Bighorn Basin

Oil and Gas Geology, Production, and Future Development

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Basin geology

The present structural configuration of the Bighorn Basin resulted from the Late Cretaceous through Early Eocene Laramide orogeny (Blackstone, 1963), during which the peripheral mountain uplifts experienced their major growth. The folding and faulting that formed the present oil-producing anticlines in the Bighorn Basin occurred during pulses of compressional stress, mainly oriented northeast–southwest.

Rattlesnake Mountain on the western flank of the Bighorn Basin. Photo by R. Lynds.

Fox and Dolton (1996) defined the types of plays prevalent in the Bighorn Basin and suggested some potential plays for future development as part of a resource assessment of the basin. Both structural and stratigraphic traps occur in Paleozoic and Cretaceous source-rock/reservoir systems in the basin. Structural plays include basin margin subthrusts, basin margin anticlines, deep basin structures, and sub-Absaroka-volcanics. Principal stratigraphic plays include Phosphoria pinch-out (up-dip facies change) and Tensleep paleogeography (dune fields versus interdune regions) (Fox and Dolton, 1996). Significant potential plays include basin center/deep gas and coalbed natural gas.

Although most of the basin's production comes from anticlinal or other structural traps, Lawson and Smith (1966) suggested that many of the structurally-controlled traps are influenced by stratigraphic effects, including intraformational variations in permeability and, as in the Bonanza-Nowood field, incised channels in the Tensleep surface that were later filled with impervious Goose Egg sediments. Later Laramide folding may have been superimposed on or near these primary traps. Pure stratigraphic traps are also productive within the Bighorn Basin. The largest of these is the Cottonwood Creek field in the southeast corner of the basin, a trap resulting from an eastward, up-dip facies change from Phosphoria carbonate to the impermeable red shale and anhydrite facies of the Goose Egg Formation.

The source of essentially all the oil and gas found in Paleozoic reservoirs in the basin is the dark, phosphatic, fine-grained, marine facies of the Phosphoria Formation (Stone, 1967). Primary migration began immediately after deposition of Triassic sediments and was completed by Early Jurassic time. Hydrocarbons accumulated in regional stratigraphic traps created by up-dip facies change, pinch-out, truncation of the reservoir rocks in the Phosphoria, and irregular truncation of

thick Tensleep Sandstone beds prior to the deposition of the impervious Phosphoria/Goose Egg Formation. This situation is especially prevalent east of the area covered by marine carbonate facies of the Phosphoria Formation (Stone, 1967). Oil and gas in some of these stratigraphic traps were later released by fracturing and faulting associated with Laramide folding. During the Laramide orogeny, these hydrocarbons moved into older Paleozoic reservoir rocks and older structures where they were trapped in common pools. The occurrence of a common oil-water contact, in many cases, is attributed to fractures joining the reservoirs. Also, the oil-water contact is often tilted as a result of hydrodynamic flow (Stone, 1967).

Mesozoic rocks produce a much lower percentage of the basin's oil and gas. The Upper Cretaceous Frontier Formation accounts for most of the production from Mesozoic rocks. Source rocks in the Mesozoic include the Cody, Frontier, Mowry, and Thermopolis black shale units (Stone, 1967).

Flatirons of the Mowry Shale on the flanks of Sheep Mountain anticline. Photo by R. Lynds.

Production

The Bighorn Basin is primarily an oil-producing basin. Oil was first discovered in the basin in 1904 as a spring on the Bonanza anticline. In 1905, the first producing oil well in the basin was drilled into the Tensleep Sandstone in the Bonanza field. Since these initial discoveries, cumulative production in the Bighorn Basin, from initial discovery through 2013, amounts to more than 2.67 billion barrels of oil (WOGCC, 2014).

The Bighorn Basin contains 134 oil fields that produce (or have produced) from 60 reservoirs and/or co-mingled reservoirs ranging in age from Cambrian to Paleocene. Nine fields within the Bighorn Basin are in the top 25 producing fields in Wyoming. Seven of these rank in the state's top ten producing fields. (Wyoming Enhanced Oil Recovery Institute, 2011).

Oil and gas production in the Bighorn Basin has steadily declined over the last 35 years. Although the Bighorn Basin produced 11.5 million barrels of oil in 2013, accounting for 18.3 percent of Wyoming's total oil production, it is a 31 percent decrease from 2000 oil production levels, a 59 percent decrease from 1990 production, and an almost 77 percent decrease from 1978 (WOGCC, 2014). Natural gas production in the basin has similarly decreased 48 percent from 1978 production levels (WOGCC, 2014).

Elk Basin field and anticline. Photo by A. Ver Ploeg.

Future development

Despite the decreasing production levels, most fields in the Bighorn Basin still contain a significant quantity of recoverable oil. In response, energy extraction companies are utilizing new and traditional secondary and tertiary recovery techniques to revitalize old fields and to activate fields that were not economically feasible in years past. Future oil production in the Bighorn Basin will heavily rely on these recovery techniques.

Unconventional reservoir plays could also improve oil and gas production in the Bighorn Basin. However, currently there are only 87 active horizontal wells in the Bighorn basin, six of which were spudded since 2000, and all target conventional Paleozoic formations (WOGCC, 2014). Near-future drilling and production efforts in the basin also do not seem to be focusing on unconventional reservoirs. In 2013, only 16 wells had a permit-to-drill status and only 8 wells were spudded in the basin (WOGCC, 2014). None of the 24 new wells are to be horizontal wells and only a couple target formations other than the Paleozoic Dinwoody (Embar) Formation, Madison Limestone, Phosphoria Formation, and Tensleep Sandstone.

Many of the same Cretaceous formations exist in the Bighorn Basin that are currently being exploited as unconventional reservoirs in other Wyoming basins. Future exploration for similar unconventional plays, horizontal drilling, and hydraulic fracturing could again make the Bighorn Basin a major player in state oil and gas production.

References

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