan Mountain and Ray Mountains. The Bokan Mountain project is NI 43-101 compliant and has higher ratios of dysprosium, terbium and yttrium. The company aims to produce 2,250 tonnes of rare earth oxides from its flagship project which includes 95 tonnes of dysprosium oxide, 14 tonnes of terbium oxide and 515 tonnes of yttrium oxide.

The Ray Mountains project hosts rare earths in alluvial sediments in addition to other heavy mineral sands.

California

The Golden State is not only home to Tesla Motors’ HQ but also one of only two rare earths mines outside of China and North America’s only producing mine, Mountain Pass.

Mountain Pass is a past producing mine that was reactivated by MolyCorp Inc. in 2010. The mine was previously operating between the 1960s and 1980s and boomed in the earlier years owing to the demand for europium in colour television screens. The mine closed in 2002 owing to the market prices for rare earths being kept low by Chinese production and also because of increasing environmental restrictions in the USA.

Simbol Materials Inc. is developing a unique process to extract battery minerals, lithium, manganese and zinc from geothermal power plant wastewater. The company was founded in 2008, and is based in the Salton Sea. It has been developing global partnerships with key Japanese traders and is privately owned.

In 2013, it produced the world’s first battery-grade lithium hydroxide from geothermal brine.

Idaho

The north-west state is home to the Idaho Cobalt Project operated by Formation Metals Inc. The company estimates it could produce 1,500 tonnes of high purity cobalt in production each year. The project has been NI 43-101 compliant since 2007. Formation has a secondary cobalt property in the state – Black Pine Property – which is 17 miles from the town of Salmon.

US Rare Earths Inc holds rare earths exploration claims in the state for the Lemhi Pass, Diamond Creek, and North Fork Properties.

Nevada

Known as the Silver State because of its rich mining history, Nevada has risen to prominence once again in recent years thanks to being the location of the only active lithium brine operation in North America. Silver Peak is the home of lithium production in the US.
Operated by Rockwood Lithium (formerly Chemetall), Silver Peak produces the key battery raw materials lithium carbonate and lithium hydroxide. In a global context, Silver Peak is a small operation contributing 6,000 tpa to the company’s production capability of 23,000 tpa (29% of global supply). Government backing to expand its hydroxide production means this is likely to become Silver Peak’s primary product going forward.

The company also has a value-added lithium chemical plant at Kings Mountain, North Carolina producing a wide range of products for battery, pharmaceutical, and fuel cell industries. This is supported by its New Johnsonville, Tennessee plant which produces butyllithium, a feedstock chemical for rubber and plastics markets.

Nevada is also the home of Western Lithium which in early 2014 received the green light to begin its lithium mine in Humboldt County. The operation is seeking to extract lithium from hectorite clay and process on-site into battery-grade material. Initially, the mine will focus on the supply of drilling mud to the oil and gas market allowing the company to build a revenue stream before eventually expanding into lithium production.

Clayton Valley is the state’s lithium exploration hotspot with a host of companies exploring and developing for new brine resources in and around Rockwood’s Silver Peak operation. These companies include: Rodinia Lithium Inc and sites developed by Amerillithium Corp.

Other areas which became subject to exploration work in lithium’s boom years of 2009-2011 were Big Smoke Valley (Ultra Lithium Inc and Li3 Energy) and Fish Lake Valley (Lithium Corporation and International Lithium Corp).

All projects in Nevada, besides Western Lithium, are pursuing brine extraction of lithium as opposed to hard rock, spodumene or petalite mines.

In terms of rare earths, Elissa Resources Inc is developing the Thor REE Project in the south, close to the border with California. It is 26km east of the USA’s only active rare earths mine, Mountain Pass operated by Molycorp in the neighbouring state. Assay samples show higher proportions of heavy rare earths in the deposit.

**North Carolina**

FMC Lithium Corp, the only other active lithium producer in the US, has a processing operation in Bessemer City, North Carolina producing lithium carbonate and lithium hydroxide as well as a host of other lithium derivative chemicals. The company sources its minerals from its large-scale brine operation in Argentina.

In total FMC produces about 10-15% of global lithium supply which equates to 13-17,000 tpa. The majority of this volume is produced in Argentina and either processed on-site or at its North Carolina plant.

**Texas**

Hudspeth County hosts the Round Top rare earths project owned by Texas Rare Earth Resources Corp. The project has a higher composition of heavy rare earths with a PEA study showing 524,000 tonnes of rare earths 72% of which were heavy elements.

**Wyoming**

Rare Element Resources has the only rare earths exploration project in Wyoming, and one of four rare earth projects at feasibility or pre-feasibility stage in North America. The Bear Lodge development is NI 43-101 compliant and has a measured resource of 2.84m tonnes at 3.88% total rare earth oxides. The company is anticipating a mine life of 40 years.
Canada

British Columbia

Critical Elements Corp is developing the Rose lithium-tantalum deposit in northern British Columbia. The company is at an advanced exploration stage and is planning to produce 26,600 tpa of battery-grade lithium carbonate and 206,000 lbs/year (94 tpa) of tantalum, the hi-tech mineral used in capacitors and high power resistors.

The Rose project is the world's largest lithium-tantalum deposit.

The province is also home to one of North America's two active graphite mines. Eagle Graphite has been mining flake graphite from near Nelson since the mid-2000s and produces between 1,000-2,000 tpa. The company has an NI 43-101 compliant resource and is an active flake graphite producer along with Imerys Graphite & Carbon in Quebec.

A handful of other graphite projects are located just outside of Vancouver and south-east of the province, close to the border with Alberta.

British Columbia also has a number of exploration stage rare earths projects operated by: Artic Star, Spectrum Mining, Eagle Star, American Manganese, Canadian International Minerals, Bolero Resources Corp.

Northwest Territories

Avalon Rare Metals Inc is developing the Nachalacho rare earths project located at Thor Lake and by April 2014 had spent C$94m on exploration and development. The project, which contains larger proportions of heavy rare earth elements, last year struck a 10-year agreement with Solvay for toll refining which takes away one of biggest challenges with rare earths – the processing and expertise of creating products acceptable to the market.

Fortune Minerals operates a gold-cobalt-bismuth-copper property called the NICO project which contains over 37,000 tonnes of cobalt. The company is looking to build a mineral processing plant in Saskatchewan to produce high grade cobalt for the battery market in addition to other associated metals.

Ontario

Northern Graphite and Ontario Graphite are the most advanced flake graphite developers in the province.

Northern Graphite was the first Canadian graphite developer of the new exploration era and has been developing the Bissett Creek deposit for nearly a decade. The project has a measured and indicated resource of 69.7m tonnes and an inferred resource of 24m tonnes at an average grade of 1.74% C. Bissett Creek has a higher proportion of large flake graphite with the company estimating up to 90% of the volumes will be +80 mesh or higher.

Ontario Graphite is overseeing the reopening of the Kearney mine which last operated in the early 1990s. The company is seeking to restart flake graphite production at a rate of 20,000 tpa. It will mine from an NI 43-
101 compliant resource with an indicated tonnages of 51.5m tonnes at 2.14% C and inferred tonnages of 46.8m tonnes at 2% C.

Zenyatta Ventures Ltd is developing a unique, hydrothermal style graphite project in Thunder Bay, with the aim of producing high purity material that can compete in both natural and synthetic graphite markets. The initial resource estimate for The Albany Project is 25.1m tonnes at 3.89% C, containing 977,000 tonnes of graphitic carbon. The company is pushing to complete its preliminary economic assessment in 2014.

Along with a rare earths project in North West Territories, Avalon Rare Metals Inc is developing a lithium-tantalum project in Ontario called the Big Whopper at Separation Rapids, 100km east of Kenora. Gossan Resources is also developing a lithium-tantalum project in the same area.

Other hard rock lithium developers in Ontario include Rock Tech Lithium Inc (Thunder Bay Project), and Ultra Lithium Inc (Armstrong Project).

In terms of rare earths projects in Ontario, Canada Rare Earths, and Aben Resources, are developing early stage projects.

In cobalt exploration, Global Cobalt Corp is developing the Werner Lake Deposit in the north-west of the province. This is in addition to its primary assets in Russia.

Quebec

Together with Ontario, Quebec has been the heartland of graphite and lithium exploration since the boom of 2009-2010. It hosts two of the most advanced flake graphite and lithium development projects.

The province also hosts one of only two active flake graphite mines in North America. Imerys Graphite & Carbon (formerly Timcal) operates the Lac des Iles mine which produces 15,000 tpa of flake graphite concentrate.

Focus Graphite was one of the first flake graphite developers on the Canadian scene and has been progressing its Lac Knife resource that holds an NI 43-101 compliant 9.6 million tonnes grading at 15% and an inferred resource of 3.1 million tonnes grading at 13.25%. The company plans to produce 44,300 tpa of 98% purity large, medium and fine flake concentrate by 2016.

The company is developing its own process to produce battery grade material.

The company also has a strategic alliance with graphene developer, Grafoid Inc, to use its flake graphite to produce commercial quantities of graphene.

Mason Graphite is developing the Lac Gueret project which has a measured and indicated flake graphite resource of 7.59m tonnes and an inferred resource of 2.75m tonnes, both at an average grade of 19.29% C. The company aims to produce 50,000 tpa of flake graphite. The project is also NI-43 101 complaint to Canadian regulations.

Canada Carbon Inc owns a vein graphite project near Grenville, Quebec called the Millar Property and filed an NI 43-101 report in April 2014. The company is looking to produce more modest volumes of vein graphite for
specialist markets such as nuclear and batteries. The veins range from 40-80% in-situ carbon with graphite pods ranging from 10-15% C. In H2 2014, Canada Carbon plans to conduct ground geophysics, surface prospecting and trenching, followed by a diamond drill program. In May 2014, the company revealed flotation results of 99.7% C of +65 mesh.

RB Energy Inc (formerly Canada Lithium) operates a hard rock lithium deposit 60km north of Val d’Or. It is looking to mine spodumene concentrate at the project to feed its lithium carbonate processing plant. The company is aiming to have the plant commissioned by Q4 2014 and produce between 9,000-11,000 tonnes of lithium carbonate this year.

Nemaska Lithium is one of the leading lithium companies in Canada and has been developing the hard rock lithium project, Whabouchi. The company plans to mine and process lithium at its project in the James Bay area and use it as a feedstock to produce battery-grade lithium hydroxide and lithium carbonate at a plant in Salaberry-de-Valleyfield.

In lithium, following a merger with Lithium One, Australian company Galaxy Resources now owns the James Bay pegmatite project, located 100km east of James Bay, which contains an indicated resource of 11.75m tonnes of 1.3% Li₂O and an inferred resource of 10.47m tonnes at 1.2% Li₂O.

Also active in the James Bay area is new development company Stria Lithium Inc., which is progressing its 100% owned Pontax spodumene lithium project. Stria also owns the Willcox brine lithium project in Southeast Arizona. Stria is developing proprietary, environmentally sustainable on-site processing technologies to produce low-cost, high purity lithium chloride. Pilot plant testing is planned for the third quarter of 2014.

In rare earths, Matamec Explorations Inc is operating the Kipawa heavy rare earths deposit that contains dysprosium, terbium and yttrium. It is at the NI 43-101 stage and seeking to produce 3,653 tonnes of concentrate over a 15 year period. The project is one of the most advanced in Canada.

Commerce Resources is developing the Ashram Rare Earth Project in north-east Quebec which hosts 1.59m tonnes of total rare earth oxides at 1.77%. The company says its project has a good distribution of all elements, including neodymium, europium, terbium, dysprosium, and yttrium.

Other companies developing rare earths projects in the province are Quest Rare Minerals Ltd and GeoMega Inc.
Global critical minerals hotspots

From Chile to Russia to Australia: a new generation of critical mineral mines are being developed to western standards across the world

Simon Moores
There are a number of critical minerals projects outside North America that are being developed to western standards by western companies.

Tesla Motors’ plan to bring down the cost of EV batteries through mass production will require the company to ethically source the right type of battery raw materials at the lowest possible cost. Such will be the scale of the Gigafactory, there is a strong possibility Tesla will need to source minerals from multiple mines around the world and not just from North America.

Mineral rich countries such as Chile, Argentina, Madagascar, Mozambique, and Russia are all likely to play a part in the EV manufacturers’ global search for the raw materials needed to feed its super-battery plant.

Graphite

Energizer Resources has developed the Molo project, a flake graphite deposit in Madagascar, to an advanced stage. The Canada-based company has an NI 43-101 indicated resource of 125m tonnes, of which 84.04m tonnes is indicated at 6.36% C. The Company released in a Preliminary Economic Assessment study in 2013.

In February this year, results from a full-scale pilot plant operational run established that 43.5% of the Molo classifies as extra-large and large

Local villagers at Syrah Resources’ flake graphite project in Mozambique
Credit: Syrah Resources
flake graphite, reaching up to 97.7% C through flotation. The company is targeting both hi-tech markets like batteries and traditional sectors such as refractories with its material.

Production at Molo is planned to reach 84,000 tpa by mid-2016 with the company anticipating the mine to be commissioned by Q1 2016. A Full Feasibility Study is expected to be released by Q4 2014.

In Mozambique, Syrah Resources is developing the Balama flake graphite- vanadium deposit in Mozambique to Australian regulatory standards, JORC. The latest data from the project confirmed a measured, indicated and inferred resource of 214m tonnes at 16% C.

In 2014, the company revealed two MOU agreements for offtakes of significant volumes: 80-100,000 tpa with the Chinese aluminium producer, Chinalco, and 100-150,000 with European trader Asmet to supply the recarburizer market.

The company’s primary focus is vanadium with flake graphite being a by-product. It is aiming to produce at least 200,000 tpa of flake graphite in its first full year of operation which is anticipated to be 2016.

The country is home to Triton Minerals which is also developing a flake deposit in the Balama area.

In Tanzania, Uranex has been progressing its Nachu Graphite Project. The company released metallurgical results in April 2014 which shows recoveries of 94.4% to 96.7% C through flotation. It stated that 45% of the finished concentrate was jumbo to large flake graphite.

Swedens is home to two graphite development projects: Flinders Resources and Talga Resources.

Flinders Resources has been developing the former producing Woxna flake graphite mine to Canadian NI 43 101 standards. The company is planning to restart operations as soon as July 2014 and has already installed the necessary processing equipment to produce flake graphite concentrate. Its flake graphite resource is 2.64m tonnes at 10.54% C.

Talga Resources is developing the Nunasvaara and Raitajärvi flake graphite projects in Sweden’s north to JORC standards. Nunasvaara has an indicated resource of 5.6m tonnes and an inferred resource of 2m tonnes at an average of 24.6% C. Raitajärvi hosts 3.4m tonnes of indicated flake graphite ore and 0.9m tonnes of inferred volumes at 7.1% C.

South Australia has also become a hotspot of flake graphite activity with companies looking to develop resources in and around the former operation mine Uley. Archer Exploration, Lincoln Minerals and Valence Industries are all developing JORC certified projects in the region.

Valence Industries also owns flake graphite processing capabilities in the country and recorded its first sales in April 2014, the first for an Australian company since the closure of the Uley mine over 20 years ago.

Lamboo Resources is developing the McIntosh Project in Western Australia near Wyndham. The company is also the only foreign company to be operating flake graphite development projects in South Korea. Lamboo’s three projects in the country are: Geumam, Taewha, and Samcheok.
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Hotspots of lithium exploration outside of North America are located in Argentina, Chile, and Bolivia, all of which host rich lithium brine resources in underground salt lakes*. Three major salars dominate the lithium resources in the area: the Salar de Uyuni in Bolivia, the Salar de Atacama in Chile and the Salar de Hombre Muerto in Argentina.

A number of companies have been developing projects in these regions since the lithium exploration boom began in 2009. In Argentina, Lithium Americas, Orocobre, Rincon Lithium (Energi Group), International Lithium Corp., and Galaxy Resources are all developing brine projects in the north-west of Argentina.

The only active lithium producer in the country is US company FMC Lithium which accounts for 11% of global output of lithium chemicals.

In Chile, the world’s leading producer of lithium, a smaller number of development companies are operation in and around the Salar de Atacama. Western companies operating projects here include: Talison Lithium, and Li3 Energy.

SQM SA and Rockwood Lithium are the only active producers in Chile.

Total exploration spend in 2013 (Non-Ferrous)

> Across the board drop in mineral exploration investment
> 2013 spend fell by 29% to $15.2bn from $21.5bn in 2012
> DR Congo emerges into the top ten displacing Argentina
> The first top ten placement for an African country, Canada and Australia still lead the world

Source: SNL Metals & Mining
The two companies produced a total of 67,500 tonnes in 2013 from the Salar de Atacama equating to 54% of the world’s lithium chemicals output.

Bolivia is more of a closed country in terms of foreign companies developing resources. Government-owned Comibol is developing the world’s largest lithium resource, the Salar de Uyuni, but little progress has been made in the last 5 years since its intentions to produce lithium were announced.

Other lithium exploration areas include: Serbia (Rio Tinto, Ultra Lithium), and Australia (Galaxy Resources, Reed Resources).

Rare earths & cobalt

Rare earths exploration has stretched from Brazil to Turkey to Australia with many companies uncovering rich resources of both light and heavy elements since 2009/2010. The highest concentration of projects are located in Canada, Australia, South Africa, and Greenland.

Leading Australian developers include: Lynas Corp, Arafura Resources, Alkane Resources, Hastings Rare Metals, Northern Minerals, Crossland Strategic Metals, Pancontinental Uranium Corp, Navigator Resources, and GBM Resources.

$21.5bn

Global budget for non-ferrous exploration in 2012

$15.2bn

The same budget for non-ferrous exploration in 2013

Energizer Resources’ flake graphite project in Madagascar
Companies with projects based in South Africa include Great Western Minerals Group, Frontier Rare Earths, Fer-Min-Ore Ltd, Galileo Resources, and Korea Resources.

In Greenland, leading rare earths projects are operated by Greenland Minerals and Energy, Hudson Resources, and Rimbal. Other notable projects include Tasman Metals in Sweden – which began a pre-feasibility study on its Norra Karr Heavy Rare Earth Element Project in April 2014 – Stans Energy in Kazakhstan, Namibia Rare Earths in Namibia, and Pacific Wildcat in Kenya.

Global exploration for cobalt has been far less extensive than that of graphite, lithium and rare earths. The majority of the world’s resources lie in central African conflict regions such as the Democratic Republic of Congo and therefore quality resources outside of these areas are harder to acquire by exploration companies.

Global Cobalt Corp has two developments in Russia: the Karakul and Altai projects in the centre of the country. This is in addition to a project in Ontario, Canada.

Other cobalt projects outside of North America include Baja Mining Corp. (Mexico), which owns a 10% stake in a zinc-cobalt-manganese project.

*Lithium is one of many minerals locked in brine solution in halite (salt rock) and not strictly an underground lake.

Comment: The underestimated role of mineral exploration

Junior mining gets a bad name but is a vital part of the mining industry

Simon Moores

The exploration sector, or junior mining industry as it is known in North America, has always struggled to gain the respect of active miners.

In general, the view of those companies trying to develop mineral resources is one of over-promotion, and a lack of commitment to actually building a mine.

In reality, without the junior mining sector, at worst we would have no new mines and at best we would have lower grade, inefficient mines being developed by the established order which do not specialise in early exploration.

An unfortunate truth that committed junior companies have to deal with is over-promotion. When a mineral gets hot, and the bandwagon gets rolling, everyone with a project becomes an expert. We have seen this in graphite, rare earths and lithium over the past five years.

But in tough times, such as we have witnessed over the past two years, those committed to the cause become apparent; they continue to develop their project in the face of evaporating funds while those riding the resource wave quickly fall off.

To paint all juniors with the same brush is harsh on those striving to either develop an asset to sell or to build a mine. After all, the long term health of the mining industry relies solely on exploration to uncover the world’s best resources and offer up reams of free, detailed drilling data for public scrutiny. The extent of the exploration we see today, even in the down times, would not happen if it was the responsibility of active mining companies.

Perhaps the most important role of the exploration industry, which is rarely discussed, is its disruptive role. New companies entering a niche area such as graphite or rare earths causes disruption to an industry which has not changed in a generation. It forces established companies to look at the way they operate and the way they think.

For this reason alone, if nothing else, the exploration sector is a vital part of the mining industry.
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A matter of US national security

Simon Moores

Supply security of natural resources has been a growing issue for the US over the last five years. At first it was quite difficult for experts to persuade politicians over the critical supply situation of minerals they had never heard of.

But as the profile of these minerals and the technologies they are used in has grown, so too has support in government.

In February 2014, Dr Latiff, Director of the Intelligence and Security Research Center, reported strong bipartisan support for a critical minerals policy act, submitted in 2013, which seeks the reinstatement of mining and processing of critical minerals in the US.

"Passage would be a strong sign that the US Government understands that critical minerals access is key to our economic strength, technological progress, and national security," Dr Latiff explained in his article for American Resource Policy Network.

The crux of the issue, however, is not about whether the USA can become 100% self-sufficient in all critical minerals and metals, but that each of these niche industries should not be dependent on one country.

We have always believed that any mineral industry which relies on one country for over 50% of supply is at risk. The weight of this risk will be dependent on the social, political and economic situation of the majority supplier.

Mineral prices are not remaining high enough for long enough

The capabilities of many of these markets to diversify have, however, been restricted by price fluctuations which fail to capture interest in individual markets for long enough to rectify supply imbalances.

The majority of niche mineral prices are now higher in real terms than they were before the global recession. But still prices are not remaining high enough for long enough to make other mineral deposits economically viable. For example, it can take ten years to develop one mine from first exploration drill hole to production.

Only government intervention, such as import taxes or subsidies, can result in rapid change of slow market forces that are swinging back in favour of specialist, western mining projects.

The US now seems to be accepting that this shift is inevitable as a matter of national security and economic health, a stance that can only bode well for niche mineral development projects in North America.
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