®
ROCKHOUND NEWSLETTER
石 犬 通 訊

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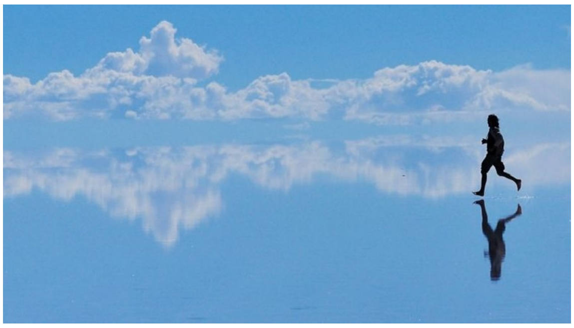
MINING・ENERGY・NATURAL RESOURCES
礦業・能源・天然資源

Lithium

Lithium is a chemical element with the symbol Li and atomic number 3. It is the first metal in the periodic table and as such the lightest of all metals. It is silvery white but, as it is highly reactive, soluble in water and flammable, it never occurs freely in nature As an alkali metal it is within the same group as sodium and potassium.



Uyuni Salt Flats in Bolivia is a famous tourist spot as it is claimed to be the mirror of the sky
位於玻利維亞的天空之境是著名旅遊境點

The importance of lithium in industrial applications has risen in the last 10 years primarily on account of its use in lithium-ion (Li-ion) batteries, both non-rechargeable and rechargeable. In the past the non-rechargeable market was dominant with lithium batteries being used in consumer electronics such as calculators and watches; in recent years with technological advances the demand for rechargeable batteries has soared as it is used in a wide variety of applications from handheld devices such as mobile phone and laptops to electric vehicles (EV). Global EV production is expected to increase five-fold by 2025, and tenfold by 2030, compared to 2017.

With its use in energy storage systems lithium is classified as a 'critical' element by the U.S. Department of Energy and because of its importance in green technologies to reduce carbon footprint and the reliance on oil and gas.

Lithium is the 30th most abundant element, on Earth, ahead of lead, tin and silver, and widely distributed. Lithium can substitute other minerals, especially magnesium, in common rock-forming minerals.

Mining and Production

Commercially viable concentrations are found in brine deposits in closed-basin salt lakes and in granite pegmatites. Ample resources have been identified worldwide to satisfy future demand.

Traditionally demand for lithium has been satisfied from hard rock sources through conventional open-pit or underground mining. Since the mid-1990s global output from brines has increased from less than 10% to 56% by 2015 with the remaining 44% from hard rock sources.

Brine — lithium salt flats or salars in South America are formed in basins from water which has leached lithium from surrounding rocks with salts concentrated by solar and wind evaporation. These deposits share several characteristics including an arid climate, a closed basin system, sufficient time, and space to concentrate the brine. According to the USGS the producing deposits have an average lithium concentration of 160ppm (0.016%) to

鋰

鋰是化學元素，符號為 Li，原子序數為 3。它是元素週期表中的第一個金屬，因此是所有金屬中最輕的。它為銀白色，但由於它具有高反應活性，可溶於水且易燃，因此不在自由介中獨立存在。作為鹼金屬，它與鈉和鉀屬於同一族。

過去十年來，鋰在工業應用中的重要性不斷提高，這主要歸因於其在不可充電和可充電的鋰離子（Li-ion）電池中的應用。過去，不可充電市場佔據主導地位，鋰電池被用於計算機和手錶等消費電子產品中。近年來，隨著技術的進步，對可充電電池的需求猛增，因為它在從手持設備（例如手機和筆記本電腦）到電動汽車（EV）的各種應用中被大量使用。與 2017 年相比，全球電動汽車生產預計到 2025 年將增長五倍，到 2030 年將增長十倍。

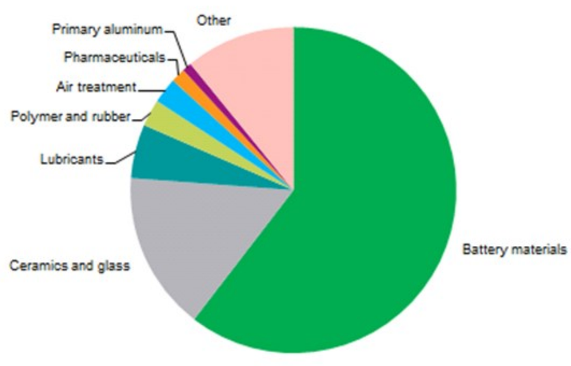
由於鋰在儲能系統中的使用，鋰被美國能源部歸類為“關鍵”元素，亦因它在減少碳足跡和對石油和天然氣的依賴的綠色技術中有重要意義。

鋰是地球上最豐富的元素中排名第 30 位，領先於鉛、錫和銀，並且分佈廣泛。鋰可以替代其他常見的成岩礦物，特別是鎂。

開採與生產

在封閉盆地鹽湖的鹽水沉積物中和花崗岩偉晶岩中發現了商業上可行的品位。全球已經找到了足夠的資源來滿足未來的需求。

過去，對鋰的需求經過常規的露天開採或地下開採從硬岩源得到滿足。自1990年代中期以來，全球鹽水產量已從不到10%增長到2015年的56%，其餘44%來自硬岩資源。



2017 world lithium consumption by sector (Source: IHS Market)
2017年的全球行業的鋰消耗比例 (來源： IHS Market)

鹽水 – 南美的鋰鹽灘或鹽沼是由盆地中的水形成的，這些水通過太陽能和風速蒸發而濃縮的鹽水從周圍岩石中浸出了鋰。這些沉積物具有幾個特徵，包括乾旱的氣候、封閉的盆地系統、足夠的時間和濃縮鹽水的空間。根據USGS，生產礦床的平均鋰濃度為160ppm (0.016%)至1400ppm (0.14%)，估計資源為0.3Mt

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1400ppm (0.14%) and estimated resources of 0.3Mt to 6.3Mt of lithium.

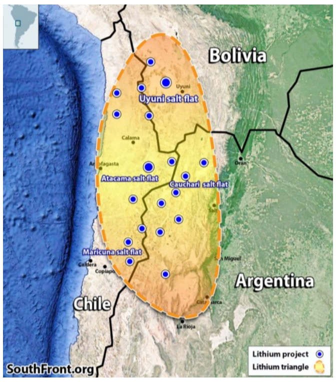
至6.3Mt鋰。

More than one-third of the world's production of lithium carbonate comes from the Lithium Triangle – located between Chile, Argentina, and Bolivia. In 2019 Chile and Argentina produced 32% of world output.

全球碳酸鋰產量的三分之一以上來自鋰三角地區-位於智利，阿根廷和玻利維亞之間。 2019年，智利及阿根廷佔世界產量的32%。

Brine mining operations may extract a variety of elemental substances and compounds from the same deposit.

鹽水開採作業可以從同一礦床中提取各種元素物質和化合物。



Lithium Triangle in South America
南美洲的鋰三角地區

Lithium-Cesium-Tantalum (LCT) Pegmatite — lithium minerals form only when rare combinations of favourable geological factors line up. Most of the known lithium hard rock minerals are found in coarsely crystalline granites containing pegmatite veins rich in LCT. Pegmatites are characterized by large crystals and are the result of fluids which crystallize out at the latter stages in a slow cooling granite. Because of its low crystallization temperature, lithium stays in the melt to the end.

鋰-銫-鉭（LCT）偉晶岩 - 僅於少數有利地質因素組合出現時才形成鋰礦物。大多數已知的鋰硬岩石礦物都在粗晶花崗岩中的富含LCT偉晶岩脈發現。偉晶岩的特徵在於大晶體，是流體在緩慢冷卻的花崗岩中後期階段結晶出來的結果。由於鋰的低結晶溫度，鋰保留在熔體中直至最後期。

Spodumene ($LiAlSi_2O_6$) is the most prevalent lithium mineral present, followed by petalite ($LiAlSi_4O_{10}$) and lepidolite ($K(Li,Al)_3(Si,Al)_4O10(F,OH)_2$). Spodumene has a theoretical Li_2O content of 8.03%, which is the highest of all minerals; thus, it is considered the most important lithium ore mineral. Typically, the head grades in commercial LCT pegmatites are > 1.0% Li_2O. Most lithium hard rock mining is carried out in Australia.

鋰輝石($LiAlSi_2O_6$)是目前存在的最普遍的鋰礦物，其次是花瓣石($LiAlSi_4O_{10}$)和鋰雲母($K(Li,Al)_3(Si,Al)_4O10(F,OH)_2$)。鋰輝石的理論$Li_2O$含量為 8.03%，是所有礦物中最高的。因此，它被認為是最重要的鋰礦石礦物。通常，LCT偉晶岩的原礦品位為 >1.0% Li_2O。大多數鋰硬岩開採都在澳大利亞進行。

Hectorite clays — are currently being explored as a potential resource. Lithium bearing clays contain an estimated 7% of the world's resources. All are found in the USA. The lithium mineral is hectorite ($Na_{0.3}(Mg,Li)_3Si_4O_{10}(OH)_2$). These deposits have not yet been commercially exploited.

鋰蒙脫石粘土 – 目前正在研究將其作為一種潛在資源。含鋰粘土估計佔全球資源的 7%。全部在美國找到。鋰礦物為鋰蒙脫石($Na_{0.3}(Mg,Li)_3Si_4O_{10}(OH)_2$)。這些礦床尚未被商業開發。

The world's top four lithium producing countries from 2019 as reported by the USGS are Australia (42,000t), Chile (18,000t), China (7,000t) and Argentina (6,400t) with a global total of 77,000t. China produces lithium from both brines (from Zabuye Lake in Tibet) and hard rock mining. Worldwide production has increased by a factor of five since 1975.

根據USGS的報告，從2019年開始，全球鋰產量最高的四個國家是澳大利亞（42,000噸），智利（18,000噸），中國（7,000噸）和阿根廷（6,400噸），全球總量為77,000噸。中國從鹽水（西藏的紮布耶湖）和硬岩開採中生產鋰。自1975年以來，全球產量增加了五倍。

Worldwide identified reserves according to USGS have increased from 14Mt in 2017 to 17Mt by 2020 Chile has over 51% of these reserves. However, an accurate estimate of reserves is difficult for brines as most classification schemes have been developed for solid rock deposits.

根據USGS的全球已探明儲量已從2017年的14Mt增加到2020年的17Mt，智利擁有這些儲量的 51% 以上。但是，由於大多數分類方案都是針對固體岩礦床開發的，因此很難準確估算鹽水的儲量。

Processing

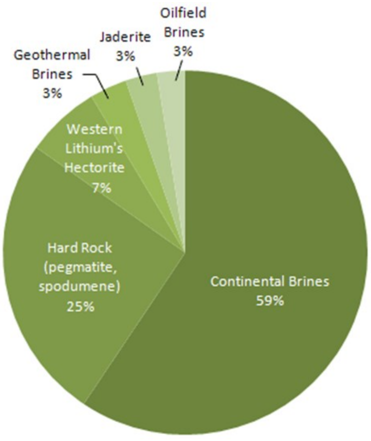
開採與加工

Lithium is commonly traded in three forms as (i) concentrates (from hard rock mining), (ii) compounds and (iii) refined metal. With both concentrates and compounds these undergo hydro and pyrometallurgical processing after removal from the mine site to increase lithium concentration to meet the specification of end users.

鋰通常以三種形式交易：（i）精礦（來自硬岩開採），（ii）化合物和（iii）精煉金屬。從礦場移走後，這些精礦和化合物都經過濕法和火法冶金處理，以提高鋰的濃度，以滿足最終用戶的要求。

The two main lithium compounds are lithium carbonate (Li_2CO_3) (from brines) and lithium hydroxide (LiOH) (from LCT pegmatites). To produce lithium carbonate from LCT pegmatites is costly with the result that lithium hydroxide has a different market to lithium carbonates. As lithium hydroxide contains 29% lithium, compared to 19% for lithium carbonate, it is more popular in the battery market. Lithium products are often quoted in LCE (Lithium Carbonate Equivalent).

兩種主要的鋰化合物是碳酸鋰 (Li_2CO_3)（來自鹽水）和氫氧化鋰(LiOH)（來自 LCT 偉晶岩）。由 LCT 偉晶岩生產碳酸鋰是昂貴的，結果是氫氧化鋰與碳酸鋰具有不同的市場。由於氫氧化鋰包含29%的鋰 而碳酸鋰僅只有 19%的鋰，因此它在電池市場上更受歡迎。鋰產品通常以 LCE（碳酸鋰當量）報價。



Source of lithium resources (Source: Energy & Capital)
鋰資源的來源 (來源： Energy & Capital)

<u>Concentrates</u> - At the mine site the ore is concentrated using a variety of methods including crushing, grinding, sieving and flotation. A typical run of mine ore can contain 1% - 2% Li_2O, while a typical spodumene concentrate for lithium carbonate production contains 6% -7% Li_2O. Most concentrate are further processed in China.

<u>精礦</u> - 在礦場，採用多種方法將礦石精礦，包括破碎、磨碎、篩分和浮選。典型的礦山礦石中可能包含 1%-2% 的 Li2O，而生產碳酸鋰的典型鋰輝石精礦中包含 6%-7%的 Li2O。

There are chemical-grade and technical-grade products. Technical-grade lithium concentrates are for uses in the glass, ceramic and metallurgical

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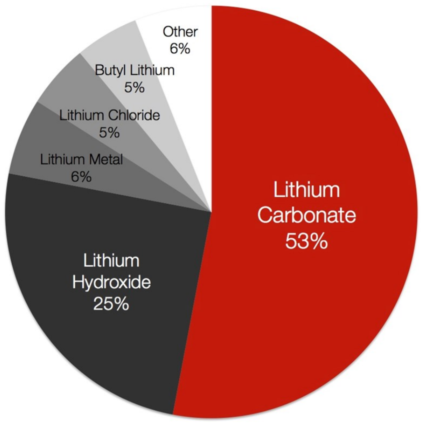
powder markets with some limitations on iron, potassium, and sodium contents. Chemical-grade lithium concentrate, with more flexibility on impurity levels is sold to be used in batteries, processors and for conversion into lithium chemicals.

<u>Compounds</u> - Lithium recovery from brine is via conventional chemical precipitation and normally starts by subjecting lithium-rich brine to a series of solar pond evaporations. Over time and pumping the brine at various times into new ponds, this will precipitate other salts leaving behind a lithium rich liquor. This can take 18 to 24 months. The enriched brine that results from these chemical precipitations is then subjected to a carbonation process, in which the lithium reacts with sodium carbonate at 80-90°C to produce technical-grade lithium carbonate. This can be further purified to produce battery-grade lithium.

<u>Refined Metal</u> - Converting lithium into metal is done in an electrolytic cell using lithium chloride mixed with potassium chloride. Added to lithium carbonate, chlorine gas is liberated while molten lithium rises to the surface. The metal is then wrapped in paraffin wax to prevent oxidation.



Lithium products in 2014 (Source: LitTHIUM X)
2014年的鋰產品比例 (來源 ： LiTHIUM X)

Market

Global consumption (based on LCE) has been growing. In 2016 demand was 195,000t LCE. By 2025 the estimate is 669,000t LCE, and by 2030 this is forecasted to be more than two million tonnes LCE.

This increase is, amongst other things, driven by demand for lithium batteries and by environmental issues to reduce the carbon footprint.

In glass lithium in small amounts, typically 0.1% to 4%, is used as a flux to reduce the melting temperature and thereby reducing energy costs while increasing hardness and reducing thermal expansion. An example of its use is in glass stove tops where ordinary glass would shatter on account of the large temperature swings. In the ceramics industry lithium is used to make porcelain enamels, glazes, and tiles. Glazes containing lithium oxides are used for ovenware.

Lithium is considered a minor metal and does not have high transparency and liquidity around pricing. As such prices are not published. At the end of 2019, according to USGS, spot lithium carbonate was $7,300/t, lithium hydrooxide $8,000/t and metal $82,000/t. This was a drop of 30% over the year, which in turn was a drop from 2018. Prices have been highly variable in recent years.

Lithium supply security has become a top priority for technology companies in Asia. Strategic alliances and joint ventures have been made to ensure reliable and diversified supplies.

大部份精礦都運往中國作下一步處理加工。

有化學級和技術級產品。工業級鋰精礦用於玻璃、陶瓷和冶金粉末市場，對鐵、鉀和鈉的含量有一定限制。化學級的鋰精礦，在雜質含量上具有更大的靈活性，出售用於電池、加工廠和轉化為鋰化學品。

<u>化合物</u> - 從鹽水中回收鋰是通過常規的化學沉澱方法達成的，通常是通過使富含鋰的鹽水經歷一系列的日光池蒸發來開始的。隨著時間的流逝，將鹽水在不同的時間泵入新的池塘，這將沉澱其他鹽，留下富鋰液。這可能需要 18 到 24 個月。然後將這些化學沉澱產生的濃鹽水進行碳酸化處理，在該過程中，鋰與碳酸鈉在 80-90°C 下反應，生成工業級碳酸鋰。可以進一步提純至電池級鋰。

<u>精煉金屬</u> - 在氯化鋰與氯化鉀混合的電解槽中將鋰轉化為金屬。添加到碳酸鋰中時，會釋放出氯氣，而熔融鋰則上升到表面。然後將金屬包裹在石蠟中以防止氧化。

市場

全球消費（基於 LCE）一直在增長。2016 年需求為 195,000 噸 LCE。到 2025 年，估計為 66.9 萬噸 LCE，到 2030 年，預計將超過 200 萬噸 LCE。

除其他因素外，這種增長是由對鋰電池的需求以及減少碳足蹟的環境問題推動的。

在玻璃中，少量的鋰（通常為 0.1%至 4%）用作助熔劑，以降低熔融溫度，從而降低能源成本，同時增加硬度並降低熱膨脹。其用途的一個例子是在玻璃爐灶台上，由於溫度波動較大，普通玻璃會破碎。在陶瓷工業中，鋰用於製造搪瓷，釉料和瓷磚。含氧化鋰的釉料用於烤箱用具。

鋰被認為是次要金屬，在定價方面沒有很高的透明度和流動性。因此，未有公佈價格。根據 USGS 的數據，2019 年底碳酸鋰現貨價格為 $7,300/t，氫氧化鋰價格為 $8,000/t，金屬價格為 $82,000/t。與去年同期相比下降了 30%，與 2018 年相比下降了。近年來價格變化很大。

鋰的供應穩定已成為亞洲科技公司的重中之重。已經建立了戰略聯盟和合資企業，以確保可靠和多樣化的供應。

Rockhound is a HK based company set up to serve the minerals industry in the Region. The company offers technical valuations and services in the natural resources sector.


CIM ICM
The Canadian Institute of Mining, Metallurgy and Petroleum
by the authority of the Council has elected
Rockhound Ltd.
a Member of the Institute with all Privileges of such affiliation
Attested to at the Head Office of the Institute by the signature affixed
July 1, 2011
Date elected
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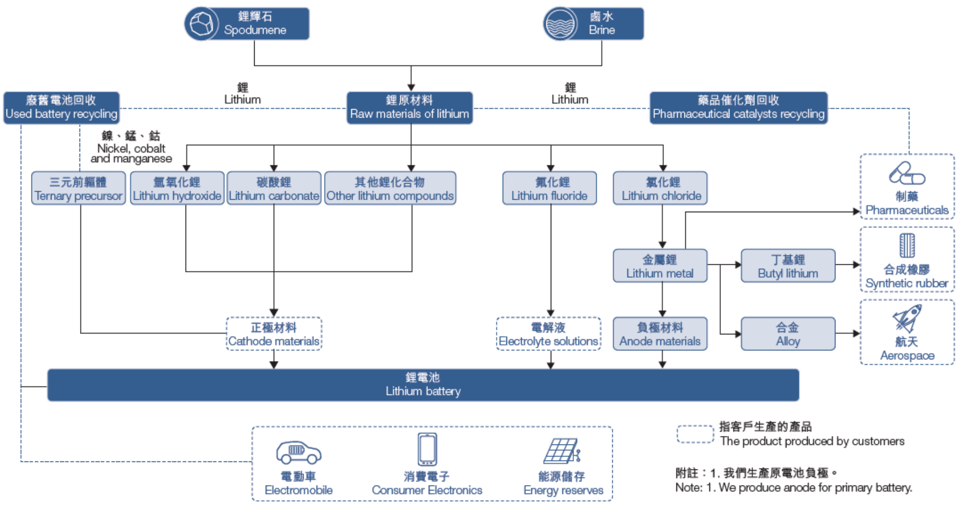
Special Ed. 6 TOP INDUSTRIAL NEWS 鋰礦相關新聞 August 2020

Ganfeng Lithium Co., Ltd. 江西贛鋒鋰業有限公司(1772.HK)

The Company is the world's leading lithium ecological enterprise. We offer five major categories of more than 40 lithium compounds and metals products, which is one of the most comprehensive product offerings among the lithium products manufactures. Our comprehensive suite of product offerings enables us to effectively address the unique and diverse needs of our customers. We started as a midstream manufacturer of lithium compounds and lithium metals and have successfully expanded both upstream and downstream. We have a vertically integrated business model, including upstream lithium resources development, midstream lithium compounds and metals processing as well as downstream lithium battery production and comprehensive recycling of retired lithium batteries which are important links of the industrial ecological chain. Our business model enables us to gather the latest market information and develop cutting-edge technologies, creates valuable synergies between our various business lines, thus strengthening our market position, so as to improve our operational efficiency and profitability. Our products are widely used in the manufacturing of electric vehicles, aerospace products, function materials and pharmaceuticals. Most of our customers are global leaders in their respective industries.

The most comprehensive industry value chain in the world that we have built covered the important sectors of the lithium industry from upstream to downstream, which we refer to as the "Ganfeng Ecosystem". The Ganfeng Ecosystem includes (1) extraction of upstream lithium resources; (2) deep processing of lithium compounds; (3) production of lithium metals; (4) production of lithium batteries; and (5) reclaiming and recycling of lithium resources. The Ganfeng Ecosystem contributes to the constant launches of new products and services, which allows us to solidify the strategic relationships with our customers and end-users. The diagram below illustrates our integrated supply and production chain and the respective functions and inter-relationship of our business lines within the Ganfeng Ecosystem.

Source: Company's Annual Report



UK to invest in Europe's first geothermal lithium recovery plant (excerpt)

06 Aug 2020 <Mining.com>

The UK government announced plans to invest, through its Getting Building Fund, in the construction of Europe's first geothermal lithium recovery pilot plant at a location near Redruth, Cornwall.

The public funds will support a £4-million collaboration between Geothermal Engineering (GEL) and Cornish Lithium at GEL's deep geothermal project, which aims to demonstrate that lithium can be produced from geothermal waters with a net-zero carbon footprint.

According to Cornish Lithium, the pilot plant will trial environmentally-responsible Direct Lithium Extraction technology, and its suitability to extract lithium from Cornish geothermal waters.

Lithium Australia eyes lithium phosphate patent (excerpt)

06 Aug 2020 <The West Australian>

Lithium Australia's patent application to take waste rock from a lithium mine, mixed metal dust from spent lithium batteries and even lithium brines and turn them directly into a lithium phosphate product, received a shot in the arm this week after an international examiner determined the process is "novel, involves an inventive step and is applicable to industry", a positive sign that the process may potentially be patentable.

The Perth-based company is attempting to modify its already patented chemical-based "SiLeach" and "LieNA" processing technologies that can produce a lithium carbonate product without the need for expensive energy-hungry roasting.

The tweak that Lithium Australia is seeking to patent for its two existing technologies will allow the carbonate stage to be skipped altogether with the product being taken straight through to a lithium phosphate, the final product actually required by the cathode manufacturers.

6月內地鋰離子電池完成產量按年增14.2%

31 Jul 2020 <AASTOCKS>

工信部發布數據顯示，6月全國電池製造業主要產品中，鋰離子電池完成產量16.3億個，按年增長14.2%；鉛酸蓄電池產量2,045.2萬千伏安時，按年增長17.1%；原電池及原電池組(非扣式)產量36.2億個，按年增長15.3%。

Work begins on the world's biggest utility-owned lithium-ion ESS (excerpt)

06 Aug 2020 <bestmag.co.uk>

Construction has begun on the world's biggest utility-owned lithium-ion energy storage systems by California, US, -based Pacific Gas and Electric Company (PG&E) and Tesla.