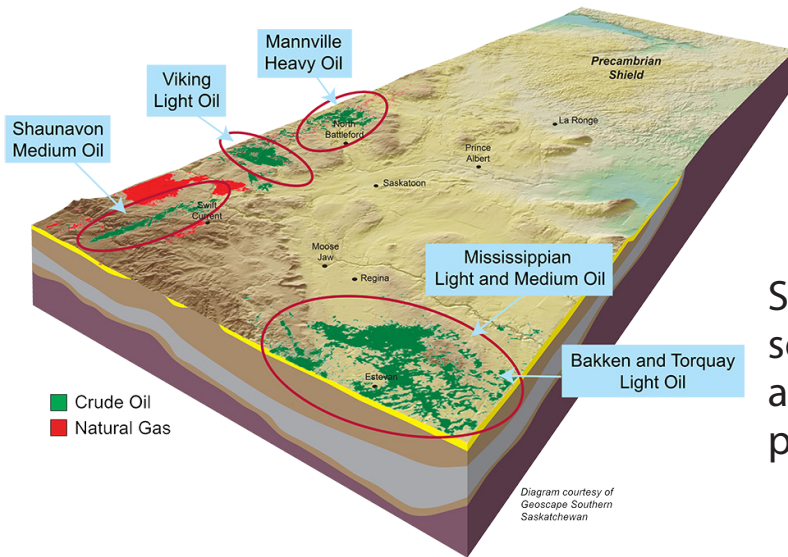


Saskatchewan's Top Oil Play Opportunities



Saskatchewan is Canada's second-largest oil producer, with about 10% of Canadian crude oil production.

Hydrocarbon Opportunities

Saskatchewan's oil patch activity levels in 2020 for drilling, exploration and development in the petroleum sector dropped slightly in comparison with 2019 levels in response to continued oil price pressures. There were an estimated 1,702 oil well completions in 2020, a decrease from 1,714 in 2019. The province also experienced a slight decrease in production in 2020: 435,826 barrels of oil per day (69,263 cubic metres/day) compared to the 486,385 barrels of oil per day (77,329 cubic metres/day) in 2019.

Saskatchewan's geology lends itself mainly to crude oil production, although it also has some production of natural gas. Over 40 formations and members produce crude oil, with oil densities that range from light to heavy. Saskatchewan's heavy oil production is from the Lloydminster area in west-central Saskatchewan, whereas the lighter crude oils are produced farther south. This geographic separation of oil pools is a result of Saskatchewan's geology: the province's western edge lies on the eastern edge of the Alberta Basin, and the southeastern part of the province lies within the northern portion of the Williston Basin. Saskatchewan oil reservoirs are relatively shallow, ranging in depth from 250 to 2,900 metres. The province's geology, combined with horizontal drilling and hydraulic fracturing, enhanced oil recovery (EOR) techniques and improved efficiencies in

field operations have enabled producers to continue to weather low oil prices and to sustain oil production.

Though there are many oil plays in the province, the seemingly most resilient five are indicated on the map above and described (from youngest to oldest) below.

Viking Light Oil

- The Cretaceous Viking Formation is a geologically complex unit consisting of interbedded, mainly marine-influenced, fine-grained sandstones, siltstones and mudstones sandwiched between two marine shales. Oil was discovered in the Viking in the 1950s.
- Approximately 9,078 oil well completions have occurred into the Viking since January 1, 2008. These wells have produced approximately 22.7 million barrels of 36° API oil (3.6 million cubic metres) in 2019, a decrease from 26.0 million barrels (4.1 million cubic metres) produced in 2018. Overall Viking production in 2020 was at a rate of 62,221 barrels/day (9,888 cubic metres/day).
- In light of the activity and success in the Viking, Kohlruess (2015) wrote an update on the Viking Formation in west-central Saskatchewan, describing the controls on hydrocarbon distribution in the area.

He emphasized that oil and natural gas distribution is largely controlled by the structural features created by the sub-Cretaceous erosional surface, where the hydrocarbons are trapped in structural roll-overs (anticlines), and/or by reservoir facies pinch-outs.

Mannville Heavy Oil

- The Lower Cretaceous Mannville Group in west-central Saskatchewan has been a known heavy oil producer since 1945. The Mannville Group is divided into nine individual members, often separated by discontinuities, and is composed of quartz-rich sandstones, siltstones, mudstones and coals that overlie and infill valleys and overlie terraces
- There have been 34,499 oil well completions in the Mannville since 1945. These wells have produced over 2.0 billion barrels (328.3 million cubic metres) of heavy (~13° API) crude oil.
- Thick sandstone reservoirs combined with shallow depths ranging from 250 to 850 metres make the Mannville Group an excellent target for EOR. Techniques such as steam-assisted gravity drainage (SAGD), cyclic CO₂ injection, polymer flooding, water flooding, microbial injections and cold production with sand (CHOPS) have extended the life of many of the Mannville pools.
- The Saskatchewan Geological Survey continues to produce detailed, regional maps, open file and other reports, to develop a better understanding of Mannville Group reservoirs. Hill's (2020) recent work focused on reservoir characterization and hydrocarbon distribution within the Lloydminster Member in the Tangleflags area. Hill (2018) also discussed how dissolution in the Prairie Evaporite controls hydrocarbon distribution within various members in the Mannville Group, and examined the hydrocarbon distribution from multiple reservoirs within the Waseca Member in the Edam area (Hill, 2017). Flynn (2018) focused on reservoir characterization and hydrocarbon distribution in the Colony Member.

Shaunavon Medium Oil

- The Jurassic Shaunavon Formation has been a known oil producer in southwestern Saskatchewan for almost 70 years. Initial production came from the Delta pool in 1952 and was followed

shortly thereafter by a second producer in the Eastend pool. Both pools are still producing.

- There have been approximately 4,954 well completions in the Shaunavon, with total production close to 493.2 million barrels (78.4 million cubic metres) of ~22° API oil.
- Since 2007, with the advancement of multi-stage fracturing (frack) techniques in horizontal wells, the Shaunavon has produced around 141.7 million barrels (22.5 million cubic metres) of oil.
- Thick carbonate-clastic reservoirs combined with very low decline rates make the Shaunavon Formation an ideal target for oil exploration and development.
- The most recent Saskatchewan Geological Survey publications include a Prospect Saskatchewan issue (Saskatchewan Geological Survey, 2016) highlighting off-trend oil production in the Upper Shaunavon Member west of the main oil field trend. There are also two Summary of Investigations papers (Marsh and Hill, 2013; Hill and Salad Hersi, 2016) that discuss the Upper Shaunavon Member reservoir distribution, depositional setting and lithofacies.

Mississippian Light and Medium Oil

- Mississippian strata have been producing oil consistently in southeastern Saskatchewan since the 1950s, providing the best overall production in the province, with over 2.64 billion barrels (420.2 million cubic metres) produced to date.
- In 2020, the Mississippian produced 34.9 million barrels (5.5 million cubic metres) of oil, keeping it amongst the province's top producers. Daily production for the year was 95,620 barrels (15,196 cubic metres), which is lower than the historical daily production average of 106,699 barrels (16,957 cubic metres).
- There are seven producing strata within the Mississippian. The Midale Beds are the most prolific of these, having the highest cumulative oil production and the second-highest monthly average oil production of any stratigraphic unit in Saskatchewan. The number of completions in the Midale in 2020 was 54, down from both the 10- and 20-year average for this unit (130 and 134 respectively). Total oil production in

2020 was 18.0 million barrels (2.9 million cubic metres), which is 2.4 million barrels (374,318 cubic metres) below its historical production average.

- The Frobisher Beds, which underlie the Midale Beds, are also very productive, having produced approximately 334.3 million barrels (53.1 million cubic metres) to date. These beds continue to be a target for future development, maintaining relatively consistent daily oil production of 18,254 barrels/day (2,901 cubic metres/day) in 2020.
- Many papers have been written over the years discussing the geology of the various beds within the Mississippian in Saskatchewan. Over the next few years the Saskatchewan Geological Survey will be producing reservoir characterization studies for the hydrocarbon-bearing intervals within the Mississippian beds.

Bakken and Torquay Light Oil

- The Mississippian-Devonian Bakken Formation, in southeast Saskatchewan, saw limited production in the 1950s. Since 2005, technological innovation led to a major increase in production.
- To the end of 2020, there have been approximately 4,154 oil well completions in the Bakken, compared to 227 completions in this unit up to 2004.
- Wells are primarily horizontal, with a multi-stage frack completion.
- In 2020, the Bakken produced approximately 11.5 million barrels of oil (1.8 million cubic metres) and currently produces approximately 31,622 barrels per day (5,026 cubic metres/day).
- The 38° API oil is hosted in very fine-grained dolomitic sandstones and siltstones that typically have about 10 to 15 percent intergranular porosity, and permeability less than one millidarcy.
- The most recent Saskatchewan Geological Survey work on the Bakken Formation includes two resource assessments (National Energy Board and Saskatchewan Ministry of the Economy, 2015; Chen et al., 2016, 2018), as well as two Summary of Investigations papers (Kohlruss and Nickel, 2009; Kohlruss and Stamatinos, 2014) and an open file report (Kohlruss and Nickel, 2013) that highlight the Bakken's depositional setting, sequence-stratigraphic framework, source rock

potential and production controls. Two Prospect Saskatchewan publications are also available, which illustrate the internal facies in the Bakken Formation and explain the importance of salt dissolution when targeting conventional Bakken plays (Saskatchewan Geological Survey, 2010, 2013).

- A Bakken-Torquay play has produced a total of 9.6 million barrels (1.5 million cubic metres) of oil since 2001, in an area along the Saskatchewan-Manitoba border, where the Lower Bakken shale is absent and the Torquay dolostones and dolomitic siltstones are directly overlain by the Middle Bakken. To the end of 2020, there were approximately 340 completions in this area.
- In 2007, new Torquay oil was discovered near the U.S. border in southeastern Saskatchewan, where the uppermost Torquay dolostone reservoir lies immediately below the Lower Bakken shale. From 2012 to the end of 2020, about 611 well completions have produced 26.7 million barrels (4.2 million cubic metres) of oil from the Torquay in this region. Despite the small volume of oil produced from the Torquay so far, the rapid increase of production from 342 barrels/day (54 cubic metres/day) in 2011 to 10,086 barrels/day (1,603 cubic metres/day) in 2020 indicates a large potential for this play.
- The most recent Saskatchewan Geological Survey work on the Torquay Formation is a Summary of Investigations paper (Yang, 2018) that establishes a fundamental stratigraphic framework for this strata and determines its control on Torquay oil production.

Value Added Commodities

The potential for lithium and helium production in Saskatchewan's Phanerozoic has been identified in analytical work performed on oil and gas wells in the province. These two commodities are now on the American (Humphries, 2019) and Canadian (Natural Resources Canada, 2121) critical minerals list and have seen their prices increase sharply over the last 10 years, due to supply shortages, and increased demand (Bradley et al., 2017; Cockerill, 2020). The current market shortage is driving the exploration for lithium and exploration and development of helium in the province.

Lithium Potential

- In 2019, 87 percent of the world's primary-source lithium was produced from Australia's spodumene mines (55%) and from Chile's and Argentina's brine and salt flat mines (32%) (United States Geological Survey, 2020). Research is currently underway in several jurisdictions, including Saskatchewan, to assess the concentrations of lithium in the subsurface from oil and gas wells.
- Work generated by the Survey (Jensen, 2011, 2012, 2106; Jensen and Rostron, 2017, 2018) indicated that the Duperow Formation displays the highest concentrations of lithium in the wells sampled to date, ranging from 130 to 190 milligrams per litre (mg/L) lithium in the southeast part of the province, and from 41 to 78 mg/L in west-central Saskatchewan. Other formations that show higher concentrations of lithium in the province are the Winnipegosis, Ratcliffe, and Birdbear. Lithium concentration in these formations ranges from 40 to 60 mg/L (background concentrations are typically 1 to 5 mg/L).
- Since the first Subsurface Mineral Rights public offering in December, 2018 the province has issued subsurface mineral dispositions for 282,391 hectares with a value of \$3,178,938. While subsurface mineral dispositions grant the right to explore for all natural mineral salts and their compounds occurring more than 60 metres below the surface, including potash and lithium, it is reasonable to infer that interest in the province's lithium potential is high based on the number of parcels located in areas that are prospective for lithium in formation water.

Helium Potential

Helium is produced globally from two sources: as a by-product of Liquefied Natural Gas Plants (LNG), where low volumes of helium are stripped off as part of the liquefaction process; and from primary sources where helium occurs in higher percentages (1 to 8%) of the total gas volumes present.

Saskatchewan is home to numerous primary helium shows of greater than 1 percent throughout the southern portions of the province. In particular, helium has been produced in southwestern Saskatchewan from 1963 to 1977 (Yurkowski, 2016; Yurkowski, in progress) and from 2014 to the present day. Gas analyses from wells drilled in the Phanerozoic are the best source of information for identifying elevated helium concentrations in the province.

As of June 30, 2021, 365 helium leases and permits have been acquired in the province, which accounts for over 6.7 million acres (over 2.71 million hectares). Almost 60 wells targeting helium have been drilled; many are completed or cased. Nine wells are listed as active, and of these, 6 produced in May of 2021. Another 16 wells are planned or are in the process of being drilled.

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