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Ronald F. Broadhead

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by *Ronald F. Broadhead*, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801

Introduction

More wells were drilled for oil and gas in New Mexico in 1989 than in 1988. Data obtained from the New Mexico Oil Conservation Division indicate 1,088 wells were completed in 1989, up 4% from the 1,043 wells completed in 1988 but down 62% from the record 2,867 wells completed in 1981. In the Permian Basin, southeast New Mexico, 631 wells were completed in 1989, down from 738 completions in 1988; 374 wells were completed as oil producers, 148 wells were completed as gas producers, and 109 wells were plugged and abandoned, resulting in a success rate of 83%. In the San Juan Basin, northwest New Mexico, 457 wells were completed in 1989, up from 305 completions in 1988; 53 wells were oil producers, 351 wells were gas producers, and 53 wells were plugged and abandoned, resulting in a success rate of 88%. In addition, one well was completed in the Bravo Dome carbon dioxide gas field of southern Union and eastern Harding Counties.

Total footage of hole drilled in 1989 was 4,665,518 ft, down from 5,344,414 ft in 1988. The average depth of wells drilled in 1989 was 4,288 ft, 836 ft less than the average depth drilled in 1988.

The downturn in drilling over the past eight years has been accompanied by seriously decreased exploratory efforts. Several major oil companies announced reduction or elimination of onshore exploration efforts in the United States. Despite this, however, significant exploratory drilling continued in the Permian, San Juan, Raton, Baca, and Pedregosa Basins and in the Jornada del Muerto of eastern Socorro County (Fig. 1). Significant drilling also took place in the Gallup–Zuni sag west of the Zuni uplift.

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 1989 are shown in Fig. 1. Table 1 summarizes the significant wildcat discoveries and Table 2 summarizes the significant wildcat dry holes. Table 3 lists other significant wildcat wells that were being drilled, were not completed, or were held "tight" at the end of 1989.

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

Southeast New Mexico

Drilling activity remained slow in 1989 in the three geologic subdivisions of the Permian Basin: the Delaware Basin, the Central Basin platform, and the Northwest shelf. Drilling activity was also light on the Roosevelt uplift. Despite the slow drilling activity, however, several significant oil and gas discoveries were made in the Permian Basin during 1989 (Fig. 1; Table 1). 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.

Two significant wildcat discoveries were made in the Delaware Basin during 1989. Oil was found in sandstones of the Delaware Mountain Group (Permian) in the Strata Production No. 1 New Mexico Federal A (1). Gas was found in Atoka clastics (Pennsylvanian) in the Manzano Oil No. 1 Wynell Federal (2).

Both oil and gas reservoirs were targets of exploratory drilling in the Delaware Basin during 1989. Main targets of oil exploration were basinal sandstones of the Bone Spring Formation and Delaware Mountain Group (Permian). Exploration for gas was concentrated in Strawn, Atokan, and Morrowan strata (Pennsylvanian).

Development drilling in the Delaware Ba- ☞

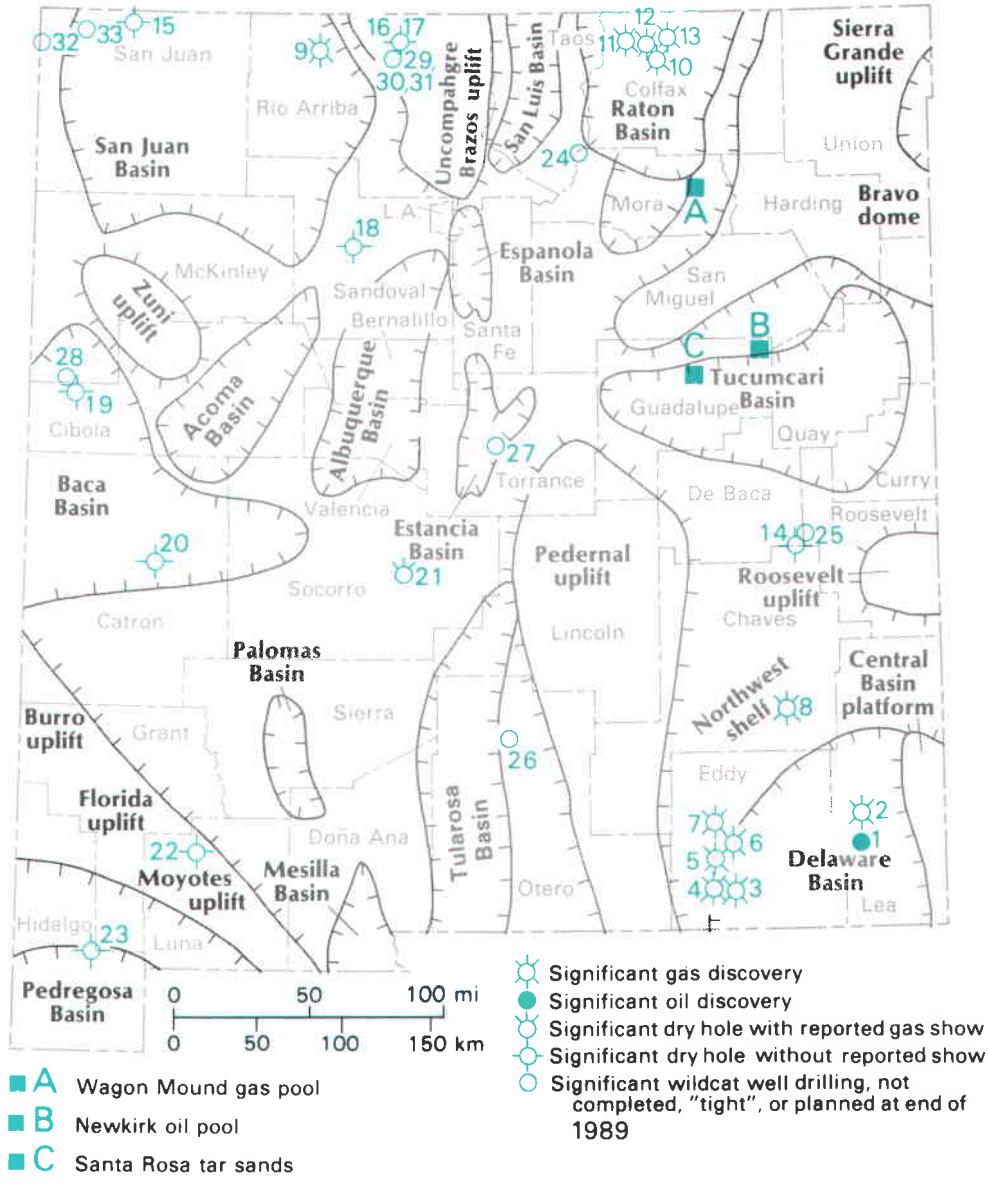

FIGURE 1—Significant oil and gas discoveries and wildcat wells drilled in New Mexico during 1989. Major geologic features are from Broadhead and King (1988), Cather and Johnson (1984), Kelley (1978), Kottlowski and Stewart (1970), Meyer (1966), Molenaar (1977), Thompson and Jacka (1981), and Woodward et al. (1978).

sin was predominantly for oil in 1989. Major targets for development drilling were oil reservoirs in basinal sands of the shallow (4,000–6,000 ft) Delaware Mountain Group (Permian) and moderately deep (6,000–10,000 ft) Bone Spring Formation (Permian). Development drilling for gas was mostly in deep (10,000–14,000 ft) Morrowan and Atokan (Lower Pennsylvanian) clastic reservoirs.

No significant wildcat discoveries were made on the Central Basin platform in 1989. Exploratory efforts were minimal in this mature, densely drilled area. 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. Development drilling was mostly for oil in the shallow (2,000–5,000 ft) San Andres, Grayburg, and Queen formations (Permian) and in moderately deep (5,000–7,000 ft) Blinebry, Tubb, and Drinkard sandstones of the Yeso Formation (Permian).

Six significant gas discoveries were made on the Northwest shelf in 1989. Gas was found in Cisco strata (Upper Pennsylvanian) in the BTA Oil Producers No. 1 8710 JV–P Tank B (3) on the southern part of the shelf. Also on the southern part of the shelf, gas was discovered in Strawn (Middle Pennsylvanian) reservoirs in the Yates Energy No. 1 Desert Rose Federal (4) and in the Bill Fenn Inc. No. 1 Roaring Springs Federal Com. (5). Gas was found in the Wolfcamp (Permian), in the Marathon Oil No. 6 North Indian Basin Unit Gas Com. (6). Gas was discovered in Abo (Permian) reservoirs in the Yates Petroleum No. 2 Agave State AAJ (7). Farther north on the central part of the shelf, gas was discovered in the Mississippian in the Hanagan Petroleum No. 2 Long Arroyo (8), a re-entry of a wildcat well that had been drilled to Ordovician strata and subsequently abandoned in 1987. Exploration on the Northwest shelf in 1989 was concentrated on oil reservoirs in Wolfcamp (Permian) carbonates and also in Abo carbonates (Permian) near the shelf edge. Oil exploration also emphasized San Andres (Permian) carbonates. There was limited exploration for gas on the Northwest shelf in reservoirs of Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian age.

Development drilling on the Northwest shelf was slow in 1989. 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. There was limited development of deeper oil reservoirs: Ordovician, Devonian, Pennsylvanian, and Wolfcamp (Permian) carbonates.

The only gas pool extensively developed on the Northwest shelf in 1989 was the Pecos Slope Abo gas pool of north-central Chaves County. There was also limited development of the "pre-Permian" gas pools in Chaves County and Strawn (Middle Pennsylvanian) and Wolfcamp (Permian) gas reservoirs in Chaves and northern Eddy Counties.

The Roosevelt uplift and adjacent areas were drilled sparsely in 1989. No significant wildcat discoveries were made. Exploration was minimal; two wells were drilled to test lower Paleozoic reservoirs in southern Roosevelt County, but neither well was successful. There was limited development of hydrocarbon accumulations in Wolfcamp and San Andres (Permian) carbonates during 1989.

Elsewhere in southeast New Mexico, the Esperanza Energy No. 1 McClain Ranch (14) was drilled to a total depth of 3,000 ft in southeastern De Baca County. Casing was set and perforated in the Glorieta Sandstone and San Andres Formation (Permian), but hydrocarbons were not recovered. The well was reported temporarily abandoned at the end of 1989. In the same township, a location was staked for the Jaguar Energy No. 1 Colter Federal (25); that well is scheduled to be drilled to a total depth of 7,200 ft in Montoya carbonates (Ordovician).

TABLE 1—Significant wildcat discoveries in New Mexico in 1989; 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; **IPF,** initial potential flowing; **IPCAOF,** initial potential, calculated absolute open flow; **IPP,** initial potential pumping; **NR,** not released; **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
1	4–21S–32E, Lea	Strata Production No. 1 New Mexico Federal A (owwo)	9/89	14,000	Chester (Mississippian)	Delaware (Permian)	6,834–6,869	IPF 148 BOPD + 201 MCFGPD + 20 BWPD
2	15–19S–33E, Lea	Manzano Oil No. 1 Wynell Federal	8/89	13,700	Morrow (Pennsylvanian)	Atoka (Pennsylvanian)	12,630–12,637	IPCAOF 32,504 MCFGPD
3	34–23S–24E, Eddy	BTA Oil Producers No. 1 8710 JV-P Tank B	3/89	9,975	Morrow (Pennsylvanian)	Cisco (Pennsylvanian)	8,036–8,120	IPCAOF 4,480 MCFGPD
4	27–23S–23E, Eddy	Yates Energy No. 1 Desert Rose Federal	11/89	10,310	Morrow (Pennsylvanian)	Strawn (Pennsylvanian)	8,772–8,816	IPF 1,606 MCFGPD
5	14–21S–23E, Eddy	Bill Fenn, Inc. No. 1 Roaring Springs Federal Com.	6/89	9,564	Morrow (Pennsylvanian)	Strawn (Pennsylvanian)	8,309–8,452	IPF 472 MCFGPD + 37 BWPD
6	4–21S–23E, Eddy	Marathon Oil No. 6 North Indian Basin Unit Gas Com.	7/89	7,680	Upper Pennsylvanian	Wolfcamp (Permian)	6,204–6,266	NR
7	32–19S–24E, Eddy	Yates Petroleum No. 2 Agave State AAJ	9/89	9,010	Chester (Mississippian)	Abo (Permian)	3,913–4,661	IPF 2,900 MCFGPD
8	33–12S–28E, Chaves	Hanagan Petroleum No. 2 Long Arroyo (owwo)	5/89	8,501	Ellenburger (Ordovician)	Mississippian	7,685–7,752	IPCAOF 1,263 MCFGPD
9	9–30N–3W Rio Arriba	Robert L. Bayless No. 1 Jicarilla 457 (owwo)	6/89	4,045	Pictured Cliffs (Cretaceous)	Ojo Alamo (Tertiary)	3,146–3,247	IPF 645 MCFGPD
10	4–29N–19E, Colfax	Pennzoil No. 041 Van Bremmer Canyon 2919	9/89	2,130	Trinidad (Cretaceous)	Vermejo (Cretaceous)	1,635–1,862	IPP 28 MCFGPD + 574 BWPD
11	2–30N–17E, Colfax	Pennzoil No. 021 Castle Rock S 3017	11/89	1,873	Trinidad (Cretaceous)	Vermejo (Cretaceous)	1,471–1,717	IPP 58 MCFGPD + 171 BWPD
12	35–30N–18E, Colfax	Pennzoil No. 351 Valdez Canyon 3018	11/89	2,720	Trinidad (Cretaceous)	Vermejo (Cretaceous)	2,246–2,514	IPP 195 MCFGPD + 70 BWPD
13	30–30N–19E, Colfax	Pennzoil No. 302 Van Bremmer Canyon 3019	9/89	2,188	Trinidad (Cretaceous)	Vermejo (Cretaceous)	1,702–2,081	IPP 3 MCFGPD + 41 BWPD

Northwest New Mexico

In 1989, 457 wells were completed in northwest New Mexico, up substantially from 305 completions in 1988 but down from 863 completions in 1985. Virtually all drilling was in the San Juan Basin, which is thus far the only productive area of northwest New Mexico. The diminished rate of drilling since 1985 has been caused by depressed gas prices and a depressed market for gas, the primary petroleum product of the San Juan Basin. Depressed oil prices have also taken a toll on drilling activity in the San Juan Basin.

Exploratory drilling resulted in one significant discovery in the San Juan Basin during 1989. Gas was discovered in the Ojo Alamo Sandstone (Tertiary) in the Robert L. Bayless No. 1 Jicarilla 457 (9) at a depth of approximately 3,200 ft. This is apparently the first well to obtain commercial production from the Ojo Alamo.

Exploratory activity was minimal within the central, productive parts of the San Juan Basin during 1989. However, several signif-

TABLE 2—Significant wildcat dry holes in New Mexico in 1989; the term formation is used in an informal sense. **TA,** temporarily abandoned; **D&A,** dry and abandoned; **perf,** perforated; **acid,** acidized; **DST,** drill-stem test.

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	Status	Comments
14	15–2S–28E, De Baca	Esperanza Energy No. 1 McClain Ranch	11/89	3,000	Glorieta (Permian)	TA	Perf 2,737–2,751 ft (Glorieta), recovered salt water. Perf & acid 2,679–2,701 ft (San Andres), with no show.
15	34–32N–15W, San Juan	Wintershall Oil & Gas No. 34–24 Straight Canyon	8/89	9,002	Pinkerton Trail (Pennsylvanian)	D&A	No porous zones were reportedly encountered in the Pennsylvanian section.
16	19–31N–3E, Rio Arriba	Spur Oil No. 2 Quinlan Ranch	7/89	1,461	Entrada (Jurassic)	D&A	Perf & acid 1,220–1,232 ft (Morrison) with no show. Perf 375–381 ft & 452–457 ft (Dakota) with no show.
17	28–31N–3E, Rio Arriba	Salazar Drilling No. 12–1 Hill Ranch	9/89	2,910	granite wash (Pennsylvanian)	D&A	No reported shows. Reportedly encountered several hundred feet of Pennsylvanian section.
18	28–18N–1W, Sandoval	Mobil Producing Texas & New Mexico No. 1 Jemez Pueblo	6/89	5,000	Entrada (Jurassic)	D&A	DST 2,320–2,325 ft (Entrada), recovered 580 ft water-cut mud + 1,160 ft water.
19	4–8N–18W, Cibola	Fossil Fuels No. 1Y Zuni Tribal	8/89	2,258	Abo (Permian)	D&A	Unable to log entire well because of sloughing shales. Completed as water well. Drilled on anticline 0.6 miles northeast of Galestina monocline.
20	16–3S–13W, Catron	Hunt Oil Co. No. 1–16 State	11/89	6,890	Precambrian	D&A	DST 3,902–3,986 ft (San Andres) recovered 1,848 ft water + 930 ft mud. DST 4,561–4,843 ft (Yeso) recovered 1,196 ft mud.
21	1–4S–3E, Socorro	James K. Anderson, Inc. No. 1 Wishbone Federal	2/89	4,989	Sandia (Pennsylvanian)	D&A	Drilled on Prairie Springs anticline.
22	19–21S–10W, Luna	XTER, Inc. No. 1 S Santa Maria DB R&R	4/89	1,150	alluvium (Tertiary)	D&A	Water-bearing sands encountered from 65 to 990 ft. Severe caving of hole encountered while drilling.
23	25–27S–17W, Hidalgo	Arthur B. Ramsey No. 1 Ramsey 25 State Unit	7/89	1,854	Permian	D&A	Reported slight, noncommercial show of hydrocarbons.

icant exploratory tests were drilled on the eastern and southeastern flanks of the basin. On the Chama platform east of the basin, two wells were drilled. The Spur Oil No. 2 Quinlan Ranch (16) tested Morrison (Jurassic) and Dakota (Cretaceous) sandstones at relatively shallow depths, but no shows were reported. The Salazar Drilling No. 12–1 Hill Ranch (17) was abandoned at a total depth of 2,910 ft in Pennsylvanian strata; several hundred feet of Pennsylvanian section were penetrated by the well. In the same area, three more wells are scheduled to be drilled in 1990 (29, 30, 31). The Heyse Oil No. 2 Rio Chama (29) is scheduled to be drilled to 2,000 ft to test the Cretaceous section. The Spur Oil No. 1 South (30) is scheduled to be drilled to 1,000 ft to test the Entrada Sandstone (Jurassic). The E. C. Yegen No. 1 Garcia (31) will be a re-entry of an abandoned wildcat well; sandstones in the Morrison Formation (Jurassic) will be re-tested in this well.

Production in the San Juan Basin is almost entirely from Cretaceous reservoirs. Relatively few wells have penetrated and tested 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. Relatively 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. The Paleozoic and Jurassic remain essentially frontiers for petroleum exploration in the San Juan Basin.

Significant exploration focused on Paleozoic and Jurassic targets during 1989. The Mobil Producing Texas and New Mexico No. 1 Jemez Pueblo (18) was drilled on the southeast margin of the basin approximately 4 miles west of the western escarpment of the Nacimiento Mountains. The well was drilled to test the Entrada Sandstone, which has been upturned to the east along the faulted front of the Nacimientos. Nearest Entrada production is 12 miles northwest in the Media Entrada oil pool. Most details concerning the well have been kept confidential, but it is known that water was recovered from the Entrada during a drill-stem test.

Exploration for hydrocarbons in Paleozoic reservoirs also continued in the northwest part of the San Juan Basin. The Wintershall Oil & Gas No. 34–24 Straight Canyon well (15) was drilled to a total depth of 9,002 ft to test Pennsylvanian carbonates; it was reported that no porous zones were encountered in the Pennsylvanian. Farther west along the Arizona State Line, the Chuska Energy No. 1 Beclabito (32) was re-entered, presumably to test the Pennsylvanian section; originally, the well had been completed in 1968 as a gas well in the Cutler Formation (Permian), but it was plugged and abandoned in 1969. During 1989 a location was staked for the Chuska Energy No. 1 Chimney Rock (33); the well is 0.75 mi northwest of the abandoned Cone Paradox oil pool, which produced from a single well in the Paradox Formation (Pennsylvanian).

Most development drilling in the San Juan Basin during 1989 was for 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. It is not known what percentage of the gas is recoverable under current or improved economic conditions, but this source certainly represents a major addition to the state's producible gas supplies. More than 250 wells were drilled to develop Fruitland coal-bed methane during 1989. 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 more 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. More importantly, producers are eligible for a federal gas-production tax credit for wells drilled before January 1, 1991; that tax credit applies to gas produced from those wells prior to the year 2000. As a result of the tax credit, a drilling boom started as operators rushed to discover and develop reserves before the deadline. Some development, no doubt, would have occurred without the tax credit. At the time this report was written, legislation was pending in Congress to extend it another two years. If that legislation passes, exploration and development should continue into 1992 at a relatively brisk pace. Meridian Oil Company and Amoco Production Company are ☞

TABLE 3—Significant wildcat wells that were being drilled, not completed, "tight," or planned in New Mexico at the end of 1989. **owwo,** old well worked over.

Number on Fig. 1	Location (section-township-range, county)	Operator, well number, and lease	Comments
24	35–24N–14E, Taos	Leonard Minerals No. 1 Taos Trough Unit	Location abandoned. Was to have tested possible overthrust.
25	4–2S–28E, De Baca	Jaguar Energy No. 1 Colter Federal	Location staked. Scheduled to drill to 7,200 ft to test Montoya (Ordovician).
26	7–14S–11E, Otero	Cibola Energy No. 1 Ysletano Canyon Federal	Spud 8/4/87. Estimated total depth 3,800 ft. Devonian test. "Tight" hole.
27	18–5N–9E, Torrance	Lyle Benz No. 2 Benz	Scheduled to drill to 1,400 ft to test Abo (Permian).
28	18–9N–18W, McKinley	Fossil Fuels No. 2 Zuni Tribal	Scheduled to drill to total depth of 2,500 ft in Yeso (Permian).
29	2–30N–3E, Rio Arriba	Heyse Oil No. 2 Rio Chama	Scheduled to drill to 2,000 ft to test Dakota (Cretaceous).
30	19–31N–3E, Rio Arriba	Spur Oil No. 1 South	Location staked. Scheduled to drill to 1,000 ft to test Entrada (Jurassic).
31	19–31N–3E, Rio Arriba	E. C. Yegen No. 1 Garcia	Re-entry of Great American Oil No. 1 John Sargent Estate, D&A on 6/19/63. Will re-test Morrison (Jurassic).
32	13–30N–21W, San Juan	Chuska Energy No. 1 Beclabito (owwo)	Drilled to total depth of 5,106 ft in Precambrian. "Tight" hole.
33	21–31N–18W, San Juan	Chuska Energy No. 1 Chimney Rock	Scheduled to drill to 8,500 ft to test Paleozoics.

the major operators in the coal-bed methane play; Nassau Resources, Southland Royalty, Northwest Pipeline, Blackwood & Nichols, and Union Texas Petroleum also have significant lease holdings and have drilled wells within the New Mexico part of the San Juan Basin (Neil H. Whitehead III, personal communication 1989). Sandra Johnson (1989) summarized the Fruitland coal-bed methane play.

Development drilling for gas in reservoirs other than the Fruitland was sluggish during 1989 and was concentrated in San Juan and Rio Arriba Counties. Gas wells were completed in Dakota, Gallup, Mesaverde, and Pictured Cliffs sandstones (Cretaceous) and in the Chacra producing interval (Cretaceous).

Although development drilling for oil was subordinate to development drilling for gas in 1989, significant oil-development efforts were still made. Major targets were offshore marine bars in the Gallup sandstone (Cretaceous). Approximately 50 wells were drilled to develop Gallup oil pools during 1989. Most wells were drilled in the Bisti, South Bisti, Lybrook, Counselors, and Gavilan Gallup oil pools of San Juan and Rio Arriba Counties.

Elsewhere in northwest New Mexico, one 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 and the Baca Basin. The Fossil Fuels No. 1Y Zuni Tribal (19) was drilled on a surface anticline in western Cibola County 0.6 miles northeast of the Galestina monocline. Total depth was reached at 2,258 ft in red beds of the Abo Formation (Permian). No shows were reported and the well was completed as a water well. The Fossil Fuels No. 1Y Zuni Tribal was the second of three wells to be drilled on the Zuni Reservation to test surface anticlines. The first well, the Burr Oil & Gas No. 1 Zuni, was drilled during 1988 on the Piñon Springs anticline of southwestern McKinley County (Broadhead, 1989); the well was abandoned after encountering an oil show in the San Andres Formation (Permian). The third well, the Fossil Fuels No. 2 Zuni Tribal (28) is scheduled to be drilled in southwestern McKinley County approximately one mile northeast of the Galestina monocline.

Two significant exploration programs will begin during 1990 in northwest New Mexico. Merrion Oil and Gas Corp. has 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, 1990e). 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 in Cibola and western Valencia Counties (Petroleum Information, 1990). PENTECO has acquired drilling rights to more than 250,000 acres held by the New Mexico and Arizona Land Company. Six drilling prospects have been under consideration; the Pennsylvanian section is the object of all six prospects. The first well will be in western Valencia County and will be spudded before July 1, 1990. It will offset the New Mexico and Arizona Land Company No. 5 Penteco Trinity (Broadhead, 1988), a wildcat well drilled during 1987 to test the Pennsylvanian section; that well was abandoned but had oil shows (Petroleum Information, 1990).

Northeast New Mexico

Petroleum exploration activities increased dramatically in northeast New Mexico during 1989. Twenty-four exploratory and development wells were drilled in the Raton Basin of Colfax County and one well was planned for 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 519 bbls heavy oil from sandstones in the Santa Rosa Formation (Triassic) with the aid of a pilot steamflood project. McKallip (1987) reported on the geology of the steamflood project in 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 the Raton Basin, Pennzoil embarked on a pilot drilling program to test and evaluate coal-bed methane resources in the Vermejo Formation (Cretaceous). Pennzoil drilled 24 exploration and development wells in the New Mexico part of the basin. Four representative wells (10–13) are shown on Fig. 1 and discussed in Table 1. Depth to production varies from approximately 1,500 ft to approximately 2,500 ft and is dependent on structural elevation of the Vermejo Formation. Fifteen of the wells have been producing since October, 1989 with promising results (Johnson, 1990). If the pilot program is successful, more than 100 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 1991, the shallow depth of the wells, and a lack of engineering problems encountered while drilling the wells (Johnson, 1990).

Exploratory interest was sustained in the Estancia Basin of Torrance County. Plans were announced to drill the Lyle Benz No. 2 Benz (27) in the central part of the basin. That well is scheduled to be drilled to a total depth of 1,400 ft and will test the Abo Formation (Permian).

Exploratory activity was quiet elsewhere in New Mexico. Plans were canceled to drill the Leonard Minerals No. 1 Taos Trough Unit

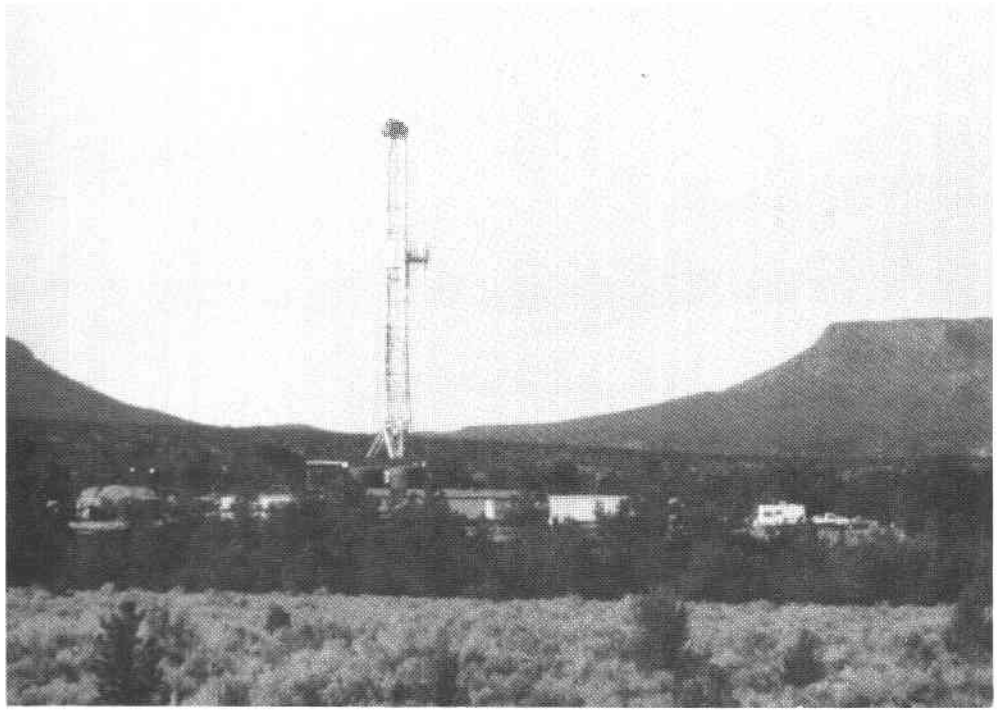

FIGURE 2—Hunt Oil Company No. 1–16 State (Fig. 1, no. 20; Table 2, no. 20) drilling in the Baca Basin, November 1989.

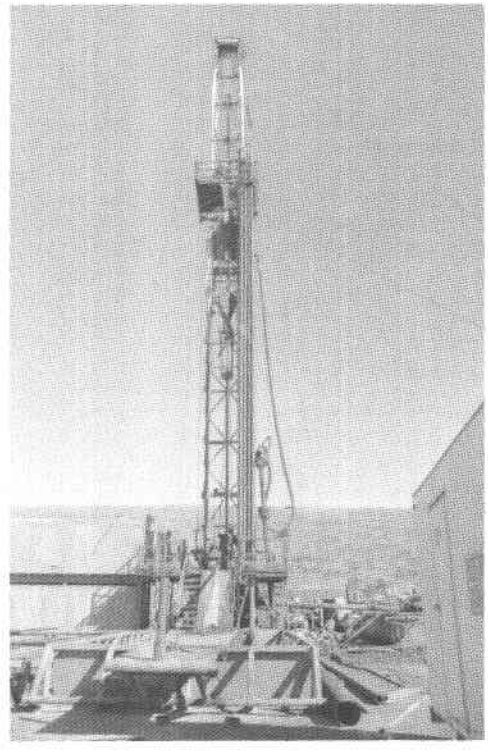

FIGURE 3—James K. Anderson, Inc. No. 1 Wishbone Federal (Fig. 1, no. 21; Table 2, no. 21) drilling in the Jornada del Muerto in eastern Socorro County, January 1989.

well (24) in Taos County. That well would have been drilled into a postulated overthrust in the Sangre de Cristo Mountains. For the first time in several years, no wells were drilled in the Tucumcari Basin during 1989. Interest has continued in the basin, however. Ownership of wells in the Newkirk oil pool was transferred from DRC Petroleum to Enercap Corporation in early 1990.

Southwest New Mexico

Four petroleum exploration wells (20–23) were drilled in southwest New Mexico during 1989. Those wells were drilled in the Baca Basin of Catron County, the Jornada del Muerto of eastern Socorro County, the Pedregosa Basin of Hidalgo County, and northwestern Luna County.

The Hunt Oil Company No. 1–16 State (20; Fig. 2) was drilled in the Baca Basin. The well was drilled to a total depth of 6,890 ft in the Abo Formation (Permian) and abandoned with no reported shows. Primary reservoir targets were carbonates in the San Andres Formation (Permian) and carbonates and sandstones in the Yeso Formation (Permian). The Hunt well is the fourth to be drilled in the Baca Basin since 1987. The other three wells were drilled during 1987 and 1988 by a consortium of Shell, BP Exploration (formerly Sohio and Standard Oil), and Elf Aquitaine with Shell as the operator (Broadhead, 1988, 1989). All three wells were abandoned, but gas shows had been reported from the Yeso Formation in the Shell No. 1 SWEPI et al. State located in sec. 2, T4S, R13W, Catron County. The consortium of Shell, BP Exploration, and Elf Aquitaine formed a federal exploration unit known as the "Magic Area" in northern Catron and western Socorro Counties. The exploration unit covers approximately 3.5 million acres. Extensive seismic-reflection surveys were conducted by the consortium in this area.

In eastern Socorro County at the northern end of the Jornada del Muerto, the James K. Anderson No. 1 Wishbone Federal (21; Fig. 3) was drilled on the Prairie Springs anticline. The well was spudded in limestones of the San Andres Formation (Permian) and reached a total depth of 4,989 ft in the Sandia Formation (Pennsylvanian). The well was scheduled to be drilled to a total depth of 4,000 ft in Precambrian basement; however, the Pennsylvanian section was thicker than expected, so Precambrian is at a greater depth than expected. Drilling was complicated by lost circulation. Small, noncommercial gas shows were reportedly encountered in the Pennsylvanian (James K. Anderson, personal communication 1990).

The XTER, Inc. No. 1 Santa Maria DB R&R (22) was drilled in northern Luna County. The well was drilled to a total depth of 1,150 ft in alluvium (Tertiary). No shows were reported. Water-bearing sands were encountered throughout most of the well.

The Arthur B. Ramsey No. 1 Ramsey 25 State Unit (23) was drilled in east-central Hidalgo County. The well was drilled to a total depth of 1,854 ft. Strata at total depth were reported to be Permian. Slight, noncommercial shows of hydrocarbons were reportedly encountered.

Oil and gas production

In 1988, 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, 1989). Production of crude oil and lease condensate in New Mexico in 1989 was approximately 67.9 million bbls, a decrease of 4.7% from the 71.2 million bbls produced in 1988 (New Mexico Oil Conservation Division data). Production of natural gas in 1989 was approximately 838 billion ft^3 (BCF), an increase of 7.3% from the 781 BCF produced in 1988. In 1988, 90% of the state's oil and 53% of the state's gas were produced from the Permian Basin and adjoining areas of southeast New Mexico; 10% of the state's oil and 47% of the state's gas were produced from the San Juan Basin of northwest New Mexico. As of December 31, 1988, New Mexico had proved crude oil reserves of 661 million bbls, an increase of 7 million bbls from December 31, 1987 (Energy Information Administration, 1989); the Permian Basin contains 94% of the state's proved oil reserves and the San Juan Basin contains 6% of the state's proved oil reserves. Additionally, New Mexico had reserves of 97 million bbls of lease condensate as of December 31, 1988 (Energy Information Administration, 1989); 75% of the state's condensate reserves are in the San Juan Basin and 25% of the state's condensate reserves are in the Permian Basin. As of December 31, 1988, New Mexico had proved natural gas reserves of 18.5 trillion ft^3 (TCF), an in-

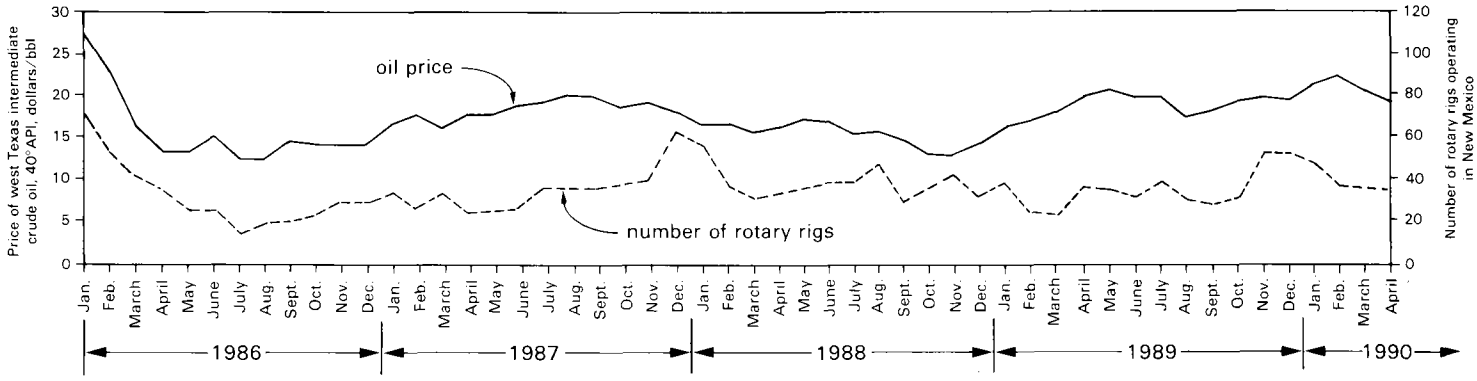

FIGURE 4—Monthly crude oil prices and number of active rotary drilling rigs in New Mexico during 1986, 1987, 1988, 1989, and early 1990. Data from Oil and Gas Journal (1986a, b; 1987a, b; 1988a, b; 1989a, b; 1990a, b).

crease of 5.9 TCF from December 31, 1987 (Energy Information Administration, 1989); the San Juan Basin contains 83% of the state's gas reserves and the Permian Basin contains 17% of the state's gas reserves.

The decrease in oil production in 1989 can be traced to the steep decline in the price of crude oil during the first half of 1986 (Fig. 4). The posted price of west Texas intermediate crude oil with a gravity of 40° API (the "benchmark" crude oil of the United States) fell 55% from $27.25/bbl in January 1986 to $12.25/bbl in July 1986. The price subsequently rose to $20.00/bbl in August 1987 and then fell to $13.75/bbl in November 1988. Since the end of 1988, posted prices for west Texas intermediate crude have risen to more than $20.00/bbl during early 1990 when this article was written.

The sharp fall in oil prices at the beginning of 1986 was due to a sudden rise in oil production by several major producing countries (notably Great Britain and Latin American and Middle Eastern countries) in an effort to increase income from oil revenues. The rise in oil production created an oversupply of oil and caused prices to plummet. A gradual reduction of world petroleum stocks, rising worldwide demand, and partially successful attempts by OPEC nations to reinstate production ceilings caused a subsequent gradual, albeit unsteady, price increase. The decrease in price at the end of 1988 was caused by rising worldwide oil production.

Declining oil prices have resulted in a decrease in drilling and exploration activity, which is reflected in the rig count for the state (Fig. 4). As a result of the decreased drilling, oil reserves were not discovered and developed as quickly as in the past. Therefore, new oil reserves were not brought into production at a rate sufficient to offset depletion of existing reserves. The inevitable result was decreased production.

Because of a decrease in oil prices, many marginal and stripper wells were shut in or plugged. Their production may never be regained unless oil prices increase sufficiently to justify the expense of re-opening such wells. Stripper wells are defined as wells that produce less than 10 bbls per day. Approximately 22% of oil production in New Mexico is from stripper wells. Reserves of crude oil that are producible from stripper wells are 98.5 million bbls (Interstate Oil Compact Commission, 1989), approximately 15% of total proved oil reserves in New Mexico.

The U.S. Department of Energy (Energy Information Administration, 1989) estimated that proved oil reserves increased by 7 million bbls from 1987 to 1988. However, discoveries of new fields resulted in only 1 million bbls of additional reserves and discoveries of new reservoirs in existing fields resulted in only 5 million bbls of additional reserves; 15 million bbls of reserves were added by extension of existing fields. These 21 million bbls of reserve additions fell short of production during 1988 by 43 million bbls. The calculated 7-million-bbls increase in reserves was caused by revision of reserve calculations in known fields. These revisions resulted partially from infill drilling programs. The increase of 7 million bbls did not result from discovery of new hydrocarbons.

Despite the decreased rig count and discovery rate, continued oil discoveries in the Permian and San Juan Basins, as well as positive signs and hydrocarbon shows encountered in wildcat wells drilled in the frontier areas, will encourage exploratory drilling and development. However, the number of active rotary rigs in New Mexico is tied to the price of oil (Fig. 4). Gradual declines in future reserves and production will probably be arrested only if oil prices rise enough to increase substantially the number of active rigs. Oil prices must not only rise, but must also stabilize if an increase in the rig count is to occur. Indeed, a decline in volatility of oil prices may affect exploration and drilling as much, or more than, an increase in prices alone. Although prices rose fairly steadily in 1989, the rig count remained low. The low rig count resulted from wary investors who were discouraged by price decreases in the last half of 1988. However, oil prices appear to have stabilized somewhat since the beginning of 1989 and the rig count appears to have increased since late 1989. Barring any drastic price reductions in 1990, drilling rates should increase. However, the rate almost certainly will still be lower than the levels needed to prevent further production declines, unless a major discovery is made. Grant and Foster (1989) discussed the geology of areas in New Mexico that may contain undiscovered oil and gas resources.

The increase in gas production in 1989 was caused primarily by an increased demand for gas. Primary markets for New Mexico gas are in California and these markets developed an increased demand in the last half of the year. The California gas markets continue to face stiff competition from alternate energy sources including fuel oil and hydroelectric power, but the demand for gas in California is expected to grow, possibly by as much as 38% by the year 2000 (Oil and Gas Journal, 1989c). Competition from fuel oil will decrease if the price of crude oil stays relatively high; also, natural gas may replace fuel oil in many of the markets because it is a more environmentally desirable fuel. Strong competition will continue to come from imported Canadian gas and gas produced in the "overthrust belt" of Wyoming; additional pipelines will be built to carry that gas to the California marketplace.

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 markets in California, the Gulf Coast, the Midwest, and the Pacific Northwest (Oil and Gas Journal, 1990c, d); these alternative marketplaces will give producers more flexibility than they presently have. In addition, Mojave Pipeline Co. will construct 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, 1990b). The Mojave pipeline will transport gas to the heavy-oil fields of central California where it will be used in thermal-enhanced oil recovery. The pipeline is expected to be completed by early 1992. The markets for coal-bed methane made available by the new pipelines should help

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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 in the basin 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). Some of these pipelines may have access to markets in the Midwest.

The calculated increase in gas reserves in 1988 (Energy Information Administration, 1989) was caused by addition of coal-bed methane reserves. Coal-bed methane had not been considered in previous reserve estimates.

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New Mexico Geological Society

Spring Meeting

The New Mexico Geological Society will hold its annual spring meeting on Friday, April 5, 1991 in Macey Center at the New Mexico Institute of Mining and Technology, Socorro, New Mexico. Papers that focus on the geology of New Mexico or adjacent areas are being solicited for oral or poster presentation. Abstracts must be received by February 15, 1991. They will appear in a proceedings volume and later will be published in *New Mexico Geology*. The abstracts should be GSA style and camera ready. The abstract must fit on an 8½ × 11" page; unused space can be used for illustrations in the proceedings volume. A $50.00 award will be presented for the student paper judged outstanding; for more information on this voluntary competition, contact either chairperson. Meeting co-chairpersons are: William X. Chavez, Jr., Mining Department, New Mexico Institute of Mining and Technology, Socorro, NM 87801 (505) 835–5317 and Neil H. Whitehead, III, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801 (505) 835–5257. Please send abstracts by February 15, 1991 to Neil H. Whitehead, III.

Also of interest on April 6. Saturday morning is the twice yearly tour of Trinity Site on White Sands Missile Range. You may enter and leave from the Stallion (north) entrance, or you may enter at the Stallion entrance and exit at the Tularosa Gate. Saturday afternoon the public may view science projects at the 49th Annual New Mexico Science & Engineering Fair on the New Mexico Tech campus.

Fall Field Conference

The New Mexico Geological Society will hold its 42nd Annual Fall Field Conference on October 9–12, 1991. The conference convenes at the Inn of the Mountain Gods near Ruidoso and focuses on the geology of the northern Sacramento Mountains. Field trips will leave from Ruidoso on all three days (Thursday–Saturday) with an optional pre-meeting tour of the Sierra Blanca volcanic terrane on Wednesday afternoon. Oral presentations will be given along with written guidebook contributions dealing with all aspects of New Mexico geology from Proterozoic to Recent. Articles and discussion will cover many topics, including new ideas on the Lincoln folds, Bent dome, Laborcita mounds, US–70 karst, Sierra Blanca coal field, Cub Mountain Formation, and several mining districts.

The first-day route is southwest to Alamogordo and back via Cloudcroft. On day two, the buses progress east to Hondo, west to Capitan, and back. On the last day we proceed by automobile to White Oaks, Ancho, and Valley of Fires Recreation Area. Field-trip leaders are Art Bowsher, Steve Cather, Bob Colpitts, Spencer Lucas, and Virginia McLemore. The pre-meeting tour will be led by Sam Moore and Tommy Thompson.

Papers for the guidebook are due by February 15, 1991. They should be sent to co-chairmen George Austin and James Barker, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801 (505) 835–5420. Barry Kues is managing editor of the guidebook. □