

THE PINEDALE ANTICLINE

The Green River Basin's Pinedale Anticline is emerging as the next giant Wyoming gas field.

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The Pinedale Anticline, which lies on the eastern flank of Wyoming's Green River Basin, shares many geological characteristics with neighboring Jonah Field. Since June 2000, when the Pinedale Environmental Impact Statement was completed, operators have been vigorously probing the potential of the 40-mile-long feature.

Another giant gas field is developing under the dry Wyoming prairie. Stunning successes with the overpressured Cretaceous Lance reservoirs at the Green River Basin's Jonah Field have spun industry attention toward its neighbor, the Pinedale Anticline. (See "Jonah's Tale," *Oil and Gas Investor*, June 1997.) A unique, 40-mile-long foreland structure, the Pinedale soars directly east and northeast of Jonah, the largest sweet-gas field in the Equality State.

The Pinedale is hardly a new discovery—for decades, various companies have probed its prodigious structure. The California Oil Co. spudded the first test in 1939, drilling a well to 10,000 feet on the anticline's crest. Other holes were poked up and down the feature throughout the years, but production from its ubiquitous low-permeability Tertiary and Upper Cretaceous sandstones never amounted to much.

Jonah's success caused the industry to look anew at the Pinedale Anticline, however. Through September 2001, Jonah has produced 429 billion cubic feet (Bcf) of gas and 4.4 million barrels of condensate from some 340 wells. Daily production is 460 million cubic feet (MMcf) of gas, and ultimate reserves on 40-acre spacing are in the neighborhood of 2.5 trillion cubic feet (Tcf).

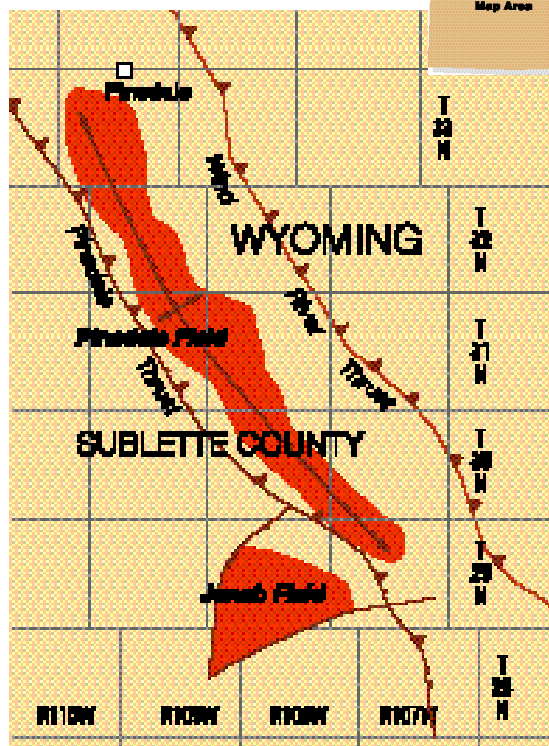
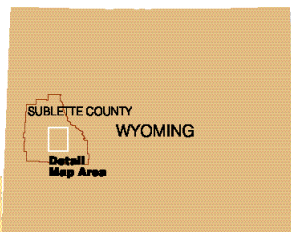
Geologists knew that the Lance reservoir that produced so prolifically in Jonah was present on the Pinedale Anticline, and that it was likewise overpressured. Given the stimulation techniques developed at Jonah, it seemed natural that the huge structure would finally come into its own.

Nevertheless, the Pinedale is not exactly a laydown to Jonah. "The Pinedale has several attributes that are very similar to Jonah Field," says John Robinson, senior vice president, McMurry Energy Co. (At press time, McMurry Energy was acquired by Shell Oil Co.) "There's no doubt that it's a multi-Tcf field. But it's a tougher play, and the Anticline is so big that its geology varies quite a bit." Indeed, the Pinedale stretches some 90 square miles, more than three times the 25 square miles occupied by Jonah.

For instance, the north end of the Pinedale hosts considerably more sands than are present in Jonah, while the reservoir characteristics seem similar. The southern end offers less sand, and the reservoir quality may be a little poorer. "There are not enough wells yet to be sure of its parallel to Jonah," says Robinson.

Andrew Logan, Denver-based research analyst, Petrie Parkman & Co., says, "There is potential for tremendous volumes of gas on the Pinedale Anticline, but there are technical differences from Jonah Field."

The Pinedale wells are generally deeper than those in Jonah, and intermediate casing is usually required due to pressure issues and well-control concerns. While Jonah wells run in the neighborhood of \$1.7 million, Pinedale wells



cost upward of \$2.8 million each. That figure can easily reach above \$3 million, depending on the drilling and casing program and number of fracture stimulations applied to each well.

Too, reserves are still a question. In Jonah, the industry is quite comfortable with average recoverable reserves of 6 billion cubic feet of gas equivalent (Bcfe) per well. Results on the Pinedale have been spottier—some wells will easily exceed 6 Bcfe, others will barely make 2 Bcfe. Certainly, open flows are quite high, and initial gauges of 10- to 22 MMcf per day have been reported along the length of the feature. Production declines are steep, as is the case in Jonah.

“The Pinedale Anticline looks good, but the economics are tight below gas prices of \$2 per

quired. The data show that a fairway of very thick sand lies along the structure, but certain areas within that trend produce more prolifically than others. Part of the variation in well quality along the crest is driven by the drilling and completion techniques and part of it is driven by the geology, says Logan. “There are cases where the wells weren’t completed properly, and other cases where the rocks just weren’t very good.”

Houston-based Ultra Petroleum Corp. owns 250,000 gross and 190,000 net acres in the Green River Basin, and it operates or has an interest in more than 100 wells—42 in Jonah and the rest on or around the Pinedale. For its part, Ultra views the play as a stratigraphic trap superimposed on a structure.

PHOTO COURTESY, ULTRA PETROLEUM



SST Energy Corp.'s Rig #17 drills the #2-2 Pinedale for Ultra Petroleum in Sublette County, Wyoming. Pinedale wells are typically around 13,000 feet deep and take 35 to 40 days to drill to total depth.

thousand cubic feet,” says Stuart Wagner, principal, Petrie Parkman. “There is a lot of drilling yet to be done.” The decline rates—coupled with current production restrictions due to inadequate takeaway capacity from the area—make it tough to judge the economics. “The question is the size and shape of the reserves of the average well. Do you get 6 Bcf in five years, or 6 Bcf in 40 years?”

The nature of the accumulation also remains ambiguous. To date, drilling has been focused along the Pinedale’s structural crest. A number of tests have been drilled both west and east of the anticline, and some have had shows of gas, some have encountered thin sections of productive sand and some have been dry.

Two extensive 3-D seismic surveys, covering more than 250 square miles, have been ac-

“The formation of the anticline in Late Eocene time enhanced fracturing and significantly contributed to the relative permeability and porosity in the Lance reservoirs,” says Steve Kneller, Ultra Petroleum vice president of exploration. “The quality of production is a function of reservoir porosity, permeability and the drainage area.”

Ultra relies heavily on analysis of the 3-D seismic to guide its drilling. The company participated in both of the large 3-D surveys, and has tied those data back into its Jonah 2-D grid. “Seismic attribute analysis has been important in helping us map potential sweet spots,” he says. “We try to pull as much as we can out of the well control and seismic data. Identification of the thick sand trends is crucial.”

Apparently, to make a superior well, fractur-

A crane hoists a frac line to the top of Ultra Petroleum's Warbonnet #8-26, Sublette County. The company typically stimulates 12 to 13 stages on a Pinedale Anticline well, treating as many as 50 sands.



PHOTO COURTESY ULTRA PETROLEUM

ing must augment the reservoir characteristics. It remains to be proven whether the thickest sands will yield the superior wells, however.

An example of the quandary: to date, the best well on the Pinedale is the Antelope #15-4 in Section 4-29n-107w. Drilled by Amoco in late 1998 at the southern end of the anticline, in an area with a relatively thin sand section, the 15-4 has produced 5.9 Bcf and 41,000 barrels of oil through June 2001. It has been offset multiple times with erratic results, and on the whole, production from wells on the southern limb of the anticline has been disappointingly variable.

Yet, there's little doubt that the Pinedale is a great field in the making. In that vein, results of recent drilling offer encouragement.

Promising developments

Salt Lake City-based Questar Corp. has been very active on the northern end of the anticline. Its subsidiaries, Questar Exploration & Production and Wexpro, have an average working interest of 60% in 14,800 gross acres in its Mesa and Stewart Point areas, 32n-33n, 109w. This is also the portion of the anticline that has seen the most drilling to date.

Questar has been intrigued with this part of the Anticline since the late 1960s, when Wexpro drilled three noncommercial wells in the Mesa Unit. In 1997, Ultra farmed into the area and drilled three additional wells. It applied the frac techniques that had been developed in Jonah Field, and achieved much better results.

Although those wells were promising,

drilling activity stalled for several years. Because federal leases cover much of the Pinedale, operators had to await the completion of an environmental-impact statement (EIS) to access that acreage. In mid-2000, the Bureau of Land Management approved the Pinedale Anticline EIS, which encompassed about 200,000 acres, and has allowed up to 900 wells to be drilled on the federal lands.

While the EIS has let development move forward, operators still contend with many restrictions. Among other issues, federal leases on the northern half of the anticline are closed to drilling during the winter months. Firms must shift drilling to fee or state leases, or move to the Pinedale's southern half until spring.

Because of the wait for the EIS, development on the anticline is years behind that of Jonah Field. This summer, around 60 wells were producing on the entire feature, with cumulative production around 50 MMcf per day.

Questar subsequently bought back into the Ultra venture and took over operations of the Mesa project; Ultra retained an average working interest of 30% in the acreage. At the same time, Ultra sold an interest in adjoining acreage to Anschutz Exploration Corp., in which it retains a 42.5% working interest.

Since mid-2000, Questar has drilled 29 wells, all successful, on the anticline. At the end of October 2001, it was producing gross gas of 39.8 MMcf per day from 22 wells, and also had about 12 MMcf per day of capacity that was constrained by the area's takeaway problems. Completion was under way on seven wells, and three wells were being drilled.

The company divides its acreage into a north and south area; the north area comprises its interests in 33n. "Up in the north end, we have average reserves of about 4.8 Bcfe. In the south end, where we have substantially more data, we're seeing gross average reserves of 5.75 Bcfe per well," says Gary Nordloh, QEP and Wexpro president and chief executive officer.

Questar's wells are about 13,000 feet deep and cost \$2.8- to \$3.6 million, depending on the casing and mud programs and on the number of stimulations. Finding costs continue to be reasonable in the south area, from \$0.44 to \$0.58 per thousand cubic feet equivalent (Mcf), says Nordloh. Costs in the north area are about \$0.57 to \$0.63 per Mcfe, as virtually all the locations there require deviated wells with intermediate casing.

The company projects it will have production capacity of 75- to 80 MMcf per day at Pinedale by year-end, but it expects to be producing no more than 45 MMcf per day because of the gathering constraints. Next year, it hopes to drill as many as 20 wells on the anticline.

Ultra has likewise been enjoying success with its exploration and development efforts. In 2000, the firm spent about \$22.2 million to drill or participate in 25 wells on its Pinedale Anticline and Jonah acreage. This year, it expects to

spend \$47 million on 33 wells, eight in Jonah and 25 on the anticline. To date, all have been successful.

A year ago, Ultra was producing 10 MMcf of net gas per day; presently it is making 35 MMcf net per day. "Our exit rate in 2001 should be in the neighborhood of 45 MMcf per day," says Michael Watford, Ultra chairman, chief executive officer and president.

For 2002, Ultra will direct its efforts at Pinedale. "We have a few locations left that we could drill in Jonah, but we have hundreds of locations on the anticline. That's where we have our upside," he says.

In Jonah, a typical Lance section is about 2,500 feet thick, with 400 to 500 feet of sandstone, says Kneller. "We have more than 4,000 feet of Lance interval on the Pinedale Anticline, and wells with sand in excess of 1,000 feet. And, the porosities and permeabilities of the sandstones on the anticline are very close to those found in Jonah."

The firm plans to participate in 10 to 12 wells

"Across the Anticline, results of this year's drilling have been very positive. The only drawback right now is that there isn't enough pipeline capacity to move all the gas." Steve Kneller, Ultra Petroleum Corp.

operated by Questar and Anschutz in the Mesa area. Anschutz, which is running two rigs, has drilled three successful wells and has two more under way.

Ultra will also drill 18 operated wells in its New Fork area, in the central part of the anticline. There, the company has 20,000 prospective acres in a seismically defined sweet spot. This year, Ultra drilled four wells in the middle part of its New Fork project and seven in its Warbonnet Unit, in 30n-108w. The firm will keep two rigs drilling throughout the winter in Warbonnet, where it doesn't face winter drilling restrictions.

As in Jonah Field, fracture stimulations are key to a successful Lance producer, notes Ultra. The firm prefers the induced stress diversion (ISD) technique developed by Dowell Schlumberger, says Roger Heckman, reservoir engineer. The lowermost stage is fractured first, and just the wellbore volumes are flowed back. "The pressure we have created in the zones below allows us to automatically divert to the next set of holes."

This method permits a very short completion cycle of about three weeks per well, versus conventional procedures that take about a week for each stage. Ultra typically stimulates 12 to 13 stages per well, and treats as many as 50 total sands. Each stage covers 150 to 200 feet, takes about 150,000 pounds of proppant and costs around \$100,000.

"Across the Pinedale, results of this year's

drilling have been very positive," says Kneller. "We expect to see a lot of new production. The only drawback right now is that there isn't enough pipeline capacity to move all the gas."

Another company with an active program has been Casper independent McMurry. In early November, Shell Oil Co. acquired McMurry Energy. Shell notes that it plans to maintain McMurry's Pinedale field operations office as well as the Denver office. It will also maintain the Casper office during the transition period. Shell acquired Nerd Energy Co., another private company with interests on the Anticline, at the same time.

Since June 2000, McMurry Energy had drilled 11 wells on the anticline, adding those to six producing wells that it had previously drilled. There is a rather steep learning curve, says Robinson. "We started drilling on the anticline in 1994, and we are getting better results from our current wells than from those early wells. All of the operators have all gotten better at drilling and completing the wells.

"Several of the 11 wells we drilled last year were exploratory," he says. "We were trying to prove that there was continuous production along the anticline, and our results show that is the case."

Pipeline predicaments

The pipeline situation has been a daunting challenge for all the Pinedale operators. Presently, the takeaway capacity is limited and the line pressure on the anticline is close to 1,000 psi. "We have to rotate around to test our wells, and we are not able to produce at capacity," says Ultra's Heckman.

Relief is in sight, however. Jonah Gas Gathering Co. is laying 50 miles of new 20-inch line from Bird Canyon to Opal, Wyoming. The company, which was recently purchased by Teppco Partners LP, a subsidiary of Duke Energy, is also adding 9,000 horsepower of compression at its Bird Canyon compressor station. The project will increase takeaway capacity to 730 MMcf per day, from current capacity of 450 MMcf per day. Teppco says the project will be complete in early 2002.

Additionally, Questar and Western Gas Resources Inc. recently formed Rendezvous Gas Services, a joint venture to provide gathering and compression services to the Pinedale area. Western has been active in the play for years, and has an approximate 10% working interest across most of the anticline. The companies plan to build pipeline and compression facilities with a capacity of 275 MMcf per day.

"We expect to get our new compression and gathering facilities on line in the first quarter of 2002," says Questar's Nordloh.

With an encouraging drilling season under their belts and clear access to their federal acreage, the Pinedale Anticline operators are ready to fill that promised capacity as quickly as possible. □