Bighorn Basin

Oil and Gas Geology, Past 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).

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

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).

Past 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, more than 134 oil fields 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). However, oil and gas production in the Bighorn Basin has steadily declined over the last 35 years.

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. 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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