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Introduction

More wells were drilled for oil and gas in New Mexico in 1990 than in 1989. Data obtained from the New Mexico Oil Conservation Division indicate 1,549 wells were completed in 1990, up 42% from the 1,088 wells completed in 1989, but down 46% from the record 2,867 wells completed in 1981. In the Permian Basin, southeast New Mexico, 803 wells were completed in 1990, up from 631 completions in 1989; 488 wells were completed as oil producers and 189 wells were completed as gas producers while 126 wells were plugged and abandoned, resulting in a success rate of 84%. In the San Juan Basin, northwest New Mexico, 746 wells were completed in 1990; 75 wells were completed as oil producers and 659 wells were completed as gas producers while 12 wells were plugged and abandoned, resulting in a success rate of 98%. In addition, four wells were completed in the west Bravo dome carbon dioxide gas unit of southern Harding County. Seven exploration and development wells were completed in Colfax County.

Total footage of hole drilled in 1990 was 6.312 million ft, up from 4.666 million ft drilled in 1989. The average footage drilled per well in 1990 was 4,075 ft, 213 ft less than the average well drilled in 1989.

The downturn in drilling over the past nine years has been accompanied by seriously decreased exploratory efforts. Several major oil companies announced reduction of onshore exploration efforts in the United States. Exploratory activity has rebounded in the last two years, however. The resurgence in exploration has generally been led by independent operators and smaller oil companies. During 1990 there was significant frontier exploratory activity in the Raton and Tucumcari Basins, in the Gallup–Zuni sag, in the Sacramento Mountains, and in the Bravo dome unit (Fig. 1).

For purposes of this report, a *significant wildcat discovery* is defined as a well in which commercial amounts of oil or gas were discovered in a stratigraphic unit more than 5 miles from the limits of previously discovered pools with commercial production from that stratigraphic unit. A *significant wildcat dry hole* is defined as a dry hole that was drilled in a not-yet-productive basin or a part of a basin and in which petroleum reservoirs were evaluated. The locations of significant wildcat wells that were completed in 1990 are shown in Fig. 1. Table 1 summarizes the significant wildcat discoveries and Table 2 summarizes the significant wildcat dry holes. Table 3 summarizes wells in which horizontal drilling took place in New Mexico during 1990. Table 4 lists other significant wildcat wells that were being drilled, were not completed, or were held "tight" at the end of 1990.

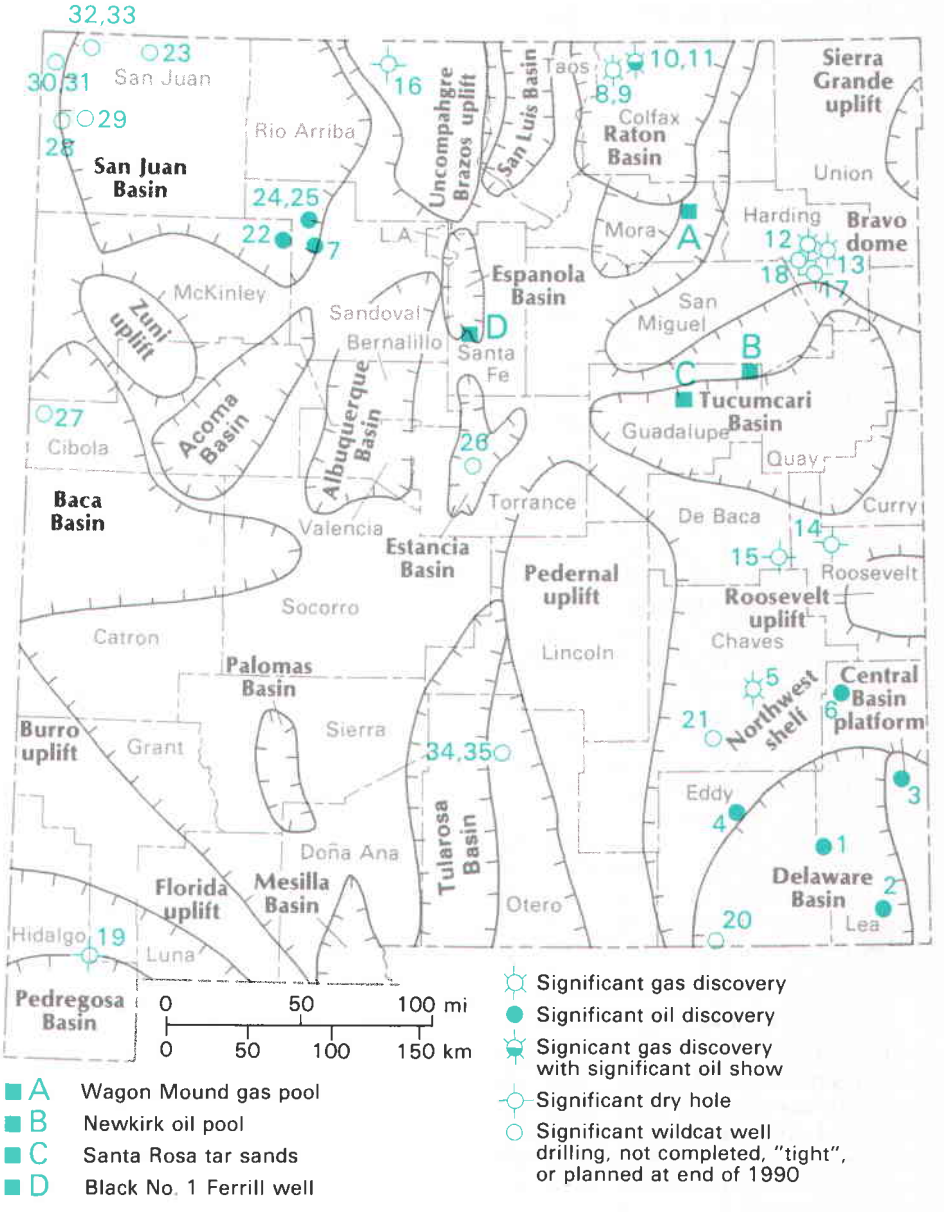

FIGURE 1—Significant oil and gas discoveries, frontier wildcat wells, and horizontal wells drilled in New Mexico during 1990. Major geologic features are from Broadhead and King (1988), Cather and Johnson (1984), Kelley (1978), Kottlowski and Stewart (1970), Meyer (1966), Molenaar (1977), Thompson and Jacka (1981), and Woodward et al. (1978).

Each well is designated by a number in parentheses that refers to its location in Fig. 1 and its description in Tables 1, 2, 3, or 4.

Southeast New Mexico

Drilling activity increased in 1990 in the three geologic subdivisions of the Permian Basin: the Delaware Basin, the Central Basin platform, and the Northwest shelf. Five significant wildcat discoveries were made in the Permian Basin during 1990 (Fig. 1, nos. 1–5; Table 1, nos. 1–5). Drilling activity remained light on the Roosevelt uplift. McKamey et al. (1988) presented stratigraphic charts of oil- and gas-producing rock units in southeastern New Mexico, as well as geologic summaries of recently discovered oil and gas pools. ☞

TABLE 1—Significant wildcat discoveries in New Mexico in 1990; the term formation is used in an informal sense. **BOPD,** bbls oil per day; **MCFGPD,** thousand ft^3 gas per day; **BWPD,** bbls water per day; **IP,** initial potential; **IPF,** initial potential flowing; **IPP,** initial potential pumping; **owwo,** old well worked over.

Number on Fig. 1	Location (section-township-range, county)	Operator, well number, and lease	Completion date (mo/yr)	Total depth (ft)	Formation at total depth	Producing formation	Producing interval (ft)	Initial potential	Oil gravity (degrees API)
1	14-20S-32E, Lea	Yates Petroleum No. 1 Belco Federal AIA (owwo)	8/90	13,250	Mississippian	(Wolfcamp (Permian)	11,074–11,273	IPF 180 BOPD + 270 MCFGPD + 240 BWPD	
2	34-24S-34E, Lea	Bruce A. Wilbanks No. 1 Moore Com 34 (owwo)	4/90	15,376	Morrow (Pennsylvanian)	Strawn (Pennsylvanian)	13,647–13,780	IPF 4 BOPD + 234 MCFGPD + 31 BWPD	53
3	11-17S-37E, Lea	Yates Petroleum No. 1 Humble City ADH (owwo)	2/90	11,903	Atoka (Pennsylvanian)	Yeso (Permian)	7,805–7,856	IPP 14 BOPD + 3 BWPD	38
4	8-18S-27E, Eddy	Hondo Oil & Gas No. 1 Pitcher Federal	9/90	3,044	Yeso (Permian)	Glorieta–Yeso (Permian)	2,832–2,901	IP 82 BOPD + 390 BWPD	
5	16-10S-27E, Chaves	Stevens Operating No. 1 Hanlad State	10/90	6,986	Fusselman (Silurian)	Lower Pennsylvanian	6,547–6,600	IPF 1,005 + 6 BWPD	
6	26-10S-33E, Lea	Western Reserves No. 3 State 26 (development well)	7/90	12,800	Devonian	Devonian	12,620–12,660	IPF 3,238 BOPD + 65 MCFGPD	20
7	14-19N-3W, Sandoval	Merrion Oil & Gas No. 1 Federal Media	11/90	5,310	Entrada (Jurassic)	Menefee (Cretaceous)	1,620–1,950	IPP 68 BOPD + 5+ BWPD	
8	3-30N-17E, Colfax	Pennzoil No. 031 F Castle Rock 3017	7/90	2,168	Trinidad (Cretaceous)	Vermejo coal (Cretaceous)	1,578–1,604; 1,737–1,849	IPP 550 BWPD	
9	14-31N-17E, Colfax	Pennzoil No. 141 Castle Rock 3117	6/90	1,152	Trinidad (Cretaceous)	Vermejo coal (Cretaceous)	894–1,004	IPF 1 MCFGPD + 213 BWPD	
10	31-31N-18E, Colfax	Pennzoil No. 311 M Castle Rock 3118	7/90	2,065	Trinidad (Cretaceous)	Raton Conglomerate (Cretaceous)			
11	32-31N-18E, Colfax	Pennzoil no. 321 I Castle Rock 3118	6/90	2,121	Trinidad (Cretaceous)	Vermejo coal (Cretaceous)	1,554–1,664; 1,725–1,837	IP 28 MCFGPD + 379 BWPD	
12	18-19N-29E, Harding	OXY U.S.A. Inc. No. 18 West Bravo Dome	12/90	2,925	Precambrian	Tubb (Permian)	2,756–2,796	IP 1,800 MCFGPD (CO_2)	
13	32-19N-30E, Harding	OXY U.S.A. Inc. No. 20 West Bravo Dome	12/90	2,165	Precambrian	Tubb (Permian)	1,924–1,954	IP 2,300 MCFGPD (CO_2)	

Two significant wildcat discoveries were made in the Delaware Basin during 1990. Both discoveries were made by re-entering abandoned wells and both were deeper pool discoveries in existing fields. Oil was discovered in a Wolfcampian (Permian) reservoir in the Yates Petroleum No. 1 Belco Federal AIA (1). Oil was discovered in a Strawn (Pennsylvanian) reservoir in the Bruce A. Wilbanks No. 1 Moore Com. 34 (2).

Both oil and gas reservoirs were targets of exploratory drilling in the Delaware Basin during 1990, although exploration for oil predominated. Main targets of oil exploration were basinal sediments of the Bone Spring Formation and Delaware Mountain Group (Permian). The Strata Production No. 1 Yeso Hills Federal (20) was a noteworthy attempt to find oil in Bone Spring reservoirs; that well was drilled horizontally in the Bone Spring and then temporarily abandoned at the end of 1990, but it was not plugged permanently. With fracture-controlled production and reservoirs of relatively low permeability, the Bone Spring Formation may be a good objective for horizontal drilling. Exploratory drilling for natural gas was concentrated mostly in Morrowan and Atokan sandstones (Pennsylvanian).

Development drilling in the Delaware Basin was predominantly for oil during 1990. Targets were diverse. Primary targets were basinal sandstones of the shallow (4,000–6,000 ft) Delaware Mountain Group (Permian) in the West Corbin, West Lusk, Cabin Lake, Livingston Ridge, and East Loving pools. Moderately deep (6,000–10,000 ft) basinal Bone Spring carbonates (Permian) were also targets, with activity concentrated in the North Young, North Shugart, and Tamano pools. Canyon and Cisco carbonates (Upper Pennsylvanian) in the North Dagger Draw pool were also primary development targets. Other targets of development drilling for oil were carbonates in the Strawn (Middle Pennsylvanian) and reservoirs in the San Andres and Grayburg Formations (Permian). Morrowan and Atokan clastics (Lower Pennsylvanian) were the main targets for gas development drilling during 1991. Other targets for gas development were Strawn, Canyon, and Cisco (Middle–Upper Pennsylvanian) carbonates and Wolfcampian (Lower Permian) carbonates.

One significant wildcat discovery was made on the northernmost part of the Central Basin platform during 1990. The Yates Petroleum No. 1 Humble City ADH (3) was an oil discovery in the Yeso Formation (Permian). Exploratory efforts were minimal on the mature, densely drilled Central Basin platform during 1990. Deep (10,000–12,000 ft) Ordovician, Silurian, and Devonian targets under the platform and along the western border areas of the platform may still hold exploratory promise. During 1990 and 1991, an exploratory well on the west side of the platform in Pecos County, Texas reportedly was drilled through 3,200 ft of Precambrian before passing through a thrust fault and encountering a significant Paleozoic section (Shirley, 1991). Development drilling was mostly for oil in the shallow (2,000–5,000 ft) San Andres, Grayburg, and Queen Formations (Permian) and in the moderately deep (5,000–7,000 ft) Blinebry, Tubb, and Drinkard sandstones of the Yeso Formation (Permian).

Two significant discoveries were made

TABLE 2—Significant wildcat dry holes in New Mexico in 1990; the term formation is used in an informal sense. **D&A,** dry and abandoned; **DST,** drill-stem test; **mcw,** mud-cut water; **perf,** perforated; **acid,** acidized; **frac,** fractured.

Number on Fig. 1	Location (section-township-range, county)	Operator, well number, and Lease	Completion date (mo/yr)	Total depth (ft)	Formation at depth	Status	Comments
14	24-1S-31E, Roosevelt	Hanson Operating No. 1 Ladson	5/90	7,075	Montoya (Ordovician)	D&A	DST 6,751–6,940 ft, recovered 510 ft MCW. DST 6,920–7,075 ft, recovered 990 ft fluid.
15	4-2S, 28E, De Baca	Jaguar Energy No. 1 Colter Federal	2/90	2,810	Yeso (Permian)	D&A	Was scheduled to dril to 7,200 ft to test Montoya (Ordovician)
16	2-30N-3E, Rio Arriba	Heyse Oil No. 2 Rio Chama	9/90	362		D&A	Was scheduled to drill to 2,000 ft to test Dakota (Cretaceous)
17	2-17N-29E, Harding	OXY U.S.A. Inc. No. 21 West Bravo Dome	12/90	3,097	Precambrian	D&A	Perf, acid, and frac 2,819–2,866 ft (Tubb-Permian)
18	7-18N-29E, Harding	OXY U.S.A. Inc. No. 19 West Bravo Dome	12/90	3,306	Precambrian	D&A	Perf and acid 3,039–3,129 ft & 3,175–3,222 ft (Tubb-Permian)
19	25-27S-17W, Hidalgo	Arthur B. Ramsey No. 2 Ramsey State 25	7/90	2,173		D&A	No reported shows.

TABLE 3—Wells drilled in New Mexico in 1990 with a significant horizontal derivation. (The amount of horizontal drilling is indicated by the difference between the total depth and the true vertical depth.) The term formation is used in an informal sense. **BOPD,** bbls oil per day; **BWPD,** bbls water per day; **owwo,** old well worked over; **TA,** temporarily abandoned; **SI,** shut in.

Number on Fig. 1	Location (section-township-range, county)	Operator, well number, and lease	Total depth (ft)	True vertical depth (ft)	Pool	Objective formation	Status	Comments
20	18-26S-25E, Eddy	Strata Production No. 1 Yeso Hills Federal	5,900	4,900	wildcat	Bone Spring (Permian)	TA	
21	26-13S-35E, Lea	Harvey E. Yates No. 3 Duncan Unit (owwo)	13,600	13,520	Northwest Austin	Mississippian		Perf 10,283–10,296 (Pennsylvanian) with no reported show. Testing open hole 13,075–13,520 ft (Mississippian)
22	15-19N-5W, McKinley	Merrion Oil & Gas No. 2 Federal 15 (owwo)	6,084	5,180	Papers Wash	Entrada (Jurassic)	oil	Perf 5,379–5,823 ft (Entrada); IPP 187 BOPD + 779 BWPD.
23	28-31N-14W, San Juan	BASF Corp. No. 14 Ute Mountain 28	5,000	4,500	Verde	Gallup (Cretaceous)		"Tight" hole.
24	11-20N-3W, Sandoval	Veteran Exploration No. 1 Renegade	6,800	3,600	Rio Puerco	Mancos (Cretaceous)	SI	Reportedly swabbed 13–15 BOPD from Mancos Shale.
25	12-20N-3W, Sandoval	Veteran Exploration No. 10 San Isidro 12	6,850	3,406	Rio Puerco	Mancos (Cretaceous)		Pumped 200–250 BOPD from Mancos Shale.

on the Northwest Shelf during 1990. Oil was found in the lowermost part of the Glorieta Sandstone (Paddock zone–Permian) in the Hondo Oil and Gas No. 1 Pitcher Federal (4), helping to extend westward production in this reservoir unit. Gas was discovered in the lower part of the Pennsylvanian section in the Stevens Operating Co. No. 1 Hanlad State (5). Exploration on the Northwest shelf was limited during 1990. Main targets were oil in the San Andres Formation (Permian) and in Ordovician and Silurian carbonate reservoirs.

Development drilling on the Northwest shelf was slow in 1990. Nevertheless, there was significant development of oil reservoirs in the shallow (2,000–6,000 ft) San Andres, Grayburg, and Queen Formations (Permian) of Chaves County and northern Eddy and northern Lea counties. There was also development of Abo (Permian) oil reservoirs along the shelf edge in Lea County. An especially significant development well drilled during 1990 was the Western Reserves Oil No. 3 State 26 (6) that had an initial potential of more than 3,000 bbls oil per day from the Devonian.

Development drilling for gas on the Northwest shelf was concentrated in the Pecos Slope Abo gas pool of north-central Chaves County. There was also limited development of the "pre-Permian" gas pools. In the Northwest Austin Mississippian gas pool, the Harvey E. Yates No. 3 Duncan Unit (21) was drilled with a horizontal deviation and was still being evaluated at the time this report was written.

The Roosevelt uplift and adjacent areas were drilled sparsely in 1990. No significant wildcat discoveries were made. Exploration was minimal; three wells were drilled to test Silurian–Devonian reservoirs, Abo (Permian) "granite-wash" reservoirs, and San Andres (Permian) carbonate reservoirs, but none was successful. There was limited development of oil reservoirs in basal Abo carbonates and in San Andres carbonates. One gas development well was drilled in the Tule gas pool, a significant Ordovician and Pennsylvanian discovery made during 1986. The Hanson Operating No. 1 Ladson (14) was drilled 10 miles northeast of the Tule pool to test the Montoya Formation (Ordovician) but was abandoned without establishing production.

Elsewhere in southeast New Mexico, the Jaguar Energy No. 1 Colter Federal (15) was abandoned in the Yeso Formation (Permian) at a total depth of 2,810 ft. The well had been scheduled to be drilled to a total depth of 7,200 ft in search of hydrocarbons in Ordovician strata.

Northwest New Mexico

In 1990, 746 wells were completed in northwest New Mexico, up 63% from 457 completions in 1989. Virtually all drilling was in the San Juan Basin. The increased ☞

TABLE 4—Significant wildcat wells that were being drilled, not completed, "tight," or planned in New Mexico at the end of 1990. **TA,** temporarily abandoned.

Number on Fig. 1	Location (section-township-range, county)	Operator, well number, and Lease	Comments
26	18-5N-9E, Torrance	Lyle Benz No. 2 Benz	Drilled to total depth of 570 ft. TA during 11/90. Shut down for winter. Scheduled to drill to 1,400 ft to test Abo (Permian).
27	34-8N-20W, Cibola	Burr Oil & Gas No. 1-34 Zuni Tribal	Spud 6/22/90. Drilled to total depth of 1,000 ft. Reported oil shows at 620–645 ft (Yeso).
28	20-26N-19W, San Juan	Chuska Energy No. 20-0-1 North Beautiful Mountain	Located staked. Scheduled to drill to total depth of 6,968 ft in Mississippian.
29	20-27N-18W, San Juan	Chuska Energy No. 20-K-1 Tocito North	Location staked. Scheduled to drill to total depth of 7,222 ft in Mississippian.
30	18-30N-20W, San Juan	Chuska Energy No. 18-E-1 Beclabito	Location staked. Scheduled to drill to total depth of 5,322 ft in Paradox (Pennsylvanian).
31	12-30N-21W, San Juan	Chuska Energy No. 20-K-1 Beclabito	Location staked. Scheduled to drill to total depth of 5,570 ft in Precambrian.
32	16-31N-18W, San Juan	Chuska Energy No. 16-B-1- North Chimney Rock	Location staked. Scheduled to drill to total depth of 8,686 ft in Precambrian.
33	21-31N-18W, San Juan	Chuska Energy No. 21-H-1 North Chimney Rock	Location staked. Scheduled to drill to total depth of 8,567 ft in Precambrian.
34	7-14S-11E, Otero	Cibola Energy No. 1 Ysletano Canyon Federal	Drilled to total depth of 3,800 ft in reported Devonian strata. TA during 6/90 amid rumors of a gas discovery. "Tight" hole.
35	20-14S-11E, Otero	Cibola Energy No. 1 Virden	Spud 6/20/90. Estimated total depth 4,800 ft. "Tight" hole.

rate of drilling was due mostly to development of coal-bed methane production in the Fruitland Formation (Cretaceous). There was a more modest increase in oil development.

Exploratory drilling resulted in one significant completion during 1990. The Merrion Oil & Gas No. 1 Federal Media (7) re-established shallow production from Menefee (Cretaceous) sandstones in the Media field. On the western flank of the San Juan Basin, Chuska Energy staked locations for six exploratory wells (28–33). All six wells are scheduled to be drilled to either the Precambrian, Mississippian, or Pennsylvanian to test upper Paleozoic strata. Production in the San Juan Basin is almost entirely from Cretaceous reservoirs; relatively few wells have penetrated the Paleozoic and Jurassic sections. Minor amounts of oil are produced from stratigraphic traps in the Entrada Sandstone (Jurassic) in the southeastern part of the basin. Minor amounts of oil and gas are produced from Devonian, Mississippian, and Pennsylvanian reservoirs in structural traps along the western flank of the basin. Helium-rich gases have been produced from Mississippian, Pennsylvanian, and Permian reservoirs in this area. So the Paleozoic and Jurassic essentially remain frontiers for petroleum exploration in the San Juan Basin.

Most development drilling in the San Juan Basin during 1990 was for shallow (approximately 2,000 ft) coal-bed methane in the Fruitland Formation (Cretaceous). Kelso et al. (1988) estimated that the total gas contained within Fruitland coal beds in the San Juan Basin is 50 trillion ft^3 (TCF); most of that gas is within the New Mexico part of the basin, but the most prolific coal beds appear to be concentrated mainly in the Colorado part of the basin. It is not known what percentage of the gas is recoverable under current economic conditions, but this reservoir represents a major addition to the state's gas supplies. Approximately 600 wells were drilled to develop Fruitland coal-bed methane during 1990. Development has been in the Basin Fruitland gas pool of eastern San Juan and western Rio Arriba counties.

Fruitland gas reservoirs have been ignored for many years because of initial low production volumes and high water cuts. Exploration and development have been concentrated in deeper reservoirs in the Upper Cretaceous, which yield relatively high volumes of gas and little or no water upon initial completion. However, water production from wells completed in Fruitland coals declines with time, and the wells become economical. Furthermore, lower costs involved with drilling the shallower Fruitland reservoirs (approximately 2,000 ft deep) compensate partially for the relatively low volumes of gas production, although some Fruitland wells produce more than 1 million ft^3 gas per day (MMCFGPD). More importantly, producers are eligible for a federal gas-production tax credit for coal-bed methane wells. That tax credit had applied to production from wells drilled before January 1, 1991. A drilling boom started as operators rushed to discover and develop reserves before the deadline although some development, no doubt, would have occurred without the tax credit. The United States Congress extended the credit for an additional two years with legislation enacted during November 1990 (Western Oil World, 1990a). Producers will now be eligible for a tax credit for gas produced from coal-bed methane wells drilled before January 1, 1993; that credit applies to gas produced from those wells prior to the year 2003. As a result of this Congressional action, exploration and development for coal-bed should continue into 1991 and 1992 at a relatively brisk pace. Western Oil World (1990b) and Whitehead (1991) have reviewed coal-bed methane drilling in the San Juan Basin.

Development drilling for gas in reservoirs other than the Fruitland continued to be sluggish during 1990. Activity was confined to San Juan and Rio Arriba Counties. Gas wells were completed in Paradox carbonates (Pennsylvanian), in Dakota, Mesaverde, Point Lookout, Cliff House, and Pictured Cliffs sandstones (Cretaceous), and in the Chacra producing interval (Cretaceous).

Development drilling for oil in the San Juan Basin increased during 1990; 75 oil wells were completed during 1990, an increase of 42% from the 53 wells completed during 1989. The main objective for oil development was the Gallup sandstone (Cretaceous) with activity concentrated in the Lybrook pool of southwest Rio Arriba County and in the Bisti and South Bisti pools of southeast San Juan County. There was minor development of Gallup reservoirs in northwest Sandoval County.

Four wells were drilled with significant, planned horizontal deviation in the San Juan Basin during 1990. In McKinley County, the Merrion Oil and Gas No. 2 Federal 15 (22) was re-entered and a horizontal sidetrack was drilled; the well was successfully completed in the Entrada Sandstone (Jurassic). In San Juan County, the BASF Corp. No. 14 Ute Mountain 28 (23) was drilled with horizontal deviation in the Verde Gallup oil pool (Western Oil World, 1990c); the well is currently "tight." In the Rio Puerco Mancos oil pool of Sandoval County, Veteran Exploration drilled

two wells (24, 25) in the Rio Puerco Mancos oil pool (Western Oil World, 1990c); the pool produces from fractured Mancos Shale (Cretaceous) and fair success has already been obtained with conventional vertical wells.

Elsewhere in northwest New Mexico, one exploratory well was drilled in the Gallup–Zuni sag. The Gallup–Zuni sag is a synclinal feature on the west side of the Zuni uplift; it connects the San Juan Basin with the Baca Basin. The Burr Oil and Gas No. 1–34 Zuni Tribal (27) was drilled on a southwest plunging structural nose located one mile northeast of the Atarque monocline. Total depth was reached at 1,000 ft and oil shows were reportedly encountered in the Yeso Formation (Permian). The Burr Oil and Gas No. 1–34 Zuni Tribal was the third well to be drilled on the Zuni Reservation to test large, previously undrilled surface structures.

Two significant exploration programs began during 1990 in northwest New Mexico. Merrion Oil and Gas Corp. entered into an agreement with Santa Fe Energy Co. to begin exploration on more than 600,000 acres of leases held by Santa Fe Energy (Oil and Gas Journal, 1990c). The leases are in San Juan, McKinley, Sandoval, and Cibola counties and cover the San Juan Basin and the Gallup–Zuni sag. Merrion also holds exploration rights to 150,000 acres on the Lee Ranch in southeastern McKinley County.

PENTECO Corporation has announced an exploration program covering Cibola and western Valencia counties (Petroleum Information, 1990a). PENTECO has acquired drilling rights to more than 250,000 acres held by the New Mexico and Arizona Land Company. The Pennsylvanian section is the objective of the exploration program.

Northeast New Mexico

Petroleum exploration activities increased in northeast New Mexico during 1990. Pennzoil continued its exploration for coal-bed methane in the Raton Basin. Two large exploratory lease plays emerged in the Tucumcari Basin. Exploration for carbon dioxide resulted in drilling in the West Bravo Dome area. Finally, a well was spudded in the Estancia Basin.

Petroleum has not been produced commercially in northeast New Mexico except for a brief period during the 1970's when marginally commercial amounts of gas were produced from the Morrison Formation (Jurassic) and Dakota Sandstone (Cretaceous) at the currently inactive Wagon Mound field in Mora County (Fig. 1, letter A). In the 1980's, the Newkirk pool (Fig. 1, letter B) produced 574 bbls heavy oil from sandstones in the Santa Rosa Formation (Triassic). McKallip (1987) reported on the geology of the Newkirk pool. In the 1930's, approximately 153,000 tons of tar sands were quarried from the Santa Rosa Formation near the town of Santa Rosa in Guadalupe County (Gorman and Robeck, 1946; Fig. 1, letter C); the tar sands were used for road-surfacing material in New Mexico and neighboring states. In southern Santa Fe County, the Black Oil No. 1 Ferrill (Fig. 1 letter D) has produced 654 bbls oil from the Niobrara Shale and lower Mancos Shale (Cretaceous) since the well was drilled in 1985.

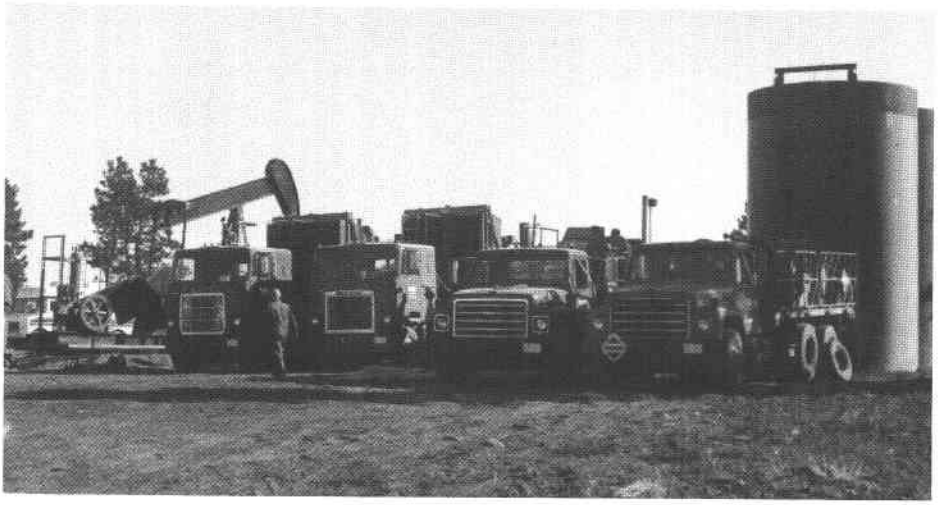

FIGURE 2—Artificially fracturing a Pennzoil coal-bed methane well in Castle Rock Park, western Vermejo Ranch, Colfax County.

In the Raton Basin, Pennzoil continued a pilot drilling program to test and evaluate coal-bed methane resources in the Vermejo Formation (Cretaceous). Pennzoil has drilled more than 30 exploratory and development wells in the New Mexico part of the basin since 1989 (Fig. 2). Three exploratory wells drilled during 1990 (8, 9, 11) are shown on Fig. 1 and discussed in Table 1. If the pilot program is successful, more than 100 additional wells may be drilled. Factors favoring the coal-bed methane play are the federal gas-production tax credit for coal-bed methane wells drilled prior to 1993, the shallow depth of the wells, and the lack of engineering problems encountered while drilling the wells (Johnson, 1990). A fourth well, Pennzoil No. 311 M Castle Rock 3118 (10), drilled in 1989 and recompleted in 1990 encountered extensive shows of live oil in Raton and Vermejo sandstones (Cretaceous) as well as gas in Vermejo coals and was completed in the Raton conglomerate. This discovery reinforces the hypothesis that undiscovered reserves of oil lurk in the subsurface of the Raton Basin.

Exploration for carbon dioxide in the west Bravo dome unit resulted in the drilling of four exploratory wells by OXY U.S.A. (12, 13, 17, 18). The principal objective was the Tubb sandstone (Permian), the main reservoir in the Bravo dome field. Two of the wells were completed as carbon dioxide discoveries and two were abandoned without establishing production. Further exploration and development of discovered carbon dioxide resources will ensue. Most of the carbon dioxide produced at Bravo dome is transported through pipelines to the Permian Basin where it is used in enhanced oil recovery. Johnson (1983) and Broadhead (1990a) discussed geology and some engineering aspects of the Bravo dome carbon dioxide field.

No wells were drilled or spudded in the Tucumcari Basin during 1990. However, two large lease plays emerged during 1990. 1) In southeast Quay County, Nerdlihc Company, Inc. successfully bid on 10,706 acres of State Trust Land during the October and November 1990 state lease sales; previously, Nerdlihc had successfully bid on 33,404 acres of State Trust Land in eastern Guadalupe and western Quay Counties during the April 1990 state lease sale. 2) In eastern Guadalupe County, Project Design Specialists, Inc. successfully bid on 8,413 acres of State Trust Land during the December 1990 State lease sale; Ben Donegan successfully bid on 80 acres in that same sale. The total amount of State Trust Lands leased during 1990 was 52,603 acres. Federal and private lands were also leased and drilling should follow. The petroleum geology and petroleum potential of the Tucumcari Basin have been discussed by Broadhead and King (1988) and Broadhead (1990b).

Southwest New Mexico

Two petroleum exploration wells (19, 35) were completed in southwest New Mexico during 1990, one in the Pedregosa Basin and one on the east flank of the Sacramento Mountains. A third well (34), also on the east flank of the Sacramento Mountains, was spudded in 1987 but is still held "tight."

In the Pedregosa Basin of Hidalgo County, the Arthur B. Ramsey No. 2 Ramsey State 25 (19) was drilled to a total depth of 2,173 ft in the Playas Valley. It is probable that Tertiary volcanic rocks are present at total depth (Sam Thompson III, ☞

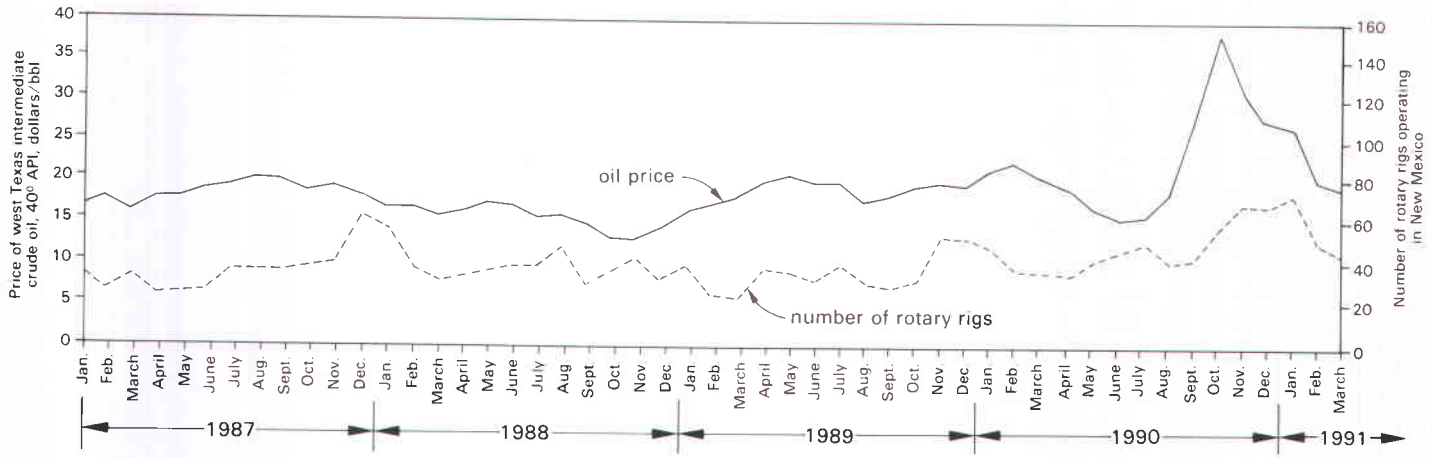

FIGURE 3—Monthly crude oil prices and number of active rotary drilling rigs in New Mexico during 1987, 1988, 1989, 1990, and early 1991. Data from Oil and Gas Journal (1987a, b; 1988a, b; 1989a, b; 1990a, b; 1991a, b).

personal communication 1991). Although production has not been established from the Pedregosa Basin, the Paleozoic and Lower Cretaceous sections are promising targets (Thompson, 1981).

On the east flank of the Sacramento Mountains, Cibola Energy has drilled two wells. The Cibola Energy No. 1 Ysletano Canyon Federal (34) was spudded in 1987 and drilled to a total depth of 3,800 ft in reported Devonian strata. The well was temporarily abandoned during June 1990 amid rumors of a gas discovery or significant gas show. The well is presently considered "tight". In the same township, the Cibola Energy No. 1 Virden (35) was spudded during June 1990 and was drilled to a total depth of 4,800 ft. This well is also considered to be "tight."

Oil and gas production

In 1989, New Mexico was the seventh largest producer of crude oil and the fourth largest producer of natural gas in the United States (Energy Information Administration, 1990). Production of crude oil and lease condensate in New Mexico in 1990 was approximately 68.1 million bbls, a decrease of 1.0% from the 68.7 million bbls produced during 1989 (New Mexico Oil Conservation Division data). Production of natural gas in 1990 was approximately 965 billion ft^3 (BCF), an increase of 12.14% from the 861 BCF produced in 1989. In 1989, 92% of the state's oil and 47% of the state's gas were produced from the Permian Basin and adjoining areas of southeast New Mexico; 8% of the state's oil and 53% of the state's gas were produced from the San Juan Basin of northwest New Mexico. As of December 31, 1989, New Mexico had proved crude oil reserves of 665 million bbls (Energy Information Administration, 1990); the Permian Basin contains 93% of the state's proved oil reserves and the San Juan Basin contains 7% of the state's proved oil reserves. Additionally, New Mexico had reserves of 70 million bbls of lease condensate (Energy Information Administration, 1990); 76% of the state's condensate reserves are in the San Juan Basin and 24% of the state's condensate reserves are in the Permian Basin. As of December 31, 1989. New Mexico had proved natural gas reserves of 16.6 TCF, (Energy Information Administration, 1990); the San Juan Basin contains 80% of the state's gas reserves and the Permian Basin contains 20% of the state's gas reserves.

The decrease in oil production during 1990 resulted from relatively low oil prices during the past four years (Fig. 3). Prior to August 1990, the price of west Texas intermediate crude oil with a gravity of 40° API (the "benchmark" crude oil of the United States) varied between $15.00/bbl and $20.00/bbl. These low prices resulted in decreased exploration and development and also were insufficient to justify production from many marginal stripper wells. Oil prices soared, however, after the August 2 Iraqi invasion of Kuwait and peaked in October at approximately $40.00/bbl. With the onset of offensive military action by the allied coalition, the safety of Middle East oil supplies seemed assured and the price of oil subsequently fell and stabilized at approximately $20.00/bbl.

The sharp climb in oil prices at the end of 1990 appears to have resulted in increased drilling activity, which is reflected in the rig count for the state (Fig. 3). However, examination of Fig. 3 reveals that drilling activity was climbing slowly and steadily prior to August. Many of the wells drilled during the peak of activity at the end of 1990 were planned prior to August. It seems likely that increased drilling activity at the end of the year resulted not only from the spike in oil prices, but also from stabilization of oil prices during 1989 and 1990. A positive effect of the price spike at the end of 1990 was increased oil production as many operators re-established or increased production from marginal wells; New Mexico oil production increased by 0.73% in October, 0.31% in November, and 2.43% in December relative to the same months of 1989. This is a strong indication that production in New Mexico will increase as a result of favorable economic changes. A sustained increase in oil prices will also result in an increase in exploration new reserves, which should help increase production or at least stem the rate of decline. Gradual declines in future reserves and production will probably be arrested only if the number of operating rotary rigs is increased substantially.

The increase in gas production in 1990 was caused primarily by an increased demand for gas, although productive capacity rose as a result of coal-bed methane drilling in the San Juan Basin. Primary markets for New Mexico gas are in California and these markets developed an increased demand during 1990. New Mexico gas faces stiff competition in California mainly from fuel oil, Wyoming gas, and imported subsidized Canadian gas. However, the demand for gas in California is expected to grow, possibly by as much as 38% by the year 2000 (Oil and Gas Journal, 1989a). Competition from fuel oil will decrease if the price of crude oil stays relatively high; also, natural gas may replace fuel oil in many markets because it is a more environmentally desirable fuel.

Coal-bed methane production in the San Juan Basin will increase despite competition from other energy sources. New pipelines are under construction in New Mexico and western Colorado that will allow producers access to new markets in California, the Gulf Coast, the Midwest, and the Pacific Northwest (Petroleum Information, 1990b; Oil and Gas Journal, 1990c, d, e, 1991c; Basler, 1990); these alternative marketplaces will give producers more flexibility than they presently have. In addition, Mojave Pipeline Co. is constructing a new pipeline in southern California to gain access to San Juan Basin coal-bed methane through existing El Paso and Transwestern pipelines in northern

Arizona and New Mexico (Oil and Gas Journal, 1990c). The Mojave pipeline will transport gas to the heavy-oil fields in central California where it will be used in thermal-enhanced oil recovery. The pipeline is scheduled to be completed by early 1992. The markets for coal-bed methane made available by the new pipelines should help provide a good long-term outlook for gas production in New Mexico and hopefully will provide incentive for additional exploration and development.

Gas production in the state will also be helped by exploration for, and development of, coal-bed methane in the Raton Basin. Current pipeline capacity and gas markets are relatively small and are unable to support a large increase in production. It appears, however, that adequate pipelines will be constructed if sufficient production is developed to support them (Johnson, 1990).

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C. V. Theis papers to UNM

The scientific and personal papers of the late C. V. Theis have been donated to the University of New Mexico by the U.S. Geological Survey and by Theis' daughter, Mrs. Marilyn Lewis. The collection is housed in the Center for Southwest Research, formerly the Special Collections Department, of UNM General Library. Technical notes, correspondence, and manuscripts resulting from more than six decades of active professional life are included in the collection. Notebooks and other papers should be of interest to researchers, both hydrogeologists and historians of the science. Although Theis is known principally for his contributions to ground-water hydraulics, he has published papers on evaporation, terrestrial heat flow, and other subjects. Inquire about accessibility to the C. V. Theis collection by calling the Center for Southwest Research, UNM General Library, (505) 277-6451.