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A supplement to *Oil and Gas Investor, E&P,*
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The Rockies Tight Sands and Shales Playbook is the 21st in Hart Energy's exclusive series of comprehensive reports delving into North America's most compelling unconventional resource plays. Our lineup of topics addresses the plays everyone is talking about and delivers answers to essential questions on reservoirs, active operators, economics, key technologies, and infrastructure issues. Some playbooks also feature a full-color map highlighting fields, drilling activity, and significant wells. To learn more, visit ugcenter.com/subscribe

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On the cover: A rig drills for liquids-rich gas in the Greater Natural Buttes area in northeastern Utah. (Source: Anadarko Petroleum Co.)

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An Anadarko production site in the Greater Natural Buttes area shows the wide-open country in the Ute Valley where operators are getting more active in the Ute Valley play. (Source: Anadarko Petroleum Co.)

A Geological Goldmine

The Rocky Mountains continue to reward the innovative geoscientist.

By Steve Thornhill
Contributing Editor

During the Upper Cretaceous, an inland waterway, the Western Inland Seaway, ran in a generally north/south direction from what is now the Arctic Ocean in northwestern Canada to the ancestral Gulf of Mexico. The Niobrara Formation, an organic-rich shale/marl/chalk/limestone formation with its lithology dependent on its basin location, remains as stratigraphic evidence of the Western Inland Seaway.

The Niobrara Formation consists of two members: the Smoky Hill and the Fort Hays members. Like many other unconventional plays, the Niobrara is both a hydrocarbon source and reservoir rock, with the middle of three chalk layers or “benches” in the Smoky Hill member being the normal horizontally drilled target. The Niobrara B bench is a friable, oil prone, source/reservoir rock with net pay thicknesses of 20 ft to 40 ft. Up until recently, Niobrara wells relied on drilling into areas with elevated porosity and permeability, natural fractures or both. It’s taken the combination of both horizontal drilling and hydraulic fracturing to reliably coax economic hydrocarbon volumes from the tight source rock.

The Niobrara source/reservoir rock formation produces hydrocarbons in numerous sedimentary basins located along the former Western Interior Seaway corridor. Basins highlighted in this report that are producing from the Niobrara are the Denver-Julesburg (DJ), North Park and Powder River basins. Other hydrocarbon-producing Upper Cretaceous strata layers are the Codell, Frontier, Turner, Shannon, Sussex and Parkman all producing in the Powder River Basin. New Mexico’s San Juan Basin has upper Cretaceous production from the Gallup/Mancos sandstone/shale formation.

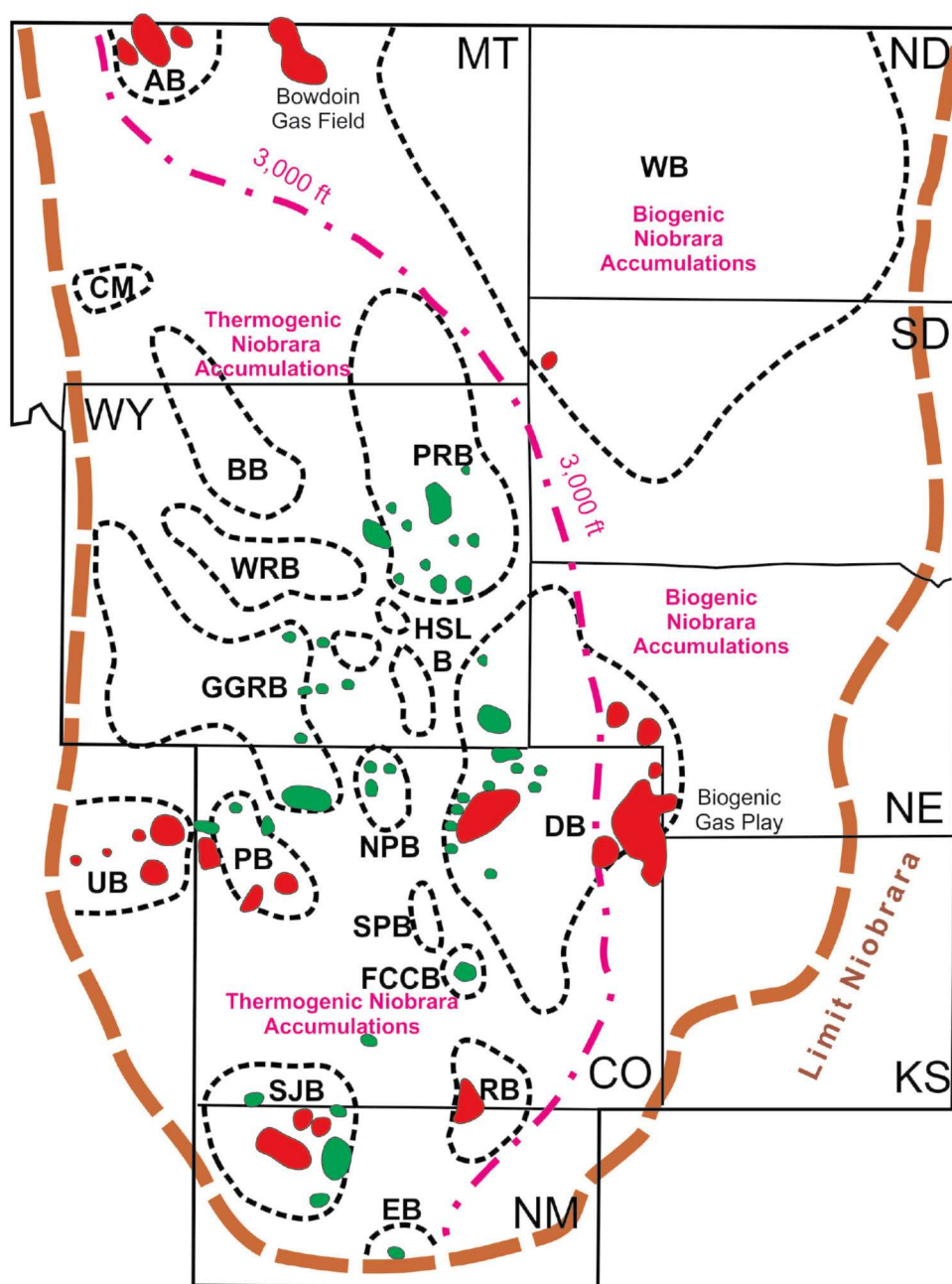
While this report is predominantly focused on Upper Cretaceous unconventional plays, it wouldn’t be complete without the addition of the Uinta Basin’s Eocene epochs Castle Peak and Uteland Butte members of the Green River Formation.

DJ BASIN

The DJ Basin is a large asymmetrical basin predominately located in Colorado east of Denver with just the northern most sections located in southeast Wyoming and the southwest corner of the Nebraska panhandle. Original basin creation took place during the Colorado Orogeny, with later basin development and deepening during the Laramide Orogeny with two adjoining deep basins formed along a north-south trending trough adjacent to and east of the Rocky Mountain Front Range. The uplifting of the adjoining mountains and subsequent erosion filled the deep elongated trough with sediments to depths of more than 17,500 ft.

NIOBRARA FORMATION

In the DJ Basin, the Niobrara Formation is found underlain by the Codell Sandstone member of the Carlile Shale and overlain by the Pierre Shale. The Niobrara itself is naturally fractured and is composed of two members, the Smoky Hill and the Fort Hays members. The Smoky Hills member is composed of alternate organic-rich layers of brittle chalk and more ductile marl and calcareous shale, with the marl/shale deposited under hypoxic/anoxic conditions. The basal Fort Hays member is composed of chalk. The total Niobrara Formation ranges in thickness from 200 ft to greater than 400 ft and is buried to depths of about 3,500 ft in the basin’s east side to about 8,000 ft in the basin’s west side.



Niobrara producing areas across the north Rockies are shown (oil fields are green; gas fields are red; modified from Longman et al., 1998). Basin abbreviations are as follows: AB-Alberta Basin; CM-Crazy Mountain; WB-Williston Basin; BB-Bighorn Basin; PRB-Powder River Basin; WRB-Wind River Basin; GGRB-Greater Green River Basin; NPB-North Park Basin; PB-Piceance Basin; UB- Uinta Basin; SPB-South Park Basin; FCCB-Florence-Canon City Basin; SJB-San Juan Basin; RB-Raton Basin; DB-Denver Basin; EB-Estancia Basin. Distribution of sapropelic oil-generation-prone Niobrara source rocks within brown dashed line (Meissner et al., 1984). Dot-dashed line equals 3,000 ft current burial depth; biogenic accumulations are east of the line; thermogenic accumulations are west of the line (Image modified from Lockridge and Scholle, 1978).

The basin's entire sedimentary column ranges from less than 5,000 ft in the east to greater than 17,500 ft in the west. The Niobrara in the DJ Basin is self-sourced with a total organic carbon (TOC) generally ranging from 2% to 4%, with a high of 8%, while averaging 3.2% across all basins where it's found. In the DJ Basin, the Niobrara sources oil from oil-prone Type II kerogen, except for a geothermal area of abnormally high subsurface temperatures around Wattenberg, Colo., that is wet gas productive.

The Niobrara produces hydrocarbons from the basin's west side at depths of about 7,000 ft. On the basin's west side formation thicknesses can vary between 200 ft to greater than 400 ft. The basin's east side produces natural gas from depths of about 3,500 ft from a formation thickness of 500 ft or more. The Niobrara Shale's Ro is generally in the 0.7% range for oil. Oil produced from the DJ Basin's Niobrara generally has API gravities ranging from 32 degrees to condensate with a gas-oil ratio of 500 to 1000.

In addition to the basal Fort Hays member, the Niobrara has three organic-rich chalk layers consisting of the Niobrara A, B and C chalk benches overlying the Fort Hays Chalk member. Operators commonly drill the Niobrara B bench horizontally. The Niobrara Chalk layers can be readily fractured and also tend to have a good deal of natural fracturing. Because of this, operators are drilling the Smoky Hill Chalk layers horizontally and are augmenting the chalk's natural fractures with staged hydraulic fracturing. Because of the Niobrara's low porosity and permeability, natural and induced hydraulic fractures are extremely important to the play's economic success.

To date operators have primarily focused on several Niobrara sweet spots. One of the earliest Niobrara sweet spots was the Silo Field located in the northern area of the basin in the far southeast corner of Wyoming along the Front Range. The Silo Field, discovered in 1981, is well known for its plethora of open fractures running through the formation. Farther south, the Wattenberg Field was originally discovered in 1970 with gas production from a deeper Middle Cretaceous Muddy "J" sandstone. The Wattenberg Field is located north/north-

east of Denver along the Front Range on a geothermal high. The field predominately produces condensate-rich wet gas because of the high localized geothermal gradient.

CODELL SANDSTONE MEMBER

The Codell Sandstone member found in the DJ Basin is the top member of the Carlile Shale. The Codell Sandstone is unconformably overlain by the Fort Hays Limestone member of the Niobrara Formation. In many mid-basin areas, the Codell member has been eroded off, while in the north basin it appears sporadically. Currently, operators are pursuing Codell plays in the Wattenberg Field and in the southern portion of Wyoming's Silo Field as well as in Laramie County, Wyo. Quite often the Codell is commingled with the overlying Niobrara.

The Codell Sandstone is thought to represent a transgression of the Western Interior Seaway. This shoreward water movement caused shoreline sands and shales to be eroded and redeposited eastward into deeper basinal waters. As a result, the Codell is an extensively bioturbated heterogeneous mixture of sandstone, siltstone, shale and various clays as well as thin interbedded limestone layers. Codell Sandstone member thickness, over several basin fields, ranges from 22 ft to 35 ft. The play produces from depths ranging from 3,000 ft to 8,000 ft, with an average producing depth of 6,800 ft. The Codell has porosities as high as 22% with a range of 10% to 14% being common. However, permeability is often very low—generally less than 0.1 mD. Important to the subject of permeability, the Codell member clays are represented by illite, chlorite and the swelling clay smectite. Operators need to be mindful of the chemistry of the drilling muds and frack fluids used in well operations because of the swelling clay presence. The Codell Sandstone is thought to be sourced from the overlying Niobrara Formation as well as from the deeper Mowry and Graneros formations.

NORTH PARK BASIN

The North Park Basin is a small 1,190-sq-mile basin located in north-central Colorado. It's bound by the Medicine Bow Mountains to the east and the Park Range to the west and is separated from Middle Park Basin by the Rabbit Ears Range along

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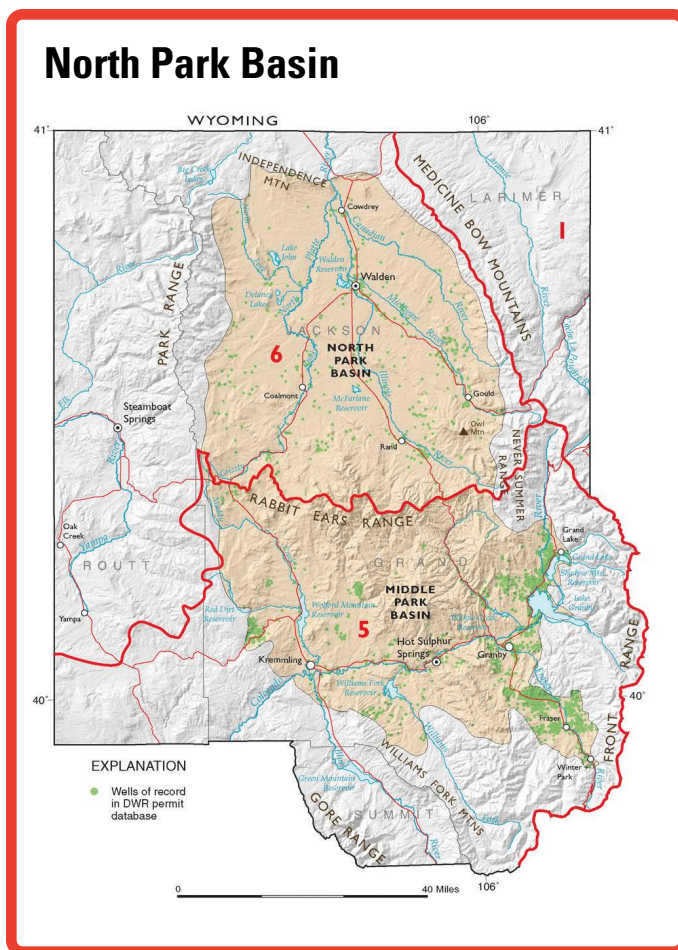


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Colorado's North Park Basin, with surrounding mountain boundaries, and the adjoining Middle Park Basin to the south are shown. (Source: Colorado Geologic Survey)

its southern boundary. The north basin boundary is Independence Mountain Basin creation took place during the Laramide Orogeny. The uplifting of the adjoining mountains and subsequent erosion filled the basin with sediments to depths of nearly 20,000 ft.

NIOBARA FORMATION

As in the DJ Basin, the Niobrara Formation is found underlain by the Carlile Shale and overlain by the Pierre Shale. The Niobrara is composed of the Smoky Hill and Fort Hays members. The Smoky Hills member is composed of alternate organic-rich layers of brittle chalk and more ductile marl and calcareous shale with the marl/shale deposited under hypoxic/anoxic conditions. The basal Fort Hays

member is composed of chalk. The total North Park Niobrara Formation reaches as much as 800 ft in thickness at an average depth of 7,000 ft. The North Park Basin's Niobrara is self-sourced with a TOC generally ranging from 1% to 4%. In the North Park Basin, the hydrocarbon source is from oil-prone Type II kerogen. The Niobrara Shale's Ro ranges from 0.5% to 1.5% expressing a range from oil to gas. API gravities of oils produced from three different Niobrara fields range from 37° API to 54° API.

The Smoky Hill member in the North Park Basin's Niobrara is similar to the Smoky Hill member in the DJ Basin except it has four chalk layers or benches—the Niobrara A, B, C and D benches—and it is underlain by the basal Fort Hays member. The Niobrara D, a bench that doesn't occur in the nearby DJ Basin to the east, is productive with horizontal drilling in the North Park Basin. Because the Niobrara Chalk layers can be readily fractured and tend to have a good deal of natural fracturing, it is the chalk layers that operators are drilling horizontally and augmenting the chalks natural fractures with staged hydraulic frac-

turing. The Niobrara has low porosity and permeability, so natural and induced hydraulic fractures are extremely important to the plays economic success.

POWDER RIVER BASIN

The Powder River Basin, an elongated structural trough, covers an approximate 34,000-sq-mile area and is roughly 100 miles wide in an east-west direction and 250 miles long running north to south. The basin is located in both Montana and Wyoming, with one-third of the basin in Montana and two-thirds in Wyoming.

The Powder River Basin records the evolution of the Western Interior Seaway, from the seaway's beginning to its final demise from the regional



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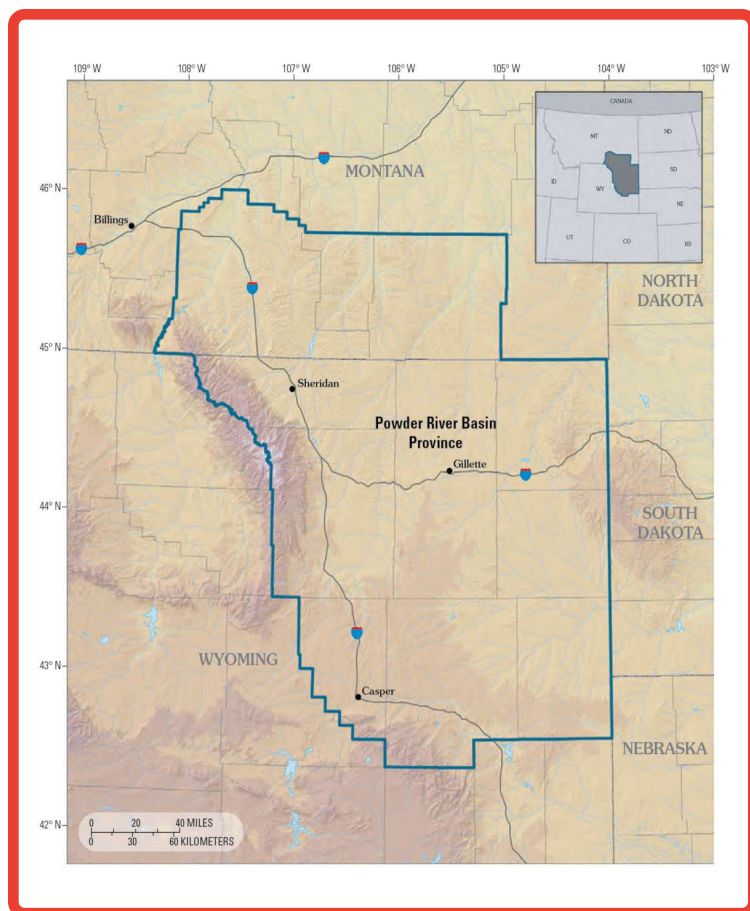
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Wyoming and Montana's Powder River Basin with surrounding mountain boundaries to the north, south and west and its geographic boundary to the east are shown. (Source: USGS)

uplifting associated with the Laramide Orogeny. The Powder River Basin is described as an asymmetric foreland basin with its deepest axis running down its western flank. The basin is bound to the west by the Bighorn Uplift and the Casper Arch and to the east by the Black Hills Uplift. It's bound by the Laramie and Hartville Uplift to the south and the Miles City Arch, Porcupine Dome and Bull Mountains to the north. The uplifting of the adjoining mountains and subsequent erosion filled the deep elongated trough with sediments to depths of more than 18,000 ft.

The Powder River Basin is a prolific playmaker with unconventional oil plays associated with the Niobrara and Frontier formations, as well as the Turner, Shannon, Sussex and Parkman members, all deposited during the Upper Cretaceous.

NIOBRARA FORMATION

The Niobrara Formation in the east Powder River Basin is found underlain by the Turner Sandy member of the Carlisle Shale and overlain by the Pierre Shale. In the basin's west side, the Niobrara is underlain by the Carlisle Shale and overlain by the Fish-tooth Shale. The Niobrara is composed of two members: the Smoky Hill and Fort Hays members. The Smoky Hills member is composed of organic-rich alternate layers of brittle chalk and more ductile marl and calcareous shale with the marl/shale deposited under hypoxic/anoxic conditions. The basal Fort Hays member is generally composed of chalk without a high TOC content.

The total Powder River Niobrara Formation ranges in thickness from 50 ft in eastern basin areas to greater than 600 ft along the basin's west margin, with an overall basin thickness average of about 400 ft. The formation is buried to depths of greater than 8,000 ft on the basin's west side. The Niobrara has porosities as high as 20% with 10% being common; however, permeability is often low—generally less than 0.01 mD. Formation porosities and permeabilities are generally in response to shale content and/or depth of burial. However, the Niobrara itself is naturally fractured, with the fracturing thought to be the result of volume and pressure changes resulting from kerogen-to-oil transformation.

The basin's entire sedimentary column is greater than 18,000 ft in the deepest western basin areas. The Powder River Basin's Niobrara has a TOC generally averaging greater than 3%, with areas adjacent to the Powder River Basin with TOC values higher than 7%. The basin's hydrocarbon source comes from oil-prone Type II kerogen. The Niobrara Shale's Ro is generally in the 0.6% to 0.68% range for oil. Oil produced from the Powder River Basin's Niobrara generally has API gravities ranging from 35° API to 52° API and a gas-oil ratio of 0 to 28,996.

FRONTIER FORMATION

The Frontier Formation in the east Powder River Basin is found at depths in excess of 8,500 ft and is underlain by the Mowry Shale and overlain by the Cody Shale. The Cody/Frontier transition is indicated by the Clay Spur Bentonite marker bed, while the Mowry/Frontier transition zone is indicated by

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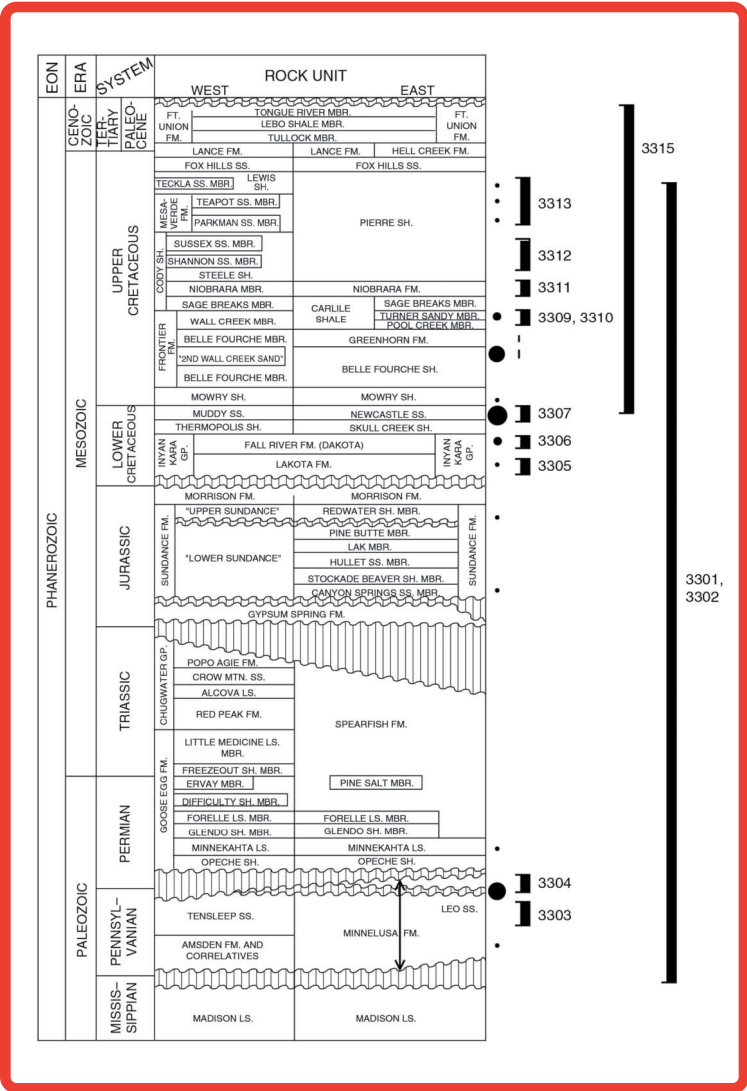
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This Powder River Basin stratigraphic column shows the various unconformational play formations, age-equivalent adjoining formations and older/younger boundary formations. (Source: USGS)

an unnamed bentonite marker bed. In the Powder River Basin, the Frontier is composed of three members. From the lowest member to the top, the three members include the Belle Fourche member, the Emigrant Gap member and the Wall Creek Sandstone member. Oil produced from the Frontier generally has API gravities ranging from 35° API to 39° API and a gas-oil ratio of 1,000 to 13,000.

The Belle Fourche member is the formation's basal member and is generally limited to the southwestern basin area. It is composed of four successive layers recording depositional environments grading

from fluvial to estuarine to nearshore and out to deepwater. Although the depositional environments might differ, they all share similar sedimentary characteristics. They all grade from fine sediment upper layers to very fine sediments with depth, and they all have an extremely coarse-grained erosional top surface or lag as the result of finer sediments being transported away during erosion. The Belle Fourche member ranges in thickness from 50 ft in the southwestern basin area to zero moving away from the southwest toward the east and southeast of the basin. The Belle Fourche has porosities ranging from 5% to 15%, with permeabilities ranging from 1 mD to nearly 100 mD.

The Emigrant Gap member is the middle member and is generally limited in extent to two long narrow sandstone, siltstone and mudstone sedimentary packages. One package near Casper, Wyo., trends in an east-west direction, while the other located south of Buffalo, Wyo., trends in a north-west-southeast direction. The Emigrant Gap member is truncated both top and bottom by unconformities with the entire sedimentary layer reaching a total thickness as much as 90 ft and individual sandstone beds a thickness as much as 30 ft.

The Wall Creek Sandstone member is the uppermost member resting on top of the Emigrant Gap member, or the Belle Fourche member if the Emigrant Gap member is eroded off. The member is overlain by the Cody Shale. The member is composed of successive upward coarsening mudstone, siltstone and sandstone layers recording a pro deltaic depositional environment. The layers all grade from medium-grained sediment upper layers to very fine sediment layers with depth, and several are truncated by an erosional top surface. The Wall Creek Sandstone member trends in an east-west orientation, ranging up to 400 ft in thickness. The member has porosities ranging from nearly zero to 20%, with permeabilities averaging less than 100 mD.

TURNER SANDY MEMBER

The Turner Sandy member of the Carlile Shale is thought by many researchers to be stratigraphically equivalent to the Frontier Formation. The member is found in the East Powder River Basin at depths

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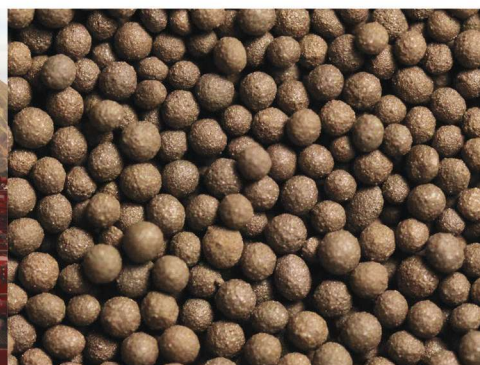
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ranging from 500 ft to 8,000 ft. The Turner has several depositional theories, with one that regards it as the basinward redeposition of eroded Wall Creek Sandstone that was subsequently reworked and redeposited after its original redeposition in shelf low areas. The Turner is well represented and productive in the Porcupine Field in the lower Powder River Basin as well as farther east in the Powder River Basin's Finn-Shurley Field.

The Turner member in the Finn-Shurley Field is up to 70 ft thick, thinning to the east and west, and produces light-gravity oil from medium-grained, well-sorted sandstone with permeabilities greater than 2 darcys. Turner core analysis in the Porcupine Field reveals permeabilities ranging from less than 1 mD to greater than 10 mD from argillaceous fine-grained sandstone. Oil produced from the Turner generally has API gravities ranging from 39° API to 43° API and a gas-oil ratio of 500 to 2,400.

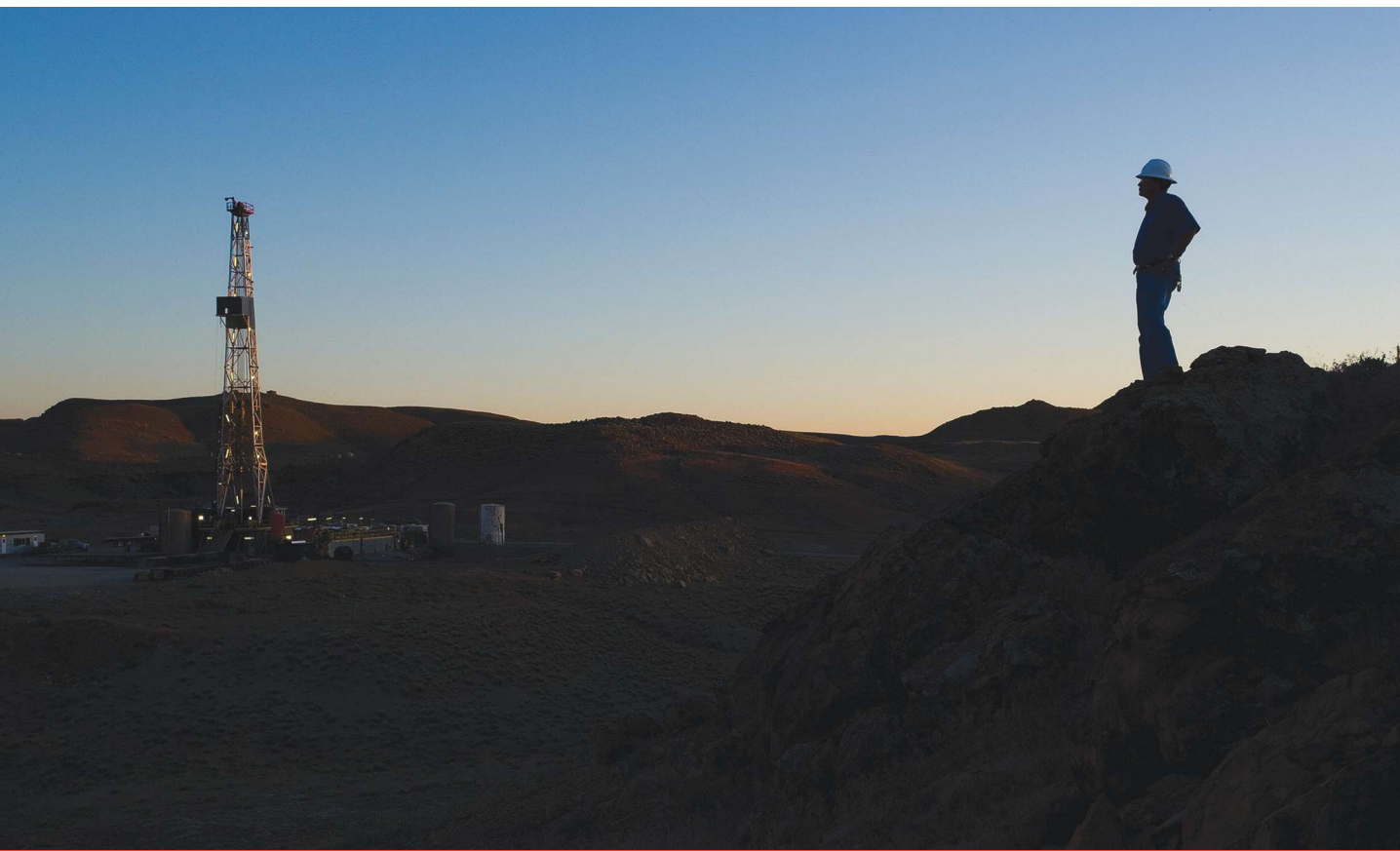
SHANNON SANDSTONE MEMBER

The Cody Shale's Shannon Sandstone member, found throughout the Powder River Basin, is

thought to be the western distal edge of a north-south trending delta. The Shannon Sandstone member is found deposited in northwest-southeast trending sandstone ridges thousands of feet wide, tens of miles in length and up to 50 ft thick. While in some areas the Shannon is represented by argillaceous and bioturbated silt and sandstone with porosities and permeabilities near zero, in other areas the member produces light gravity oil from clean, medium-grained, well-sorted sandstone with porosities ranging to greater than 20% and permeability greater than 100 mD. Oil produced from the Shannon generally has API gravities ranging from 35° API to 39° API and a gas-oil ratio of 300 to 2,100.

SUSSEX SANDSTONE MEMBER

The Cody Shale's Sussex Sandstone member, found throughout the Powder River Basin, overlies the Shannon member by 10-plus ft of marine shale. The Sussex member, like the Shannon, is found deposited in northwest-southeast trending sandstone ridges 2 miles to 3 miles wide, tens of miles in





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length and up to 50 ft thick. There are several depositional theories, with one theorizing that it represents backstepping deposition during several marine transgressions, with the member's top represented by an erosional disconformity.

The Sussex member is divided into three units: an upper A sandstone, a middle shale unit and a basal B sandstone. The Sussex A and B units are both represented by argillaceous, bioturbated silt and sandstones with varying porosities and permeabilities. The two units both grade from coarse sediment upper layers to very fine silt and shale with depth, and they both have an extremely coarse-grained erosional top surface or lag—the result of finer sediments being transported away during erosion. Oil produced from the Sussex, like the Shannon, generally has API gravities ranging from 35° API to 39° API and a gas-oil ratio of 300 to 2,100.

The Sussex upper A sandstone unit is represented by stacked sandstone ridges of various thicknesses based on the erosion that took place between ridges. Overall, the A unit is thinner than the underlying B unit, which achieves a maximum thickness of 50 ft. However, the A unit has a higher average porosity of 13.5% and a higher permeability ranging from 2.5 mD to 77 mD.

The Sussex middle marine shale unit consists of heavily bioturbated mudstones, shales and fine-grained sandstones.

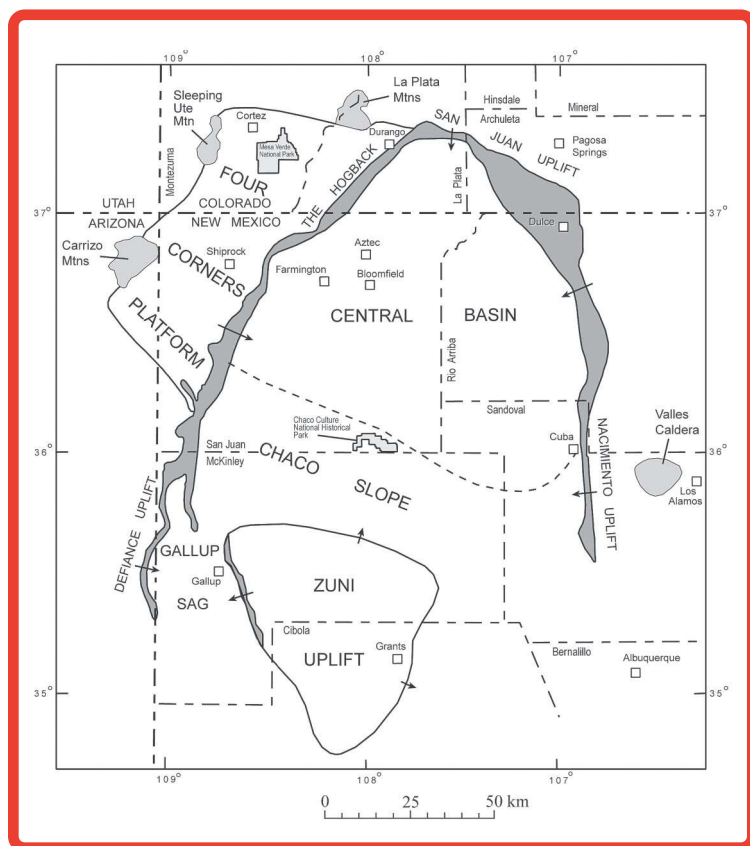
The Sussex basal B sandstone unit, like the A unit, is represented by stacked ridges of various thicknesses based on the erosion that took place between ridges. The B unit achieves a maximum thickness of 50 ft. The B unit has an average porosity of less than 10% and a permeability ranging from 0.01 mD to 5.4 mD.

PARKMAN SANDSTONE MEMBER

The Mesaverde Formation's Parkman Sandstone member represents a progradational delta complex with lithologies that include an upper prodelta shale interbedded with very fine-grained, well-sorted sandstone. This is underlain by near-shore coarsening upward successions of medium-grained sandstone and interbedded siltstone. The basal member deposits consist of terrigenous sourced carbonaceous to lignitic silt and mudstone. The Parkman member ranges from 10 ft to 150 ft in thickness, with porosities ranging from 12% to 18% and permeabilities from 2 mD to 34 mD, with occasional sweet spots having in excess of 100 mD. The member produces from depths ranging from 5,000 ft along the basin's east side to 9,500 ft along the deeper basin axis area toward the west side.

SAN JUAN BASIN

The San Juan Basin is a roughly circular depression, covering an approximate 22,000-sq-mile area and measuring about 100 miles in diameter. The basin is predominantly located in New Mexico with a portion extending north into Colorado. Though areas of the San Juan Basin might have a tie-in to the earlier Paleozoic, the basin owes its shape and structure to regional uplifting associated with the Laramide Orogeny. The San Juan Basin's deepest



New Mexico and Colorado's San Juan Basin, with surrounding uplifts and the distinctive Hogback Monocline to the west, north and east, is shown. (Source: New Mexico Geological Society Guidebook 61st Field Conference, modified from a 1984 structure map of the basin area by Thaden and Zech)

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AGE	SW	FORMATION OR GROUP	NE
TERTIARY		San Jose Formation	
		Nacimiento Formation	
		Ojo Alamo Sandstone	
CRETACEOUS	LATE	Kirtland Shale (Farmington Sandstone Member)	
		Fruitland Formation	
		Pictured Cliffs Sandstone	
		Lewis Shale	
		Cliff House Sandstone	
		Mesaverde Group	
		Menefee Formation	
		Point Lookout Sandstone	
		Upper Mancos Shale	
		Gallup Ss. (Torrivio Mbr.)	Tocito Ss. Lentil
		Lower Mancos Shale	Greenhorn Limestone
		Dakota Sandstone	
	EARLY	Burro Canyon Formation	
		Morrison Formation (Todilto Limestone Member)	
JURASSIC		Wanakah Formation	
		Entrada Sandstone	
TRIASSIC		Chinle Formation	
PERMIAN	Cutler Group	De Chelley Sandstone	
		Organ Rock Shale	
		Cedar Mesa Formation and related rocks	
		Halgaito Formation	
PENNSYLVANIAN	Hermosa Group	Rico Formation	
		Honaker Trail Formation	
		Paradox Formation and related rocks	
		Pinkerton Trail Formation	
		Molas Formation	
MISSISSIPPIAN		Leadville Limestone	
DEVONIAN		Ouray Limestone	
		Elbert Formation	
CAMBRIAN		Ignacio Quartzite	
PRECAMBRIAN			

This San Juan Basin stratigraphic column shows the Mancos shale relationship to Colorado's Gallup Sandstone, as well as age-equivalent adjoining formations, and older/younger boundary formations.

(Source: USGS)

portion is located in the northeast basin area just south of the Colorado-New Mexico border. The basin is bound to the west by the Four-Corners Platform and the Defiance Uplift and to the east by the Puerco Platform and the Nacimiento and Brazos uplifts. It's bound by the Zuni and Lucero uplifts to the south and the San Juan Uplift to the north. The Central Basin is partially surrounded on the northeast, north and west sides by an uplifted ridge of erosion-resistant strata called the Hogback Monocline. In its deepest northeast area, the San Juan Basin is filled with sediments to a 15,000-ft depth.

MANCOS SHALE MEMBER

The New Mexico San Juan Basin's Mancos Shale member of the Gallup Sandstone Formation represents fine-grained shale and siltstone deposition in seawater depths of 300 ft to 400 ft. In addition to the shale and siltstone, scattered bentonite clay beds, thin limestone deposits and some sandstone beds are found interbedded in the Mancos. The low porosity and permeability of the Mancos causes most of the oil production to come from either natural fractures or more recently from horizontal drilling combined with hydraulic fracturing. The Mancos Shale has a TOC ranging from 1% to 3%. Oil produced from the Mancos is sweet paraffin-based crude with API gravities ranging from 33° API to 43° API. To avoid confusion, the Mancos member is sometimes referred to as the Gallup Sandstone in Colorado.

UINTA BASIN

The Uinta Basin, an elongated structural trough, covers an approximate 9,300-sq-mile area and is about 100 miles wide in an east-west direction and 120 miles long running north to south. The basin is predominantly located in northeast Utah, with a small northeast corner located in Colorado. During the Upper Cretaceous, the Utah and Colorado Uinta Basin area was located along the western margin of the Western Inland Seaway. Later, during the Late Cretaceous, the area was subject to tectonic events associated with the Laramide Orogeny. These tectonic events formed the basin that later became Eocene Lake Uinta.

Much of the Green River Formation, including the Castle Peak and Utecland Butte members, record the evolution of Lake Uinta with its numerous lake level changes and subsequent stacked deltaic deposition resulting in distributary mouth bars, channels and near-shore bars. Researching the local sedimentary deposition, one researcher counted 17 lake level changes during the Castle Butte's deposition. The Uinta Basin is described as an asymmetrical lacustrine basin with a deep trough running along its steeply dipping north flank, while the basin's south flank dips gradually toward the basin's north flank trough. The basin is bound to the west by the Wasatch Mountains and by the Douglas Creek Arch to the east. The Uinta Mountains bound the basin to the north, while the San Rafael Uplift and Book Cliffs bound the basin to the south.

Earlier sedimentation, as well as erosion from the adjoining mountains, filled the basin with sediments to depths greater than 30,000 ft.

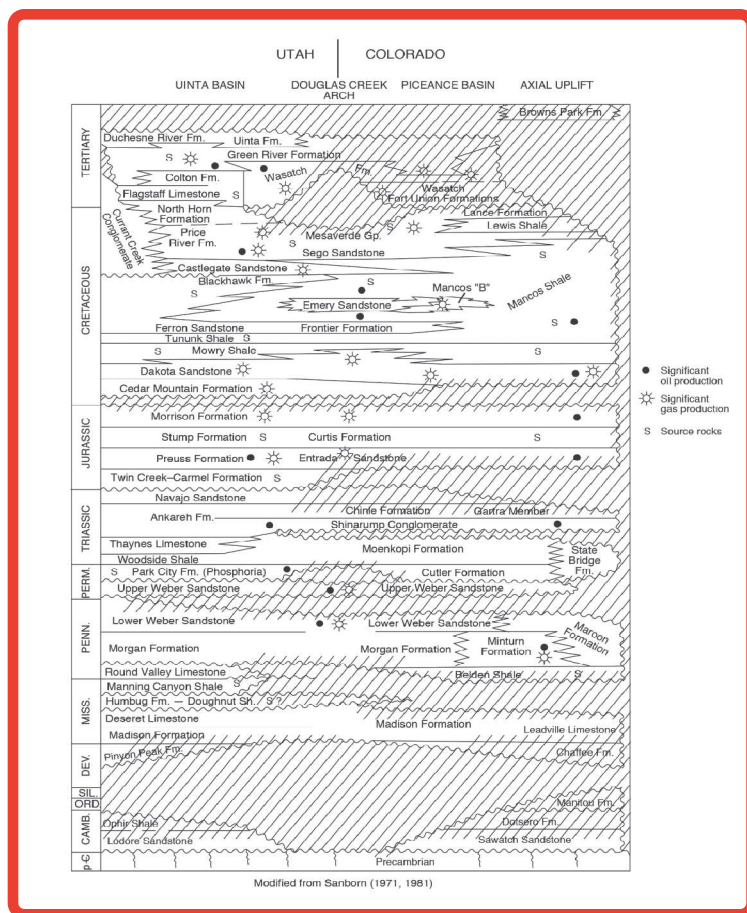
UTELAND BUTTE MEMBER

The Uteland Butte member, the lowermost member of the Green River Formation, records both fluvial as well as carbonate deposition associated with the filling of Lake Uinta during the Paleocene and Eocene. Depending on its location in respect to the paleo shoreline, the Uteland Butte might be organic-rich limestone, dolomite, marl, mudstone, siltstone or sandstone. The member ranges in thickness from less than 60 ft to more than 200 ft. In areas where the Uteland Butte is dolomitic, it can have porosities ranging from 15% to 30%. However, matrix permeabilities tend to be extremely low. Uteland Butte sandstone reservoirs have been found with porosities ranging from 5% to 15% and with permeabilities greater than 1 mD. The Uteland Butte member is self-sourced from oil-prone Type II/III kerogen with TOCs found ranging between 2% and 5% and Ro values between 0.7 and 1.1. In response to the Uteland Butte's low permeabilities, operators have learned that horizontal drilling to intercept the member's plentiful natural fractures, as well as hydraulic fracturing, can make the play highly economic. Uteland Butte reservoirs are found at depths ranging from 4,500 ft to 6,000 ft at normal formation pressures, while deeper basin areas to 14,000 ft are overpressured. The most productive Uteland Butte wells to date have been drilled in the deeper overpressured basin areas.

CASTLE PEAK MEMBER

The Green River Formation's Castle Peak member, located just above the Uteland Butte member at depths between 4,000 ft and 5,500 ft, is readily defined by a carbonate marker bed. The member's stratigraphic record reveals as many as 17 lake level shoreline changes in Uinta Lake during the Eocene. The Castle Peak member ranges in thickness from 0 ft to 300 ft, thickening in both north and south directions away from the basin center. The member generally consists of medium-grained, poorly to moderately sorted, lithic arkose and/or feldspathic litharenite sandstone grains.

Generally, the sandstone is highly compacted with porosities ranging between 8% and 12% and



This Uinta Basin stratigraphic cross-section shows the magnitude and complexity of the Uinta Basin's Green River Formation. (Source: USGS)

permeabilities between 0.5 mD and 3 mD. Because of the constantly changing lake levels, individual Castle Peak sandstone beds are typically capped with thin limestone layers, each of which marks a shoreward onlap. Natural fracturing found in the Castle Peak member is typically found at the base of the sandstone beds where higher carbonate content, associated with the limestone cap of the underlying bed, increases the rock's brittleness. The thicker Castle Peak layers are found in the basin's shallower 4,000-ft to 5,500-ft depths.

In summary, the Rocky Mountains continue to be a geological goldmine for the innovative geoscientist. Not only are there important new field discoveries to be made in both conventional and unconventional plays, but the basin variety abounds with opportunities for economic secondary and tertiary recovery projects as well. ■

Horizontals Crack Rockies' Challenge

Modern drilling and fracturing techniques bring new pay potential to the hard-rock country.

By Don Lyle
Contributing Editor

The Bakken boom is legend, and the Niobrara newcomers are making their own tales of fame and fortune. Newer prospects also are bringing captivating stories to the Rocky Mountain storybook.

The Codell has joined the Niobrara in the Denver-Julesburg Basin, and the Niobrara is reawakening drillers in the North Park Basin. The Sussex-Shannon, Parkman, Turner, Frontier and Mowry are making news in the Powder River Basin, and the Heath is offering potential in Montana.

Furthermore, the Niobrara-Mancos pay is tempting operators in the Sand Wash and Piceance basins, and horizontal wells are testing the Uteland Butte and Castle Peak in the Uinta Basin of Utah. Moreover, the Gallup-Mancos combination is refreshing the San Juan Basin in Colorado and New Mexico.

The shale and tight-sand plays often offered pay to vertical wells, but horizontal drilling and multistage fracturing offer many times the payback and profit of vertical wells.

Profiles of operators working these plays demonstrate reasons for the newfound and increasing popularity of Rocky Mountain tight formations.

Key Players

AmeriCo Energy Resources LLC

- *Drilled Mancos Shale well*
- *Operations in New Mexico and Texas*

Houston-based AmeriCo Energy Resources LLC is a privately held company with operations focused on the Permian Basin, the Texas Gulf Coast and the San Juan Basin in New Mexico.

It has drilled one well to the Mancos Formation on its property in Rio Arriba County, N.M. According to a presentation by T. Greg Merrion, president and chairman of Merrion Oil & Gas Corp., the company's AlMagre Arroyo #001 oil well tested for a high rate of 116 boe/d. Overall, it produced 3,606 bbl of oil and 136 bbl of water and tested for an EUR of 70 Mboe.

Anadarko Petroleum Co.

- *Likes Rockies power plays*
- *Multiple basins enhance returns*

Anadarko Petroleum Co. likes horizontal drilling

and the Rocky Mountain oil formations, a match that puts money on the company's bottom line.

Those preferences put Anadarko in the Codell and Niobrara plays in the Denver-Julesburg (DJ) Basin, the multiple horizontal-friendly zones in the Powder River Basin and the emerging Uteland Buttes play in the Uinta Basin of Utah.

DJ BASIN

"Wattenberg HZ [horizontal] is a billion-barrel opportunity in an existing core area, making this field one of the largest and most cost-efficient onshore oil and natural gas projects in the U.S.," said Jim Kleckner, executive vice president, international and deepwater operations, on the company website.

The company's DJ program aims horizontal wells to a vertical depth of about 6,000 ft, primarily in the giant Wattenberg Field and also into Wyoming.

The company controls some 350,000 net acres of leases in Wattenberg alone—much of it railroad land grant properties on which it pays no owner royalties. Its estimated net resource potential is between 1 Bboe and 1.5 Bboe.

Anadarko's Wattenberg HZ program, working since 2011, combines horizontal wells to the Niobrara and Codell formations to find high-liquid content pay. It holds about 4,000 horizontal drilling locations in that play with EURs of 350 Mboe per well.

In a February 2014 presentation, Anadarko said its Wattenberg HZ production climbed from 4 Mboe/d in 2011 to 22 Mboe/d in 2012 and to 56 Mboe/d in 2013. It is allocating capital to projects that generate returns from 30% to 100%, and the Wattenberg program falls easily into that requirement. It has the highest growth rate of any of the company's major onshore horizontal projects, and only its Marcellus shale program generates higher production volumes.

Wells generate a \$6.7 million before-tax net present value with a 100% rate of return at current oil prices.

With that encouragement, Anadarko plans to

double its well activity in the play using 13 rigs in the Wattenberg to drill more than 360 wells in 2014 and grow production well beyond the combined vertical and horizontal Wattenberg production of 109 Mboe/d in 2013.

In its fourth-quarter report to shareholders, the company said its spud-to-release time on a 4,000-ft lateral well at Wattenberg fell from 12.4 days in fourth-quarter 2012 to 9.4 days in fourth-quarter 2013.

POWDER RIVER BASIN

Anadarko is the largest landholder among oil and gas companies in Wyoming, but it's moving slowly as it pursues horizontal oil well opportunities. In fourth-quarter 2014, its Powder River Basin oil program produced from 19 operated wells, and its three operated rigs drilled eight wells.

In addition to its coalbed methane wells and property, Anadarko controls about 350,000 net acres with oil potential. It planned 10 wells in 2013 to reach five target reservoirs.

The company's second-quarter 2013 report to shareholders said it planned to test multiple oil



Wild horses roam a wild countryside around tight sand operations in the Greater Natural Buttes area in Utah.

(Source: Anadarko Petroleum Co.)

objectives, including the Parkman, Shannon, Niobrara and Frontier/Turner.

Those formations are longtime producers in the Powder River Basin, but operators have only tested horizontal wells and modern fracture techniques in recent years.

UINTA BASIN

Anadarko also is the largest producer in Utah with its operations concentrated in the tight sands of the Greater Natural Buttes area of the eastern Uinta Basin.

The company holds 189,000 net acres of leases with more than 8,000 low-risk drillsites and operates more than 2,400 wells in the area with plans to pull out NGL.

Anadarko is high grading its targets in the basin and enhancing recoveries with deeper Black Hawk production as it tries to lower costs.

While much of the production comes from the Wasatch zone, the company also is testing liquids potential from the Green River. The Green River Formation includes the Uteland Butte zone.

Although the company doesn't specify the Uteland Butte as a target, the Utah Department of Natural Resources said at a poster presentation at the 2013 American Association of Petroleum Geologists' annual meeting that the company had a Uteland Butte play in the Natural Buttes area.

Berry Petroleum Co.

- *Early mover in the Uteland Butte play*
- *Building Utah position*

Berry Petroleum Co., now working on a merger into LINN Energy, started operations in the Uinta Basin of northeastern Utah in 2003 and has built its land position to 165,000 net acres.

That acreage holds net risked resources of about 75 MMboe from an inventory of targets in the Green River and Wasatch formations. The Green River Formation includes the growing Uteland Butte horizontal play. The play gave the company 37 MMboe in proved reserves at year-end 2012, and the company directed one-fourth of its E&P capex to the Uinta Basin in 2013.

Berry's oil production rose more than 36% from third-quarter 2012 to third-quarter 2013. As it increased production, it reduced average drilling

days from 12 in 2012 to eight in 2013.

Berry's website said the company holds leases in Brundage Canyon Field and Lake Canyon Field immediately to the west. It also holds property in Ashley National Forest.

The company drilled 102 gross (87 net) operated wells in the Uinta Basin in 2012 with 95 gross wells going to the Wasatch. It also participated in four Green River/Wasatch commingled wells with its partner in Lake Canyon Field. Combining those zones raises oil content to about 80%.

Berry produced 7,500 boe/d from its Uinta properties in fourth-quarter 2012.

About 400 vertical Uteland Butte wells have been drilled by operators in the basin. Since it started drilling its Uinta assets, the company has concentrated on incorporating vertical production from several Green River zones, including the Uteland Butte. It has tested 30 of those wells at 30-day IP rates between 10 boe/d and 80 boe/d.

The company participated in two nonoperated Uteland Butte horizontal wells at Lake Canyon in second-quarter 2011. The first showed a 30-day IP of 717 boe/d, and the second well "came on production at an encouraging initial rate." It planned to participate in three additional operated and three more nonoperated horizontal Uteland Butte wells.

Bill Barrett Resources LLC

- *Built a home in the Rockies*
- *Expanding in high-potential plays*

Bill Barrett Resources LLC's founder Bill Barrett built his company using some of the most innovative exploration in the Rockies. The company that bears his name continues that spirit as it works existing and emerging plays in the hard-rock country.

Its activities include the Niobrara Shale play in the Denver-Julesburg (DJ) and Powder River basins; emerging horizontal plays in the Shannon, Parkman and Frontier/Turner members in the Powder River Basin; and the Uteland Butte horizontal play in the Uinta Basin in Utah.

DJ BASIN

Bill Barrett holds 76,115 net acres of land with 1,697 gross Niobrara and Codell drilling locations in three areas of the DJ Basin. It produced 1.28

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MMboe from 65.8 MMboe in proved reserves from those areas during 2013, and it plans further growth in 2014.

The properties include the Chalk Bluffs/Wyoming border area; the Wattenberg Interior in the southern Wattenberg Field in Colorado; and its prime property, Northeast Wattenberg in Weld County near the northwest Morgan County border.

During 2013, the company grew its proved reserves in the DJ Basin by 85% above 2012, levels driven primarily by success at the Northeast Wattenberg delineation program.

That program also tested a number of production enhancement concepts with results good enough that the company will spend 75% of its \$500 million to \$525 million 2014 capital budget working a three-rig drilling program in the basin. Most of that drilling will spud on pads. It has 844 drilling locations to work with.

The \$390 million planned for 2014 will test the Niobrara B and C benches and the adjacent Codell Chalk.

Bill Barrett expects to see a 40% rate of return from that investment.

The company also said neighboring operators to Northeast Wattenberg found EURs of more than 300 Mboe on their wells, and Noble Energy had drilled extended-reach laterals within 2 miles of Barrett and had tested 40-acre spacing within 3 miles of the Barrett properties.

POWDER RIVER BASIN

The company put all of its Powder River Basin properties up for sale in late April 2014. Most of those properties lie in Campbell, Converse and Johnson counties in Wyoming. Its April production gave the company a net 1,450 boe/d with a 73% oil cut on its 67,825 net acres of land. It operates only 47% of those properties as it works with some of the basin's strongest producers. Bill Barrett said earlier it would spend \$56 million in the basin during 2013 and will pull back 5% to 10% of its \$500 million to \$524 million budget for 2014 to drill about 15 nonoperated wells.

Bill Barrett drilled and completed five wells in the Powder River Basin in 2013—all horizontal wells to the Shannon Formation, an emerging horizontal

play. Those wells averaged 516 bbl/d of oil during the first 30 days online and helped the company increase its production by 258% and reserves by 52%.

The company also participated in nonoperated horizontal wells to the Frontier, Turner and Parkman zones. A Parkman well tested for 858 boe/d with 91% oil, and another Parkman well produced 950 boe/d with 96% oil. A Turner well showed an IP of 741 boe/d with 96% oil, another Turner well found 818 boe/d with 92% oil, and a Frontier well reached 1,602 boe/d with 75% oil.

UINTA BASIN

Bill Barrett called its Uinta Basin oil program a core oil project and key source of growth in production and reserves.

It controls 129,400 net acres of land with 1,795 vertical and horizontal drilling locations in the basin and produced an average 2.645 MMboe from proved reserves of 53 MMboe in 2013. Reserves rose 10% during the year from properties in the Blacktail Ridge/Lake Canyon area in the western part of the basin and the South Altamont and East Bluebell area in the central basin.

The company's properties produce mostly from conventional wells in the Wasatch and Green River formations, but they have upside potential from increased densities and extension of known producing areas.

That could include horizontal wells to the Ute-land Butte and Castle Peak zones of the Green River beneath its existing production, but the company hasn't publicized any wells to those zones.

It spent \$204 million in the basin in 2013 and will lower that figure from 15% to 20% of its \$500 million to \$525 million capital budget in 2014.

Bill Barrett also holds 3,875 net acres of leases in the San Juan Basin with an average working interest of 50%. Apparently, it is not actively working those properties.

Black Hills Corp.

- *Evaluating the Mancos Shale*
- *Building on conventional production*

Black Hills E&P, the oil and gas arm of Black Hills Corp. set its sights on the Mancos Formation, the western Colorado/New Mexico equivalent of the

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it’s expensive to
hire a professional...
wait until you hire
an amateur”

- Red Adair

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Niobrara, to supplement growth in more conventional formations.

The company has operating interests on properties in the Powder River, Piceance and San Juan basins and nonoperated wells in North Dakota, California, Montana, Oklahoma and Texas.

The company's largest holdings, in both reserves and production, are on the Jicarilla Apache Reservation in the San Juan Basin where it produced 1,746 bbl of oil and 5.1 Bcf of gas in 2011. It produced another 1.1 Bcf of gas from its Piceance Basin properties in northwestern Colorado.

It operated 220 oil and gas wells in the San Juan Basin where it applies technology, including horizontal drilling and underbalanced drilling, to improve results.

The company is working on a three-year, three-well test program on horizontal wells drilled to the Mancos, including two in the Piceance Basin and one in the San Juan Basin. It started drilling those wells in 2011.

The company also operates 66 gas wells in the Piceance Basin.

In a February 2014 presentation, Black Hills said it had 74,100 acres of land with Mancos potential in the San Juan Basin. It drilled and completed two additional Mancos wells in the Piceance Basin to earn an additional 20,000 net acres in the southern part of the basin that is prospective for Mancos production. It currently holds 75,000 acres with Mancos potential from 340 wells.

In the original program, the company's second Piceance Basin well produced condensate and higher-Btu gas. Based on that result and results from nearby wells, it expects 6 Bcf to 8 Bcf of gas reserves per well for its two 2013 wells.

The two Piceance Basin wells were completed for 2.04 Tcf and 1.632 Tcf, respectively, in resource potential from the Mancos.

Black Hills has Mancos potential in 19,000 net acres with 120 potential well sites in the San Juan Basin. The single Mancos well completed there tested for 720 Bcf gross (576 Bcf net) resource potential.

The company's 2013 to 2015 Mancos-Piceance program calls for three well pads with 10 horizontal extensions on its Homer Deep Unit where one horizontal well already was drilled and one pad with

two horizontal extensions on its Horseshoe Canyon Unit where the other horizontal well was completed.

The company planned to drill and complete up to six horizontal wells in the Piceance Basin in 2014.

Its San Juan Basin Mancos properties lie 16 miles east-southeast of properties where Williams Cos. drilled two Mancos horizontal wells in 2010 and 45 miles northeast of five Mancos horizontal wells drilled by Encana.

Bonanza Creek Energy Inc.

- *Found a home in the Niobrara*
- *Working Denver-Julesburg and North Park basins*

Bonanza Creek Energy Inc. drilled wells into the Codell-Niobrara combination in Wattenberg Field's northeastern extension in northeastern Colorado as early as 1999. The company also worked its way to a position as the second-largest leaseholder in the play in the North Park Basin of north-central Colorado.

In a February 2014 presentation, the company said it had 500 Mbbbl of oil of proved reserves in the North Park Basin and another 31.9 MMboe in proved reserves in the Codell-Niobrara play in the Wattenberg area, where it has drilled more than 100 operated horizontal wells.

It holds a 17-year inventory of wells in Wattenberg, Colo., or 1,500 wells at its current pace of drilling.

The company's Rocky Mountain production increased 135% in the year leading to the end of third-quarter 2013 to a high of 11,802 boe/d. That included a 271% increase in production from horizontal wells to 11,128 boe/d.

Bonanza Creek plans to drill 121 operated wells and participate in another 19 nonoperated wells during 2014. It will spend 77% of its \$575 million to \$625 million in planned capex working four horizontal rigs in the basin. Its segment of the basin produces 60% crude oil with liquids-rich gas.

From its Niobrara B-bench wells, the company expects 313,000 boe of recovery, 62% oil, with a 30-day IP of 458 boe/d and a 10% net present value of \$4.2 million with \$90/bbl of oil. Payout arrives in a year and a half.

The Codell Formation is prospective on 15,000 net acres in the area, and three wells produced an average 539 boe/d in the first 30 days online with a 71% oil cut.

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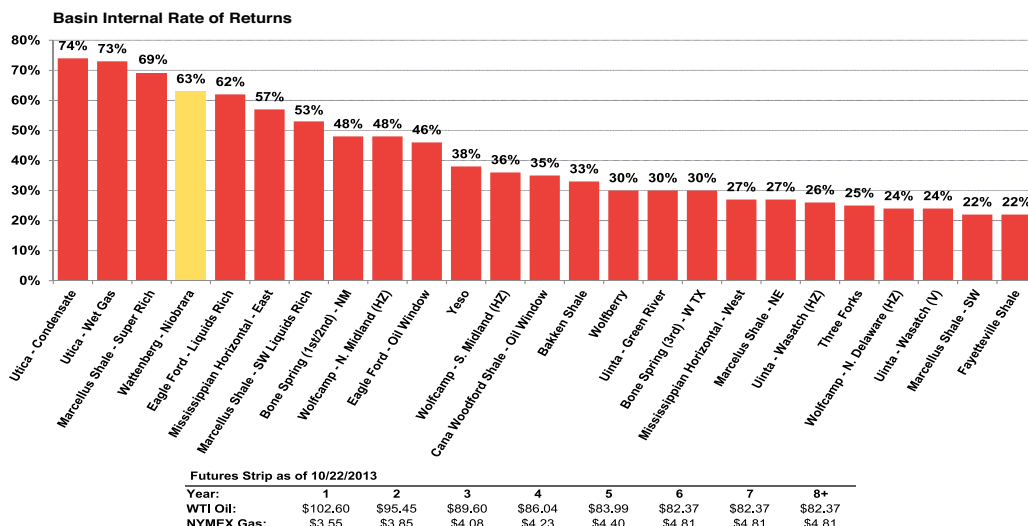


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Wattenberg Niobrara: A Premier Oil Resource Play



An internal rate of return of 63%—the fourth best in the country—shows why operators are flocking to the Niobrara play in the Wattenberg Field in northeastern Colorado. (Source: Bonanza Creek Energy Inc., Courtesy of Credit Suisse Equity Research)

Five wells drilled to the Niobrara C bench averaged 422 boe/d in their first 30 days of production with an 83% oil cut.

The company also is testing new concepts including 80-acre spacing with stacked Niobrara B and Codell wells and offset Niobrara C wells; 40-acre spacing on Niobrara B wells with offset 40-acre spacing on Niobrara C wells; and 80-acre spacing on Niobrara B wells with offset 80-acre spacing on production from Niobrara C. It expected first production from those test pads in March 2014.

The Niobrara Formation is about 600 ft thick on the company's North Park properties and lies about 7,500 ft deep.

Bonanza Creek is evaluating those properties for future horizontal development.

BP North America

- Major player in the San Juan Basin
- Taking a closer look at the Mancos Shale

BP North America isn't talking much about its holdings in the San Juan Basin in New Mexico and Colorado since gas production dropped from economic feasibility, but it is looking at the newest play in the basin.

It's the top gas producer in the basin with more than 1,500 wells in Colorado, most of them coalbed methane producers, and another 2,100 gas wells in New Mexico, mostly conventional producers.

The oily part of the Gallup segment of the Mancos lies in the southern part of the basin in New Mexico and phases to condensate and gas to the north.

BP established a Mancos Shale appraisal unit to examine the potential of that formation for oil production.

According to the *Farmington Daily Times*, reporting on a March 2013 San Juan Basin Energy Conference, Darryl Willis, vice president subsurface, North America gas region for BP, said, "We're optimistic about the potential for liquids, and we're optimistic about the Mancos."

The *Durango Herald*, quoting Willis at the same conference, said, "It's reasonable that the Mancos Shale could be a really, really good shale play in the San Juan Basin."

Amoco, a predecessor company to BP, drilled the Amoco No. 14 Jicarilla A118 vertical well on the Jicarilla Apache reservation and tested the Gallup section for an IP of 454 bbl/d of oil, 442 Mcf/d of gas and 50 bbl/d of water.

Carrizo Oil & Gas Inc.

- Holds 47,500 acres in the Niobrara
- Raising investment in 2014

Carrizo Oil & Gas Inc. dug a strong toehold in some of the better plays in the U.S., and it carried that tradition into the northeast Wattenberg area of the Denver-Julesburg Basin in Colorado and to the Codell-Niobrara combination.

The company's 47,500 net acres contains 33 MMboe in proved developed reserves and 51 MMboe in proved undeveloped reserves, and it's working a one-rig program in the play. That program used \$68 million of Carrizo's \$795 million capital budget in 2013, and it will use \$80 million of a \$735 million capital budget in 2014. Downspacing could add another 106 MMboe.

Currently, the company is participating with Whiting Petroleum and Noble Energy on super pads to test the Niobrara A, B and C benches in various spacing units. The Carrizo properties overlap Whit-

ing's Redtail development and Noble's East and West Pony fields to the north and west. The Razor project with Whiting tests the feasibility of 40-acre spacing. Potential under test programs could increase the company's drilling inventory sixfold.

Carrizo drilled 89 gross (36 net) wells on its property to date with another eight gross (four net) wells awaiting completion. For 2014, it plans to drill 33 gross (13 net) wells and fracture 45 gross (20 net) wells.

For a gross well investment of \$3.6 million, the company expects a gross 240 Mboe in recovery for a finding and development cost of \$18.75/bbl of oil. Assuming an oil price of \$100/bbl on the New York Mercantile Exchange, Carrizo expects a 60% internal rate of return. Even with an oil price of \$85/bbl, pay-out arrives in 2.6 years.

In October 2012, the company completed two deals with Asia-based companies. Under one joint venture (JV) agreement, it sold a 10% share of its properties, or 6,000 net acres, to Lanzhou Haimo



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Technologies Co., including 24 Niobrara producing wells for \$27.5 million. In the other JV, the company sold a 30% share, or 18,000 net acres, including 24 wells for \$41.25 million in cash and another \$41.25 million development carry.

In June 2013, Carrizo requested spacing authorization to drill 231 wells on its properties.

Chesapeake Energy Corp.

- *Downsizing the Niobrara*
- *Concentrating on the Powder River Basin*

Chesapeake holds a strong position in the Niobrara, but the Rockies play second fiddle to several other resource plays for the company.

For example, it will devote 5% of its 2014 capex to the Niobrara compared to 35% for the Eagle Ford, 15% for the Utica and 10% each for the Marcellus and Haynesville plays. That investment will keep three rigs working in the Niobrara and 15 turning right in the Eagle Ford.

Chesapeake hasn't been standing still in the Niobrara. It drilled 46 wells to the formation by year-end 2013 and produced 7 Mboe/d in December that year.

The company acquired its first Powder River Basin leases in 2008, and the company's fall 2012 issue of *The Fall* magazine said it held 5.5 Bboe of resource in its core Niobrara area.

It said the 142,000-acre Southern Core area of the Niobrara play in the Powder River Basin held more than 1,200 identified operated drilling locations, and an additional tier of acreage surrounding the core gave it another 1,600 Niobrara locations.

The company's Niobrara acreage also gave it potential in productive formations from the Teapot at about 7,000 ft down through the Dakota at 13,000 ft.

In January 2014, Chesapeake completed the #32-34-68 A 1H Rankin in Converse County, Wyo., in the Powder River Basin. That horizontal Niobrara well tested for 742 bbl/d of oil, 1.85 MMcf/d of gas and 720 bbl/d of water.

Chesapeake, however, was disappointed with its results in both the Niobrara in the Denver-Julesburg (DJ) Basin and the Bakken in the Williston Basin. It put 503,863 acres of leases up for sale, including all of its properties in the DJ Basin in Colorado and southeastern Wyoming but not its position in the Powder River Basin.

Commenting on its Powder River Basin Niobrara play in its second-quarter 2012 earnings conference call to analysts, former Chesapeake COO Steve Dixon said, "In the Powder River Niobrara play, we have finally cracked the code with numerous recent wells drilled in our newly identified overpressured, liquids-rich core area of 100,000 net acres delivering outstanding flow rates of more than 1,500 boe/d."

At that time, he said the limited gas processing and takeaway capacity in the basin was restricting growth, but "we expect to see this area take off in 2013 and beyond."

He also said an area of 350,000 acres in the Powder River Basin was prospective for other formations, including the Teapot, Parkman, Sussex, Shannon and Frontier.

At one point, Chesapeake was the biggest leaseholder in the Niobrara with about 800,000 acres about equally split between the Powder River and DJ basins.

Cirque Resources LP

- *Grasping new opportunities*
- *Strong presence in the Rockies*

Cirque Resources LP works the more traditional unconventional formations, including the Codell and Niobrara, but it also seeks upside earnings from the less traditional unconventional plays, including the Heath and Mowry formations.

In an April 2013 presentation, the company said it held 550,000 acres in the Rockies with several billion dollars in resource potential.

Among those properties, it has the Big Snowy and Castle Rock projects in the Heath Shale in Montana, the Sure Shot project in the Mowry Shale in the Big Horn Basin of northern Wyoming, the Java project in the Mowry in the Powder River Basin, the Pingora project in the Niobrara in the Hanna Basin of southeastern Wyoming and the Brennsee project in the Codell-Niobrara play in the Denver-Julesburg Basin in southeastern Wyoming. All the projects produce oil.

In early 2014, Norway's Statoil ASA, a 50% partner with Cirque on some projects, said it planned to back away from its participation in the Heath and Mowry prospects to focus on larger projects in other parts of the world. The companies had drilled five wells, including the Educated Guess 11-1H, before



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ConocoPhillips, the biggest gas producer in the San Juan Basin, has taken initial steps to evaluate the production potential of the Mancos Shale. (Source: ConocoPhillips Co.)

Statoil looked for other opportunities. That well included a 6,000-ft lateral.

Cirque, as operator, drilled four wells on the Heath prospect and reported one commercial well with an IP rate of more than 270 bbl/d of oil. Its only Heath producer, the Rock Happy 33-3H-2 in Rosebud County, Mont., produced more than 34,310 bbl/d in about 371 days onstream.

The Denver-based company leads the Heath play in permitting with 35 applications.

ConocoPhillips Co.

- *Working plays in Colorado, Utah and New Mexico*
- *Looking for higher potential*

ConocoPhillips Co. put its talent and skills to work on the southern rim of the Niobrara play in the Denver-Julesburg (DJ) Basin and made a hesitant step in assessing the Mancos Formation in the San Juan Basin in New Mexico.

The company also has interests in the Uinta Basin in Utah and Wyoming.

ConocoPhillips is the largest gas producer in the San Juan Basin with about 900,000 net acres of leases HBP and about 10,000 gas wells. Low prices forced the company to stop working its three gas rigs in the basin in May 2013, but it has other potential in the area.

In its 2013 fact sheet, the company said it produced 2 Mbbbl/d of oil, 47 Mbbbl/d of NGL and 750 MMcf/d of gas from the San Juan Basin. That's the highest output of any company region, including the Eagle Ford, Gulf Coast and Gulf of Mexico.

Ryan Lance, CEO, said his company started tests in the Mancos Shale.

According to a presentation on the Mancos Shale by president and chairman of Merrion Oil & Gas Corp., T. Greg Merrion, ConocoPhillips drilled the YERT COM HZMC horizontal well to the Mancos in October 2012. The well produced at a high rate of 110 boe/d with a cumulative production of 1.116 Mbbbl of oil and 13.318 MMcf of gas. It had an EUR of 66 Mboe from the well.

The company holds about 130,000 net acres in the southern DJ Basin with potential to produce Niobrara oil. That area lies in Adams, Douglas and Elbert counties south of the main Wattenberg part of the play in Colorado. ConocoPhillips had four horizontal producers and two vertical monitoring wells in the area at year-end 2012, and the company said results were encouraging. It planned well-appraisal activity and extended production tests before moving to full development. It was working one rig in the area and planned to add more as potential improved.

In early 2014, the company planned two horizontal Niobrara wells from a common drilling pad within the Aurora, Colo., city limits.

It produced 102 MMcf/d from its Wyoming and Uinta Basin properties in 2012.

Continental Resources Inc.

- *Selling out of Niobrara*
- *Tested prospects in Colorado and Wyoming*

Continental Resources Inc., a highly successful pioneer in the Bakken/Three Forks in North Dakota and Montana and in the South Central Oklahoma Oil Province play, looks as if it will concentrate on those plays rather than pursue opportunities in the Niobrara in the Denver-Julesburg (DJ) Basin of northeastern Colorado and southwestern Wyoming.

In mid-2012, the company said it was completing its second and third wells to the formation in Weld County, Colo., where it held about 25,000 net acres of leases. In March 2012, it held more than 92,842

net acres in the play and was the first company to drill a 1,280-acre spaced well to the formation.

Subsequently, it put two packages of leases in Laramie, Goshen and Platte counties in Wyoming on the sale block. Those parcels contained about 39,000 net acres of leases.

Late in 2013, Pacific Energy Development Co. said it planned to buy 28,727 net acres of land in the DJ Basin from Continental for \$30 million with a closing scheduled in mid-February 2014. That parcel included 2,200 net acres of leases in the Wattenberg area, 11 operated and 14 nonoperated wells and about 400 boe/d of production.

Crescent Point Energy Corp.

- *Uinta Basin pays dividends*
- *Horizontal targets raise prospects*

Conventional production, waterfloods and horizontal completions put the Uinta Basin in the winner's column for Crescent Point Energy Corp.

Already the largest operator in the Viewfield oil field, the biggest Bakken field in Canada, Crescent Point acquired Ute Energy Upstream Holdings LLC in late 2012. That acquisition gave it 590 gross (270 net) sections of leases in the center of the Uinta Basin light-oil play for \$861 million. That includes \$784 million in cash and the assumption of \$77 million in debt.

At the time, Scott Saxberg, president and CEO said, "This resource play is a new core area for Crescent Point and is consistent with our strategy of acquiring high-quality, large oil-in-place pools with long-term upside potential. We believe we can apply the extensive horizontal multistage fracturing stimulation expertise that we've developed in Canada to the Uinta Basin to deliver long-term value to our shareholders."

The company also worked up exploration and development agreements with the Ute Indian Tribe to give it access to another 150 sections of land.



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The property in the center of the basin lies at the junction of Monument Butte and the Altamont-Bluebell fields, both with more than 50 years of production history.

The package of properties offered Crescent Point about 7,800 boe/d of production, 88% oil and 24 net wells drilled but not completed. It received more than 1,000 net drilling locations, including 400 in the 100%-operated Randlett area. Current production gave the company a \$40/boe netback with a \$90/bbl price for West Texas Intermediate and the Henry Hub gas price of \$3.75.

Independent engineers estimated about 55.1 MMboe of proved and probable reserves with 37.6 MMboe in the proved category.

Following the acquisitions, the company set a capex budget of \$242 million with \$195 million of that directed to the Uinta Basin with plans to drill about 74 net wells and spend \$10 million on infrastructure and facilities.

Crescent Point set a capital budget of \$172 million for the basin in its 2014 capital budget. It set aside that money for 53 net wells with \$36 million directed to facilities. The company planned to start a waterflood in the conventional zones at Randlett with first injection set for 2015.

It also planned to continue to test new completion techniques and optimize fracturing efficiency in the area.

The company started a 3-D seismic permitting program in the Randlett area early in fourth-quarter 2014, and it set up a rail-loading site in the previous quarter to move about 2 Mbbl/d of oil to markets beyond Salt Lake City.

The company also started working with partners to design and participate in horizontal wells in both the Wasatch and Uteland Butte formations. It called initial wells drilled to date “encouraging.”

In a February 2014 presentation, the company said it had used a coiled tubing rig to drill 11 successful recompletions on the property. By that time, its production had climbed to 10 Mboe/d.

The company estimated room for 660 wells on its property for a total investment of \$1.258 billion to reach more than 77 MMboe in reserves

with a maximum production rate of 85,800 boe/d and a finding and development cost of \$16.46/boe.

In an earlier presentation, the company said vertical wells had encountered stacked pay zones within a 1,000-ft to 3,000-ft gross interval.

Devon Energy Corp.

- *Three Rockies areas show tight potential*
- *Actively working Codell and Niobrara*

Devon Energy Corp. holds conventional and unconventional play properties across the country with one active oil project and two relatively passive gas plays in the Rocky Mountain states.

Among the less active plays, the company operates 400 coalbed methane (CBM) wells in the San Juan Basin. That property might have potential for horizontal drilling to oil and gas in liquids and gas areas of the emerging Gallup/Mancos play.

Devon also operates CBM wells in the Drunkards Wash area in the southern Uinta Basin in Utah—an area with possible horizontal drilling opportunities in the Uteland Butte and Castle Peak zones. The company was not active in that play in 2012 or 2013.

It also has CBM production in the Powder River Basin of northeastern Wyoming.

According to a 2012 fact sheet, Devon controls about 100,000 net acres of leases in the Denver-Julesburg Basin in southeastern Wyoming, most of which is prospective for Codell and Niobrara production. It planned five wells in that area in 2012.

The company holds another 160,000 acres of leases in the Powder River Basin where it started drilling CBM wells in 1998. Now, however, it has switched its targets in the area to oil, specifically through testing in the Niobrara, Turner, Mowry and Frontier zones. It planned to drill 16 horizontal wells in that area in 2012.

In its second-quarter 2013 report to shareholders, Devon said it had drilled, completed and started production from seven Parkman and Turner horizontal wells with an average 675 boe/d of production in its first 30 days online. More than 90% of that production was light oil. The company has 600 risked locations for oil in the basin and expects that number to grow as it derisks its oil properties.

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Cornfields play host to higher payoffs from horizontal wells in the giant Wattenberg Field in northeastern Colorado.

(Source: Encana Corp.)

EE3 LLC

- *Niobrara pure play*
- *Working Colorado's North Park*

A small company takes opportunities where it can find them, and EE3 LLC found a fine opportunity with its first two wells in North Park along the Colorado-Wyoming border.

In October 2013, the company reported that its Hebron #3-12H horizontal well tested the Niobrara for about 1,054 bbl of oil in 24 hrs.

EE3 followed up in December with the Damfino #02-06H horizontal well to the same formation.

That record-setting well for the basin produced an average 685 bbl/d of oil or a cumulative 20,542 bbl of oil for its first 30 days onstream and peaked at more than 1,000 bbl/d of oil in a 24-hr test. Average flowing casing pressure, with no tubing in the hole, was 727 lb/sq in. in 5.5-in. casing. Two days after the 30-day test, the Damfino well flowed 715 boe/d on a 25/64-in. choke with 340 lb/sq in. of flowing casing pressure.

A month later, Scott Martin, chairman and CEO, said, "And it's still flowing 500 barrels a day. That's a phenomenal well."

The company drilled the well to 7,205 vertical ft with a 3,330-ft lateral in the Niobrara D bench and completed it with an 18-stage plug-and-perf treatment using 3.7 MMLb of sand. The well is located in the central part of the basin.

EE3 holds about 100,000 acres in North Park, most of which it purchased from EOG Resources.

Encana Corp.

- *Reopening the San Juan Basin*
- *Dominant leaseholder in the Mancos Shale*

Encana Corp. works five core areas, which include the Montney and Duvernay plays in Canada and the Tuscaloosa Marine Shale, Denver-Julesburg (DJ) Basin and San Juan Basin in the U.S.

Those plays passed the company's stiff participation filter. They produce returns of more than 40%, and they each show growth potential of about 50 Mboe/d.

DJ BASIN

Encana calls its DJ Basin assets "a light-oil play with significant scale." The company holds a piece of the action in the heart of the Wattenberg Field—a sweet spot in the Codell-Niobrara play and the most productive field in the area. The company produces from wells that tap the Codell, Niobrara and J Sand zones.

As a bonus, the DJ Basin has no takeaway capacity problems, and Encana's wells produce with a liquids cut of up to 70%.

For 2014, the company plans to drill 45 to 50 net wells while improving capital efficiency on its operations by increasing its pace of operations, reducing costs and optimizing well spacing. Those new wells

will help the company reach a 70% annual production growth.

The play easily passes the company's filter with estimated returns between 55% and 85%.

Encana leases about 49,000 net acres in the area with an average 50% working interest. It expects EURs between 324 Mboe and 425 Mboe per well and has room for 500 to 700 wells. Those wells cost between \$4.5 million and \$5.5 million to complete.

The company hasn't reached its production goal yet. It plans to work four to six rigs in 2014, at a net capital cost of \$250 million to \$300 million to produce between 8 Mbbbl/d to 8.5 Mbbbl/d of liquids, 4.2 Mbbbl/d to 4.6 Mbbbl/d of NGL and 40 MMcf/d to 50 MMcf/d of gas.

Encana had six rigs working the basin in 2013—up from two rigs in 2012. It also set a record of about eight days from spud to rig release and posted a 2013 average of 13 days per well.

At the same time, the company reduced fracture treatment costs by 34%.

SAN JUAN BASIN

The San Juan Basin program is a fairly new light and sweet oil play in northwestern New Mexico with the Gallup and Mancos silt as targets. Encana claims a dominant land position in the oily part of the play as well as a dominant position in the number of wells drilled with at least 20 tests.

The company plans to drill 45 to 50 new wells in 2014 as it improves commercial development.

Although operators previously had drilled wells to the Mancos, Encana said it discovered the play with modern techniques.

The play meets one of the company's criterion with the potential to produce 50 Mboe/d. Wells drilled to date cost between \$4 million and \$5 million, give the company a 30-day IP of 400 bbl/d to 500 bbl/d of oil and should offer returns between 45% and 70% when the program goes into resource play hub mode.

In addition to optimizing completions, Encana will spend time in 2014 working with the U.S. Bureau of Land Management to streamline permitting.

By 2017, the company plans to bring in wells producing 75% oil and condensate, 10% NGL and 15% gas.

Encana controls 176,000 net acres in the basin with an average 54% working interest in a partner-

ship with independents, including Dugan Production and Robert L. Bayless.

It has room for more than 700 wells in the play with an estimated 600 Mboe to 680 Mboe of recovery per well.

During 2014, the company plans to produce 3 Mbbbl/d to 3.3 Mbbbl/d of oil and condensate, 450 bbl/d to 500 bbl/d of NGL and 5 MMcf/d to 10 MMcf/d of natural gas. It will spend \$350 million to \$400 million to work between two and four drilling rigs—up from one rig in 2013.

EnerVest Ltd./EV Energy Partners LP

- *Acquiring property in the Rockies*
- *Zeroing in on tight oil*

A top-25 producer of hydrocarbons in the U.S., EnerVest Ltd., and its EV Energy Partners LP Ltd. partner operate more than 27,000 wells in the U.S. Properties outside the Rockies include the Barnett Shale, Permian Basin and the largest conventional production in Ohio.

The company's Rocky Mountain properties include leases in the San Juan Basin and the Uinta Basin.

The company started a buying and selling spree in late 2013 as it sold assets in Colorado in October, acquired assets in New Mexico in November and acquired additional assets in the Uinta Basin of Utah in December.

The November 2013 acquisition from Bill Barrett Corp. included 35,570 net acres in the Uinta Basin for \$325 million, including 67 MMcf/d of gas equivalent and 368 Bcf of gas equivalent in proved reserves. That was Barrett's West Tavaputs natural gas field, which produced from 300 wells. Barrett started full field development on the West Tavaputs Plateau in 2010 but reduced activity with falling gas prices.

The company already had a presence in New Mexico with its purchase of the Bear Canyon Unit from Apache Corp. in San Juan County in 2007. That unit produces from Mancos and Gavilan reservoirs. The environmental impact statement for West Tavaputs covered only gas production, with no potential oil production from the lower Green River Formation zones.

EnerVest also purchased 20,936 net acres of land in the San Juan Basin from Noble Energy for \$68 million. That purchase included 11 MMcf/d of gas equiv-

alent and 72 Bcf of gas in proved reserves. It also bought 2,819 net acres of property in the San Juan Basin for \$7 million from an undisclosed seller. That property produced 3 MMcf/d of gas equivalent and measured 9 Bcf of gas equivalent in proved reserves.

EnerVest drilled a Lindrith area horizontal well—the Bear Canyon Unit #6—to the Mancos in 2010 and produced 60 Mcf of gas.

EOG Resources Inc.

- *Opened Niobrara boom*
- *Easing some Rockies activities*

A powerhouse in the Bakken/Three Forks in the Williston Basin and the Eagle Ford in South Texas, EOG Resources Inc. will aim most of its 2014 capex at those formations and the Leonard Shale in New Mexico as it backs away from activities in the Denver-Julesburg (DJ), Uinta and Green River basins.

Essentially, that is the same strategy the company followed in 2013 as it targeted its oilier properties.

EOG drew attention to the DJ Basin and the Niobrara play in 2010 when it brought in the Jake 2-01H horizontal well in Weld County, Colo., at a rate of 1,558 bbl/d of oil. It followed up with the Red Poll 10-16H with an IP rate of 1,100 bbl/d of oil and the Elmer 8-31H at a rate of 730 bbl/d.

The company held 400,000 net acres of land in Colorado and Wyoming with Niobrara potential, but it confined its activity to only about 100,000 acres. Its Weld County, Colo., wells produced 82% oil, 12% NGL and 6% gas.

In January 2014, the company announced the #7-33H Big Sandy Niobrara discovery well in Laramie County, Wyo. The well tested for 241 bbl/d of oil, 115 Mcf/d of gas and 172 bbl/d of water during its first two months onstream.

Outside of the DJ basin, EOG held a substantial position with Niobrara potential in the North Park Basin of Colorado. It later sold at least some of those properties to EE3 LLC.



A rig probes for oil in the Altamont Field in the Uinta Basin of northeastern Utah where EP Energy is the largest producer. (Source: EP Energy Corp.)

The company didn't report on any activity in the Green River or Uinta basins other than noting in a February 2013 presentation that it owned properties in both areas.

EP Energy Corp.

- *Working the Green River and Wasatch formations*
- *Producing conventional, testing shale*

EP Energy Corp., the former E&P arm of El Paso Corp., holds 170,523 net acres of land in Duchesne and Uintah counties in Utah and concentrates its production on the Altamont Field area, including Bluebell and Cedar Rim fields.

Altamont-Bluebell is the largest field in the Uinta Basin, and EP Energy is the largest landholder in that field.

"Our current activity is mainly focused on the development of our vertical inventory on 160-acre spacing. We have identified an inventory of 1,104 net drilling locations, including 758 vertical locations and 346 horizontal locations. The industry is currently piloting 80-acre vertical downspacing programs in the Wasatch and Green River formations and horizontal development programs in the multiple shale and tight sand intervals. Because our acreage in the area is largely held by production, if these programs are successful, it will result in additional vertical and horizontal drilling opportunities that could be added to our inventory of drilling locations," the company said on its website.

EP Energy completed 27 wells at Altamont in 2013, raising production to 11.9 Mboe/d. It also added rail capacity to handle its increased production.

It expected to test horizontal well potential in 2014.

Overall, the company planned to focus its 2014 activity on its three main plays: the Eagle Ford in South Texas, the Wolfcamp in the Permian Basin and Altamont.

With a capital budget of about \$2 billion, EP expected to spend \$240 million in the Uinta Basin in 2014.

In a February 2014 presentation, the company said it held 97 MMboe in proved reserves at Altamont with 1,135 gross drilling locations and planned to use three or four drilling rigs through-

out the year. It has 327 net producing wells, and its vertical wells come in at IP rates as high as 1,477 boe/d with an 85% oil cut.

The company plans to complete 35 to 40 wells in 2014 to generate a 36% internal rate of return.

The Utah Geological Survey said the company has drilled one corehole to black shale in the southern Altamont-Bluebell Field and has proposed a horizontal Green River Formation program in the southwestern section of the field. The Castle Peak and Uteland Butte formations are the two lowest zones in the Green River Formation.

Gulfport Energy Corp.

- *Found a home in western Niobrara*
- *No spending planned in 2014*

Gulfport Energy Corp. has a Niobrara oil play in an area of northwestern Colorado sandwiched between the Piceance and Sand Wash basins.

Production in the area comes from the Buck Creek, Tow Creek and Wolf Mountain benches that are the geological equivalent to the Niobrara reservoirs of the Denver-Julesburg and Powder River basins.

The area produces oil and gas from depths between 3,000 ft and 14,000 ft, generally from naturally fractured areas of the Niobrara.

Gulfport showed a 3-D seismic survey in its Craigs Dome acreage in 2011 and is processing data from that survey. It held 8,386 net acres in the area in September 2013 with 220 Mboe in proved reserves and another 160 Mboe in probable reserves.

Hunt Oil Co.

- *Active in the San Juan Basin*
- *Reached Mancos in a test well*

Hunt Oil Co. works oil and gas wells worldwide, and it chose the San Juan Basin as one of its outposts in the U.S.

In September 2012, the company spudded the Elk Com 34 #01H horizontal well in the Lindrith, N.M., area. The well tested at a high rate of 75 bbl/d of oil and posted a cumulative 1,278 bbl of oil. The well's EUR was 45 Mbbl of oil.

The company filed an application with the New Mexico Oil Conservation Division for two nonstandard 320-acre spacing and proration units in the Gavilan Mancos Pool in Rio Arriba County, N.M. A

standard spacing unit in the pool is 640 acres.

Hunt asked for unorthodox locations for its proposed Regina Com 26-2-14-13 #1H and for the Regina Com 26-2-14-15 #1H well, both about 6 miles north of Lindrith, N.M.

Lilis Energy Inc.

- *Looking for Niobrara acreage*
- *Targeting conventional and unconventional pay*

Lilis Energy Inc. hit a snag when it tried to add to its northeast Colorado acreage with the planned purchase of Shoreline Energy Corp. for about \$40 million in stock and debt assumption for properties in northeastern Colorado, Wyoming, Nebraska and the Peace River Arch area in Alberta, Canada.

Shoreline planned to invest up to \$50 million in the Denver-Julesburg (DJ) Basin.

In early April 2014, Lilis terminated the planned acquisition of Shoreline, a purchase that would have given Lilis 1,520 net working interest acres and 4,835 royalty acres in the Greater Wattenberg Field, prime territory for the accelerating Codell-Niobrara unconventional play. Even without the acquisition, Lilis holds 125,000 gross (110,000 net) acres of land in the DJ Basin.

The company said it planned to explore other acquisition opportunities.

Lilis, formerly Recovery Energy Inc., listed the conventional Dakota and Muddy J sands and the unconventional Niobrara Shale as its primary targets in the basin.

Marathon Oil Corp.

- *Suspending action in the Colorado Niobrara*
- *Potential in the Powder River Basin*

Marathon Oil Corp. plans to concentrate on its activities in the Eagle Ford and the Bakken formations and also on its Oklahoma resource basin properties.

Therefore, it will suspend activity in its 155,000 net acres of properties in the Denver-Julesburg (DJ) Basin in northeastern Colorado and southeastern Wyoming. In August 2013, the company said it will suspend further development of the Niobrara Shale in the basin because of lower economics and low well productivity.

The company's 2012 fact book said it produced 1 Mbbl/d of oil and 14 MMcf/d of gas from Colorado that year from a proved and probable resource

of 50 MMboe to 60 MMboe, and it drilled 17 gross wells. Most of its oil production came from the DJ Basin, while most gas production came from the Piceance Basin.

In 2011, Japan's Marubeni bought a 30% working interest in 180,000 acres Marathon held in the Niobrara play at the time. It paid \$270 million (\$5,000/acre). Marathon began leasing in the Niobrara in the DJ Basin in 2010.

The company also has properties in the Big Horn and Wind River basins and the Wamsutter area of Wyoming. It also leases 74,000 net acres of coalbed methane properties in the Powder River Basin. Some of those Wyoming properties could be prospective for the Niobrara, Sussex, Shannon, Turner-Frontier or Parkman plays.

Noble Energy Inc.

- *Plans to double Niobrara drilling*
- *Opening new Nevada play*

Noble Energy Inc. will get nearly half of its discretionary cash flow from the Codell-Niobrara play in the Denver-Julesburg (DJ) Basin in 2014, and that percentage will grow.

A full half of that cash flow will come from the DJ Basin by 2018. "In the DJ Basin, we have a very successful legacy of resource development and are accelerating activity levels in this premier liquids-rich field," the company said on its website.

That's a significant statement, considering the company also has substantial operations in the Marcellus Shale, the deepwater Gulf of Mexico, offshore West Africa and in the eastern Mediterranean.

According to a 2014 presentation, Noble plans to devote \$2 billion or 40% of its \$4.8 billion capex to the DJ Basin in 2014.

The company already installed its first integrated development plan during 2013 at its Wells Ranch operation in the northeastern Wattenberg Field, and nearly one-third of its 22% reserve increase came from the DJ Basin.

Noble holds 609,000 net acres of leases in the basin, and 87% of that property lies in the oil window of the Codell-Niobrara. The land has room for 9,500 normal-length-lateral horizontal wells as the company tries to reach a 2.6-Bboe net risked resource.

The company plans to double its activity in the play to nearly 700 equivalent wells per year by 2018 to increase net present values by 30% to 50%. It plans 320 horizontal wells in 2014, including 55 extended-reach laterals, and it expects to increase production by 28%.

To help with that production increase, and a reserve increase, the company is working on a downspacing program throughout its properties from 24 wells per section to 32 wells per section. That downspacing will account for 30 to 40 of its 2014 wells. Those extended-reach wells are located in the five integrated development areas that account for more than half of Noble's total acreage in the basin.

The Wells Ranch and East Pony integrated development areas are in the works.

The program already confirmed that 16 wells per section is minimum spacing in the oil window, and the company now is confirming optimal spacing in each of the five integrated development areas.

Among those areas, East Pony has room for 20 to 35 downspaced wells to the Niobrara A, B and C benches; Wells Ranch can take 50 to 80 downspaced wells to the A and C benches; Mustang will take six to 12 downspaced wells to the B, C and Codell benches; and the Greeley Crescent will handle six to 12 downspaced wells to the A, B, C and Codell benches. It plans four to eight downspaced wells to the A, C and Codell benches.

The company's first extended-reach well with a 9,040-ft lateral at East Pony tested for 600 bbl/d of oil and 800 Mcf/d of gas after 90 days. Production reached 3,200 boe/d after 30 days on the company's five-well Loeffler pad in the core area. Those wells had 4,400-ft average lateral lengths.

The integrated development areas allow Noble to decrease footprints and increase economics in all phases of the life cycle of its wells. They reduced development costs by \$400,000 to \$800,000 per well, or the equivalent of \$1.15/boe to \$2.30/boe. Among other savings, the company doesn't need tanks for each well; it reduces water trucking with distribution lines, and it gains efficiency from pad drilling.

NEVADA

Noble drilled its first two wells in fourth-quarter 2013 at its Wilson unconventional play in north-eastern Nevada.

The company is currently drilling additional wells and conducting production tests. Those Elko formation wells show initial encouraging results, the company said. It plans additional production tests and additional drilling during 2014.

During a March 2013 U.S. Bureau of Land Management Forum in Elko, Nev., in March 2013, Noble said it planned five to eight vertical wells starting in 2013. By that time, it had conducted two 3-D seismic surveys and planned another in 2013.

The company estimated a gross, risked resource potential of 190 MMbbl of oil to 1 Bbbl of oil from its 350,000 net acres. The properties lie generally in a line from south of Elko to northeast of Elko in the northeast corner of the state in Mary's River, Huntington and Starr valleys.

Noble planned a \$130 million exploration budget for the play from 2011 through 2014 with an IP in 2014 and potential production as high as 50 Mbbl/d of oil by 2020.

Pacific Energy Development Co.

- *Increases acreage in the Niobrara play*
- *Adds to existing production in Colorado*

PEDEVCO Corp., which does business as Pacific Energy Development Co., increased its northeastern Colorado holdings by more than 10 times as it announced plans to acquire 28,727 net acres of land in the Niobrara play.

The acquisition agreement also called for the transfer of interests in 40 wells and about 400 boe/d of production from an unnamed U.S. independent. The purchase includes 2,200 net acres in the Watenberg Field area. The property lies largely in Weld County, Colo., and in the northwestern corner of Morgan County, Colo. The companies set the purchase price at about \$30 million.

The new acreage is close to land where the company already holds a 27.13% net working interest in 10,224 gross acres of leases.

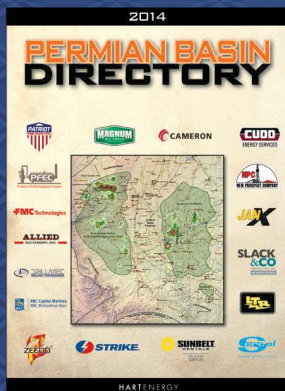
That property is operated by Condor Energy Technology, a partnership between Pacific Energy Development and MIE Holdings Corp. of Hong Kong. The Hong Kong company also operates in China and Kazakhstan. Condor participated in five horizontal wells spudded on the existing properties between April 2012 and June 2013—one with an IP of 1,105 boe/d.

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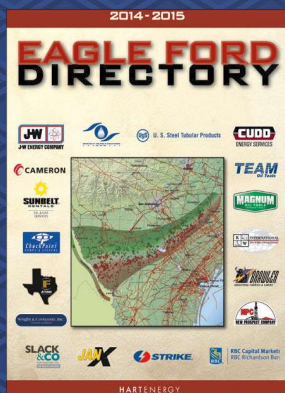
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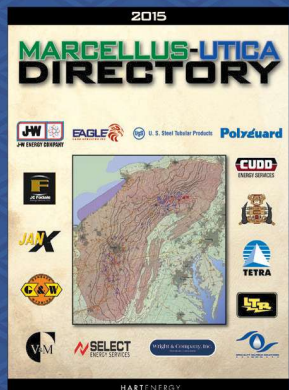
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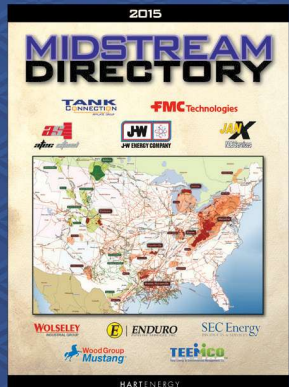
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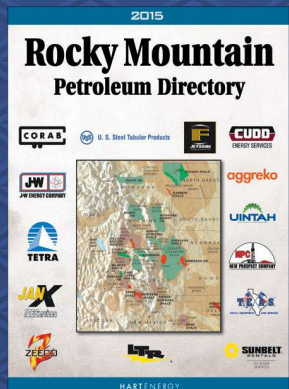
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In March, Condor scheduled six additional horizontal wells in Morgan County, Colo.

PDC Energy Inc.

- *Third-largest leaseholder in the Wattenberg core*
- *Codell potential under Niobrara*

PDC Energy Inc., a longtime operator in the Denver-Julesburg Basin, looks at plenty of remaining potential in the growing horizontal Codell-Niobrara play.

According to a February 2014 presentation, the company holds 98,000 net acres in the Wattenberg Field—the core of the play—and 95% of that acreage is held by existing production.

PDC can drill a potential 2,000 horizontal Niobrara wells and 800 horizontal Codell wells on the property with a liquids cut between 60% and 80%.

To date, the company holds 63 MMboe in proved developed reserves, another 149 MMboe in proved undeveloped reserves and another 480 MMboe in probable and possible resource.

PDC plans \$647 million in capex in 2014, and \$467 million of that will go into the Wattenberg area. That money will fund an average 4.5 rigs during the year to drill 59 Codell and 56 Niobrara horizontal wells. About 20 wells will feature extended-lateral legs of 6,500 ft to 7,000 ft.

The company spudded 119 gross horizontal wells in 2013, including 70 operated and 49 nonoperated. It has 2,300 net producing vertical wells and 113 operated producing horizontals. It currently operates four drilling rigs and will add another in May 2014.

It will drill 16 wells per section in 2014 using three to eight wells on a pad. Pad drilling will help PDC achieve spud-to-spud cycle time of 12 to 15 days, and its 16-stage to 25-stage fracture treatments can be completed in about 24 hrs.

Among the company's properties, its inner core of the Niobrara produces wells with EURs of 500 Mboe and a 125% internal rate of return (IRR). Middle core wells offer a 400 Mboe EUR and a 75% IRR, while outer core wells come in at a 285 Mboe EUR and a 46% IRR. The Codell Formation lies under most of the acreage, and those wells achieve a 370 Mboe EUR with a 73% IRR.

PDC produced 2.783 MMbbl of oil from Wattenberg during 2013, representing a 40% gain from the 1.979 MMbbl in 2012. In the same periods, it

produced 12.7 Bcf of gas compared to 9.8 Bcf—up 29.3%. NGL production grew to 1.03 MMbbl from 837 Mbbl, for a 23.5% increase.

Peak Exploration & Production LLC

- *Working the Powder River Basin*
- *Stacked pay offers multiple opportunities*

Peak Exploration & Production LLC, operating as Peak Energy Resources Inc. and Peak Powder River Resources LLC, acquired nearly 25,000 acres of leases in the Powder River Basin since it entered the area in 2012.

The company chose the Shannon and Turner formations as its primary horizontal drilling targets, but it also lists potential in the Parkman, Frontier, Muddy and Dakota sands and the Mowry and Niobrara shales.

Strategically, it drills horizontal wells along the fringes of existing fields in the basin. Among companies with offset locations targeting the Shannon and Turner are Devon Energy, Anadarko Petroleum, Samson Resources and Southwestern Production.

Peak drilled six horizontal wells by July 2013, and five of them were completing and producing. The other was waiting on completion equipment.

That month the company said it completed the Iberlin1-10 TH horizontal well in Campbell County, Wyo., in the Cretaceous Turner for an IP rate of 2,607 bbl of oil and 4.298 MMcf of 1,385-Btu/d gas. It tested the well through a 40/64-in. choke with 1,965 psi of flowing casing pressure. It drilled the well to a measured depth of 15,667 ft, including a 4,000-ft lateral section, and added a 14-stage fracture treatment.

Peak has more than 40 potential horizontal well locations on its property.

Petroglyph Energy Inc.

- *Drilling to the Uteland Butte*
- *Working in the eastern Monument Butte area*

Petroglyph Energy Inc., the oil and gas operating general partner of III Exploration II LP, a division of Intermountain Industries Inc., focused its operating expertise on the Uinta Basin of northeastern Utah.

To date, 12 wells have been drilled on its property in the eastern Monument Butte area, and two

of those wells bottomed in the Uteland Butte or Black Shale zones—the lowest zones in the Green River sequence.

Petroglyph is a limited partner of IIIX LP and exercises complete control over the operations of the general partner.

The companies started their participation in the Uinta Basin in 1994 through a joint venture with an industry partner. The successor to that partner and operator of the properties is QEP Resources. That leaves IIIX LP and Petroglyph with 25,000 net acres with associated oil and gas production.

Petroglyph entered the area in 1994 with the purchase of Antelope Creek and Duchesne fields and later acquired leases in the Natural Buttes Extension area for its waterflood potential. The company is drilling both vertical and horizontal wells in the area.

QEP Resources Inc.

- *Big presence in the Uinta Basin*
- *Testing the Lower Green River Formation with vertical wells*

QEP Resources Inc. produced 74 MMcf/d of gas equivalent from the Uinta Basin in fourth-quarter 2014 and has plans to increase that production rate.

Although primarily gas, its overall production contained a 34% liquids cut. About 38 MMcf/d of gas equivalent came from the Lower Mesaverde play.

The company supplemented its production when it began ethane recovery in October 2013, and that recovery continued into first-quarter 2014.

It operated one drilling rig in the Lower Mesaverde play at year-end 2013. It had 80 producing wells and has more than 3,200 potential remaining drilling locations if it can drill on 10-acre spacing. Also, at year-end 2013, the company drilled its second Lower Mesaverde well with a new design that could improve economics and lead to an accelerated development program.

QEP had another rig drilling vertical wells to the Lower Green River Formation at a depth of 5,500 ft in fourth-quarter 2014. Although it didn't specifically identify the Uteland Butte or the Castle Peak Formation, it drilled one horizontal and seven vertical wells to those lower zones.

The company plans to spend only 4% of its \$1.8 billion capital budget in the Uinta Basin in

2014 as it works higher priority properties in the Bakken and Pinedale plays, the Permian Basin and the Midcontinent.

The company holds 32,300 net acres of land in the Uinta Basin with 428 Bcf of gas equivalent in proved reserves, 3.4 Tcf equivalent in probable reserves and 5.4 Tcf equivalent in possible reserves.

Red Willow Production Co.

- *Petroleum arm of the Southern Ute Tribe*
- *Potential in the Gallup and Mancos plays*

Since it was founded in 1992 to oversee the Southern Ute Tribe's energy resources, Red Willow Production Co. has assembled interests in more than 290,000 acres of land with more than 1,800 wells in 10 oil and gas basins in the U.S. It has operations in Colorado, New Mexico, Texas and Louisiana and undeveloped acreage in Oklahoma, New York, Arkansas, Wyoming, North Dakota, California and the Gulf of Mexico.

Most of the Southern Ute's 700,000-acre reservation lies in southwestern Colorado in the northern part of the San Juan Basin where it produces from the Fruitland Coal and Mesa Verde, Pictured Cliffs and Dakota formations. It has interests in more than 1,300 producing wells on more than 148,000 acres of leases and operates more than 400 of the reservation wells.

Red Willow drilled one well to the Mancos Shale in December 2012 and planned to lease 12,000 acres of tribal mineral properties on Fort Lewis Mesa east of Marvel in La Plata County, Colo., for further exploration.

Exploration initially would begin in the Niobrara member of the Mancos Shale, a Bureau of Indian Affairs document said, and Red Willow plans horizontal wells with fracture treatments.

Robert L. Bayless, Producer LLC

- *Properties throughout south and central Rockies*
- *Working through partnerships*

Privately owned Robert L. Bayless, Producer LLC holds substantial acreage in several Rocky Mountain basins with operated and nonoperated interests in about 800 wells.

It has working interests in about 500,000 acres of leases, most of which are in the San Juan, Uinta

and Powder River basins. Those properties include 200,000 acres in the San Juan Basin in Colorado and New Mexico, 40,000 acres in the Piceance Basin of Colorado, 80,000 acres in the Uinta Basin of Utah and 200,000 acres in the Mowry Shale in the Big Horn Basin of Wyoming.

The company operates about 150 wells in the San Juan, Paradox, Piceance and Sand Wash basins. Most of those are gas wells in the San Juan Basin. It has about 600 nonoperated wells in those basins and in the Uinta, Powder River and Green River basins in Utah and Wyoming.

Bayless also is looking for partners to take a 75% working interest in a southern extension of the Niobrara play in the Denver-Julesburg Basin of Colorado. That prospect includes about 16,000 gross (12,000 net) acres of leases southeast of Denver in Elbert, Douglas, Pueblo and El Paso counties with most of the properties in Douglas and Elbert counties.

Samson Oil & Gas Ltd.

- *Australian spirit in U.S. prospects*
- *Experimenting with the Niobrara*

Samson Oil & Gas Ltd. chose to focus its operations on the Bakken and Niobrara shales with additional activity in the Permian and Green River basins.

Its Niobrara concentration settles on the 19,500-acre Hawk Springs Project where Samson is operator with a 40% working interest.

The company acquired a 63-sq-mile 3-D seismic survey over the project in early 2011; processed and interpreted the data; and worked up an inventory of the Niobrara, Muddy-Dakota, Sundance and Permo-Pennsylvanian prospect.

The survey led the company to discover the first oil from the Niobrara north of the Silo Field in the Denver-Julesburg Basin in southeastern Wyoming at its Defender U.S. 33 #2-29H well.

Production from that Goshen County, Wyo., well has been spotty because of pumping mechanics, but Samson is learning how to treat the issues, is starting to establish a consistent 75 bbl/d of oil production rate and is working to increase that production rate. The well has produced a cumulative 10,000 bbl of oil.

Samson also drilled the Spirit of America well at Hawk Springs in Wyoming. The company drilled the Bluff #1-11 to 1,037 ft at Hawk Springs and

plans to complete that project after executing a farm-out in the short term and solidify the value of the remaining 18 prospects on the project. It is talking with several companies about completing the Bluff well in first-quarter 2014.

While it works out the Niobrara puzzle, the company is completing a Permo-Penn well.

Samson Resources Corp.

- *Active in the Powder River Basin conventional zones*
- *Suspended activity in the San Juan Basin*

The Samson Resources Corp., subsidiary of KKR & Co. LP, drilled horizontal wells in the Bakken Shale in the Williston Basin and conventional zones in the Powder River Basin and the Fort Union play in the Green River Basin.

The company also holds 82,000 acres of properties in the San Juan Basin in Colorado and New Mexico, which it acquired from a private seller in 2004. It produced an average 93 Mcf/d of gas equivalent from the properties in fourth-quarter 2013, but it has no working rigs in the gas play for 2014.

In a February 2014 presentation, the company said its Powder River Basin property in Wyoming totaled 310,000 acres and produced 3.5 Mboe/d in fourth-quarter 2013. Potential targets include the conventional Sussex, Shannon and Frontier and the unconventional Mowry and Niobrara shales, all with oil potential.

Samson's current horizontal well focus is on the Shannon in North Tree Field on the border between Johnson and Campbell counties in Wyoming and on the Sussex in Hornbuckle Field in northwestern Converse County, Wyo.

The company plans to spend \$180 million on drilling and completions in 2014, 85% operated, and to spud 28 gross (20 net) operated wells.

Most of the work will go into North Tree, which already has seven producing Shannon horizontal wells. During 2014, the company plans to run two rigs in the field, spending \$105 million, 100% operated, to drill 16 gross (12 net) wells. It expected first sales on 10 wells in first-quarter 2014. For the year, it plans 11 short-lateral wells with 1-mile legs and five long-lateral wells in 2-mile legs.

Three recent horizontal wells in the field posted 30-day IP rates between 200 boe/d and 810 boe/d.

San Juan Resources Inc.

- *Concentrates in the San Juan Basin*
- *Works as operator and interest holder*

Established in 1990 by Jerry McHugh Jr., San Juan Resources Inc. works conventional and unconventional zones in the San Juan Basin in southwestern Colorado and northwestern New Mexico.

It operates more than 25 wells in the basin and holds nonoperating working, overriding royalty and royalty interest in several properties in San Juan, Rio Arriba, Sandoval and La Plata counties producing from conventional Dakota, Gallup, Mesaverde and Pictured Cliffs formations and from the unconventional Fruitland coal.

Among the company's properties with tight Gallup and Mancos production are West Lindrith Gallup Dakota & South Blanco PC Production, which operates six Pictured Cliffs and five Gallup Dakota wells, and the Bear Canyon Unit, operated by EnerVest Operating, in which San Juan Resources holds a nonunit participating working interest in six wells drilled to the Gavilan Mancos reservoir.

SM Energy Co.

- *Producing from the Powder River Basin*
- *Targeting horizontal Frontier and Shannon*

SM Energy Co. gathers most of its profits from its operations in the Eagle Ford and Bakken plays, but it uses its drillbit to grow its activity in the Powder River Basin.

It controls about 140,000 net acres of land in the basin, and about 100,000 net acres are prospective for Frontier production.

The company operated one rig in the basin in fourth-quarter 2013 with wells aimed at the Frontier Formation. At year-end 2013, it had identified 355 gross (150 net) Frontier well locations and another 265 gross (145 net) Shannon-Sussex locations. Those locations offer the company a potential 215 MMboe.

It plans to drill 10 wells and complete another eight wells during 2014.

In a March 2014 presentation, the company said it had 15 Frontier permits in hand and more applications in approval stages.

SM Energy has land in the northwestern corner of Converse County and southern Campbell County, Wyo., with most of its activity in three areas of Converse County.

The company had one rig working in early 2014 and anticipated adding another rig at its Loco area where a Frontier well showed a 30-day IP potential of 1,408 boe/d. It completed three operated Frontier wells in first-quarter 2014.

SM Energy had approved permits to drill to the Shannon Formation in its Bridget area, where a well tested for 499 boe/d in its first 30 days online.

In the Dandy area, the Frontier tested for 927 boe/d during a 30-day period.

The company plans to spend \$140 million of its total \$1.9 billion capex budget in the Powder River Basin in 2014.

Southwestern Energy Co.

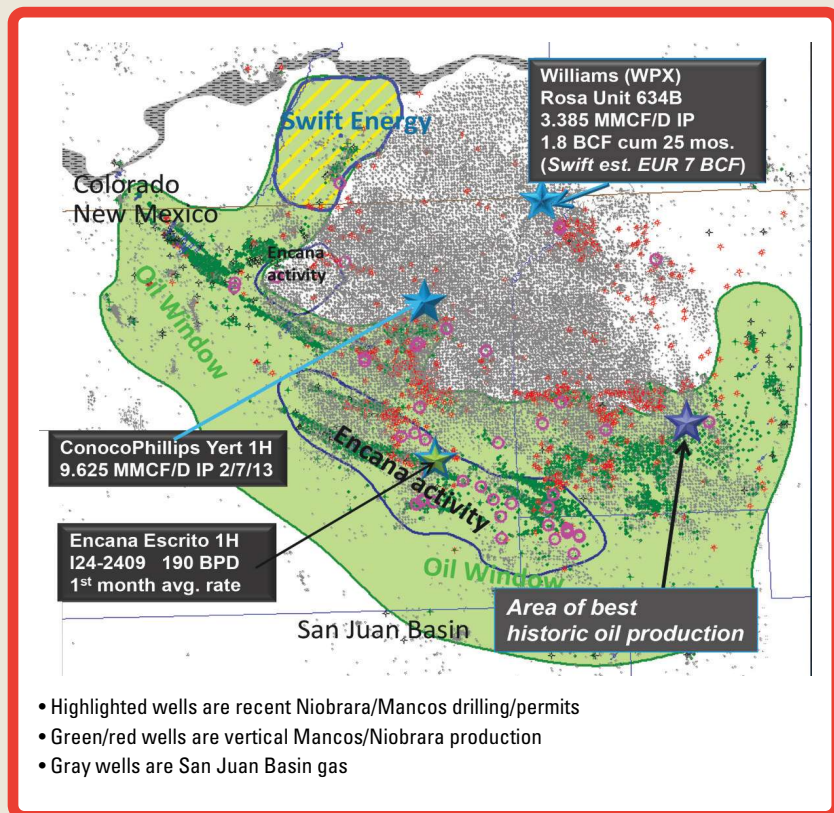
- *Bought Niobrara potential in the Sand Wash Basin*
- *Fayetteville Shale pioneer has added Rockies acreage*

Southwestern Energy Co. raised its bets on the Niobrara play in March 2014 as it signed an agreement to purchase about 312,000 net acres of land in northwestern Colorado from Quicksilver Resources Inc. and SWEPI LP, a Royal Dutch Shell Plc subsidiary, for about \$180 million. It anticipated closing the deal in second-quarter 2014.

The land in the Sand Wash Basin is prospective for oil production from the Niobrara Shale. The basin has proven Niobrara production with a minimal water cut. It is overpressured with matrix permeability. Well decline behavior indicates a continuous reservoir, and the area has additional potential from downspacing and stacked reservoir bench production.

The company plans to initiate a drilling program as early as June 2014.

Southwestern also held about 302,000 net acres of land in the Denver-Julesburg Basin where it targets unconventional oil from middle and late Pennsylvanian and Permian carbonates and shales. A horizontal well in Arapahoe County, Colo., tested for 146 bbl/d of oil and 59 Mcf/d of gas after a 14-stage frac-



This map shows areas of historic vertical production and new and proposed horizontal production from the Niobrara (Mancos) in the San Juan Basin in Colorado and New Mexico. (Source: Swift Energy Co.)

ture treatment. Those carbonates and shales lie at a vertical depth of 8,000 ft to 10,500 ft and range from 300 ft to 750 ft thick.

That property lies generally east and south of the main Codell-Niobrara play, and Southwestern calls it a new ventures area. The company plans additional tests on the land in second-quarter 2014.

Swift Energy Co.

- *Seeking Mancos/Niobrara in the San Juan Basin*
- *One well drilled to date*

Swift Energy Co. purchased about 70,000 net acres prospective for the Mancos Shale, the geological equivalent of the Niobrara in most of Colorado, in the southwestern corner of the state.

The company followed the La Plata County, Colo., purchase with plans to drill to a 40-ft to 60-ft section of brittle Mancos with a high-content, oil-charged reservoir.

It drilled a “strategic pilot hole,” the Waters 34-12-32 #1H, to multiple zones of interest in third-quarter 2013 and drilled a lateral leg in the Mancos. It collected logs and cores that will help the company evaluate its acreage. Until it completes the evaluation, it has suspended activity on the well.

Horizontal tests on the same zone have been drilled nearby by Red Willow, Robert L. Bayless and Encana.

Swift’s test is near Red Mesa Field in the Mesa Verde sub-basin, and the company anticipated an EUR between 250 Mboe and 400 Mboe, or 3.5 to seven times a typical recovery from a vertical well and two to 3.3 times the recovery from other horizontal wells with 4,000-ft laterals.

If the evaluation is favorable, Swift plans to drill the remaining 859 locations on its property between 2014 and 2053 to recover 125 MMboe to 200 MMboe risked potential resources, assuming 160-acre spacing.

Initial calculations estimate \$5.3 billion for full development and a return of 3.11 times the company’s investment. The wells should generate a 72% internal rate of return and payout in 63 months.

Synergy Resources Corp.

- *Building a core in the DJ Basin*
- *Stacked pay multiplies opportunities*

Synergy Resources Corp. started drilling horizontal wells in the giant Wattenberg Field in Colorado in May 2013 and put two full-time rigs to work expanding operations and production.

That doesn’t mean Synergy is a newcomer. It has worked the Denver-Julesburg (DJ) Basin for 30 years building a solid base of production and income from low-cost, low-risk vertical wells. In all, it built a land-base of more than 392,000 gross (286,000 net) acres of land in the basin in Colorado and Nebraska.

The company has 361 gross producing wells, including 283 operated wells, 145 wells drilled by Synergy since 2009 and 11 horizontal wells in the Codell-Niobrara play.

It controls 25,200 net acres in the high-liquids area of Greater Wattenberg; 24,700 net acres in the

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Wattenberg extension in the northern DJ Basin; 61,000 net acres capable of producing dry gas in Yuma and Washington counties (economic with gas prices higher than \$4/MMBtu); and 160,000 net acres in the southwestern Nebraska prospective for oil from Pennsylvanian and Mississippian zones.

The company's first-quarter 2014 operations offered 81% oil, 7% NGL and 12% gas. All of its production to date comes from wells in the Wattenberg Field. It hasn't drilled any dry holes.

Like other efficient operators in the basin, Synergy drills from pads. It started producing from five horizontal wells on its Renfro pad in September 2013 and from six horizontal wells on its Leffler pad in January 2014. It also participated in 24 gross nonoperated horizontal wells in the past two years.

Synergy plans to drill 34 gross horizontal wells in its 2014 fiscal year. It will spend 97% of its \$189 million fiscal year budget in the Wattenberg Field. Its two-rig program will target the Niobrara A, B and C benches, Codell, Greenhorn Shale and J-Sand.

During its first fiscal quarter of 2014, which ended on Nov. 30, 2013, the company produced a net 291,094 boe, or 3,208 boe/d, representing a 93% gain from the same period in the previous fiscal year.

Whiting Petroleum Corp.

- *Efficient techniques learned from Bakken*
- *Focused on Niobrara A and B benches*

Whiting Petroleum Corp., one of the more successful and efficient companies working the Bakken play in North Dakota, brings the same concentration and technology to its Redtail Niobrara project in the northeast Wattenberg extension in the Denver-Julesburg Basin of Colorado.

Whiting is targeting 169,677 gross (122,278 net) acres of land, where it holds a 73% working interest and 59% net revenue interest. It plans four to eight wells per spacing unit in its Niobrara A program and eight wells per spacing unit in its Niobrara B program with both programs working from drilling pads.

With those parameters, it can drill 2,400 to 3,300 locations on its property at a completed horizontal well cost between \$4 million and \$5.5 million per well. It also has potential in the Niobrara C bench.

The company has 3,310 gross (1,654 net) pri-

mary drilling locations at Redtail with 16 wells per spacing unit.

It bracketed its Phase 1 acreage to the west and east with the Wildhorse 04-0424H and Horsetail 18-0713H wells. The Wildhorse well tested for 443 boe/d during a 90-day period, and the Horsetail tested for 458 boe/d during a 60-day test period.

The company drilled 33 Phase 1 wells through Sept. 30, 2013, and permitted 18 more. It has 267 wells lined up in a two-year drilling inventory and another 581 future wells. It also has wells drilling two-year plans and total drilling planned through four phases. During that time, it will install gathering lines, frack water supply lines and a gas treatment plant.

The company booked 65.9 MMboe in proved Niobrara reserves at Redtail in 2013 and estimated the total resource potential of the project at 492.4 MMboe net to Whiting. It produced a net 5.1 Mboe/d on Feb. 1, 2014—up 58% from its fourth-quarter 2013 average of 3,230 boe/d.

During second-quarter 2014, the company plans to test a 32-well pattern on a 960-acre spacing unit. If successful, that spacing would increase potential well locations to more than 6,600. Its property contains an estimated 70 MMboe of original oil in place on each 960-acre unit.

Whiting plans to drill about 1,024 gross wells with an average 84% working interest between 2014 and 2018.

WPX Energy Inc.

- *Rockies operations in Colorado, New Mexico and Wyoming*
- *Huge Niobrara potential in the Piceance Basin*

WPX Energy Inc., former subsidiary of the Williams Cos., works the coalbed methane (CBM) play in the Powder River Basin, the Niobrara in the Piceance Basin of northwestern Colorado and the Mancos-Gallup play in the San Juan Basin.

Although most of the company's production and reserves are in natural gas, the company is looking at increased oil and liquids production for higher profit margins.

During 2013, it raised reserves by 5.5% to 4.9 Tcf of gas equivalent with 4.76 Tcf of gas equivalent in the U.S. Reserves consisted of 76% gas, 13% oil and 11% NGL.

The company owns interests in more than 14,000 oil and gas wells and operates more than half of them. It produces 80% gas and 20% liquids.

In addition to Colorado, New Mexico and Wyoming, WPX has substantial operations in the Bakken and Marcellus plays.

POWDER RIVER BASIN

WPX controls 360,000 net acres and 2,000 wells in the Powder River Basin of northeastern Wyoming and has produced CBM there since 2001. It has joint-ownership interests in another 2,800 wells. Its activities are focused in Campbell and Johnson counties—an area that also has potential for the emerging deeper horizontal plays, including the Shannon-Sussex, Frontier-Turner, Niobrara and Parkman.

The company spent \$6 million on its activities in the basin in 2013 and completed 37 wells.

PICEANCE BASIN

The company holds 216,000 net acres of land with 4,100 wells and thousands of additional well locations. It produces more gas from the area than any other operator.

In 2012, WPX announced a discovery well in Garfield County, Colo., that came in at 16 MMcf/d of gas with 7,300 psi of flowing casing pressure and that produced more than 1 Bcf of gas in its first 100 days online. It drilled the well to a 10,200-ft vertical depth and added a 4,600-ft lateral. That was the start of its HP/HT Niobrara program. That program has the potential to more than double the company's proved, probable and possible reserves.

It wasn't easy. In addition to pressures up to 13,800 psi, well temperatures reached as high as 300 F in some spots. Those conditions required specialized down measuring, drilling and completion equipment. Pressures required ceramic proppants.

After experimenting with bits and drilling assemblies, the company chose a 12¼-in. drillbit.

It planned four horizontal Niobrara wells in 2013—up from two originally planned.

The company spent more than \$340 million and kept seven rigs working in the Niobrara and shallower formations in 2013.

Its first vertical well in the play in the east, in Rulison Field, went to a total depth of 13,797 ft with an initial reservoir pressure of 8,200 psi. The company's fourth horizontal well produced at a peak rate of 6.4 MMcf/d from a 1,000-ft lateral.

The company reported completion of the #702-23-HN1 Bosely SG, a horizontal well drilled to the Niobrara in Garfield County, Colo., in the Piceance Basin. The company choked back the well to 8 MMcf/d of gas with a flowing tubing pressure of 5,400 psi after an 18-stage fracture treatment.

It expects growth of 6% in the basin as it runs nine rigs during 2014 to drill 285 wells. The company produces 17.3 Mbbbl/d of NGL.

The 2014 program includes 10 Niobrara wells to further delineate the play in Parachute Valley and Ryan Gulf Highlands fields.

SAN JUAN BASIN

WPX, with about 160,000 net acres and 860 wells in the San Juan Basin, is one of the most active operators in the emerging Mancos-Gallup oil play. It has five of the top seven producing wells from that play, and its first 13 horizontal wells produced at an average 30-day rate of 388 bbl/d of oil. The company added 13,000 net acres of land to bring its holdings in the Mancos-Gallup play to 44,000 net acres in the oil window.

Its best well was the Chaco Z30 19M #191H with a 30-day IP of 559 bbl/d of oil.

For 2014, the company expects year-on-year growth of 275%. By February 2014, it already had spud five of the 29 gross wells it expected to spud during the year. It will average 1.8 rigs during 2014 as it drills from multiwell pads. By February 2014, it had drilled 16 Gallup wells.

WPX began using zipper fracks on its wells in first-quarter 2014.

It plans to invest \$160 million in the basin during 2014 on the New Mexico side of the San Juan Basin. The company also has property in La Plata County, Colo.

Current average drilling time for a Gallup oil well is 16.7 days, although the company completed one well in 14.6 days. It finished 2013 with Gallup production moving through 2,489 bbl/d of oil and 2,875 boe/d. ■

Challenges in Exploration, Drilling and Completions

Technologies expand options in difficult Rocky Mountain basins.

By MJ Selle
Contributing Editor

Stretching from the Canadian border to northern New Mexico, unconventional shale plays in the Rocky Mountains encompass a myriad number of challenges that vary from basin to basin and sometimes even within a formation.

Understanding a reservoir's complex structure is the biggest challenge facing operators and a key step to unlocking unconventional resources in the most efficient manner according to all the leading service companies.

"A common theme through all the tight, unconventional resource development is that there is a lack of understanding of the reservoir," said Gary S. Malasky, principal reservoir adviser with the Well Solutions team at Baker Hughes. "For various reasons, we are doing a poor job as an industry of characterizing these reservoirs. This lack of characterization becomes magnified in horizontal wellbores where complex heterogeneity along 5,000-ft to 10,000-ft laterals influences drilling, completion, stimulation and production strategies. Poor primary production and recoveries across many of the unconventional resource plays are evidence that we can do a better job of characterizing the laterals."

However, with technology leading the way, additional subsurface information can be gained and efficiencies for drilling, completion and production gained.

"You have to have a lot of empirical information and spend millions to drill wells," said Veronica Gonzales, Well Services stimulation domain manager for Schlumberger. "We're trying to move that toward a more scientific approach. We're continu-

ously telling our clients, 'Please collect data, please collect science,' so we can understand what your drivers are."

The Rockies region is not unknown to the industry. Vertical drilling has taken place in the Niobrara Formation for almost 100 years; however, the unconventional development now occurring is relatively new. According to Weatherford, most basins in the Rockies are averaging four to six wells per pad. Laterals are being drilled out as far as 2 miles in length, which is showing significant production gains and reducing the environmental footprint, especially in the Williston, Niobrara and Uinta basins.

As with most formations in the Rockies, the fracturing techniques used depend upon the reservoir's needs. Both sliding sleeve and plug-and-perf (PNP) techniques bring significant advantages to customers depending on well construction, production target and overall economic benefit.

"Each formation has different drivers," Gonzales said. "In some areas, sliding-sleeve technology is better while in others plug and perf is effective. We've seen movement both ways, even within one basin. If you move 10 to 20 miles across a basin, it's something different so it's a combination of both across the Rockies."

Another challenge the Rockies pose for operators is the number of stacked plays in existence. "The multiple horizons in the Powder River Basin are a perfect example of where different formations and pay zones meet. To connect multiple pay zones at the same time, crosslinked gels have provided that con-



Halliburton operates in many Rocky Mountain areas, including Grand Junction, Colo. (Source: Halliburton)

nectivity so we can drain multiple horizons at once,” Gonzales said.

According to Weatherford, these gels are widespread across the entire Rockies for their better long-term production and fracture placement efficiency despite the low cost of slickwater fluids. As a result, the Williston Basin is an area completely transitioning to crosslinked gel systems to minimize required surface horsepower and provide a system with high apparent viscosity that can carry necessary volumes of proppant.

Environmental concerns also require significant attention from operators in the Rocky Mountains. Bi-fuel systems and recycled water are two ways the service companies are meeting operators’ environmental goals.

Kumar Ramurthy, technology manager of Halliburton’s Rockies tech team said, “The oil and gas industry has been in the Rockies for decades, but because of the attention horizontal drilling has brought, we are even more conscious about being friendly neighbors as we have been for the last several decades.”

Better efficiencies gained through technology use

Reservoirs in the entire Rocky Mountain region pose uncertainties for operators and require an open mindset for E&P.

Baker Hughes' Malasky believes it's not the heterogeneity of the reservoirs that is the challenge as much as the ability to identify that heterogeneity. "Faulting, fracture densities, geologic and pressure compartmentalization, pinch outs, laminations, low porosities and permeability are often not insurmountable issues if you can identify them and address the challenges," he said. "Complex heterogeneity often can vary across a basin, field or between section locations. Our industry has the expertise and technology to effectively address the heterogeneity issues if we know what they are and where they exist."

Derek Allan, senior manager of integrated accounts with the Well Solutions team at Baker Hughes, added, "There's a mindset the operator has that if you don't make any measurements of your reservoir, then you've decided it's homogenous. You fracture and complete based on that assumption, which is why operators are not seeing the expected reservoir models. The reservoir is varied. We have noted success when we have identified that variation and optimized to match what information we have."

Allan said Baker Hughes' clients are asking the service company to provide an extra return on the investment they're making in that well, field or pad. "They're expecting and anticipating that we will be able to lift that initial production and expand the decline curve out," he said. "We bring our efficiency and expertise and 'tune in' to each individual operator's reservoir, treating each case differently. We make decisions based on the information we receive to improve the recovery and then evaluate again to see if those recommendations actually made the changes we expected. Our technologies give us a better understanding of the reservoir to make recommendations."

With a large number of stacked formations in the Rocky Mountain basins, trying to connect those formations can prove challenging. "In the Denver-Julesburg [DJ] basin, you have the Niobrara Bench A, B and C and the Codell," said Russell Hadsall,

business development manager for Baker Hughes' Reservoir Development Services. "Operators are trying to decide if they can connect these different formations with multiple laterals or if a single lateral can be drilled in one and stimulated up into the other zone."

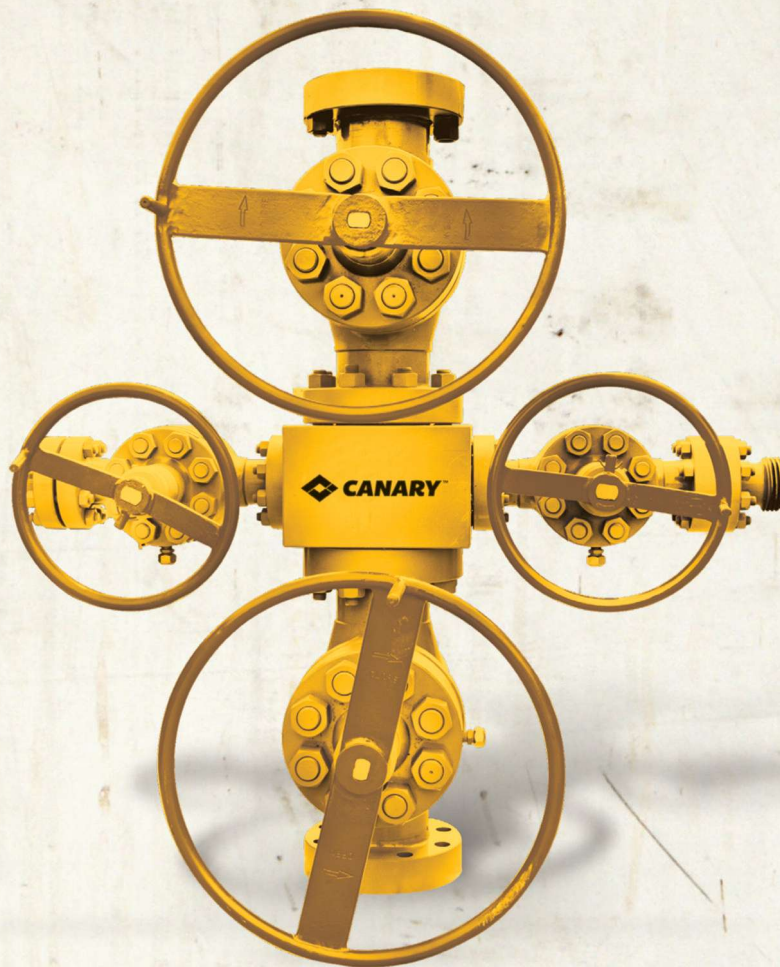
Other areas, such as the Williston Basin, contain the Three Forks structure while the Powder River Basin has the Shannon, Sussex, Mowry and Teapot structures in which Baker Hughes' clients are seeking assistance to optimize drilling and completion programs to connect these zones.

"Another challenge facing operators is whether proppant can be placed across those zones and, if it carries, will the connectivity between those zones be maintained?" Hadsall said. "Every area is unique, and the rock textures between formations have to be understood. If there is limestone between formations, it's not hard to maintain that fracture connectivity. But if it's a very ductal formation, such as marl, then the proppant will embed, and it will be difficult to keep that fracture open. Each one is a unique situation."



Developed as part of the Baker Hughes-CGG Shale Science Alliance, CGG's RoqSCAN provides mineralogical analysis along the length of the lateral. (Source: CGG)

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One technology relaying pertinent information comes as part of the Baker Hughes Shale Science Alliance with CGG—the CGG RoqSCAN technology. RoqSCAN analyzes samples while drilling but is not invasive to the drilling process. The technology provides mineralogical analysis along the length of the lateral. “It gives us information about the mineralogy of the formation to help us identify if we’re in or out of the zone and help steer the drilling,” Hadsall said. “It also tells us if we’re in brittle or ductile rock and allows us to modify the completion and stimulation design accordingly.

“If we can understand how the rock changes along the lateral, we can better place the stages across similar or homogeneous rock,” he continued. “Characterizing the lateral will help us stimulate rock with similar initiation pressures and helps us optimize the design and the stimulation treatments for each of those stages.”

Other technologies to help characterize the lateral include the company’s MWD service and StarTrak LWD technology, along with deep shear wave imaging.

Another benefit of RoqSCAN includes optimizing fracturing parameters, such as fluid rheology, proppant, size and spacing, and hydraulic horsepower requirements, to help improve costs.

The OptiPort Multistage Fracturing System is a Baker Hughes technology that is new to the Rocky Mountain area. Successfully used in more than 900 wells in Canada and North Dakota where adjacent water is present, the system can target very select areas.

“We estimate that 40% of all laterals are not producing,” said Dave Smith, area technical manager, Pressure Pumping, Applications Engineering for Baker Hughes. “While the majority of wells drilled and completed are optimized for efficiency either

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The advertisement for Tank Connection Affiliate Group features a central world map with the company name 'TANK CONNECTION' in large, bold, blue letters across it. Below the map, the words 'AFFILIATE GROUP' are written in a smaller font. Surrounding the map are six photographs of various industrial storage tanks and facilities, including large cylindrical tanks, silos, and complex piping systems. The images are arranged in a grid-like fashion, with three on the top and three on the bottom. The overall design is professional and emphasizes the company's global presence and diverse range of storage solutions.

through sliding sleeves or plug and perf, the effectiveness in those systems to target and control stimulations hasn't been effective. As a single-entry system, OptiPort uses very low rates to pinpoint fracturing and stay out of an interval in the case of water."

Smith added that the system also can be used more aggressively. "Because the OptiPort collars are hydraulically opened using a specially designed coiled tubing bottomhole assembly [BHA], operators can react to issues regarding screenout quickly and independently. With a full diameter wellbore, you also don't have to go back in and drill out, which saves time between stages as well as time and cost in lieu of running plugs or sleeves."

Hadsall said the system also has a smaller footprint on the surface. "Because it only stimulates one zone at a time, it requires less horsepower," he said.

All of the company's representatives indicated that changes are coming into the Rockies and other U.S. basins. "For the last three to five years, there's been a big land rush in the unconventional plays to gather acreage," Malasky said. "We are now seeing a move to monetize those acreage positions. Operators often are under pressure to drill quickly because of lease expirations, accelerated returns on their acreage investments and to gain a competitive edge as an early mover in a play. Understanding the reservoir often takes a back seat to the logistical emphasis placed on trial-and-error drilling and completion activities. This approach often results in low resource recovery and marginal economics. Baker Hughes is committed to taking a life-cycle approach toward a given resource asset integrating research and technical skill sets to develop strategies for ultimate primary, secondary and enhanced recovery considerations."

Subsurface characterization key to understanding reservoirs

Even though some basins in the Rockies have been drilled for many years, the challenge remains to economically drill and complete a well. With a wide variety of structures, pore pressures and environmental issues, operators need to know how these and other factors will impact their assets.

"In the early days of the Bakken Shale development, operators were drilling laterals to hold their



The Baker Hughes OptiPort system is a single-entry system that eliminates the need for sliding sleeve or PNP technology.

(Source: Baker Hughes)

lease acreage," said Kumar Ramurthy, technology manager of Halliburton's Rockies tech team. "Those days are gone now, with the current focus on improving production/maximizing estimated ultimate recovery and well economics."

Similarly, Ramurthy said the Niobrara Formation in the DJ Basin has been drilled for a long time with probably thousands of legacy vertical wells in existence. "When the Niobrara took off with horizontal wells, there was a lot of interest, and so operators went into Wyoming and other parts of Colorado to start looking at it. Everyone thought it was the same play, and so if they didn't already have legacy acreage, they started acquiring acreage in Wyoming. We soon found out that the reservoir there is not the same as in Colorado let alone in the core area of the DJ Basin. It has different maturity levels. The majority of the Niobrara wells drilled in Wyoming did not turn out to be economic, and the enthusiasm died down pretty soon."

Ramurthy said the Colorado part of the Niobrara is very complex. "The reservoirs are different from a structural perspective. When drilling the horizontal wells, one can suddenly get out of the target zone due to these structures."

For the Gallup/Mancos Formation of the San Juan Basin, which has seen recent activity, the reservoir pore pressure is quite low. "Reservoir pore pressure in New Mexico for the Gallup/Mancos Formation is very low and presents problems with regard to stimulations, stimulation fluids and, ulti-



Halliburton operates a fracturing spread in Brighton, Colo. (Source: Halliburton)

mately, hydrocarbon recovery,” said Pat Kundert, Halliburton’s senior technical adviser.

All of these varying geologic formations bring a number of important decisions that have to be considered by operators.

“Pumping a larger job may give you needed results, but in the end understanding the subsurface reservoir and optimizing the completions accordingly to lower the finding cost are critical,” Ramurthy said. “Focusing more on lowering the finding costs is completely different from getting cheaper services. Spend the money on technology that will bring a much higher return on the field and will still lower the finding cost.”

Subsurface characterization has become a key factor in helping operators to lower their costs. “Subsurface understanding is still evolving but with the use of Halliburton’s structural earth modules, an operator can visualize things ahead of time and be proactive, rather than reactive. Operators need to look at the reservoir from a 3-D perspective and know what to expect ahead of time,” Ramurthy said. “Halliburton’s CYPHER Seismic-to-Stimulation Service is designed to improve shale and tight reservoir economics.”

The CYPHER service is an asset-level workflow that begins with exploration through to mature field harvesting. The workflow can be implemented at any time during the life cycle of a field since it relies on key modules for field development, from basin modeling through production analysis and field optimization.

Working with a local Halliburton technical team and its specific basin knowledge, operators have access to basin and geologic modeling, geochemistry and core testing to capture rock composition, type and maturity, effective porosity, fluid compatibility and mechanical properties.

By incorporating the geomechanics and pore pressure information in addition to other reservoir information, the CYPHER service maximizes drilling efficiency by determining the optimum well path and drilling fluid density.

Other technologies by the company also are adding value to the completion portion of the asset-development process.

The PermStim fluid fracturing system is a nonguar-based fluid system. “When the price of guar went up a few years ago, everyone was looking for alternatives,” Ramurthy said. “We looked at the development of this fluid system not only as an alternate to guar, but also from the point of view of finding a fluid system that is cleaner and leaves lower residue in the formation. For some operators, it’s become their main and preferred fluid system, not just because it’s an alternate to guar, but because they are seeing improvements in production that could be attributed to the cleaner fluid.”

To better understand downhole conditions, reduce uncertainty and make quicker operational decisions, the company deploys microseismic and fiber-optic monitoring. “The FracHeight Downhole Micro-deformation Instrument is a hybrid tool



array that is a combination of microseismic and tiltmeter sensors,” Ramurthy said. “It will clearly give us an indication of the height of the fracture and show the rest of the world that hydraulic fracturing is safe.”

Improving environmental performance is the goal of Halliburton’s Frac of the Future equipment and Water Management Solutions (i.e., H₂O Forward).

In addition to minimizing the environmental footprint, the Frac of the Future equipment is designed to minimize the hydraulic horsepower at the wellsite, thereby reducing emissions, Ramurthy said. Adapted from the Barnett Shale and in use in the Eagle Ford and Permian basins, the fracking equipment uses dual-fuel technology, including natural gas from the field.

Through the company’s water management solutions, flowback and produced water can be treated to reuse it in service operations and contribute to water conservation. Components include the CleanStream Ultraviolet Light Bacteria Control Process, the CleanWave Frac Flowback and Produced Water Treatment, the H₂O Forward Service and the UniSti Hydraulic Fracturing Fluid System. “By using recycled water, we not only minimize water use but also limit the number of road trips water trucks have to take,” Ramurthy said.

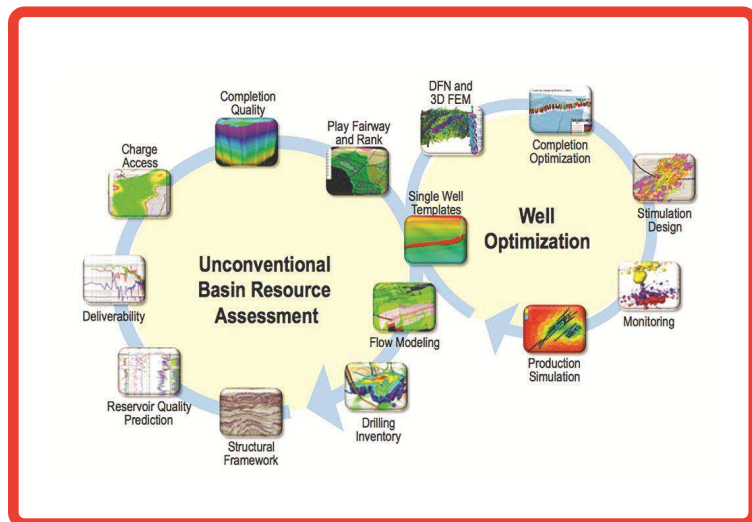
“Halliburton has been using recycled water in hydraulic fracturing for quite a few years,” Kundert added. “It was fairly simple chemistry when we were doing it in western Colorado in the Piceance Basin

because of the type of fracturing fluids being pumped and the quality of the water. In North Dakota’s Williston Basin, we’re challenged with very high TDS [total dissolved solids] water, so we’ve formulated fluid chemistries specifically for recycling produced and flowback water in those environments. It’s a challenge to get a system that performs properly with that type of base water chemistry, and we have done that.”

Integration of services brings needed information on formations

The Rocky Mountains region doesn’t provide many easy answers. With thousands of legacy vertical wells in the mature Niobrara Formation yet unconventional development just beginning in the San Juan Basin, there is a greater need than ever for operators to understand their resources’ production drivers.

Schlumberger has instituted an Unconventional ROC (UROC) workflow designed specifically for unconventional basins. “We are working together to help our customers make decisions ahead of drilling,” said John Cadenhead, strategy manager at Global Unconventional Resource Group. “Drilling operations get going so fast, and the drill gets ahead, so that it becomes a ‘drilling monster’ and you’re chasing the rig.” With the UROC integrated workflow, Schlumberger is putting information in customers’ hands to help them make informed decisions and to be clear on options such as where the well needs to be, where to land the horizontal, where to steer it and how to stay in the zone.



Schlumberger's UROC workflow integrates information across a multitude of disciplines. (Source: Schlumberger)

"This is a step change in the way we develop unconventional resources," Cadenhead said. "Originally it was 'drill, drill, drill,' but now this workflow helps operators make a decision to drill in the optimal place for those wells to be productive."

Cadenhead said that, in most places, only about 60% of the stimulated area produces. "We're working to get that to 100%. While we have cut drilling times down to just 15 to 20 days compared to 30 to 40 days in the past, there are still improvements that can be made. We're trying to understand how the reservoirs drain and produce, and what's the best spacing an operator should use to help efficiency and help make decisions ahead of production to deliver continuous improvements on wells and field recovery."

Schlumberger's Veronica Gonzales explained that the company sees significant reservoir heterogeneity and variability within the Rocky Mountain regional basins. "That poses uncertainty for operators to understand their drivers and changes from one area to the next and in other plays," she said. "We're spread over every Rockies basin—the Bakken, Niobrara and Powder River. We're present in the Uinta and moving to study the San Juan. Each basin is in a different phase of activity level. We evolve our workflow to adapt to what every basin needs. You can't take one workflow and make it work across the entire U.S."

With the UROC workflow, the company integrates multiple domains—geomechanics, petro-

physics, reservoir engineering and hydraulic fracturing characterization—to answer specific needs. "Schlumberger's strength is integration—being able to pull everything together and show the value to an operator by giving them answers on multiple fronts," Gonzales said.

Spearheading this workflow is the company's Technical Integration Group—engineers who have integrated their experience across different disciplines in every domain. "We tend to get segregated into drilling, completions and reservoirs in our industry, and our solution is to pull everything together," Gonzales said. "This helps answer the big questions regarding how to effectively place hydraulic fractures, how to drill in certain areas and how to drain reservoirs effectively."

Each basin has its own unique challenges. "In the Williston Basin, the Middle Bakken is not very difficult drilling, and the formation is large enough that it is fairly straightforward technically to keep the wellbore path in zone," said Mike Brunstein, Schlumberger's vice president of the Rockies region. "Laterals are 10,000 ft to 15,000 ft in length, and we're using a gamma-ray measurement to directionally steer the drillbit." He said that pad drilling has really taken off in the last 18 months, because all the HBP drilling is completed, and 80% of all drilling is now done on multiwell pads.

However, the DJ Basin is another story. "They've been drilling verticals for years and years, but the horizontal plays are about three years old," Brunstein said. "They're only now coming in and putting pads together with two to four wells on location for operational efficiency."

And the Powder River Basin brings even more challenges. "The Powder River Basin is a difficult area with some surface constraints," Brunstein said. "The horizontal development isn't quite mature enough for the deployment of pad drilling, although we do see this as a possibility in the future."

As each area matures, Gonzales pointed out that the lateral length is increasing. "We continue to deploy technology leading to increased efficiency from 4,000-ft laterals to 10,000 ft or more," she said. "The question now hinges on optimum spacing and timing of laterals. We can begin to answer this

because of integrated solutions depending on which basin you're in—the Williston is most evolved with the Niobrara just now taking off. The Powder River is challenging, because it has a multitude of horizons to pursue and you have to study each horizon.”

Schlumberger has seen significant success in the Niobrara Formation using technology adapted from other shale plays.

“From a pumping point of view, the HiWAY flow-channel fracturing technique is more prevalent in the Eagle Ford Shale, but we've had significant success with it in the Niobrara and several other basins in the Rockies,” Brunstein said.

This technique decouples fracture productivity from proppant permeability and creates flow channels, using the company's proprietary technology. Instead of flowing through the proppant in the pack, hydrocarbons flow through channels, increasing conductivity. Since this conductivity extends to the tip of the fracture, it allows a longer effective fracture half-length, higher effective contact area, better fluid and polymer recovery and less fracture face damage, thereby optimizing production and hydrocarbon recovery.

“This technique helps promote placement and provides efficiency as we move to longer laterals and at a faster pace,” Brunstein said.

“With the HiWAY technique, we have improved our logistics by finding new and more efficient ways to deliver reduced quantities of fluids and proppants,” Gonzales said. “We have at the same time, significantly reduced our operational footprint.”

Another technology that is just being released into the Rockies is Schlumberger's BroadBand Sequence fracturing technique. “We're using this technique to stimulate wells and increase the number of producing stages per well,” Brunstein said.

This technology uses a composite fluid comprised of a proprietary blend of degradable fibers and multimodal particles. The fracturing technique temporarily isolates perforations on demand, using only a small volume of material and has the ability to reduce the number of bridge plugs used per completion. It also can be used as an alternative to bridge plugs in situations where a bridge plug cannot be used.

Case studies in the Eagle Ford Shale have shown a 46% reduction in completion time for PNP operations as well as a 21% increase in productivity.

“Schlumberger's aim is to capture and integrate all the data available, apply the right technology innovation, and improve operating efficiency to lower our customers' cost per barrel and increase overall production,” Gonzales said.

Using the right technology helps control costs

In any unconventional shale basin, reducing exploration and development costs is a primary goal for operators and service companies alike.

“The optimal development of shale resources is dependent upon our understanding of how a completion [nurture] interacts with the reservoir [nature]. For these types of reservoirs, the well's productivity is not only a function of geology but also completions. Hence collecting, integrating and analyzing appropriate data are key to providing specific insights into improving production and capital efficiency,” said Linda Smith, business unit sales manager for petroleum consulting at Weatherford.

Seeking this capital efficiency impacts all phases of an operator's development plan. One way Weatherford's clients have sought to control costs is by requesting medium bit-to-bend (MBTB) motors on their wells to drill the vertical and curve portions of the well in one run and cut the cost of a trip after the vertical.

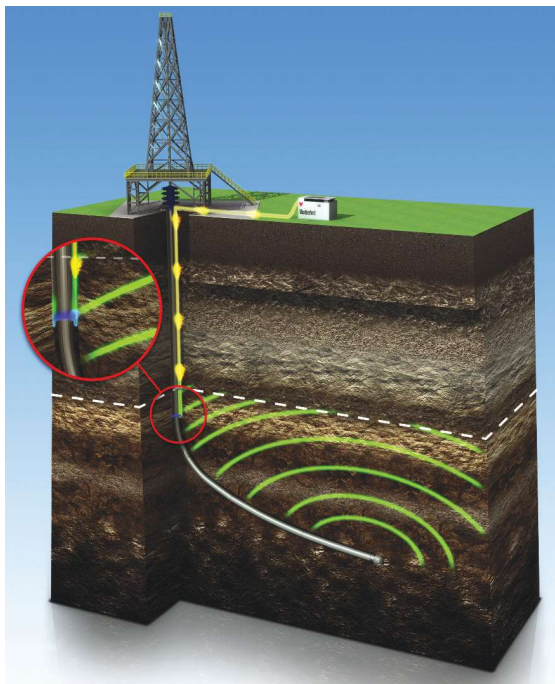
“Typically after drilling the vertical portion of the well with a low-degree motor, you would then have to trip out to surface and change the degree of the motor to a higher bend setting depending on the build rates needed through the curve portion of the well,” said Ryan Schaefer, a Rockies area drilling services technical representative.

“With the long bit-to-bend motor set at higher-degree angles, the motors are more susceptible to damage when rotated at higher rpms, yet the lower degree motor used in the vertical will not produce large enough build rates to drill the curve,” he added. “However, we have been supplying medium bit-to-bend motors that are being utilized at ~2 degrees throughout the entire vertical and curve, which allow us to rotate at higher rpms in the vertical as well as utilize the higher bend angle to acquire the build rates needed to complete the curve. The difference in length from the bit-to-the-bend setting of the LBTB

[long bit-to-bend] and MBTB has allowed us to drill the one-run vertical and curve while reducing damages to the downhole equipment.”

Another operator was having issues with lost circulation in the lateral portion of its Powder River Basin well. “They were spending a large amount of well cost on their mud program that was unfortunately being pumped into the formation,” Schaefer said. “Because of the depths and formation’s resistivity in the area, the common tool being used is the Positive Pulse MWD (PP MWD) tool. However, with the amount of lost circulation, the company had to pump a large amount of loss-circulation material (LCM) downhole to plug the formation and regulate its losses. Because the PP MWD tool operates based off of pressure drops across an orifice, the high amounts of LCM were plugging up that small orifice. This kept the tool from pulsing the necessary directional data up to surface, which resulted in additional trips to replace the tool.”

Weatherford was able to propose its EM CasingLink System, which allows use of its electromagnetic (EM) MWD system by running a “downhole antenna” along the backside of the casing string.



Weatherford’s EM CasingLink was used successfully in the Powder River Basin. (Source: Weatherford)

“Since the EM system works off of electromagnetic signals instead of pressure pulses, there are no mechanically moving parts downhole,” Schaefer said. “This meant that the operator could pump large amounts of LCM downhole without affecting the MWD system. They could manage their losses downhole and continue drilling their lateral, saving the operator a large amount of money spent on the mud system and unplanned trips for plugged pulse tools.”

While many in the industry have debated the efficiency and effectiveness of sliding sleeve vs. PNP technology, Weatherford believes both methods can offer significant advantages to customers.

“Efficiency-wise, we are seeing the sleeve technology currently the most popular as we are able to stimulate more stages per day than with plug-and-perf-operations,” said Mike Gray, Rockies area sales manager for completions. “The reduction of days on location is very significant in some areas. Added to that, depending on the customer’s reservoir response these completions may not require intervention such as drilling out ball and seat.”

However, Gray said that as operators are extending their laterals farther, PNP operations are becoming popular once again. He believes this is driven by two factors:

- Extended-reach laterals are subject to limited packer/sleeve stages due to increasing friction pressure related to inside diameter (ID) restriction caused by systematically reducing ball-and-seat ID reduction. Most systems can support a maximum of 40 stages.
- Some operators are now suggesting that their production values are far greater with PNP or sleeve-cemented systems. “We think that this is due to a reduction of the near wellbore hydraulic pressure that can create fracture breakout around the packers and create communication between stages that reduces fracture conductivity,” Gray said. “In addition, operators can better isolate undesirable water production with a cemented wellbore than with openhole completions.”

Proprietary technologies employed by Weatherford in the Rocky Mountain region include:

- Asset Capturing System (ACS) that allows for the production and capture of produced

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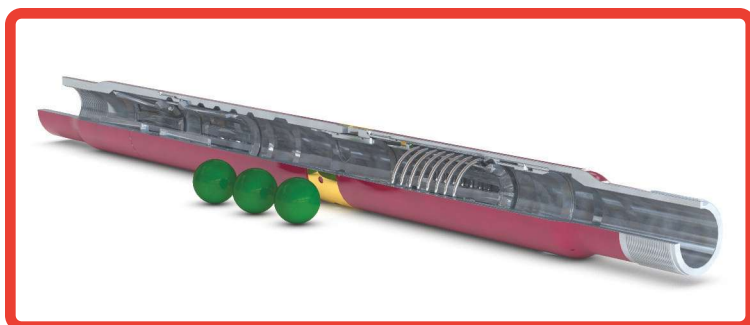


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gas, eliminating flaring and venting during field operations. The system also uses natural gas from the operator's pipeline/infrastructure to assist in well servicing operations such as wellbore cleanouts, dewatering and flowback.

During operations in the San Juan Basin in New Mexico, the ACS service was deployed in a Mesa Verde/Dakota well. In 12 days of operation, the economics of cleanout operations were improved by selling 27 MMcf and buying only 108 Mcf of gas where it was once lost by flaring off, leaving a cleaner wellbore for production.

"The reduction of emissions and gas flare-off garnered the support of government agencies such as the U.S. Bureau of Land Management and the New Mexico Oil and Gas Commission," said Larry Harvey, Rockies area operations manager for the Secure Drilling Systems. "Additionally, the use of gas in place of oxygen for the operation greatly reduced the risk of downhole fires, but most importantly it allows the operators to recover and sell wellbore gas that would have been otherwise vented or flared."



The Weatherford IBall Completions system allows full access to the ID of the liner system. (Source: Weatherford)

Additional Weatherford technologies used in the Rockies include:

- IBall Completions System, which includes cementing IBall Sleeves in cased liners and allows full access to ID of liner system has proven to increase access to production and reduce time required per stimulated stage.
- SpectralWave Azimuthal Gamma Ray (SAGR) allows clients to evaluate structural dip of their reservoir and enables geosteering

in real time. The client can correlate the depth of the images retrieved from the SAGR with all other logs run in their wells. This service also can be provided through the company's petroleum consulting team.

"In the DJ and Powder River Basin, we have made several lateral runs using the SAGR tool in order to geosteer and improve in-zone efficiencies," Smith said. "The Spectral tool produces the highest quality image when it comes to azimuthal gamma-ray tools. This real-time image allows the geologists and geosteers to make a more confident decision on where they need to be in zone, because the tool allows you to see the angle at which the wellbore is being drilled in relation to the dip of the formation. The tool is particularly helpful in the Niobrara because of the amount of faulting that occurs in the basin."

- EM CasingLink eliminates geological limitations (resistivity challenges) to enable two-way communication between the surface and the directional BHA.
- Compact Micro Imager is an oil-based system that provides an image tool that can be conveyed on drillpipe in an oil-based environment. Until now only a water-based system has been available.
- DF RamForce 2500 pumping trucks equipped with dual fuel, CAT engine, transmission and fuel conversion modifications allow operations to use natural gas as a "clean fuel" and economic alternative to traditional diesel operations.

"Artificial lift practices in the unconventional market also are evolving," said Nick Greene, Rockies area sales coordinator for Production Systems. "We're discussing with our customers the implementation of 'phasing' lift with the best technology to contribute to long-term well productivity. For example, in the Niobrara, there is a movement toward implementing gas lift for high liquid volume production and reservoir drawdown. This system is followed up (depending on drawdown time and efficiency) with pumping units. Often times, the gas lift phase has made it possible for our clients to downsize the pumping unit and minimize the operating expenditures of excessive rod pump servicing." ■



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Good Problems to Have: Midstream Rushes to Keep Pace in Niobrara

Rich gas and crude oil pour out as producers move into delineation.

By Gregory DL Morris
Contributing Editor

Call it the “New Niobrara.” When producers first realized that they could apply the seismic, drilling and completion techniques pioneered in original resource plays to legacy reservoir basins, areas like the Niobrara and the Permian saw a flurry of new activity. The Permian proved to be tractable, but the Niobrara was found to be a bit of a puzzle above and below ground. Both its geography and its stratigraphy were highly heterogeneous, and many of the early pioneers in the play went away disappointed. That was partially true in the Powder River Basin (PRB) of Wyoming to the west but especially so in the Denver-Julesburg (DJ) Basin northeast of Denver.

Those that stuck it out often used the term “science project” in their updates on the play. Now the Niobrara is back from the laboratory bench and ready to party. Producers’ tenacity is starting to pay off, and as producers boost their projected liftings, midstream companies are pulling out all the stops to catch up.

Someone shouting “Hey, Mr. DJ, pump up the volume!” usually means there is a party going on, and so it is with DCP Midstream. The company already is calling the tune as the largest midstream operator in the DJ Basin and is indeed pumping up the volume. Greg Smith, president of Permian and

north business units for DCP Midstream, said growth is accelerating.

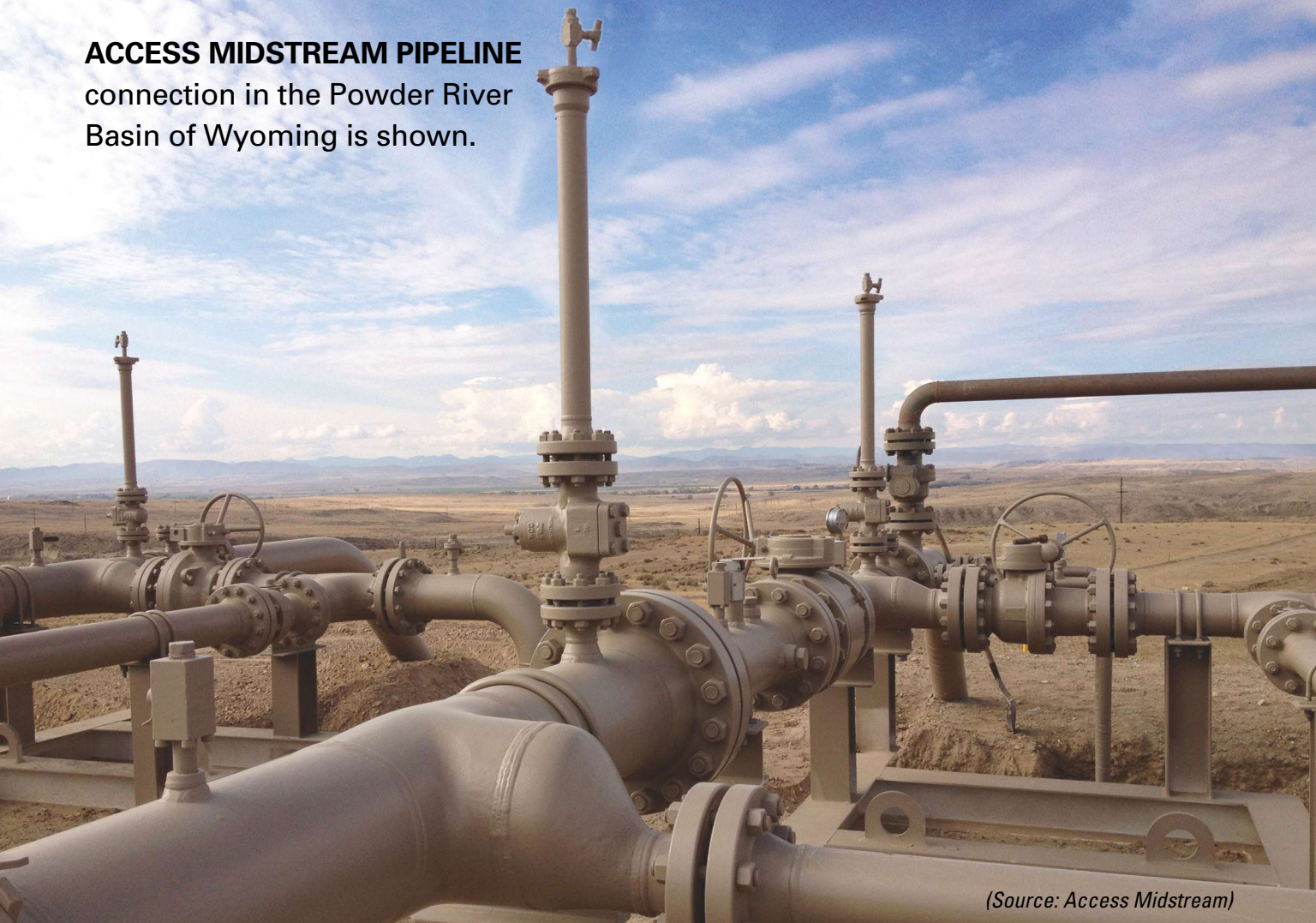
“As soon as we build processing plants, producers are filling them,” he said. “Producers have moved significantly from vertical drilling to horizontal, and we are seeing growth not like anything before.”

The DCP Midstream enterprise will have doubled its processing capacity in the DJ Basin in four years to 800 MMcf/d once the 200 MMcf/d Lucerne 2 plant is operating by mid-2015. It is owned by DCP Midstream Partners and will be the DCP enterprise’s ninth and largest processing plant in the DJ Basin. In the meantime, DCP Midstream Partners’ O’Connor plant has expanded from 110 MMcf/d to 160 MMcf/d five months after it went into service. O’Connor is part of an eight-plant system with current total capacity of about 600 MMcf/d.

The DCP Midstream enterprise also has grown logistics for NGL takeaway from the DJ Basin to higher-value markets, Smith said. “In 2010 we first started talking about more fully integrated processing and transportation options. That is why we purchased the Wattenberg NGL pipeline of the DJ Basin to Conway [Kansas]. We recently put into service additional lines for takeaway from the DJ to Mont Belvieu [Texas].” DCP Midstream Partners holds partial ownership interests in the new Front

ACCESS MIDSTREAM PIPELINE

connection in the Powder River Basin of Wyoming is shown.



(Source: Access Midstream)

Range and Texas Express NGL pipelines, in addition to 100% interest in the Wattenberg area.

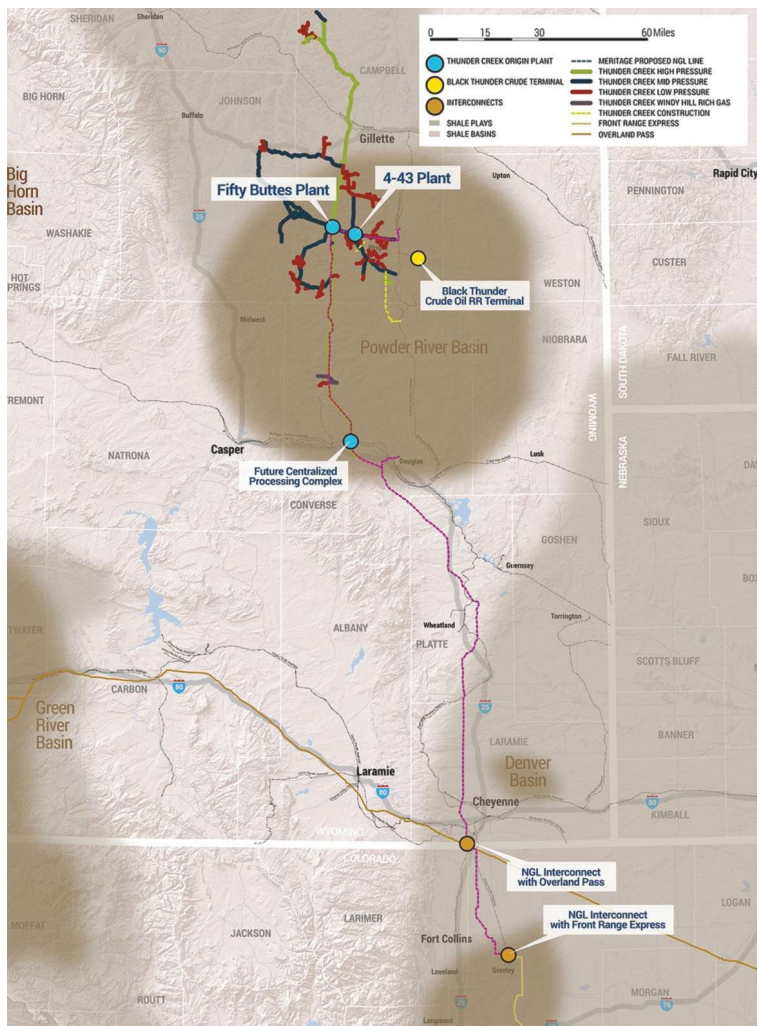
The Niobrara already has gone through several developmental stages, including a consolidation among producers after the initial rush where the basin was found to be more challenging geographically and stratigraphically than other shale plays had been. While it might be valid for other parts of the play, Smith said it does not pertain to the DJ. “Success rates for producers in the DJ Basin, especially in the core, are very high,” he said. “This is not a science project.”

DCP’s sizeable footprint gives it the ability to offer producers what Smith calls a “super system.” “Having those assets gives us more than just capacity. It gives us flexibility to route gas in several dif-

ferent ways to allow for maintenance or outages. That is a key benefit, and it makes us very user friendly,” Smith said.

He also added that as the largest midstream player in the DJ, DCP works with the larger producers, such as Noble Energy, as partners. “Both producers and midstream operators have so much investment in place already and also plans for growth that we really depend on each other,” Smith said.

For all the development that has taken place to this point, as well as what already is planned, Smith said that “we are still very much in the early innings in the DJ Basin, for both E&P and midstream operations. It is a really nice position to be in heavy-growth mode.”



An overview map of Meritage Midstream's system in the PRB.
(Source: Meritage)

Keeping pace in crude

"For us and our key customers, the Niobrara is a great area to work these days. There has really been a lot of success on both the upstream and midstream segments of the market," said Tim O'Sullivan, vice president for corporate planning and strategic initiatives for Rose Rock Midstream, the crude oil MLP of SemGroup. "For a crude oil infrastructure provider, there could not be a better basin to develop than the Niobrara."

The anchor shippers on Rose Rock's White Cliffs Pipeline are Anadarko and Noble Energy, and O'Sullivan said that they are increasing production. Beyond that, newer shippers are looking for transportation as well.

"Our biggest challenge is the big operators," he said. "These are good problems to have, but it is imperative that we keep pace with what our anchor shippers need from us even as we do more business with the new producers."

Those include Whiting, Encana, Bill Barrett, Bonanza Creek, Kaiser-Francis and Carrizo, among others. "Just look at the guidance that Anadarko and Noble have made public, as well as some of the newer players. In the greater Wattenberg area, they are using longer laterals and downspacing basin-wide. It's really quite remarkable. Production is seeing compound annual growth rates of 20%, and producers are seeing internal rates of return on wells in excess of 100%," O'Sullivan said.

He is serious when he said the challenge for Rose Rock is to keep pace, but O'Sullivan is not just blowing sunshine at the producers. "The production targets move so fast that it really is difficult to keep track. It seems each time we complete a truck rack, new tanks or a pipeline, we wake up the next morning and the producers need something more," he said.

Pausing a moment, O'Sullivan rephrases the problem of both producers and midstream operators together working on the challenges of a basin that has proven to be highly prolific if not yet completely understood. "The variability in the Niobrara is primarily an upstream problem, but with each quarter it seems that the operators look like they are going to be able to figure it out," he said.

The original White Cliffs Pipeline was built in 2009 from Platteville, Colo., to Cushing, Okla.—527 miles of 12-in. pipe, with 10 truck unloading stations at the origin. Another six truck spots were added in 2012, and in 2013, the line was extended 37 miles with the Wattenberg Oil Trunkline. Rose Rock isn't involved in crude by rail but has connected its line with a 12-mile lateral to the Plains All-American unit-train loading facility at Tampa, Colo.

More tanks also have been added in Platteville, Colo., and by year-end 2014 there will be another 38 miles of extension to the Wattenberg Oil Trunkline. "The biggest development," O'Sullivan said, "is the looping of the entire length of the White Cliffs Pipeline. That will take our capacity to 150,000 bbl/d and will be operational by the middle of the year."

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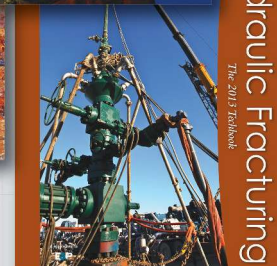
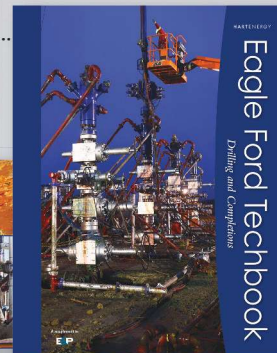
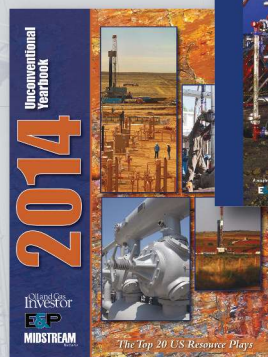
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Thunder on the PRB

The Niobrara play in general and the coalbed methane (CBM) zones of the PRB in particular are an important growth area for Meritage Midstream and other competitors, because the multistack pay formations that are both appealing and challenging for producers mean that there is that much more demand for specialized gathering, treating, processing and transportation services.

In more uniform, homogeneous plays producers sometimes reason that they can build out infrastructure themselves or otherwise push a little out from the wellhead into the midstream, but in the Niobrara, producers need to have midstream partners onboard early. Still, both producers and midstream companies acknowledge that the lack of processing capacity remains the key bottleneck in both the PRB and the DJ Basin.

Meritage set the table for its Niobrara growth in August 2013 when it completed the acquisition of Thunder Creek Gas Services in the PRB from Devon Energy and PVR Partners. “We saw Thunder Creek as an opportunity to repurpose underused assets, and we have been executing on that plan since completing the transaction,” said Steven B. Huckaby, chairman and CEO of Meritage Midstream, based in Denver, Colo.

The acquisition included the Buckshot treating plant in Converse County, Wyo., which has a capacity of 450 MMcf/d. “CBM requires a great deal of compression,” Huckaby said. “We also received a large fleet of CBM stations that we are converting to rich gas compression.” By year-end 2013, Meritage had expanded the Thunder Creek gathering system by about 20% by adding 100 miles of rich-gas trunkline and associated gathering lines to the existing 500 miles of trunk, connecting four major development areas to processing services. “We are going to add another 100 miles of rich-gas trunk plus associated gathering through 2014,” Huckaby said.

“West of Wright, Wyo., we expanded the 4-43 Processing Plant from 14 MMcf/d day by 10 million to a total of 24 MMcf/d. We are also in the process of building another plant in Campbell County [Wyoming] that will process 70 MMcf/d just 6 miles to the west of the initial, smaller plant. We expect to bring the Fifty Buttes Processing Plant online in August 2014.”

Historically, CBM has been the focus of the PRB. In today’s environment, Huckaby likes the outlook for crude and NGL. “We look at the PRB as the younger brother of the Bakken. In terms of development, the PRB today is like the Bakken in 2007. Producers are exploring and getting to know the lay of the land. In terms of infrastructure, especially for crude, the PRB today is like the Bakken in 2010. There is a lot of rail transportation in place and a lot more being built,” Huckaby said.

That said, both industry operators and other stakeholders are not just repeating every part of the development cycle. “Citizens in the Gillette and Douglas regions have looked at what took place in Williston, N.D., and are asking good questions as their areas are developed. They are balancing the burdens and the benefits and being sure that the gains can be made for everyone without diminishing the quality of life for people living there.”

Bucking straight out of the chute

The PRB is one of four key plays for Crestwood Midstream, along with the Bakken, Permian Delaware Basin and Marcellus. The PRB is a rich-gas and crude operation for Crestwood, but despite the success the company and its upstream partners have had, the basin remains very much in the shadow of the better-known plays to the north, east and south.

“The PRB shale play is still in an early stage of development from a resource standpoint and certainly isn’t getting as much attention as the Marcellus, Eagle Ford or Bakken,” said Heath Deneke, president of the natural gas business division at Crestwood. “But if you look at producers’ returns—internal rates of return and netbacks—the PRB is probably only second to the Marcellus.”

Crestwood is active in Converse County, Wyo., in the heart of the PRB. Crestwood and its joint venture (JV) partner Access Midstream have about 310,000 acres under dedication from such producers as Chesapeake and RKI Exploration. Crestwood and Access have installed 150 miles of pipe and expect to have the 120 MMcf/d Bucking Horse processing plant near Douglas, Wyo., completed by year-end 2014. In the JV, Crestwood handles commercial development, and Access is responsible for operations.

Crestwood also owns a 50% interest in the Douglas Terminal crude-by-rail facility. Currently, its capacity is 6,000 bbl/d moving toward 20,000 bbl/d once the unit-train loading rack is completed in second-quarter 2014. Year-end capacity is projected to be 60,000 bbl/d. Crestwood also is moving about 3,000 bbl/d of crude via trucks in the basin.

“We do have a lot of oil and gas production waiting on gas processing in the PRB,” Deneke said. “Currently there is only 60 million cf/d of processing available to producers in our particular area of dedication, but those constraints will be resolved once our Bucking Horse plant is placed in service later this year. It is not unusual for there to be a bit of a lag in midstream infrastructure as a basin moves out of the delineation phase and into the commercial phase of development.”

Deneke continued, “We have a very mature and well-defined process for working with our producers. It is very cooperative, but there is always some difference between producers’ drilling plans and their readiness to make long-term commitments to certain infrastructure. However, by the end of the year, we should be effectively caught up.”

Putting PRB development onto a timeline, Deneke summarizes that 2013 was largely a delineation/planning year, 2014 will be an execution year, and by the beginning of 2015, Midstream infrastructure will have caught up with the producers.

Given the recent declines in conventional and CBM gas production in the Rockies, Deneke said that there is ample gas pipeline takeaway capacity to move PRB gas to markets. Also, with recent build out of NGL pipelines spurred by the DJ Basin to the south and Bakken to the north, there are now three nearby NGL pipeline outlets that are well positioned to provide cost effective access to move NGL to Mont Belvieu, Texas, and Conway, Kan.,

markets. “With much of the large-scale gas and NGL pipeline infrastructure in place, we believe the PRB is ripe for rapid production growth in the coming years,” Deneke said.

To date, crude has largely been dependent on trucking to local markets because until recently there was not sufficient economy of scale to develop crude gathering and pipelines in the basin. “For the most part, crude has been trucked to local markets in the PRB, but now we are getting it to rail. As crude production continues to grow, there will be more cost-effective opportunities to gather and transport crude providing producers with even better netbacks and access to attractive crude markets,” Deneke said.

As producers begin to shift out of delineation to production, Deneke added that midstream competition is likely to increase. “Once the prolific nature of the PRB becomes better known, we do expect more midstream companies to look at the play, but Crestwood was an early mover, and we like our position. We have contracts and relationships in place with some of the largest and most active producers in the PRB,” Deneke said.

Building positions

One of the fresh new faces in the Niobrara region is Access Midstream, bringing practical operating savvy and solid capitalization. “To start, we are just

DCP MIDSTREAM PARTNERS O'Connor Plant, formerly known as the LaSalle Plant, is a deep-cut cryogenic facility near Kersey, Colo.



(Source: DCP Midstream Patners)

The Upstream View of Niobrara Midstream

The essential challenge and opportunity of the Niobrara is that it is different from all other shale plays. It is even different from itself. “The Powder River Basin [PRB] is very different from the Denver-Julesburg [DJ] Basin,” said Ryan Duman, upstream analyst for Wood Mackenzie. To a large degree, the pace of development has been set by exploration, but Duman said that “producers have been taking a measured approach while they wait for processing to catch up.”

Between the two primary regions of the Niobrara, the DJ Basin is dominant. He added, “The Wattenberg and its extension will account for about 70% of the production from the basin. That is because there was so much vertical drilling in that area in previous decades. There is a great deal of well data in hand.” That said, it has still proven to be a tricky area to produce and has frustrated as many bonanza seekers as it has blessed.

The top producers in the DJ are Anadarko and Noble, but Duman said new entries such as Bonanza Creek, Synergy Resources and Whiting—a major player in the Bakken to the north—are helping to push the boundaries. “Some of them have small positions, but they are very high quality,” Duman said. Among all the DJ players, he said that

downspacing has become very important as is testing new horizons. “The Niobrara B bench has been primary so far, but there is upside to the A bench, C bench and the Codell below.”

The PRB is even more complex. “It is highly variable,” Duman said. “Chesapeake is the primary developer there, and they have had good success, but I don’t know if I can say even they have cracked the code as some seem to have in the DJ.” The riddles in the PRB start with the nomenclature. It’s a coal region named for a river that is part of an oil and gas basin named for a formation that is not even the primary producing horizon in that part of the play. “In the PRB, the Sussex, the Shannon, the Turner and the Frontier are even better than the Niobrara Formation itself,” Duman said.

Therein lies another riddle of the basin: the deeper producers go, the more upside they find—and they are not holding back anymore. “When we talk to producers,” Duman said, “they are certainly aware of the midstream projects coming on in both the DJ and in the PRB. They are cognizant of the processing capabilities and growing access to market. That in turn is likely to accelerate development upstream across the Niobrara.”

in one area in the southeast of Converse County [Wyoming],” said Walter Bennett, senior vice president of western operations. “We began from scratch, having to build all new assets.” Access is a JV partner with Crestwood Energy.

The position from which Access is building is a legacy from its days as Chesapeake’s midstream business. “When our predecessor company first got into the play, there were some geographical challenges with the Niobrara being more isolated from some of the other producing basins in that part of the country,” Bennett said.

For Access, those challenges now give the company a range of opportunities. “In our instance today, there is definitely a need on the part of producers for additional services, especially processing. The gas is sweet, so there is not a major H₂S [hydrogen sulfide] concern, but it is very rich. They cannot just flow it into the transmission system,” he said.

Access has just started building the Bucking Horse processing plant. “We just completed the dirt work in the middle of March, and construction was slated to begin in early April,” Bennett said. The plant is expected in service in fourth-quarter 2014.

“We have no current plans for a second plant at Douglas,” he added, “but it is certainly something we would consider as producers in the area become more successful. Access would be interested in pursuing gas, liquids and crude transport if there is a need from our customers. We are very willing to pursue other services [such as water handling] if producers indicate that is something that they would like to see from us.”

Until Bucking Horse comes into service, gas produced in the gathering area is processed at the Tallgrass plant in Douglas, Wyo., and moved via Kinder Morgan (KM). After Bucking Horse is onstream, gas also will go to market via the KM Wyoming Interstate system. Bucking Horse will not have a connect

to the Phillips 66 line, but volumes could be trucked from Bucking Horse and then injected into that line wherever they have a truck rack receipt point. Bucking Horse will have access to that line as well as ONEOK. It also will have truck loading capability.

Another signal that the Niobrara was no longer a backwater for either producers or midstream operators was a year ago when Kinder Morgan Partners (KMP) completed its acquisition of Copano Energy for \$5 billion. The Copano Rocky Mountain region provides midstream natural gas services in the PRB of Wyoming, including gathering and treating. The region includes KMP's 51% equity ownership interest in Bighorn Gas Gathering, the sole owner of the Bighorn natural gas gathering system, and a 37% equity ownership interest in Fort Union Gas Gathering, the sole owner of the Fort Union natural gas gathering system.

The Rocky Mountain region also includes firm-gathering agreements with Fort Union; firm transportation agreements with Wyoming Interstate Co., a wholly owned subsidiary of El Paso Pipeline Partners; and services provided to producers in the PRB, including producers that deliver natural gas into the Bighorn or Fort Union gathering systems.

Logical logistics

CBM stands for coalbed methane, but in the PRB it also stands for coal-built movement. During the preceding decades, the railroads built some of the smoothest, fastest and best-equipped freight rights-of-way worldwide to move vast volumes of coal. Now that natural gas has overtaken coal as the primary fuel for power generation in the U.S., those tracks built as coal raceways have less business in black rocks and are free for moving instead unit trains of crude oil.

Meritage is making the most of that opportunity. "The Douglas-to-Gillette rail corridor was built for high-speed, unit-train operations," Huckaby said, "but coal shipments are down 30% to 40% from their peak. We were fortunate to already have had a relationship with Arch Coal going back several years and had talked about joint operations."

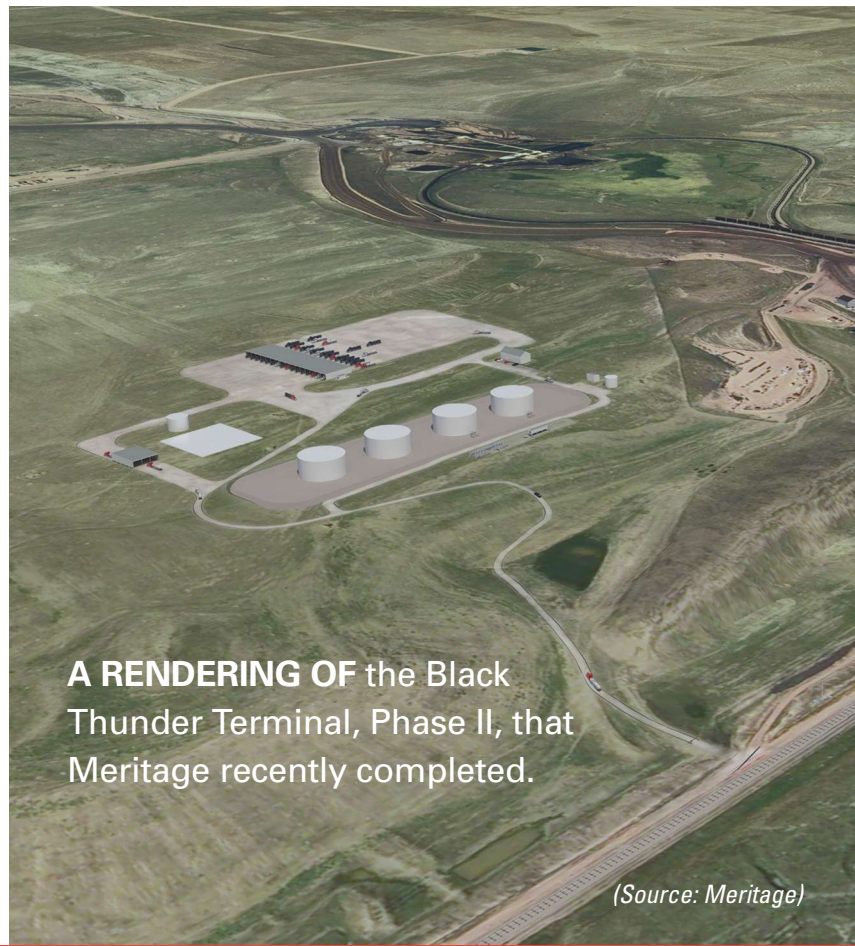
As a result, Meritage and Arch entered into a JV to develop the Black Thunder Terminal at Arch Coal's Black Thunder mine near Wright, Wyo. The

terminal will offer storage, blending and rail loading services for crude oil and condensate. Crude oil transloading from trucks into rail cars began in April, while the unit-train loading rack is being developed. The first unit-train shipment could be made before year-end or in early 2015.

In an effort to provide diversified services to producers, Meritage also is exploring the idea of bringing fracture sand, tubulars and diesel into the PRB. If the company decides to move ahead with the plan, a formal announcement could be made in second-quarter 2014.

"What we are seeing in the PRB is a huge influx of truck traffic hauling sand in from facilities in the DJ Basin," Huckaby said. "It takes about 70 truckloads of sand per well, and that is a lot of truck traffic. It is much better for everyone—drillers, local communities, roads—to localize sand distribution as much as possible.

There is a wide disparity in opinions about rail services, in general, and about ancillaries, like sand



A RENDERING OF the Black Thunder Terminal, Phase II, that Meritage recently completed.

(Source: Meritage)

and steel. Some midstream firms, Meritage included, are very enthusiastic while others are not. “I understand that some believe that sand and other products can be a distraction, a loss of focus,” Huckaby said, “but we think of the Black Thunder Terminal as [a] logistics hub.” He explained that, according to Meritage, it just makes sense to offer as many goods and services as producers need and that handling those out of one facility is efficient and effective for everyone.

One ditch, many lines

For all the multiple options that some midstream firms are making available to producers, the one essential service is simply getting molecules to market. Both processing and transport capacity remain challenges for upstream and midstream players alike in the Niobrara.

“Getting across the front range into Colorado is a major bottleneck for development in the PRB,” Huckaby said, “as is NGL takeaway. Either you have the Phillips 66 line to Borger [Texas] or the announced project by ONEOK from the Bakken or our Thunder Creek NGL Pipeline project that will move product from multiple points of origin either to Conway [Kan.] or Mont Belvieu [Texas].”

With an initial design capacity of 40,000 bbl/d expandable to 80,000 bbl/d, the Thunder Creek NGL Pipeline is expected to come into service in 2015 and has interconnects to the Overland Pass and Front Range Express pipelines. Looking at the geography that is usually considered the Niobrara Basin, Huckaby said that the notoriously variable nature of the Niobrara Formation masks the greater potential of the region. “The Niobrara itself has been pretty nice in the DJ Basin and up to Cheyenne [Wyo.], but in all of the focus on that, the PRB tends to get lost in the conversation,” Huckaby said.

Once started, that can be an interesting conversation, he added. “Once you start digging into the PRB, it just might turn out that the Niobrara itself could be only the fourth best horizon, after the Frontier, the Turner and the Parkman. In addition to those four, we’re also seeing a lot of interest in the Sussex, the Shannon and Mowry. All of these formations are looking economical for horizontal, multistage development.”

“Producers are just starting to delineate the Niobrara region, and they are finding it looks a lot like the Permian in terms of multiple targets,” Huckaby said. “That is just great for producers.”

It is also great for midstream companies, because the variability means that producers rely more on their midstream partners, they tend to involve them earlier in the development and tend to need more from them. “In the Bakken, producers are getting a very homogenous crude,” Huckaby said. That makes it relatively easy to lift, load and ship. “There is much more variability in the Niobrara region from crude to rich gas. That means Niobrara development needs more and more complex infrastructure, which means more opportunities for midstream operators.”

The focus for many midstream operators remains gas and liquids, but Huckaby said that in the PRB, oil production increased 30% from 2012 to 2013, while associated gas production rose by half. In contrast, pure-play CBM in the PRB was actually down by 22% in the same period.

“We continue to see a clear shift to liquids, both NGL and crude,” Huckaby said. “The challenge is to provide the correct mix of assets and services. That can include converting underused assets—[like] CBM lines [and] coal railways—to something more valuable.”

Extending that logic, “bundled services is a strategy we continue to pursue to minimize our footprint, help get trucks off the road and maximize development efficiencies and economics for our customers,” Huckaby said. “The way we look at it,” Huckaby continued, “if we have a ditch open, we want to make best use of that. If we are laying a gas line, why not also lay a crude line and a water line?”

That approach would make sense anywhere, just from the basis of economies of scale, cost and complication, especially rights-of-way and permitting. But in the Niobrara region, those desirables are brought into sharp focus by the bright light shining from Washington.

“There is a significant amount of federal land in the region,” Huckaby said. “That means a lot of involvement by and with the Bureau of Land Management [BLM]. BLM has been pushing industry to minimize impacts, even in remote areas. That emphasis strongly supports our belief in bundled services.” ■

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Back to the Future: Wyoming's Surging Oil Production

The Powder River formations are the main focus of unconventional resource exploration and represent substantial hydrocarbon reservoirs in the basin.

By Maggie Salamon

Hart Energy Research & Consulting

Wyoming's Powder River Basin is known historically for its oil production. Dating back to 1889, the first oil well was drilled north of the Salt Creek Field, which is still the most productive oil field in the state. Conventional oil production has since waned and coalbed methane (CBM) production took over in the early 1990s. Horizontal drilling and hydraulic fracturing, however, increased natural gas supply and depressed prices making some CBM wells largely uneconomic. Of course, low natural gas prices also caused shale operators to target more liquids-rich resources, which have allowed Wyoming to complete the circle and target oiler assets in deeper unconventional formations within the basin.

During the past four years, operators have shown increased interest in Wyoming's Powder River Basin, especially its deep shale and sandstone intervals from the Cretaceous system. Formations, such as the Frontier, Parkman, Shannon, Sussex, Teapot, Turner and Niobrara, are now the main focus of unconventional resource exploration and represent substantial hydrocarbon reservoirs in the basin. In this report, the focus is on the Shannon, Sussex, Turner and Frontier formations and wells drilled within from 2010 to 2014.

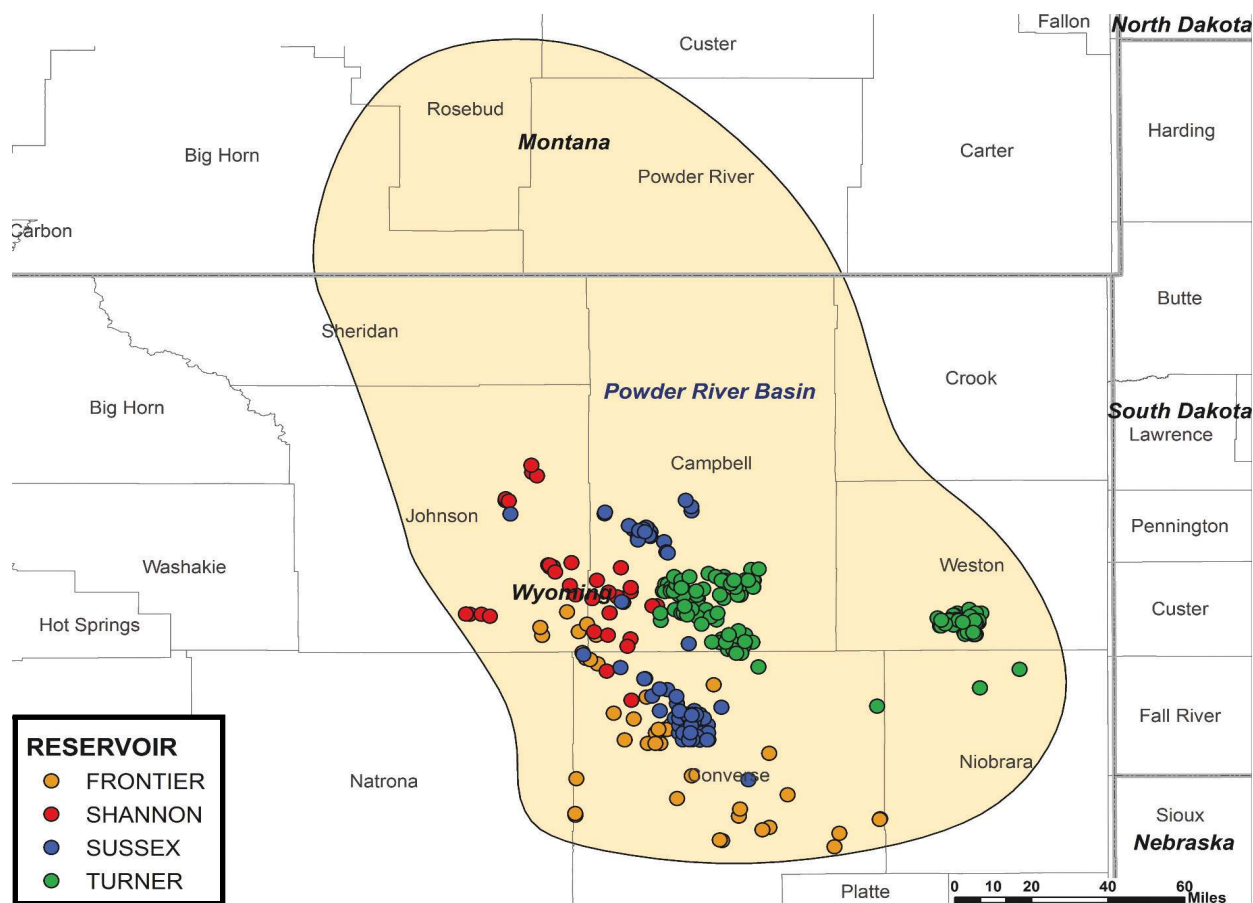
Powder River's deep oil formations are primarily targeted in the southern portion of the basin in the Campbell, Converse, Johnson, Weston and Niobrara counties of Wyoming. Operators remain optimistic about their horizontal drilling activity and continue to delineate additional portions of the region in hopes of finding more oil.

The key operators in the region are the usual subjects—Chesapeake Energy, Anadarko Petroleum Corp., EOG Resources and Devon Energy. Of the three companies, EOG Resources has had the best track record in regard to targeting liquids-rich unconventional formations in the U.S.

Chesapeake Energy has been the most aggressive company targeting the liquids-rich formation. In 2013, it drilled 46 wells with three rigs running for most of the year. The company will cut capex to the Powder River Basin by 5%, according to their first-quarter 2014 company guidance. Given its capital spending reduction in 2014, the Powder River Basin could be one of its assets that might be put on the block to raise about \$1 billion.

Anadarko Petroleum Corp. also owns roughly 350,000 lease acres and its midstream business unit owns and operates the Powder River CBM gathering system located in northeastern Wyoming. At year-end 2013, Anadarko had three

Powder River Wells by Formation



(Source: Images and data by Hart Energy Research & Consulting)

rigs working with a well inventory of 19. The company has significantly upped its capital commitment in the basin from \$5 million in 2013 to \$47 million in 2014. Anadarko also recently acquired more wells, interest in existing wells and more lease acres in the dry gas Moxa Field in the southern part of the Powder River Basin for a \$310 million acquisition.

SM Energy also has increased spending to \$140 million in the Powder River Basin, focusing on the Frontier Formation. The company plans to allocate two rigs and drill/complete eight flowing completions in 2014. With continued success, SM Energy might add another rig and more wells to its 2014 drilling schedule for the formation.

Privately held Anschutz Corp. recently acquired roughly 300,000 acres with deep rights in Wyoming's Powder River Basin. The company is participating in the drilling of test wells with established operators and actively pursuing permitting for future E&P.

Given increased spending in the Powder River Basin, oil production is set to continue its incline. In 2013, 204 horizontal oil wells were spudded and 522 unconventional permits were granted targeting liquids formations in the two hottest counties of Wyoming—Campbell and Converse. Oil production from the basin increased 15% year-over-year (yoy) to more than 20,000 bbl/d and contributed 48% of Wyoming's total oil production. As with any early

Powder River Wells Drilled by Formation

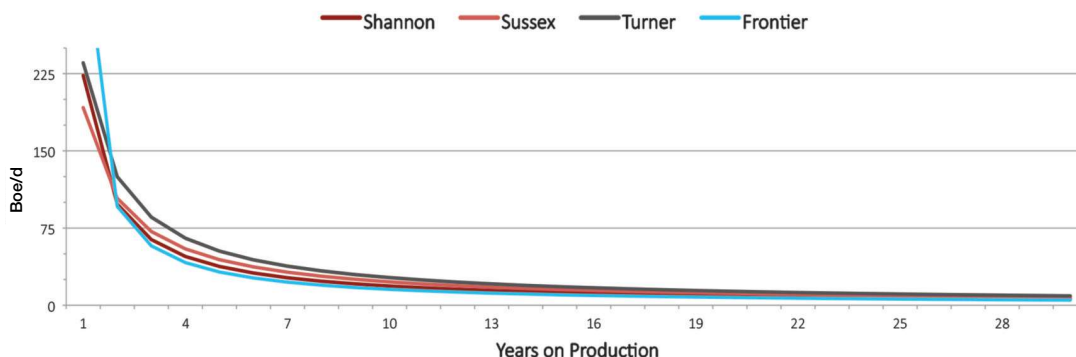
	SHANNON	SUSSEX	TURNER	FRONTIER
2010		7		3
2011		22	7	7
2012	16	26	37	6
2013	14	10	48	15
2014	1			
Total	31	65	92	31

development phase play, infrastructure could serve as a temporary bottleneck. The state is expecting continued yoy growth out to at least 2020, according to the Wyoming State Geological Survey.

This economic analysis will focus on well results from the Shannon, Sussex, Turner and Frontier intervals of the Cretaceous age strata. Upon initial assessment of each well drilled within each formation, Hart Energy's Research & Consulting team has created a decline-curve analysis, which entails creating an average type-curve, calculating its IP, decline rates and EURs as well as calculating its hydrocarbon splits. In the last stage of analysis, our analysts used the Workbench (in-house well database of 17 unconventional formations) to run well economics on those average type-curves to measure the profitability of Powder River formations.

There are only small samples of wells per formation, and their average type-curves tend to get thrown off by outliers, which make their assessment tricky. In the chart below, 30-year average EURs have been calculated for all four formations. The Turner Formation wells exhibit the highest average type-curve of 374,000 bbl, with Sussex following closely behind at 312,000 bbl, Frontier wells averaging 310,000 bbl, and the Shannon Formation displays the lowest EURs of 287,000 bbl per well. A notable similarity in all the recently drilled wells is their relatively slow decline rates. Nearly all these deep oil wells exhibit a harmonic decline pattern rather than a power law decline, which we have found to be prevalent in many other shale and tight-oil plays. The most valuable takeaway from this

Powder River Basin Oil Type Curves by Formation



Powder River Basin Hydrocarbon Splits by Formation

Formation	Oil	NGL	Gas	Avg. GOR	Year Decline
Shannon	93%	2%	6%	472	-70.1%
Sussex	93%	1%	6%	457	-56.1%
Turner	86%	3%	11%	1000	-57.6%
Frontier	83%	4%	14%	1264	-91.3%

realization is that Powder River wells have a much longer shelf life than other hot plays throughout the states. Even though there is only a small number of wells in each sample, there is much variability and still much uncertainty.

Each of the formations has been drilled since the early 2010s, but a stark difference in IP rates were noticed between the early wells drilled and wells drilled recently. Operators are beginning to understand the most optimal drilling methods for the basin and rates of return are beginning to grow more positive. For example, Chesapeake Energy mentioned that the company “had finally cracked the code” for the Powder River Basin moving the company quickly into the “optimization phase of drilling” with some well results hitting IP peak rates of 1,500 boe/d. Most deep oil Powder River wells have been targeting the Turner formation, which is understandable since its EUR range is the highest.

The Sussex, Frontier and Shannon formations are attracting much more attention recently, due to their high oil content and low gas-oil ratio (GOR).

Hydrocarbon splits from each formation exhibit high oil content and relatively low GORs. While the hydrocarbon splits are rather similar, the first-year decline varies considerably given the limited number of well results in this early development play.

Given well costs of about \$7 million per well, half-cycle breakeven prices are relatively high with commodity price forecasts of \$80/bbl of oil, \$4 MMBtu of natural gas and \$37.80/bbl of NGL. Given that most of the wells have been drilled in the delineation phase of development, the analysis suggests that the net present value (NPV) of wells will increase and breakeven prices will fall as core companies play more into the “harvest” phase in the years to come. ■

Powder River Breakeven Prices by Formation

Type Curve	NPV (After Tax)	Breakeven \$/Bbbl	Well Cost \$MM
Shannon	\$804,305	\$61.79	\$7.0
Sussex	\$1,009,836	\$65.34	\$7.0
Turner	\$1,667,527	\$57.45	\$7.0
Frontier	\$1,176,731	\$59.56	\$7.0

Additional Information on the Rocky Mountain Tight Sands and Shales

For more details on the Niobrara, Powder River, Uinta and San Juan basins, consult the selected sources below.

By Ariana Benavidez

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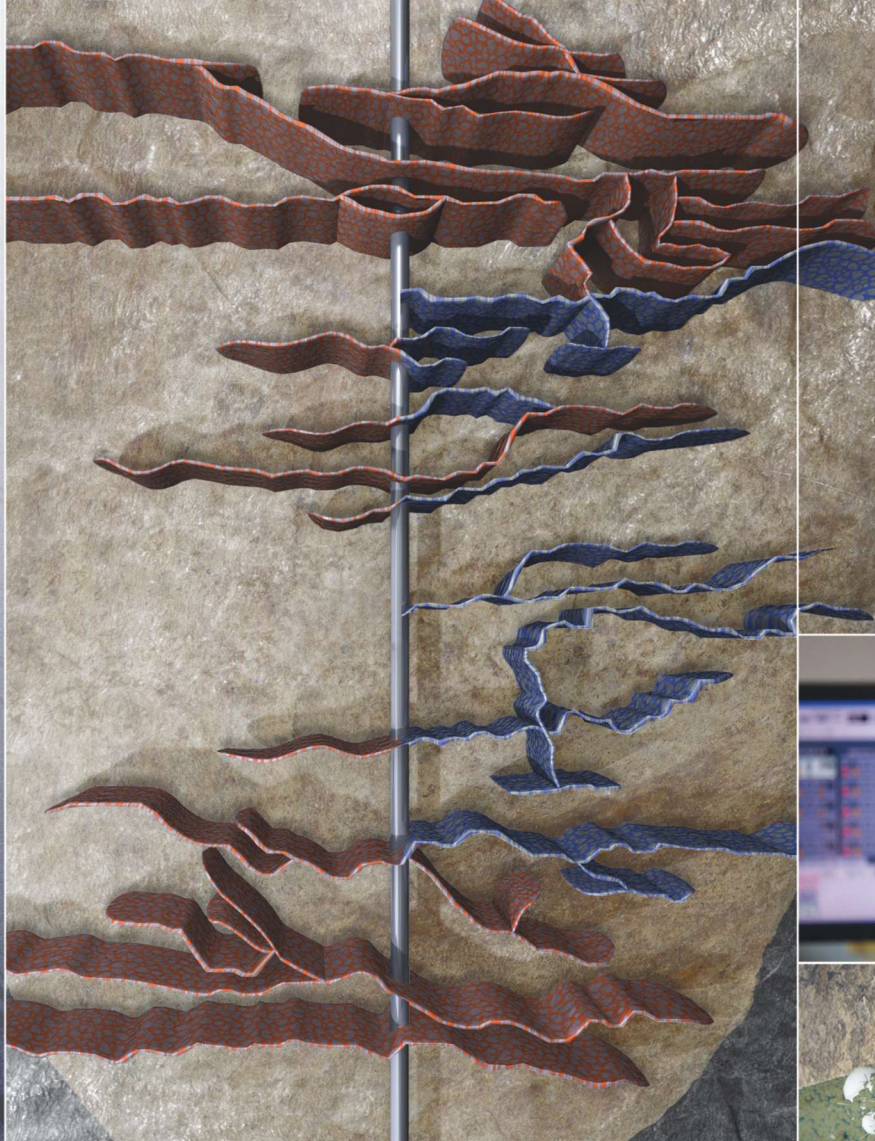
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