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COALBED METHANE FROM THE FRUITLAND FORMATION, SAN JUAN BASIN, NEW MEXICO

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Abstract—Natural gas is the cleanest of the world's three main fossil fuels. Governor Bruce King emphasizes natural gas as the fossil fuel of choice for New Mexico in the State Energy Policy, released in 1991. Coalbed methane, also called coal seam gas, is a type of natural gas that is generated within and produced from coal. Coalbed methane is greatly expanding New Mexico's already substantial natural gas reserves and production capability. The Fruitland Formation of the San Juan Basin contains up to 50 trillion ft^3 of coalbed methane in place, and half of this may be producible reserves. Fruitland pore systems range from overpressured to underpressured, which greatly affects gas and water production rates and carbon dioxide content. The overpressured area, in the north-central part of the basin, contains the highest rate coalbed methane wells in the world, with some producing over 20 million ft^3 of gas per day (MMcfd). Most of these wells are completed using an open hole cavity created by sloughing coal which is then removed. Normally pressured and underpressured coals are completed through cemented casing and hydraulically stimulated. The San Juan Basin is the largest coalbed methane producing area in the world, with more than 380 billion ft^3 produced in New Mexico as of September 1991, when almost 1100 wells were producing over 700 MMcfd. Two new major pipeline projects are under construction by El Paso Natural Gas Company and Transwestern Pipeline Company to transport additional gas out of the San Juan Basin. Meridian Oil accounts for about two-thirds of total coalbed methane production, and other major producers include Amoco, Blackwood and Nichols, Phillips Petroleum and Nassau Resources. Coalbed methane is eligible for a federal tax credit, worth about $0.87 per MMBtu (about 1 Mcf) in 1990, if produced before 2003 from wells drilled prior to 1993. Coalbed methane provides substantial benefits to New Mexico through increased natural gas reserves, economic activity and revenues.

INTRODUCTION

Natural gas, oil and coal are the three main fossil fuels that provide the world with most of the energy it consumes today. In spite of the push towards renewable energy sources, fossil fuels will continue to provide the bulk of our energy supply for many years to come. The United States cannot produce enough oil to meet its own needs, and is dependent on foreign sources for almost half of what it consumes. Coal is available in large quantities, but has limited practical uses outside of electrical generation, and is the "dirtiest" of the fossil fuels. It produces more carbon dioxide, nitrogen and sulfur compounds, particulate matter and residual ash than any of the other fossil fuels per unit of energy produced.

Natural gas burns the cleanest of the three, and also produces the least carbon dioxide per unit of energy. This is a factor of increasing importance with the growing concern over possible global warming due to higher levels of atmospheric carbon dioxide. Gas is also expected to be more widely used in markets traditionally dominated by oil and coal. Use of natural gas is projected to steadily increase for the foreseeable future because of these and other factors.

Governor Bruce King and the New Mexico Energy, Minerals and Natural Resources Department have just released a state energy policy (King, 1991), which intends that natural gas will be the "fossil fuel of choice" for New Mexico. This policy proposes to promote production and marketing of New Mexico natural gas resources, including coal seam gas. There is currently an adequate supply of natural gas in the United States, which has kept prices competitive with other energy sources. If gas is to continue as the fossil fuel of choice, adequate supplies must be assumed well into the future. Coalbed methane may increase U.S. natural gas reserves substantially, and already has had a significant effect on New Mexico's reserves.

Coalbed methane, or coal seam gas, is a natural gas generated within and produced from some coals. It is composed dominantly of methane, but can contain other gases such as water and carbon dioxide, as well as small amounts of lighter hydrocarbons, including ethane, propane and butane. This gas has traditionally been considered only a dangerous nuisance to coal miners, and not economically recoverable in its own right. Coal seams are sometimes "wet," or saturated with water. Attempts to produce this gas often resulted in high water and low gas production, and the wells were plugged. Thus, coalbed methane was overlooked for decades as a viable natural gas resource.

Conventional natural gas reservoirs contain gas instead of water within the pore spaces, or "holes" within the rock. This gas often is not generated within the reservoir rock, but migrates into it from somewhere else. Most natural gas deposits in the San Juan Basin are sandstone reservoirs in this category. Coalbed methane, however, is a nonconventional gas in that it is adsorbed, or attached to the internal surfaces of the coal itself.

New Mexico has enormous coal resources that underlie one-fifth of the state. Of the 13 major coal fields in New Mexico, the two largest are in the San Juan and Raton Basins. Only these two areas to date have been tested for coalbed methane potential. The development of the Fruitland Formation coalbeds in the San Juan Basin has been so successful that this area has become the most productive coalbed methane area in the world, containing more than 1500 wells and producing almost one-quarter of all New Mexico's natural gas in 1991.

HISTORY

The San Juan Basin has been a gas producing region long before coalbed methane development began. In fact, before coal gas additions, the San Juan Basin field was already the second largest gas field in the conterminous United States after the Hugoton field of Oklahoma, Texas and Kansas (Fassett, 1988).

The Pictured Cliffs Sandstone, Mesaverde Group and Dakota Sandstone were early targets for gas drilling. The Fruitland Formation, however, was undeveloped and considered nonproductive, even though gas shows, kicks and sometimes blow outs were seen in the Fruitland sands and coals. The first Fruitland completion was made in 1952 in one of the sands (Dugan and Williams, 1988). Even after drillers began to target the Fruitland Formation, the coals were always bypassed if a sand was present. A completion in the coals was only attempted as a last-ditch effort to make a well. Efforts to complete the coals usually encountered high water production along with the gas, or had very little water or gas.

Stanolind Oil and Gas Company, now Amoco Production Company, completed several wells in the Ignacio Blanco field in Colorado beginning in 1951 (Dugan and Williams, 1988). These wells had open hole completions through both the Pictured Cliffs and Fruitland Formations. Other Stanolind wells were strictly Fruitland wells, such as the Garcia #1, drilled in 1953. This well had only small amounts of sandstone, the traditional reservoir rock, but produced for 16 years due to gas

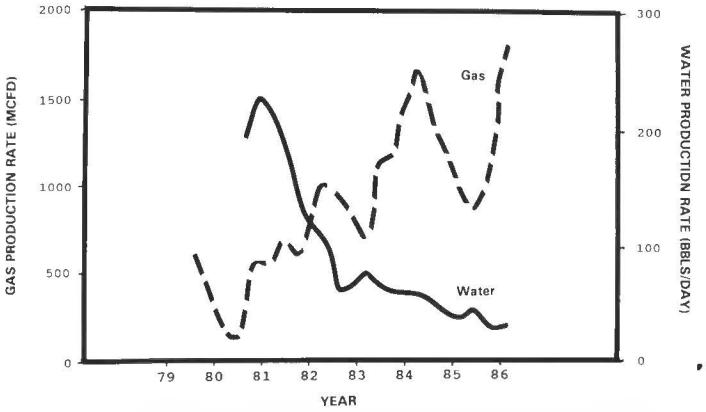


FIGURE 1. Gas and water production curve for the Amoco Production Company Well, Cahn Gas Com No. 1. Note increasing gas and decreasing water rates over time (data from Amoco Production Company, Southern Rockies Business Unit, 1992).

contributions from coal before being plugged because of high water rates.

In 1953, Phillips Petroleum drilled the San Juan Unit 32-7 No. 3 well. Because of an absence of reservoir sandstone, the well was completed only in the coal. Later that same year, the San Juan Unit 32-7 No. 6 was drilled, and its history of increasing production has been widely noted as a classic coalbed methane well (see below). In spite of these successes, some of which were not recognized as coalbed methane producers at the time, other targets were more attactive and the Fruitland coals were largely ignored for the next two decades.

Amoco drilled the Cahn Gas Com No. 1 near Cedar Hill, New Mexico, in 1977 and completed it only in Fruitland coals in order to test the potential outlined by their research efforts. By 1983, this well was producing at a rate of over one million cubic feet of gas per day (1 MMcfd) with less than 100 barrels of water, after starting out poorly (Fig. 1). Amoco had drilled four other coal wells at Cedar Hill, New Mexico, which were producing at commercial rates by 1983.

The Crude Oil Windfall Profits Tax Act of 1980 went into effect on January 1, 1980, and contained a tax credit for gas produced from nonconventional reservoirs, including coal seams. This spurred large numbers of operators to look closely at coalbed methane as an economic gas resource. Tenneco, William Perlman and Amoco all embarked on substantial coal seam gas development projects. Tenneco later sold its San Juan Basin properties to Amoco.

Meridian Oil, a wholly owned subsidiary of Burlington Northern, acquired the properties of El Paso Natural Gas Co., and began evaluating its holdings for coalbed methane potential. In 1986, drilling began in the San Juan 30-6 Unit, which had experienced numerous blowouts in the Fruitland while El Paso was drilling Mesaverde wells in the 1950s. Wells in this unit and surrounding areas proved to be extremely successful. In fact, these are the most productive coalbed methane wells in the world, with some production rates exceeding 20 MMcfd. With this phenomenal success, there was no longer any doubt that the Fruitland coalbeds were a valuable and economically viable resource.

The Section 29 tax credits included in the Windfall Profits Tax Act have now been extended to include production from coal seam gas wells drilled before January 1, 1993, but massive drilling programs were carried out by many operators during 1990 in anticipation of the earlier expiration date of January 1, 1991. As of early 1992, most operators are now concentrating on completing, testing and tying previously drilled wells into gas gathering systems. Coal seam gas operators are also closely monitoring declining natural gas prices, which threaten the profitability of many projects. Regardless of the short-term changes in

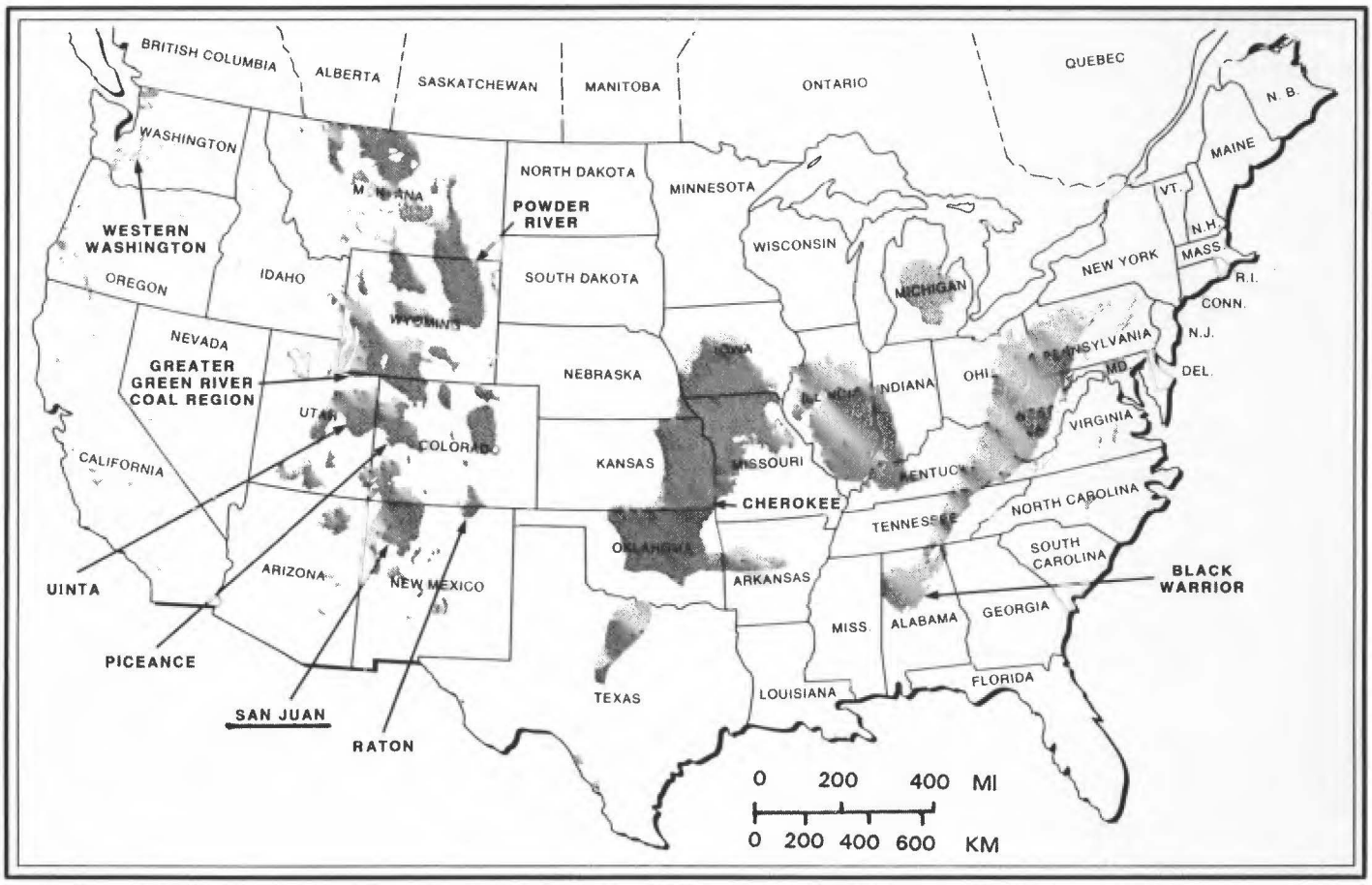


FIGURE 2. Location map of major U.S. coal basins, including the San Juan Basin (after Gas Research Institute, 1991).

the industry, activity in the Fruitland coal seam gas play in the San Juan Basin during the past five years has proven that this resource will be a major contributor to deliverable New Mexico gas supplies for decades to come.

THE RESOURCE

Geological setting

The San Juan Basin

The San Juan Basin is located in the east-central part of the Colorado Plateau in northwest New Mexico and southwest Colorado (Fig. 2). It is a roughly circular, asymmetric structural basin that dips steeply on the east and north and gently on the west and south. It was formed as a result of the Laramide orogeny during Late Cretaceous through Eocene time (80–40 Ma). The basin contains sedimentary rocks from Cambrian age to recent times. The total stratigraphic section may be as much as 5000 m thick, with the Cretaceous interval more than 2000 m thick (Fassett and Hinds, 1971). The Fruitland Formation and the Menefee Formation of the Mesaverde Group, located stratigraphically below the Fruitland, are the main formations containing coal in the San Juan Basin, although coal is present throughout the Cretaceous system. Currently, virtually all coalbed methane production in the San Juan Basin is attributed to the Fruitland Formation.

The Fruitland Formation

The Fruitland Formation is Late Cretaceous in age, and 60–160 m thick. The average thickness is 100–110 m with a general thickening trend from southeast to northwest (Fassett and Hinds, 1971). It directly overlies the Pictured Cliffs Sandstone, which was deposited during the final retreat of the Late Cretaceous sea. The Fruitland is composed of intertonguing marine and chiefly nonmarine sediments deposited at the edge of the Cretaceous seaway that transgressed and regressed across the basin. The dominant rock types are sandstone, siltstone, shale and coal.

The coalbeds were originally deposited as organic matter in swampy areas near the shoreline of the shallow sea to the east. They are found throughout, but are usually thickest in the lower one-quarter of the formation. As many as 16 separate coal seams have been identified, but commonly there are 6 to 9 (Fig. 3). Individual seams can be more than 10 m thick. Total net thickness varies considerably, but averages about 11 m (Fig. 4). A northwest-trending belt in the north-central San Juan Basin contains more than 22 m net of coal, and is the region of highest gas production. Maximum depths to the Fruitland coals are about 1230 m in the deepest part of the basin. Coal rank varies from subbituminous B to low-volatile bituminous (Ayers and Ambrose, 1990).

The Fruitland Formation in the San Juan Basin is divided into three different regions of formation pressure. In the northern portion of the basin the pressure is greater than the normal pressure gradient, so it is overpressured (Fig. 5). This is a result of fresh water recharge from precipitation along Fruitland outcrops in the San Juan Mountains of Colorado, along the northern edge of the basin. The rest of the basin is normally pressured or underpressured. Pore pressure greatly affects the reservoir and gas production characteristics of the coals.

Coalbed methane resources and reserves

Coalbed methane resources typically include the gas contained within the coal that is currently or potentially recoverable, considering economic conditions and technological advances that may not yet be available. This figure approaches the total amount of gas in the formation, also called original gas in place. Reserves, however, only include that portion of the known resource which can be economically extracted at the time of determination.

Coalbed methane resource determination involves calculating the tonnage of coal in areas of prospective coalbed methane development. Ayers and Ambrose (1990) included only coals greater than 123 m deep, and calculated 245 billion short tons in the Fruitland. This value is then multiplied by gas content per ton of coal, which varies depending on coal rank, formation pressure and ash content, but averages around 200 ft^3/ton. They calculated gas in place values of 43 to 49 trillion

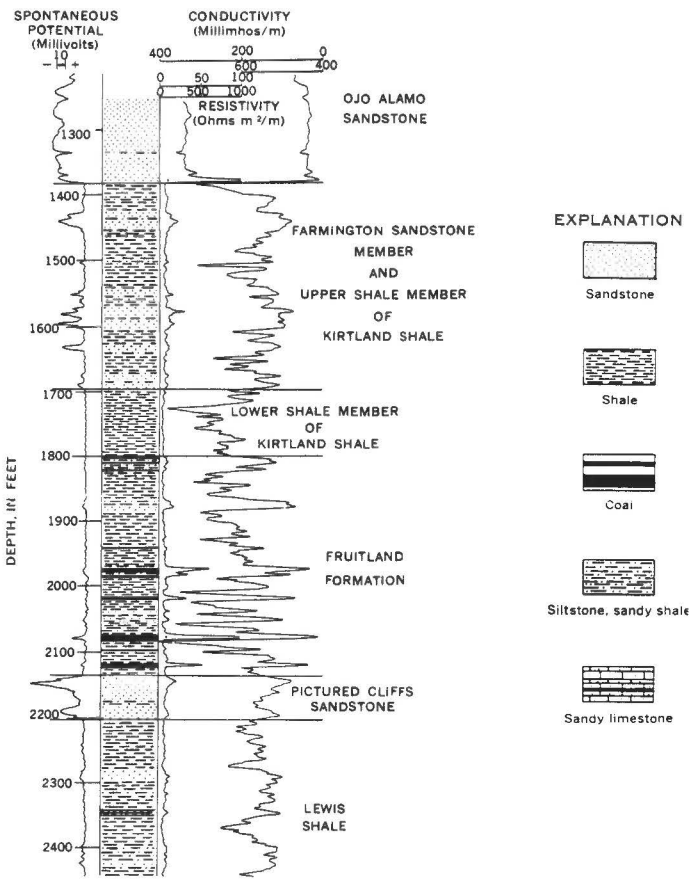


FIGURE 3. Induction-electric log and lithologic column of the Fruitland and surrounding formations (after Mullen, 1988).

cubic feet (Tcf). This compares with 50 Tcf reported by Kelso and Wicks (1988) and 31 Tcf determined by Choate et al. (1984).

The most difficult figure to identify is the recoverable gas in place. The most important factor influencing ultimate recovery is the variation in natural permeability, which is determined by fractures, or cleats in the coal. These cleats provide pathways for the gas to migrate to the wellbore. The better developed the cleating system, the easier it is for the gas to desorb and be produced. Other factors include continuity of the coalbeds, reservoir heterogeneity and reservoir pressure.

Another factor that varies with time is the economic viability of individual wells in an area. Natural gas prices, new technology, development and production costs, and completion techniques all play a role in determining if wells will be drilled and what production rates are necessary to keep wells on line. It is too early in the development of this enormous resource to determine what the ultimate recovery factor will be, but some areas of the Fruitland are expected to yield 70 to 80% of the gas in place, and other areas considerably less. Estimates of recovery for the entire basin average 50%. This gives ultimate coalbed methane gas production of up to 25 Tcf for the Fruitland Formation. About 17 Tcf of this is located in New Mexico. This could double New Mexico's natural gas reserves, which already rank second in the nation for onshore gas reserves (United States Department of Energy, 1991). As of January 1991, 3.5 Tcf has been added to the New Mexico proven gas reserves based on drilled wells and demonstrated production (Bland, 1991).

DRILLING AND PRODUCTION

Drilling methods

Drilling methods above the coals are similar for coal wells and conventional oil and gas wells. As with conventional wells, the primary objectives are to prevent formation damage and maintain well control.

According to Logan (1989), rotary drilling rigs, readily available in the San Juan Basin due to the well-developed oil and gas industry, are usually used to drill 7 7/8 or 9 1/2 in. holes in which 5 1/2 or 7 in. production strings are run. These rigs need drilling pads more than 100 m across, which can add significantly to costs because of the often rough terrain of the basin. Some coalbed methane wells are drilled on existing pads constructed years ago for conventional gas wells, in order to cut costs and prevent further environmental disturbance.

Drilling fluids are generally held in large mobile holding tanks (Logan, 1989) near the drilling rig. Reserve pits are commonly dug on location to manage excess fluids that may be produced during drilling and completion. Most wells are drilled with fresh water or polymer mud systems, and near balance or underbalanced with respect to formation pressure to prevent formation damage. Often, casing is set just above the coal objectives, and an underbalanced mud system is used to drill through the coal. This is in effect a controlled blowout, and prevents any drilling fluids from penetrating into the formation.

Nearly all coalbed methane wells have been vertical, but horizontal drilling techniques have been tested with success. Meridian Oil tested one horizontal well for over 7 MMcfd (Western Oil World, 1990), but

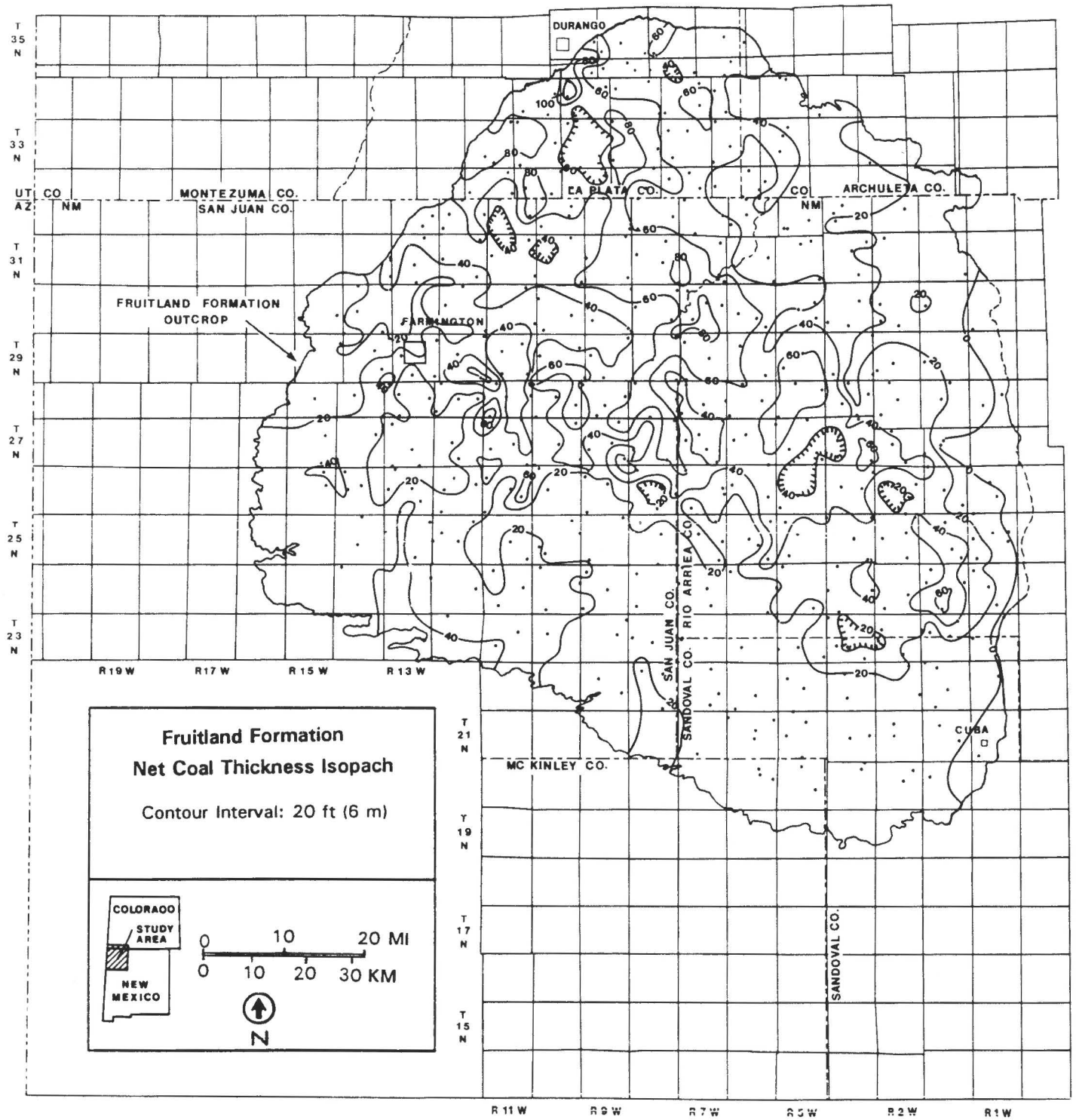


FIGURE 4. Fruitland Formation net coal thickness isopach map (after Kelso and Wicks, 1988).

has had such good success with vertical wells that the added expense of horizontal drilling is not economical at this time (M. K. Dawson, personal comm. 1991). Other areas of the basin that do not have such high natural permeabilities and formation pressures may prove to be better target areas for horizontal drilling.

Completion options

Several completion techniques have been used successfully in the Fruitland coals. Geologic conditions vary from location to location, so what works in one area may not be the best option elsewhere. Prior to the late 1980s open hole completions were commonly used, but coal fines that accumulated during production eventually reduced gas rates, requiring expensive workovers to clean out the wellbore. Gravel packs were tried, but quickly plugged up and had to be removed.

Cased hole fractured completions

Many operators use the cased hole completion method, which involves running casing, cementing it into place, and then perforating the casing. This procedure is often followed by a hydraulic fracture, or "frac" treatment. This method is the most common completion and stimulation method for conventional sandstone reservoirs in the basin. In most cases, productivity is increased substantially.

In some cases, where the wellbore is completed in a deeper zone, a recompletion can be made in the coal. In areas where the coal is known not to have tremendous potential, this is the most economical method to recover the coalbed methane. The Fruitland coals are sometimes commingled with other conventional gas reservoirs (M. Stogner, personal comm. 1992). Also, when several coal zones are completed at once, it is important to set casing through the entire interval to prevent sloughing and swelling of the shale and clay that separates the coals. Here, frac jobs are usually used to enhance permeability.

Open hole cavity completions

In the north-central part of the basin, where permeability and reservoir pressure are higher than average, a unique and more effective completion method was developed to maximize gas production (M. K. Dawson, personal comm. 1991). This method involves setting casing just above the coal and drilling it underbalanced with water, air or foam.

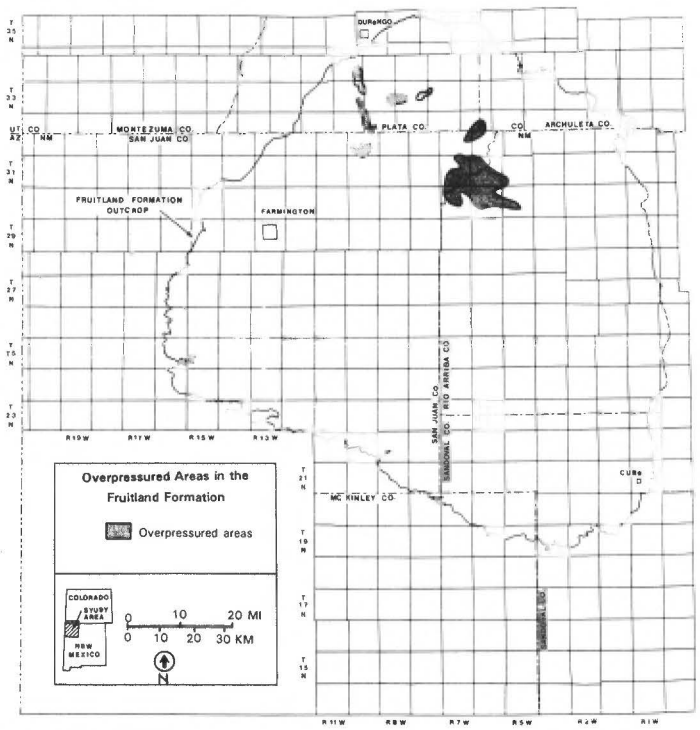


FIGURE 5. Location of overpressured areas in the Fruitland Formation (after Kelso and Wicks, 1988).

A cavity is then created within the coal seam by allowing the coal to collapse or crumble into the wellbore. This allows the coal near the cavity to fracture, thus increasing permeability as water and gas within the cleat system move toward the wellbore, which is the area of lower pressure. The coal cuttings are removed from the resultant cavity by displacing with air or foam. A perforated liner is then run in the hole for control purposes.

When naturally high pressure and permeability are already present in the coals, a procedure called "surging" can be used to create the cavity. First, the well is shut in to build the pressure up, then it is quickly released. This causes the coal near the wellbore to slough into the well. It is then removed. When the coal stops caving, the well is then shut in to again build up pressure, and the procedure is repeated. This process continues until the coal no longer sloughs, and the well is considered to be stabilized. The gas and water moving toward the well release pressure, which widens the natural cleats and fractures within the formation. This effect may extend as much as 100 m into the coal seam. After the hole is stabilized, a perforated liner is installed across the cavity (W. LeMay, personal comm. 1992).

Amoco Production Co., Gas Research Institute and Resource Enterprises Inc. are completing a joint research project that compares performance of hydraulically fractured cased hole wells to open hole cavity wells in the San Juan Basin. Amoco owns the Colorado site and wells on which the research took place. Gas Research Institute funded and is managing the project. Resource Enterprises Inc. is compiling and analyzing the data, which will be passed on to coalbed methane producers. The project's main goal is to develop guidelines for open hole coalbed methane completions that will outline reservoir properties required to develop successful cavities (Oil and Gas Journal, 1991a).

Costs

The average cost to drill, complete and install production equipment on a 900 m San Juan Basin Fruitland coal well using the open hole cavity method is about $375,000 to $450,000 (M. K. Dawson, personal comm. 1991). If problems such as greater than average site preparation, stuck drill pipe and slow cavity stabilization occur, costs can be much higher.

Costs usually are much lower in other areas of the San Juan Basin. Giant Exploration drilled wells in the southwestern area of the Fruitland coals that are 365–400 m deep; total costs to drill and complete are about $80,000. These wells are cased through the coal interval, and completed using a nitrogen and gel hydraulic fracture treatment. These wells average 200 thousand ft^3/day, and with expected ultimate recovery of around 1 billion ft^3 (Bcf) per well, are profitable even without the tax credit (M. D. Haddenham, personal comm. 1991).

Coal fines accumulate in the wellbore during production, and must be cleaned out periodically. This requires a workover, which costs about $50,000 (Logan, 1989). These operations may be needed less frequently as time goes on, especially as water production and formation pressure decrease.

Production characteristics

Gas and water production characteristics of the Fruitland coals depend on geologic and hydrologic conditions, which vary widely across the basin. Three major factors affecting production are reservoir pressure, reservoir permeability and coal thickness. The three separate pressure regimes in the Fruitland include an overpressured area (where the formation pressures are greater than fresh water gradient), a normally pressured area and an underpressured area.

The overpressured area, located in the north-central portion of the basin (Fig. 5), has the highest gas and water production rates. This indicates high permeabilities due to well developed coal cleats, with possible permeability enhancement from regional tectonic fractures. Some wells are flowing at pressures higher than the maximum pressure for desorption of the methane to begin, indicating that the production is currently being derived from the primary fractures and cleats in the coal (M. K. Dawson, personal comm. 1991). Once the formation pressure drops below this critical point, desorption of the methane from the

coal particles will begin to take place. In addition, the overpressured area is characterized by gas with a CO_2 content of 3–10%. This is too high for pipeline specifications, so the CO_2 must be removed before the gas can be sent to market. This gas is generally quite dry, containing only small amounts of heavier hydrocarbons such as ethane, propane and butane.

Wells in the overpressured areas often display the unusual "negative decline curve." Most conventional oil and gas wells display a normal decline curve for production, which means the highest production rates are usually observed at or near the beginning of the producing life of the well. Rates than decline until abandonment. Coalbed methane wells, however, can initially produce large volumes of water along with the gas as the natural fractures and cleats are drained. As pressure drops, water production decreases. This reduces the hydrostatic head that the gas must overcome to make its way to the surface, and allows desorption of the gas to begin. Because most of the methane contained in the coal is adsorbed onto the surfaces of the coal, desorption is very important. As water production and formation pressure drop, gas rates increase, thus the "negative decline" (Fig. 1). Eventually, the rate will level off and begin to decline as in a conventional well. Coal can contain several times the amount of gas per unit volume of rock as a conventional reservoir; thus, coalbed methane wells are expected to have very long producing lives.

The underpressured areas lie in the western, southern and eastern portions of the basin. They are characterized by little or no produced water, low reservoir pressures, thinner coals and generally lower production rates (Kaiser et al., 1991). The permeabilities are usually lower than those of the overpressured area. Carbon dioxide content is commonly less than 2%, and higher amounts of heavier hydrocarbons are present (M. D. Haddenham, personal comm. 1991). This gas does not require processing and can be put directly into the pipeline, greatly reducing processing costs. However, compression is needed because the low wellhead pressures cannot feed directly into high pressure pipelines.

As of January 1992, all coalbed methane recovery has been from primary recovery methods. However, in November 1991 Amoco Production Co. began a two-year, nitrogen enhanced, coalbed methane recovery pilot project in La Plata County, Colorado, in the northern San Juan Basin (Oil and Gas Journal, 1991b). The goal is to quantify methane recovery gains achieved by injecting nitrogen directly into a 6 m interval of the Fruitland Formation. Nitrogen injection reduces the partial pressure of methane and allows it to desorb without having to reduce the total reservoir pressure to stimulate methane desorption. Injection should also produce higher pressure, which is expected to increase permeability and production rates by opening fractures in the cleat system, according to Amoco laboratory tests. If successful, this procedure would also be applicable to producing areas in the New Mexico portion of the basin and elsewhere.

Gas gathering and processing

Much of the coalbed methane produced in New Mexico is not "pipeline quality," meaning that it must be processed so that it meets specifications for pipeline gas composition. The main problem is the high CO_2 content. Conventional gas produced in the San Juan Basin does not require this type of processing, so the coal seam gas must be collected and processed separately. In addition, the high volumes of water produced along with the gas must be managed. More than 1100 km of pipelines for transporting the gas to special processing plants have been constructed. Pipelines for transporting produced water are often laid with gas pipelines to minimize the need for additional trenches, right-of-way acquisition, and environmental disturbance. In addition, almost all new pipelines are to be laid along existing pipelines and roads to further minimize environmental impacts, as outlined in U.S. Bureau of Land Management guidelines.

Two plants remove carbon dioxide and water from the gas stream coming directly from the wells. Most water is physically separated from the gas at the well site, but the gas still contains water vapor that must be removed. Meridian Oil's Val Verde plant and the Milagro plant, operated by Williams Field Services, have a combined treating capacity of 920 MMcfd.

Carbon dioxide production

Meridian's Val Verde plant processed 74 Bcf of gas from February 1990 through December 1990. Approximately 7.7 Bcf of CO_2 was removed, or about 10% of the original gas input (Whitehead, 1991). Currently, this gas is being vented to the atmosphere. Up to 15 Bcfg/yr could be generated if the plant operates at capacity, and CO_2 percentage remains constant. In addition, if the Milagro plant also operates at capacity with a similar CO_2 component, an additional 17.5 Bcfg/yr could be generated.

CO_2 gas is used in enhanced oil recovery projects in the large oil fields of the Permian Basin in west Texas and eastern New Mexico. This CO_2 currently comes from southwestern Colorado and northeastern New Mexico. The Cortez pipeline that transports this gas is only 13 km from the Val Verde plant, but a pipeline would have to be constructed and compression added in order to tie into the line. At present, economics do not favor this construction (M. K. Dawson, personal comm. 1991). In the future, a tie-in to this line may be made to market this product, prevent waste of a natural resource, and to reduce atmospheric CO_2 emissions. New Mexico CO_2 sold for $0.29 per Mcf during July 1991 (New Mexico Taxation and Revenue Department, unpubl. 1991). At this figure, 32.5 Bcf of CO_2 would have a sales value of almost $10 million. New Mexico 1990 sales were about 117 Bcfg from the Bravo Dome, located in Harding and Union Counties. It is unknown whether additional sales contracts could be obtained for CO_2 production from coalbed methane processing plants.

Water disposal

The large volumes of water produced from coalbed methane wells must be managed in an environmentally sound manner. All water produced from oil and gas operations, including coalbed methane wells, is regulated by the New Mexico Oil Conservation Division (OCD). Most of this water is too saline to be used for domestic purposes, such as irrigation or watering of livestock, except in the extreme northern end of the San Juan Basin in Colorado.

Most water disposal techniques include truck or pipeline transport to sites for underground injection or surface evaporation pits. Injection wells have high start-up costs, and can require on-site storage. Evaporation pits also have high start-up costs, often require large land surface areas, and are frequently subject to environmental problems such as seepage or retaining wall failure (Zimpfer et al., 1988).

Underground injection is the preferred method for most water disposal. Injection plans are approved by the OCD, and fresh surface and ground waters must be protected when drilling and using injection wells. Meridian Oil, by far the largest water producer, currently operates six disposal wells for Fruitland water. These wells inject into the Morrison, Bluff and Entrada Formations. As of January 1, 1991, more than 23 million barrels of water have been produced from the Fruitland Formation in New Mexico alone, and most was reinjected (NM Oil and Gas Engineering Committee, 1991). High volume production wells usually have pipelines that transport water directly to a disposal well. However, it is usually more economical to install storage tanks on site if water production is lower. These tanks are periodically emptied into trucks, which transport the water to disposal facilities.

Evaporation pits are shallow with a large surface area to maximize evaporation rates, especially in cold winter periods when these rates are low. An evaporation pit must be constructed so as to prevent seepage. In most cases, the pit must be lined with an impermeable artificial liner or clay. A pump-and-spray method may be used to increase evaporation by 5 to 10 times normal rates. This allows for smaller pit surface areas, or larger daily water input. Pits can be more economical than injection for large water volumes (Zimpfer et al., 1988).

All pits must go through a hearing process before OCD approval is granted. New Mexico state law (Rule 711, Sec. A-9) now requires open pits to be covered with nets to prevent migratory birds from coming in contact with oily and polluted waters. Surface appearance and po-

tential environmental problems, such as retaining wall failure and leakage of brines into ground water, are causing increasing concern over the existence of evaporation pits, and regulations which manage them are becoming more restrictive.

CURRENT STATUS OF INDUSTRY

Major players and gas production

The San Juan Basin has been a major oil and gas producing region for more than forty years. As such, most of the acreage in the basin was already leased for oil and gas long before interest in the Fruitland coal seams began to grow. When the significance of the productive Fruitland methane reserves was realized, it was very difficult for companies without existing holdings to acquire large blocks of cheap land for development of a "new" play.

A major advantage of this situation was the well-developed petroleum industry infrastructure already in place. Most companies now producing coalbed methane had staff working the area, leases to drill upon, subcontractors to work with, equipment and facilities to utilize, and rights-of-way in place. In some areas, it was possible to recomplete existing wells or commingle the Fruitland with other zones to lower costs, allowing coal seam development in areas that otherwise would be uneconomic. These factors undoubtedly spurred experimentation and development sooner than if the basin had been barren of other petroleum reserves.

Coal seam gas production has increased dramatically in recent years, exploding from practically no production at all in the mid-1980s to more than 700 MMcfd in September 1991 (New Mexico Oil Conservation Division, unpubl. 1991) from the New Mexico portion of the basin. This production figure is higher than total natural gas production from all but seven states, and is more than half of the total for the prolific San Juan Basin in New Mexico. As of September 1991, Fruitland coal seams have yielded more than 380 Bcf. Virtually all production in New Mexico is attributed to one of three reservoirs—the Basin Fruitland Coal (gas) Rio Arriba County, the Basin Fruitland Coal (gas) San Juan County, and the Cedar Hill Fruitland Basal Coal (gas). In this case, the reservoirs are administrative subdivisions of the Fruitland coalbed methane deposits, and not indicative of pressure separation.

Coalbed methane producing companies

During the 1980s, Amoco purchased properties from Tenneco and William Perlman, and Burlington Resources purchased El Paso Natural Gas Company, Southland Royalty, and Union Texas Petroleum. Meridian Oil, a subsidiary of Burlington Resources, operates all their petroleum properties. These acquisitions, plus existing lease holdings, have helped to make two companies the dominant players in both the Colorado and New Mexico sections of the San Juan Basin coalbed methane industry (Table 1). They have aggressively pursued research and innovative drilling and completion technology.

Meridian Oil accounts for almost three-quarters of total New Mexico coal seam gas production, as of September 1991. Meridian owns much of the acreage in the overpressured area, which yields very high rate wells. The San Juan 30-6 Unit is legendary for wells that produce at least several MMcfd. Meridian has produced more than 176 Bcf as of 1 January 1991, with 142 Bcf from the 30-6 Unit (NM Oil and Gas Engineering Committee, 1991). They have actively pursued drilling, laying of pipelines, and construction of facilities necessary to bring coal seam gas to market. Meridian's success was unparalleled in the history of the coalbed methane industry, and is in part responsible for spurring other companies to develop their own leases.

Amoco is more active in Colorado than New Mexico, but is still the second largest coalbed methane producer in this state, having produced more than 20 Bcf by the end of 1990. Amoco also was a pioneer in early coalbed methane exploration, and is continuing research in many sectors of the industry, including the completion comparison and nitrogen injection programs mentioned earlier. Blackwood and Nichols, an affiliate of Devon Energy, is the third largest coalbed methane producer in New Mexico, with more than 7 Bcf. They have acreage in the Northeast Blanco Unit, located in the prolific overpressured area.

TABLE 1. All companies with coalbed methane production as of 12/31/90. Included are number of producing wells and total accumulated gas, in million cubic feet (MMcf) (NM Oil and Gas Engineering Committee, 1991).

	Company	No. of Wells	Total Gas
1.	Amoco Production Co	59	20,827
2.	Arco Oil & Gas Company	6	35
3.	Basin Minerals, Inc.	1	47
4.	Robert L. Bayless	6	42
5.	BHP Pet. (Americas, Inc.)	3	36
6.	Blackwood & Nichols Co Ltd	48	7481
7.	Joel B. Burr, Jr.	4	100
8.	Dugan Production Corporation	5	580
9.	Giant Exploration & Prod. Co.	18	404
10.	Great Western Drilling Company	1	13
11.	Hallwood Petroleum Inc.	5	55
12.	Curtis J. Little	1	.1
13.	Manana Gas Incorporated	1	204
14.	Marathon Oil Company	3	74
15.	Jerome P. McHugh	1	37
16.	McKenzie Methane	6	191
17.	Meridian Oil Incorporated	351	176,595
18.	Merrion Oil and Gas Incorporated	5	5
19.	Mesa Operating Limited Partnership NW	6	508
20.	Nassau Resources, Inc.	57	4141
21.	Northwest Pipeline Corp	4	49
22.	Phillips Petroleum Company	42	4447
23.	Richmond Petroleum Inc.	4	32
24.	D. J. Simmons, Et Al	5	175
25.	Simmons Engr. & Consulting Co.	2	210
26.	Orville S. Slaughter, Jr.	2	50
27.	Southland Royalty Company	34	4822
28.	Texaco Inc.	4	5
29.	Union Oil Company of California	48	672
30.	Union Texaco Petroleum Corporation	4	536
	TOTALS	736	222,373

Southland Royalty Company, Phillips Petroleum and Nassau Resources all have produced more than 4 Bcf of coalbed methane as of 1 January 1991. Phillips had little activity in the San Juan Basin until 1989, when it returned as a working interest owner. Phillips drilled 142 wells in 1990, but not all have been placed on production as of late 1991 (R. Flesher, personal comm. 1991). Union Oil of California has several dozen wells in production, and has drilled others. Giant Exploration has lease holdings in areas where costs are lower, and has drilled 64 wells as of September 1991, with 30 on line. A 60-well drilling program is planned for 1992 (M. D. Haddenham, personal comm. 1991). As of 1 January 1991, Giant had produced over 400 MMcfg.

Pipeline status

Three major pipeline systems move gas out of the San Juan Basin to interstate and intrastate markets. Sunterra Gas Gathering Company, an affiliate of Gas Company of New Mexico, delivers gas within this state. El Paso Natural Gas Company, a subsidiary of Burlington Resources, provides gas primarily to California, but also has markets in Arizona and Nevada. Northwest Pipeline Corporation markets gas in the Pacific Northwest.

The tremendous increase in natural gas production capacity of the San Juan Basin has caused problems in moving available gas. Currently, production capacity exceeds pipeline capacity to transport gas out of the basin. This has caused competition between producers for access to pipelines, which in turn has caused wellhead gas prices to fall. New projects currently under construction should help increase access to various markets in the end use sector.

Two major projects are currently under construction in the San Juan Basin. El Paso Natural Gas has the largest, a $241.5 million expansion program that is the largest in the company's history. This project will

increase capacity on El Paso lines out of the San Juan Basin by 835 MMcfd to 2.5 Bcfd (Southwest Oil World, 1991). Currently, all San Juan gas is transported west. One part of the El Paso project will convert the San Juan crossover between Plains, Texas, and Gallup, New Mexico, to two-way operation. For the first time, this will allow for the movement of up to 429 MMcfd eastward to markets in the Midwest and East. Another part of the project will increase capacity on the mainline system to California by 406 MMcfd. This will feed the new Mojave Pipeline, which delivers gas to the heavy oil fields in Kern County, California. El Paso hopes to have the project finished by April 1992.

Transwestern Pipeline Company, a subsidiary of Enron, has started construction on a $93 million project to add 170 km of 77-cm pipeline from the Blanco producing area to the Transwestern main line in Thoreau, New Mexico. This lateral expansion will carry an additional 520 MMcfd out of the basin, and may also be marketed in Texas and Oklahoma. A second part of the project will add 340 MMcfd of capacity on the main line to California by adding 335 km of 77-cm pipeline in Arizona. Completion is targeted for 1992 (Southwest Oil World, 1991).

Gas prices and tax credits

Coalbed methane is priced and sold the same as natural gas derived from conventional sources. However, the tax treatment for "nonconventional fuels," which includes coal seam gas, affects marketing of the gas. San Juan Basin wellhead gas deliverability has increased by over 50% in the past three years due to coalbed methane development, and this figure is certain to rise further. It is commonly believed that once a coal seam well is put on production and begins to dewater, it is better to flow the well continuously and not shut the well in. Shut-in allows water to again collect near the wellbore, thus increasing reservoir pressure. This will inhibit desorption of gas and reduce well productivity. As a result, when pipeline capacity restricts gas transport out of the basin, coalbed methane is sometimes given preference by operators, and conventional wells are shut in. This high degree of competition for space in the pipelines has led to reduced gas prices paid to producers for most types of gas, particularly coalbed methane, partly because much of it is not dedicated to long-term contracts. A tax credit that applies to coal seam gas can help to offset low prices if the interest holder can use the credit (see section on tax credits below).

Gas prices have dropped by as much as 50% during 1991 and early 1992. Coal seam gas and conventional gas have both been selling for less than $1.00 per Mcf at the wellhead in some areas. During 1992, these low prices have been prevalent throughout most of the central and western U.S., reducing fears that San Juan coalbed methane was priced well below other gas sources. Revenues derived from gas sales are directly proportional to wellhead price, and a small drop in price has a significant effect on revenues to the state of New Mexico. Even before the big drop in natural gas prices in 1991, the overall trend of gas prices in New Mexico has been down since they peaked in 1984 (Table 2).

TABLE 2. Wellhead prices, marketed production and value of all New Mexico natural gas from 1980–1990. Real price is inflated, using the consumer price index for urban wage earners and clerical workers (CPI-W), with 1990 = 100 (Bland, 1991).

YEAR	WELLHEAD PRICES (dollars per thousand cu. ft.) NOMINAL	REAL	MARKETED PRODUCTION (billion cu. ft.)	VALUE OF SALES (million $)
1980	1.80	2.80	1,097.2	1,975.2
1981	2.15	3.04	1,080.8	2,332.6
1982	2.52	3.37	969.5	2,444.3
1983	2.73	3.52	858.0	2,351.9
1984	2.77	3.46	912.5	2,527.6
1985	2.67	3.20	868.6	2,321.6
1986	1.89	2.25	673.4	1,275.7
1987	1.69	1.94	761.1	1,287.1
1988	1.74	1.91	740.5	1,285.1
1989	1.60	1.68	817.2	1,304.1
1990	1.72	1.72	899.2	1,554.5

Once the new pipeline projects now under construction are completed, San Juan Basin producers will have access to more diverse markets, and not be captive to California utilities. Greater access could mean additional sales and higher prices as producers are able to seek higher-valued markets.

Nonconventional tax credit

The Crude Oil Windfall Profit Tax Act of 1980 (outlined in Section 29 of the IRS Code, formerly Section 44D) provided an incentive for production of various nonconventional fuels such as oil from shale and tar sands, gas from geopressured brines, biomass, and Devonian shales (Soot, 1987). Gas from "tight" or low permeability reservoirs was originally included, later deleted, and then made eligible once again in 1991.

Petroleum from these sources originally was eligible for the tax credit if the production well was drilled before January 1, 1990, and the production itself occurred within the next 10 years. It has since been extended twice, giving operators until December 31, 1992 to drill production wells, and through 2002 to produce gas that is eligible for the tax credit. This tax credit was intended for times when a general decline of oil prices might lead to market noncompetitiveness for nonconventional fuels, such as conditions in the current market. The tax credit can be calculated from the following formula:

TAX CREDIT = ($3/BOE) × (I) × (PH) where:

BOE = Barrel of oil equivalent, 5.8 MMBtu

I = Inflation Adjustment Factor, which is based on the GNP implicit price deflator

PH = Phaseout Factor (always less than or equal to 1)

The tax credit varies depending on factors I and PH. The Phaseout Factor is based on domestic crude oil prices, and may cause the tax credit to be either partially or totally phased out. During the early 1980s, oil prices were high enough to phase out the credit. In 1991, however, oil would have had to reach over $42 per barrel for phaseout to begin, and more than $53 per barrel for complete phaseout of the tax credit. Due to conditions in the oil industry around the globe, oil prices are not expected to escalate to levels that would cause phaseout during the next decade. For 1990, the tax credit was $0.865 per MMBtu, which is approximately one Mcf. The credit is subtracted from tax liability and must be taken during the same year the gas is produced.

With spot market gas prices less than $1.00 in many areas during the summer and fall of 1991, some have said it would be more profitable to give away the gas and take the tax credit. This may be a slight exaggeration, but for those companies able to take advantage of the tax break, it certainly increases profitability. Unfortunately, many small producers who are on the brink of financial disaster because of the depressed condition of the industry do not have corporate structures or tax situations that allow them to utilize all or even part of the tax credit. Large companies like Meridian often are not able to take full advantage of the credit either. Fortunately, the wells in the San Juan Basin often can stand on their own, and are profitable without the tax credit.

A report titled *An Economic Analysis of the Coalbed Methane Tax Credit* was prepared by Dr. Alfred Parker, Professor of Economics at the University of New Mexico, under contract to the Office of Interstate Natural Gas Markets within the New Mexico Energy, Minerals and Natural Resources Department. The report examines several scenarios of natural gas production in the state. The analysis indicates that in the short term, the tax credit will cause coalbed methane to displace conventional gas, and prices will fall. Total gas production is not affected, so all revenues to producer and the state alike will also fall. In the long run, total gas production will increase, but added capacity will still cause prices to decrease. The interaction of these two factors makes it difficult to determine the ultimate effect on producer and state revenues.

The report also addresses the impact of a state tax levied to offset the federal tax credit. The analysis suggests that it would be very difficult to properly establish the amount of this tax, but that coalbed methane production would continue even with the tax. Also addressed is the impact of restricting coalbed methane production, which would be of questionable benefit to the industry and state. Such restrictions may

benefit conventional natural gas producers at the expense of coalbed methane producers, but the total effect on industry and state revenues is unknown (Gas Marketing Bureau, 1991c).

Regulation

Oil and gas exploration, production and processing are regulated principally by the Oil Conservation Division (OCD) of the New Mexico Energy, Minerals and Natural Resources Department. Coalbed methane is considered natural gas, and is regulated as such. Oil and gas leases are obtained in order to procure rights to develop coalbed methane. The San Juan Basin of New Mexico has not seen the ownership disputes found in other states like Pennsylvania.

The first pool specifically established by the New Mexico OCD for coal seam gas was the Cedar Hill Fruitland Basal Coal (Gas) pool, designated in 1984. In October 1988, the OCD established the Basin Fruitland Coal (Gas) pool. It was designed to include all coal seams within the Fruitland Formation except the previously outlined Cedar Hill pool. For accounting purposes, production from San Juan and Rio Arriba Counties is recorded separately.

The OCD established a 320-acre drilling spacing for the Basin Fruitland Coal. Several operators recommended a 160-acre spacing in part of the pool due to geologic conditions and expected drainage patterns. The relatively recent development of the coals has resulted in a lack of detailed knowledge about the coals as a gas reservoir. Acknowledging this fact, the OCD ruled in a hearing that individual operators may petition for a 160-acre spacing in certain cases. This will, in effect, make the Basin Fruitland Coal pool the only one in the state to have different spacings within the same pool (Whitehead, 1991).

Much development in the San Juan Basin has taken place on federal lands, partly because most of the land in this area is managed by the BLM. The OCD regulates the actual production of oil and gas, but the BLM has established rules and regulations for certain other activities on their land. These most commonly pertain to site preparation, construction of surface facilities and laying of pipelines. Increasing attention is being given to minimal environmental disturbance, and provisions in construction permits reflect this trend.

IMPORTANCE OF NEW MEXICO'S COALBED METHANE INDUSTRY

Revenues

The coalbed methane industry has had a large impact on the San Juan Basin area and New Mexico as a whole. Local and regional revenue benefits are already being derived from increased oil field activity. State revenues in the form of taxes and royalties on coalbed methane are growing rapidly, but most are currently replacing revenues that would have been collected from conventional gas production. Increased gas deliverability has prompted pipeline companies to build new lines to increase capacity out of the basin, which should ultimately increase gas sales and revenues. The greatly increased resource base should ultimately provide larger total tax revenues.

In 1991, almost one-fourth of all New Mexico natural gas sold will come from coal seams. The state was the major recipient of taxes and other revenues collected from coal seam gas production. As of September 1991, a total of 380 Bcf of coal seam gas had been produced. Total taxes paid on this gas to the state, including school, severance, conservation, production, equipment and processors taxes amounted to almost $75 million. A significant portion of this goes to support schools throughout the state. An additional $35 million has been generated through lease royalties, rentals and bonuses, for a total exceeding $100 million. Figures from 1991 alone are expected to total about $50 million (D. M. Bland, unpubl., 1991).

Over half of natural gas taxes are earmarked for deposit in the two state permanent funds, which are not themselves spent, but do provide interest income each year to state coffers. In 1990, more than $380 million in interest was generated from these two funds. Almost all of the funds in these accounts were derived from petroleum sources, with natural gas providing well over half. With coalbed methane deliverability expected to increase substantially, gas will continue to be the largest contributor to these two funds. New Mexicans will continue to benefit from this industry long after the gas is gone, even though the resource is expected to last many decades.

Using reserve estimates outlined earlier, recoverable gas from the Fruitland Formation in New Mexico alone could total 17 Tcf. If this gas was produced at today's prices and tax rates, it would generate almost $2 billion in indirect taxes, not counting interest generated from the two permanent funds. An additional $1.3 billion would be generated from lease royalties, rentals and bonuses, for a total of over $3 billion. On top of this, several hundred million dollars will be generated each year from coalbed methane's share of the permanent funds. These figures are not intended to be predictions of future revenues, because future prices and tax rates will change, and total gas production is not known. However, they can be used to illustrate the importance of the resource. For comparison, total revenues dispersed from the New Mexico 1991–1992 fiscal year's General Fund are expected to be just over $2 billion, which supplies most of the state's operating budget.

Local and regional benefits

Throughout much of the twentieth century, northwestern New Mexico has been greatly influenced by the development of natural resources, including not only oil and gas, but also coal and uranium. The nature of these industries in the past has been cyclic, where activity swells and then declines. During the past 10 years, there has been an enormous variation in activity level, particularly in the petroleum and uranium industries. In 1981, more than 7000 people were employed in the uranium industry, and more than 17,000 were directly employed in the petroleum industry in New Mexico. Virtually all of the uranium and about one-quarter of the petroleum employment was in the San Juan Basin. By 1990, those numbers had dwindled to less than 100 in uranium, and under 10,000 for oil and gas.

San Juan County petroleum employment, including those directly employed in the petroleum and pipeline industries, peaked during the last boom at more than 4100 in 1981. Employment then declined to just over 1740 in 1987. In 1990, petroleum employment declined further in the rest of the state, but San Juan County logged a 67% increase by jumping to over 2900 (NM Department of Labor, 1991). Virtually all of this was due to coalbed methane activity (Table 3).

The number of drilling rigs operating in the area is also a good indicator of the health of the petroleum industry. After the first extension, the federal tax credits were applicable to coal seam gas production from wells drilled before January 1, 1991. Many companies believed this tax break would not be extended further, so they initiated very aggressive drilling programs during 1990 in order to meet the deadline. The average rig account for the entire state during 1989 fluctuated between 30 and 40. During 1990, the count was as high as 75, and averaged between 50 and 60. Most of this increase was due to coal seam gas drilling in the San Juan Basin. In 1991, after the tax credit was extended to apply to all wells drilled before January 1, 1993, the rush to drill wells was off and drilling programs were reduced. Many companies are now working on completing and tying previously drilled wells in to pipelines in order to begin selling gas. Throughout 1991,

TABLE 3. Average oil and gas employment by county in New Mexico for 1980–1990 (Bland, 1991).

YEAR	LEA COUNTY	EDDY COUNTY	SAN JUAN COUNTY	OTHERS	TOTAL NEW MEXICO	PERCENT CHANGE
1980	7,381	1,359	3,472	1,229	13,441	+23.1
1981	9,161	2,242	4,173	1,503	17,079	+27.1
1982	8,182	2,277	3,412	1,561	15,432	-9.6
1983	6,984	1,842	2,895	1,257	12,978	-15.9
1984	7,348	1,801	3,008	1,293	13,450	+3.6
1985	7,302	1,847	3,255	1,150	13,554	+0.8
1986	5,433	1,266	2,321	915	9,935	-26.7
1987	5,020	1,095	1,742	1,036	8,893	-10.5
1988	5,116	1,135	1,942	1,007	9,200	+3.5
1989	4,430	1,166	1,991	943	8,529	-7.3
1990	4,678	1,207	2,906	1,164	9,955	+16.7

more and more wells began producing gas and total coalbed methane production continued to increase.

Exploration and development companies also have expanded in order to develop coal seam gas. About 30% of Meridian's office staff of 350 are working directly on coalbed methane (M. K. Dawson, personal comm. 1991), and their staff has doubled since the beginning of the Fruitland project (C. R. Owen, personal comm. 1991). Prior to the buyout by Meridian Oil, El Paso Natural Gas may have closed its office if not for the coalbed methane play. Many of Phillips Petroleum's staff of 58 are working on coalbed projects. Their office was opened in Farmington in 1989. Unocal has also opened an office. Many others, including Conoco and Marathon, have expanded existing offices or added field personnel.

In addition to direct employment, many people are indirectly employed because of the increase in activity. These include service industries and support businesses for the oil and gas industry. In the past two years, additional expansions of personnel and equipment have taken place at these companies. This increased activity also provides a further economic boost through other ancillary businesses, such as restaurants, food stores, retail outlets, equipment and machinery suppliers, and the like, which benefit from money being pumped into the local area. Even the real estate market has taken an upturn recently. Also, Wal-Mart is constructing one of their largest stores in the Farmington area (D. A. Schoderbek, personal comm. 1991). Increased sales of all kinds mean a shot in the arm for local government revenues, due to higher taxes collected on these added sales.

Markets for coalbed methane

Coalbed methane is natural gas, so the markets for it are the same as markets for conventional gas from the San Juan Basin. Because of production costs and tax considerations, total costs to the producer may be lower for coalbed methane than for conventional gas. It could then be sold at a lower price and still generate a profit, whereas conventional gas may have to be shut in to avoid operating at a loss. This may keep certain markets open to coalbed methane that would be closed to conventional gas. Access to a wider variety of markets in more diverse locations will benefit producers, consumers and pipeline companies. In this light, the ability to sell gas to points east of New Mexico would be a major step forward in marketing this state's natural gas.

Projects under way aim toward this end. Intrastate pipelines are working to establish numerous intra- and interstate pipeline interconnects, offering flexible transportation arrangements, innovative capacity access agreements and storage access. Some of the advantages of using intrastate pipelines to increase marketing efforts include numerous interconnects allowing shippers to offer diverse supply sources, the ability to nominate on most lines up to the last minute, and the availability of firm intrastate transportation, which provides access to local distribution centers and industrial customers (Gas Marketing Bureau, 1991b).

The Gas Marketing Bureau was created in 1987 within the Oil Conservation Division, a part of the New Mexico Energy, Mineral and Natural Resources Department. The objective is to aid in marketing New Mexico natural gas.

> The Gas Marketing Bureau seeks to be proactive in gas industry matters, without being radical and to lead rather than to follow. As an agency of the Executive Branch we seek to be an advocate for New Mexico without favoring any one segment of the natural gas industry over any other. We seek not to favor nor disfavor any one company or interest over another and we try to work for the good of the State as a whole. (Gas Marketing Bureau, 1991a, p. 2).

The Gas Marketing Bureau has testified before the FERC, intervened in rate cases, supported expanded markets and pipeline construction, compiled and dispersed information on New Mexico natural gas reserves and production capacity, and publicized the increasing coalbed methane resource, among other tasks.

New Mexico's gas reserves are being substantially augmented by coal seam gas development. This enormous resource can provide significant economic and financial benefit to New Mexico and the United States.

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Vertical aerial view of Shiprock with one minette dike prominent in the photograph. Mancos Shale exposed around the dike. Photograph taken the morning of 13 April 1992. Copyright © Paul L. Sealey, 1992.