MAJOR OIL PLAYS IN UTAH AND VICINITY

QUARTERLY TECHNICAL PROGRESS REPORT

Reporting Period
Start Date: April 1, 2004
End Date: June 30, 2004

by
Thomas C. Chidsey, Jr., Editor and Principal Investigator/Program Manager,
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Utah Geological Survey

July 2004

Contract No. DE-FC26-02NT15133

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ABSTRACT

Utah oil fields have produced over 1.2 billion barrels (191 million m^3). However, the 13.7 million barrels (2.2 million m^3) of production in 2002 was the lowest level in over 40 years and continued the steady decline that began in the mid-1980s. The Utah Geological Survey believes this trend can be reversed by providing play portfolios for the major oil-producing provinces (Paradox Basin, Uinta Basin, and thrust belt) in Utah and adjacent areas in Colorado and Wyoming. Oil plays are geographic areas with petroleum potential caused by favorable combinations of source rock, migration paths, reservoir rock characteristics, and other factors. The play portfolios will include: descriptions and maps of the major oil plays by reservoir; production and reservoir data; case-study field evaluations; locations of major oil pipelines; identification and discussion of land-use constraints; descriptions of reservoir outcrop analogs; and summaries of the state-of-the-art drilling, completion, and secondary/tertiary recovery techniques for each play.

This report covers research activities for the eighth quarter of the project (April 1 through June 30, 2004). This work included (1) describing the Pennsylvanian Paradox Formation fractured-shale play, (2) land classification and summaries in the major petroleum-producing provinces, and (3) technology transfer activities.

Fractured-shale beds in the Pennsylvanian Paradox Formation are oil productive in the Paradox Basin fold and fault belt (northern Paradox Basin) of southwest Utah. The Cane Creek shale of the Paradox Formation is composed of marine carbonate, evaporite, and organic-rich shale beds. The Cane Creek is a fractured, self-sourced oil reservoir that is highly overpressured – an ideal target for horizontal drilling. Horizontal drilling increases the probability of encountering the near-vertical fractures, has resulted in numerous new field discoveries, and greatly improved the success rate in the Cane Creek play.

Land classification maps and land ownership acreage summaries for the major oil-producing provinces portray multiple types of surface and/or mineral ownership. These maps and summaries will help guide petroleum companies in planning exploration and land-acquisition strategies, pipeline companies and gas processors in planning future facilities and pipeline extensions, and government agencies in decision-making processes in Utah and vicinity.

Technology transfer activities during this quarter consisted of exhibiting a booth display of project materials at the 2004 Annual Convention of the American Association of Petroleum Geologists, a technical presentation on reservoir outcrop analogs, and publications. Project team members joined Utah Stake Holders Board members in attending the Uinta Basin Oil and Gas Collaborative Group meeting in Vernal, Utah. The project home page was updated for the Utah Geological Survey Web site.

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Utah oil fields have produced over 1.2 billion barrels (191 million m^3). However, the 13.7 million barrels (2.2 million m^3) of production in 2002 was the lowest level in over 40 years and continued the steady decline that began in the mid-1980s. The overall objectives of this study are to: (1) increase recoverable oil from existing field reservoirs, (2) add new discoveries, (3) prevent premature abandonment of numerous small fields, (4) increase deliverability through identifying the latest drilling, completion, and secondary/tertiary recovery techniques, and (5) reduce development costs and risk.

To achieve these objectives, the Utah Geological Survey is producing play portfolios for the major oil-producing provinces (Paradox Basin, Uinta Basin, and thrust belt) in Utah and adjacent areas in Colorado and Wyoming. This research is funded by the Preferred Upstream Management Program (PUMPII) of the U.S. Department of Energy, National Petroleum Technology Office (NPTO) in Tulsa, Oklahoma. This report covers research activities for the eighth quarter of the project (April 1 through June 30, 2004). This work included (1) describing the Pennsylvanian Paradox Formation fractured-shale play, (2) land classification in the major petroleum-producing provinces, and (3) technology transfer activities.

Fractured-shale beds in the Pennsylvanian Paradox Formation are oil productive in the Paradox Basin fold and fault belt (northern Paradox Basin) of southwest Utah. Jointing and fractures are controlled by regional tectonics, and salt movement, dissolution, and collapse. In the fold and fault belt, the Cane Creek shale of the Paradox Formation is composed of marine carbonate, evaporite, and organic-rich shale beds. The Cane Creek is a fractured, self-sourced oil reservoir that is highly overpressured – an ideal target for horizontal drilling. Fracture data in the Cane Creek show a regional, northeast to southwest, near-vertical, open, extensional fracture system. Horizontal drilling increases the probability of encountering the near-vertical fractures needed for economic oil production. Horizontal drilling in the Cane Creek has resulted in numerous new field discoveries and greatly improved the success rate of new economical discoveries.

Land-use constraints within oil plays are a critical concern to current and potential operators exploring and developing petroleum resources in Utah and vicinity. Land classification maps and land ownership acreage summaries for the major oil-producing provinces portray multiple types of surface and/or mineral ownership. These maps and summaries will help guide petroleum companies in planning exploration and land-acquisition strategies, pipeline companies and gas processors in planning future facilities and pipeline extensions, and government agencies in decision-making processes.

Technology transfer activities during the quarter consisted of exhibiting a booth display of project materials at the 2004 Annual Convention of the American Association of Petroleum Geologists in Dallas, Texas. A poster technical presentation was made at the convention on reservoir outcrop analogs in Utah. Project team members joined Utah Stake Holders Board members in attending the Uinta Basin Oil and Gas Collaborative Group meeting in Vernal, Utah. The project home page was updated for the Utah Geological Survey Web site. Project team members published an abstract and semi-annual report detailing project progress and results.

INTRODUCTION

Project Overview

Utah oil fields have produced over 1.2 billion barrels (bbls) (191 million m^3) (Utah Division of Oil, Gas and Mining, 2003). However, the 13.7 million bbls (2.2 million m^3) of production in 2002 was the lowest level in over 40 years and continued the steady decline that began in the mid-1980s (Utah Division of Oil, Gas and Mining, 2002). Proven reserves are relatively high, at 283 million bbls (45 million m^3) (Energy Information Administration, 2001). With higher oil prices now prevailing, secondary and tertiary recovery techniques should boost future production rates and ultimate recovery from known fields.

Utah's drilling history has fluctuated greatly due to discoveries, oil price trends, and changing exploration targets. During the boom period of the early 1980s, activity peaked at over 500 wells per year. Sustained high petroleum prices are likely to provide the economic climate needed to entice more high-risk exploration investments (more wildcats), resulting in new discoveries.

Utah still contains large areas that are virtually unexplored. There is also significant potential for increased recovery from existing fields by employing improved reservoir characterization and the latest drilling, completion, and secondary/tertiary recovery technologies. New exploratory targets may be identified from three-dimensional (3D) seismic surveys. Development of potential prospects is within the economic and technical capabilities of both major and independent operators.

The primary goal of this study is to increase recoverable oil reserves from existing field reservoirs and new discoveries by providing play portfolios for the major oil-producing provinces (Paradox Basin, Uinta Basin, and thrust belt) in Utah and adjacent areas in Colorado and Wyoming (figure 1). These play portfolios will include: descriptions (such as stratigraphy, diagenetic analysis, tectonic setting, reservoir characteristics, trap type, seal, and hydrocarbon source) and maps of the major oil plays by reservoir; production and reservoir data; case-study field evaluations; summaries of the state-of-the-art drilling, completion, and secondary/tertiary techniques for each play; locations of major oil pipelines; and descriptions of reservoir outcrop analogs for each play. Also included will be an analysis of land-use constraints on development, such as wilderness or roadless areas, and national parks within oil plays.

Project Benefits

The overall goal of this multi-year project is enhanced petroleum production in the Rocky Mountain region. Specifically, the project goal will benefit from the following projects:

(1) improved reservoir characterization to prevent premature abandonment of numerous small fields in the Paradox and Uinta Basins,

(2) identification of the type of untapped compartments created by reservoir heterogeneity (for example, diagenesis and rapid facies changes) to increase recoverable reserves,

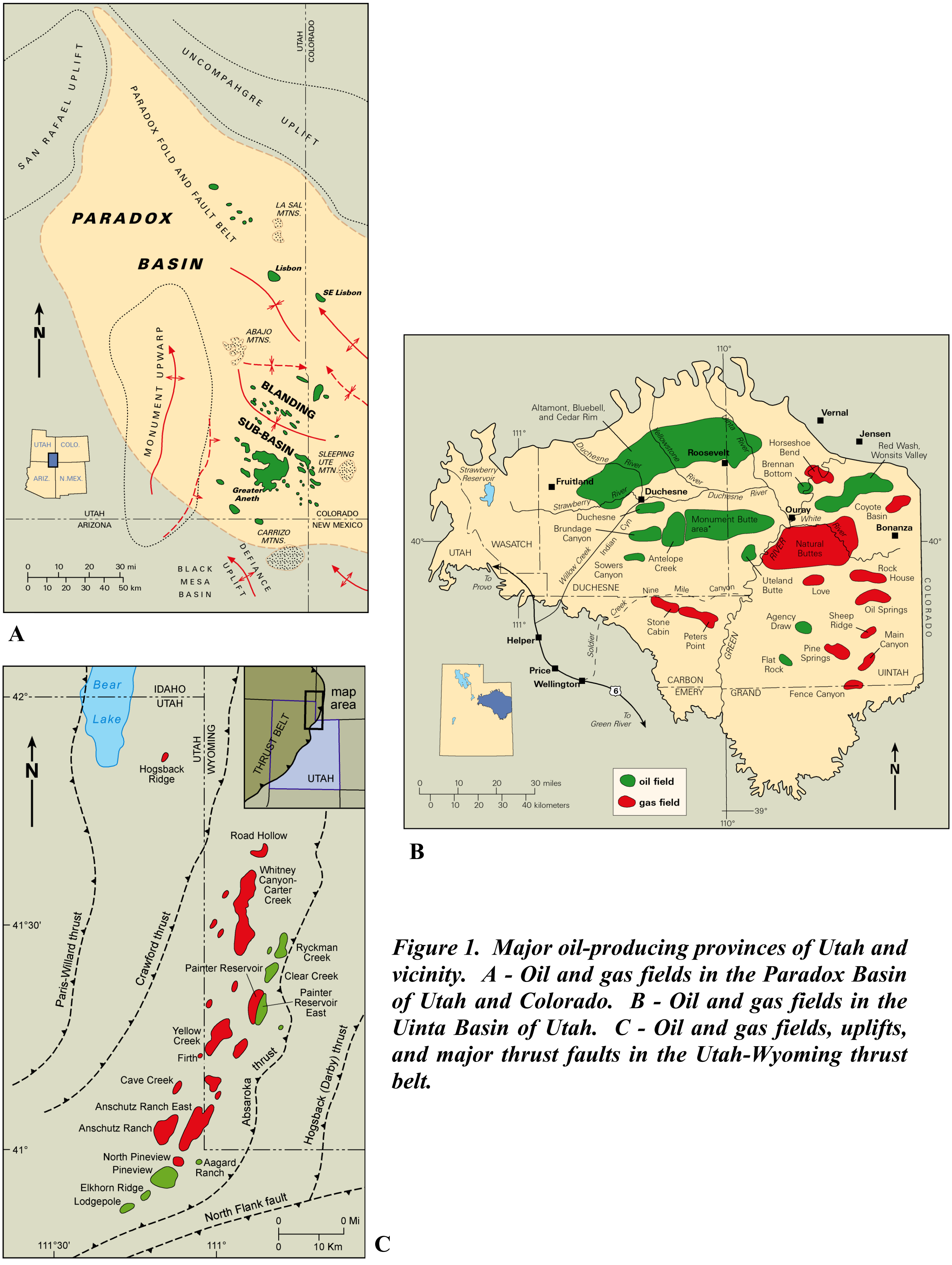

Figure 1. Major oil-producing provinces of Utah and vicinity. A - Oil and gas fields in the Paradox Basin of Utah and Colorado. B - Oil and gas fields in the Uinta Basin of Utah. C - Oil and gas fields, uplifts, and major thrust faults in the Utah-Wyoming thrust belt.

(3) identification of the latest drilling, completion, and secondary/tertiary techniques to increase deliverability,

(4) identification of reservoir trends for field extension drilling and stimulating exploration in undeveloped parts of producing fairways,

(5) identification of technology used in other identified basins or trends with similar types of reservoirs that might improve production in Utah,

(6) identification of optimal well spacing/location to reduce the number of wells needed to successfully drain a reservoir to reduce development costs and risk, and allow limited energy investment dollars to be used more productively, and

(7) technology transfer to encourage new development and exploration efforts and increase royalty income to the federal, state, local, Native American, and fee owners.

The Utah play portfolios produced by this project will provide an easy-to-use geologic, engineering, and geographic reference to help petroleum companies plan exploration, land-acquisition strategies, and field development. These portfolios may also help pipeline companies plan future facilities and pipelines. Other users of the portfolios will include petroleum engineers, petroleum land specialists, landowners, bankers and investors, economists, utility companies, manufacturers, county planners, and numerous government agencies.

The results of this project will be transferred to industry and other interested parties through establishment of Technical Advisory and Stake Holders Boards, an industry outreach program, and technical presentations at national and regional professional society meetings. All of this information will be made public through: (1) the Utah Geological Survey (UGS) Web site; (2) an interactive, menu-driven digital product on compact disc; and (3) hard copy publications in various technical or trade journals and UGS publications.

PENNSYLVANIAN PARADOX FORMATION FRACTURED-SHALE PLAY – DISCUSSION AND RESULTS

Paradox Basin Overview

The Paradox Basin (figure 1), located mainly in southeastern Utah and southwestern Colorado, is an elongate, northwest-southeast-trending, evaporitic basin that predominately developed during the Pennsylvanian (Desmoinesian), about 330 to 310 million years ago. At that time, uplift of the Ancestral Rockies in the western United States also occurred. The Uncompahgre Highlands (uplift) in eastern Utah and western Colorado initially formed as the westernmost range of the Ancestral Rockies. The southwestern flank of the Uncompahgre Highlands is bounded by a large, basement-involved, high-angle, reverse fault identified from seismic surveys and exploration drilling. As the highlands rose, an accompanying depression, or foreland basin, formed to the southwest – the Paradox Basin. Rapid subsidence, particularly during the Pennsylvanian and continuing into the Permian, accommodated large volumes of evaporitic and marine sediments that intertongue with non-marine arkosic material shed from the highland area to the northeast (Hintze, 1993). The Paradox Basin is surrounded by other uplifts and basins, which formed during the Late Cretaceous-early Tertiary Laramide orogeny (figure 1).

The Paradox Basin can generally be divided into three areas: the Paradox fold and fault belt in the north, the Blanding sub-basin in the south-southwest, and the Aneth platform in southeasternmost Utah (figure 1). Hydrocarbons are produced in all three areas. The source of the oil is several black, organic-rich shales within the Pennsylvanian Paradox Formation (Hite and others, 1984; Nuccio and Condon, 1996). Fractured-shale beds in the Paradox Formation are oil productive in the Paradox Basin fold and fault belt of southwest Utah (figures 2 and 3). In Pennsylvanian time the Paradox Basin was rapidly subsiding and filled with a thick, cyclical sequence of marine carbonate, evaporite, and organic-rich shale (Peterson and Hite, 1969; Hite and others, 1984). Rejuvenation of pre-existing (late Precambrian), northwesterly trending structures within the basin partly influenced deposition of the lower cyclic units and the development of salt-cored anticlines that are the dominant structural features in the Paradox Basin fold and fault belt (Kelley, 1958; Baars and Stevenson, 1981). Jointing and fractures are controlled by regional tectonics and more locallized salt movement, dissolution, and collapse (Doelling, 2000; Doelling and others, 2000).

The Paradox Formation is part of the Pennsylvanian Hermosa Group (Baker and others, 1933) (figure 4). The 500 to 5000 foot-thick (150-1500 m) Paradox is overlain by the Honaker Trail Formation and underlain by the Pinkerton Trail Formation (Wengerd and Matheny, 1958; Hintze, 1993). The Paradox is divided into: (1) a lower member consisting of interbedded black shale, siltstone, dolomite, and anhydrite, (2) a middle (saline) member consisting of thick halite beds interbedded with dolomite, dolomitic siltstone and shale, and anhydrite, and (3) an upper member of interbedded dolomite, dolomitic shale, and anhydrite.

Hite and Cater (1972) and Reid and Berghorn (1981) divided the Paradox Formation into informal zones, in ascending order: Alkali Gulch, Barker Creek, Akah, Desert Creek, and Ismay. Hite (1960) divided the middle (saline) member of the Paradox into 29 cycles. Each cycle consists of a clastic interval/salt couplet. The clastic intervals are typically interbedded dolomite, dolomitic siltstone, organic-rich shale, and anhydrite. The clastic intervals typically range in thickness from 10 to 200 feet (3-60 m) and are generally overlain by 200 to 400 feet (60-120 m) of halite.

Cane Creek Shale

Oil shows have been reported from many of the clastic intervals, but the primary fractured shale target is the Cane Creek shale of the Alkali Gulch zone. The Cane Creek is a self-sourced oil reservoir that is highly overpressured with fluid gradients exceeding 0.08 pounds per square inch per foot (psi/ft [1.81 kPa/m]). Hydrocarbon generation occurred during maximum burial in the Late Cretaceous and early Tertiary. The Cane Creek is the basal part of cycle 21 and generally ranges from 0 to about 160 feet (48 m) thick. The depositional strike of the Cane Creek is northwest to southeast, and it thins to the southwest where it laps onto the lower Paradox member or the Pinkerton Trail Formation. Thickness variations are the results of diapiric salt movement, depositional thickening on the downthrown side of faults, or depositional thinning on the upthrown side of faults (figure 5).

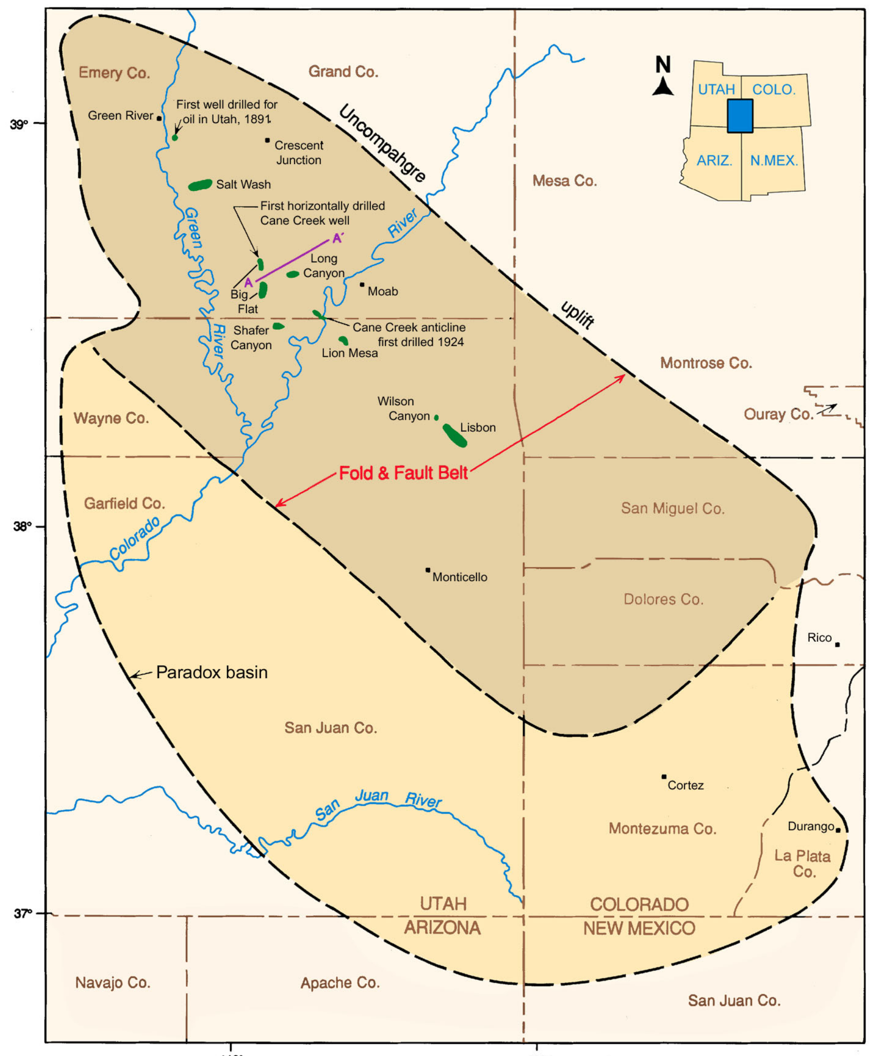

Figure 2. Location map of the Paradox Basin showing the fold and fault belt. Key fields are shown, solid outlines are productive from the Cane Creek shale of the Pennsylvanian Paradox Formation and open outlines are productive from the Mississippian Leadville Limestone. Line A – A' is figure 3.

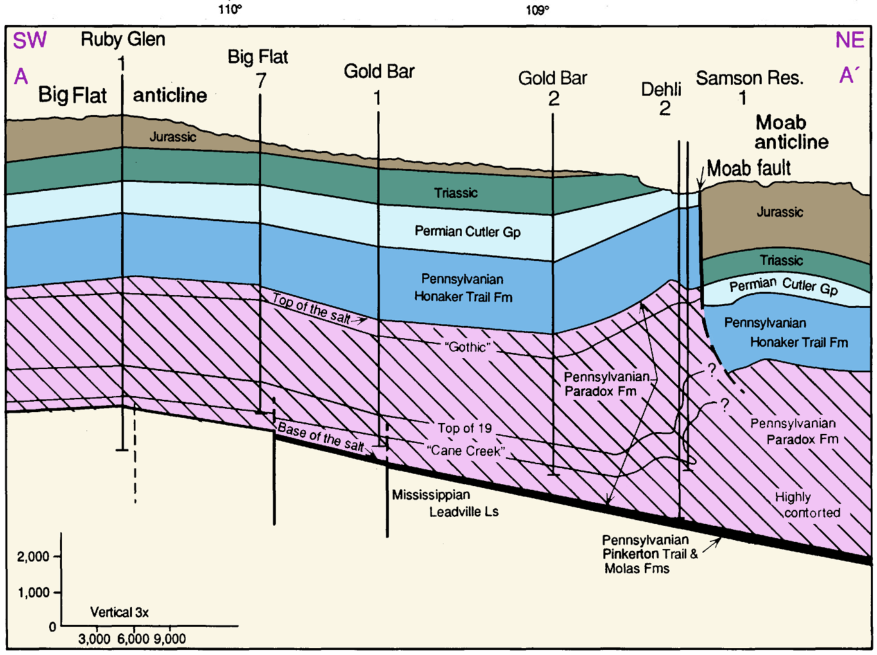

Figure 3. Cross section, A – A', from the Moab anticline to the Big Flat anticline. Location of cross section is shown in figure 2. The Paradox Formation is mostly salt which can be highly deformed. The interbeds in the Paradox are organic-rich shales, dolomite, and clastics, that are both source and reservoir for oil. The Cane Creek shale is the most prolific producer and is in the basal portion of the Paradox.

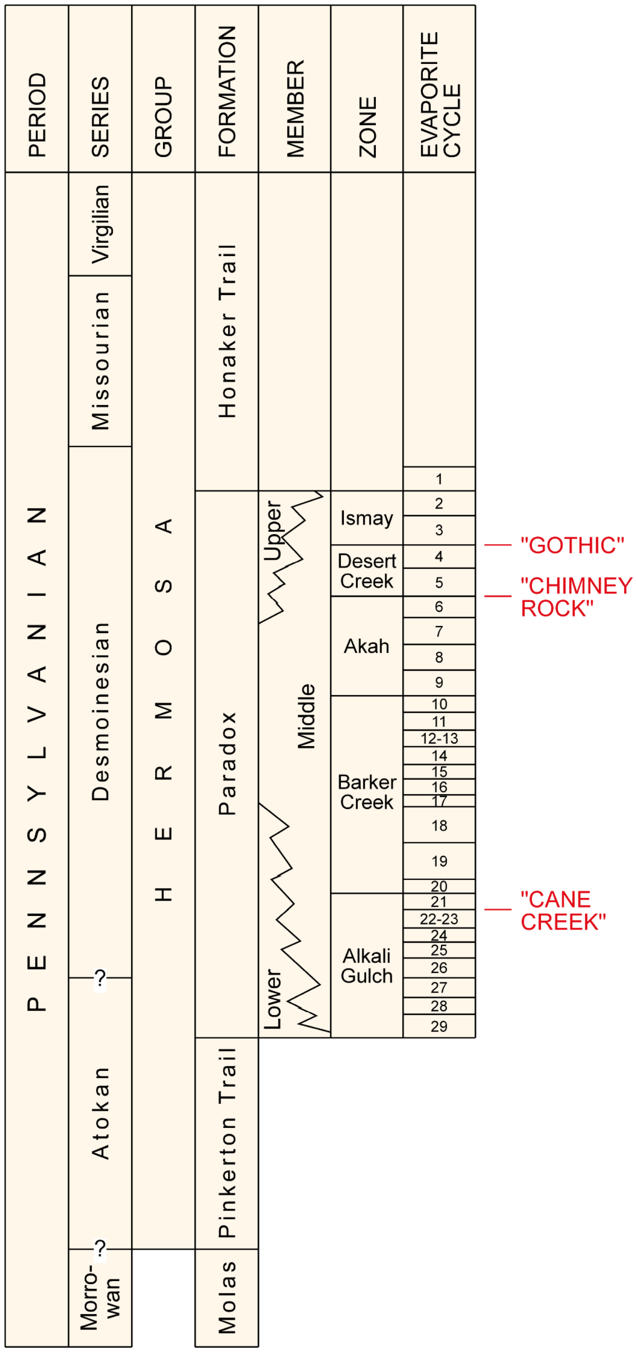

Figure 4. Pennsylvanian stratigraphic chart for the Paradox Basin; informal organic-rich shale units are highlighted.

The Cane Creek shale is divided into units in descending order: upper A, middle B, and lower C. The Cane Creek is overlain and generally underlain by anhydrite and halite (figure 6). Unit A is composed of alternating thin beds (1 to 4 feet [0.3-1.2 m] thick) of silty carbonate with interbedded, gray to black shale and laminated to nodular anhydrite. Unit B is both the primary source and reservoir for oil and gas in the Cane Creek. Unit B is composed of interbedded, gray and black shale, and silty to sandy carbonate. The average total organic carbon content of the black shale in unit B is 15 percent with some samples containing up to 28 percent (Grummon, 1993). Unit C is composed of interbedded silty carbonate and anhydrite. Upper and lower seals are provided by anhydrite and halite. Lateral seals are permeability barriers in unfractured rock.

Prior to 1991, oil had been produced from 11 vertical wells perforated in the Cane Creek shale (table 1). All wells drilled and completed in the Cane Creek since 1991 have used horizontal drilling technology (table 2). The play has been described by Smith (1978a, 1978b, 1978c, 1978d, 1978e), Fritz (1991), Morgan and others (1991), Morgan (1992a, 1992b), Montgomery (1992), Grove and others (1993), Grummon (1993), Grove and Rawlins (1997), and Doelling and others (2000).

Fracture data from oriented cores in the Cane Creek shale show a regional, northeast to southwest, near-vertical, open, extensional fracture system that is not significantly affected by orientations of localized folds (Grove and Rawlins, 1997). Horizontal drilling increases the probability of encountering the near-vertical fractures needed for economic oil production. Second-order folds due to salt flowage have amplitudes of 15 to 100 feet (5-30 m) and apparent wavelengths of 300 to 1000 feet (90-300 m). The localized folds create a significant challenge to keeping a horizontal well in the productive zone of the Cane Creek shale.

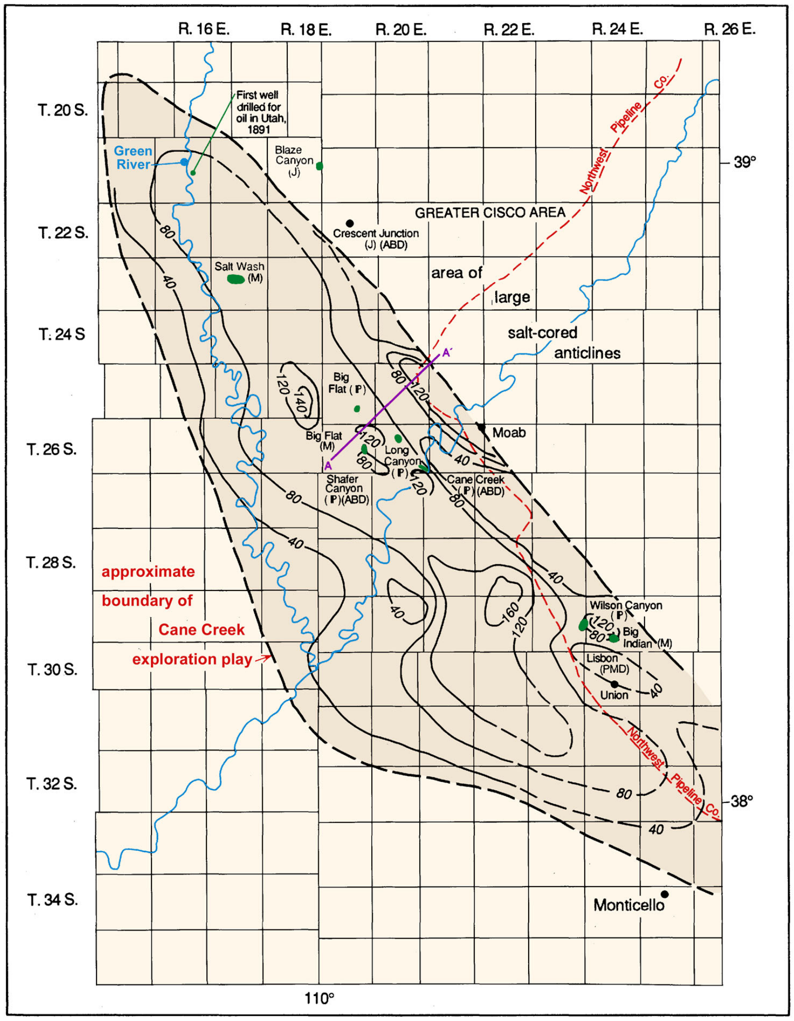

Figure 5. Generalized thickness map of the Cane Creek shale of the Paradox Formation. The shale onlaps to the west and southwest. Thickness of the Cane Creek shale in the area of large salt-cored anticlines is unknown. Local thickness varies due to salt flowages over anticlines and fault blocks.

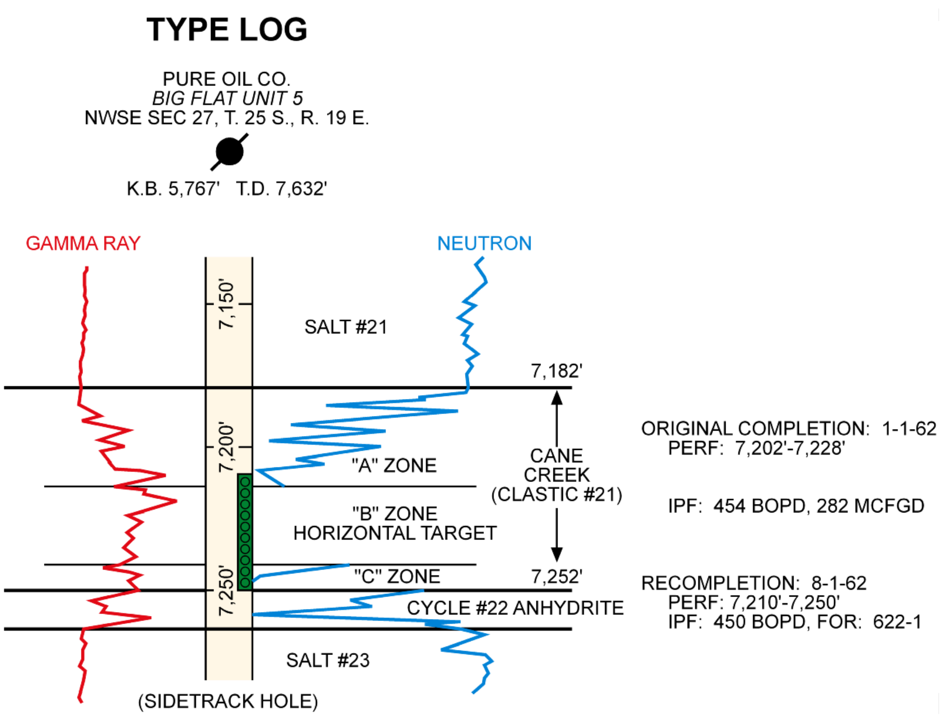

Figure 6. Log section of the Cane Creek shale of the Paradox Formation from the Big Flat No. 5 well. The Cane Creek is divided into zones A, B, and C. The B zone is the primary fractured oil reservoir.

Table 1. Cumulative oil and gas production from vertical wells completed in the Cane Creek shale. Data from the Utah Division of Oil, Gas and Mining as of December 31, 2003. All locations are Salt Lake Base Line and Meridian (SLBLM). Production is in barrels of oil (BO) and thousand cubic feet of gas (MCFG).

Field Name **Well Name** **Location**	**Completion Date**	**Current Status**	**Cumulative Production** **Oil** **Gas**
Bartlett Flat Field Big Flat 5 Section 27, T. 25 S., R. 19 E.	1961	Abandoned 1965	39,393 BO 22,051 MCFG
Unnamed Gold Bar 1 Section 29, T. 25 S., R. 20 E.	1982	Abandoned 1984	13,393 BO 14,800 MCFG
Unnamed Mathew Federal 1 Section 4, T. 26 S., R. 20 E.	1981	Abandoned 1982	1,343 BO 0 MCFG
Unnamed Skyline 1 Section 5, T. 26 S., R. 20 E.	1982	Abandoned 1982	675 BO 1,430 MCFG
Unnamed Skyline 8-44 Section 8, T. 26 S., R. 20 E.	1976	Abandoned 1976	507 BO 0 MCFG
Long Canyon Field Long Canyon 1 Section 9, T. 26 S., R. 20 E.	1962	Producing	1,087,375 BO 1,128,167 MCFG
Cane Creek Field MGM 2 Section 36, T. 26 S., R. 20 E.	1959	Abandoned 1969	1,887 BO 25,000 MCFG
Shafer Canyon Field Shafer 3 Section 4, T. 27 S., R. 20 E.	1963	Abandoned 1963	1,325 BO 0 MCFG
USA 1 Section 6, T. 27 S., R. 20 E.	1962	Abandoned 1967	66,231 BO 63,807 MCFG
Lion Mesa Field Lion Mesa 27-1A Section 27, T. 27 S., R. 21 E.	1980	Shut in	1,608 BO 0 MCFG
Wilson Canyon Field Chevron Federal 1 Section 24, T. 29 S., R. 23 E.	1968	Producing	98,544 BO 129,713 MCFG
TOTAL			1,312,281 BO 1,384,968 MCFG

Many vertical wells have been completed in the Cane Creek shale, but only the Long Canyon No. 1 well (section 8, T. 26 S., R. 20 E., Salt Lake Base Line and Meridian [SLBLM]) has been an economic success. The Long Canyon No. 1 well was drilled in 1962 and has produced more than 1 million bbls (159,000 m^3) of oil. The well is estimated to have produced more than 1 billion cubic feet (BCF [0.03 billion m^3]) of gas, but is not gauged due to a lack of a gas pipeline. Columbia Gas Development Corporation formed the Kane Springs Federal unit (figure 7), and in 1991 drilled the first horizontal well in the abandoned Bartlett Flat field, the Kane Springs No. 27-1 well (section 27, T. 25 S., R. 19 E., SLBLM). Exploration in the Kane Springs unit has resulted in numerous new field discoveries. Horizontal drilling has not resulted in wells that produce more oil than the Long Canyon well (figure 8), but has greatly improved the success rate of new economical discoveries.

Table 2. Cumulative oil and gas production from horizontal wells completed in the Cane Creek shale. Data from the Utah Division of Oil, Gas and Mining as of December 31, 2003. All locations are SLBLM. Production is in barrels of oil (BO) and thousand cubic feet of gas (MCFG).

Field Name **Well Name** **Location**	**Completion Date**	**Current Status**	**Cumulative Production** **Oil** **Gas**
Hell Roaring Field Kane Springs Federal 10-1 Section 10, T. 25 S., R. 18 E.	1992	Producing	536,743 BO 497,672 MCFG
Wildcat Cane Creek Federal 7-1 Section 7, T. 25 S., R. 19 E.		Shut in	No production
Big Flat Kane Springs Federal 27-1 Section 27, T. 25 S., R. 19 E.	1991	Producing	426,879 BO 473,336 MCFG
Kane Springs Federal 25-19-34-1 Section 34, T. 25 S., R. 19 E.	1993	Producing	305,136 BO 258,329 MCFG
Cane Creek Federal 11-1 Section 11, T. 26 S., R. 19 E.	2002	Producing	18,944 BO 8,567 MCFG
Wildcat Kane Springs Federal 28-1 Section 28, T. 25 S., R. 19 E.	1992	Shut in	No production
Big Flat West Kane Springs Federal 20-1 Section 20, T. 26 S., R. 20 E.		Shut in	No production
Park Road Kane Springs Federal 19-1A Section 19, T. 26 S., R. 20 E.	1991	Producing	301,233 BO 288,611 MCFG
TOTAL			1,588,952 BO 1,526,515 MCFG

Bartlett Flat - Big Flat Field

Big Flat field was discovered in 1957, with oil and gas production from the Mississippian Leadville Limestone. Big Flat field included parts of section 11, 14, and 23 in T. 26 S., R. 19 E., SLBLM. Big Flat field was abandoned in 1988. Later exploration in the area resulted in the discovery of oil in the shallower Cane Creek shale. The Big Flat No. 5 well (section 27, T. 25 S., R. 19 E., SLBLM) was completed in the Cane Creek in 1961, and was designated the Bartlett Flat field. The Big Flat No. 5 well was abandoned in 1965 due to collapsed casing after producing 39,393 bbls (6264 m^3) of oil. Two wells, the Husky No. 1 and Big Flat No. 6, were drilled within 100 feet (30 m) of the abandoned Big Flat No. 5 well, but were unable to establish economical oil production (figure 9).

Columbia Gas Development Corporation drilled the Kane Springs Federal No. 27-1 which included a 1012-foot (308 m) horizontal leg in the Cane Creek shale and passed within feet of the Big Flat No. 5 well. The Kane Springs No. 27-1 well was completed in 1991, with an initial production rate flowing 914 bbls of oil per day (BOPD [145 m^3/d) and 290 thousand cubic feet of gas per day (MCFGPD [8200 m^3/d]) from 7438 to 8240 feet (2267-2512 m) (7248 feet [2209 m] total true vertical depth), a bottom-hole pressure of 6143 psi (42,356 kPa), and an average pressure gradient of 0.85 psi/ft (19.2 kPa/m).

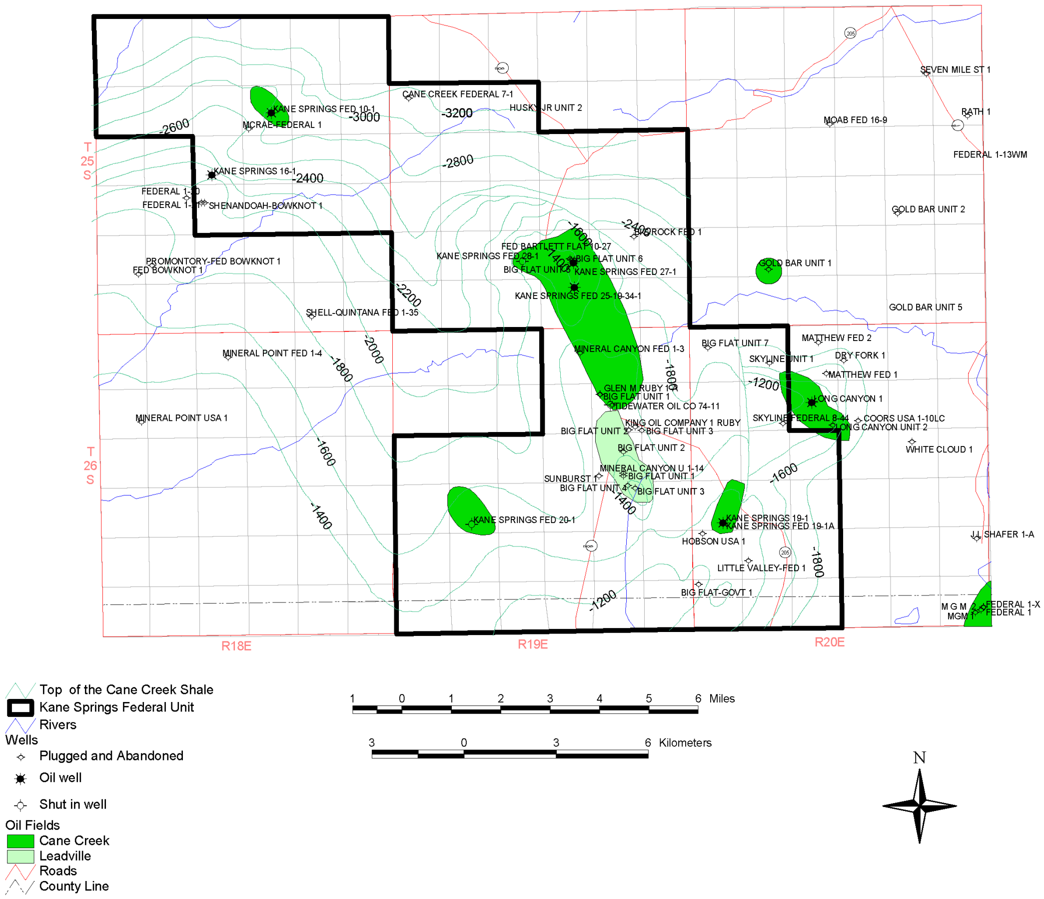

Figure 7. Map of the Kane Springs Federal exploratory unit. Structure contours on the top of the Cane Creek shale. Contour interval = 200 feet; datum = sea level.

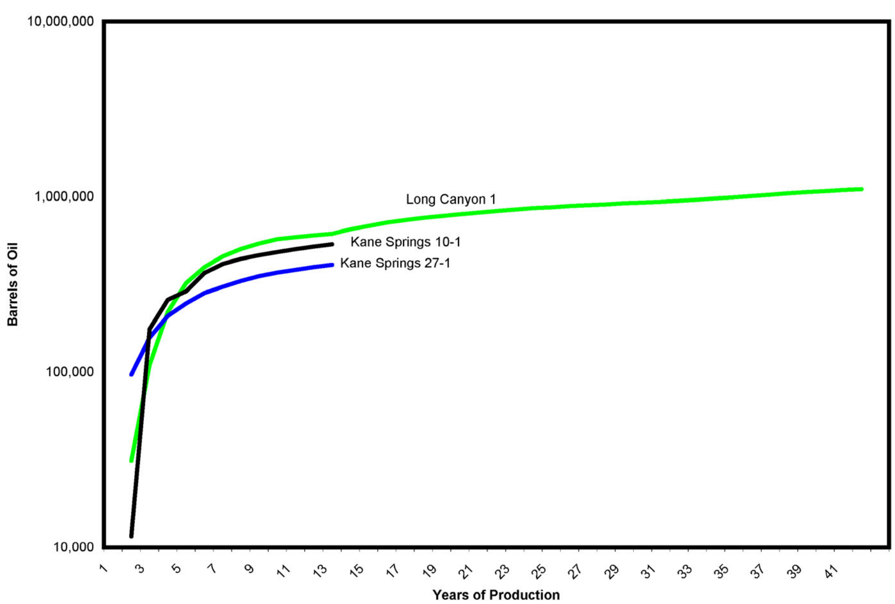

Figure 8. Cumulative production curves for the vertical Long Canyon No. 1 well and the horizontally drilled Kane Springs Nos. 10-1 and 27-1 wells. The Kane Springs Nos. 10-1 and 27-1 wells are the most productive of the horizontally drilled wells. Horizontal drilling does not appear to improve the cumulative production of a well, but it does improve the exploratory success of Cane Creek drilling.

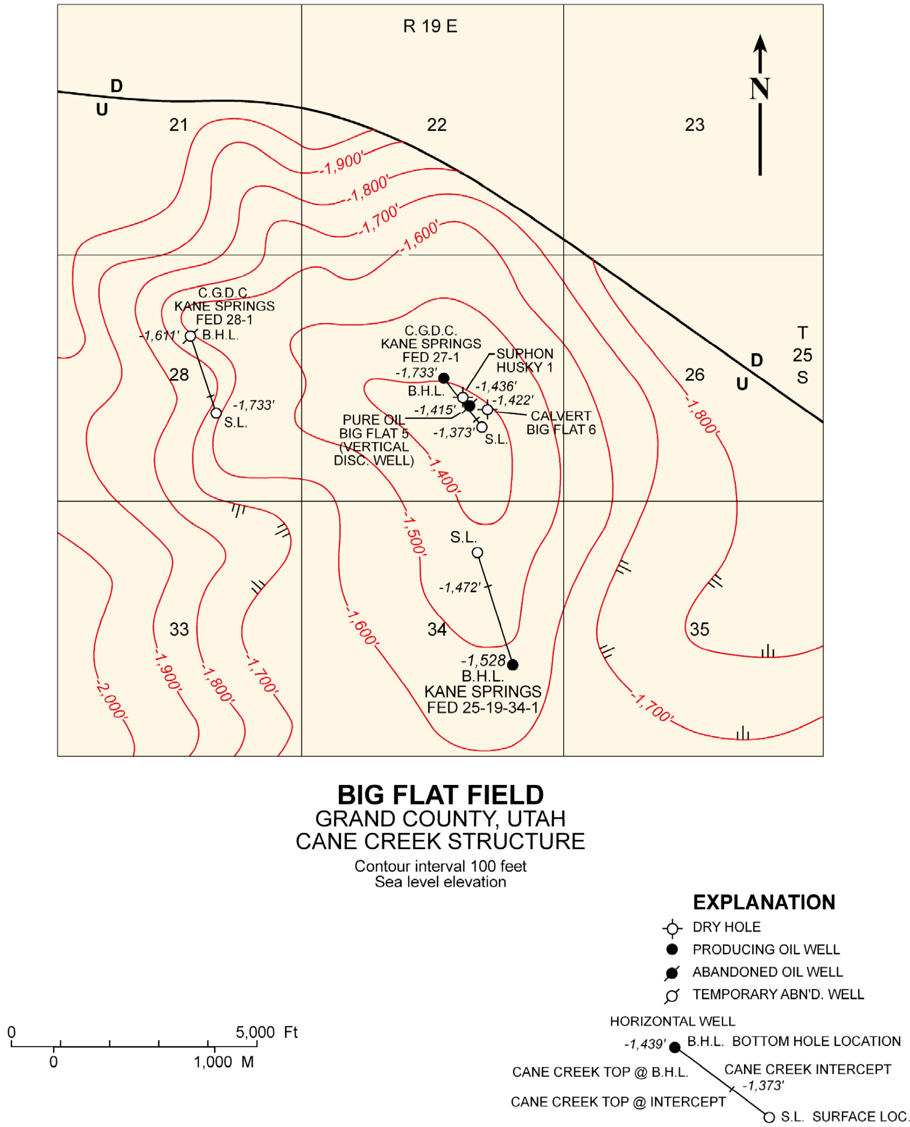

Figure 9. Map of Big Flat field showing the original vertical discovery well, the Big Flat No. 5, and the first horizontal discovery, the Kane Springs No. 27-1 well. Structure contours on top of the Cane Creek shale. Contour interval = 100 feet; datum = sea level.

The discovery was designated Big Flat field. Two additional wells have been drilled in Big Flat field: the Kane Springs Federal No. 25-19-34-1 (section 34, T. 25 S., R. 19 E., SLBLM), completed in 1993, and the Kane Springs Federal No. 11-1 (section 11, T. 26 S., R. 19 E., SLBLM) completed in 2002. The Kane Springs Federal No. 28-1 (section 28, T. 25 S., R. 19 E., SLBLM) was drilled in 1992 on the Big Flat structure, but is currently listed as a shut-in wildcat that has never produced. Cumulative production from the three horizontal wells, as of December 31, 2003, is 750,959 bbls (119,403 m^3) of oil and 740,232 MCFG (20,963 m^3). There is no gas pipeline in the Big Flat area so the gas is vented except for what is used on location.

LAND CLASSIFICATION SUMMARY

Land-use constraints on development, such as wilderness or roadless areas, and national parks within oil plays, are a critical concern to current and potential operators exploring and developing petroleum resources in Utah and vicinity. Land classification maps and land ownership acreage summaries have been prepared for the major oil-producing provinces: thrust belt, Uinta Basin, and Paradox Basin (table 3). These maps and summaries are designed to help guide petroleum companies in planning exploration and land-acquisition strategies, pipeline companies and gas processors in planning future facilities and pipeline extensions, and government agencies in decision-making processes.

Table 3. Summary of land classification and acreage for the thrust belt, Uinta Basin, and Paradox Basin.

Province	Land Classification	Mineral Mgt. Agency	Acres	% of Play Area
Thrust Belt	BLM	State/District office	94,797	13.38
	Private	Private/Corporate	576,701	81.41
	State Lands	State	23,009	3.25
	State Parks/Wildlife Reserves	State	10,210	1.44
	Water	State/Federal	3,702	0.52
Total			708,419	100.00
Uinta Basin	BLM	State/District office	2,026,363	37.57
	Forest Service	State/District office	482,576	8.95
	Native American Reservations	BIA/Indian Tribe	1,058,240	19.63
	Private	Private/Corporate	1,200,348	22.26
	State Lands	State	591,718	10.97
	USFWS (wildlife refuge)	USFWS	8,975	0.17
	Water	State/Federal	23,874	0.45
Total			5,392,094	100.00
Paradox Basin	BLM	State/District office	4,246,997	55.47
	Forest Service	State/District office	479,966	6.27
	Military Reservations	Department of Defense	1,631	0.02
	National Parks/Monuments	National Park Service	677,890	8.85
	Native American Reservations	BIA/Indian Tribe	554,321	7.24
	Private	Individual/Corporate	1,146,324	14.97
	State Lands	State	493,697	6.45
	Wilderness Area	Federal	45,956	0.60
	Water	State/Federal	9,806	0.13
Total			7,656,588	100.00

Each oil-producing province consists of multiple types of surface and/or mineral ownership. For example, the Utah/Wyoming thrust belt is composed primarily of Bureau of Land Management (BLM), private, and state (managed by the Utah School and Institutional Trust Lands Administration) lands (figure 10). Each type of ownership is further divided to include other lands that fall within or under management of a particular land classification. For instance, in the Uinta Basin there are seven categories of land that are classified as BLM.

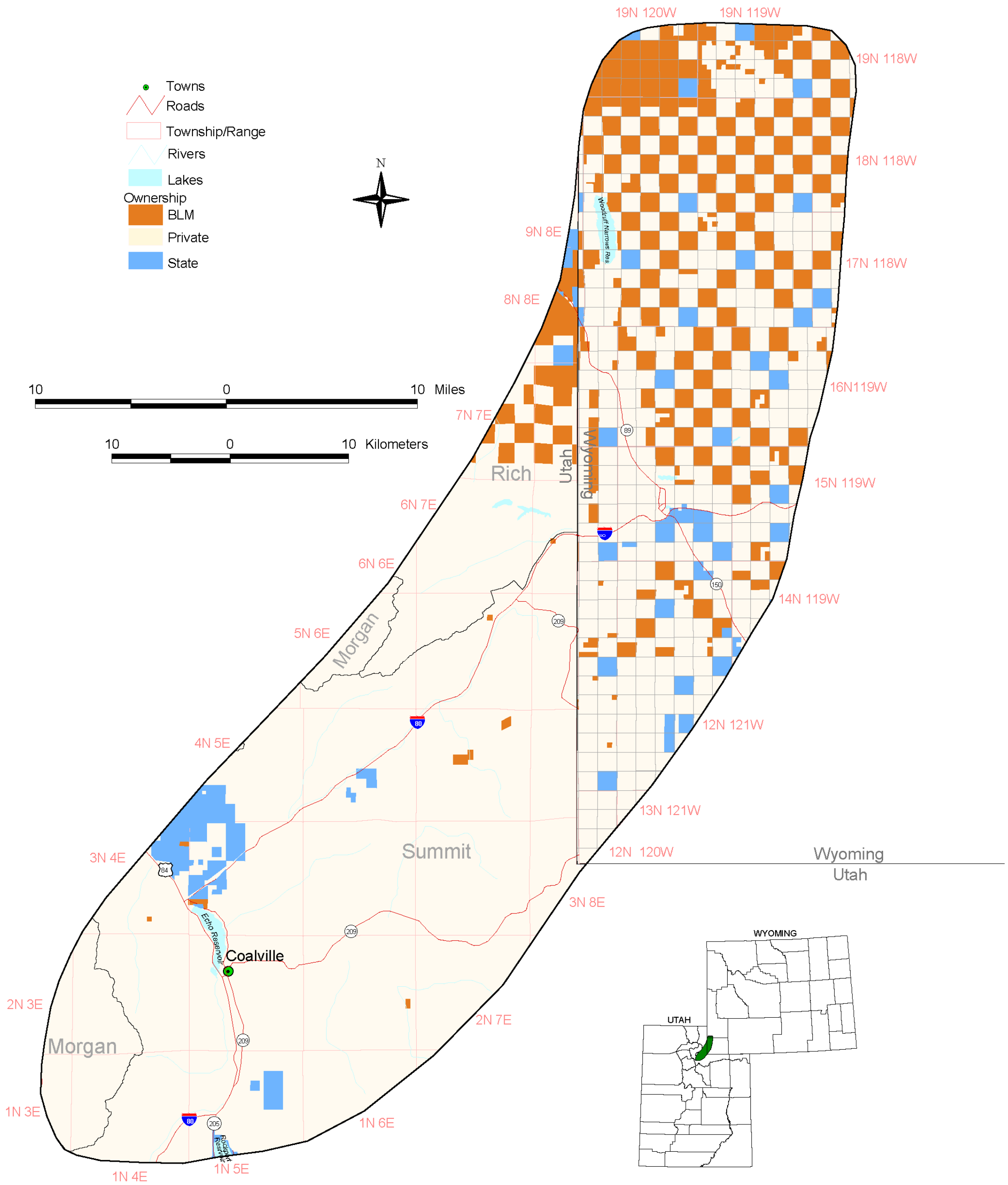

Figure 10. Surface and/or mineral ownership map for the Utah/Wyoming thrust belt oil-producing province.

Geographic Information Systems (GIS) mapping has enabled us to color code each category, and a color-coded index map showing each category for each land classification is depicted on each area map. Some of the categories include restricted lands and withdrawal lands that are not open to leasing or development. For example, in the Uinta Basin province there are lands classified as Forest Service, but are under a withdrawal order. Work is continuing to determine the nature of these withdrawals and to what extent oil and gas leasing is affected.

TECHNOLOGY TRANSFER

The Utah Geological Survey (UGS) is the Principal Investigator and prime contractor for the PUMPII project. All play maps, reports, databases, and other deliverables produced for the PUMPII project will be published in interactive, menu-driven digital (Web-based and compact disc) and hard-copy formats by the UGS for presentation to the petroleum industry. Syntheses and highlights will be submitted to refereed journals, as appropriate, such as the *American Association of Petroleum Geologists (AAPG) Bulletin* and *Journal of Petroleum Technology*, and to trade publications such as the *Oil and Gas Journal*.

The technology-transfer plan included the formation of a Technical Advisory Board and a Stake Holders Board. These boards meet annually with the project technical team members. The Technical Advisory Board advises the technical team on the direction of study, reviews technical progress, recommends changes and additions to the study, and provides data. The Technical Advisory Board is composed of field operators from the oil-producing provinces of Utah that also extend into Wyoming or Colorado. This board ensures direct communication of the study methods and results to the operators. The Stake Holders Board is composed of groups that have a financial interest in the study area including representatives from the State of Utah (School and Institutional Trust Lands Administration and Utah Division of Oil, Gas and Mining) and the Federal Government (Bureau of Land Management and Bureau of Indian Affairs). The members of the Technical Advisory and Stake Holders Boards receive all quarterly technical reports and copies of all publications, and other material resulting from the study. Board members will also provide field and reservoir data, especially data pertaining to best practices. During the quarter, project team members joined Utah Stake Holders Board members in attending the Uinta Basin Oil and Gas Collaborative Group meeting in Vernal, Utah.

Project materials, plans, and objectives were displayed at the UGS booth during the AAPG Annual Convention, April 18-21, 2004, in Dallas, Texas. Three UGS scientists staffed the display booth at this event. Project displays will be included as part of the UGS booth at professional meetings throughout the duration of the project.

Utah Geological Survey *Survey Notes* and Web Site

The UGS publication *Survey Notes* provides non-technical information on contemporary geologic topics, issues, events, and ongoing UGS projects to Utah's geologic community, educators, state and local officials and other decision-makers, and the public. *Survey Notes* is published three times yearly. Single copies are distributed free of charge and reproduction (with recognition of source) is encouraged. The UGS maintains a Web site on the Internet, http://geology.utah.gov. The UGS site includes a page under the heading *Utah Geology/Oil, Coal, and Energy*, which describes the UGS/DOE cooperative studies (PUMPII, Paradox Basin [two projects], Ferron Sandstone, Bluebell field, Green River Formation), and has a link to the DOE Web site. Each UGS/DOE cooperative study also has its own separate page on the UGS Web site. The PUMPII project page, http://geology.utah.gov/emp/pump/index.htm, contains (1) a project location map, (2) a description of the project, (3) a reference list of all publications that are a direct result of the project, (4) poster presentations, and (5) quarterly technical progress reports.

Technical Presentation

The following technical presentation was made during the second six months of the second project year as part of the technology transfer activities:

> "Outcrop Analogs in Utah – Templates for Reservoir Characterization and Modeling" by Thomas C. Chidsey, Jr., Craig D. Morgan, and Kevin McClure, American Association of Petroleum Geologists Annual Convention, Dallas, Texas, April 20, 2004. Reservoir outcrop analogs included the Mississippian Madison Limestone, Pennsylvanian Paradox Formation, Jurassic Navajo Sandstone and Twin Creek Limestone, and Tertiary Green River Formation.

Project Publications

Chidsey, T.C., Jr., Morgan, C.D., McClure, K, 2004, Outcrop analogs in Utah – templates for reservoir characterization and modeling [abs.]: American Association of Petroleum Geologists 2004 Annual Convention Abstracts, v. 13, p. A24.

Chidsey, T.C., Jr., Morgan, C.D., McClure, K. Bon, R.L., Gwynn, J.W., Jarrard, R., and Curtice, R., 2004, Major oil plays in Utah and vicinity – quarterly annual technical progress report for the period January 1 to March 31, 2004: U.S. Department of Energy, DOE/FC26-02NT15133-7, 31 p.

CONCLUSIONS AND RECOMMENDATIONS

A combination of depositional and structural events created the right conditions for oil generation and trapping in the major oil-producing provinces (Paradox Basin, Uinta Basin, and thrust belt) in Utah and adjacent areas in Colorado and Wyoming. Oil plays are specific geographic areas having petroleum potential due to favorable source rock, migration paths, reservoir characteristics, and other factors. This report focuses on the Pennsylvanian Paradox Formation fractured-shale play and the classification of lands with the thrust belt, Uinta Basin, and Paradox Basin.

Fractured-shale beds in the Pennsylvanian Paradox Formation are oil productive in the Paradox Basin fold and fault belt of southwest Utah. Jointing and fractures are controlled by regional tectonics and more localized salt movement, dissolution, and collapse. In the fold and fault belt, the Cane Creek shale of the Paradox Formation is composed of marine carbonates, evaporites, and organic-rich shale. The Cane Creek is a fractured, self-sourced oil reservoir that is highly overpressured – an ideal target for horizontal drilling. Fracture data from oriented cores in the Cane Creek show a regional, northeast to southwest, near-vertical, open, extensional fracture system that is not significantly affected by orientations of localized folds. Horizontal drilling increases the probability of encountering the near-vertical fractures needed for economic oil production. Prior to 1991, oil had only been produced from vertical wells in the Cane Creek. Since then, wells completed in the Cane Creek have used horizontal drilling technology. Horizontal drilling in the Cane Creek has resulted in numerous new field discoveries and greatly improved the success rate of new economical discoveries.

Land-use constraints within oil plays are a critical concern to current and potential operators exploring and developing petroleum resources in Utah and vicinity. Land classification maps and land ownership acreage summaries for Utah's major oil-producing provinces portray multiple types of surface and/or mineral ownership. These maps and summaries will help guide petroleum companies in planning exploration and land-acquisition strategies, pipeline companies and gas processors in planning future facilities and pipeline extensions, and government agencies in decision-making processes.

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Jim Parker and Vicky Clarke of the UGS prepared the figures. This report was reviewed by Dave Tabet and Mike Hylland of the UGS. Cheryl Gustin, UGS, formatted the manuscript.

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