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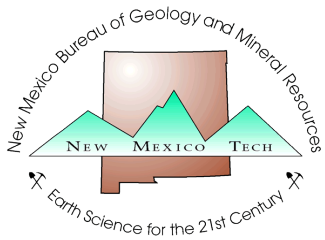

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Petroleum exploration targets in New Mexico for the late 1980's and beyond

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Introduction

Oil and natural gas are produced in southeast and northwest New Mexico from eight of New Mexico's 33 counties. In southeast New Mexico, production is from the Permian Basin, which includes parts of Lea, Eddy, Chaves, and Roosevelt Counties. The New Mexico part of the Permian Basin includes the Central Basin Platform, the Northwest Shelf, and the deep-marine Delaware Basin (Fig. 1). In northwest New Mexico, production is from the San Juan Basin, which includes parts of San Juan, Rio Arriba, McKinley, and Sandoval Counties. Small amounts of oil have been produced from the Española Basin (Santa Fe County) and the Tucumcari Basin (Guadalupe County).

New Mexico ranks fourth among states in the production of natural gas and seventh in the production of oil (Energy Information Administration, 1985). In 1985, 78,529,514 bbls oil and 893,291 million ft³ gas were produced in New Mexico (New Mexico Oil Conservation Division, unpublished report 1986). Approximately 90% of the oil and 50% of the gas were produced from the Permian Basin. Approximately 10% of the oil and 50% of the gas were produced from the San Juan Basin; 93 bbls oil were produced from the Tucumcari Basin and 50 bbls oil were produced from the Española Basin. As of December 1984, New Mexico had reserves of 796 million bbls oil and lease condensate and 12.0 trillion ft³ of natural gas (Energy Information Administration, 1985).

The oil reserves include oil that can be recovered by enhanced-recovery techniques. Since 1974, annual oil production has decreased 20% and annual gas production has decreased 27%. Oil reserves have increased by 20% since 1974, and natural-gas reserves have increased by 0.8%. Production and reserve declines can be replaced partially by new discoveries that are made every year in the Permian and San Juan Basins. For example, discoveries of oil in the last 5 years in the Permian Basin in sandstones of the Delaware Mountain Group (Permian) and sandstones and limestones of the Bone Spring Formation (Permian) have resulted in rapid development of new oil pools that have added oil production and reserves. Although the Permian and San Juan Basins are in a mature stage of exploration, additional oil and gas discoveries will undoubtedly be made in the future.

Currently non-productive frontier areas associated with major sedimentary basins probably will contribute to reserve additions of the future. Before 1977, no petroleum had been produced from the Abo red beds (Permian) on the Northwest Shelf of the Permian Basin, and many operators thought there would never be any commercial development. In that year, Yates Petroleum Corporation drilled the discovery well of the large Pecos Slopes Abo gas field in north-central Chaves County (Fig. 1; Broadhead, 1984a). Production is from the "tight" Abo gas sands in three separate gas pools: Pecos Slope Abo pool, South Pecos Slope Abo pool, and West Pecos Slope Abo pool. Discovery was from the Yates No. 1 McConkey well. The Abo red beds were tested to verify gas indicated by interpretation of wireline logs. After the well was acidized and artificially fractured, the Abo was measured to have an initial potential of 2,550 thousand ft³ gas per day through perforations from depths of 4,764 to 4,782 ft.

The discovery prompted operators to drill several more wells to test the red beds, but drilling continued at a slow pace until 1980. In that year, the Abo red beds were designated a "tight gas sand" by the Federal Energy Regulatory Commission (FERC). The FERC had created this special category of gas-bearing formations for low-permeability reservoir sandstones of doubtful economic value in an effort to stimulate development of reserves by offering special price incentives. The tight-sand designation raised the initial ceiling price at which producers could sell Abo gas from $2.81 to $4.92 per thousand ft³, and also provided for subsequent increases in the price of Abo gas. At these higher prices, gas could be produced economically from the Abo red beds. Consequently, approximately 400 gas wells have been drilled and completed in the Abo since 1980. In 1985, ☞

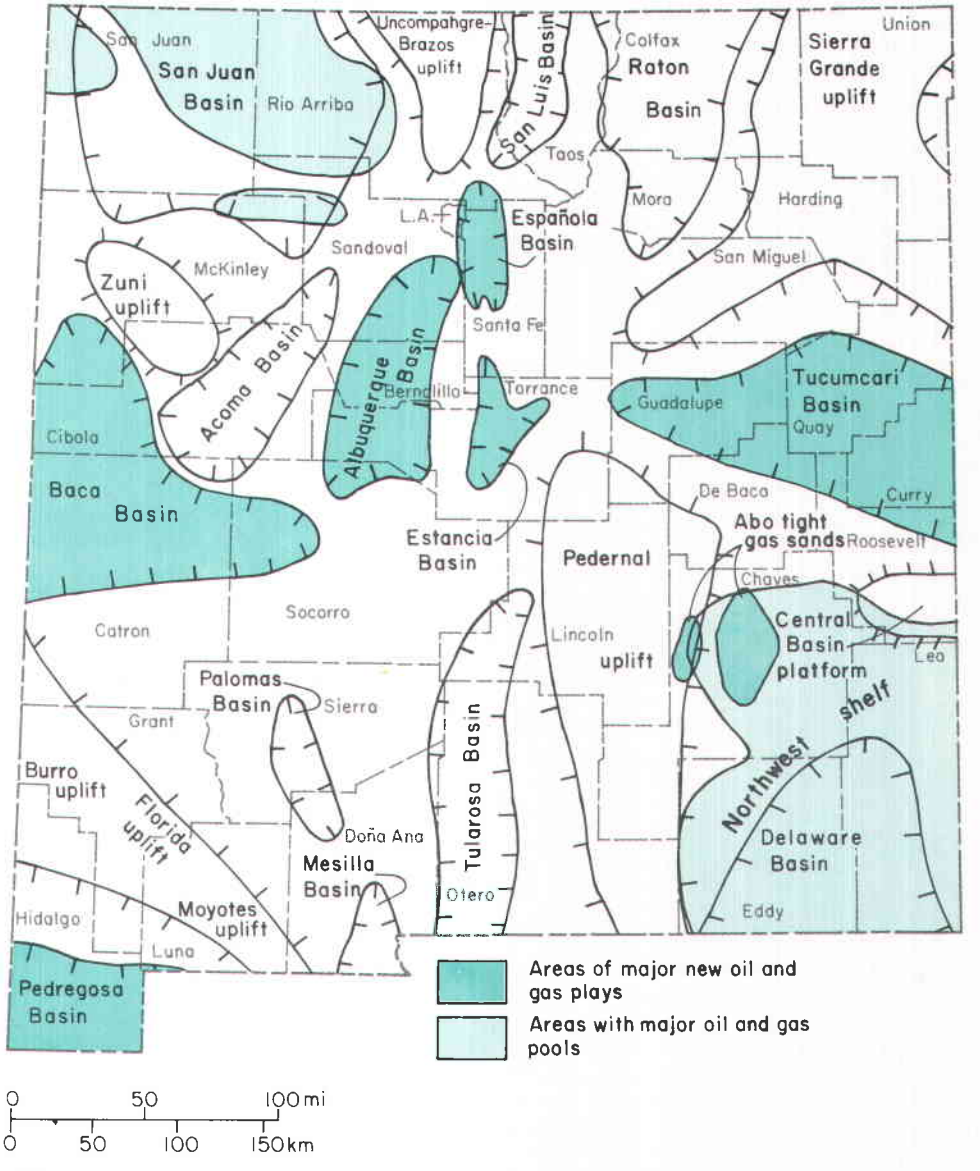

FIGURE 1—Oil and gas production in major basins and uplifts and frontier basins with major new oil and gas plays in New Mexico. Geologic features are taken from Cather and Johnson (1984), Kelley (1978), Kottlowski and Stewart (1970), Meyer (1966), Molenaar (1977), Roberts et al. (1976), Thompson and Jacka (1981), and Woodward et al. (1978).

31,198 million ft³ of gas were produced from the Abo red beds in New Mexico; this is approximately 3.5% of the total gas produced in New Mexico during that year.

Although the Pecos Slope Abo field is located within the productive Permian Basin, it is located within an area that was considered to be an exploration frontier before discovery of gas in the Abo red beds. The Pecos Slope Abo field is an excellent example of how nonproductive frontier areas of New Mexico may be found to contain significant volumes of undiscovered petroleum resources.

Paleozoic sedimentary rocks of the San Juan Basin constitute an important and largely untested exploration target in New Mexico. Almost all of the oil and gas production in the San Juan Basin is from Cretaceous sandstones and shales; some oil is produced from Jurassic sandstones. Production from Paleozoic reservoirs is limited to the western flank of the basin from nine small fields associated with structural traps (Fig. 2). Producing Paleozoic reservoirs in the San Juan Basin are Pennsylvanian, Mississippian, and Devonian in age. Most wells in the San Juan Basin have been drilled to Cretaceous objectives. Only approximately 30 exploratory wells have been drilled deep enough to test the Paleozoic section, which is generally present at depths of more than 8,000 ft. Recently drilled Paleozoic tests are shown in Fig. 2. Possible Paleozoic exploration targets are Pennsylvanian sandstones and carbonates, Mississippian carbonates, and Devonian sandstones.

Frontier basins

In New Mexico, only two basins, the Permian and San Juan, produce significant amounts of oil and gas. There are 12 other major frontier basins that do not yet produce significant amounts of oil and gas. The petroleum potential of some of these basins appears to be more favorable than others based on analyses of three key factors: source rocks, reservoir rocks, and traps (Fig. 3).

Source rocks are organically rich sedimentary rocks that have generated and expelled petroleum in sufficient quantity to form commercial accumulations (Dow, 1979). After source rocks have been identified, their distribution, richness, and maturity should be determined and mapped. Reservoir rocks are porous, permeable rocks through which petroleum can move and accumulate. After reservoir rocks have been identified, their distribution, thickness, porosity, and permeability should be determined and mapped.

After petroleum is generated in the source rock, it migrates into the reservoir rock. Pores in the reservoir rock are initially saturated with water; because petroleum is less dense than water, it tends to migrate updip through the porous reservoir until it is trapped against an impermeable seal (normally a shale, dense sandstone or limestone, or an impermeable fault) of the reservoir rock. Some types of structural, stratigraphic, and hydrodynamic petroleum traps are depicted in Figure 4. Where possible, the types of traps should be identified and their probable locations mapped.

In the following sections, the petroleum potential is summarized for seven of the more promising frontier basins in New Mexico: the Tucumcari, Albuquerque, Española, Estancia, Pedregosa, Baca, and Raton Basins (Fig. 1). All have been targets of major exploration activity in the last 4 years.

Tucumcari Basin

There are two known major accumulations of heavy oil in the Tucumcari Basin (Fig. 5). The Santa Rosa tar sands, a deposit of Santa Rosa Sandstone (Triassic) that is impregnated with heavy oil, crops out approximately 7 mi north of the city of Santa Rosa in Guadalupe County. The Santa Rosa tar sands were mined for road-surfacing materials in the 1930's (Gorman and Robeck, 1946), but have not been mined since then due to unfavorable economics. The Santa Rosa tar sands contain an estimated 90.9 million bbls of oil in place (Budding, 1980). Heavy oil also occurs in the Santa Rosa Sandstone at depths of 400–800 ft in the Newkirk oil pool, northeast Guadalupe County. Attempts have been

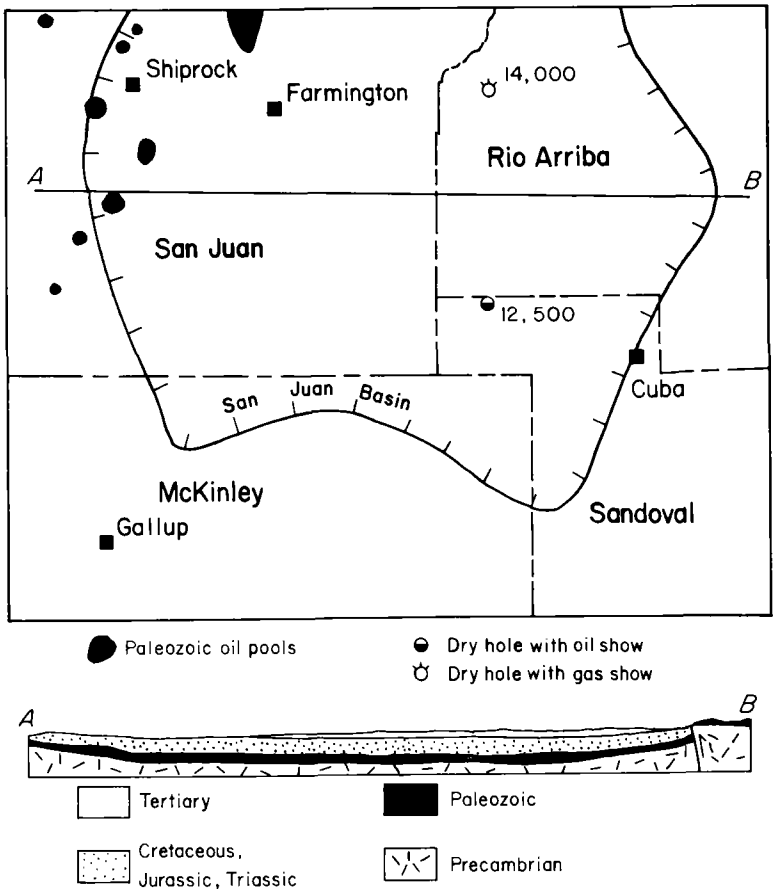

FIGURE 2—Paleozoic oil pools and recent Paleozoic tests drilled in the San Juan Basin. Numbers indicate total depth of wells in feet.

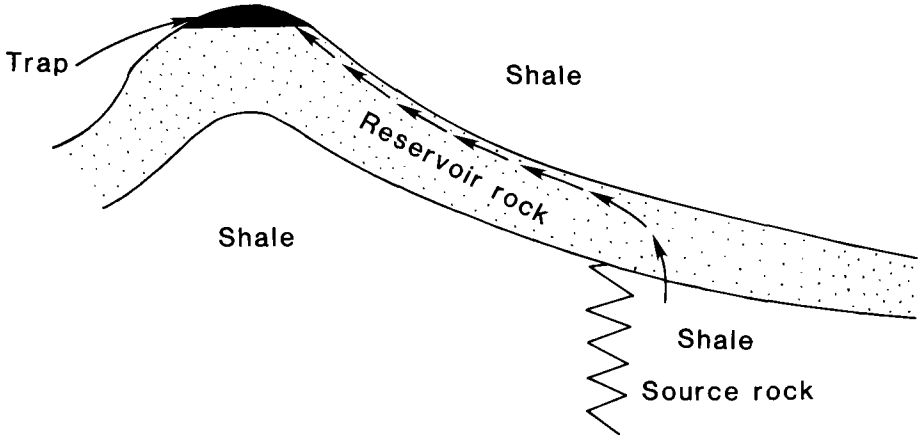

FIGURE 3—Relationships among source rocks, reservoirs, and traps.

made recently to recover the heavy oil with two pilot steamflood projects; the Newkirk pool produced 93 bbls oil in 1985. Estimates of the volume of oil in place at the Newkirk pool range from 23 to 62 million bbls (McKallip, 1985).

Several petroleum exploration wells have been drilled in the Tucumcari Basin during the last 4 years (Fig. 5). Two significant noncommercial discoveries were made. In northeast Guadalupe County, at the Trans-Pecos Resources No. 1 Latigo Ranch A (Fig. 5, letter A) gas was found in Pennsylvanian sandstones at depths of 6,165–7,098 ft. Two low-volume gas wells were subsequently drilled to confirm the discovery. In western Quay County in the Yates Petroleum Corporation No. 1 T–4 Cattle Company (Fig. 5, letter B), gas and oil were found in Pennsylvanian-age sandstones at depths of 6,610–6,615 ft. Other wells drilled in the Tucumcari Basin in the last 4 years have resulted in low-volume gas discoveries in the San Andres Formation (Permian) and the Yeso Formation (Permian), and oil and gas shows were encountered in Santa Rosa Sandstone (Triassic), Artesia Group (Permian), San Andres Formation (Permian), Yeso Formation (Permian), and Pennsylvanian-age sedimentary units.

Major exploration targets in the Tucumcari Basin are the Santa Rosa Sandstone at depths of less than 2,000 ft (Broadhead, 1984b), carbonate rocks of the San Andres Formation at depths of 1,000–3,000 ft (Pitt and Scott, 1981), and Pennsylvanian sandstones and carbonate rocks at depths of 5,000–10,000 ft. The presence of oil in the Santa Rosa tar sands, the Newkirk oil pool, and Pennsylvanian sandstones indicates that source rocks are present in the basin. Those source rocks are probably Pennsylvanian in age, but their quality, volume, and distribution are unknown.

Albuquerque Basin

The Albuquerque Basin (Fig. 5) has been the site of an exploration and drilling program for the last 14 years. Ten wells have been drilled by Shell Oil Company, Transocean Oil Company, and UTEX Oil Company to depths ranging from 10,000 to 21,000 ft, primarily to test Upper Cretaceous sandstones. Gas shows have been encountered in several of the wells in the Upper Cretaceous section. The Paleozoic section remains virtually untested.

Rocks that have characteristics indicating that they may be petroleum source rocks are Upper Cretaceous marine shales and fetid lacustrine limestones of the Todilto Formation (Jurassic; Black, 1982). Possible reservoirs are Upper Cretaceous sandstones similar to the Upper Cretaceous paralic and shallow-marine sandstones that produce large volumes of oil and gas in the San Juan Basin (Black, 1982). Both fault traps and stratigraphic traps formed by sand lenses are likely to exist. Possible Paleozoic reservoirs are Permian and Pennsylvanian sandstones and carbonates.

Española Basin

Thirty-two petroleum exploration wells have been drilled in the Española Basin since 1914, and 27 of those wells have been drilled since 1974 (Black, 1984a; unpublished NMBMMR data). Oil or gas shows have been reported from 26 of those wells. Only five wells were drilled deep enough to penetrate Paleozoic sedimentary rocks. Oil and gas have been encountered in Cretaceous sandstones and fractured shales in several recently drilled wells (Fig. 5). The Pelto Oil Company No. 1 Ortiz (Fig. 5, letter E) swabbed oil from Cretaceous rocks before it was abandoned. The Colorado Plateau Geological Services No. 1 Ferrill (Fig. 5, letter F) is a shut-in gas discovery with Upper Cretaceous pay (Black, 1984a).

Two oil discoveries were completed in 1985. The Black Oil Inc. No. 1 Ferrill (Fig. 5, letter G) was completed in the Niobrara Shale (Cretaceous) for an initial production of 80 bbls of oil per day. The Chace Oil Company No. 1 Piñon Unit (Fig. 5, letter D) was completed in the Gallup Sandstone (Cretaceous) for an initial production of 30 bbls of oil per day; after initial completion, production quickly decreased to a subeconomic rate of approximately 1 bbl of oil per day, and the well was subsequently abandoned.

Yates Petroleum Corporation has recently begun a three-well exploration program in the Española Basin. One well, the Yates No. 2 La Mesa unit (Fig. 5, letter H) was drilled to a total depth of 7,710 ft in reported Precambrian rocks; the well was abandoned with no reported shows of oil or gas. The Yates No. 3 La Mesa unit (Fig. 5, letter I) was drilled to a total depth of 4,755 ft in reported Triassic rocks and also was abandoned with no reported shows of oil or gas. An additional well is planned to be drilled to approximately 7,000 ft to test the Paleozoic section (Fig. 5, letter C).

Primary exploration targets in the Española Basin are Upper Cretaceous sandstones, which lie along southeastward extensions of the productive stratigraphic trends in the San Juan Basin to the northwest. Fractured Upper Cretaceous shales are also attractive targets. Upper Cretaceous shales are possible source rocks. The Paleozoic section is virtually unevaluated. Both stratigraphic and structural traps may be present in Cretaceous and Paleozoic rocks. Traps may be associated with the thrust-faulted Paleozoic section (Black, 1984b).

Estancia Basin

The Estancia Basin (Fig. 5) has been the site of sporadic petroleum exploration for the last 60 years. Carbon dioxide gas was produced from two fields in the Estancia area in the 1930's and 1940's. The fields are currently inactive. Oil and gas shows in Pennsylvanian sedimentary units have been encountered in several wells at depths ranging from approximately 2,000 to 5,000 ft.

The primary exploration targets in the Estancia Basin are Pennsylvanian sandstones. Pennsylvanian limestones and Permian sandstones, dolostones, and limestones are secondary exploration targets. Gray to black Pennsylvanian shales may be source rocks,

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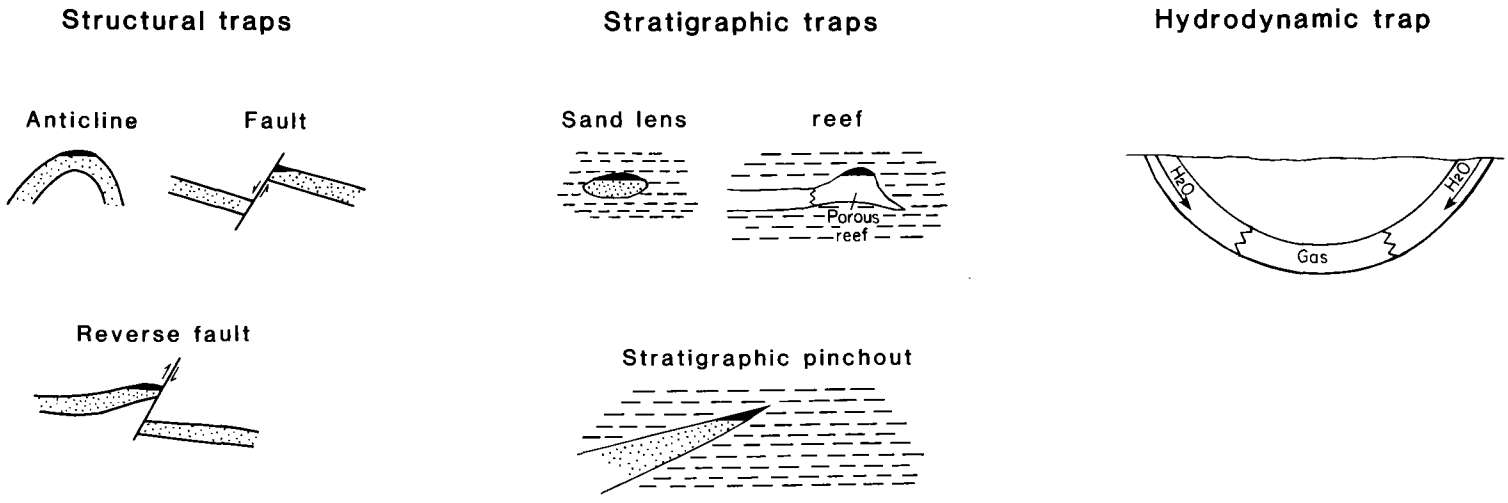


FIGURE 4—Some typical types of petroleum traps.

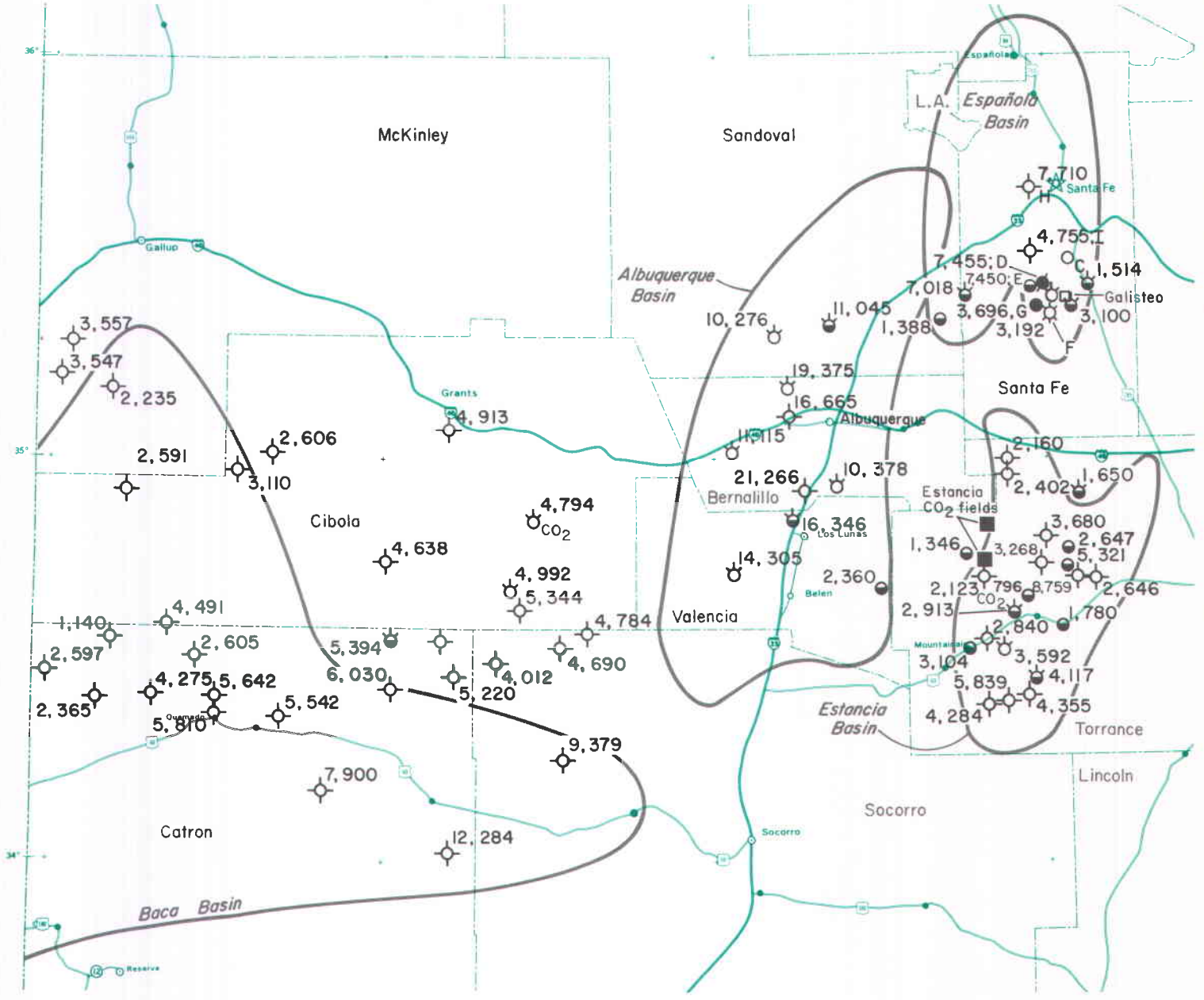
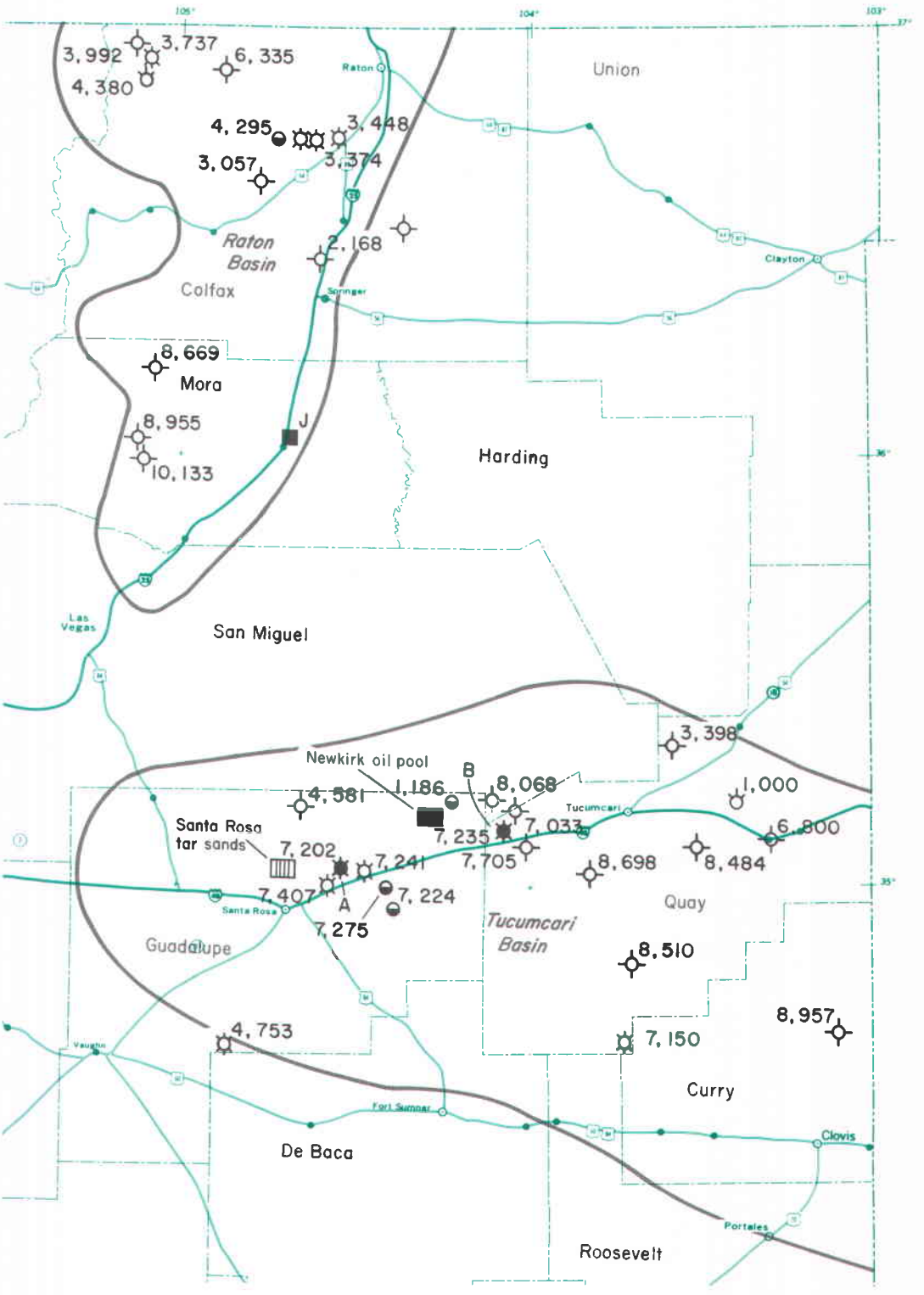


FIGURE 5—Selected recent petroleum exploration wells drilled in New Mexico and adjacent part of Mexico. Numbers indicate total depth of wells in feet. Letters designate specific wells discussed in text. Data from New Mexico Bureau of Mines and Mineral Resources, Black (1982), Black (1984a), Thompson (1982), and Thompson et al. (1978).



- Dry hole with oil show
- Well productive of oil
- Abandoned oil producer
- Dry hole with oil show and gas show
- Well productive of oil and gas
- Dry hole
- Location of hole not drilled or not completed
- Well productive of gas
- Dry hole with gas show

0 10 20 30 40 mi
0 10 20 30 40 50 60 km

but their organic geochemistry has not been evaluated fully. Both structural and stratigraphic traps may be present. The structure of the basin is poorly understood.

Pedregosa Basin

Promising shows of oil and gas have been encountered in several wells drilled in the Pedregosa Basin (Fig. 5). Favorable reservoirs may be found in Lower Cretaceous sandstones and carbonate rocks and in Paleozoic carbonate rocks (Thompson and Jacka, 1981; Thompson, 1982). Possible source rocks are Paleozoic shales and carbonate rocks and Lower Cretaceous shales and carbonate rocks (Thompson, 1981).

Baca Basin

The Baca Basin has been explored sporadically during the last 60 years, and several significant exploratory wells have been drilled (Fig. 5). Exploration was greatly intensified in 1985 when 2 million acres of federal land were leased by several firms including Shell, Elf Aquitane, Sohio, Hunt Oil Co., High Plains Petroleum Corp., Monarch Petroleum Corp., Leed Petroleum Corp., Zimmerman Resources, Love Oil Co., New Mexico and Arizona Land and Cattle Co., Sam Gary, and Greg Merrion. No significant oil and gas shows have been encountered in the Baca Basin, but porous and permeable zones have been encountered in several wells.

Possible reservoir objectives in the Baca Basin are Upper Cretaceous sandstones, the San Andres, Yeso, and Abo Formations (Permian), and Pennsylvanian-age sandstones and limestones. Possible, but undocumented, source rocks are Upper Cretaceous shales and Pennsylvanian shales. Both structural and stratigraphic traps may be present within the basin.

Raton Basin

The Raton Basin is an asymmetric structural depression situated on the east-side of the Sangre de Cristo Mountains (Fig. 5); it extends northward into Las Animas and Huerfano Counties, Colorado. The structural axis of the basin trends north–south and is located in the western part of the basin (Speer, 1976).

Exploration for oil and gas in the Raton Basin has been cyclical (Speer, 1976). Currently, exploration appears to be at the end of an active stage. Natural gas has been produced from the Garcia positive element on the east flank of the basin in Colorado since the 1920's. Marginally commercial amounts of gas were produced in the late 1970's from the Morrison Formation (Jurassic) and Dakota Sandstone (Cretaceous) at the currently inactive Wagon Mound field (Fig. 5, letter J). Carbon dioxide gas is produced from the Sheep Mountain uplift at the northern end of the basin near Walsenburg, Colorado. Numerous petroleum exploration wells have been drilled in the Raton Basin since 1906. Selected wells drilled in this basin since 1978 are shown in Fig. 5.

Major exploration targets in the Raton Basin are the regressive marine Trinidad Sandstone and the paralic Dakota Sandstone (Cretaceous; Speer, 1976). In both units, porous, reservoir-quality sandstones are present, and shows of oil and gas have been encountered. Secondary exploration targets are fluvial sandstones of the Raton Formation (Tertiary) and coastal sandstones of the Vermejo Formation (Cretaceous; Speer, 1976). Oil and gas shows have been encountered in the Raton Formation. Generally, the Raton and Vermejo Formations appear to be less permeable and "dirtier" than the Trinidad and Dakota Sandstones.

Possible, but largely untested, pre-Cretaceous reservoir targets are the eolian Entrada Sandstone (Jurassic), the marginal marine Glorieta Sandstone (Permian), alluvial sandstones of the Sangre de Cristo Formation (Pennsylvanian–Permian), and marine sandstones of the Madera Formation (Pennsylvanian). Possible source rocks are marine Cretaceous shales and marine shales of the Madera Formation.

Stratigraphic traps may be present in the Raton, Vermejo, and Trinidad Formations (Speer,1976); they are especially prospective in Trinidad Sandstone where they intertongue with Cretaceous marine source rocks. Structural traps may be present in the Raton and Vermejo Formations and in the Trinidad and Dakota Sandstones; compressive structures (folds, reverse faults, and possible thrust faults) may trap petroleum in the western part of the basin. Rose et al. (1984) suggested that gas may be hydrodynamically trapped in the deeper, more central parts of the Raton Basin.

Conclusions

Significant oil and gas production in New Mexico is limited currently to four counties of the Permian Basin in the southeast part of the state and four counties of the San Juan Basin in the northwest part of the state. Twelve major basins, which currently do not produce petroleum, are petroleum exploration frontiers. The Tucumcari, Albuquerque, Española, Estancia, Pedregosa, Baca, and Raton Basins have been actively explored and drilled in the last 10 years; exploration activity is continuing in those basins. Those seven frontier basins, as well as the remaining five, may contain undiscovered petroleum resources that could supplant the declining production and reserves of the Permian and San Juan Basins.

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