Powder River Basin

Oil and Gas Geology, Production, and Future Development

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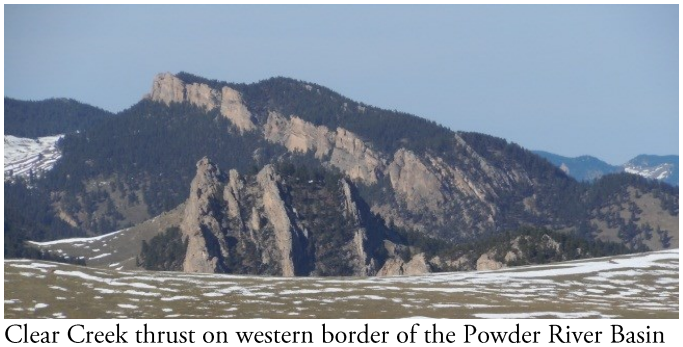
Basin geology

The Powder River Basin is an asymmetric basin with near-vertical to overturned dips along the western margin and gentle sub-horizontal (basinward) dips along the eastern margin. Structural deformation began in the Powder River Basin region during deposition of the Upper Cretaceous (Maastrichtian) Lewis Shale and ended during deposition of the Eocene Wasatch Formation (Curry, 1971), resulting in structural relief greater than 7,620 m (25,000 feet) (Blackstone, 1981). Nearly 2,438 m (8,000 feet) of syn-Laramide sedimentary rocks are preserved within the Powder River Basin (Curry, 1971).



Clear Creek thrust on western border of the Powder River Basin near Buffalo, WY. Photo by R. Lynds.

Hydrocarbon fields within the Powder River Basin generally occur as stratigraphic traps or in basin-bounding anticlinal structures. The Tensleep Sandstone and Minnelusa Formation are the major Paleozoic oil producers. According to Dolton and others (1990), the Tensleep primarily produces from structural (anticlinal) traps and the Minnelusa produces from both structural and stratigraphic traps.

The hydrocarbon source rocks that likely charged the Tensleep and Minnelusa reservoirs were Permian shales in western Wyoming. Dolton and others (1990) argue that the hydrocarbons were generated by Jurassic time, migrated east and were trapped until the Laramide orogeny. Subsequent uplift allowed some hydrocarbons to escape, while some remained in the Tensleep and Minnelusa reservoirs. In the eastern parts of the basin, lower Minnelusa reservoirs may have been locally sourced from interbedded black shales (Clayton and Ryder, 1984).

Dune-scale cross-stratification preserved in the Eocene Wasatch Formation. Photo by N. Jones.

Formations deposited during the Cretaceous represent the other major hydrocarbon reservoirs in the Powder River Basin. These include the Muddy Sandstone (eastern equivalent of the Newcastle Sandstone), 2nd Wall Creek Sandstone Member of the Frontier Formation, and Turner Sandstone Member of the Carlile Shale. Historically less-productive Cretaceous-age

reservoirs such as the Lakota Formation, Fall River (Dakota) Sandstone, Mowry Shale, Frontier Formation, Niobrara Formation, Shannon and Sussex sandstone members of the Cody Shale, Teapot and Parkman sandstone members of the Mesa Verde Formation, and the Tecla Sandstone Member of the Lewis Shale are now the main focus of unconventional resource exploration and production in the Powder River Basin.

The source rock for the bulk of the Upper Cretaceous-age hydrocarbon reservoirs is the Mowry Shale, with significant contributions from the Niobrara Formation and Carlile Shale (Momper and Williams, 1984; Dolton and others, 1990). Hydrocarbons were generated in the deeper western part of the basin and migrated up-dip toward the east into the Cretaceous reservoirs. Estimates suggest nearly 12 billion barrels of oil were generated in the Mowry Shale (Momper and Williams, 1984).

Production

Development of the Powder River Basin as a hydrocarbon-producing basin followed slowly behind development in the other Laramide basins. The first producing oil well in the basin was drilled in 1889 north of Salt Creek field, which is still the most productive oil field in Wyoming. Numerous fields were discovered over the following years, but development was not steady until crude prices and transportation stabilized (Hughes, 1983).

The Powder River Basin was historically an oil-producing basin. Gas occurrences were rare and were usually gas caps associated with oil reservoirs. However, coalbed natural gas (CBNG) development in the late 1990s and 2000s changed the Powder River Basin into a significant natural gas-producing region. At its peak in 2009, the Powder River Basin produced over 584 billion cubic feet of natural gas (WOGCC, 2014).

Natural gas production has been declining in the Powder River Basin since 2009, largely due to low gas prices, depleted CBNG reservoirs, and competition from large unconventional gas plays. In 2013, gas production from 191 fields in the basin was 368.3 million cubic feet, a 37 percent decrease from 2009 (WOGCC, 2014). However, the Powder River Basin still accounted for nearly 18 percent of Wyoming's total 2013 production, and the Powder River Basin coalbed natural gas fields had the second-highest 2013 field gas production with more than 312 billion cubic feet (WOGCC, 2014).

Future development

Oil production in the Powder River Basin has fluctuated since 1978, but is currently increasing and is on track to be equal to late-1990s production levels. Lengthy horizontal laterals, multi-lateral completions, and multi-stage hydraulic fracturing are now allowing operators to produce large amounts of oil from previously-uneconomic tight sands and shales.

Large oil and gas developments on federal land in Converse and Campbell counties have taken advantage of these technological advancements. Operators in the Spearhead Ranch, Hornbuckle, Highland Loop Road, Scott Field, East Converse, and Crazy Cat East developments are expected to drill nearly 900 wells—the majority of which will be horizontal—that target unconventional Cretaceous-age reservoirs. Wyoming is already benefiting from the increased oil production in these areas and Campbell and Converse counties in general. In 2013, Campbell

County was the state's leading producer of crude oil (12,973,941 barrels), followed by Converse County (7,995,514 barrels). Converse County's crude oil production more than doubled from 2011 to 2013 (WOGCC, 2014).

The boom in Powder River Basin oil production is expected to continue. In 2013, 204 horizontal oil wells were spudded and 522 other horizontal oil wells were granted permit-to-drill status in Campbell and Converse counties (WOGCC, 2014). Continuing CO_2-EOR projects in the Salt Creek field contributed to it again being the most productive Wyoming oil field in 2013 with 4.1 million barrels produced (WOGCC, 2014). In 2013, production from 504 Powder River Basin fields produced 48 percent of Wyoming's total 2013 crude oil production, an increase of 15 percent from 2011 (WOGCC, 2014). In total, the Powder River Basin has produced more than 2.9 billion barrels of oil through 2013 (WOGCC, 2014).

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