

Paths to Lithium Nirvana

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1. Introduction

Many are sweating how we are going to supply enough lithium to meet the demands of a growing number of electric vehicles. This number needs to expand hugely over the next few decades to reduce our greenhouse gas (GHG) emissions from burning petroleum products.

One solution is to use some other more accessible element in lieu of lithium. We looked at this path in an earlier post, summarized and linked below.

Sodium-Ion Battery Energy Storage Systems: *This paper is about a leading technology in the manufacture of electric vehicles (EVs), and the title technology, a rapidly developing competitor. If you know anything about EVs, you've immediately guessed that the above "...leading technology..." is lithium-ion batteries, and you are correct. However, electric vehicles are not the only market that that uses these batteries, and one of them offers the first step up a ladder that may lead the new-comer to an entry-point into the EV market. Furthermore lithium-ion battery technology has some vulnerabilities, one of them very recent, very large, particularly with respect to sodium-ion batteries.*

<https://energycentral.com/c/gr/sodium-ion-battery-energy-storage-systems>

On the other hand, the supply of lithium is not a critical issue currently, and there are many alternative sources of this abundant element, as I found out in several articles that I came across lately, thus this post.

In the last section of this post, we will also look at a new development in lithium-chemistry batteries.

2. No Lithium Supply Problem

The soaring demand for lithium has prompted US policymakers to restart the nation's long dormant lithium mining industry. There being no such thing as a free lunch, though, new lithium mining proposals have provoked a firestorm of protest over environmental and cultural impacts. On the bright side, the US Geological Survey anticipates that there may be an alternative lithium supply dangling right underfoot.¹

The US has always had a copious supply of lithium at hand. An epic case of bad timing is one way to characterize the supply problem. Lithium mining in the US dwindled down to practically zero by the early 2000s, just when the newborn EV industry was beginning to send demand skyrocketing.

¹ Tina Casey, Clean Technica, "How The US Can Solve Its Lithium Supply Problem In One Fell Swoop," Oct 21, 2024, <https://cleantechnica.com/2024/10/21/how-the-us-can-solve-its-lithium-supply-problem-in-one-fell-swoop/> “

Restarting the US lithium mining industry is an effort years in the making and it is fraught with environmental and socio-cultural impacts.

In the meantime, the US Department of Energy has been promoting geothermal brine as an alternative to mining for lithium. Called DLE (short for direct lithium extraction), the process leverages geothermal energy to avoid the extensive impacts involved in conventional lithium operations. One such example in the pipeline is the Hell's Kitchen geothermal brine project in California.²

Author's comment: The 2023 post summarized and linked below covered using geothermal brine in Southern California to supply lithium.

Domestic Lithium: *Currently Electric Vehicles (EVs) are ramping up production very rapidly. Ditto Battery Energy Storage Systems (BESS), mostly used in conjunction with renewable energy production from Wind and Solar-Power. The primary chemistries used in conjunction with the batteries in both of the products is Lithium-Ion (Li-Ion) Batteries. Although other non-lithium chemistries have been proposed, Li-Ion is the state-of-the-art presently.*

Although there are several viable types of Li-Ion batteries, each requiring different other elements in their cathode chemistries, all of these require lithium. The primary questions about these product's supply chain are: (1) can we ramp up the Lithium supply rapidly enough, and (2) can we source these domestically (from the U.S.)?

<https://energycentral.com/c/cp/domestic-lithium>

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The waste brine that results from oil and gas drilling is another potential lithium supply pathway that avoids the full impacts of mining.

The leading driller ExxonMobil, for one, has spotted an opportunity. CleanTechnica editor Zachary Shahan took note last year when ExxonMobil announced its intention to become “a top lithium producer and supplier for the electric vehicle (EV) battery industry by 2030.”

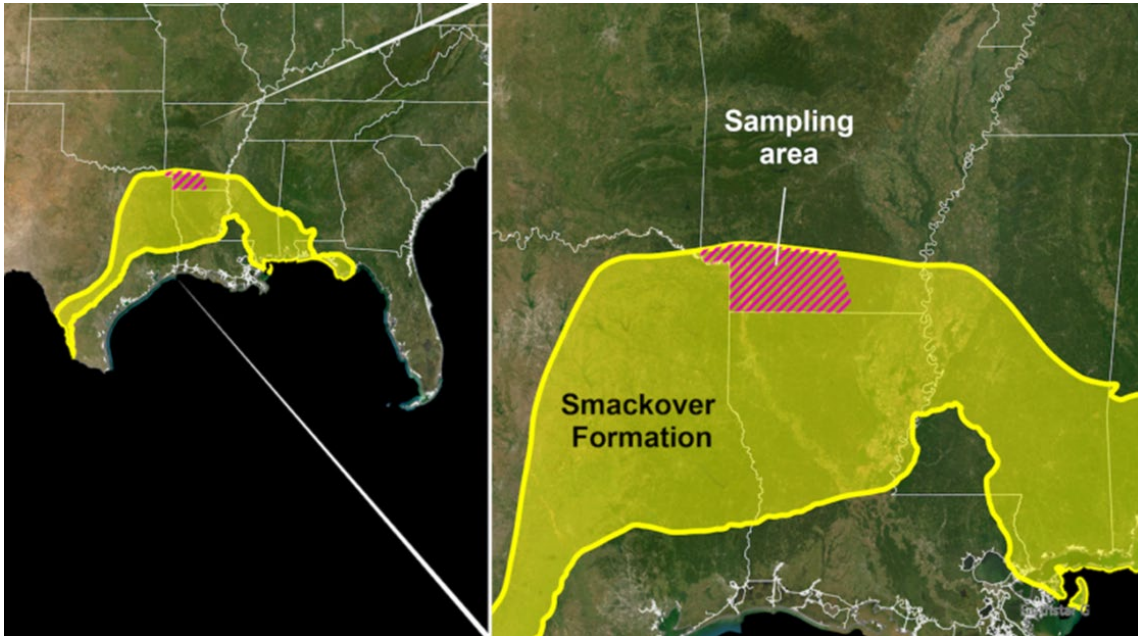
“Earlier this year, ExxonMobil made the move to acquire the rights to the 120,000 gross acres of the Smackover Formation in southern Arkansas that it is now tapping into,” Shahan observed, adding that ExxonMobil has cited Smackover as “one of the most prolific lithium resources of its type in North America.”

2.1. Machine Learning Used to Uncover New Lithium Supply

The Smackover Formation has also caught the eye of the US Geological Survey, which is the agency tasked with tracking the supply of lithium and other substances deemed critical to US interests.

On October 21, CleanTechnica received an email from USGS that outlines a new study of one small piece of the Smackover Formation, in southwestern Arkansas (see figure on the next page). In collaboration with the Office of the State Geologist in the Arkansas Department of Energy and Environment, the first-of-its kind study combines water test samples with machine learning to predict the amount of lithium that could be co-produced from oil and gas operations.

² The active Hells Kitchen project that the author found was in Imperial County in Southern California, on the south shore of the Salton Sea. For additional information go here. <https://www.cthermal.com/>



It's quite an amount. The research team arrived at a low-end estimate of 5 million tons of lithium, which it describes as "equivalent to more than nine times the International Energy Agency's projection of global lithium demand for electric vehicles in 2030."

That's just for starters. On the high side, that one piece of the Smackover Formation could hold 19 million tons of lithium in its brine.

Not to rain on the lithium supply parade, but the principal researcher of the study, hydrologist Katherine Knierim, does advise that the researchers were tasked with developing a predictive model of lithium availability, not accessibility.

"It is important to caution that these estimates are an in-place assessment," Knierim cautioned. "We have not estimated what is technically recoverable based on newer methods to extract lithium from brines."

Still, the study, titled "Evaluation of the lithium resource in the Smackover Formation brines of southern Arkansas using machine learning," does indicate that a copious lithium supply is close at hand. Based on the USGS predictive model, in 2022 the brine brought to the surface in the area of study contained 5000 tons of dissolved lithium. The total included bromine operations as well as oil and gas.

That helps explain why ExxonMobil is suddenly so interested in boosting the lithium supply chain for EV batteries. At first glance it doesn't make much sense for an oil producer to help decarbonize the transportation sector, but gas producers have a different set of priorities. Although ExxonMobil is better known as an oil company, it has spent the early 2000s amplifying its gas business.

3. Potential Alternate Sources

Once the EV battery recycling industry gets into gear, that will also help supplement the lithium supply chain and reduce the need to extract new lithium from the Earth.

Recovering lithium from saltwater is another approach that has crossed the CleanTechnica radar from time to time. That seemed like a pipe dream just a couple of years ago, considering that the concentration of lithium in seawater is extremely low. However, lots can happen in a couple of years. In June, for example, a research team from the Pritzker School of Molecular Engineering at the University of Chicago described an economical method for extracting lithium from seawater as well as groundwater and drilling wastewater. Their study, "Identifying critical features of iron phosphate particle for lithium preference," was published in the journal Nature on June 7.

3.1. Deep Groundwaters in Sedimentary Basins

Deep saline groundwaters in sedimentary basins could also be of interest but have not been studied in detail. Yet, sedimentary formation waters are usually produced in large volumes in oil and gas fields, low-enthalpy geothermal fields and CCUS (carbon capture, utilization and storage) operations in saline reservoirs. Lithium concentrations in these waters have been widely documented. However, a global analysis of the potential resource in lithium is still lacking. Here, a database of published lithium concentrations from sedimentary formation waters worldwide was built.³

The main features of the reservoirs (depth, temperature and age of host rocks) and chemical parameters, such as Total Dissolved Solids were examined to evaluate the first-order parameters controlling lithium concentrations in sedimentary formation waters as well as Mg/Li which is relevant for lithium recovery. The lithium resource was calculated for selected lithium-rich reservoirs based on available lithium concentrations and conservative estimates of fluid volumes. The estimated lithium resources were compared to current lithium resources from hard rocks and salars (salt-encrusted depressions) to examine how they can face forecasted lithium demand.

On the next page is the beginning of a 4-page table from reference 3 defining potential lithium sources from deep saline groundwaters in sedimentary basins world-wide. The table is alphabetical order by country, and the U.S. sources are under "USA."

³ Elza J. M. Dugamin, Antonin Richard, Michel Cathelineau, Marie-Christine Boiron, Frank Despinos & Anne Brisset, Nature, "Groundwater in sedimentary basins as potential lithium resource: a global prospective study," 26 Oct 2021, <https://www.nature.com/articles/s41598-021-99912-7>

Countries	Basin name	Identification number	Number of samples	References
Closed basin brines				
Argentina	Puna—Atacama—Altiplano—Northwest	A	490	Ericksen et al. 1976; Ericksen and Salas 1987; Risacher and Fritz 1991; Risacher et al. 1999; Steinmetz et al. 2018; Gabriela et al. 2020
China	Qaidam	B	13	Qishun et al. 2010; Tan et al. 2011
Sedimentary formation waters				
Australia	Amadeus	46	26	Andrew et al. 2005
Australia	Canning	45	19	Ferguson et al. 2007
Australia	Eromanga	47	10	von Strandmann et al. 2014
Australia	Murray	48	42	Cartwright et al. 2004
Canada	Quebec	2	5	Pinti et al. 2011
Canada	West Canadian-Alberta	1	147	Connolly et al. 1990; Hitchon 1971; Eccles and Berhane 2011; Hitchon 2001
China	Jiangnan	43	12	Yu et al. 2021
China	Qaidam	41	27	Qishun et al. 2010; Tan et al. 2011
China	Sichuan	42	92	Xun et al. 1997; Xun et al. 2018; Gao et al. 2020
England	Cheshire—Worcester	24	15	Tellam 1995

Countries	Basin name	Identification number	Number of samples	References
France	Aquitaine	29	81	Négrel et al. 2012
France	Gulf of Lion	31	6	Aquilina et al. 2002
France	Limagne	32	10	Millot and Négrel 2007
France	Paris	28	79	Michard and Bastide 1988; Fontes and Matray 1993; Millot and Négrel 2007 Linard et al. 2011; Millot et al. 2011; Castillo et al. 2015
France	Pyrenean Foothills	30	3	Millot and Négrel 2007
France-Germany	Rhine Graben	27	65	Pauwels et al. 1993; Aquilina et al. 1997; Millot and Négrel 2007; Sanjuan et al. 2010; Stober and Butcher 2015; Sanjuan et al. 2016; Sanjuan et al. 2020
Germany	Northwest German	26	45	Kloppmann et al. 2001; Luders et al. 2010
Germany	Southern North Sea—Anglo Dutch	25	12	Grobe and Machel 2002
Hungary	Pannonian	34	129	Varsanyi et al. 1997; Varsanyi and Kovacs 2009; Rowland et al. 2011
Iran	Zagros Foldbelt	36	98	Mirnejad et al. 2011; Bagheri et al. 2014; Boschetti et al. 2020
Israel	Sinai—Levant	35	22	Chan et al. 2002
Italy	Po	33	36	Boschetti et al. 2011

Countries	Basin name	Identification number	Number of samples	References
Italy	Po	33	36	Boschetti et al. 2011
Mexico	Salinas—Sureste	21	32	Birkle et al. 2002; Birkle et al. 2009
Russia	Anabar—Olenek	39	9	Alexeev et al. 2020
Russia	Nepa-Botuoba	38	7	Alexeev et al. 2020
Russia	Tunguska	37	8	Alexeev et al. 2020
Russia	Vilvuy	40	6	Alexeev et al. 2020
Spain	Betic Cordillera	23	75	Sanchez et al. 1999
Thailand	Pattani	44	20	Lundegard and Trevena 1990
USA	Appalachian	17	184	Sanders 1991; Dresel and Rose 2010; Skeen 2010
USA	Black Warrior	19	2	Collins 1976
USA	Delaware	9	70	Bodine and Jones 1990
USA	East Texas Salt	11	5	Collins 1976
USA	Forest City	14	23	Banner et al. 1989
USA	Georges Bank	18	14	Hogan and Blum 2003

Countries	Basin name	Identification number	Number of samples	References
USA	Green River	4	5	Collins 1976
USA	Gulf Coast Tertiary	12	330	Collins 1976; Macpherson 1989; Land and Macpherson 1992; Land 1995
USA	Illinois	15	144	Stueber and Walter 1991; Stueber et al. 1993; Demir and Seyler 1999
USA	Michigan	16	112	Wilson and Long 1993
USA	Midland—Permian	8	57	Stueber et al. 1998
USA	Mississippi Salt	13	62	Carpenter et al. 1974; Collins 1976
USA	North Louisiana Salt	10	105	Moldovanyi and Walter 1992
USA	Northeast Gulf Salt	20	2	Collins 1976
USA	Salton Trough	7	15	Thompson and Fournier 1988; Williams and McKidden 1989
USA	San Joaquin	6	66	Merino et al. 1975; Fisher and Boles 1990
USA	Williston	3	38	Collins 1976; Peterman et al. 2016
USA	Wind River	5	5	Collins 1976
Venezuela	Maracaibo	22	10	Boschetti et al. 2016

4. South 8: LiGas Batteries

Lithium-ion batteries have quickly become the standard for powering vehicles, but South 8 CEO Tom Stepien says they have three problems: “fire, cold, and cost.” South 8 addresses all three with LiGas, a liquefied gas electrolyte that, when injected into battery cells, provides a more stable and longer-lasting charge than conventional liquids. While lithium-ion battery fires can burn for up to five to 10 minutes, LiGas batteries burned for just six seconds in a U.S. Army test, reducing fire risk. The LiGas batteries work in minus 60°F, versus minus 30°F for conventional batteries, and cost around \$100 per kilowatt hour, versus \$150. LiGas also allows batteries to charge in minutes versus hours. South 8 has a contract with the U.S. Department of Defense and is talking to major car companies.⁴

South 8 is in San Diego, California. Their website is linked below.

<https://south8.com/>

⁴ Micheline Maynard, Time Magazine, The Best Inventions of 2024, “A Longer-Lasting Charge,” Oct 30, 2024, <https://time.com/7094815/south-8-ligas/>