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(Photo: the salt flats of Uyuni in Bolivia reputedly hold approximately 50% of world reserves)

Is Lithium the 21st Century's Oil?

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Lithium-ion batteries power most of the world's laptops and mobile phones and lithium has become an important mineral. But lithium could have a more serious and lasting global impact. With tumultuous and uncertain oil prices and growing environmental concerns, governments and manufacturers are turning to alternative fuels. Hybrids and pure electric vehicles require batteries. And these batteries will most likely use lithium. Unlike nickel-based batteries, lithium batteries weigh less and have longer storage capacity. Therefore electric car batteries that use lithium will be able to store more energy and be driven longer distances.

The demand for lithium is projected to more than double by 2020. Most of the production needed to satisfy the market will come from Latin American countries like Argentina, Chile, and Bolivia which control over 75% of the world's lithium reserves. In this report we seek to analyze the lithium industry while highlighting the special relationship between China and Latin America.

Overview

Although new technologies are—by definition—subject to change, lithium is currently the best raw material for making rechargeable batteries. Today, lithium-Ion (Li-Ion) batteries power most of the world's laptops, mobile phones and cameras. But lithium enthusiasts are also pinning their hopes on the electric car.

Hybrid cars are driving lithium fever. But there are only a few economically viable lithium reserves in the world. These are located in South America.

The number of economically viable lithium deposits in the world is limited; most are found in South America, and some are in China. As the market for lithium grows, countries with large lithium deposits will become very important from a geo-economic standpoint.

China is the leading producer of consumer electronic appliances including laptops, mobile phones, and cameras. China also has a very strong battery industry whose growth has even attracted the likes of Warren Buffett who in 2008 made an investment in one of the country's leading battery companies and (now) electric vehicle maker, "BYD." China realizes that in order to continue to have a globally-competitive battery industry and not be dependent on imports, it must have a "lithium strategy." As a result, Chinese firms have spent the last several years prospecting and developing lithium in western provinces such as Qinghai and Tibet.

In the future China will need to go outbound (to South America) to invest in lithium deposits

If electric vehicles become as popular as expected, China will not be able to solely depend on domestic sources of lithium. As it has done in other sectors such as oil and copper, China will have to look outbound. Over the coming years, we believe that Chinese firms will make acquisitions overseas to secure lithium reserves. And the most attractive location is South America's "lithium triangle," an area that covers roughly 43,000 kilometers between Argentina, Bolivia and Chile.

What is Lithium?

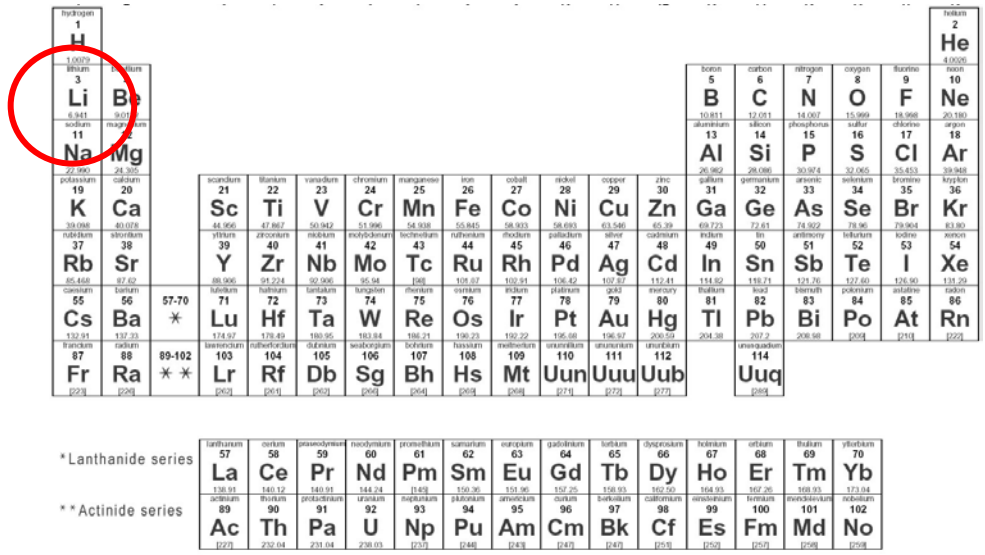
Lithium is considered the lightest solid element on earth. It is a highly reactive silvery metal and quickly tarnishes in air after just a few minutes. Due to its high reactivity, it only appears naturally in the form of compounds. The first lithium compound discovered was Petalite (lithium aluminum silicate) by a Brazilian chemist named José Bonifácio de Andrade e Silva in 1800. Several years later in 1817, pure lithium was extracted from Petalite by Johan August Arfwedson.

For a long period of time, lithium was considered not much more than a laboratory curiosity. But Over the years, lithium's commercial applications have expanded tremendously. First, the pharmaceuticals industry discovered that lithium had properties that affected brain chemistry (i.e. mood stabilizers used to treat bi-polar disorder). And later, lithium was discovered to have ideal qualities for laptop, camera, and mobile phone batteries. In the coming years lithium will have a significant global impact as hybrid and electrical vehicles switch to lithium-ion technology.

Lithium occurs in a number of rock minerals, but the lithium used in batteries is commonly obtained from brine deposits (i.e. dry salt lakes).

Exhibit 1: The Lightest Solid Element in Existence

Lithium is the lightest solid element on earth. It is a metal with unique qualities that make it ideal for battery production



Lithium does not occur in its natural state, but in compounds. For purposes of battery production, lithium is sold in the form of lithium carbonate (Li_2CO_3). In this article we reference pure lithium (in metal equivalent) as well as Li_2CO_3.

Where Is Lithium Found?

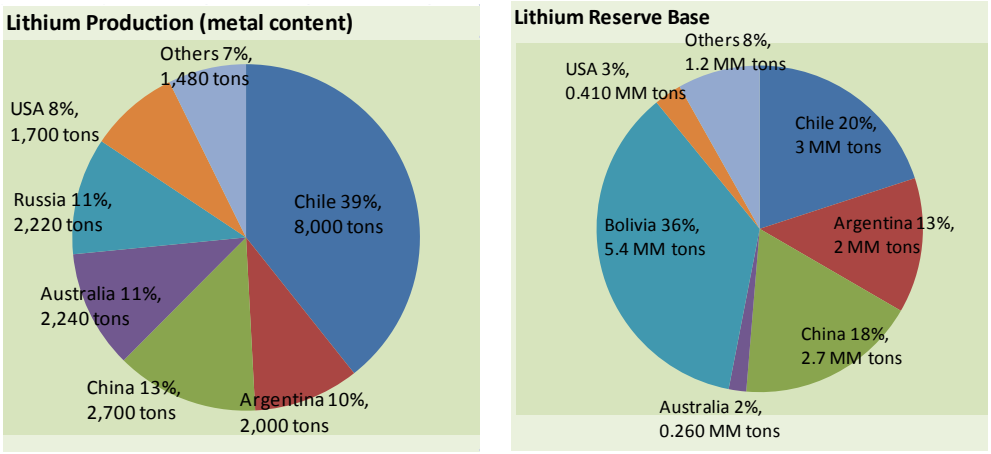
There are two major types of lithium deposits: (a) Spodumene - a hard silicate mineral (i.e. glass), and (2) Brine Salt Lake Deposits – dry salt lakes containing lithium chloride (in South America these are called "salares"). Today, most of the world's lithium comes from dry salt lakes because these deposits are more economically viable for making Li-Ion batteries. These lakes result when pools of salt water containing lithium chloride (LiCl) accumulate in places lacking drainage. Over the centuries the water evaporates leaving a dense layer of salt behind. Underneath the salt crust is a layer of brine — salty groundwater with a high concentration of lithium chloride. It is this brine that is pumped out and converted to lithium.

Around 75% of the world's lithium is found in South America – in dry salt lakes known as "salares"

An estimated 70-75% of the world's salt lake lithium deposits are found in South America. Chile is the world's largest producer — not only because Chile already has highly developed mining, transport and processing infrastructure, but also because its climate and geography is favorable for the optimal solar evaporation that is central to producing lithium. Neighboring Bolivia purportedly has the largest known reserves but it does not currently produce any lithium.

Exhibit 2: Global Production and Reserve Base

Chile leads the world in lithium production but Bolivia has the world's largest untapped reserves



Source: US Geological Survey, SinoLatin Capital Analysis

Lithium that comes from dry salt lakes is much more economically viable than lithium that comes from rocks

Until 1997, most lithium carbonate was made from Spodumene, a silicate that is compound of lithium and aluminum. In order to make lithium chloride from Spodumene, it must be first ground to a powder, calcinated at 1100 degrees Celsius, treated with sulfuric acid at 250 degrees C, put in a solvent to extract lithium sulfate, put in a separator to extract aluminum sulfate, and finally the lithium is precipitated out using soda ash. By comparison, the extraction from a salt lake is relatively simple and therefore considerably more economical and viable.

Is Spodumene irrelevant? No, because Spodumene still has characteristics that make it quite suitable for certain types of glass and high-temperature ceramics.

Commercial lithium deposits are found along high-altitude belts in the earth's desert regions. Most of them are in South America where the salt lakes are known as *salares*. According to industry experts, South American salares in three countries

alone (Bolivia, Chile and Argentina) hold 70-75% of the world's global lithium reserves. Information on some of the major South American salares is provided below.

Exhibit 3: South America's Lithium Triangle

Source: US Geological Survey, SinoLatin Capital Analysis

Chile, Argentina and Bolivia have the potential to become the "Middle East of lithium" given their vast unexploited reserves

Argentina: Salar de Hombre Muerto – Owned by FMC Lithium (NYSE: FMC), a New York Stock Exchange-listed firm with a stock market value of US$4 billion. Hombre Muerto which literally translates as "Dead Man" is located in the remote north of Catamarca Province, 4,000 meters above sea level.

Argentina has several "salares" and the most important one is "Hombre Muerto" owned by FMC

- Reserves: 360,000-400,000 tons at 0-30 meters of depth; 850,000 tons at 0-70 meters of depth with brine grades of 0.062%
- 100% of the production is for export. The product is transported by rail to Antofagasta (Chile) where it is exported
- Neighboring Salar de Olaroz is being developed by Australian-listed Orocobre (ASX: ORE). Bankable Feasibility study expected in 2010
- Salar de Rincon was being developed by Australian-listed Admiralty Resources (ASX: ADY) but they sold it to the Sentient Group, a natural resources-focused private equity fund

Bolivia also has many salares but the attention is focused on the Salar de Uyuni which could hold 50% of the world reserves

Bolivia: Salar de Uyuni - It is located in the Potosí and Oruro departments in SW Bolivia 3,650 meters high. It purportedly holds half of the world's reserves of lithium. There is currently no mining plant at the site and the Bolivian government doesn't want to allow exploitation by foreign corporations. Instead it intends to build its own pilot plant.

- Reserves: 5,400,000 tons (different estimates suggest 9 million tons)
- Comibol (Bolivian State Mining Company) is investing roughly US$6 million in a small plant near the village of Río Grande on the edge of Salar de Uyuni, where it hopes to begin Bolivia's first industrial-scale effort to mine lithium

- In early February 2010 the Bolivian government created "Empresa Nacional de Evaporíticos," a national entity responsible for the development of the lithium, boron, phosphates and potash
- Indigenous groups near the Salar de Uyuni are pushing the government to grant them total or partial ownership of the lithium in the area. The new Constitution that Bolivia just passed in January 2009 could grant the demands of the indigenous groups. One clause could give the indigenous group control over the natural resources in their territory, strengthening their ability to win concessions from the authorities and private companies, or even block mining projects. Yet none of this has discouraged foreign enterprises from attempting to gain access to Uyuni's lithium.
- Assuming Uyuni began operating, it could take as long as 5 years before the lithium carbonate would hit the market
- Other than Uyuni there are many other much smaller salt lakes in Bolivia in which the government has little involvement. These opportunities are being developed by private mining companies such as New World Resources

Political constraints could get in the way of producing lithium carbonate in a meaningful way at the Salar de Uyuni

Chile: Salar de Atacama - is the largest salt flat in Chile. It is located south of San Pedro de Atacama, is surrounded by mountains. The Salar de Atacama contains one of the largest and best quality reserves of lithium-brine in the world with high concentrations of potassium, lithium and boron. A US Geological survey estimate pegs the reserve base of the Salar de Atacama to be around 3MM tons while the Chilean State mining agency (CORFO) estimates it to be 4.5MM tons.

- There is some friction between the local communities and the mining companies over water rights. Mining already consumes 65% of the limited water in the Salar de Atacama region
- The largest lithium chloride producer in Chile is SQM, a US$10 billion stock market value firm listed on the New York Stock Exchange
- Environmentalists are also concerned about the unique flora and fauna of the region, including damage to the habitat of the famous pink flamingoes
- SQM only employs several hundred people at the evaporation plant. Therefore, an expansion in lithium production will not bring great employment benefits to the region, adding to the complexities of balancing growth and the environment

The Salar de Atacama is one of the best lithium assets in the world. Chile also has access to the Pacific Ocean, making exports relatively easy (Bolivia is landlocked)

Exhibit 4: Comparison of South American Salares

	Bolivia	Chile	Argentina
Salar Name	Uyuni	Atacama	Hombre Muerto
Altitude (kms)	3.7	2.3	4.3
Area (km2)	8,000	3,000	570
Li Concentration (% by wt)	0.0350%	0.1500%	0.0620%
Mg/Li Ratio	18.6	6.4	1.4
Evaporation Rate (mm/year)	1,500	3,200	2,300

Source: US Geological Survey, Stratfor, "An Abundance of Lithium" by Keith Evans, Meridian International

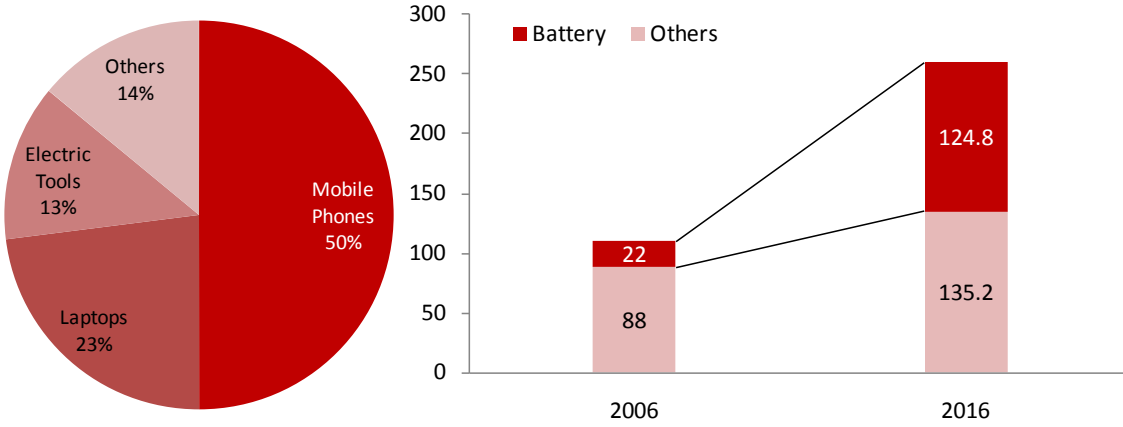
Why is the Lithium Battery Better?

Other types of battery technologies may come along. Today, however, lithium is the best (lighter, greater charge density)

There are three main types of rechargeable batteries: Nickel Metal Hydride (Ni-MH), Nickel Cadmium (Ni-Cd), and Lithium Ion (Li-Ion). The main advantage of using lithium batteries over the others is higher charge density. Lithium batteries are smaller than equivalents such as nickel metal hydride (Ni-MH), and much lighter. In layman's terms they "punch above their weight." And unlike nickel cadmium batteries, lithium ion batteries do not suffer from "memory effect[1]." They also have a low self-discharge rate of approximately 5% per month, compared with over 30% per month in common Ni-MH batteries 10% per month in nickel cadmium batteries.

Exhibit 5: Lithium ion Battery Applications and Growth (000tons)

Today lithium batteries are mainly used in consumer electronics. But the industry's "holy grail" lies with hybrid or all electric vehicles.



Source: Uncomtrade, USGS, CapitalIQ, China MII, Infobank

Lithium batteries are used in great quantities in consumer electronics. Most mobile phones, laptops, cameras and PDA's use lithium batteries. But the industry's "holy grail" is the electric vehicle market. An average laptop has around 5 grams of lithium while an electric vehicle, depending on the technology, could have more than 150 grams per battery.

Ironically, reducing dependency on oil from the Middle East will mean increasing dependency on imported lithium from South America.

Lithium Ion batteries are rapidly becoming the technology of choice for the next generation of electric vehicles, and "green technology" is being heavily encouraged by the U.S. government and auto industry. To reduce dependency on non-renewable oil, a considerable percentage of the world fleet of 1 billion vehicles will likely convert to partial or full electric mode in the next ten years. And potentially, all future production (currently ~ 70 million vehicles per year), will be replaced with electrified vehicles. Ironically, reducing dependency on oil from the Middle East will mean increasing dependency on imported lithium from South America.

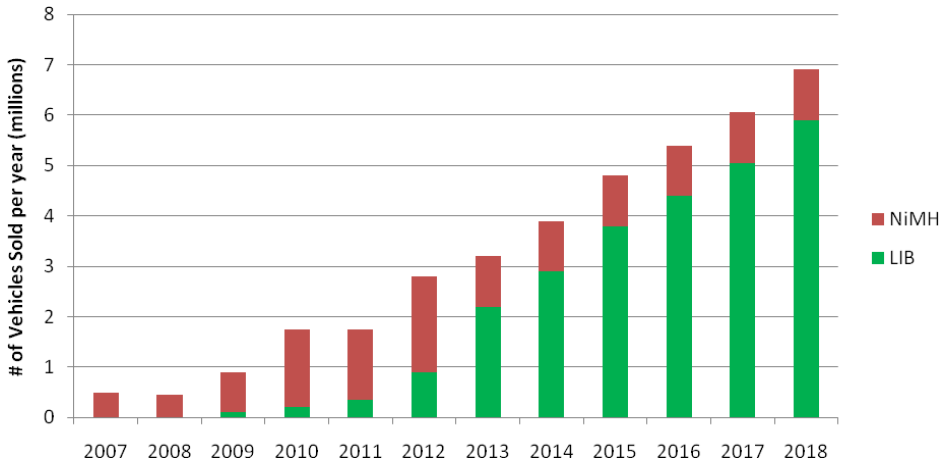
Today, hybrid vehicles such as the Prius still use nickel metal hydride (Ni-MH) batteries, not lithium. That said, Toyota confirmed that the next generation Prius will use lithium. The premise behind the shift is the simple fact that Ni-MH batteries are heavy and their energy output/per unit of mass is approximately 50% that of a

[1] Memory effect, also known as lazy battery effect or battery memory, is an effect observed in nickel cadmium rechargeable batteries that causes them to hold less charge. It describes situations in which certain NiCd batteries gradually lose their maximum energy capacity if they are repeatedly recharged after being only partially discharged. The battery appears to "remember" the smaller capacity.

lithium-ion battery. In an industry as focused on performance (and weight), the only reason auto companies are still using Ni-MH is that they have not yet developed an effective means to mass produce the amount of lithium necessary to gain economies of scale.

Exhibit 6: Expected Growth in Electric Vehicles

Today lithium batteries are mainly used in consumer electronics. But the industry's "holy grail" lies with hybrid or all electric vehicles.



Source: Chemetall

Assuming conservative figures, there is not (by a long shot) enough lithium to power even 10% of the world's 70 million vehicles produced annually

According to lithium producer Chemetall, there could be 6 million lithium-powered vehicles by 2018. Each of these vehicles would likely have a 10kWh (kilowatt hour) Li-Ion battery. And each of these batteries requires roughly 0.3kg of lithium metal equivalent per kWh of capacity.

So 6,000,000 vehicles x 0.3kg x 10 amounts to 18,000 tons of lithium (metal) or 84,000 tons of $(Li2CO3)^2$. This figure equates to almost the entire 2008 world production of lithium and assumes that all of the lithium would be used to make electric vehicles (i.e. none in laptops or cell phones).

As of 2009, the following auto companies had introduced hybrid or plug in cars. Note: these are just some of the brand name companies and don't include any Chinese firms such as BYD, specialty car companies like Tesla, or the thousands of electric government vehicles.

- Toyota (Prius)
- Honda (Civic Hybrid)
- Ford/Mercury (Escape, Fusion, Mariner, Milano)
- Chevrolet (Malibu hybrid, Volt)
- Mercedes (S-Class hybrid)
- Lexus (HS 250h)

If annual vehicle production is around 70 million per year, then Chemetall's 6 million electric cars seems conservative (less than 10%). What if the figure were 15% or 20%? The math is pretty straightforward. We need more lithium.

[2] A Li-Ion battery requires between 1.4-1.5 kg of lithium carbonate per kWh. Said a different way, 1kg Li = 5.28 kg lithium carbonate

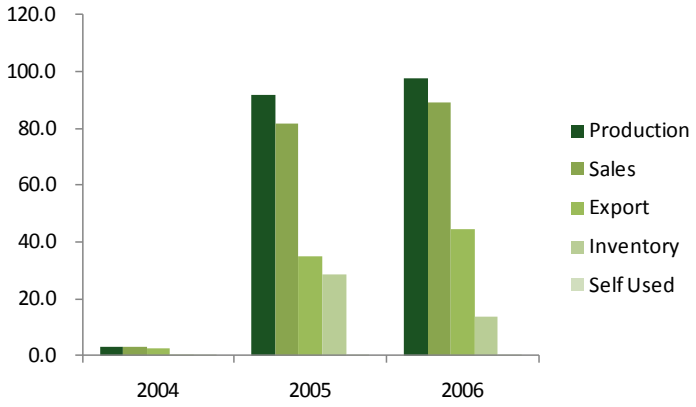
Lithium and China

China has a huge presence in laptop, mobile phone and other consumer electronics manufacturing. All of these devices use lithium batteries

Over the last decade, China has led the world in battery exports for laptop computers, cell phones, and other electronic devices. In China there are hundreds of companies, both small and large, that are involved in development of Ni-MH, lead-acid, and lithium-ion batteries. In the past 3 to 4 years, many multinational companies have brought advanced battery technologies to China and set up partnerships and/or joint ventures to manufacture batteries for these and other applications (such as electric bikes, electric vehicles, and hybrids) to take advantage of low labor costs in China and incentives provided by the Chinese government.

Exhibit 7: Growth in Chinese Lithium Ion Battery Market (million kVA[3])

The growth in the Li-Ion battery market has been astronomical

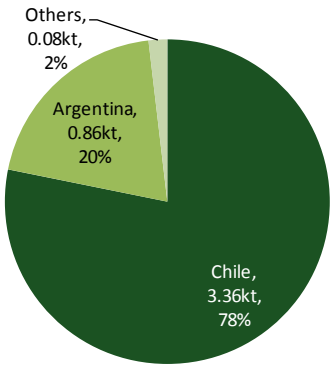


Source: Uncomtrade, USGS, CapitalIQ, China MII, Infobank

While China does have domestic sources of lithium, the country does not have sufficient reserves to cope with the expected demand of consumer electronics, hybrids and electric vehicles. It therefore has no choice but to import lithium. In 2008 China imported roughly 4,300 tons of lithium (mainly from Chile).

Exhibit 8: Chinese Lithium Imports 2008 (tons)

To cope with the surge in demand, China has had to import lithium – mainly from Chile



Source: US Geological Survey, SinoLatin Capital Analysis, Uncomtrade, USGS, CapitalIQ, China MII, Infobank

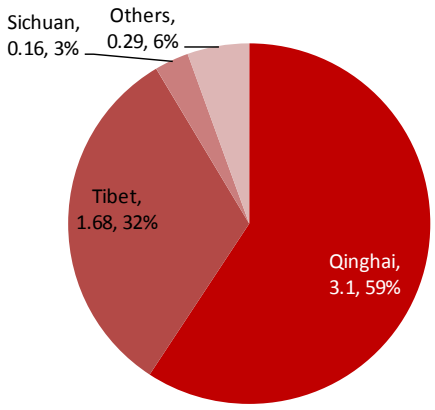
[3] In 2007 the Chinese government changed the measurement statistic from kVA to number of lithium ion cells, making comparisons difficult.

China has quietly been developing its salt lake lithium for the past several years

What many people don't realize is that next to Chile, Argentina and Bolivia, China is one of the countries with the largest lithium reserves in the world. China's lithium reserve base is 2.7 million tons (other estimates peg it at 3.35 million tons), ranking the country 3rd in the world in terms of salt lake brine lithium reserves, and 4th in terms of total lithium ore resources.

Exhibit 9: Chinese Lithium Reserves (MM tons)

The two main areas of focus are in western China – Qinghai Province and Tibet



Source: Uncomtrade, USGS, CapitalIQ, China MII, Infobank

China has three major salt lake deposits: (a) Taijinaier Salt Lake (Qinghai Province), (b) Dangxiongcuo, or DXC (Tibet), and (c) Zhabuye (Tibet). The Qaidan Basin, where Tiaijinaier is located is supposedly the largest salt bed lithium reserve in China. The main operator in the area is CITIC Guoan, who is purportedly building the largest lithium carbonate plant in the world.

One issue facing Chinese lithium deposits is a lack of infrastructure. Similar to their Andean counterparts, the dry salt lakes in China are in very remote and inhospitable places. Trains and highways are crucial if the lithium is to be transported to end users at the right price.

The bottom line is that China does not want to be left behind. If it wants to be the leader in consumer electronics, electric vehicles, and by extension batteries, it needs to do several things: further develop its domestic lithium deposits, beef up the physical infrastructure that lead to those deposits (i.e. roads, rail), and opportunistically look for acquisitions abroad.

Conclusion

Latin America and China have a special bond when it comes to lithium. While China does have reserves of lithium in Qinghai and Tibet, the growth of the hybrid and electrical vehicle markets will dwarf current global production (an electric automobile uses a quantity of lithium equivalent to 700 cell phones). Latin America, especially Chile, Argentina and Bolivia may hold a key.

China is the world's largest auto market but the country lags the United States and Europe in technology for gas-powered vehicles. As a result, Chinese leaders are now focusing on electric cars. They plan to turn China into one of the leading global producers of hybrid and all-electric vehicles in the next few years. A clear winner could be BYD, a firm relatively unknown outside of China. BYD is the world's 2nd largest cell phone Li-Ion battery manufacturer and in 2008 it received $230 million for a 10% stake from Warren Buffett's MidAmerican Energy Holdings. David Sokol, Chairman of MidAmerican, said he thought that BYD's technology was a "potential game changer if we're serious about reducing carbon-dioxide emissions." Today BYD has roughly 12,000 engineers working on battery technology in the southern Chinese city of Shenzhen.

From our vantage point in Shanghai, we think that the "road to riches" in the 21st century may not necessarily be paved with gold, but with a silvery metal known as lithium. And as fate would have it, this road to riches may also inexorably bind two regions of the world that have a lot to gain from each other: China and Latin America.

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