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Coal-bed methane in New Mexico

by *Neil H. Whitehead, III*, New Mexico Bureau of Mines & Mineral Resources, Socorro, NM 87801

What is coal-bed methane?

Coal-bed methane or coal-seam gas is natural gas found associated with coal beds. The gas is a product of the coalification process whereby, through time, peat-like muck is converted to coal by the application of heat and pressure. After the energy crisis of 1973, geologists began to look seriously at coal-bed methane, not just as an explosive gas to be vented from coal mines but as an enormous resource of high-quality, pipeline gas. In the last five years, vast amounts of methane have been developed by drilling hundreds of wells in coal beds too deep to mine in the San Juan Basin and the Raton Basin of New Mexico (Fig. 1).

In conventional gas reservoirs, gas occurs in interconnected voids (pores) in the rock. Coal-bed methane is an unconventional gas in that the methane is adsorbed or attached to internal surfaces within the coal. As the reservoir pressure of the coal is decreased by removing water or gas, more gas desorbs from the coal and is available to flow to the well bore.

Why is coal-bed methane important to New Mexico?

The coal-bed methane resource base for the San Juan Basin of New Mexico and Colorado is estimated to be between 65 and 83 trillion ft^3 (TCF) for the Fruitland and Menefee Formations. The Raton Basin of New Mexico and Colorado is estimated to contain between 8 and 18 TCF of gas in the Raton and Vermejo Formations. The combined resource base for these two basins is between 73 and 101 TCF.

The percentage of gas produced from a well is called the recovery factor. This factor for coal-bed methane is not well established because of the unconventional nature of these reservoirs. Assuming a conservative recovery factor of 50%, between 36.5 and 50.5 TCF of gas will be produced from these coal beds over the next 20 to 40 years.

To place these amounts in perspective, natural gas consumption in the United States in 1989 was 19 TCF. The annual production from New Mexico in 1990 was 0.95 TCF. Cumulative production through 1989 for all reservoirs in the New Mexico part of the San Juan Basin was approximately 15.3 TCF. In 1988, the first year production records for the Basin Fruitland pool were kept, coal-bed methane production from the San Juan Basin of New Mexico was 14 billion ft^3 (BCF, = 0.014 TCF) from a year-end total of 77 wells. Annual production in 1989 increased to 55 BCF from 323 wells and in 1990 was 131 BCF from 734 wells. In December 1990, Fruitland coal-bed methane production made up about 31% of the monthly gas production from the San Juan Basin and 17% of the monthly gas production from New Mexico. By the end of March 1991, 831 wells were producing from the Basin Fruitland pool. Production during that month made up about 38% of the gas production from the San Juan Basin and 22% of the total gas (associated and nonassociated) production from New Mexico. Many additional wells are waiting to be connected to pipelines. Thus, the deliverability of coal-bed methane is expected to increase.

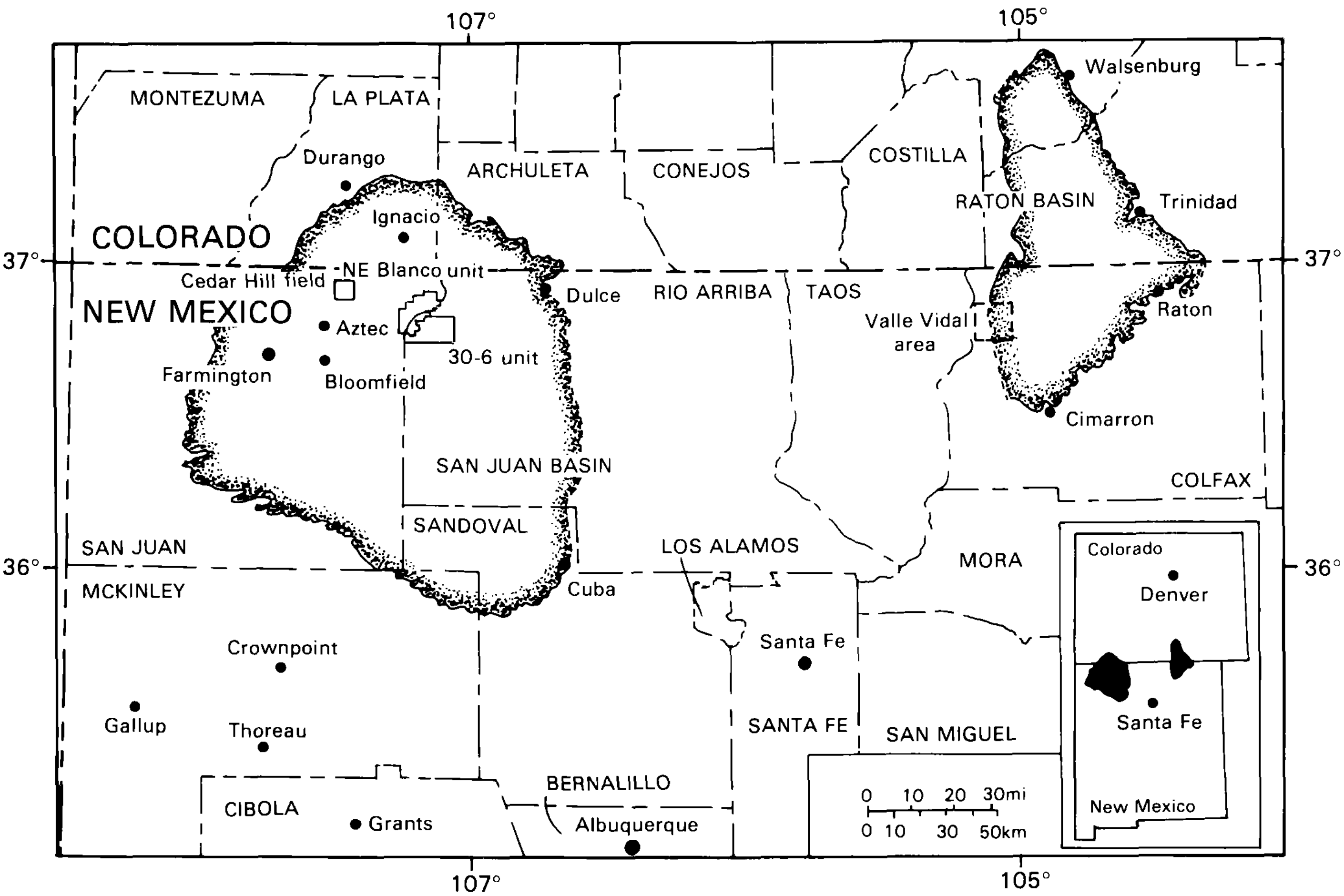

FIGURE 1—Index map showing that part of the San Juan Basin underlain by the Fruitland Formation (Dane and Bachman, 1965) and the Raton Basin underlain by the Vermejo Formation (Dane and Bachman, 1965; Tweto, 1979).

Nonconventional fuel tax credit

An important force in the exploitation of coal-bed methane in New Mexico is the nonconventional fuel tax credit. This tax credit, enacted by Congress as part of the Crude Oil Windfall Profit Tax Act of 1980, rewards producers faced with high initial costs in developing unconventional energy sources, such as oil from shale and tar sand and gas from geopressured brine and Devonian shale. Coal-bed methane development projects in the north-central part of the San Juan Basin have been compared to offshore ventures in terms of initially high capital requirements (e.g., pumping units, water storage and settling tanks, separators and other surface equipment, gathering lines for both gas and produced brine, and deep brine-disposal wells) and long lead times involving planning, design, and regulatory agency approval.

The nonconventional fuel tax credit had been scheduled to expire January 1, 1990, but was extended to January 1, 1991, and recently was extended again to January 1, 1993. The tax credit for 1990 was $0.865/MMBTU (million British Thermal Units, approximately 1 MCF (thousand ft^3 of gas)) as determined by the inflation adjustment factor and reference price for calendar year 1990 (Internal Revenue Service, 1991). The tax credit will apply to gas produced until January 1, 2003 from wells drilled before January 1, 1993. The credit is subtracted from the tax liability and must be taken in the year of production. The average New Mexico well-head price in 1990 was $1.73/MCF of gas (New Mexico Taxation and Revenue Department, 1991), so allowing for the costs of lifting gas from the well, producers will net by the tax credit a significant part of their income from coal-bed methane properties.

Fruitland gas: a thirty-year-old discovery is rediscovered

The Fruitland Formation gas play is unusual in that this immense reservoir was "found" about thirty years before the play was "discovered." The first thorough, basin-wide subsurface study of the Fruitland Formation published in 1971 contains these prophetic passages:

> Gas shows in the Kirtland and Fruitland are ignored during most drilling in the San Juan Basin. In parts of the basin, however, it has become customary for drilling companies to take precautions against blowouts before penetrating the Kirtland and Fruitland, since at least five drilling rigs have been lost by fires owing to gas blowouts from these stratigraphic units. (Fassett and Hinds, 1971, p. 42)

Beginning in the early 1950's, thousands of wells were drilled through Fruitland coals to deeper gas and oil reservoirs in the San Juan Basin. However, geologists and petroleum engineers did not explore for gas in coal, gas was to be found in sandstones. Additionally, strong gas shows were encountered in areas where there were large volumes of water in the coal. In conventional gas reservoirs, high water production indicates the reservoir is watered out or depleted, another reason for ignoring the coal-bed reservoirs.

The first well specifically for coal-bed methane in New Mexico was drilled in 1977 by Amoco Production Co. in the Cedar Hill field northeast of Aztec. The major push for coal-bed methane development wells began in the mid-1980's. The prime benefactors of the boom are the original and successor companies that drilled wells as much as 30 or 40 years ago and established production from deeper horizons beneath the Fruitland coals. The two largest players by acreage are Amoco Production Co., an original company, and Meridian Oil Inc. (a wholly owned subsidiary of Burlington Resources), which purchased El Paso Natural Gas in 1983 and Southland Royalty in 1985. Amoco's position was strengthened in late 1988 when it acquired for $900 million the Rocky Mountain properties (90% of which are in the San Juan Basin) of Tenneco Exploration and Production. In mid-1990 Meridian acquired for $399 million all the producing leases of Unicon Producing Co. (Union Texas Petroleum), most of which are in the San Juan Basin. Table 1 lists companies and Fruitland coal-bed methane wells in operation as of March 31, 1991. Other companies with coal-bed methane drilling activity in New Mexico include: Basin Fuel Ltd., Bonneville Fuels, Caulkins Oil Co., Columbus Energy, Fairplay Oil & Gas Co., Incline Reserves, Koch Exploration, Mitchell Energy Corp., Parker & Parsley Petroleum Co., and Quinoco Petroleum Inc.

Gas in the Fruitland Formation

Volumetric determination of gas in place in the Fruitland Formation involves making a map of coal thickness from well logs, determining drillable acres, obtaining coal density (tons/acre-foot) values from well logs, and measuring the gas content (ft^3/ton of coal) from desorption of coal samples. These values are multiplied to arrive at a gas-in-place (ft^3) value. The parameter most difficult to determine accurately is gas content (ft^3/ton). The best procedure is to place well core, as soon as it is brought to the surface, in a desorption canister and measure the methane gas given off. An estimate of the gas that escaped while the core was being drilled is added, and gas content (ft^3/ton) is then calculated.

Choate et al. (1984) calculated a gas-in-place value of 31 TCF for the San Juan Basin; Kelso et al. (1988) estimated 50 TCF. Ayers and Ambrose (1990), using the gas content and coal density of Kelso et al. (1988), with mean coal-ash contents of 30% and 20%, calculated gas resources of 43 TCF and 49 TCF.

The gas-in-place map (Fig. 2) contoured in BCF/mi^2 (after Ayers and Ambrose, 1990, fig. 27) shows the highest values in the northern part of the basin, reflecting the presence of thick coal beds, high thermal maturity, and high reservoir pressures (which allow more gas to be adsorbed per unit of coal). The northwest–southeast elongation of gas-in-place contours (Fig. 2) reflects the trend of thick coals that tended to form shoreward (southwest) of the northwest–southeast-trending shoreline sands of the Pictured Cliffs Formation, which underlies the Fruitland Formation and intertongues to the northeast with the Fruitland (Fassett and Hinds, 1971).

TABLE 1—Operators of producing Fruitland coal-bed methane wells as of March 31, 1991 (New Mexico Oil Conservation Commission, 1991). *, San Juan producing properties sold to Conoco, Inc., April 30, 1991.

Company	Wells
Meridian Oil Inc.	365
Nassau Resources, Inc.	62
Blackwood & Nichols Co.	62
Amoco Production Co.	61
Phillips Petroleum Co.	60
Union Oil Company of California	48
Southland Royalty Co. (Meridian)	38
Giant Exploration & Prod. Co.	26
Marathon Oil Co.	11
McKenzie Methane	9
Hallwood Petroleum Inc.	8
Mesa Operating Limited Partnership NW*	7
Arco Oil & Gas Co.	6
Robert L. Bayless	6
Richmond Petroleum Inc.	6
Texaco Inc.	6
Dugan Production Corp.	5
Merrion Oil and Gas Corp.	5
D. J. Simmons et al.	5
BHP Petroleum	4
Joel B. Burr, Jr.	4
Northwest Pipeline Corp.	4
Union Texas Petroleum Corp.	4
Falcon Seaboard Gas Co.	3
Maralex Resources, Inc.	3
Morgan-Richardson Operating Co.	2
Simmons Engr. & Consulting Co.	2
Orville S. Slaughter, Jr.	2
Basin Minerals, Inc.	1
Conoco, Inc.	1
Great Western Drilling Co.	1
Curtis J. Little	1
Manana Gas Inc.	1
Jerome P. McHugh	1
Total	830

Overpressured and underpressured reservoirs in the Fruitland

Ayers et al. (1991) demonstrated that the Fruitland Formation in the San Juan Basin (Fig. 2) is divided into two distinct domains exhibiting different reservoir and production characteristics. The northern part is overpressured, the rest is mostly underpressured. Overpressured (or underpressured) means that the pressure in the reservoir is greater than (or less than)

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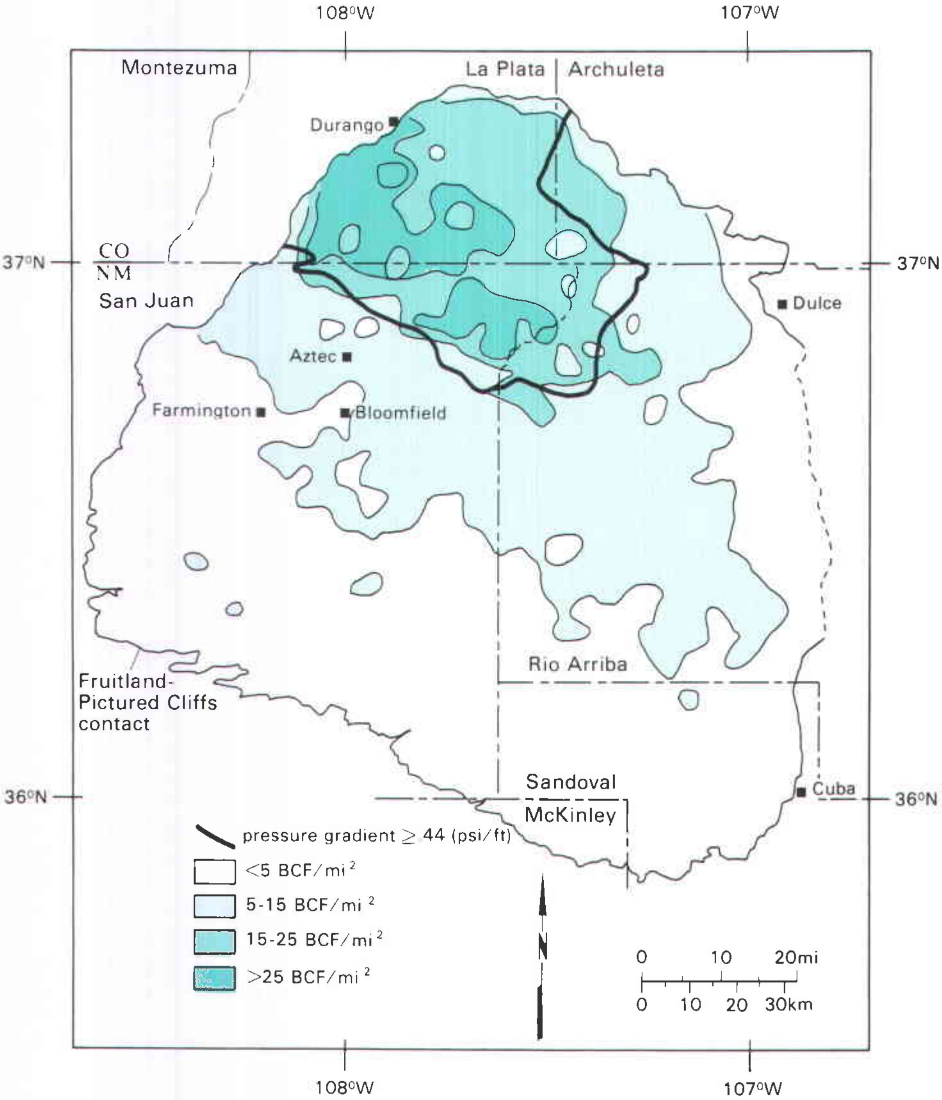

FIGURE 2—Gas-in-place map for the Fruitland Formation coal beds, calculated on the basis of 20% mean ash content in coal (modified from Ayers and Ambrose, 1990, fig. 27), and the extent of overpressuring in the Fruitland Formation (modified from Kaiser, Swartz, and Hawkins, 1991, fig. 6).

the pressure exerted by a column of fresh water the height of the drilling depth to the reservoir.

Overpressured reservoir conditions in the Fruitland Formation result from an artesian system (Kaiser, Swartz, and Hawkins, 1991). Water, recharged by rain or snowmelt at a high elevation along the Fruitland outcrop southwest and east of Durango, Colorado, moves basinward within the Fruitland coal seams. The subsurface limit of overpressuring coincides closely with the pinch-out or truncation of the thick coal seams. Production of both gas and water is generally high in wells drilled in this area. High gas-in-place values per section (Fig. 2) have led to extensive development drilling in this part of the San Juan Basin in New Mexico.

Wells in the overpressured area may show the highly publicized negative-decline production curve in contrast to decline production curves from conventional gas reservoirs in which high initial-production rates decline over time. Coal-bed methane wells where the coal beds are initially 100% water saturated require the reservoir pressure to be lowered by pumping out water, allowing the gas to desorb. The production pattern then shows a decline in water production rate with an increase (or negative decline) in the gas production rate. At some point, the increase in production begins to level off and then decline as in a conventional well. Gas composition (Scott et al., 1991) in the overpressured area is commonly $\geq$3% CO_2 and is very dry (low in ethane and heavier hydrocarbons).

In overpressured reservoirs, the large volume of produced brine usually requires a pipeline gathering system to be tied to a central, deep-disposal well. The high CO_2 content ($\geq$3%) of the coal-bed methane also requires a separate gas-gathering system and construction of CO_2 gas-stripping plants to meet pipeline gas specifications.

The underpressured area of the Fruitland reservoir has received less attention in the rush to complete high-volume wells before the tax credit drilling deadline. The underpressured areas are characterized by little or no produced water, low reservoir pressures, and thinner coals. The production from these wells is generally low, although the initial production values overlap those in the lower range of the overpressured Fruitland reservoirs (Kaiser, Ayers, Ambrose, Laubach, Scott, and Tremain, 1991). The CO_2 gas content is generally $<$1% while ethane and other natural gas liquids generally resemble those found in the underlying Pictured Cliffs Sandstone (Scott et al., 1991). The production mechanism seems to be one of producing gas from gas-saturated fractures in the coal, which then lowers the reservoir pressure and allows more methane to desorb from the coal matrix.

Underpressured reservoirs tend to have low reservoir pressures that require initial compression to overcome gathering-line pressures. Favorably, underpressured reservoirs generally have small amounts of produced water and shallow drilling depths to approximately 1,000 ft; produced gas is low in CO_2 and thus is generally compatible with existing gas-gathering systems and treatment plants. Because Fruitland gas is similar to deeper Cretaceous gases, Fruitland zones are attractive recompletion targets as production from deeper horizons is depleted. In addition, many areas may offer shallow drilling targets in acreage not held by production.

Hydraulic-fracture (conventional) vs. open-hole cavity (unconventional) well completions

In the overpressured Fruitland reservoir area, two different completion methods are used. The conventional method involves drilling through the Fruitland coals, setting and cementing casing, perforating the casing, and then hydraulically fracturing the well. The hydraulic-fracturing process creates vertical fractures extending from the well bore into the coals, overcoming loss in permeability from formation damage caused by plugging by drilling mud and casing cement.

The open-hole cavity method was pioneered by Meridian in 1985 (Logan et al., 1989) during development of their 30–6 San Juan Unit (Fig. 1). The procedure involves: setting seven-inch casing at the top of the Fruitland coal zone; drilling the Fruitland underbalanced (the weight or hydrostatic pressure of the drilling mud is slightly below the reservoir pressure) to prevent the drilling mud from plugging fractures in the coal; and then unloading the well bore by pumping in air or foam to decrease well-bore pressure with respect to reservoir pressure, thus inducing a large amount of caving and sloughing of the coal into the well bore, forming a cavity. These caved fragments are entrained in the foam and carried up out of the well bore. As the cavity is created, stress relief occurs in the coal as the coal fails and moves towards the well bore. The stress-relief effect, which allows cleats and other natural fractures to open wider, can extend as much as 300 ft around the well bore (Logan et al., 1989). Wells are completed by running an uncemented liner with predrilled perforations. Initial production rates greater than 20 MMCFGPD (million ft^3 of gas per day) have been achieved by the open-hole cavity method. In the Northeast Blanco Unit (Fig. 1) operated by Devon Energy, eight wells were completed conventionally with flow rates of 0.145 to 1 MMCFGPD. Nearby redrilling of the same eight wells using the open-hole cavity method achieved initial flow rates of 6.0 to 22.9 MMCFGPD (Petzet, 1990).

Regulation of coal-bed methane production

The agency with the primary responsibility for regulating gas and oil production in New Mexico is the Oil Conservation Division, Energy, Minerals and Natural Resources Department. Important goals of this agency include the prevention of surface or subsurface waste of gas and oil and the protection of correlative rights of all owners within a contiguous reservoir or common source of supply.

In October 1988 the Oil Conservation Division (1988a) created the Basin–Fruitland coal-gas pool consisting of all the coal seams within the Fruitland Formation. The horizontal (plan view) extent of the pool encompasses all of the subsurface extent of the Fruitland Formation. Well spacing was set at 320 acres (2 wells/mi^2). The existing Cedar Hill–Fruitland Basin coal-gas pool, established in 1984, was allowed to stand. In a separate order (Oil Conservation Division, 1988b), 20 pools producing primarily from Fruitland sandstones and seven pools producing from the Fruitland–Pictured Cliffs interval were contracted within the Fruitland portion to include only the sandstones within the Fruitland Formation.

The order (Oil Conservation Division, 1988a) noted that several operators recommended a 160-acre well spacing (4 wells/mi^2) over part of the Basin–Fruitland coal-gas pool. The Oil Conservation Division established the 320-acre spacing, but it acknowledged a lack of detailed reservoir information on this unconventional gas pool.

After a two-year promulgation of the order, the final rules for the Basin–Fruitland pool were issued in July 1991 (Oil Conservation Division, 1991). However, determination of the minimum number of wells required to drain a certain number of acres in the Basin–Fruitland reservoir is still subject to vigorous debate, mainly because it is so early in the production history of this giant, unconventional reservoir. As a compromise, the 320-acre spacing was maintained but, in a hearing before the Oil Conservation Division examiner, individual operators may apply to drill a second well on the 320-acre spacing unit. Thus, the effect of this rule will make the Basin–Fruitland pool unique in New Mexico by having different spacings in the same pool.

Gas gathering and gas-treatment plants

Pipelines for gathering gas and brine produced from coal-bed methane wells have been built or are under construction along approximately 700 mi of right-of-way (ROW) in the San Juan Basin of New Mexico. The first ROW for these gathering lines was granted by the Bureau of Land Management (BLM) on November 1, 1988. Over much of this distance, gas and produced-brine pipelines are buried in the same ditch; thus, the actual mileage of pipe laid is considerably more than 700 mi. Pipeline sizes range from 2" O.D. (outside diameter) to 22" O.D. Major projects have been completed or are nearing completion by Meridian, Blackwood & Nichols, Amoco, and Williams Field Services. Approximately 275 mi of ROW for gathering lines are being permitted or are awaiting construction in the near future by Meridian, Amoco, and Phillips Petroleum (Bureau of Land Management, 1990).

Beginning with the permitting of the Fruitland coal gas-gathering pipelines, the BLM changed its philosophy on pipeline construction methods to lessen the impact of pipelines on the environment (Bureau of Land Management, 1990). Cross-country construction is not to be the norm, at least 90 of every 100 miles of pipeline are to be laid adjacent to existing roads or pipelines. Blasting of rim rock is to be done sparingly, and rock saw and hydraulic wheel ditchers are to be used to minimize surface disturbance.

Coal-bed methane gas is conveyed through the gathering system by compressor booster stations through successively larger diameter pipelines to two main treatment plants where the gas is stripped of CO_2 in an amine treatment process. The Val Verde plant, operated by Meridian at Bloomfield, went on stream in 1988 and has an inlet capacity of 420 MMCFGPD. The Milagro treatment plant, also at Bloomfield, is operated by Williams Field Services (a subsidiary of The Williams Companies). This plant was placed on line in March 1991. A second unit was added in May 1991 increasing the capacity to 360 MMCFGPD. A third unit will be added (Albuquerque Journal, 1991) to bring the daily process capability of the plant to 500 MMCFGPD.

The Val Verde plant took in about 74 BCF of gas from February 1990 through December 1990 and in processing this gas, vented about 7.7 BCF of CO_2 (Meridian Oil Gathering Co., 1990). These figures indicate the coal-bed methane supplied to this plant contains approximately 10% CO_2. Operators of the Val Verde plant and the Milagro plant may convert a waste product (CO_2) to a marketable commodity by installing a compressor and a pipeline to connect to the Cortez line only 8 mi away. The Cortez pipeline, operated by Shell Oil Co., transports CO_2 from southwestern Colorado to west Texas for CO_2 flooding of oil fields. Carbon dioxide produced from the Bravo dome area in northeastern New Mexico was valued at an average of $0.31/MCF in 1990 (New Mexico Taxation and Revenue Department, 1991). At this value, the CO_2 vented at the Val Verde plant was worth at least $2.387 million.

Produced-brine disposal

Coal-bed methane production in the overpressured area (Fig. 2) commonly involves large amounts of produced water. In 1989, 4.5 million barrels of water (BW) were produced from 323 Basin–Fruitland wells. In 1990, 14.9 million BW were produced from 734 Basin–Fruitland wells. The cost is significant to the producer to dispose of this water by tank truck or pipeline conveyance to an evaporation pit or brine-disposal well. Over time the cost of disposal by pipeline is much lower than by trucking. Some operators have gambled that they can haul water for a year or two until the coal beds are dewatered, and thus avoid laying a pipeline.

About 90% of the produced water is injected into brine-disposal wells. Twelve wells in the New Mexico part of the San Juan Basin are exclusively or partially used to dispose of produced water from coal-bed methane wells. Wells drilled specifically to dispose of coal-bed methane brines are 9,000 to 10,000 feet deep and usually have perforations across the Entrada, Bluff, and Morrison Formations.

Southwest Water Disposal Inc., Farmington, and Basin Disposal, Inc., Bloomfield, operate commercial evaporation ponds. By using aeration on a hot summer day, thousands of barrels of water can be evaporated. However, in the winter, subfreezing temperatures can cause operational problems.

Moving gas out of the San Juan Basin: laterals and loops

Three pipeline systems serve as outlets for gas in the New Mexico part of the San Juan Basin. El Paso Natural Gas Co. (a fully owned subsidiary of Burlington Resources) primarily serves markets in Arizona, Nevada, and California; Northwest Pipeline Corp. delivers gas primarily to Oregon and Washington; and Sunterra Gas Gathering Co. (an affiliate of Gas Company of New Mexico) serves the intrastate market in New Mexico.

In February 1990 El Paso put in service

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14 mi of 30-inch gas pipeline to complete a line from Ignacio, Colorado, to its Blanco plant at Bloomfield, New Mexico. In April 1991 El Paso completed a $22 million project with two pipeline loops (new pipe laid adjacent to and tied to the existing line) along their Bloomfield-to-Gallup lateral. These loops allow a 165-MMCFGPD increase in the takeaway capacity from the San Juan Basin (Gas Marketing Bureau, 1990a). In February 1990 Northwest Pipeline Corp. completed a 33-mile-long, 30-inch pipeline from its Ignacio plant in Colorado to connect with El Paso at the Blanco hub near Bloomfield, New Mexico. This $28 million expansion will deliver 300 MMCFGPD to El Paso's San Juan Triangle pipeline system (Gas Marketing Bureau, 1990b).

At present, producers are curtailed by the lack of pipeline capacity resulting from a surge in gas deliverability. New pipeline construction and increased compressor horsepower in existing lines will result in greatly increased capacity, which may increase competition, allowing higher wellhead prices to the producer.

The following projects are underway or are in the regulatory approval process:

1) El Paso received final approval for its $241.5 million San Juan Basin and mainline expansion project from the Federal Energy Regulatory Commission (FERC) in July 1991. This project adds 12,000 compressor horsepower and 54 mi of loop pipeline to the San Juan Basin lateral that ties to the El Paso main line at Gallup. This combination will add 835 MMCFGPD takeaway capacity for El Paso from the San Juan Basin. Other parts of the system expansion not only will add 406-MMCFGPD capacity to the main line to move gas to California but also will install bidirectional flow capability to allow easterly gas flow as much as 429 MMCFGPD from the San Juan Basin to west Texas. This will permit San Juan Basin gas to be marketed for the first time in the central and eastern United States. El Paso plans to have this expansion completed by April 1, 1992 (El Paso Natural Gas Co., 1990; Gas Marketing Bureau, 1991; PennWell Publishing Co., 1991).

2) Transwestern Pipeline Co. (a subsidiary of Enron Corp.) received preliminary approval from FERC in December 1990 to construct a San Juan lateral pipeline from Bloomfield to Transwestern's main line at Thoreau, New Mexico. A compressor station will be built at Bloomfield, and 100 mi of 30-inch pipeline will be laid. This lateral pipeline has a capacity rated at 520 MMCFGPD. Final regulatory approval was granted in July 1991, and Transwestern expects to have the line in service by the 1991–92 heating season. The project is estimated to cost $93 million. Additionally, Transwestern will expand the capacity of its main-line system to California by 340 MMCFGPD (Enron Corporation, 1990, 1991).

3) Gas Company of New Mexico is adding approximately 2,000 compressor horsepower to allow the delivery of as much as 40 MMCFGPD through its San Juan gathering system via the Rio Puerco interconnection southwest of Albuquerque to either the Transwestern or El Paso main line. The gathering system of the Gas Company of New Mexico is underutilized, especially in the summer, and this expansion, scheduled for completion in August 1991, will move additional gas out of the San Juan Basin (Gas Company of New Mexico, 1990).

When these pipeline expansions are in place, producers will have greatly increased flexibility to ship gas to markets in California, the Midcontinent, and the Pacific Northwest. Permian Basin and San Juan Basin gas traditionally have been important gas sources for California. However, in the next several years major pipeline projects will be completed that will link western Wyoming gas and Canadian gas to the California market. While the San Juan Basin will continue to supply California, long-term declines in deliverability of 5.4%/yr for the Permian Basin and 5.3%/yr for onshore Gulf Coast (Spiegel et al., 1990) suggest that the San Juan Basin will become an important supplier to points east.

Menefee coal: a giant unknown gas reservoir?

In the San Juan Basin, the Menefee Formation contains the second largest coal reserves after the 245 billion tons (Ayers and Ambrose, 1990) in the Fruitland Formation. Much less is known about Menefee coals than Fruitland coals. Shomaker and Holt (1973) estimated 12.3 billion tons of Menefee coal deeper than 500 ft in the Ute Mountain Ute and Southern Ute tribal areas of Colorado and New Mexico. In New Mexico, 10.5 billion tons of Menefee coal between 500 and 4,000 ft deep were reported by Shomaker and Whyte (1977). Crist et al. (1990) estimated the Menefee coal resources at 138 billion tons for New Mexico and Colorado; no explanation is given why their estimate is at least five times the combined tonnage values of Shomaker and Holt (1973) and Shomaker and Whyte (1977). Crist and others calculated the coal-bed methane resource base to be between 22 and 34 TCF. The lower value (22 TCF) was calculated by extrapolation from five desorption samples available from Menefee coals, and the upper value (34 TCF) was calculated by treating the Menefee coals as equivalent in gas content to similar rank (thermal maturity) coals from the Fruitland Formation.

No wells in the Menefee Formation in New Mexico have been specifically completed as coal-bed methane wells. However, considerable volumes of gas may have been produced already from Menefee coal as part of the vertical stratigraphic interval contained in the Blanco Mesaverde reservoir, which consists of, in descending order: Cliff House, Menefee, and Point Lookout Formations. Dugan and Williams (1988) noted that between 1948 and 1955, most wells in this reservoir were completed open hole by shooting with solidified nitroglycerine throughout the entire stratigraphic interval.

Maximum drilling depths to the base of the Menefee Formation are about 6,000 ft, compared to about 4,000 ft for the Fruitland Formation. Other aspects of the Menefee that contrast to the Fruitland Formation are an increase in target-interval thickness, a decrease in individual seam thickness, and a decrease in reservoir continuity (Crist et al., 1990).

Raton Basin: Pennzoil's bonanza?

The New Mexico part of the Raton Basin (Fig. 1) lies mostly in Colfax County. Pennzoil Co. is the dominant player in this county because it owns the mineral rights on 780,000 acres and surface rights on 547,000 acres. Much of this acreage was acquired early in 1989 through purchase of certain assets of Kaiser Coal Co.

Relatively little is known publicly about the coal-bed methane resources of the Raton Basin. Jurich and Adams (1984) estimated 8 to 18.4 TCF of gas in place for the entire basin. In New Mexico, drilling depths for coal beds in the Raton and Vermejo Formations range from approximately 1,000 to 2,400 ft.

From 1989 through early 1991 Pennzoil drilled approximately 30 wells, of which 22 were completed and produced. These wells were cased, perforated, and hydraulically fractured. Initial production ranged from 1 to 390 MCFGPD with 20 to 580 BWPD (barrels of water per day). Through December 1990, cumulative production from these wells was approximately 263 MMCF and 596,000 BW. As there are no pipelines in this area, the gas is flared or used on location to power lease equipment. Produced water is placed in evaporation pits at the well sites. As of April 1991 the Oil Conservation Division reported 18 wells inactive and four producing. Initially, the company had studied "the economic feasibility of developing approximately 22,000 acres believed geologically favorable for methane gas production" (Pennzoil, 1990). Then, in July 1991 Pennzoil announced plans to plug all their wells in the Raton Basin. Long-range plans still include drilling 140 to 340 additional wells and reentering the previously drilled wells (Petroleum Information, 1991). Low gas prices certainly had a major impact on the decision by Pennzoil not to proceed with development at this time. Spot gas prices dropped below $1.00/MCF in many areas of the United States in July 1991.

Along the western edge of the Raton Basin in the Valle Vidal area, Pennzoil in 1977 gave 100,000 acres to the U.S. Forest Service (before the value of coal-bed

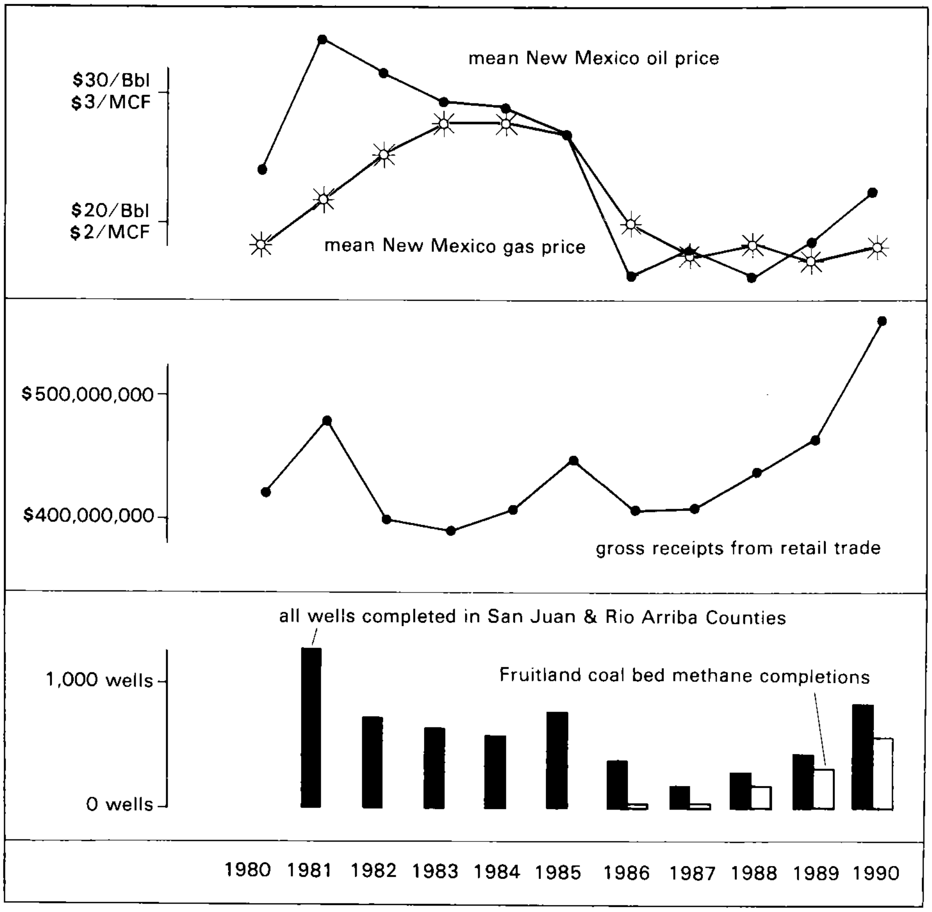

FIGURE 3—The economic benefits of coal-bed methane development. Sources of data: mean oil and gas prices in New Mexico (New Mexico Taxation and Revenue Department, Oil and gas accounting report—summaries for years 1980–1990: unpublished reports); gross receipts from retail trade, San Juan County (New Mexico Progress Economic Review, 1980–1990, Sunwest Financial Services Inc., Albuquerque, New Mexico); all wells completed in San Juan and Rio Arriba Counties, and Fruitland coal-bed wells completed in San Juan, Rio Arriba, and Sandoval Counties (Oil Conservation Division, Santa Fe, New Mexico).

methane was realized). In 1989 Pennzoil obtained coal and coal-bed methane rights on these acres through the purchase of Kaiser Coal Co. and now wants to drill for coal-bed methane. Attorneys for the U.S. Department of the Interior have released an opinion (*The Taos News*, 1990) stating that rights to the methane are not included in the rights to the coal. This opinion is now being reviewed by Pennzoil.

Economic benefits of coal-bed methane development

The exploration, discovery, drilling, production, and pipelining of coal-bed methane from Fruitland coal has created much wealth for the people, companies, and government in northwestern New Mexico. New Mexico oil prices peaked in 1981 (Fig. 3) and gas prices peaked in 1983. San Juan County began an economic decline, as expressed by gross revenues from retail sales, that only improved in 1988 because of coal-bed methane activity. Without these wells, in the face of continued low oil and gas prices, it is likely that Farmington and the San Juan Basin area would have remained at a much lower level of economic activity. The unique desorption process in coal-bed methane wells make them very long lived, thus these wells will continue to produce and benefit New Mexicans for another 20 to 40 years.

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Summary of New Mexico state taxes on natural resource production as of July 1, 1991

compiled by *James M. Barker*, New Mexico Bureau of Mines and Mineral Resources

Commodity	Tax	Rate and base
Potash	Resource Processor; Service* Severance	0.50% of taxable value 0.125% of taxable value 2.5% of taxable value
Molybdenum	Resource Processor; Service* Severance	0.333% of taxable value 0.75% of taxable value 0.125% of taxable value
Other taxable resources (except potash and molybdenum)	Resource; Processor; Service*	0.75% of taxable value
Copper	Severance Service; Processor* Ad valorem	0.50% of taxable value 0.75% of taxable value Depend on local county and school district (see HB 428)
Gold, silver	Severance	0.20% of taxable value
Lead, zinc, molybdenum, manganese, thorium, rare-earth, and other metals	Severance	0.125% of taxable value
Clay, sand, gravel, gypsum, pumice, and other nonmetals	Severance	0.125% of taxable value
Coal: surface underground	Severance Severance	$1.17 per short ton until July 1, 1993 $1.13 per short ton until July 1, 1993 $0.57 exempt (surface) (see HB 283) $0.55 exempt (underground) (see HB 283)
Uranium	Resource Severance	0.75% of taxable value 3.5% of 50% of sales price
Oil, gas, and carbon dioxide	Severance Ad valorem	3.75% of taxable value Many rates (counties certify annually on September 1 to Taxation and Revenue Department)
Oil, gas, geothermal energy, carbon dioxide, coal, and uranium	Conservation School	0.18% of taxable value 3.15% of taxable value
Gas and hydrocarbons incidental to processing	Natural gas processor	0.45% of taxable value

*Subject to only one of these taxes at a time. Data source: Taxation and Revenue Department, P.O. Box 2308, Santa Fe, New Mexico 87504–2308 (505/827–2700). For information about severance and resource taxes contact Cindy Lovato (505/827–0812); for oil and gas taxes contact Michael Holden (505/827–0805); for copper ad valorem tax contact Richard Martinez (505/827–0895).