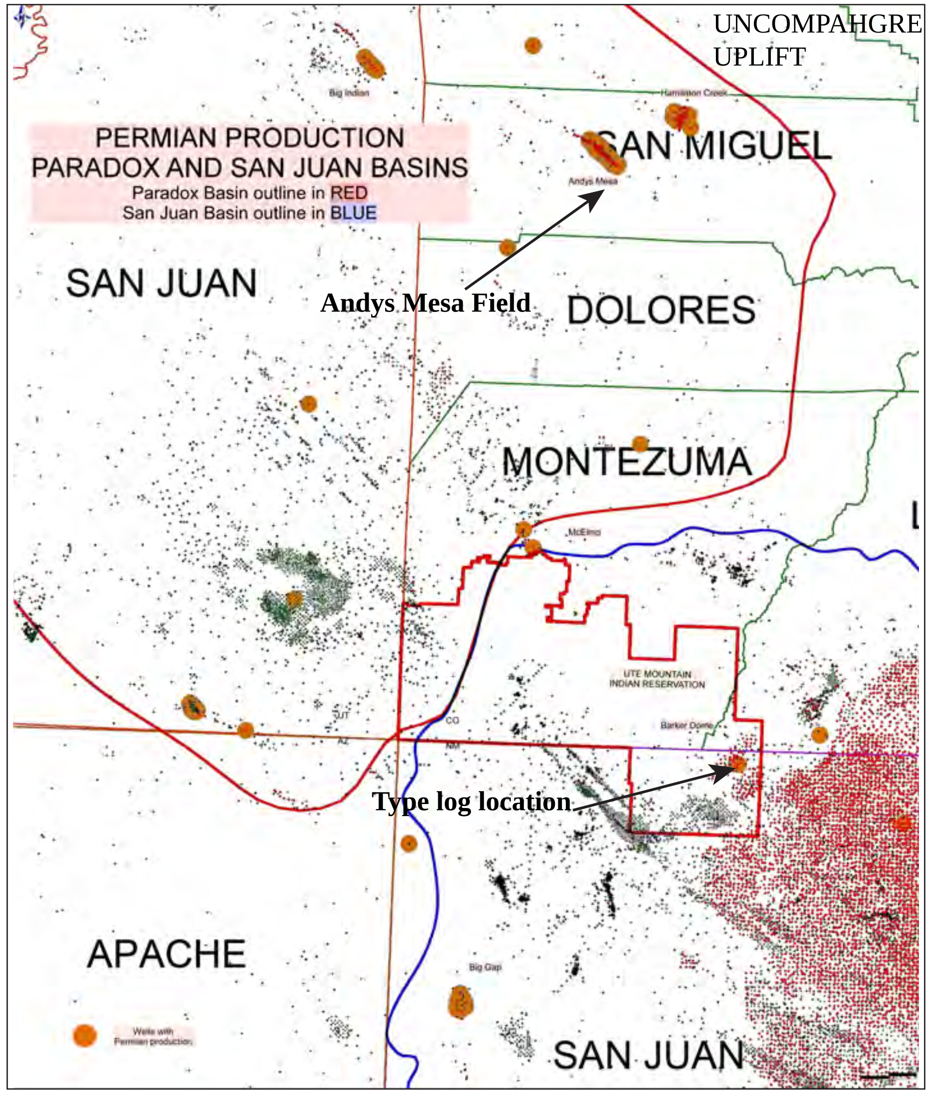

FIGURE UM-22.1. Location of Permian Gas Play. Wells with production are highlighted in tan.

ANALOG FIELD	
ANDYS MESA FIELD UM-21.1	
LOCATION OF DISCOVERY WELL:	NW/SE, Sec. 34, T44N-R16W (1966)
PRODUCING FORMATION:	Permian Cutler, Pennsylvanian Honaker Trail, Ismay, Lasal
NUMBER OF PRODUCING WELLS:	67 wells (30 Cutler, 33 Honaker Trail, 4 Ismay)
PRODUCTION:	94.6 BCFG (2020) 85 MBO (2020)
GAS CHARACTERISTICS:	44 API
AVERAGE NET PAY:	100-200 Feet
POROSITY:	15%
PERMEABILITY:	30 - 150 mD

PERMIAN CUTLER GROUP

GENERAL CHARACTERISTICS

This play, formerly known as the Silverton Delta Play (Peterson, 1989), has been renamed to more accurately encompass the depositional environment of the reservoir rocks within all Permian age rocks. The Silverton fan delta is limited to an area near the Colorado-Utah state line, but marginal clastic rocks extend the length of the ancestral Uncompahgre Uplift (Figure UM-22.1). These clastics were deposited as coalesced outwash fans that intertongue with the cyclic marine deposits of the Pennsylvanian Hermosa Group.

RESERVOIRS: Gas production is found in porous and permeable sandstone intervals within the generally arkosic Permian Cutler Formation in the vicinity of the ancestral Uncompahgre Uplift (Figures UM-22.2 and 22.3). Reservoir rocks are present where feldspar and clay were winnowed out by wave action or fluvial stream flow. For most of the area, the lower part of the Pennsylvanian interval is more likely to contain reservoir quality beds than the upper part because of the lower original feldspar content of the lower part. In the upper part of the Pennsylvanian interval, the southeastern Paradox Basin province is more likely to contain reservoir quality beds because of the presence of a large fan delta complex that provided the necessary depositional environments to clean the sandstone.

SOURCE ROCKS: This play is dependent on the presence of Desmoinesian, organic-rich, dolomitic shale and mudstone in contact or close proximity to reservoir lithologies. Because this juxtaposition is necessarily close to the ancestral Uncompahgre Uplift, the play is gas prone due to the preponderance of Type III kerogen from the uplift, as well as the depth of burial in the deep trough along the basin margin.

TRAPS: Trap types are expected to be dominantly combinations of updip pinchouts of permeable sandstone lenses localized on folded and faulted structures. Seals are provided by shale beds as well as by reduced permeability due to clay.

EXPLORATION STATUS AND RESOURCE POTENTIAL: Modest production has taken place within this play. Two fields having greater than 10 BCFG are Andys Mesa and Hamilton Creek, which account for 90% of the total gas Permian reservoir production. Sporadic Permian production can be noted from Figure UM-22.1. The presence of excellent source rocks and structures are factors in favor for additional discoveries in the future.

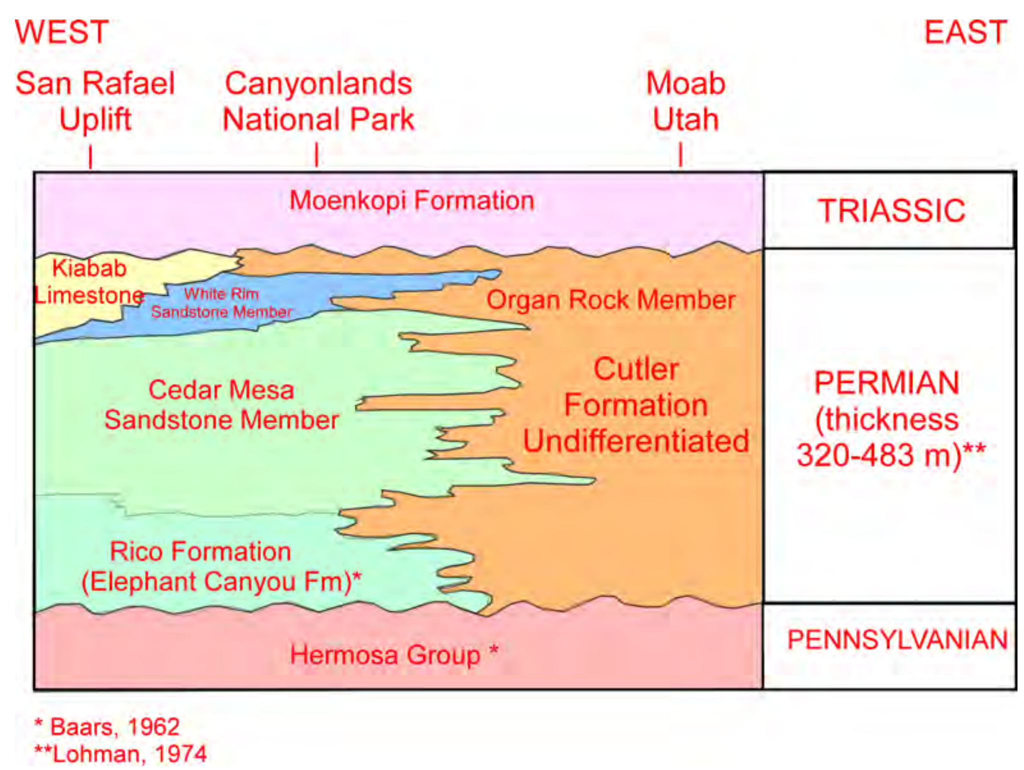

Figure UM-22.2. Generalized east-west stratigraphic section, Canyonlands National Park and surrounding area of the Paradox Basin (modified from Baars and Seager, 1970).

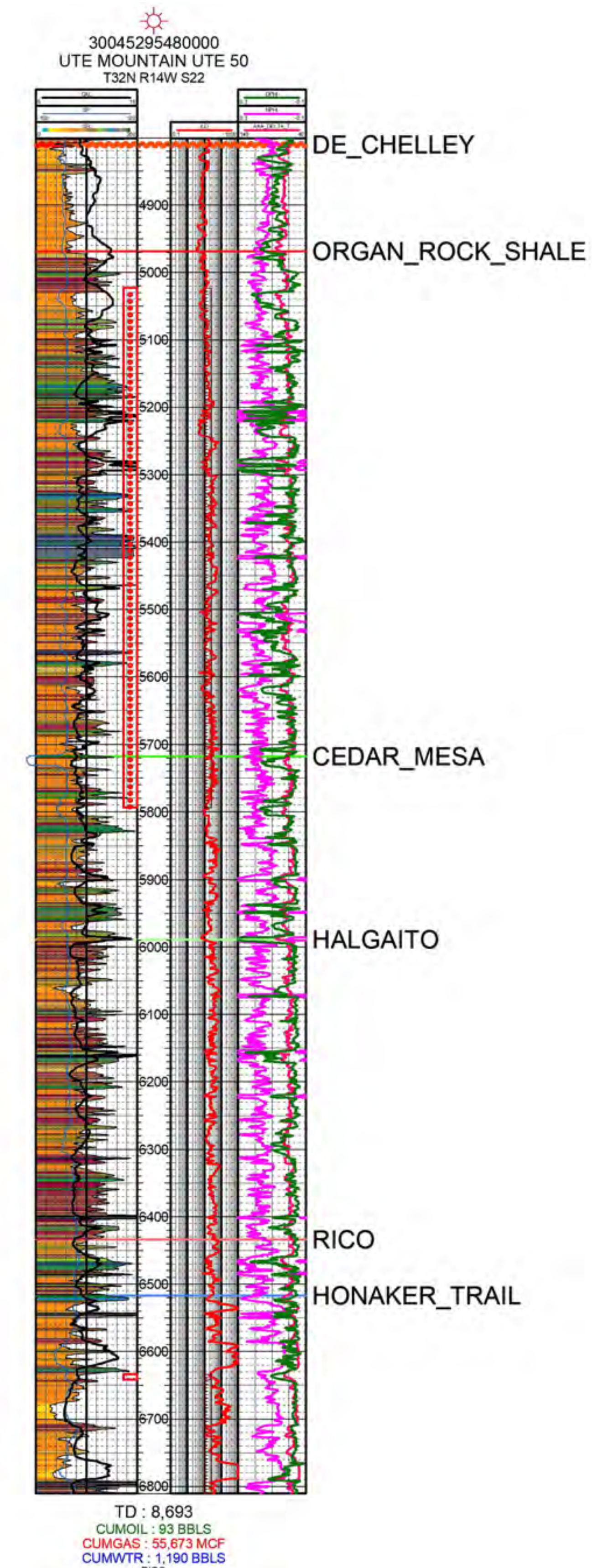

FIGURE UM-22.3. Type log of Permian section. Perforations shown in red.

PARADOX CARBONATE OIL PLAY

GENERAL CHARACTERISTICS

The Paradox Carbonate Oil Play in the Paradox and San Juan Basin Provinces (Fig. UM-23.1) is characterized by oil and gas accumulations in mounds of algal (Ivanovia) limestone associated with organic-rich black shale rimming the evaporite sequences of the Paradox Formation of the Hermosa Group (Fig. UM-23.2). Most developed fields within the play produce from combination traps in the Paradox Basin Province.

RESERVOIRS: Almost all hydrocarbon production has been from vuggy limestone and dolomite reservoirs in five zones of the Hermosa Group. In ascending order, they are the Alkali Gulch, Barker Creek, Akah, Desert Creek, and Ismay Stages (Fig. UM-24.1). The zones gradually become less distinct toward the central part of the San Juan Basin. Net pay thicknesses generally range from 10 to 50 feet and have porosities of 5-20 percent.

SOURCE ROCKS: Source beds for Pennsylvanian oil and gas are believed to be organic-rich shales and laterally equivalent carbonate rocks within the Paradox Formation. The presence of hydrogen sulfide (H_2S) and appreciable amounts of CO_2 at the Barker Creek and Ute Dome fields probably indicates high-temperature decomposition of carbonates, (Rice, 1983). Correlation of black dolomitic shale and mudstone units of the Paradox Formation with prodelta facies in clastic cycles present in a proposed fan delta complex on the northeastern edge of the Paradox Evaporite Basin helps to account for the high percentage of kerogen from terrestrial plant material in black shale source rocks.

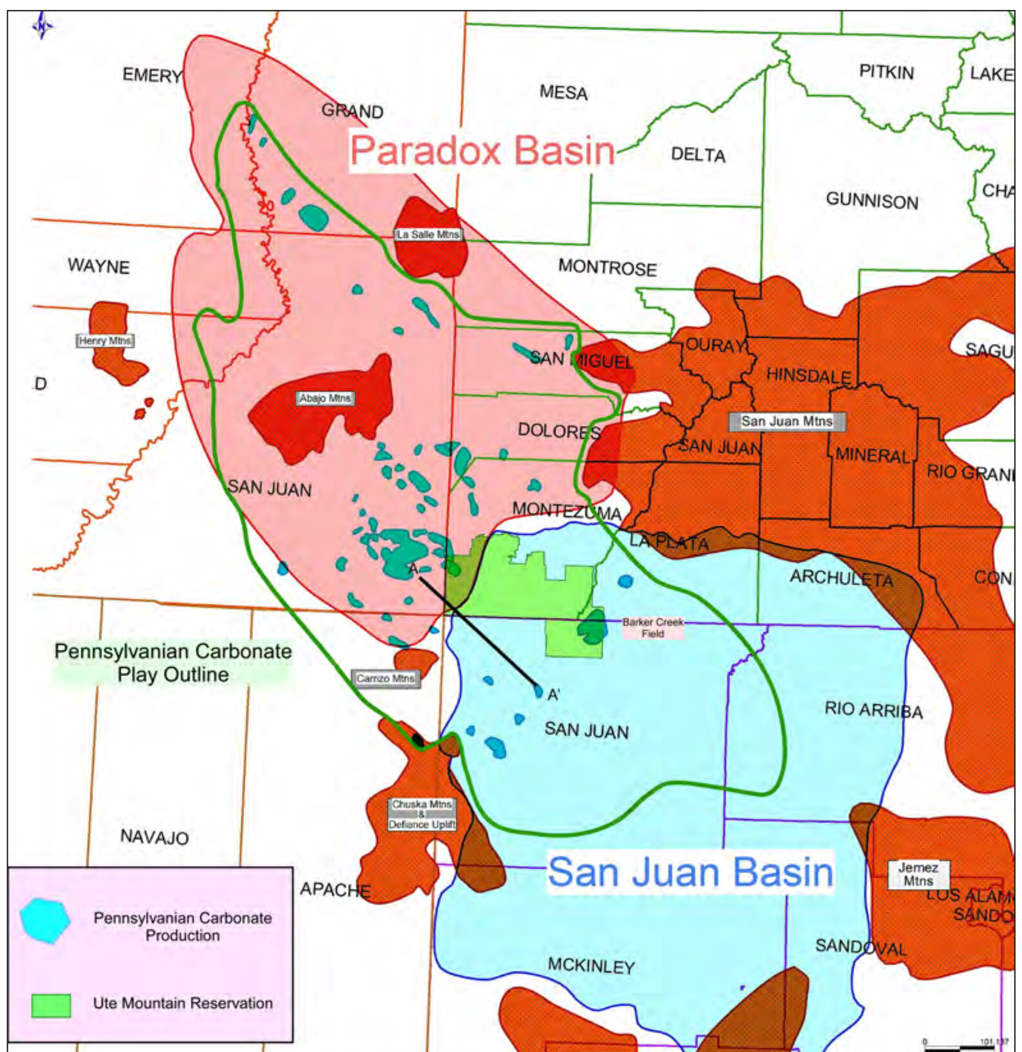

FIGURE UM-23.1. Location of Porous Carbonate Buildup Play (mod. after Peterson, 1996).

TIMING AND MIGRATION: In the central part of the San Juan Basin, Pennsylvanian sediments entered the thermal zone of oil generation during the Late Cretaceous to Paleocene, and the dry gas zone during the Eocene to Oligocene. It also is probable that Pennsylvanian source rocks entered the zone of oil generation during the Oligocene throughout most of the Four Corners Platform. Updip migration and local migration from laterally equivalent carbonates and shale beds in areas of favorable reservoir beds predominate, and remigration may have occurred in areas of faulting and fracturing.

TRAPS: Combination stratigraphic and structural trapping mechanisms are dominant among Pennsylvanian fields of the San Juan Basin and Four Corners Platform. Most fields are located on structures, although not all of these structures demonstrate closure. The structures may have been a critical factor in the deposition of bioclastic limestone reservoir rocks. Seals are provided by a variety of mechanisms, including porosity differences in the reservoir rock, overlying evaporites, and interbedded shales. Most production on the Four Corners Platform is from depths of 5,100 to 8,500 feet, but minor production and shows in the central part of the San Juan Basin are from as deep as 11,000 feet.

EXPLORATION STATUS AND RESOURCE POTENTIAL: Field sizes in the play vary considerably; most oil discoveries are in the 1–100 MMBO size range and include associated gas production. The largest fields, Tocito Dome and Tocito Dome North, have produced a total of about 14 MMBO and 32 BCFG. Eight significant nonassociated and associated gas fields have been developed in the play, the largest of which, Barker Creek, has produced 97 BCFG. The Pennsylvanian is basically a gas play and has a moderate future potential for medium-size fields.

CHARACTERISTICS OF PLAY

In the Ute Mountain Ute Indian Reservation, the Paradox Formation is conformably bounded by the Pinkerton Trail Formation at its base and the Honaker Trail Formation at its top (Fig. UM-24.2). It ranges from 800 feet thick in the south to 1700 feet thick in the north (Fig. UM-24.2). The Paradox Formation was deposited during the Desmoinesian age of the Pennsylvanian Period under strong cyclic conditions involving transgressive and regressive movements of the Pennsylvanian sea. The transgressive phase is represented by black organic rich dolomitic muds while the regressive phase is represented by carbonate mounds. Reservoirs within the reservation are biogenic/bioclastic carbonate mounds deposited in shoaling areas of an evaporite basin. The four main cycles of Desmoinesian deposition are the Barker Creek, Akah, Desert Creek, and Ismay Stages (Fig. UM-24.1).

The Barker Creek Stage has a gross thickness of 500 feet. It is a fossiliferous, algal, dolomitic limestone with vuggy secondary dolomite. Most reservoir rock is algal, dolomitic limestone with enhanced porosity and permeability due to dolomitization and weathering. The Barker Creek was deposited on paleostructural features related to the Hogback Lineament.

The Akah Stage is not considered to be an exploration objective within the reservation because salt and anhydrite deposition was dominant during this stage. The Akah Stage represents the maximum extent of evaporite limits.

The Desert Creek Stage carbonates were deposited in a definable arcuate trend around the southeast terminus of the basin. The Desert Creek is bounded by the Chimney Rock and Gothic Shales, which represent transgressions (Fig. UM-24.1). Growth of the Desert Creek carbonate bank occurred during slow subsidence of the Paradox Basin. Source rocks for hydrocarbons are the Chimney Rock and Gothic Shales.

The Ismay Stage is divided into lower and upper units. In the lower unit, bounded by the Gothic and Hovenweep Shales, oil is produced from algal carbonate mound buildups. The upper unit is bounded by the Hovenweep and Boundary Butte Shales. Production there is from algal or fossiliferous detrital bioclastic/biogenic reservoirs. The source rocks for the Ismay stage are the Gothic, Hovenweep, and Boundary Butte Shales. During the Ismay Stage the southern part of the basin was slowly subsiding.

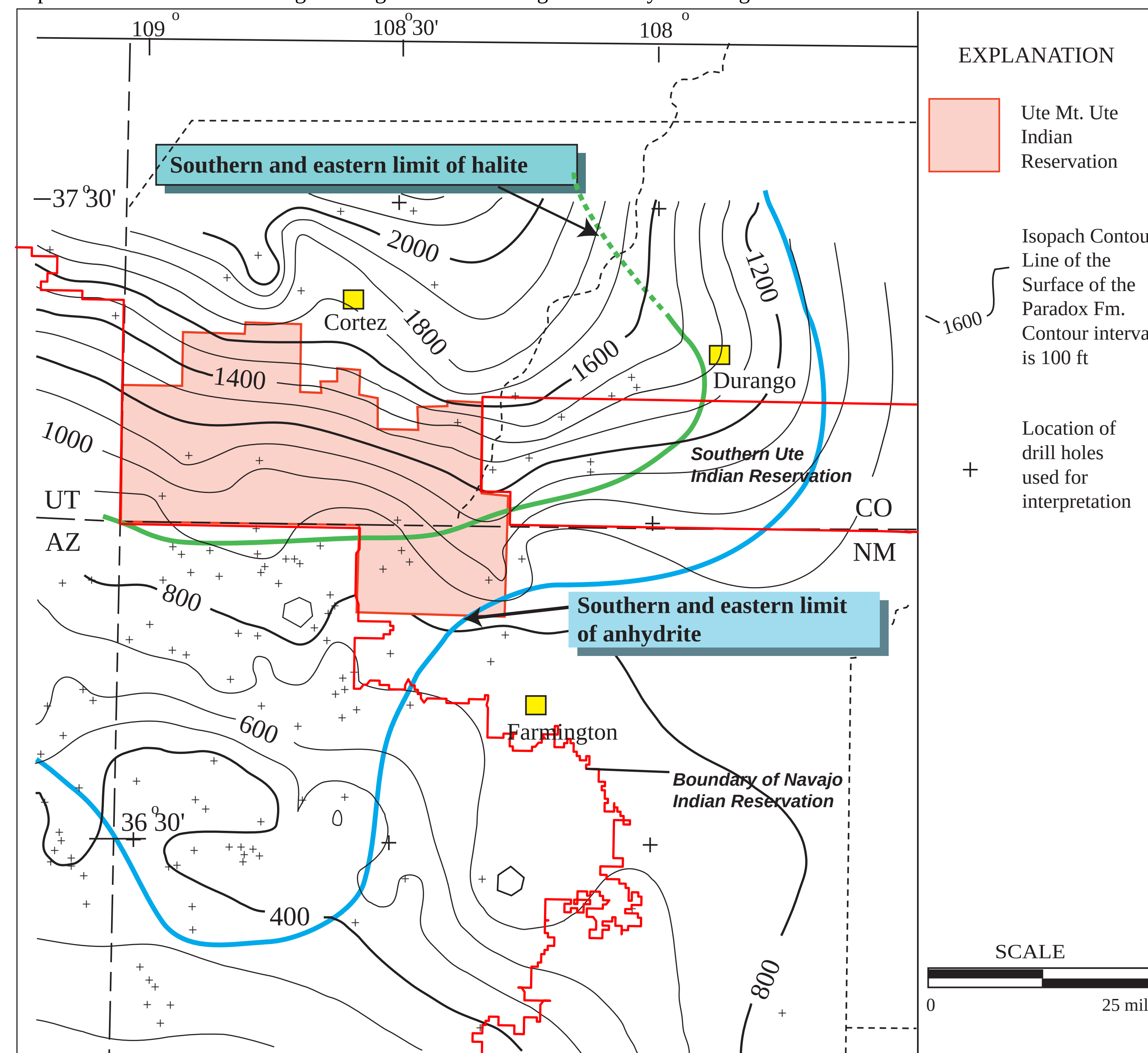

FIGURE UM-23.2. Isopach map of the Paradox Formation (modified after Huffman and Condon, 1993).

PARADOX CARBONATE OIL PLAY *(Cont)*

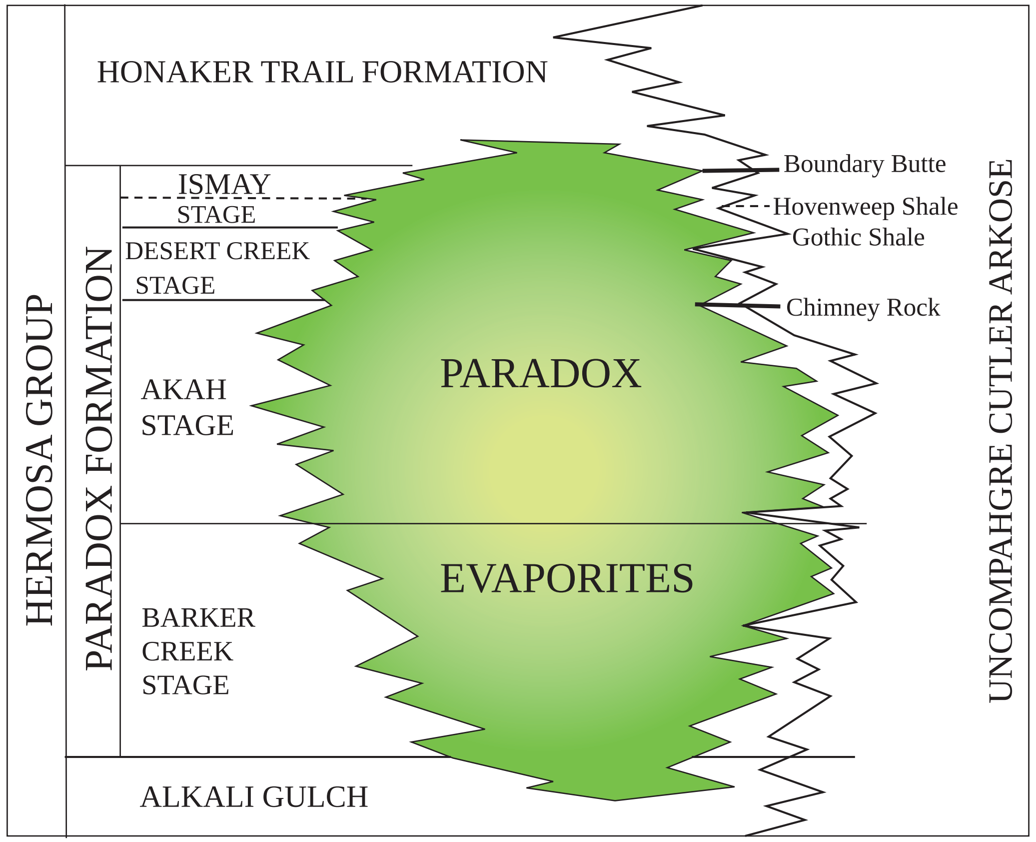

FIGURE UM-24.1. Stratigraphic chart of the Pennsylvanian Hermosa Group illustrating the Paradox facies change across the basin. Each stage is bounded by a time stratigraphic marker bed of sapropelic, dolomitic mud. These markers are continuous and mappable throughout the basin (modified from Harr, 1996).

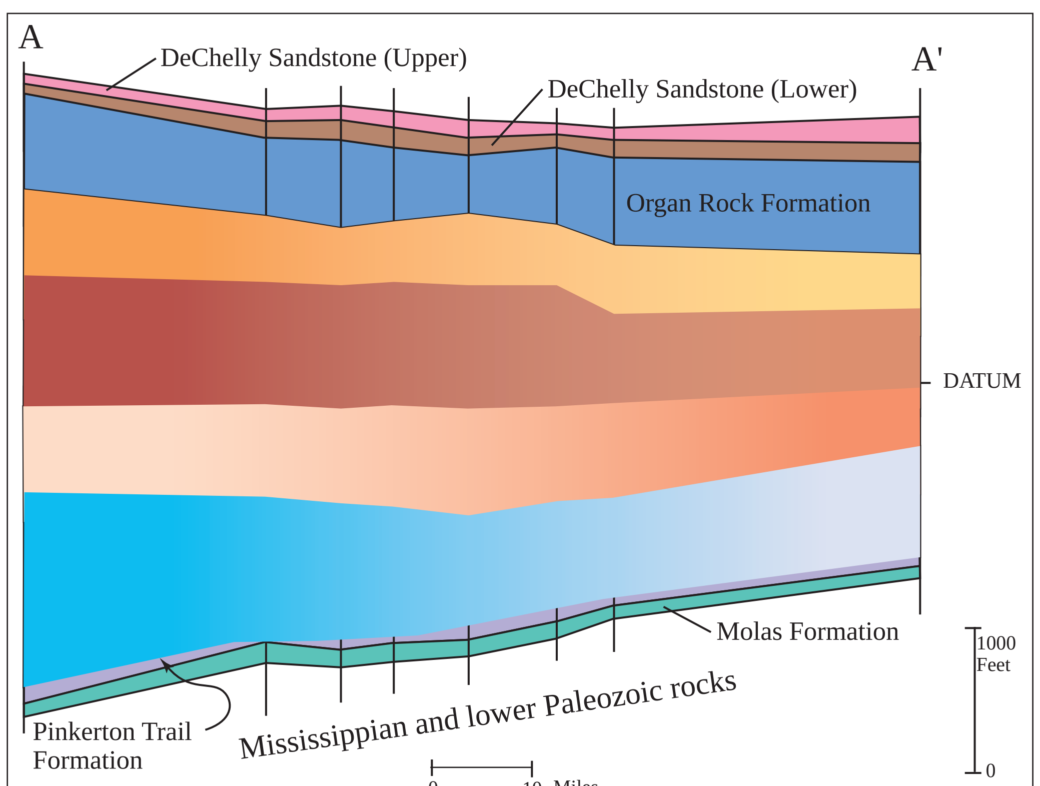

FIGURE UM-24.2. Stratigraphic cross section through Ute Mountain Ute Indian Reservation (modified from Huffman and Condon, 1993). Location is shown in Figure UM-23.1.

ANALOG FIELDS WITHIN OR NEAR RESERVATION

(*) denotes field lies within the reservation boundaries

*BARKER CREEK PARADOX FIELD (Fig. UM-24.3 and 24.4)	
LOCATION OF DISCOVERY WELL:	SE¼, SE¼, NW¼, Sec 21, T32N, R14W, NMPM (March, 1945)
PRODUCING FORMATION:	Paradox Formation
NUMBER OF PRODUCING WELLS:	71 (2020)
PRODUCTION:	316.4 BCFG (2020) 1,312 MBO (2020)
GAS CHARACTERISTICS:	BTU 777 (dry basis)
TYPE OF DRIVE:	Solution gas, fluid expansion, ineffective bottom water encroachment
AVERAGE NET PAY:	± 100 feet
POROSITY:	2-10%
PERMEABILITY:	Extremely variable

*ROADRUNNER FIELD	
LOCATION OF FIELD:	Sec. 14,15,23, T33.5N, R20W
PRODUCING FORMATION:	Ismay Stage, Paradox Formation
NUMBER OF PRODUCING WELLS:	9 (2020)
PRODUCTION:	3.07 BCFG (2020) 1,352 MBO (2020)
AVERAGE NET PAY:	25 feet
POROSITY:	15%
PERMEABILITY:	NA

*CACHE FIELD	
LOCATION OF FIELD:	Sec 1-3, T34N, R20W, Sec 34,35, T33N, R20W
PRODUCING FORMATION:	Ismay Stage, Paradox Formation
NUMBER OF PRODUCING WELLS:	18 (2020)
PRODUCTION:	7.8 BCFG (2020) 4,720 MBO (2020)
GAS CHARACTERISTICS:	NA.
TYPE OF DRIVE:	Gas expansion
AVERAGE NET PAY:	15 feet
POROSITY:	8-12%

*UTE DOME PARADOX FIELD	
LOCATION OF DISCOVERY WELL:	NE ¼, NE ¼, Sec 35, T32N, R14W (September, 1948)
PRODUCING FORMATION:	Barker Creek Stage, Paradox Formation
NUMBER OF PRODUCING WELLS:	82 (2020)
PRODUCTION:	175.6 BCFG (1996)
GAS CHARACTERISTICS:	BTU 777 (dry basis)
TYPE OF DRIVE:	Primary volumetric with limited water drive in Barker Creek zone
AVERAGE NET PAY:	116 feet
POROSITY:	3.5%
PERMEABILITY:	0.5 md (enhanced by fracturing)

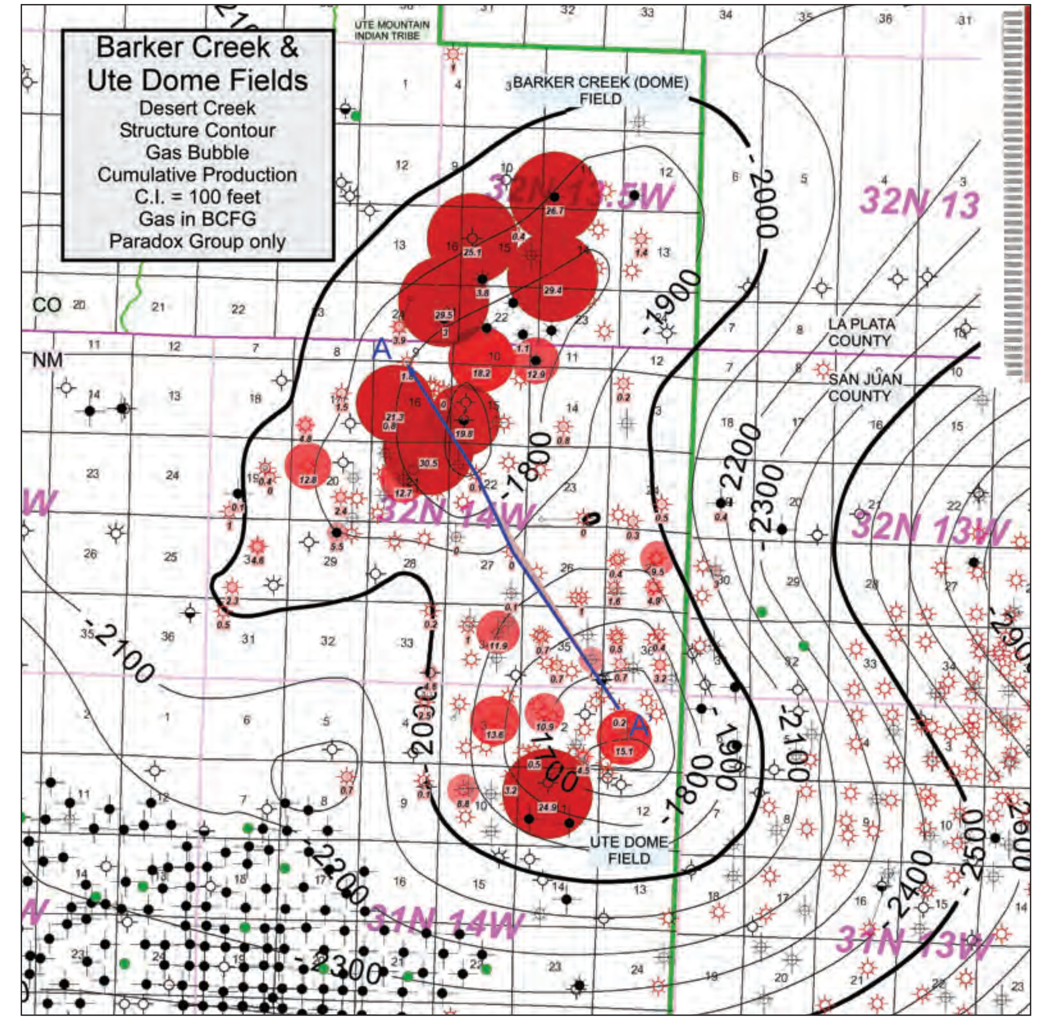

FIGURE UM-24.3. Structure contour map of Barker Creek Paradox Field. Location of cross section is shown in Figure UM-24.4.

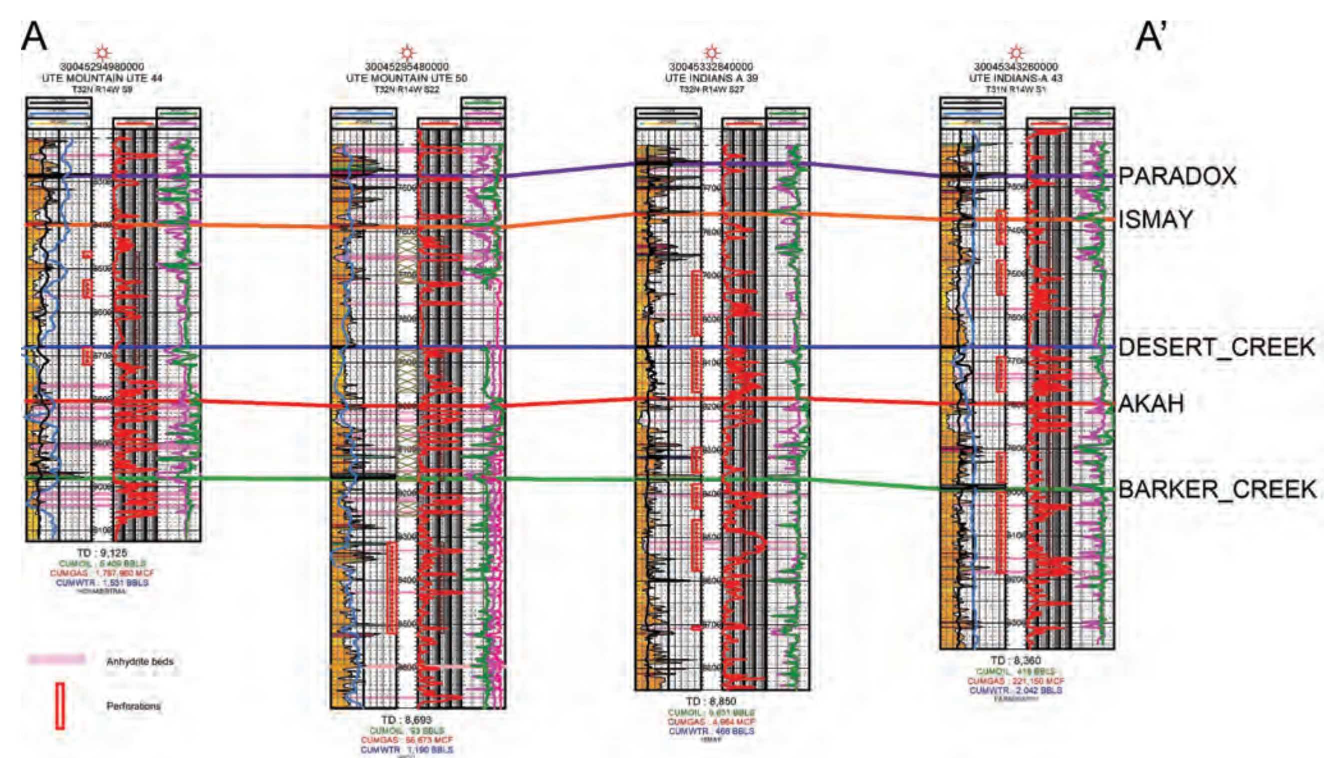

FIGURE UM-24.4. Cross section of Barker Creek Paradox Field. Location is shown in Figure UM-24.3.

MISSISSIPPIAN / DEVONIAN PLAY

GENERAL CHARACTERISTICS

The play is based on the occurrence of oil accumulations in fault blocks involving pre-Pennsylvanian rocks, mainly in the salt anticline area of the Paradox Basin. The play covers an area of approximately 7,500 square miles (Figure UM-25.4). Most of the structures are associated with the salt anticlines themselves and were growing at the same time that the salt was moving.

RESERVOIRS: Reservoirs are in porous dolomite or dolomitic limestone beds of the Mississippian Leadville Limestone (Figures UM-25.1, UM-25.2, and UM-25.3) and the Upper Devonian McCracken Sandstone Member (Figure UM-25.3) of the Elbert Formation. Reservoirs are as thick as 200 feet, and porosity varies from 5 to as high as 25% in local cases. Permeability is generally low, but is as much as several hundred mD in places.

SOURCE ROCKS: Probable source rocks are the organic-rich black dolomitic shales of the Pennsylvanian Paradox Formation. Migration into Leadville or McCracken reservoirs occurs where faulting juxtaposes the reservoirs into contact with the black shale, which is commonly highly fractured.

TIMING AND MIGRATION: Hydrocarbon generation began as early as Permian time and has continued to the present in some cases. Migration into pre-salt reservoirs was probably contemporaneous with the growth of salt structures. Migration pathways were enhanced by severe fracturing of interbedded organic-rich shales during salt movement.

TRAPS: Known traps are on uplifted fault blocks adjacent to salt anticlines or swells. Seals are Paradox Formation evaporite beds that overlie, or are in fault contact with Mississippian or Devonian reservoirs. Drilling depths range from 7,000-8,000 feet at the Lisbon field, to greater than 10,000 feet in other areas.

EXPLORATION STATUS AND RESOURCE POTENTIAL: Six oil and gas accumulations produce from pre-salt structural blocks. The largest of these is the Lisbon Field, which has produced approximately 46 million BO and 782 BCFG. Additional production is from the Devonian McCracken Sandstone. The McElmo Dome Field is the second largest Mississippian producing field in the play area with 21 BCFG in cumulative production. The remainder of the fields are noncommercial or marginally commercial. The play is only moderately explored with respect to smaller structures. Future potential is low to moderate, and based on previous production history, undiscovered fields are estimated to be small to medium in size and have minimal oil columns.

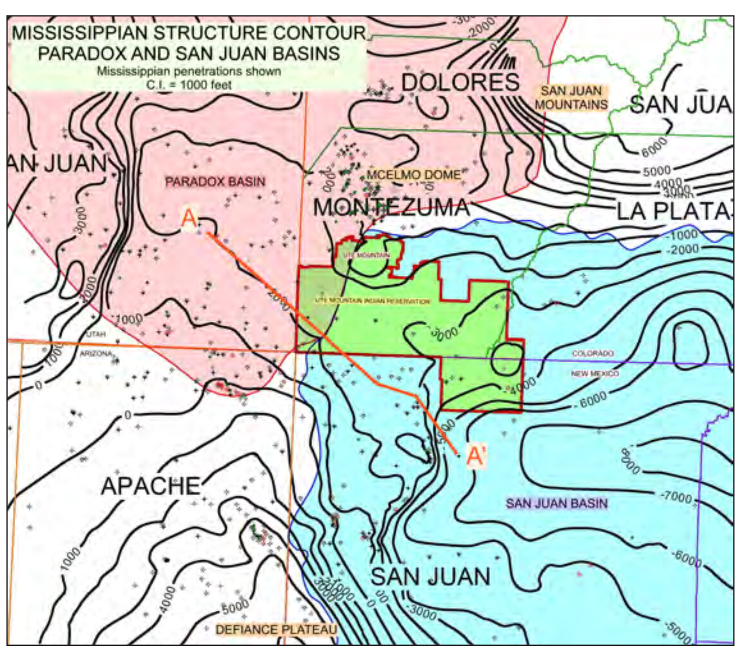

FIGURE UM-25.1. Structure contour map of the top of the Mississippian Leadville Limestone and location of cross section in figure UM-25.3.

CHARACTERISTICS OF THE MISSISSIPPIAN/DEVONIAN PLAY

In the Ute Mountain Ute Indian Reservation, the Mississippian/Devonian Play consists of the Mississippian Leadville Limestone and the Devonian McCracken Sandstone Member of the Elbert Formation.

The McCracken Sandstone (Figure UM-25.3) is mainly a dolomitic sandstone, sandy dolomite, and dolomitic mudstone. Cyclical fluctuations in relative sea level during McCracken time produced three coarsening- and thickening-upward intervals (parasequence sets), which correspond to the main reservoir units. Depositional environments range from intertidal-supratidal carbonate flats to siliciclastic prodelta and delta fronts. Reservoir flow units are strongly dominated by siliciclastic lithofacies, whereas carbonate lithofacies compose major flow barriers and baffles.

The Leadville Limestone (Figures UM-25.1, UM-25.2, and UM-25.3) is Kinderhookian to Osagean in age and rests unconformably on shaly limestones of the Devonian Ouray Limestone. The Leadville is capped by a major unconformity, which has truncated the formation. Two well defined intraformational markers exist in the Leadville (Figure UM-26.4). They are interpreted as major erosional channels caused by upward shoaling cycles that include a full suite of environments ranging from shallow marine tidal shelf through lagoonal and supratidal. The markers represent time stratigraphic lines which form the boundaries between depositional units and separate facies of the Leadville. The Leadville has undergone complex diagenesis. Moldic porosity and vuggy porosity are common.

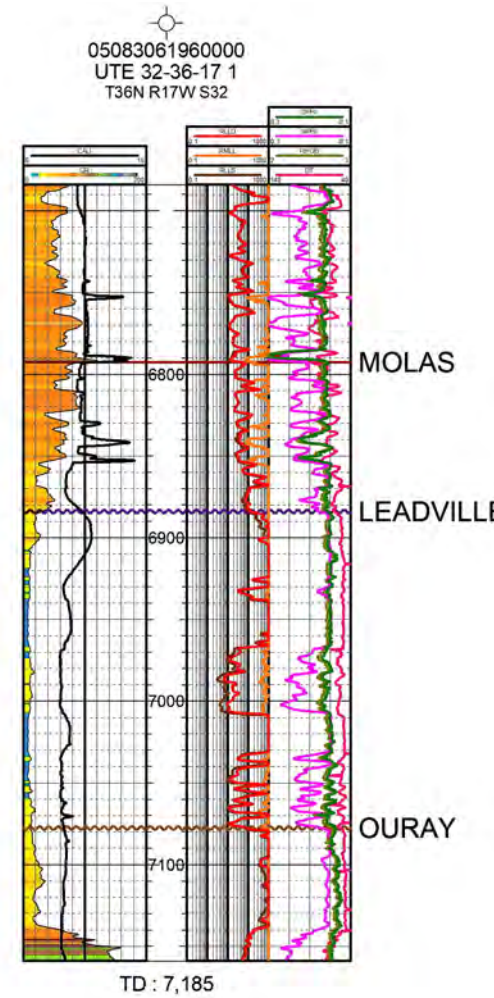

FIGURE UM-25.2. Type log for Mississippian Oil Play. This well is located in the northern edge of the Ute Mountain Indian Reservation.

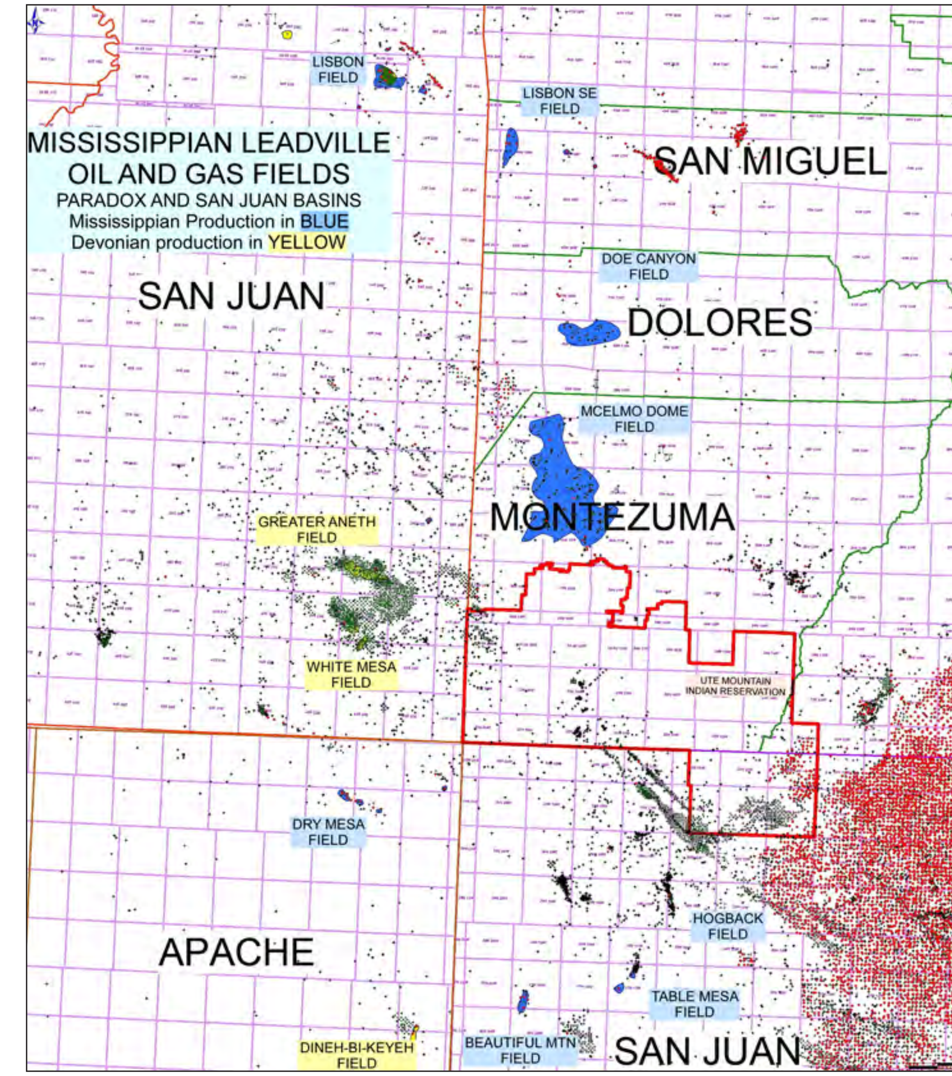

FIGURE UM-25.4. Location of Mississippian and Devonian oil fields surrounding the Ute Mountain Indian Reservation.

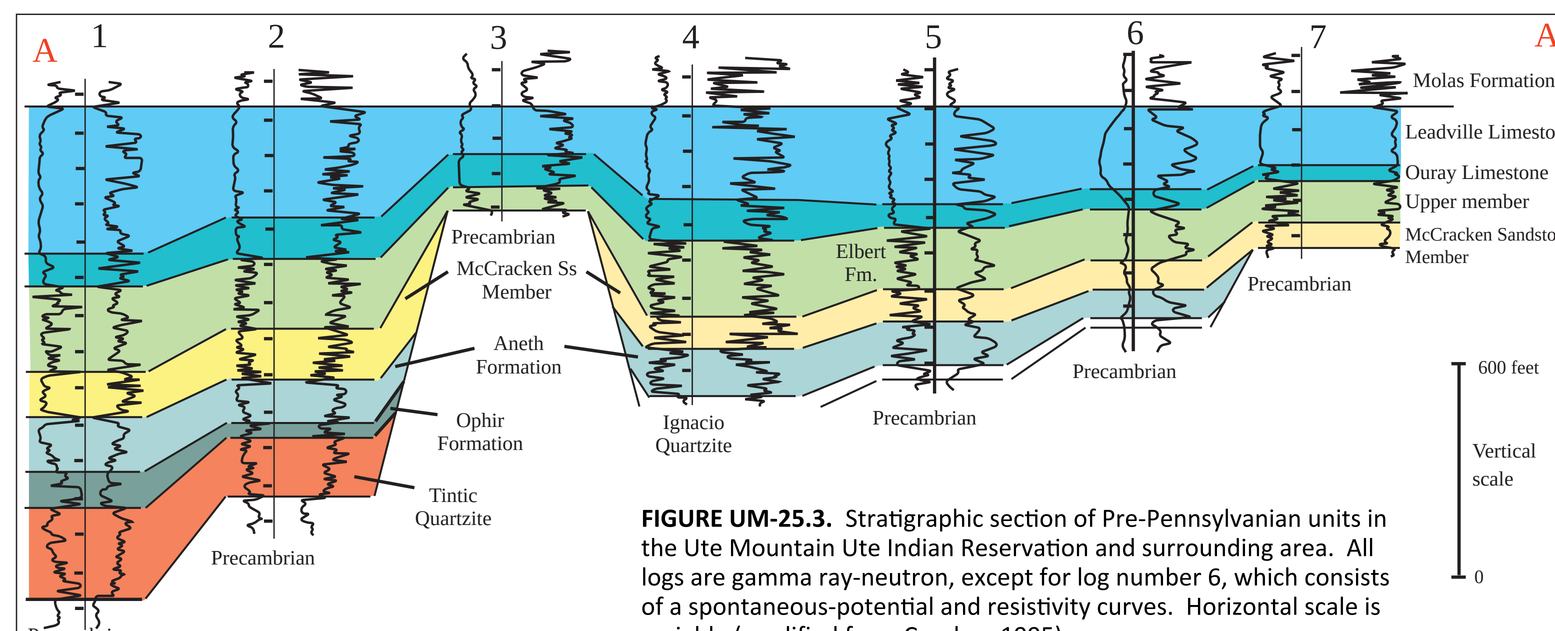

FIGURE UM-25.3. Stratigraphic section of Pre-Pennsylvanian units in the Ute Mountain Ute Indian Reservation and surrounding area. All logs are gamma ray-neutron, except for log number 6, which consists of a spontaneous-potential and resistivity curves. Horizontal scale is variable (modified from Condon, 1995).

MISSISSIPPIAN/DEVONIAN PLAY *(Cont)*

ANALOG FIELD NEAR RESERVATION	
LISBON FIELD (Figs. UM-26.1 - UM-26.4)	
LOCATION OF DISCOVERY WELL:	NW/NE/NE, Sec. 10, T30S-R24E (1959)
PRODUCING FORMATION:	McCracken Sandstone Member of the Elbert Formation, Leadville Limestone
NUMBER OF PRODUCING WELLS:	34 Leadville, 4 McCracken, 1 Penn
PRODUCTION:	798 BCFG, <2 MMBO McCrackenn (2020) 46.1 MMBO Leadville (2020)
OIL CHARACTERISTICS:	44 API
AVERAGE NET PAY:	39.4 Feet
POROSITY:	0.3 - 16.9%
PERMEABILITY:	<0.01 - 272 mD

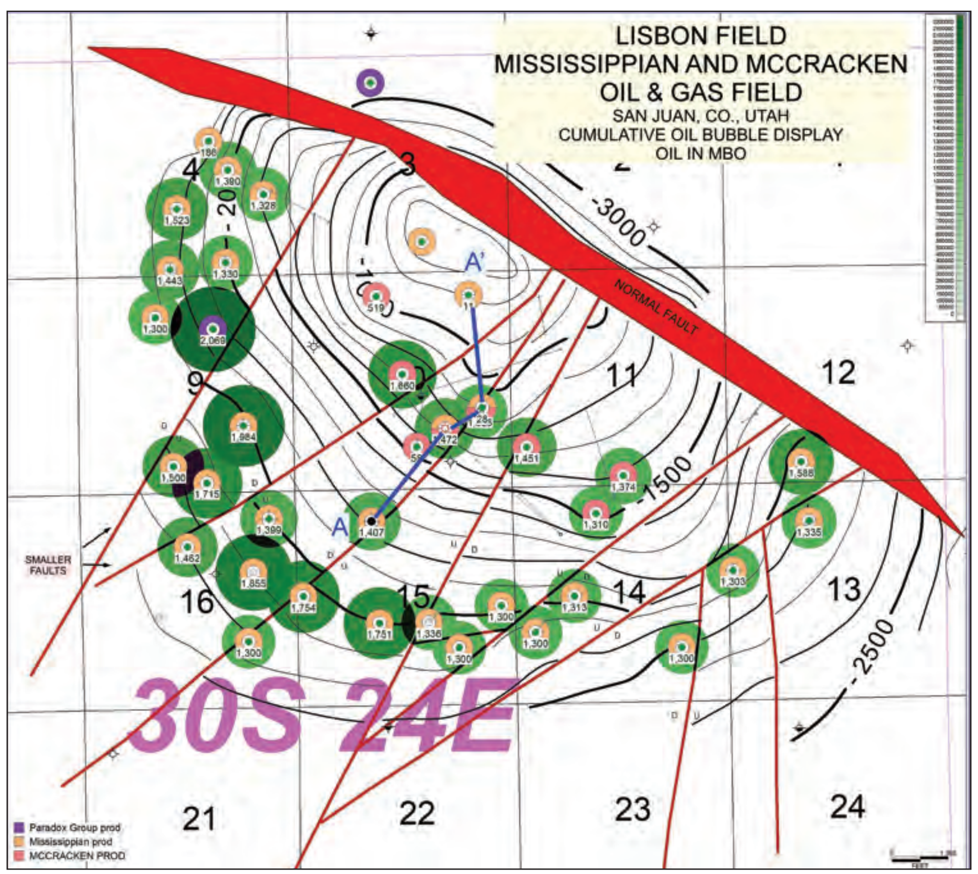

FIGURE UM-26.1. Structure contour map of the top of the Leadville Limestone for Lisbon Field and location of cross section in Figure UM-26.2. Cumulative oil production bubbles display oil production for each well. Color-coded symbols are for the primary producing formation.

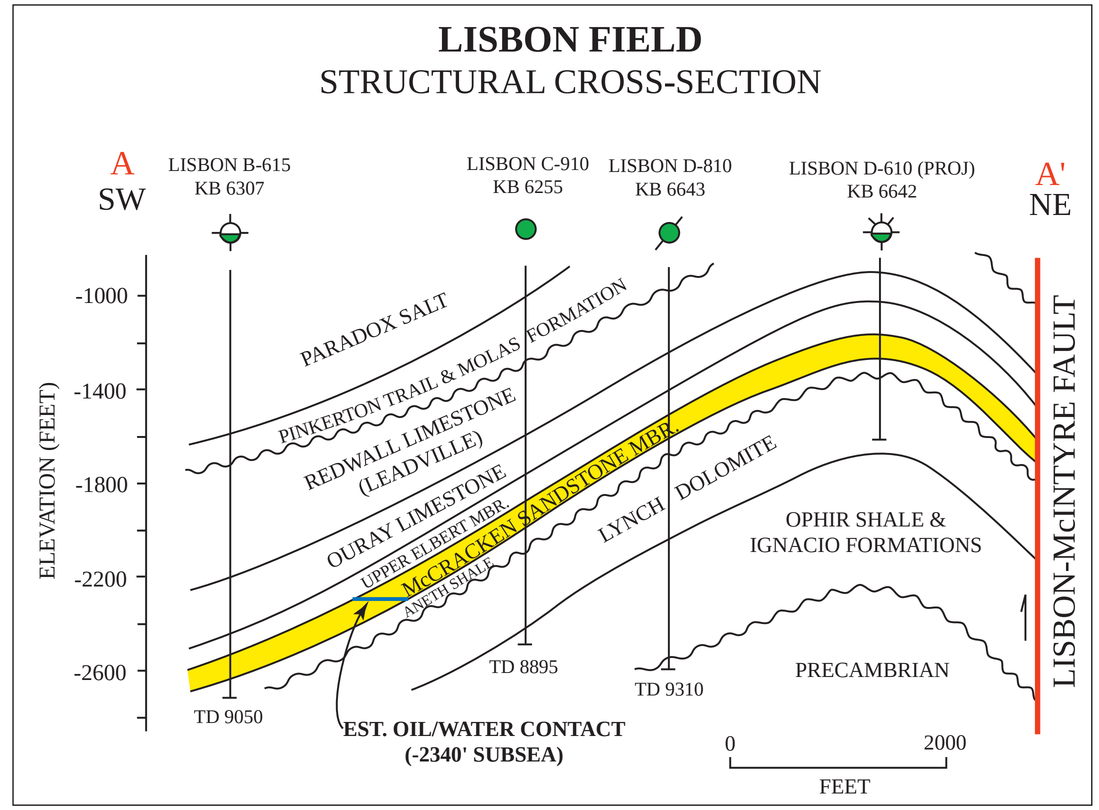

FIGURE UM-26.2. Structure cross-section of Lisbon Field (modified after Cole and Moore, 1996).

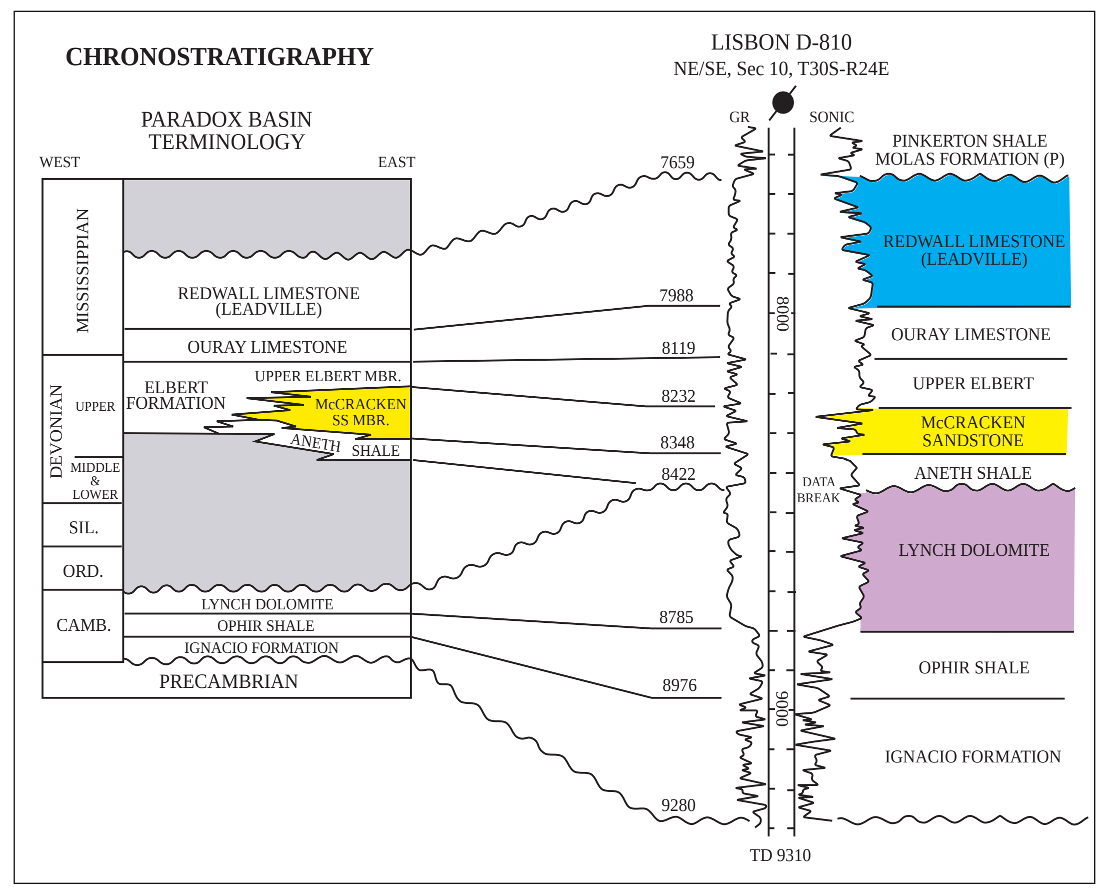

FIGURE UM-26.3. Type log for McCracken unit at Lisbon Field (modified after Cole and Moore, 1996).

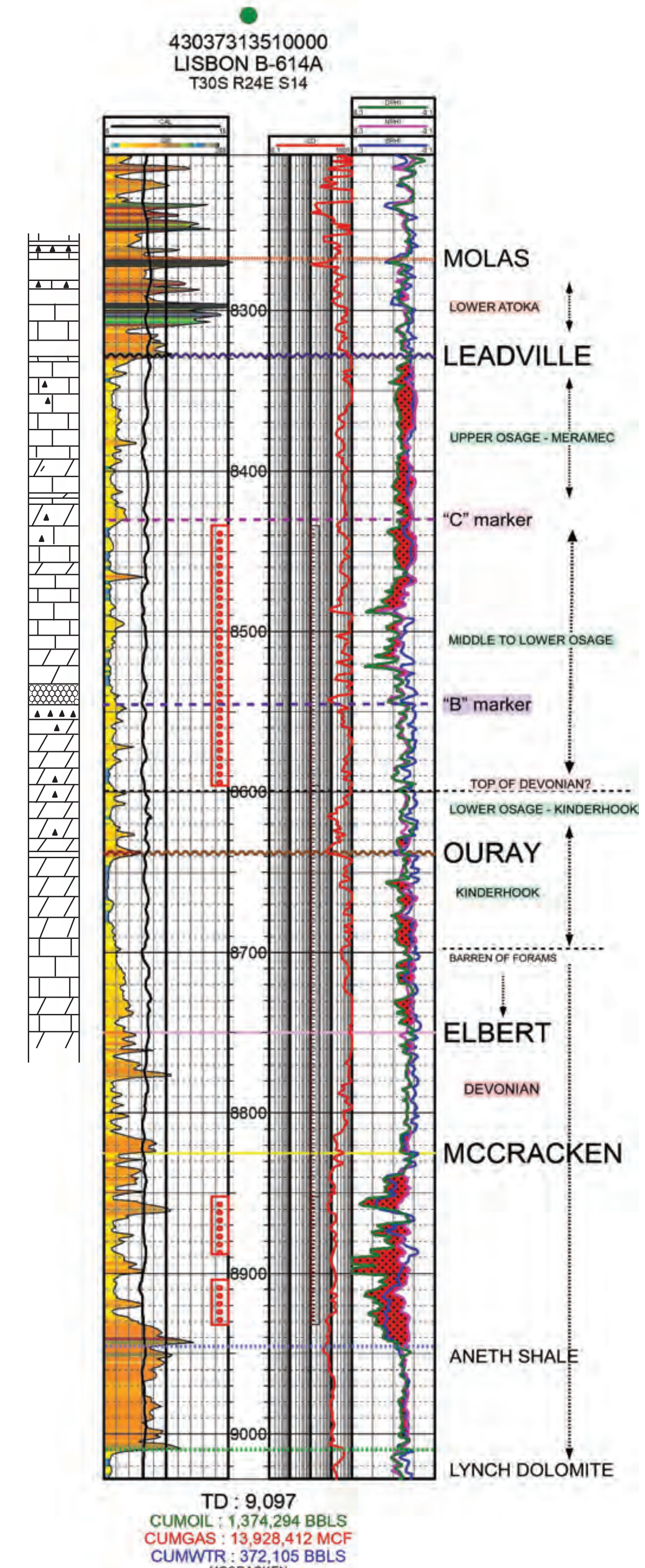

FIGURE UM-26.4. Type log for Leadville Limestone unit at Lisbon Field (modified after Fouret, 1996).

UTE MOUNTAIN UTE RESERVATION

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