

Essential Minerals for the Green Revolution – 1 Lithium An element which is pulling more than its weight in the world

As we try to reduce our “carbon footprint” the world is turning to new elements, as well as increasing the demand for “old” ones. As an example, we shall look at electric cars.



An electric car being charged (Photo: J. Devon)

It is claimed that, over the lifetime of a car, an electric vehicle is responsible for less carbon emissions than a petrol or diesel one. This includes the extraction and processing and transport of the raw materials, the manufacture of the car itself, its use on the road and its disposal once it is scrapped.

But what exactly goes into the huge battery of an electric car?

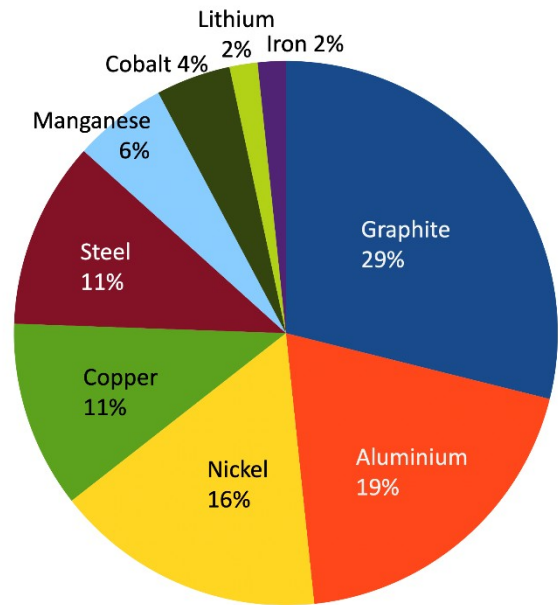
The table shows the mass of each material in the manufacture of a lithium-ion battery for a typical electric car. (Most materials are elements, but steel is an alloy of iron and other metals. Source – www.mining.com, quoted in Daily Telegraph of 21.1.2023, with slight rounding of figures)

Element/ Alloy	Symbol	Mass, kg	Angle °	%
Graphite	C	52	104	29
Aluminium	Al	35		19
Nickel	Ni	29		16
Copper	Cu	20		11
Steel	Fe, etc	20		11
Manganese	Mn	10		6
Cobalt	Co	8		4
Lithium	Li	3		2
Iron	Fe	3		2
Total		180		

Use the figures to plot a pie graph of each element. The total mass is 180kg so the angle for each element is: $\frac{360^\circ}{180} \times \text{mass}$. So for

graphite the angle is $\frac{360^\circ}{180} \times 52 = 104^\circ$.

The completed pie graph



Although lithium is a minor constituent by weight, it is a vital component of the battery and it is estimated that the conversion of the UK vehicle fleet from internal combustion engines to battery electric vehicles will require an estimated 264,600 tonnes of lithium carbonate.

Five of these elements would not have been needed to any extent in the manufacture of a petrol or diesel engine. Suggest their names (C, Ni, Mn, Co, Li). Of these, lithium is completely new. It is estimated that world demand for lithium will rise from about 0.5 million tonnes (MT) in 2023 to 3.5 MT by 2030.

Can we obtain enough lithium to meet this need by recycling existing products? (No, there is not enough lithium in circulation and even by 2030 most electric cars built before then will still be on the road).

So, where will it come from? (It will have to be extracted from lithium resources in the ground) Lithium occurs in minerals in and around granite masses, which can be mined. It may also be naturally weathered out of granite and dissolved naturally into lithium-rich brines, which can be pumped out and the lithium compounds extracted. In the UK in 2023, two companies are prospecting for lithium in Cornwall – one drilling into granite: the other testing for lithium in underground brines. Suggest what might determine if a successful mine might be opened in Cornwall. (The grade of lithium in the ore; its concentration in the brine; the price of lithium worldwide; environmental controls; local support or opposition. In a former mining area with high unemployment rates such as Cornwall, fresh mining ventures are often welcomed).



A drilling rig prospecting for lithium in a former china clay pit in Cornwall (www.businesscornwall.co.uk/news)



Lithium lagoons in the Atacama Desert in Chile (courtesy of Tom Hegen, www.tomhegen.com)

Another important source of lithium is high up in the Andes Mountains of South America, where naturally occurring lithium-rich brines are pumped from one lagoon to another as evaporation in the sun concentrates the lithium content. Suggest reasons why lithium extraction might be of benefit or disadvantage to Chile. *(It would boost the national income and provide jobs for local people. However, it takes up a lot of land and may displace local people; it uses scarce water resources; it may pollute the area; processing releases carbon dioxide.*

The map shows the main countries with reserves of lithium in 2023. Suggest advantages and disadvantages of this distribution for your own country. Australia was the largest lithium producer in 2021, followed by Chile, China and Argentina, but Chinese companies own some of the mines in countries beyond China itself. *(Answers may cover uneven distribution, transport distances and difficulties, political instability or war).*

Companies are currently actively seeking other sources of lithium including lithium-bearing clays, and the situation is changing rapidly.



Worldwide lithium reserves from <https://www.mining.com/wp-content/uploads/2018/11/Global-Lithium-Reserves.jpg>

The back up

Title: Critical Minerals – 1 Lithium

Subtitle: An element which is pulling more than its weight in the world

Topic: An investigation into the sources of lithium as worldwide demand rises, with the introduction of new technology, such as lithium-ion batteries.

Age range of pupils: 12 years and above

Time needed to complete activity: 30 minutes

Pupil learning outcomes: Pupils can:

- plot a pie graph showing the relative amounts of elements needed to make a battery for an electric car;
- explain why so much more lithium is needed as new technologies are employed to counter the rise in carbon emissions;
- evaluate different possible sources of lithium;
- explain why there is no alternative to mining to meet current and future demands for lithium;
- discuss the impact of large-scale lithium extraction on local environments and communities and suggest mitigating factors;
- appreciate that lithium is just one of many industrial minerals where demand is rising rapidly across the world;
- assess the implications of the uneven distribution of lithium resources on their own country.

Context: This activity could be used in a lesson on the need to identify and exploit lithium minerals in vital applications in many different fields, especially, lithium-ion batteries. Worldwide demand for lithium and related metals is rising rapidly as new technologies are embraced.

Following up the activity:

Pupils could carry out a web search for more information and for staying up to date, since the situation is changing rapidly.

Underlying principles:

- The conversion of the UK vehicle fleet from internal combustion engines to battery electric vehicles will require an estimated 264,600 tonnes of lithium carbonate.
- Lithium is found in widespread brines in arid regions with a high evaporation rate, e.g. the altiplano of the Andes, where it is concentrated into commercial concentrations by further controlled evaporation.
- It also occurs in mica minerals in granite masses, where it may be mined.
- Lithium-bearing brines also form around granites, from which they may be pumped out.
- Lithium is used in heat-resistant glass and in metallurgical flux, but its greatest use by far is in making batteries.

Thinking skill development:

Establishing the worldwide demand for lithium and the need to extend the mining of it involves construction. Metacognition is involved when the impact of mining is discussed. Applying thinking to new contexts is a bridging skill.

Resource list:

- access to the photographs in this activity, or the equivalent on the web

Useful links: <https://post.parliament.uk/research-briefings/post-pb-0045/>
https://www.earthlearningidea.com/home/Mining_Green_Revolution.html
and <https://www.ejatlaz.org/conflict/mineria-de-litio-en-el-salar-de-atacama-chile> for conflicts in Chile
https://www.earthlearningidea.com/PDF/391_Net_zero_Batteries.pdf
https://www.earthlearningidea.com/PDF/402_Net_zero_Electric_vehicles.pdf

Source: Written by Peter Kennett of the Earthlearning idea team with advice from Ben Lepley of SRK Consulting (UK) Ltd.

Note: This activity was as accurate as possible in spring 2023. Rapid developments are taking place in the technology of low and renewable energy.

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Essential Minerals for the Green Revolution

Earthlearningidea has compiled a series of activities on the minerals which are essential if modern technology is to be able to reduce the World's carbon footprint. Some are regarded as "critical" minerals and many of them are relatively "new" in terms of needing to be exploited.

This table will be updated as fresh activities are added.

All titles begin with: Essential Minerals for the Green Revolution...

Mineral	Title
Lithium	1 Lithium: an element which is pulling more than its weight in the world
Copper	2 Copper: an element for which the demand is increasing rapidly
Rare Earths	3 Rare Earth Elements: vital components in modern technology
Graphite	4 Graphite: from a pencil to the electric car!
Cobalt	5 Cobalt: mined by children
Tin, Tungsten, Tantalum	6 "The Three Ts": Tin, Tungsten and Tantalum
Gold	7 Gold: an essential mineral - or is it?
Critical minerals	8 Critical Minerals: Essential mineral - critical mineral: what is the difference?