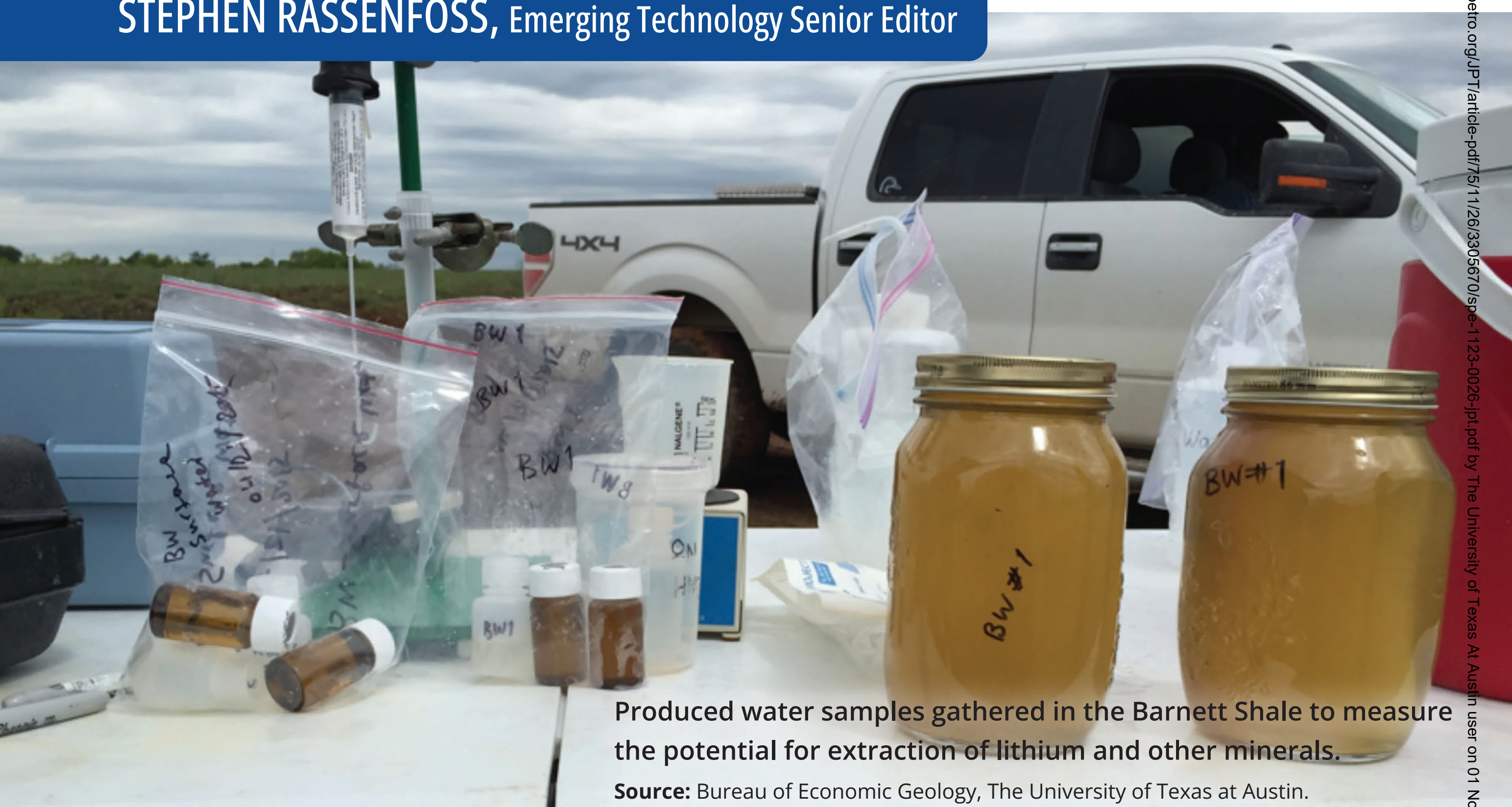
It Is Easy To Find Lithium; Turning a Profit Is Hard

STEPHEN RASSENFOSS, Emerging Technology Senior Editor



Produced water samples gathered in the Barnett Shale to measure the potential for extraction of lithium and other minerals.

Source: Bureau of Economic Geology, The University of Texas at Austin.

Finding lithium in the water from oil and gas wells is easy. Finding enough to make money is hard.

In the US and Canada there has been growing interest in directly extracting lithium from the water coming out of the oil/water separator, which is competing with more established techniques such as mining and evaporating lithium-rich fluids.

The race to find lithium is driven by expectations that fast-rising electric car sales will make the lithium required for batteries in those vehicles a valuable commodity. Those chasing direct extraction are also betting that their innovations can do what they say.

Direct extraction from water started looking like a real possibility earlier this year when **ExxonMobil paid $100 million to buy a company holding 120,000 gross acres of leases in south Arkansas**.

The price reflected the location in the heart of the direct lithium extraction industry of the future. The area offers a unique combination of lithium-rich water plus the infrastructure and expertise needed to transport, process, and dispose of the billions of gallons of water needed for industrial-scale mineral extraction.

Commercial production of battery-quality lithium carbonate in Arkansas is years off. But the sprawling network of water-producing wells, pipelines, and processing that have made the state one of the world's leading bromine producers, lowers the risk and cost of commercial lithium production.

The source of the lithium-rich water is the Smackover—an oil formation discovered near El Dorado, Arkansas, back in 1921 when a gusher blew in. A year after that discovery, there were 608 producing wells nearby, according to the ***El Dorado News-Times***.

Now with lithium looking like battery gold, investors are rushing in. In this emotional market, lithium carbonate prices have swung like cryptocurrency.

As of mid-October, a ton of it was selling for about $25,000. Over the past quarter it averaged $32,000/ton. Late last year it stood at $85,000. And in 2021 it was going for $10,000, said Graham Bain, vice president for subsurface opportunities at Enverus. He offered $25,000/ton as a "go forward price."

As with oil and gas, hopes of high prices have a way of rapidly increasing supplies, resulting in price-crashing gluts. So far, most oil companies sound curious but far from committed to lithium.

"There's a big rush. I have received several requests from companies in the Permian Basin to discuss lithium in the water," said Jean-Philippe Nicot, senior research scientist at the Bureau of Economic Geology (BEG) at The University of Texas at Austin.

He is the lead author on recent paper that offered a primer on what's known about lithium brines from oil wells in states from Texas to Mississippi. It is based on nearly 1,802 water analyses from the US Geological Survey (USGS)—some dating back to the 1960s—plus a recent 576-well survey by the BEG.

The geologists, whose work ranged from hard-rock mining to water research, said this is an early effort to begin figuring out how to find the lithium in subsurface water.

The survey of past data offers a few places to look for the next Arkansas, starting with the Smackover in east Texas and elsewhere, as well as prospects in south Texas and the Texas Panhandle.

The biggest source of US onshore oil production was not on the list.

"Unfortunately, there is not much lithium as far as we can tell in the Permian Basin, which is regrettable because there's so much produced water being pulled out of the ground over there," Nicot said.

But a consistent message in the report is that it is early in the hunt. At this stage the available public data is limited. That and questions about the quality of analyses dating back more than 50 years led the BEG to do a survey with support from the US Department of Energy.

The tricky job of getting permission from oil companies to sample and test their water was done by Kristine Uhlman, a hydrogeologist, who retired from the BEG some years ago but continues to work on research projects for the bureau.

Her pitch to well owners was, "We'll collect your sample and analyze it, and if you have a lot of lithium, you might make more money from the lithium than you do from the petroleum," she said.

Based on the survey, she wondered if that message was exaggerating the chance of success. Only about 6% of the wells had commercial levels of lithium in the water (80 mg/L).

When it comes to lithium claims, landowners are wise to be cautious, said Laura Capper, principal at EnergyMakers Advisory Group, an energy industry consultant specializing in water treatment for emerging markets.

Based on thousands of water analyses she has seen, the average lithium concentrations reported in some industry reports are based on "wishful thinking."

It some ways it is like the early days of oil, when wildcatters armed with little understanding or tools for finding oil and gas, drilled a lot of dry holes in search of a big discovery.

While the USGS database is the best available public starting point for exploration, it has its flaws.

In the 268 old USGS samples in the Anadarko Basin, the 50 from Texas averaged more than 100 mg/L—with the highest numbers concentrated near the Amarillo Arch. On the other side of the border, Oklahoma averaged less 6 mg/L, the BEG paper said.

When the BEG checked on those results by trying to sample "the same areas and possibly the same wells," the new samples "did not show any Li [lithium] enrichment."

The paper concluded that lithium resources in the Anadarko Basin "need to be more clearly demonstrated."

What Looks Good

Based on the recent BEG review, the most promising spots were the in the Smackover, ranging from east Texas to Mississippi. Also on the list were: the gas-producing deep Edwards formation in south Texas and, to a lesser degree, gas-producing areas in the Eagle Ford Shale. And despite their inability to confirm some old positive results in the Anadarko, it is still a possibility.

Shale plays generally lack a feature common to good lithium water sources, the high permeability needed to deliver high volumes of water. A big exception is the Permian, particularly in the Delaware Basin.

While good lithium concentrations have been found in the Marcellus Shale, the water production falls short of what is needed to efficiently extract tons of a mineral measured in parts per million (ppm). The same is true in the Haynesville Shale. The Barnett Shale suffers from low lithium concentrations.

The Smackover in east Texas has some of the highest lithium concentrations outside of Arkansas, It has attracted the interest of Standard Lithium, which is developing a $1.3-billion-plus lithium production project in Arkansas, the company said on its website.

But even the Smackover is "not a sure bet" everywhere. Nicot said there are wide localized swings in the test results. The lithium in 12 samples from northern Louisiana, just across from prime acreage in Arkansas, ranged from less than 5 mg/L to a couple samples exceeding 100 mg/L.

Nicot suspects the differences reflect the ability of lithium to travel up to the water-producing formations. "You need a way to transport the brine because clearly the Smackover is a clean carbonate with no lithium in the rock itself," he said.

One explanation is that lithium comes from lithium-rich granitic rocks, such as feldspar.

This theory favors carbonate formations down near the basement rock because the trip up is short. Concentrations will vary based on the presence or absence of highly conductive faults.

Lithium Measures Matter

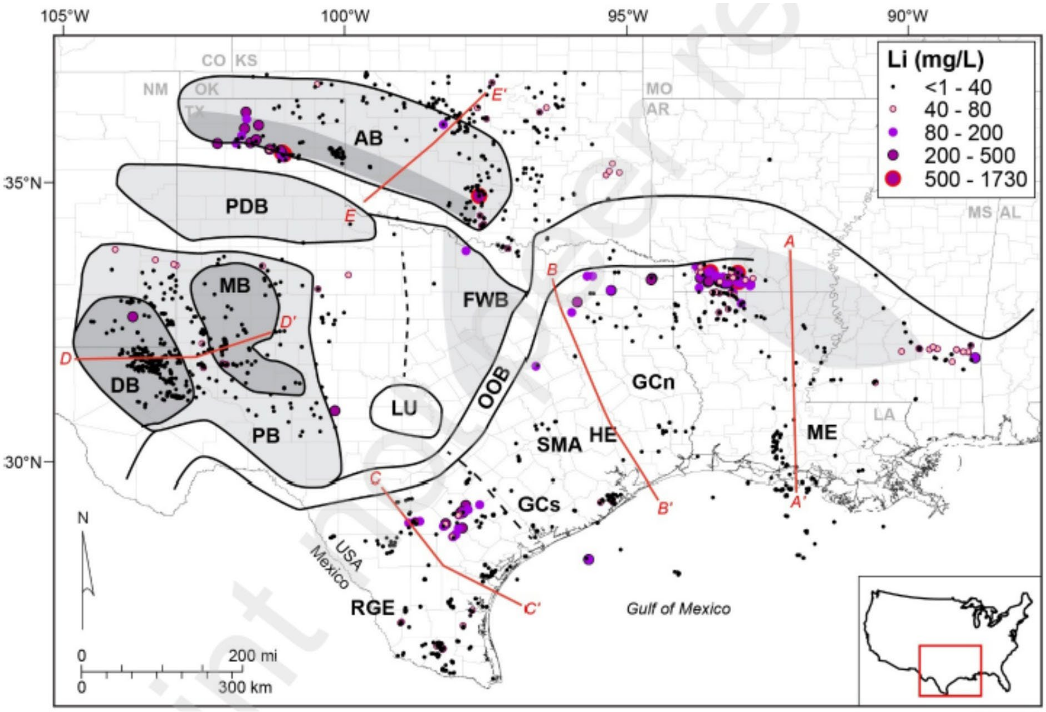
Lithium concentrations in brine are measured two ways—ppm and mg/L.

In general discussions, 100 ppm and 100 mg/L are roughly equivalent measures, but not in engineering work.

For those working with formulas, this matters because lithium is found in fluids with high levels of dissolved solids—which can vary widely—leading to significant differences between ppm and mg/L measures.

ppm should be understood as mg/kg—mg of lithium and kg of fluid whose weight will vary based on the density of the dissolved solids. A volume measure does not reflect the variability in density.

Source: Kristine Uhlman, Bureau of Economic Geology.



Larger dots show the location of water samples with high concentrations of lithium. Source: Bureau of Economic Geology.

Carbonates are a plus because they are less likely to combine with highly reactive lithium.

There are other origin stories. A paper from the **Alberta Energy Regulator/Geological Survey** identified promising areas among deeper strata—the Devonian. Possible sources of lithium include granitic pegmatites—an amalgam including feldspar. Another source is ancient deposits of seawater or meteoric brines that evaporated, concentrating the lithium.

The huge gap between the number of produced water samples tested and the number of possible formations has left Nicot wanting a lot more samples and the grant money to collect them.

Nicot said that he is continually asking well owners for water to test "because many formations haven't been sampled, so we don't know exactly where they are" in terms of mineral content.

On the list of interesting but undrilled possibilities includes the Smackover in south Texas. Because an area has not justified drilling by oil companies does not mean it is not good for lithium.

"The problem is, you need gas production" to justify drilling wells, Nicot said, adding, "You may have high-lithium formations with no oil or gas nearby. But these formations would be hard to sample because we're not going to drill 5,000- or 10,000-ft wells. It just doesn't make sense at this point."

The Permian Question

In the Permian, old USGS data offered one spot that looked extremely promising. A well in the northern Delaware Basin—the accompanying data did not say exactly where—appeared to have lithium concentrations riveling the best in Arkansas—493 mg/L.

The problem was other samples from nearby wells were not nearly as good. The BEG paper said, "We believe this isolated concentration might be too high by an order of magnitude and might result in a transcription error."

Even if accurate, that high reading would need to be repeated many times over a large area to deliver the volumes of water needed for lithium extraction. Permian sampling has found relatively low-concentration water in the Wolfcamp, Bone Springs, and Spraberry formations. But this huge, deep basin has many horizons to consider.

Earlier this year, an emailed report summary from Enverus estimated that five operators in the Delaware Basin could produce from 3,000 to 11,000 tons of lithium carbonate a year—which at the current price per ton would be worth from $105 million to $385 million.

Based on some quick calculations, Nicot said that would require lithium concentrations of around 100 ppm, and the samples he had seen in that area were around 15 ppm.

When asked about the estimates, Bain said they were focused on the potential of the enormous volumes of produced water flowing through Permian pipeline networks. The water from that growing transportation network could eliminate two expensive items from the budget for an extraction facility: wells and pipelines.

For example, a breakdown of the $1.3-billion cost of Standard Lithium's planned extraction operation in south Arkansas lists the wells as the highest-cost line item. That plus pipelines equals nearly one-quarter of the capital cost, and one-third of the energy cost to run it.

For big oil companies, extraction could represent an added source of income. While lower concentrations would likely mean margins lower than Standard Lithium's 33% profit (IRR), Bain said it could still be "wildly economic."

He said, "There are going to be other player oil production companies willing to develop lower-concentration sources."

Lithium concentration breakevens needed for direct extraction of lithium require educated guesses ranging from details of future lithium prices to likely performance of new processing methods. While Nicot uses a 100-ppm limit for breakeven development, sometimes the paper dropped to 80 ppm. Uhlman said that in China 45 ppm is used for breakeven.

Enverus also sees potential in data from the Alberta Geological Survey. Bain said nine companies have been started up to pursue lithium extraction in an oil- and gas-rich province where the highest average concentration measured is 59 ppm in the Woodbend Group.

A paper from the Alberta Geological Survey said previous Canadian papers have set "exploration threshold values" at a minimum of 75 ppm for producing wells, and at an average of 50 ppm as a regional exploration limit.

A review of a 130,000 formation water analyses there pointed to lithium levels as high as 130 mg/L in Devonian carbonates in west-central Alberta. The paper suggested that like oil exploration, over time the industry would get better at identifying top sites for water production.

Standard Lithium said it was able to increase the estimated average lithium levels in one of its Arkansas projects by 52% by tightening the boundaries of its producing area.

On the other side, the prices can rise significantly based on cost overruns, rising interest rates, inflation and the other risks associated with scaling up new technology.

Surface Effects

Finding a source of lithium water is the gateway to the billion-dollar question: Can you find enough lithium-rich water production nearby to justify a billion-dollar development?

Unlike oil and gas development, where a pipeline connection to the Gulf Coast can make it possible to sell to customers in China, the volume of water required for lithium extraction argues for local processing.

The surface costs shown in Standard Lithium's description of its planned lithium extraction project in Arkansas offer a breakdown based on estimates of what they will be if the 2-year construction project begins in 2025 as expected.

The bottom line looks attractive. The $1.3-billion project is expected to deliver a nearly 33% return (IRR) and be worth $3.1 billion (NPV), both after taxes.

The capital budget for its Lanxess project includes 200 miles of pipelines connected to 64 production and reinjection wells covering 150,000 acres of unitized brine leases. The system is expected to handle 3 billion gallons of brine annually—more than 1 million gal/D—to produce 30,000 tons of lithium carbonate a year.

That is a huge amount of water, but the high lithium concentration—an average of 437 mg/L—means its pipelines and processing units will be able to produce that much product with a fraction of system capacity and energy needed for a project with 100 mg/L water or less.

South Arkansas offers another cost advantage. Standard Lithium is operating in a place where it benefits from infrastructure and expertise developed where extraction has made this one of the world's leading producers of bromine.

The Lanxess project is a joint venture named after Standard Lithium's corporate partner, which operates the biggest bromine extraction operation in Arkansas. Lanxess will provide the brine supply "via certain commercial agreements—plus access to Lanxess' processing infrastructure in the area," according to **the announcement of that deal**.

Standard Lithium assumes that the all-in annual operating costs will be just over $5,200/ton and that it will be able to sell its lithium carbonate for $30,000/ton.

Based on that, lithium extraction will be widely profitable. In the real world, the price of lithium is extremely volatile and the cost of getting it out of produced water is yet to be confirmed by high-volume commercial operations.

Predicting at this early stage is so iffy that Bain described Enverus' prediction that 500 lithium wells will be drilled next year as a "hypothetical number."

Extracting lithium from produced water is one of many ideas under consideration to increase the value of what is now mostly a waste product, which includes projects to process produced water to a level that has value, Capper said.

Extracting other minerals is a possibility being studied. Based on what Nicot has seen, nothing jumps out as a good candidate.

While the BEG study observed high levels of potassium and boron where lithium was high, there are low-cost sources of those commodities, he said.

Factors Associated With High Lithium Content

- Large faults are located nearby, allowing lithium to rise to high-permeability formations.
- Brine has high levels of dissolved solids other than sodium chloride.
- Concentrations of potassium and calcium can indicate rock-water interactions that also could add lithium.
- High boron is a "common companion of lithium."
- Carbonate formations are not likely to react with lithium.
- Rock formed in hot, dry depositional environments may be a factor.

Source: ***Controls on Lithium Content of Oilfield Waters in Texas and Neighboring States.***

Unlike the gusher that announced the discovery of the Smackover, this is not going to be a sudden change.

"The science is tricky, and big players have a really long trajectory," Capper said. **JPT**

FOR FURTHER READING

Controls on Lithium Content of Oilfield Waters in Texas and Neighboring States *by Roxana Darvari, Jean-Philippe Nicot, Bridget R. Scanlon, and J. Richard Kyle, The University of Texas at Austin; Brent A. Elliott, Independent; and Kristine Uhlman, The University of Texas at Austin.* Journal of Geochemical Exploration, *preprint, in review.*

Lithium and Helium in Alberta: Data Compilation and Preliminary Observations *by S. Lyster, T.E. Hauck, G.P. Lopez, T.L. Playter, C. Reimert, D. Palombi, and S.K. Schultz, Alberta Energy Regulator/Alberta Geological Survey, AER/AGS Open File Report 2021–04.*