UINTAH AND OURAY RESERVATION

Introduction

The Uintah and Ouray Indian Reservation is located in the Uinta Basin, in northeast Utah (FIGURES UO-1 and UO-2). The terrain is High Mountain desert in the central part of the basin, which is surrounded by mountain ranges on the edge of the basin. Elevation varies from approximately 5,600 feet to over 11,000 feet above sea level. The area's main transportation conduit is U.S. Highway 40, which leads east to Salt Lake City, Utah, and west to Denver, Colorado. The basin covers approximately 11,500 square miles, and Ute Indian Tribe jurisdiction comprises just over 4 million acres of this area, reaching from the Utah-Colorado border west to the Wasatch Mountain range.

Mineral Ownership

The Uintah and Ouray Indian Reservation is a checkerboard ownership reservation containing Ute Indian Tribe, Ute Indian Allotted, Ute Indian Tribe and Ute Distribution Corporation Jointly Managed Indian Trust minerals, along with fee (privately owned) and federal minerals. Indian properties cover approximately 1.2 million surface-owned acres, and 400,000 mineral-owned acres within the 4 million-acre jurisdictional boundary. Ute Indian Allottees, the Ute Indian Tribe, and the Ute Distribution Corporation own both surface and mineral properties in joint management.

Currently, the Ute Tribe, Ute Allottees, and the Ute Distribution Corporation in joint management hold 102,000 acres under lease, and more than 490 wells in production. The Utah Oil, Gas, and Mining Board conduct conservation spacing in cooperation with the Ute Tribe. Spacing rules for the Altamont-Bluebell field are set at a multi-well level allowing two wells per section, while undesignated field spacing is 40 acres for oil and 640 acres for gas. Some variations or exceptions exist by special ruling and order (Anderson, 1995).

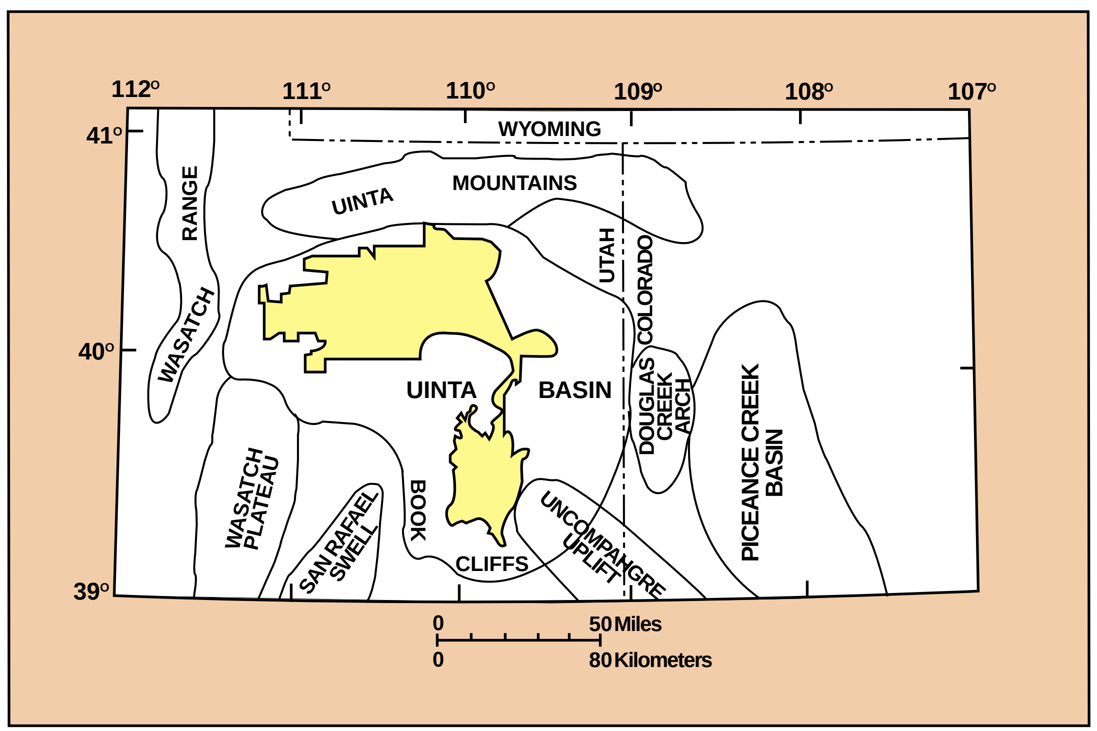


Figure UO-1. Location of Uinta Basin and surrounding structural and physiographic features. Yellow area shows approximate boundary of Uintah and Ouray Indian Reservation (modified after Cashion, 1992).

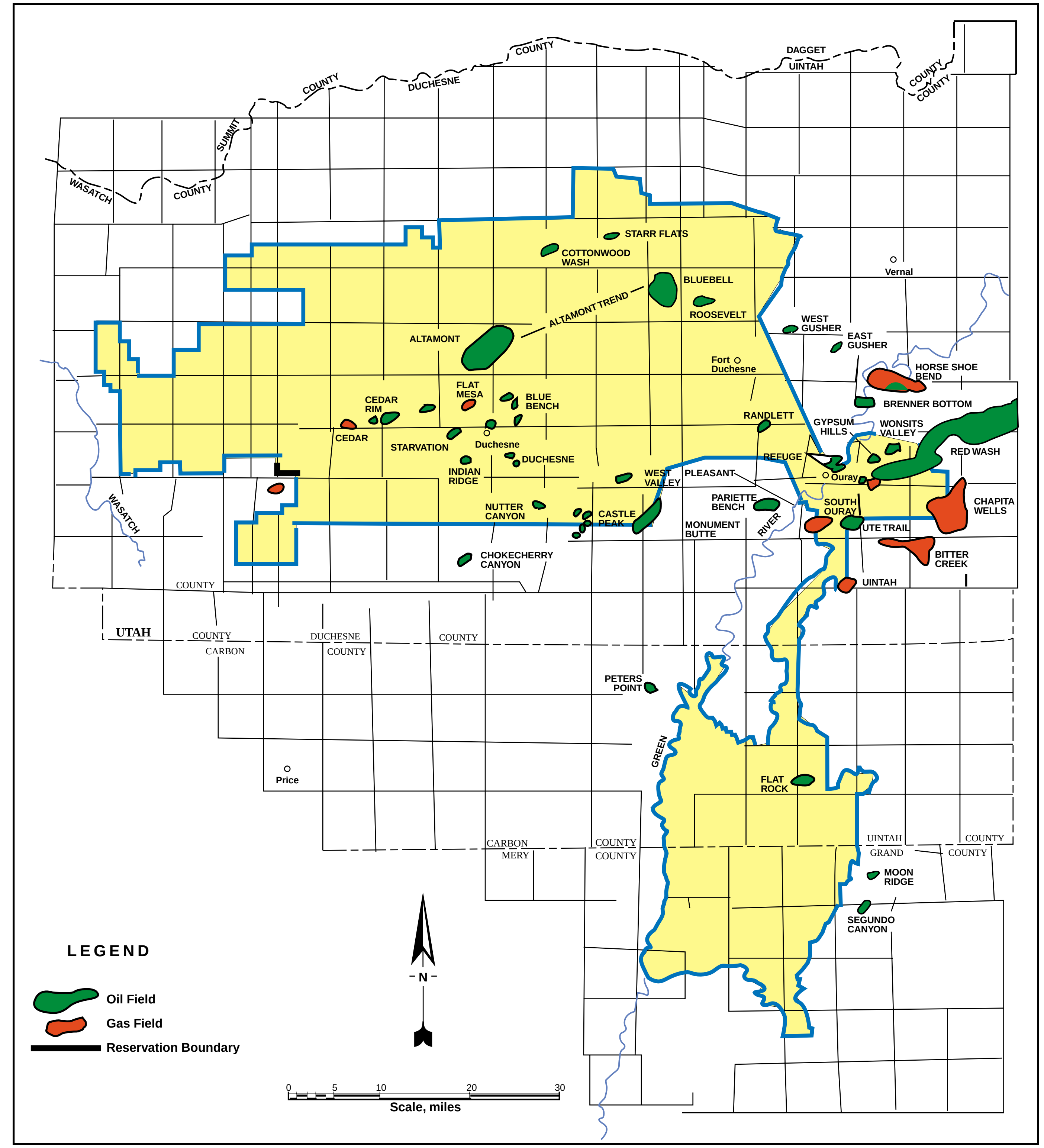


Figure UO-2. Index map showing the Uintah and Ouray Indian Reservation in yellow (modified after Anonymous, 1995).

Uintah and Ouray Reservation
Petroleum Exploration and Development

The Uinta Basin is a rich source of many energy-producing minerals. The greatest portion of the energy resources is hydrocarbons in the form of coal, oil, gas, oil shale, and bituminous sandstone and limestone.

Resources contained within the Uintah and Ouray Reservation include conventional and unconventional hydrocarbon deposits of oil and gas, oil shale, and tar sands in major quantity; coal, uranium, silver, copper, gold, gypsum, and phosphate are also present in minor to mid-economic quantities.

Cretaceous and older rocks contain many productive oil and gas zones. However, the major portion of the energy production from the Uinta Basin is from Tertiary rocks, and the distribution of the hydrocarbons and minerals is directly related to their depositional environment.

Uinta Basin production of oil and gas began in the late 1940's, with major development commencing in the late 1960's and expanding in the late 1970's and early 1980's. Over 300 million barrels of oil (MMBO) have been produced from the Greater Altamont-Bluebell field alone. Conventional oil and gas deposits have been extensively explored and developed. The Green River and Wasatch Formations contain the bulk of the producing zones, with depth to these zones ranging from 6,000 to 18,000 feet. This has resulted in the development of the Greater Altamont-Bluebell oil field, and numerous undesignated smaller fields (FIGURES UO-2, UO-6).

The oil produced is high in paraffin content (pour point = 120 degrees F), making it an excellent gasoline refining feedstock. It is extremely rich with associated natural gas, with values falling between 900 and 1700 British thermal units (Btu). Only one natural gas field has been developed, and it is located east and south of the Green and White Rivers. It is bordered by the Natural Buttes Gas Field Unit, which covers 76,000 acres.

Total Ute Indian oil production approximates 1,250 barrels per day, a level that has held for the last 10 years. New well development and workover activity has been sufficient to offset the normal decline of the many oil and gas fields within the basin and the reservation area (Anderson, 1995).

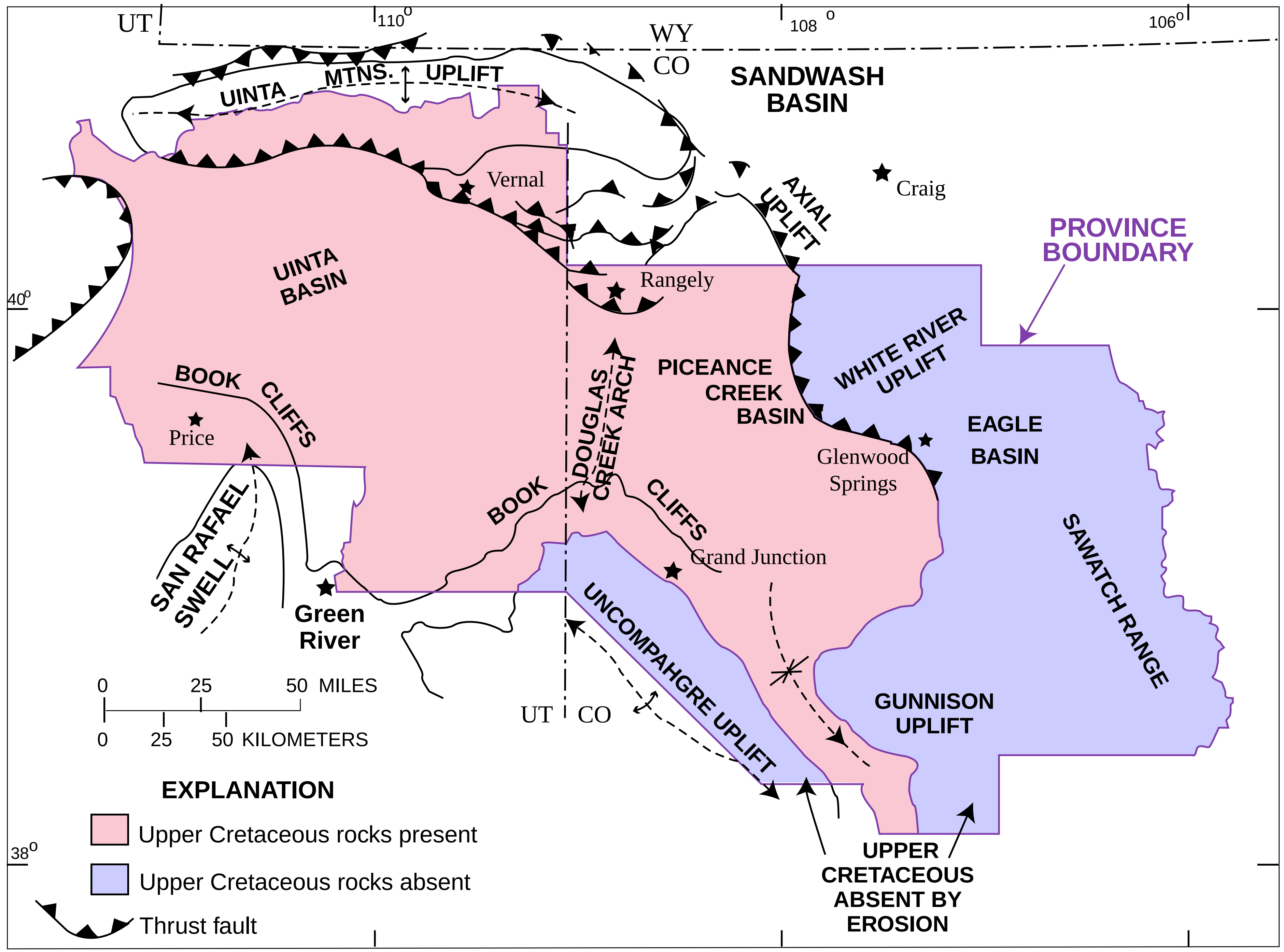
Geology of the Uinta Basin

The Uinta Basin is a major sedimentary basin in the western-central Rocky Mountain province. It is bounded by the Uinta Mountain Uplift on the north and by the Wasatch Mountain Uplift and the eastern faulted margin of the Wasatch Plateau on the west. On the southwest and south, the San Rafael Swell and the Uncompahgre Uplift border the basin (FIGURES UO-2 and UO-3). The southern basin edge is generally considered to be the Book and Roan Cliffs, escarpments of Upper Cretaceous and Lower Tertiary formations which dip northwest, north, and northeast into the basin. The northwest-southeast trending salt folds of the northern Paradox Basin plunge beneath the Book Cliffs in the southernmost part of the basin, and the two downwarps merge imperceptibly in this area. On the east, the Uinta Basin is separated from the Piceance Basin of northwest Colorado by the Douglas Creek Arch, which parallels the Utah-Colorado border (FIGURE UO-3).

The basin is quite asymmetric. Beds on the north flank dip 10 to 35 degrees south, whereas beds on the south flank dip only 4 to 6 degrees north (Chidsey, 1993). The north flank is highly complex, with major faulting, steep to overturned beds, and multiple unconformities that allow youngest Eocene rocks to lie unconformably on top of Precambrian rocks. The basin axis is close to the mountain flank and moves northward with depth.

The Uinta Basin formed in Late Cretaceous and Paleocene time when, in response to rapid uplift and formation of the Uinta Mountains, the dominant north-south tectonic and sedimentation patterns of Cretaceous time shifted to west-east. The Uintas impose a dominant west-east trend through most of the basin; however, structures in the southeast portion have a strong northwest grain, reflecting the older buried Uncompahgre and Paradox trends.

Figure UO-3. Location and structural element map of the Uinta and Piceance Basin Provinces (modified after Gautier et al., 1995).



The Uinta Basin is filled with 30,000 to 32,000 feet of sediment in its northern and deepest portion (Figs. UO-4 and UO-5). Although the majority of the rocks exposed on the reservation are of Tertiary age, some pre-Tertiary age rocks are exposed on the northern and northwestern boundaries. Percentages of basin strata are subdivided as follows:

Tertiary (Eocene - Paleocene) -	55%
Upper Cretaceous -	25%
Triassic - Lower Cretaceous -	10%
Paleozoic -	10%

GEOLOGIC TIME		GROUP AND FORMATION	CHARACTER OF BEDS	THICKNESS (ft.) EAST	THICKNESS (ft.) WEST
Quaternary		Alluvium	Alluvium, gravel surfaces, talus deposits, and other windblown deposits		
		Pleistocene Glacial Deposits	Glacial drift, alluvium, and terrace deposits	0-70	0-70
Tertiary	Miocene	Bishop Conglomerate	Conglomerate, boulders 1 to 6 feet in diameter, sand and gravel	0-500	0-500
	Oligocene	Duchesne River Formation	Varicolored shale, sandstone, and conglomerate	1370	1500
	Eocene	Uinta Formation	Shale with sandstone interbeds	700-1650	1800-5400
		Green River Formation	Green to white shale, sandstone, oil shale in middle of formation	1800-2400	0-5000
		Wasatch Formation	Varicolored sandstone, shale, limestone	0-5000	—
Paleocene deposits absent due to unconformity					
Cretaceous		Current Creek Formation	Conglomerate, sandstone, and varicolored shale	—	0-4800
		North Horn Formation	Varicolored shale with sandstone interbeds	0-400	0-200
Upper Cretaceous		Mesaverde Group	Upper section - Brackish-water sandstone, sandy shale, carbonaceous shale, and coal	0-3000	1000-2200
			Lower section - Marine sandstone	0-500	300-1000
		Mancos Shale (including Frontier Sandstone Member)	Black marine shale, thick massive sandstone, shaly sandstone	5000-6000	800-3500
		Dakota Sandstone	Cross-bedded tan sandstone	30-50	30-50
Jurassic		Morrison Formation	Varicolored shale with sandstone interbeds	780-800	780-800
Triassic		Chinle Formation	Shale with minor sandstone and conglomerate	230	300-380
		Moenkopi Formation	Shale, sandstone, siltstone, and limestone	2300	800
Permian		Park City Formation	Argillaceous, sandy limestone	80-500	80-500
Pennsylvanian		Weber Sandstone	Massive sandstone	1000-1500	1000-1500
		Morgan Formation	Varicolored shale and limestone with sandstone	300-800	300-800
Mississippian	Upper	Manning Canyon Shale Humbug Formation Great Blue Formation Molas Formation Doughnut Formation	Interbedded shale, limestone, and sandstone	0-900	0-900
	Lower	Redwall Formation Leadville Formation Deseret Formation Madison Formation	Massive dolomite and limestone	0-1100	0-1100
Devonian		—	Sandstone, shale, carbonate	1000	2000
No identifiable Silurian or Ordovician deposits					
Cambrian		Tintic Quartzite or Lodore Formation	Sandstone, shale, and carbonate	0-2000	0-2000
Precambrian		Uinta Mountain Group	Quartzite with shale and conglomerate	12,000-20,000	
		Uncompahgre Suite	Schist, gneiss, and granite		

Figure UO-4. General stratigraphic column of the Uinta Basin (modified after Anonymous, 1995).

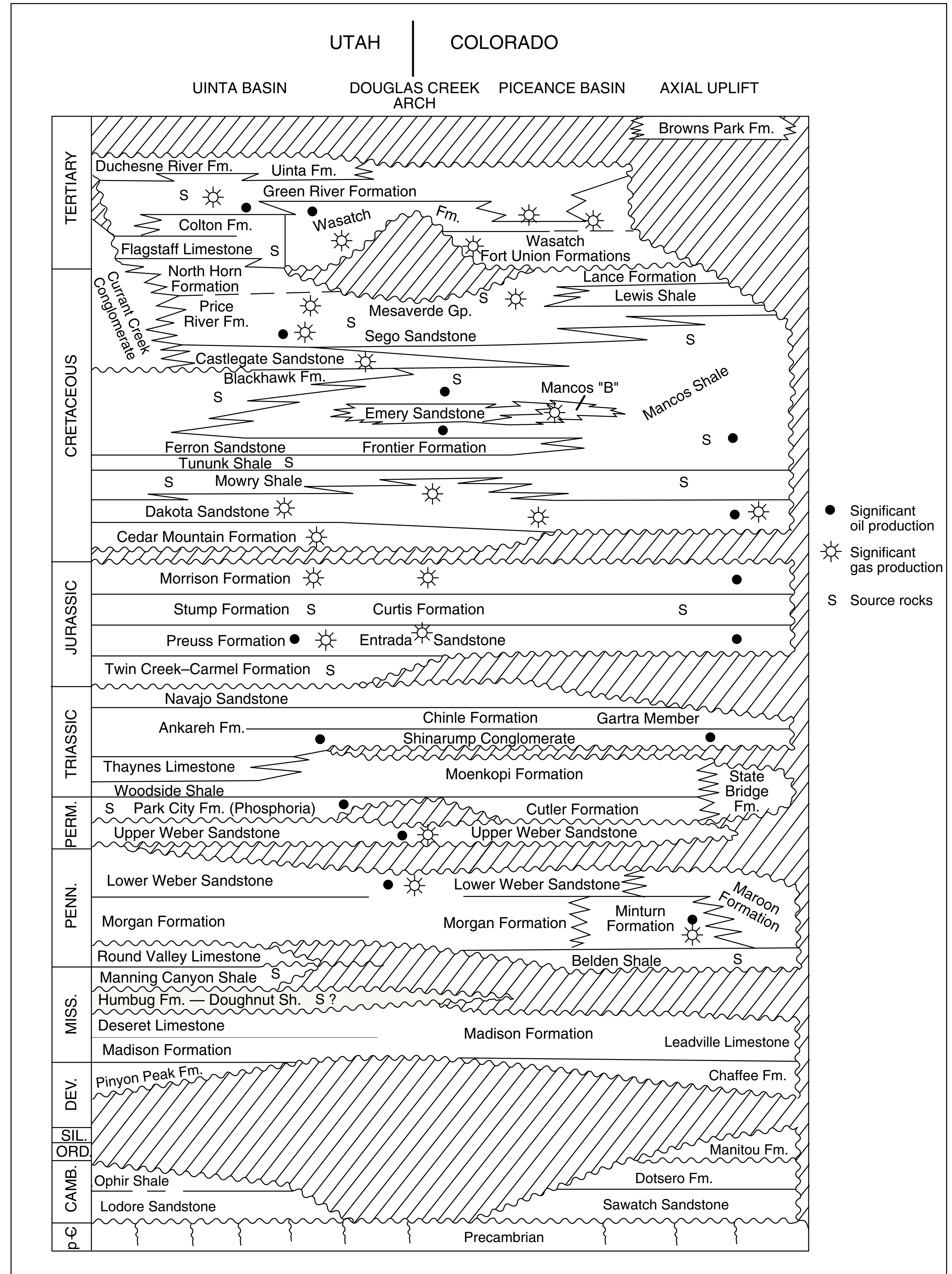


Figure UO-5. Diagram showing general correlation of rock units from the Uinta Basin, Utah, to the Axial Uplift, Colorado, and significant producing and source horizons (modified after Spencer and Wilson, 1988)

During Eocene time (38-50 million years ago) large amounts of sediment from adjacent higher areas were deposited in lacustrine and fluvial environments in the basin. These sediments, assigned to the Wasatch, Green River, and Uinta Formations, are perhaps more than 15,000 feet thick in the center of the basin, and contain important mineral resources (FIGURE UO-6).

Much of the area now occupied by the Uinta Basin was covered by a large lake during Eocene time. Lacustrine marlstone, oil shale, limestone, siltstone, and sandstone of the Green River Formation were deposited in the lake. During the lake's expansionary periods, fluvial sediments were deposited which are now beneath and peripheral to the lacustrine sediments. These fluvial deposits form the shale, sandstone, and conglomerate of the Wasatch Formation. As the lake receded, fluvial sediments were deposited on its periphery, and eventually covered the entire area formerly occupied by the lake. These deposits comprise the Uinta Formation (Anderson,1995).

Uinta Formation

The Late Eocene Uinta Formation consists of fluvial deposits that overlie the Green River Formation from the last phase of Lake Uinta. Later, the lake filled up with volcaniclastic material, followed by abundant bedded evaporites. Depths to the top of the formation range from 2,566 feet to 3,678 feet, with the average being 3,554 feet.

Most of the production is from the Lower Uinta, which is a transitional unit between the Green River Formation and the fluvial Upper Uinta. The Lower Uinta is 350 to 450 feet thick in the Horseshoe Bend field, a reservoir that has produced over 15 BCF of non-associated gas and 5,000 barrels of condensate. This is the only reservoir that has produced at least 5 BCFG from the Uinta Formation, although minor production exists elsewhere in the basin (FIGURES UO-6 and UO-7).

The primary drive mechanism is gas expansion and gravity, and the trap is an updip stratigraphic pinch-out. The average monthly gas production has been increasing since 1981 due to development drilling and new wells that were drilled in the early to mid-1980s.

The Uinta Formation is rarely a primary drilling target, but it is a shallow, low cost target with potential for new discoveries (Morgan, 1993a).

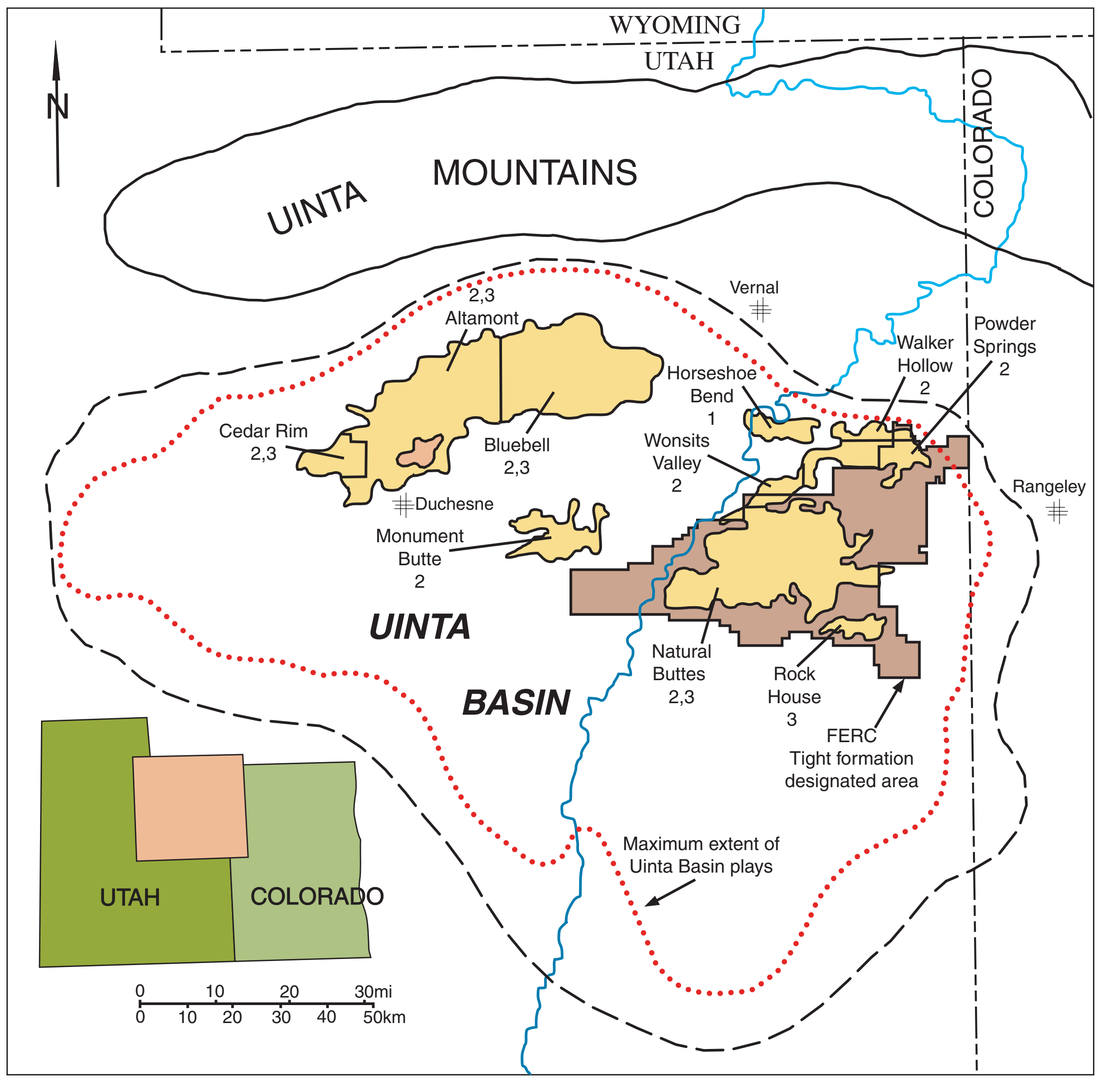


Figure UO-6. The Uinta Basin with the maximum extent of play areas based on production and hydrocarbon shows. Reservoirs are labeled: 1, Uinta Formation; 2, Green River Formation; and 3, Wasatch Formation. Note outline for Federal Energy Regulatory Commission (FERC) tight formation designated area (Wasatch/Mesaverde) in the east part of the basin. Hachured line indicates approximate limits of Tertiary units in the Uinta Basin (modified after Chidsey, 1993a).

Green River Formation

The Eocene-Paleocene Green River Formation is 2,000 to over 8,000 feet thick. It accumulated in and around ancestral Lake Flagstaff and Lake Uinta, along with the alluvial-fluvial deposits of the Wasatch Formation. The Green River Formation was deposited as thick, regionally extensive stratigraphic sequences in marginal and open lacustrine environments. Depths to the top of the formation range from 2,315 to 7,456 feet, and most wells produce from zones 3-4,000 feet below the top.

The majority of the producing zones are channel sandstones about 10 to 30 feet thick, but some reservoirs produce from carbonate grainstones 10 to 20 feet in thickness (FIGURE UO-8). The porosity and permeability of these zones can be either reduced or enhanced by diagenetic effects. The average porosity of Green River reservoirs ranges from 5 to 20 percent, and the permeability ranges from 0.1 to 42 millidarcies (mD).

The source rocks for oil and associated gas found in the Green River Formation are interbedded organic-rich carbonate mudstones located at depths of 8,500 to 12,500 feet in the north-central part of the basin. Hydrocarbons, which were generated in deep overpressured zones, migrated laterally along fracture systems to shallow reservoirs located on the south and east flanks of the basin.

There are more than 60 known reservoirs producing from the Green River Formation, 9 of which have each produced more than 5 BCFG (FIGURE UO-6). The Roosevelt reservoir was the first to produce gas from this formation in 1949. Monthly production peaked in the mid-1970s, and decreased to a low in 1982. It has been increasing since then due to in-fill drilling programs in several reservoirs (Chidsey, 1993b).

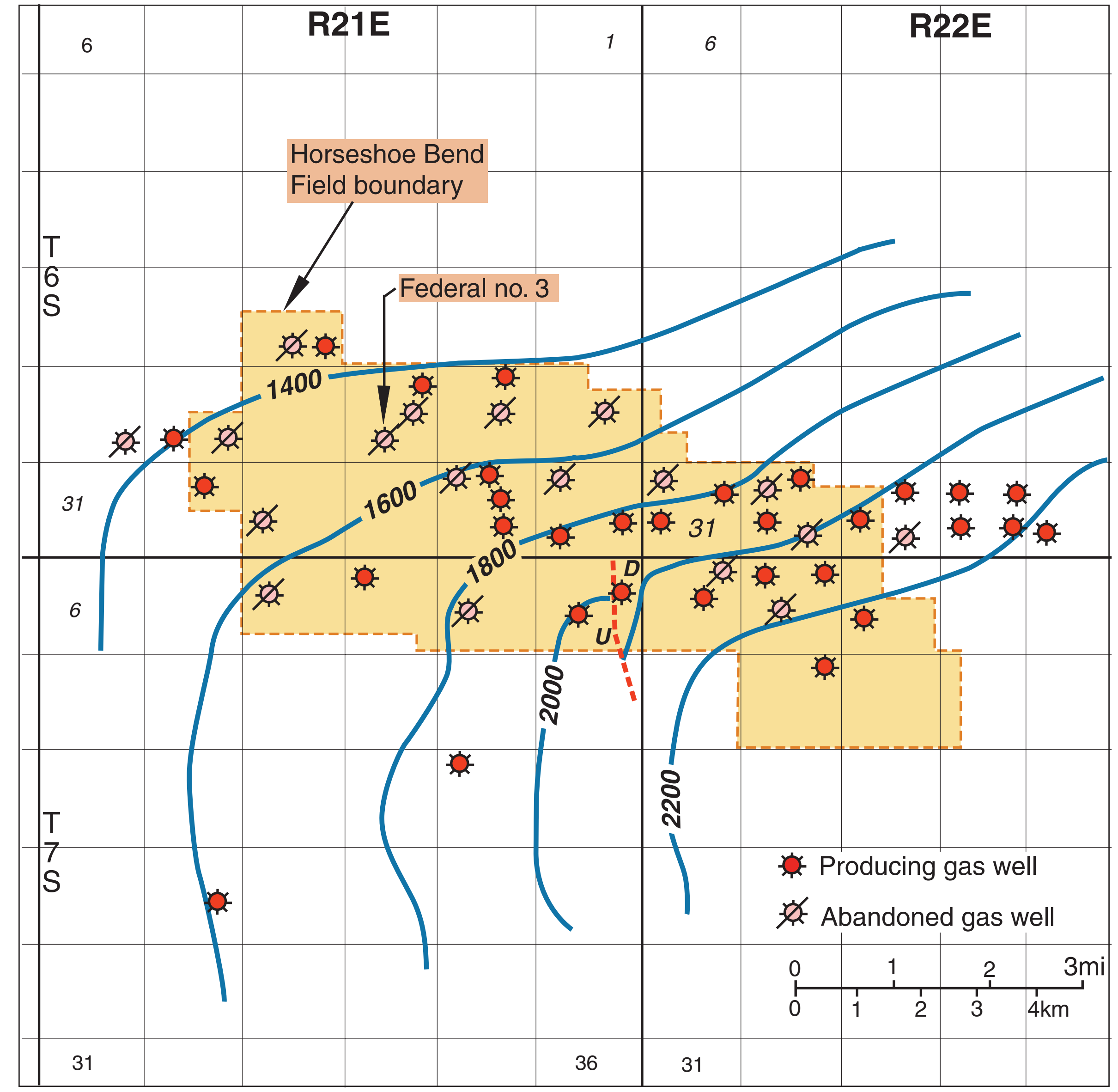


Figure UO-7. Structure contour map of the Horseshoe Bend area. Datum is the top of Unit A, Uinta Formation with a contour interval of 200 ft. Only wells that have produced from the Uinta Formation are shown (modified after Morgan, 1993a).

Wasatch Formation

The Eocene-Paleocene Wasatch Formation is up to 3,000 feet thick. It accumulated in and around ancestral Lake Flagstaff and Lake Uinta in an intertonguing relationship with the Green River Formation. It was deposited as thick, regionally extensive stratigraphic sequences primarily in an alluvial-fluvial environment peripheral to the ancestral lakes. Depths to the top of the formation range from 3,147 to 10,754 feet (FIGURE UO-9).

Most of the production comes from lenticular fluvial-alluvial channel and alluvial overbank sandstone deposits. The productive sandstones are usually isolated and encased in siltstones, mudstones, and shales (Figure UO-10). Porosity and permeability are generally reduced by diagenesis, so production is enhanced near or along major fault and fracture zones. The average porosity ranges from 5 to 20 percent, and the permeability is 0.1 mD or lower.

The source rocks for oil and associated gas found in the Wasatch Formation are organic-rich carbonate mudstones of the Green River Formation, and are located at a depth of 8,500 to 12,500 feet in the north-central part of the basin. Source rocks for the non-associated gas are organic-rich siltstones and mudstones, carbonate shales, and coals of the Mesaverde Group, located at depths of 6,000 feet or greater.

There are more than 60 known reservoirs, 5 of which have produced at least 5 BCFG (Figure UO-6). The first reservoir to produce from the Wasatch Formation was Peters Point in 1953. The total monthly gas production increased between 1973 and 1982, and has been fairly constant since then (Chidsey, 1993c).

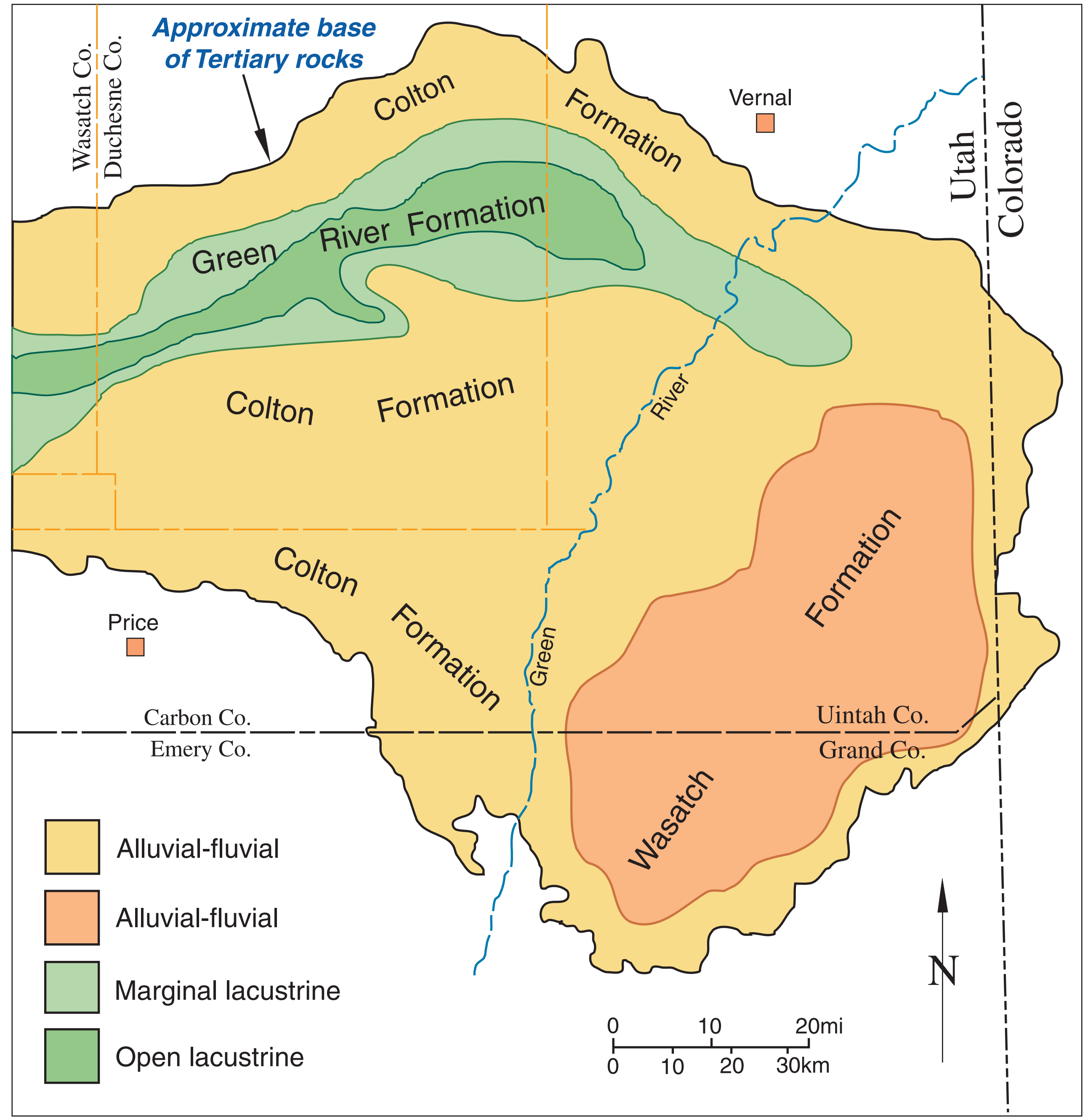


Figure UO-9. Major depositional facies and distribution of formations at the Paleocene-Eocene boundary. Note widespread Wasatch-Colton deposition in the Uinta Basin (modified after Chidsey, 1993).

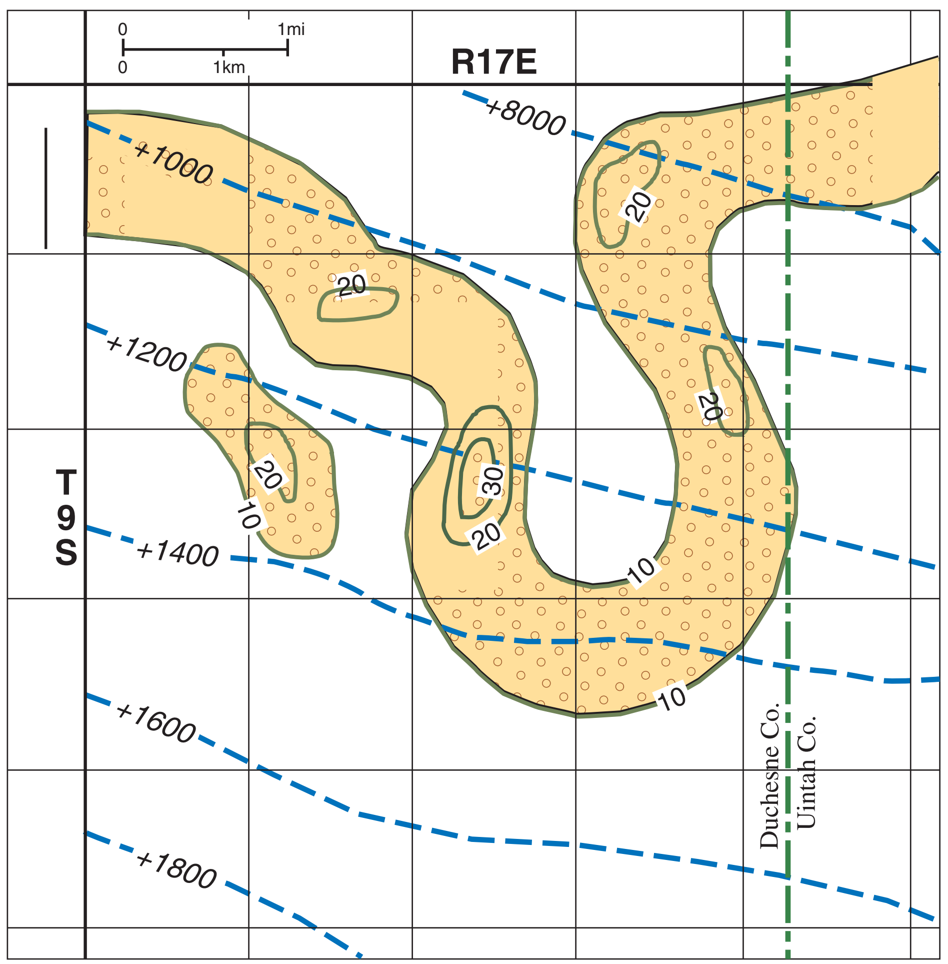


Figure UO-8. Structure contour map with isopach of single sandstone bed, Monument Butte reservoir, Duchesne and Uinta Counties, Utah. Structure contours (dashed lines with contour interval of 200 ft.) are based on a datum approximately 150 ft. below the middle marker of the Green River Formation and show no structural closure. Net sandstone isopachs (solid lines with contour interval of 10 ft.) are based on one of many individual productive sandstone units encased by shale or mudstone. Isopach geometry indicates deposition of sandstone by meandering streams. The trap is created by updip pinch-out of channel sandstone to south along regional strike (modified after Chidsey, 1993b).

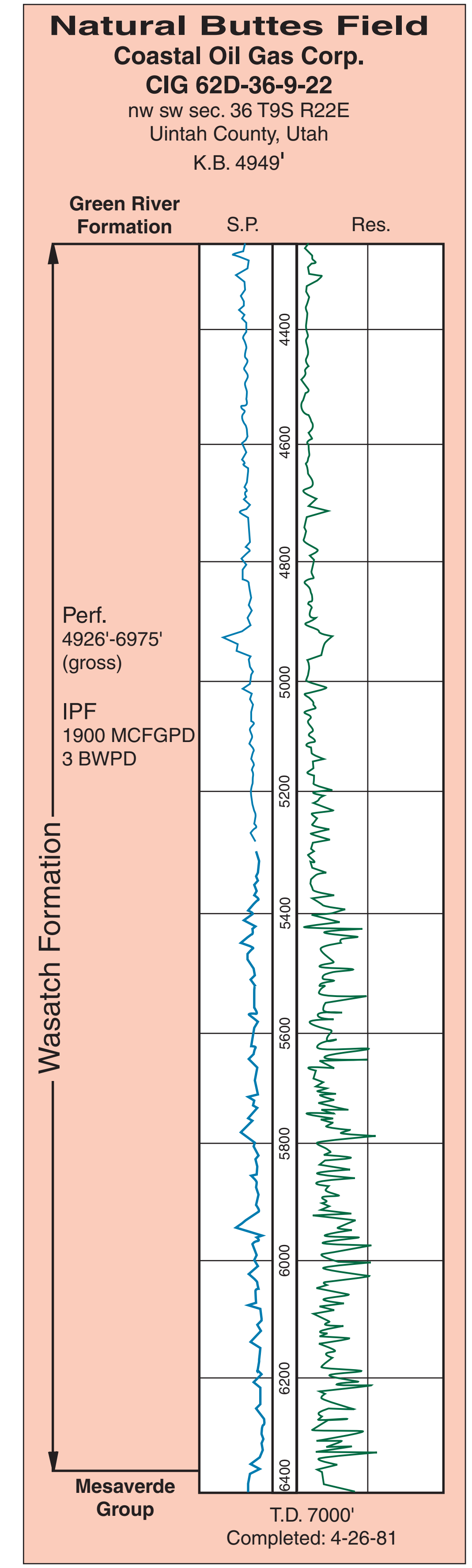


Figure UO-10. Typical SP-resistivity log of the Natural Buttes Wasatch reservoir, Uintah County, Utah (modified after Chidsey, 1993c).

Mesaverde Group

Gas from Mesaverde Group reservoirs is found in both structural and stratigraphic traps. Some reservoirs, like those in Natural Buttes Field, are part of larger, basin-centered gas traps where the gas collects downdip from more permeable water-filled reservoirs. Average depth to the top of productive reservoirs ranges from 1300 to >8500 feet.

The terminology of the Mesaverde Group is complex, due to facies changes that occurred as the Cretaceous Interior Sea transgressed and regressed along its western margin in the Piceance-Uinta Basin area. The Mesaverde consists of three dominant reservoir facies: lenticular, fluvial sandstones of the Williams Fork Formation, coals that occur in the basal portion of the Williams Fork Formation, and extensive shoreline-marine sandstones of the Iles Formation.

The fluvial sandstones of the Williams Fork Formation are approximately 4000 feet thick in the eastern part of the Piceance Basin, thinning to <2000 feet on the Douglas Creek Arch and 2200-2900 feet in Natural Buttes Field in the Uinta Basin. These sandstones are lithic arkoses and feldspathic arenites containing authigenic quartz and carbonate cement. They have low porosities, ranging from 7-12%, and low matrix permeabilities (<0.1 mD) due to the abundance of authigenic clays.

The shoreline-marine sandstones of the lower Mesaverde Iles Formation were deposited during transgressive and regressive cycles along northeast-southwest trending shorelines. These sandstones merge with fluvial facies to the northwest and the Mancos Shale to the southeast. The most productive members are the Cozzette, Corcoran, and Castlegate Sandstones.

The Castlegate Sandstone is a clean, fine-grained, subarkose to sublitharenite, with low porosity and permeability due to pore-filling authigenic clays. It was deposited along ancient shorelines or as offshore bars. In the southeastern part of the Uinta Basin, 50-70 feet thick Castlegate sandstones produce from structural traps at depths of 8000 feet. Permeabilities range from 0.5-0.9 mD. All fields that produce from the Castlegate involve some type of structural closure, and several close against faults. Production rates are enhanced by the associated tectonic fractures.

Source rocks for gas produced from the fluvial sandstones at Natural Buttes Field are coals and carbonaceous shales. The source for the shoreline-marine sandstones is probably the Mancos Shale. Porosities of the Mesaverde Group sandstones remain unusually stable over a large vitrinite reflectance interval (FIGURES UO-11 and UO-12), implying that sparsely explored deep central basins may hold some promise (Tremain, 1993).

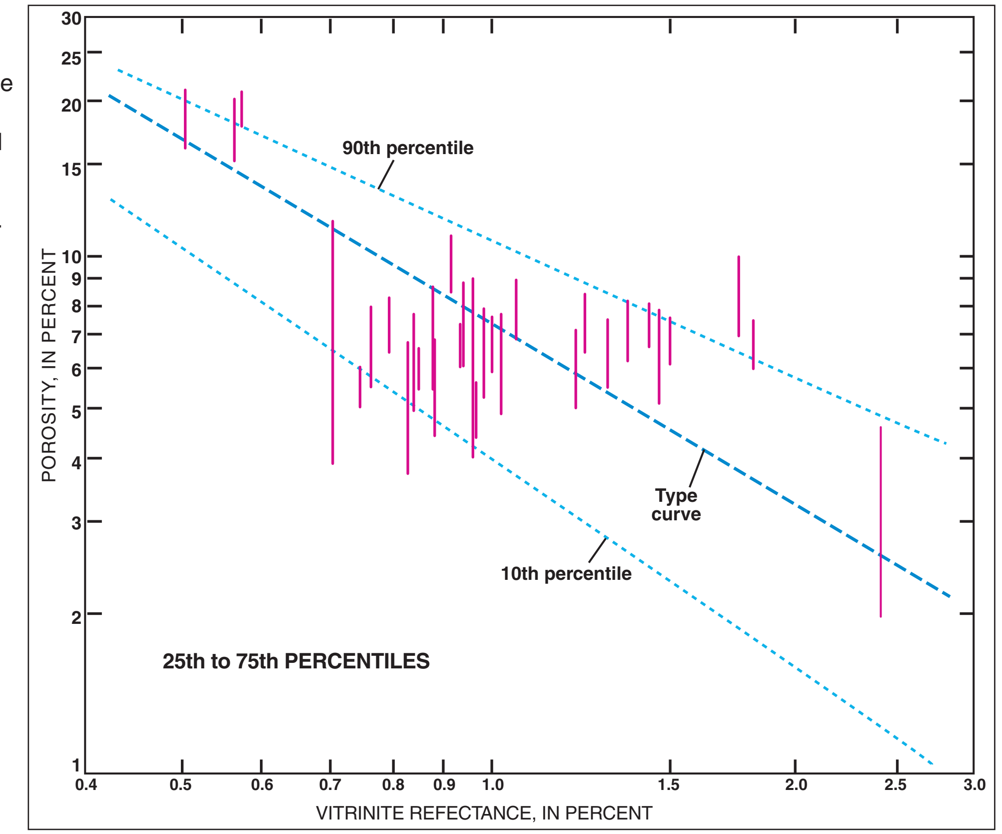
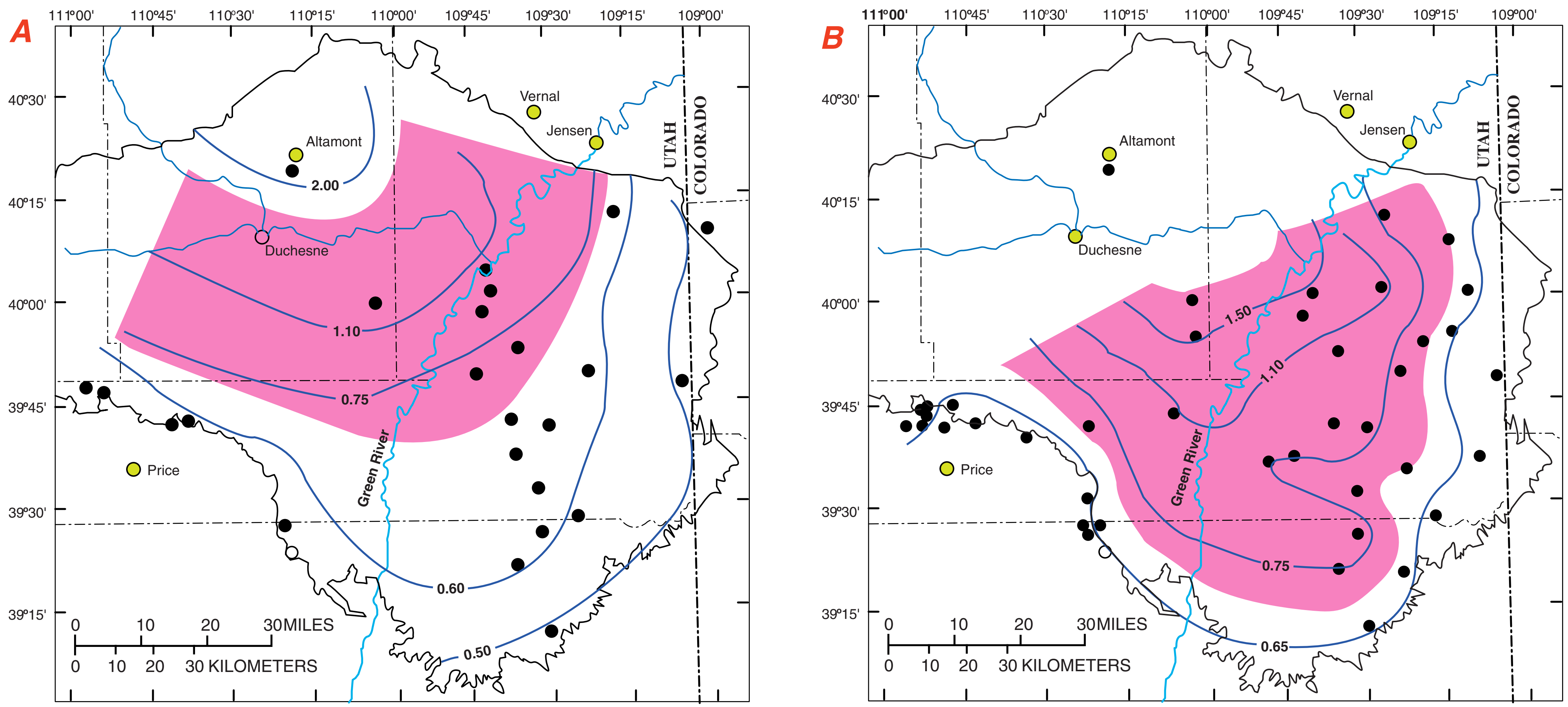


Figure UO-11. Plot of core-plug porosity vs. reflectance for 25th and 75th porosity percentiles (joined by vertical lines) of nonmarine sandstone intervals of the Mesaverde Group, Uinta and Piceance Creek Basins. Mesaverde data are compared with type curve and to 10th and 90th porosity percentiles representing sandstones in general. Note that the porosity does not decrease within the window of hydrocarbon generation (R_O of 0.070-1.8%) (modified after Nuccio et al., 1992).



Figures UO-12A and 12B. Map showing the region (pink area) between R_O 0.70 and 1.8%, where porosity of sandstones at the base of the Mesaverde Group does not decrease as a function of increasing R_O. This region defines the area of optimum gas recovery for **A**, Upper Mesaverde; **B**, Lower Mesaverde (modified after Nuccio et al., 1992).

Mancos Shale

As of December 1990, almost 359.5 BCF of natural gas have been produced from Upper Cretaceous Mancos Shale reservoirs (FIGURE UO-13). Most of the production comes from the silty, tight gas sandstone reservoirs of the Mancos B (also called the Emery Sandstone) in the middle of the Mancos Shale. Gas is also produced from the Mancos A/Morapos Sandstone, a conventional, clean sandstone found in the upper transition zone between the Mancos Shale and the overlying Mesaverde Group (FIGURE UO-14).

The Douglas Creek North Field has produced >5 BCFG from the Upper Mancos/Morapos Sandstone (figure 13). In this area, the Upper Mancos consists of up to 34 feet of mud to coarse-grained, well-sorted sandstone with 20% porosity and 100 mD permeability. It was deposited as shelf sands in a marginal-marine setting, and is probably time-equivalent to the Castlegate Sandstone.

The Mancos B consists of 500 to >1000 feet of finely interbedded and discontinuous claystone, siltstone, and very fine- to fine-grained sandstone, with an average net pay interval of 30-250 feet. It is characterized by low porosities and permeabilities, with porosities ranging from 10-11% on the Douglas Creek Arch, to <2% on the flanks. Permeabilities are <0.1 mD on the average. Mancos B sediments were deposited on a northerly prograding submarine slope or foreslope, approximately 100 miles to the east of the time-equivalent Emery shoreline in Utah (Noe, 1993a).

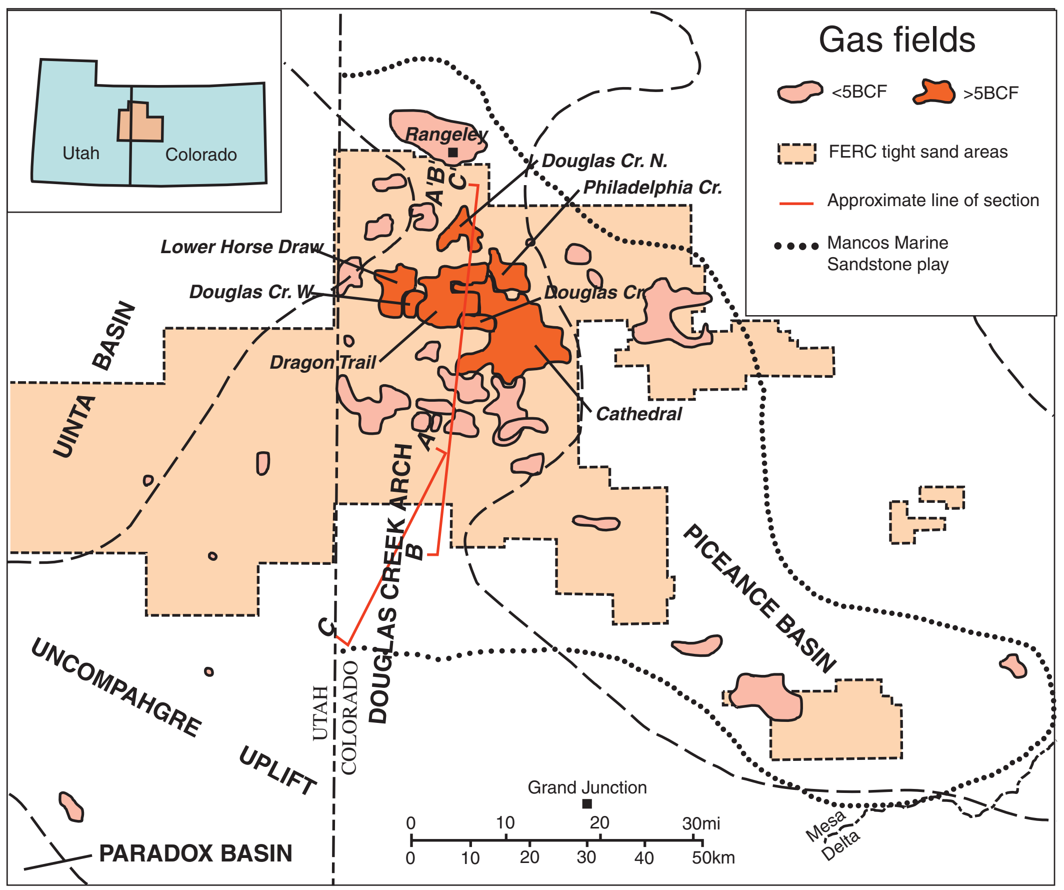


Figure UO-13. Gas fields of the Upper Cretaceous Mancos Shale (modified after Noe, 1993a)

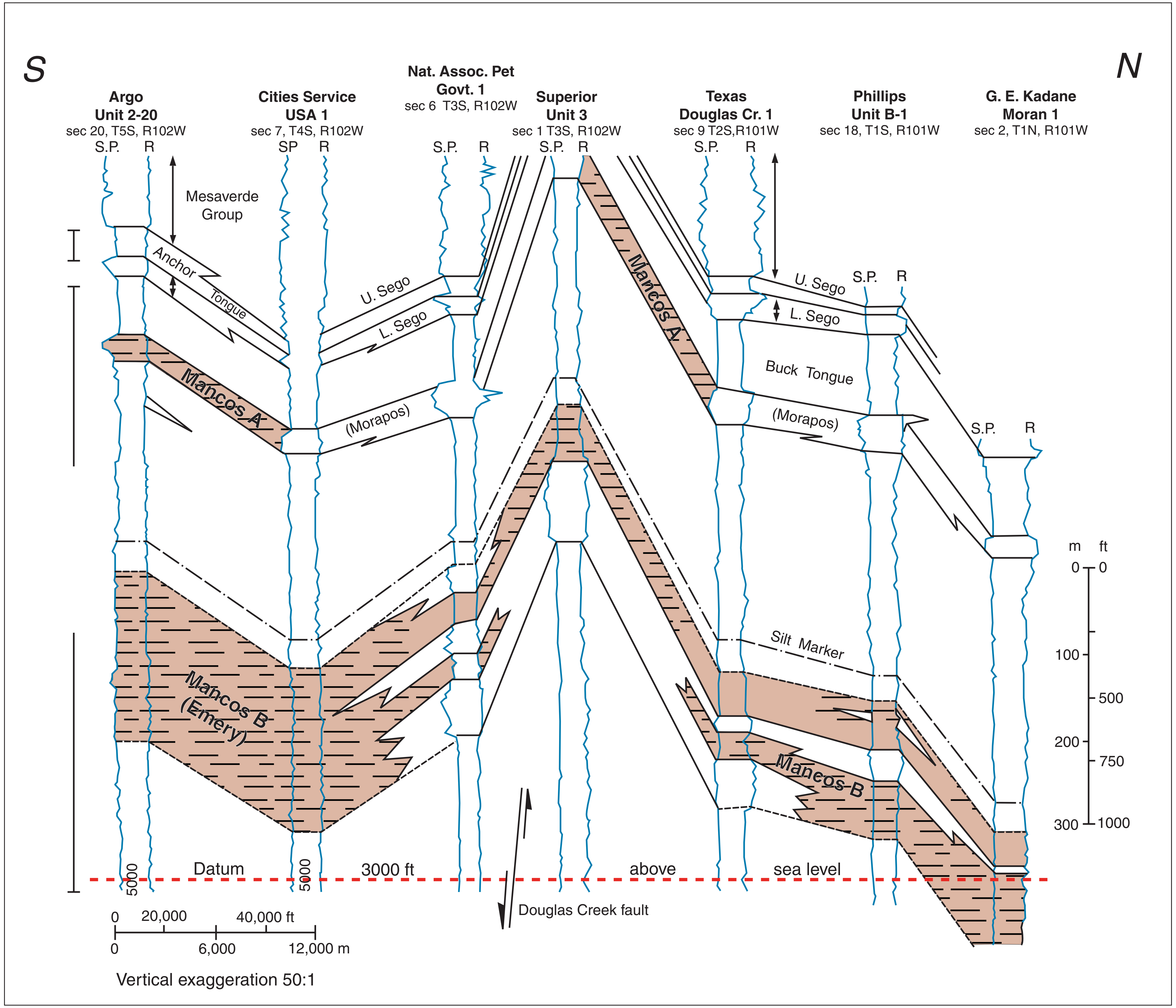


Figure UO-14. South to north structural cross section along the Douglas Creek Arch of the Mancos B interval and other sandstones in the transitional zone between the Mancos Shale and Mesaverde Group (modified after Noe, 1993a).

Dakota Sandstone, Cedar Mountain Formation, Morrison Formation

The Dakota Sandstone, Cedar Mountain Formation, and Morrison Formation are similar in lithologic succession. Each contains a basal, continuous, conglomeratic sandstone or conglomerate, like the Salt Wash Member of the Morrison Formation, the Buckhorn Conglomerate of the Cedar Mountain Formation, and the lower part of the Dakota Sandstone. This is overlain by interbedded shales and lenticular sandstones, like the Brushy Basin Member of the Morrison and the upper units of the Cedar Mountain and Dakota (Figure UO-15). The basal conglomeratic units are braided stream deposits, while the upper units of the Morrison and Cedar Mountain Formations are thought to be floodplain and meandering stream deposits. The Upper Dakota was deposited in a complex coastal setting consisting of coastal plain, fluvial, swamp, marsh, tidal flat, delta, beach, and nearshore marine environments (Fig. UO-16).

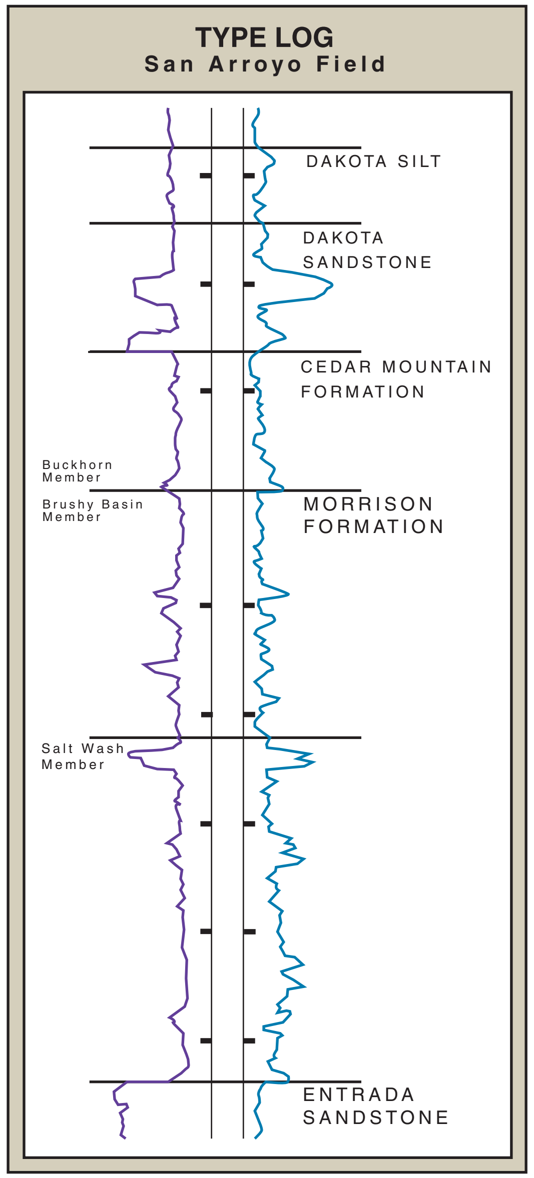


Figure UO-15. Type log from the San Arroyo Field (modified after Hill and Bereskin, 1993).

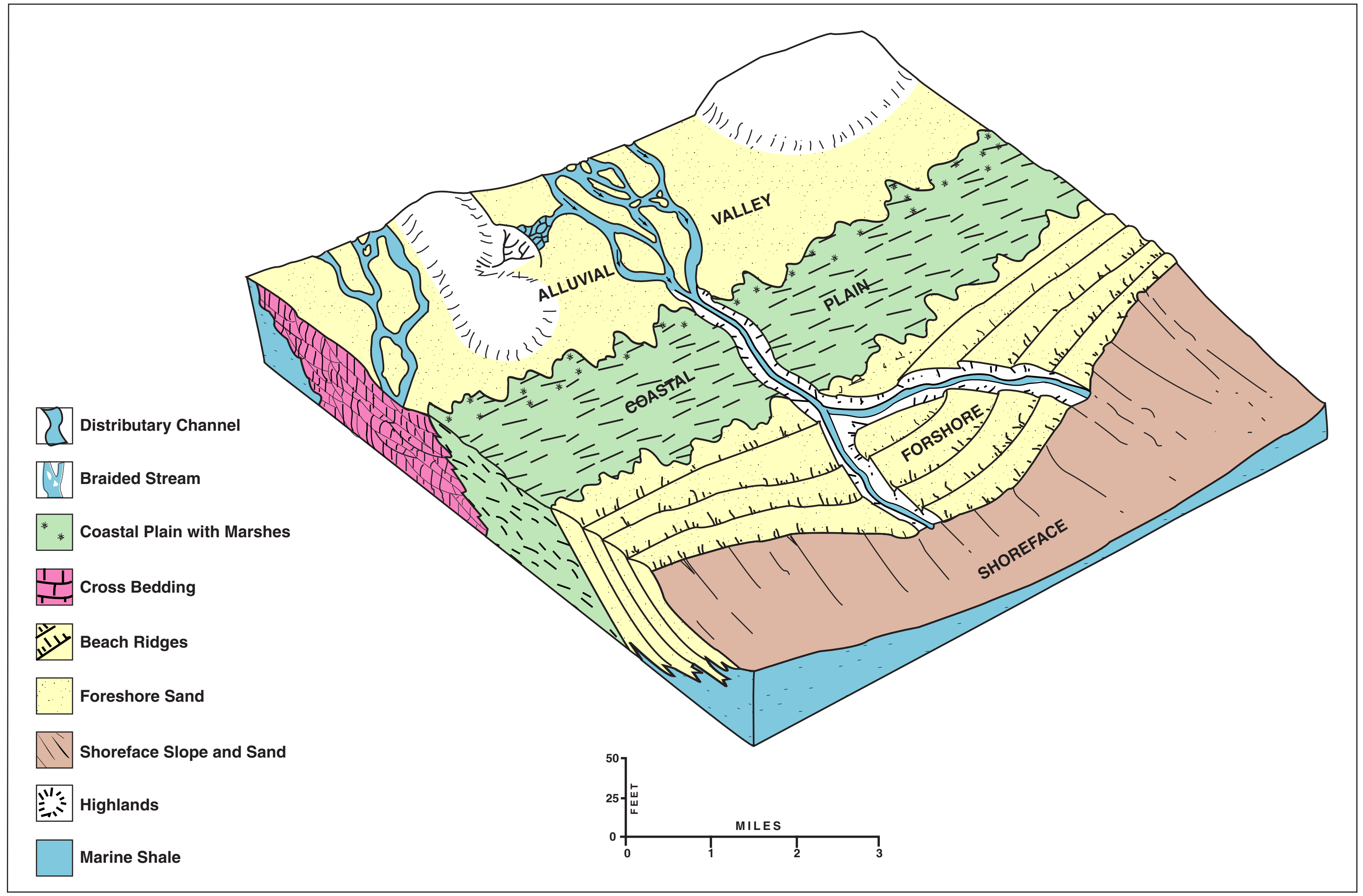


Figure UO-16. Three dimensional model of Dakota Sandstone depositional environments at Hell's Hole Field (modified after Moretti et al., 1992).

The Morrison Formation is approximately 350-450 feet thick, the Cedar Mountain Formation is approximately 0-150 feet thick, and the Dakota Sandstone is approximately 40-250 feet thick (Noe, 1993b).

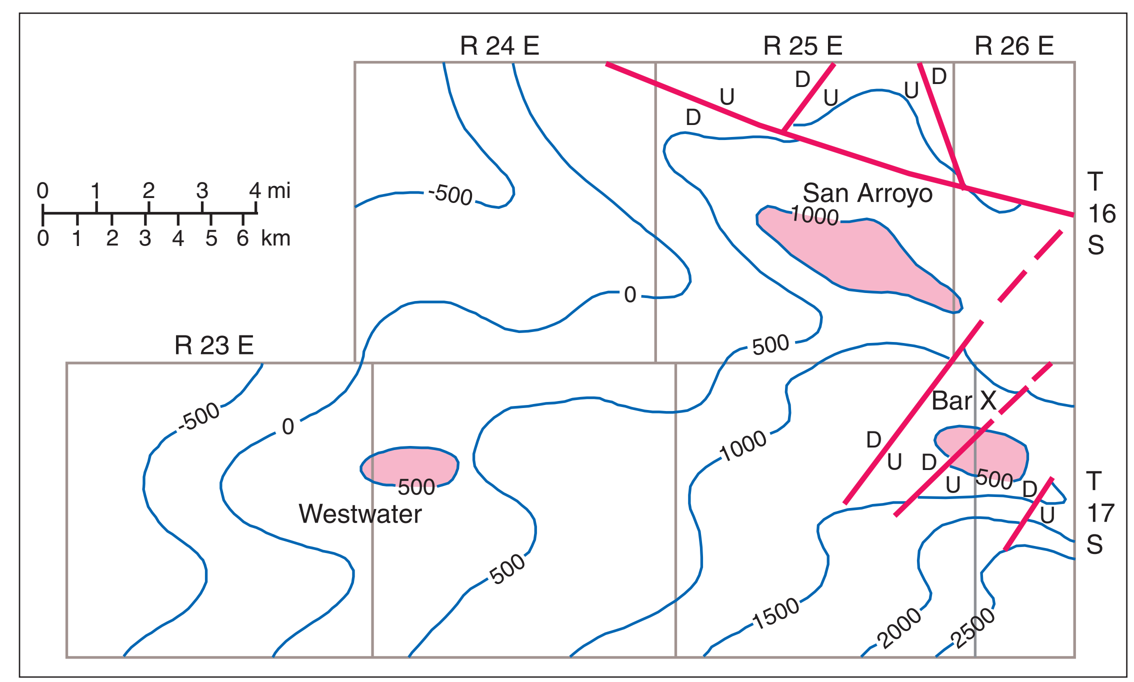
Entrada Sandstone

In northeastern Utah, the Entrada Sandstone consists of dune and interdune eolian deposits associated with the northerly retreat of a Jurassic sea. The sandstones are gray to orange, fine- to medium-grained, well-sorted and cross-bedded.

Gas and some oil are produced from traps formed by anticlinal closures on Laramide structures. Three Entrada reservoirs have produced >44 BCF gas; most of this production comes from San Arroyo Field (FIGURE UO-17). Average depth to the top of the reservoir varies from 5250 feet at San Arroyo to 6700 feet at Wilson Creek Field in Colorado. Average net pay thickness in the Uinta Basin is 118 feet at Westwater Field. Average porosity ranges from 16% at San Arroyo to 24% at Westwater.

Source rocks for San Arroyo and Westwater Fields may have been organic-rich marine deposits of the Permian Phosphoria and Pennsylvanian Paradox Formations (Morgan, 1993b).

Figure UO-17. Structure contour map of the top of the Entrada Sandstone, San Arroyo/Westwater area, Grand County, Utah. The area that is productive from the Entrada Sandstone is colored in pink. The Bar X Field has produced less than 5 BCF of gas from the Entrada Sandstone. Contour interval is 500 feet (modified after Morgan, 1993b).



Weber Sandstone

The Weber Sandstone is a fine-grained, subarkosic to quartz arenite of eolian origin deposited during Desmoinesian, Missourian, and Wolfcampian time. In Rangely Field, productive eolian sands were deposited in dune, interdune, and extradune environments (FIGURE UO-19). These sandstones are either cross-laminated or massively-bedded, the cross-laminated lithofacies being the major producer with an average porosity of 12%. Permeability along laminae averages 2 mD, while permeability across laminae averages 0.4 mD.

Cumulative production from the Weber Sandstone as of 1990 is 724.7 BCF of associated gas and 772 MMBO. The Rangely Weber reservoir contributed 98.9% of the total gas production (FIGURE UO-18). Average depth to the top of the Weber is 6500 feet, and the trapping mechanism in all Weber reservoirs is anticlinal closure (Hemborg, 1993).

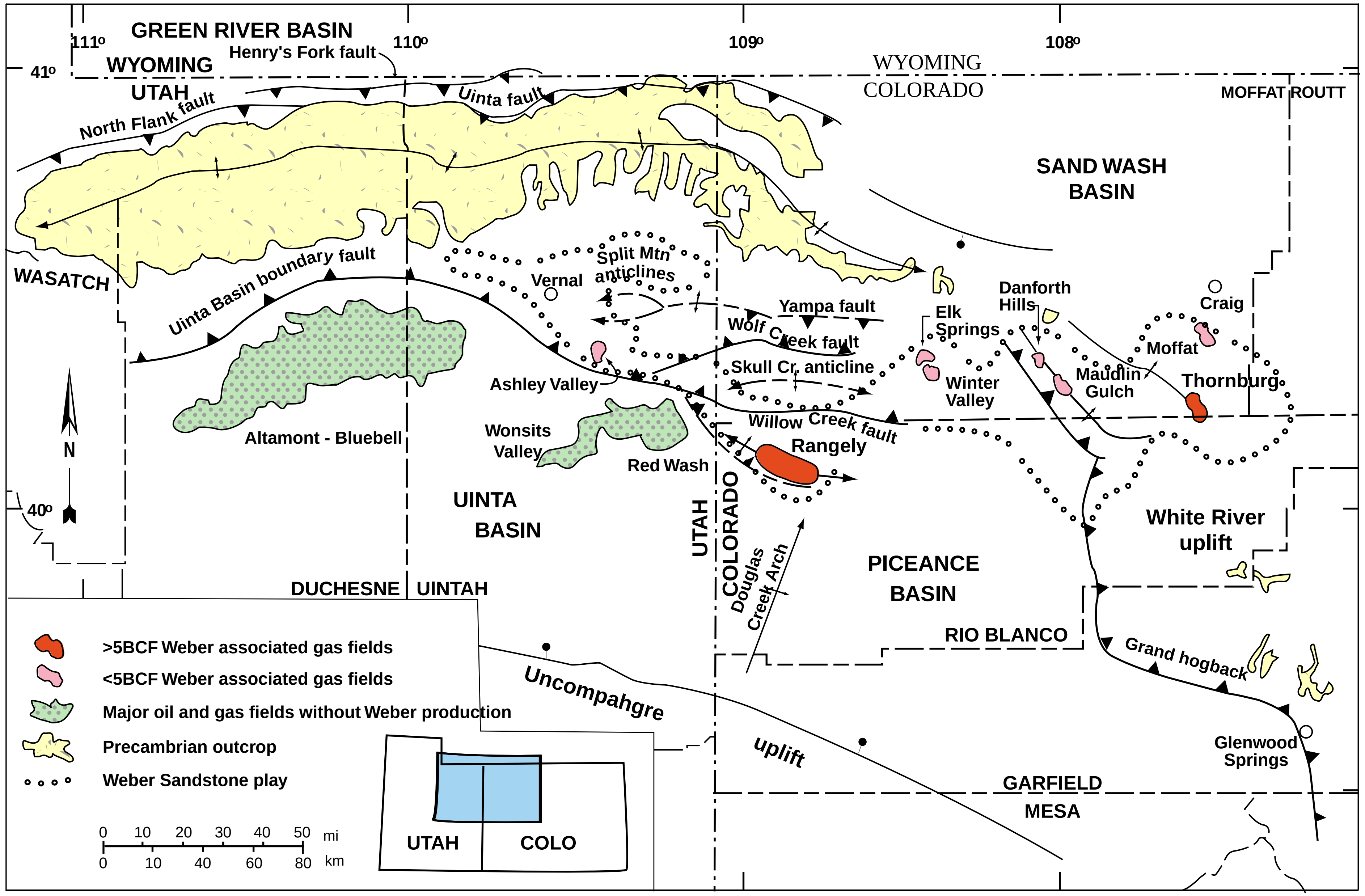


Figure UO-18. Location map of Rangely Field and other major and minor Weber Sandstone reservoirs (modified after Hemborg, 1993).

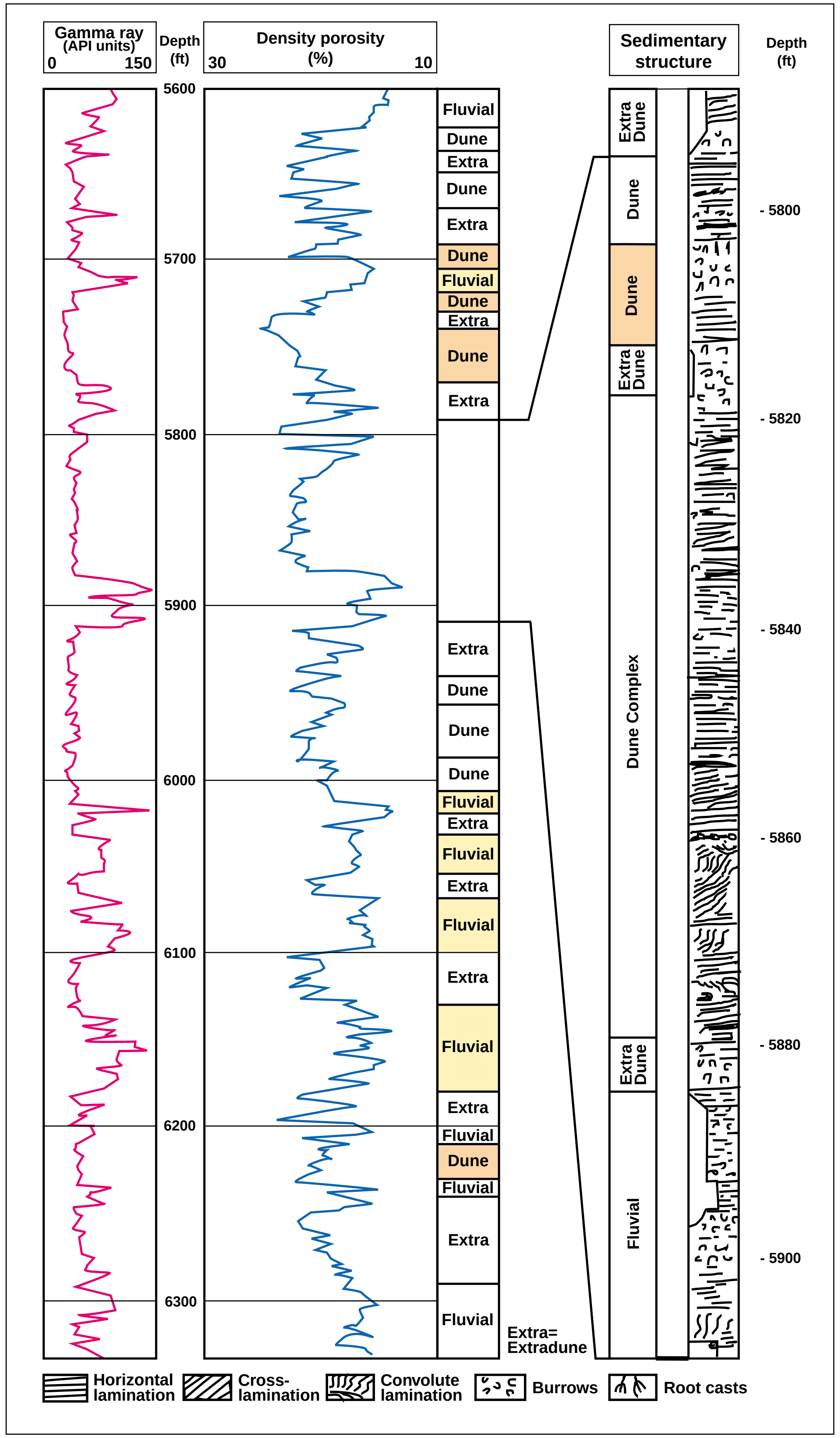


Figure UO-19. Wireline log and core description of the No. 139Y UPRR, Rangely Field. Core shows one cycle of Weber deposition (modified after Hemborg, 1993)

Play Summary

The United States Geological Survey identifies several petroleum plays in the Uinta-Piceance Basin Province and classifies them as Conventional and Unconventional (Gautier et al., 1995). The discussions that follow are limited to those with direct significance for future petroleum development in the Uintah and Ouray Indian Reservation (TABLE 1).

Play Types

Conventional Plays- Discrete deposits, usually bounded by a downdip water contact, from which oil, gas or NGL can be extracted using traditional development practices, including production at the surface from a well as a consequence of natural pressure within the subsurface reservoir, artificial lifting of oil from the reservoir to the surface where applicable, and the maintenance of reservoir pressure by means of water or gas injection.

Unconventional Plays- A broad class of hydrocarbon deposits of a type (such as gas in tight sandstones, gas shales, and coal-bed gas) that historically has not been produced using traditional development practices. Such accumulations include most continuous-type deposits.

Reservation: Uintah and Ouray
Geologic Province: Uinta-Piceance Basin
Province Area: 40,000 sq. miles (25.6 million acres)
Reservation Area: 6250 sq. miles (4 million acres)

Total Production in Province as of 1996 — Uinta-Piceance Basin
Oil: 486,712 MBO
Gas: 1,992,627 MMCFG
NGL: 40,262 MBNGL

Undiscovered resources and numbers of fields are for Province-wide plays. No attempt has been made to estimate number of undiscovered fields within the Uintah and Ouray Indian Reservation.

Play Type	USGS Designation	Description of Play	Oil or Gas	Known Accumulations	Undiscovered Accumulations > 1 MMBOE Field Size and Number	Play Probability (chance of success)	Drilling depths (min., mean, max.)	Pay Thickness	Porosity/Permeability
Uinta Tertiary Oil and Gas Play **1**	2002	Fluvial and lacustrine sandstones in the Wasatch and Green River Formations.	Both	Gas (917,288 MMCFG) Oil (485,592 MBO)	**Field Size (median, mean)** Gas (15 BCFG, 18.9 BCFG) Oil (2 MMBO, 2.8 MMBO) **No. of Undiscovered Fields (min., median, max., mean)** Gas (2, 6, 15, 7.1) Oil (4, 13, 30, 14.7)	1	Gas (500, 3000, 6000)ft Oil (1000, 5000, 14000)ft	Variable	10-15%/v, low to 1000 md
Upper Cretaceous Conventional Play **2**	2003	Shallow sandstones of the Mesaverde Group.	Mostly Gas	Gas (129,540 MMCFG)	**Field Size (median, mean)** Gas (12 BCFG, 15.2 BCFG) **No. of Undiscovered Fields (min., median, max., mean)** Gas (10, 23, 50, 25.9)	1	Gas (500, 3500, 6000)ft	up to 80 feet	8-18%/<0.1md
Cretaceous Dakota to Jurassic Play **3**	2004	Fluvial Dakota Sandstone, discontinuous fluvial Morrison Sandstone, blanket eolian Entrada Sandstone.	90% Gas 10% Oil	Gas (579,169 MMCFG)	**Field Size (median, mean)** Gas (10 BCFG, 13.1 BCFG) Oil (1 MMBOE, 1.5 MMBOE) **No. of Undiscovered Fields (min., median, max., mean)** Gas (3, 15, 25, 14.6) Oil (1, 2, 4, 2.2)	1	Gas (500, 3500, 6000)ft Oil (1000, 4000, 6500)ft	Dakota - 25 feet Buckhorn - 26 feet Morrison - 11 feet	10-25%/ Unknown Permeability
Permian-Pennsylvanian Sandstones and Carbonates Play **4**	2005	Very high risk Permian-Pennsylvanian sandstones and carbonates.	Mostly Oil	Oil EUR (980.5 MMBO) Gas EUR (>706 BCFG)	**Field Size (median, mean)** Oil (9 MMBO, 25.0 MMBO) **No. of Undiscovered Fields (min., median, max., mean)** Oil (1, 4, 15, 5.7)	1	Oil (6000, 10000, 12000)ft	275 feet	11-14%/ Unknown Permeability
Basin Margin Subthrusts Play (hypothetical) **5**	2014	Closures beneath thrusts, reservoirs range from Paleozoic to Tertiary in age.	Both	**N/A**	**Field Size (median, mean)** Oil (2 MMBO, 5.3 MMBO) Gas (15 BCFG, 25.0 BCFG) **No. of Undiscovered Fields (min., median, max., mean)** Oil (1, 2, 7, .05) Gas (1, 3, 10, .07)	0.18	Oil (5000, 12000, 18000)ft Gas (5000, 14000, 25000)ft		Unknown
Cretaceous Self-Sourced Fractured Shales Play (hypothetical, continuous) **6**	2009	Upper Mancos fractured shale. Best fracturing occurs in brittle siltstones, carbonates, and calcareous shales.	Both	Oil EUR(14 MMBO)	Per well EUR estimates vary	1	Oil/Gas (500, 2800, 6000)ft	10->50 feet	10-20%/0.01-100md
Tight Gas Uinta Tertiary East Play (continuous) **7**	2015	Medium- to fine-grained fluvial sandstones interbedded with mudstones, siltstones, shales, and some coal of the Wasatch Fm.	Gas	**N/A**	**N/A**	1	Gas (3000, 6400, 10500)ft	up to 80 feet	<5-9%/<0.1md
Tight Gas Uinta Tertiary West Play (hypothetical, continuous) **8**	2016	Medium- to fine-grained fluvial sandstones interbedded with mudstones, siltstones, shales, and some coal of the Wasatch Fm.	Gas	**N/A**	**N/A**	1	Gas (4500, 7500, 11000)ft	up to 80 feet	4-8%/<0.01md
Basin Flank Uinta Mesaverde Play (hypothetical, continuous) **9**	2018	Based on widespread occurrence of tight, gas-saturated continental and marginal marine sandstone.	Gas	**N/A**	**N/A**	1	Gas (8000, 9500, 15000)ft		4->12%/<0.1md
Deep Synclinal Uinta Mesaverde Play (hypothetical, continuous) **10**	2020	Based on expected occurrence of gas-saturated tight Mesaverde Sandstone at depths >15,000 feet.	Gas	**N/A**	**N/A**	1	Gas (15000, 20000, 25000)ft	N/A	3-8% Unknown permeability

Table 1. Play summary chart.

Conventional play type (plays 1–5)

Unconventional/Hypothetical play type (plays 6–10)

Summary of Play Types

The United States Geological Survey has identified many petroleum plays in the Uinta-Piceance Basin Province, classifying them as Conventional and Unconventional. The discussions that follow are limited to those plays with direct significance for future petroleum development on the Uintah and Ouray Indian Reservation. Most of the following is extracted from USGS CD-ROMs DDS-30 and 35 (Gautier et al., 1995). Table 1 is a summary of applicable USGS plays of the Uinta-Piceance Basin Province pertaining to the Uintah and Ouray Reservation.

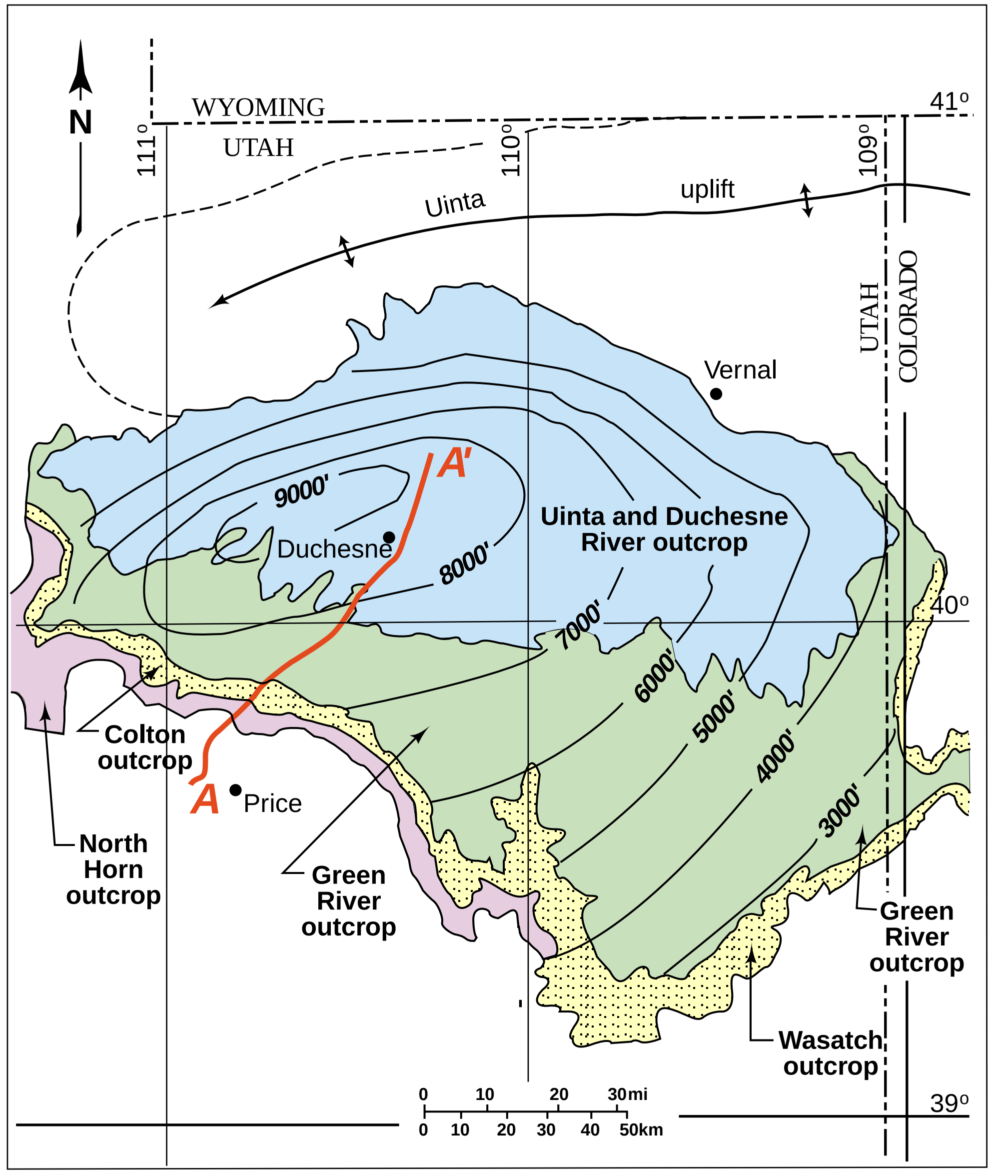


Figure UO-20. Combined thickness of the Green River, Wasatch/Colton, and North Horn Formations with outcrop areas indicated. Contour interval is 1000 feet. Cross section A-A' is shown in Figure UO-21 (modified after Chidsey, 1993a).

Conventional Plays

Definition - Discrete deposits, usually bounded by a downdip water contact, from which oil, gas, or NGL can be extracted using traditional development practices, including production at the surface from a well as a consequence of natural pressure within the subsurface reservoir, artificial lifting of oil from the reservoir to the surface where applicable, and the maintenance of reservoir pressure by means of water or gas injection.

PLAY 1 - UINTA TERTIARY OIL AND GAS PLAY

The Uinta Tertiary Oil and Gas Play is based on oil and gas accumulations primarily in stratigraphic traps in fluvial and lacustrine sandstones in the Wasatch and Green River Formations. The play area is limited updip by the presence of brackish and fresh water in rocks near the outcrop.

Reservoirs: Reservoir sandstones of the Wasatch and Green River Formations are Paleocene and Eocene in age and are predominantly litharenites and feldspathic litharenites over most of the basin. Some lacustrine limestones produce in the deeper part of the basin. Porosities range from <10 percent in the deep Altamont-Bluebell field area to >15 percent at shallower depths (<4,000 feet).

Source rocks: The source rocks for much of the non-associated Wasatch gas in the basin are the underlying Cretaceous Mesaverde gas-prone coals, shales, and mudstones, but some may have a Tertiary origin. In the northern part of the basin, oil is the predominant hydrocarbon. This oil comes from lipid-rich lacustrine shales and marlstones in the Green River Formation. A complex mixing of oil and gas from different sources has resulted in more gas fields at shallower depths and predominantly oil in deeper reservoirs. This is the opposite of what occurs in many other basins.

Timing and migration: The Mesaverde Group began generating gas in the Early Tertiary, and the Green River Formation began generating oil and gas in the Middle Tertiary to the present. The deep (>10,000 feet) Tertiary oil fields are highly overpressured as a result of present-day hydrocarbon generation.

Traps: The traps are mostly stratigraphic, but some structural-stratigraphic traps occur, such as the Red Wash Field area (EUR 175 MMBO, 373 BCFG). The largest producing area is the greater Altamont-Bluebell area, which has an estimated ultimate recovery of 260 MMBO and 378 BCFG; however, the field is being actively downspaced from 640 acres per well to 320 acres per well. This additional drilling should significantly increase recovery.

Exploration status and resource potential: The conventional gas part of this play is fairly well explored, but a maximum of 15 conventional fields greater than 6 BCFG may be found, according to U.S.G.S. estimates (Table 1). Because of the very large volume of oil generated deep in the basin, a maximum of 30 oil fields greater than 1 MMBO may remain to be found.

Analog Example: Greater Altamont - Bluebell

Figures: UO-20 and UO-21

Location:	T 1 N - 4 S, R 2 E - 7 W, on Reservation
Producing formations:	Wasatch and Green River Formations
Other significant shows:	Mesaverde Sandstone, gas; Uintah Formation, gas and oil
Lithology:	Fluvial sandstone, lacustrine sandstones, limestones, dolomites
Type of drive:	Solution gas
Net pay thickness:	Multiple zones with variable thickness
Porosity:	2-20%, average >10%
Permeability:	Variable in individual pay sections, ranges from very low up to 1,000 mD in unconsolidated sands
Estimated primary recovery:	316 MMBO, 360.5 BCFG, 330.2 MMBW
Other major analog fields:	Greater Natural Buttes Monument Buttes Red Wash Walker Hollow Wonsits Valley

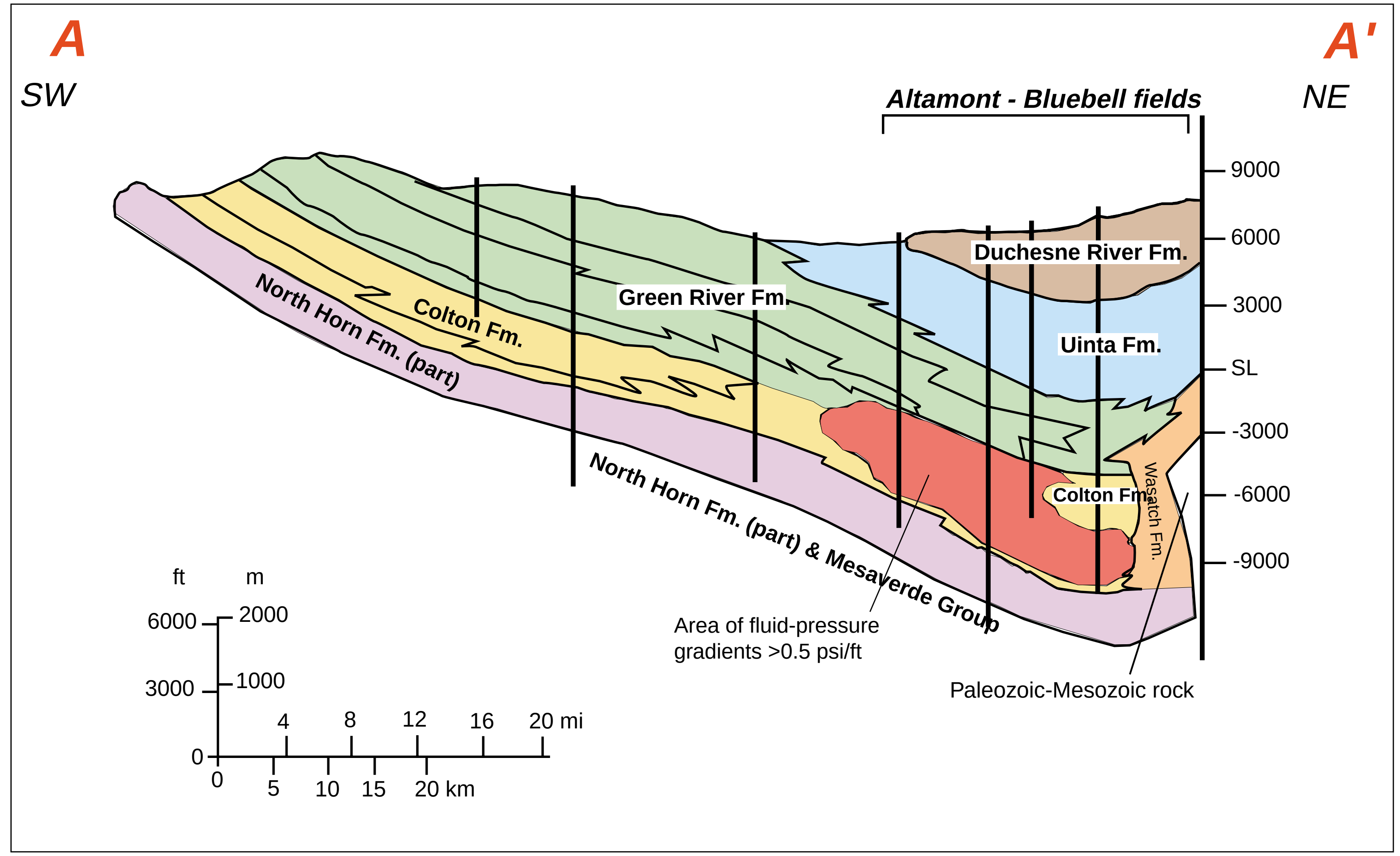


Figure UO-21. Generalized southwest to northeast cross section of Tertiary rocks in the Uinta Basin showing major facies, intertonguing relationships, and stratigraphic names. Area of fluid-pressure gradients >0.5 psi/ft indicated in red. Line of section is shown in Figure UO-11 (modified after Chidsey, 1993a).

UPPER CRETACEOUS CONVENTIONAL PLAY

This is primarily a gas play in sandstones of the Mesaverde Group at shallow depths in both the Piceance and Uinta Basins; however, discovered fields are mostly in the Piceance Basin. Fields are localized by structure, but stratigraphic traps have also been found. The play is limited downdip where the reservoirs become unconventional (tight) and is limited updip by fresh-water flushing. The Mesaverde part of this play has some areal overlap with tight Mesaverde reservoirs. The tight rocks are generally beneath and/or downdip of conventional Mesaverde reservoirs.

Reservoirs: The reservoir rocks are Cretaceous Mesaverde Group sandstones deposited in marginal-marine, fluvio-deltaic, and fluvial environments. Some very fine-grained sandstone and siltstone reservoirs were deposited in a shallow-marine shelf environment seaward of, and in part beneath, the Mesaverde Group. These reservoirs include the Mancos Shale "B" and equivalents, but much of the Mancos "B" fields are tight and developed by drilling, although there is some potential for field growth.

Source Rocks: The Mesaverde Group source beds are organic shales (including some coals) interbedded with sandstones.

Timing and Migration: Time of generation is Late Tertiary to present.

Traps: Traps are predominantly structural-stratigraphic and stratigraphic. Accumulations are found at depths of <1,000 feet to 6,000 feet, with a median depth of 3,500 feet.

Exploration Status: The conventional part of the play is well explored in the Piceance Basin and only moderately explored in the Uinta Basin. Because of the large volume of gas generated by Mesaverde source beds, the U.S.G.S. estimates that a minimum of 10 and a maximum of 50 conventional fields may be discovered (Table 1).

Analog Field
Greater Natural Buttes
Figures: UO-22 *to* UO - 25

Location:	T 8-10 S, R 19-23 E (SLB&M), T 36 S, R 25-26 E (SLPM), Uinta County, Utah, on Reservation
Producing formations:	Green River Formation, Wasatch Formation Mesaverde Group
Other significant shows:	None
Lithology:	Fluvial and lacustrine sandstones, limestones, dolomites
Type of drive:	Pressure depletion
Net pay thickness:	Individual sands may be up to 80 feet in thickness
Porosity:	8-18%, average 12% (logs)
Permeability:	Generally less than 0.1 mD
Estimated ultimate recovery:	0.5 BCFG
Other major analog fields:	Devil's Playground Red Wash Wonsits Valley

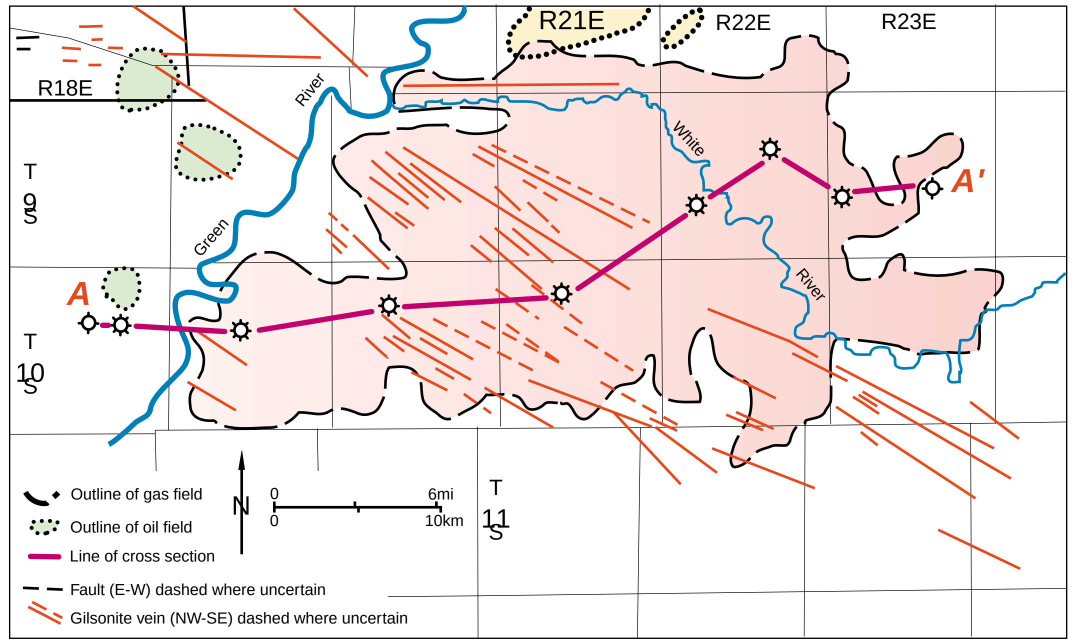


Figure UO-22. Map of the Greater Natural Buttes Gas Field (modified after Osmond, 1992).

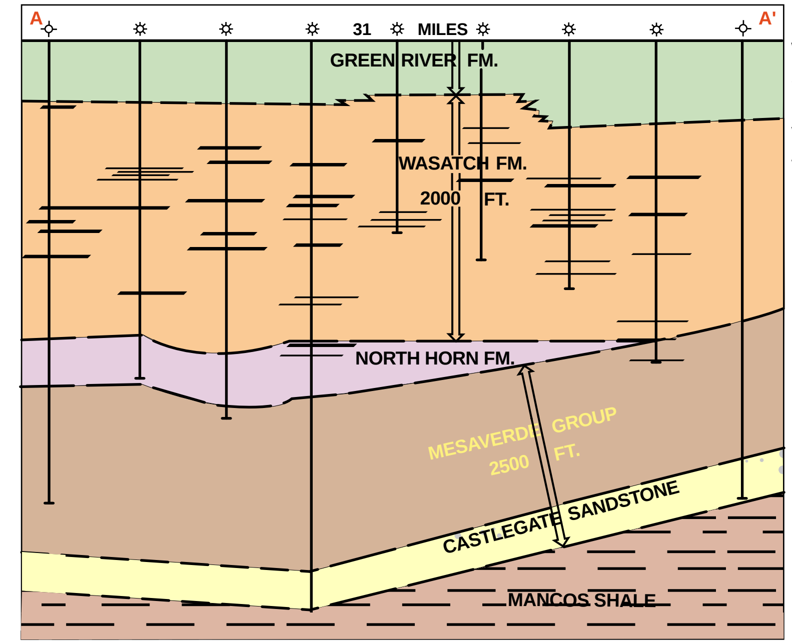


Figure UO-23. Diagrammatic west-east cross section showing stratigraphy of the Greater Natural Buttes Field and position of Wasatch producing sandstones that overlie the Mesaverde. Line of section is shown in Figure UO-14 (modified after Osmond, 1992).

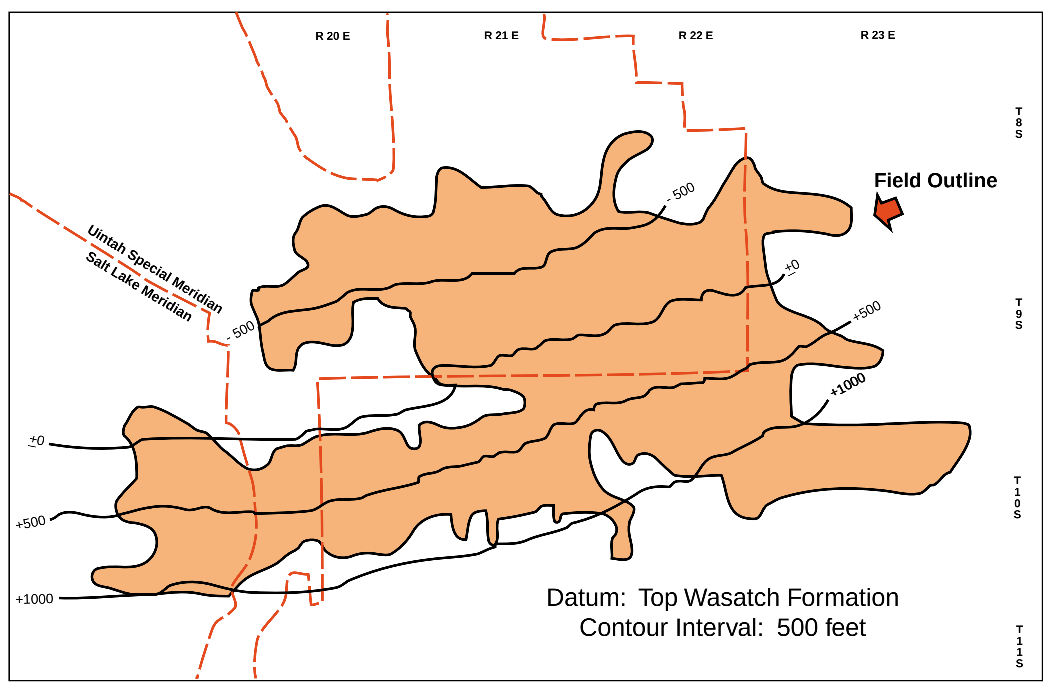


Figure UO-24. Structural contour map of Natural Buttes Field. Bold line depicts approximate Reservation boundary (modified after Hill and Bereskin, 1993).

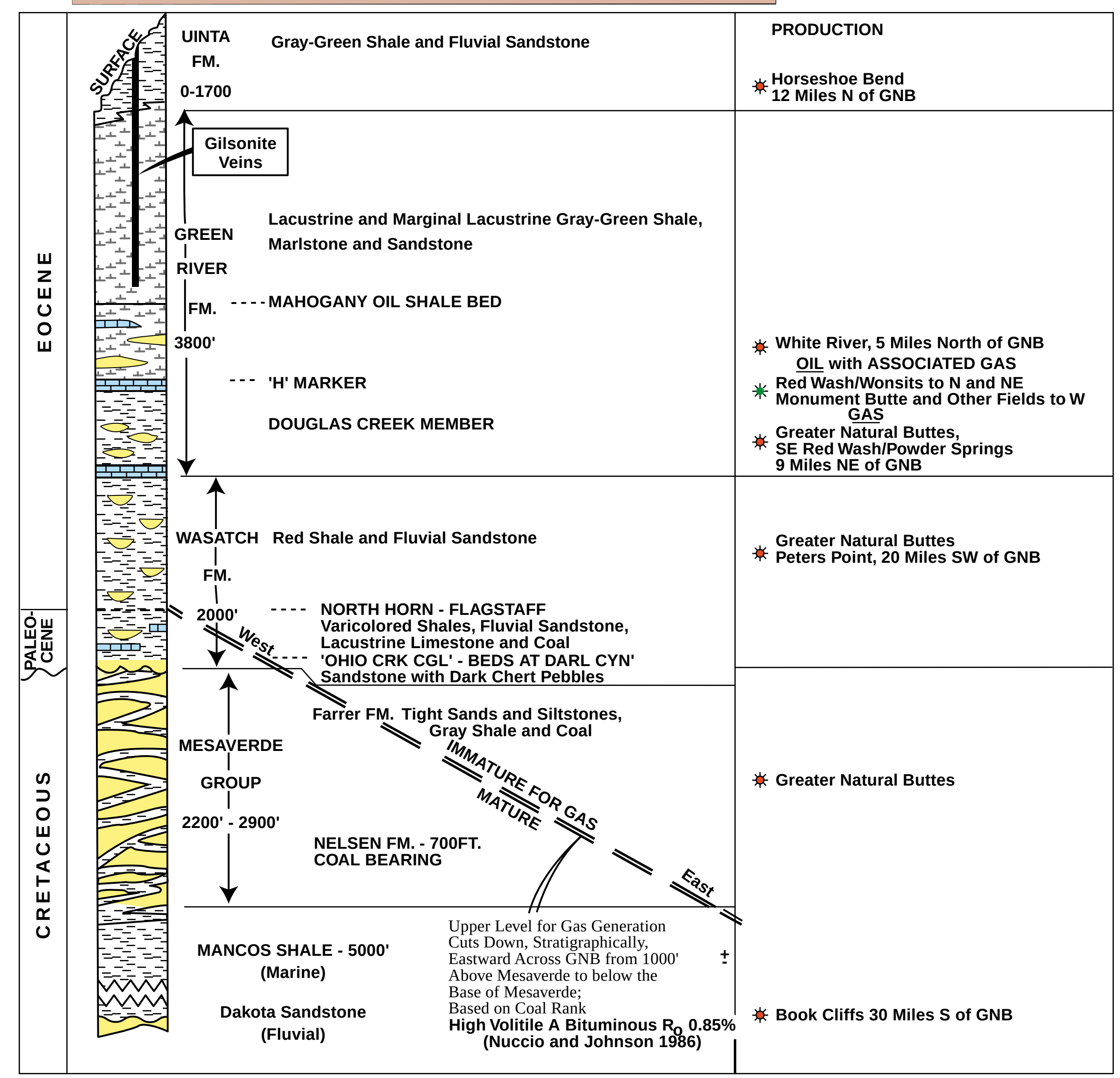


Figure UO-25. Stratigraphic column for Greater Natural Buttes (GNB) Field, showing formations which produce oil and gas in GNB and nearby fields (modified after Osmond, 1992).

CRETACEOUS DAKOTA TO JURASSIC PLAY

This is primarily a conventional reservoir play, but tight reservoirs are mixed with the conventional rocks. The discovered fields are mostly structurally controlled. Based on known fields, it appears to be predominantly a gas play (90 percent gas, 10 percent oil). The Cretaceous Dakota Group (including the Cedar Mountain Formation) and the Jurassic rocks were combined into one play by the U.S.G.S. because many fields produce from rocks of both ages and any structure drilled has the potential for accumulations in both. The Wilson Creek Field is the southeasternmost structure along a series of producing structures that includes the Maudlin Gulch Field. The downdip limits of the play are where the rocks become tight and reservoirs are unconventional (>6,000 feet).

Reservoirs: The Cretaceous Dakota reservoirs vary from lenticular to continuous, and are predominantly fluvial in the play area. The Jurassic reservoirs range from discontinuous fluvial sandstones of the Morrison Formation to blanket eolian sandstones of the Entrada Sandstone. Porosities range from <11 percent to about 25 percent.

Source rocks: Source rock data for this play are lacking in the public record, but some dark shales, mudstones, and thin coals are present in the Dakota Group. The overlying marine Cretaceous Mowry and Mancos Shales are both known source beds (mostly oil prone).

Timing and migration: The hydrocarbons were probably generated in Late Cretaceous to Early Tertiary time, and some may have migrated into younger Tertiary structures.

Traps: The known traps are predominantly structural, and some have stratigraphically modified the accumulation. Many of the fields are situated on surface anticlines; they tend to be large and were discovered relatively early in the exploration cycle. San Arroyo-East Canyon (EUR 174 BCFG) was discovered in 1955 and produces from the Dakota Group (including the Cedar Mountain Formation) and the Jurassic Entrada Sandstone (FIGURES 27 and 28). Many of the fields have significant amounts of nitrogen and CO_2 (as much as 25 percent).

Exploration status and resource potential: The play is maturely developed for large fields, but subtle structures and stratigraphic traps may contain as many as 25 significant accumulations (TABLE 1).

Analog Example: Fence Canyon
Figure 26

Location:	T 15-16 S, R 22-23 E, (SLB&M), Uinta and Grand Counties, Utah, on Reservation
Producing formations:	Dakota Sandstone, Buckhorn Conglomerate, Morrison Formation
Other significant shows:	Cretaceous Mancos Shale
Lithology:	Sandstone, white, fine-medium grained, conglomeratic
Type of drive:	Gas expansion
Net pay thickness:	Dakota - 25 ft., Buckhorn - 26 ft., Morrison - 11ft.
Porosity:	10-16%
Permeability:	Unknown
Estimated ultimate recovery:	10 BCFG
Other major analog fields:	Evacuation Creek, Hell's Hole, Park Mountain, San Arroyo

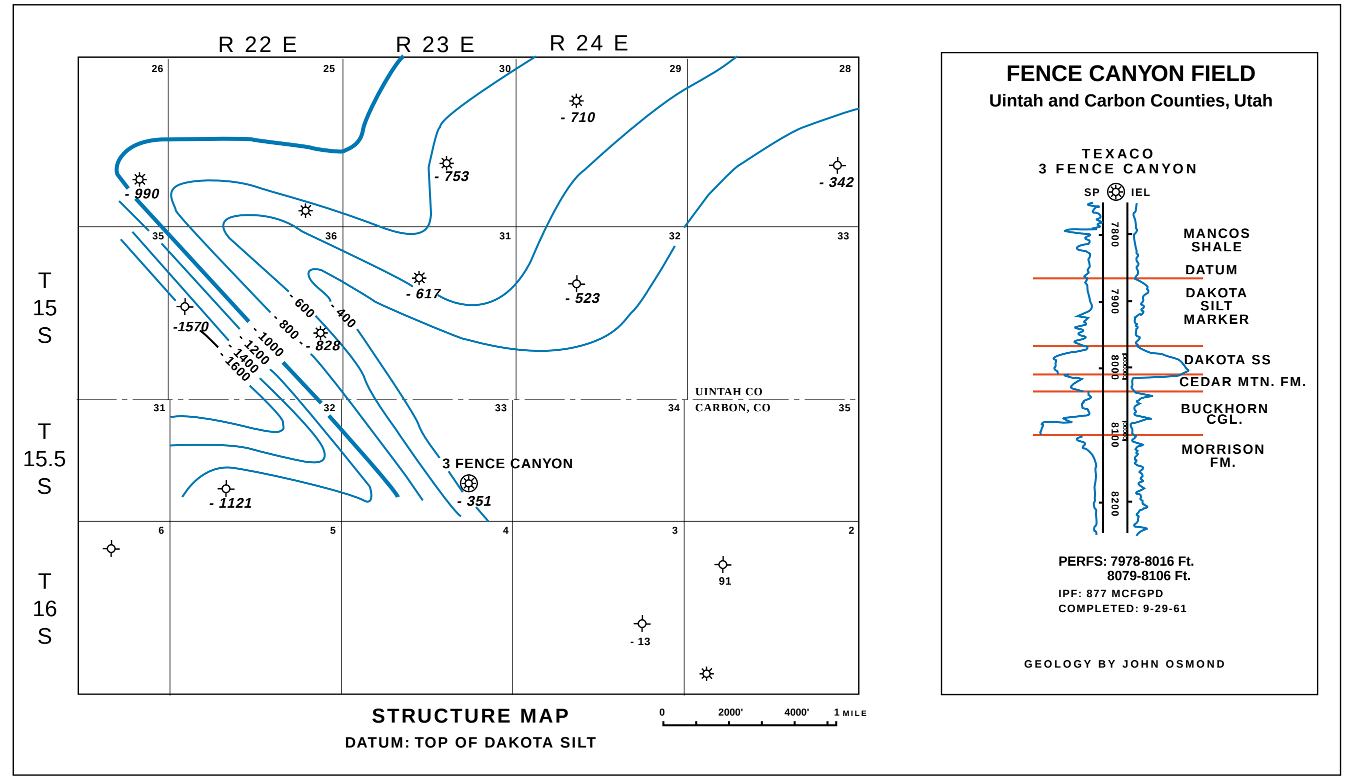


Figure UO-26. Structure map and typical electric log from Fence Canyon Field (modified after Hill and Bereskin, 1993).

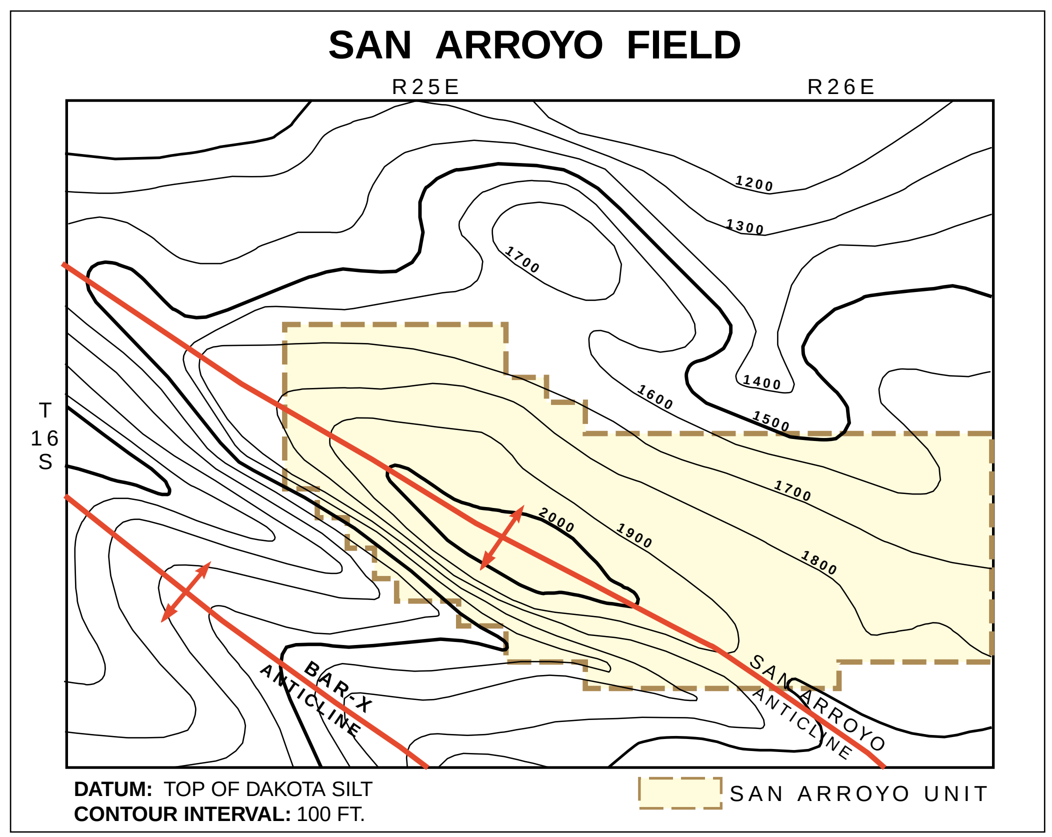


Figure UO-27. Structural contour map of San Arroyo Field (modified after Hill and Bereskin, 1993).

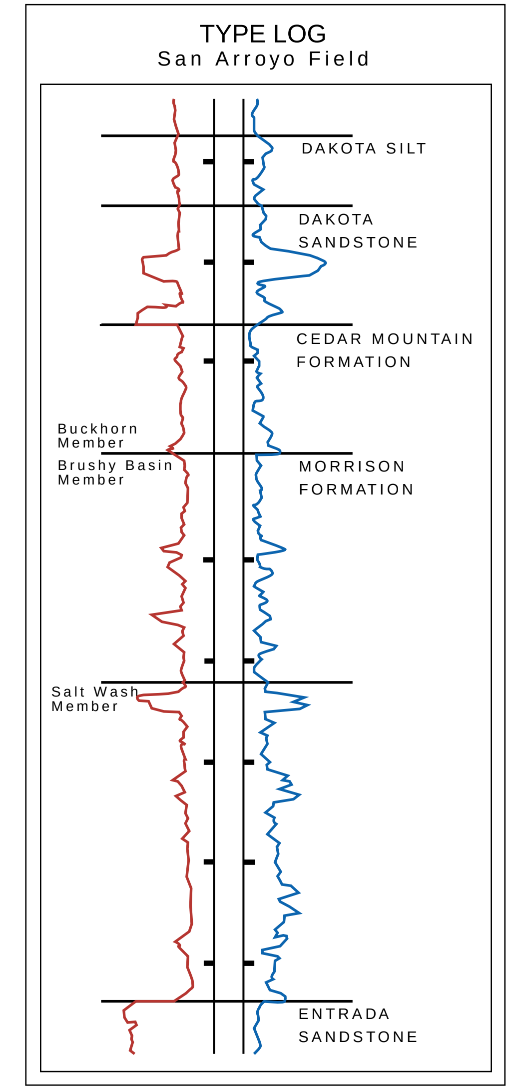


Figure UO-28. Type log from the San Arroyo Field (modified after Hill and Bereskin, 1993).

Figures: UO-27, UO-28

Location:	T 16 S, R 25-26 E, (SLPM), Grand County, Utah, just east of Reservation
Producing formations:	Dakota Sandstone
Other producing zones:	Castlegate Sandstone, Cedar Mountain and Buckhorn Conglomerate Members of the Cedar Mountain Formation, Brushy Basin and Salt Wash Members of the Morrison Formation, Entrada Sandstone
Other significant shows:	None
Lithology:	Interbedded sandstone and shale (Dakota), variegated mudstone with sandstone lenses (Cedar Mountain), sandstone to conglomerate (Buckhorn Member), shale with occasional sandstone beds (Morrison), sandstone (Entrada)
Type of drive:	Gas expansion
Net pay thickness:	13-80 feet, variable
Porosity:	10-20%
Permeability:	NA
Estimated primary recovery:	Not calculated

Analog Field: Greater Hell's Hole
Figures: UO-29 *to* UO-31

Location:	T 10 S, R 25 E, (SLB&M), Uinta County, Utah; T 1-2 S, R 104 W, Rio Blanco County, Colorado, east of Reservation
Producing formations:	Dakota Group
Other significant shows:	Mesaverde shales and coals, Mancos Shale (B), Weber Sandstone (Maroon), Leadville
Lithology:	Sandstone
Type of drive:	Gas depletion
Net pay thickness:	25 ft. average, max 57 ft., min 5.5 ft.
Porosity:	14-18%
Permeability:	0.1-10 mD
Estimated ultimate recovery:	26.2 BCFG, 65,000 BC

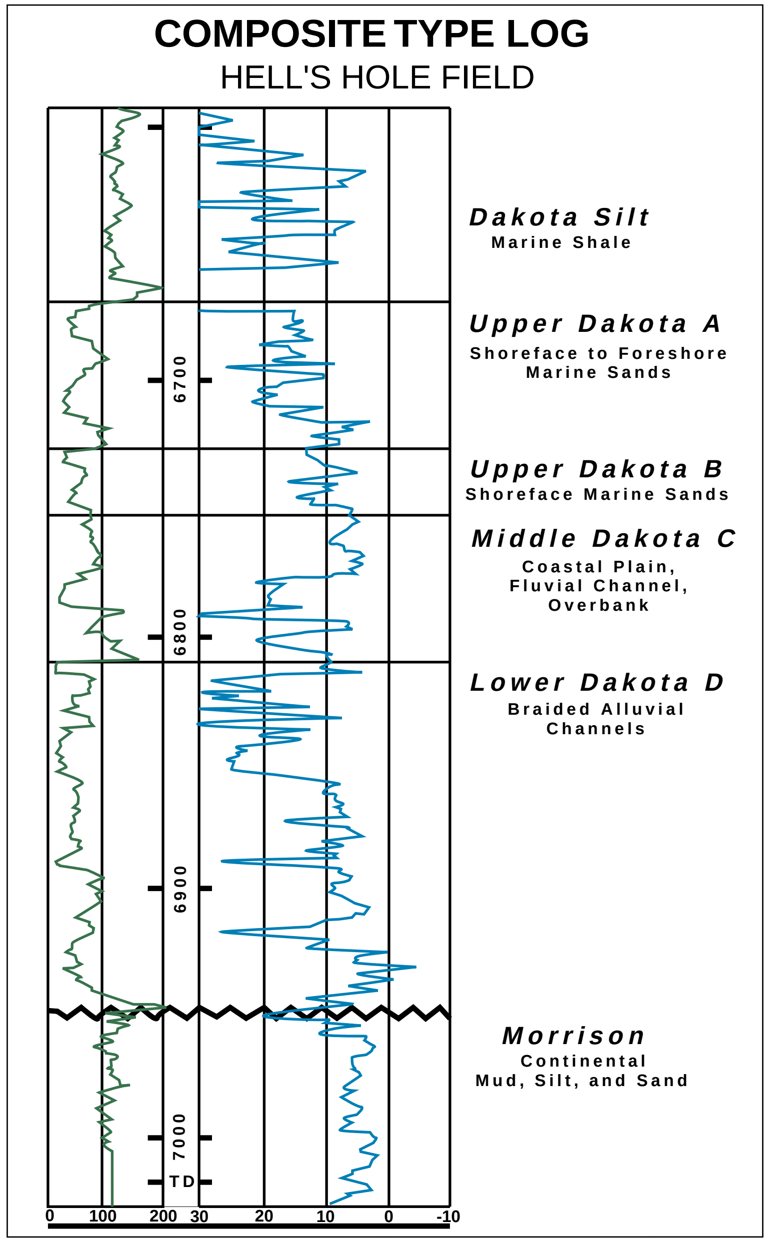


Figure UO-29. Composite type log for the Dakota section at Hell's Hole, Rio Blanco County, CO, and Uintah County, UT (modified after Moretti et al., 1992).

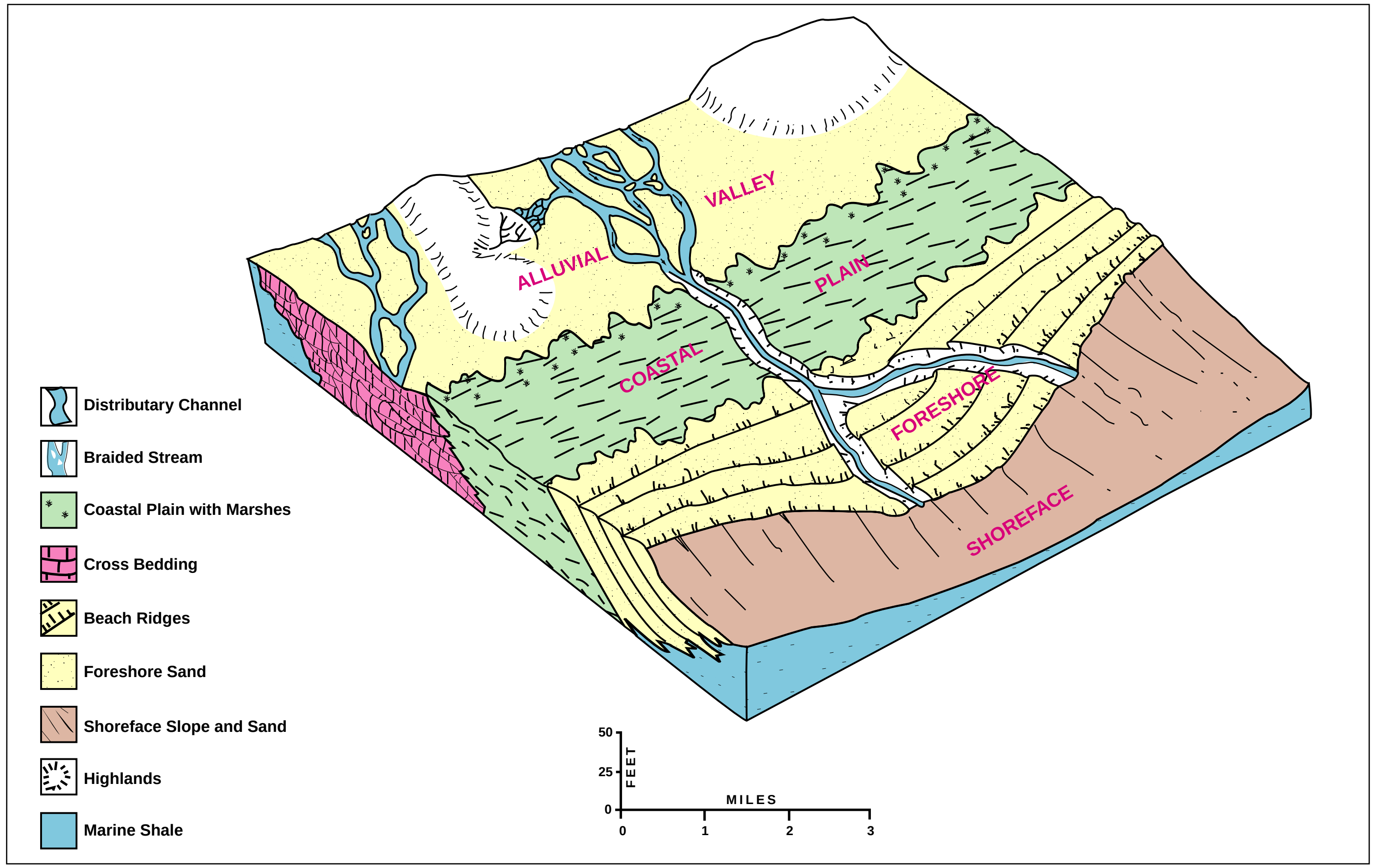


Figure UO-30. Three dimensional model of Dakota Sandstone depositional environments at Hell's Hole Field. (modified after Moretti et al., 1992).

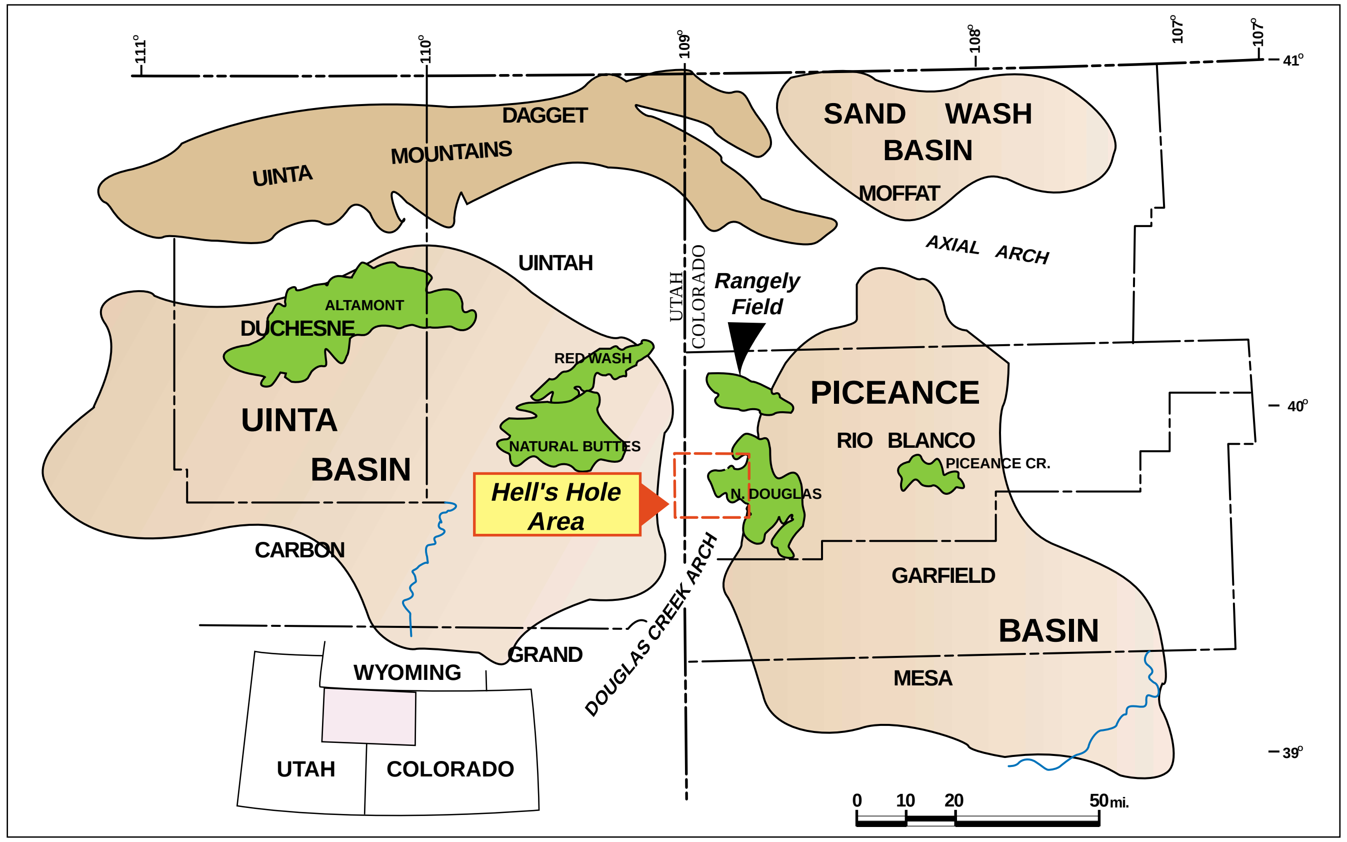


Figure UO-31. Map showing the Hell's Hole area (modified after Moretti et al., 1992).

PLAY TYPE 4

PERMIAN-PENNSYLVANIAN SANDSTONES AND CARBONATES PLAY

This is primarily a play for structural and stratigraphic traps in Permian and Pennsylvanian sandstones and carbonates. The objective reservoirs were deposited in predominantly marine and eolian environments. Some redbeds occur, but are not part of the prospective facies.

The eastern part of the play is bounded by the expected limit of porous sandstone. The southern boundary is limited by expected presence of structural and stratigraphic traps in the Uinta Basin; the northern limit is based on the expected limit of conventional reservoirs. This play is thought by the U.S.G.S to be very high risk.

Reservoirs: The Permian-Pennsylvanian reservoirs are both sandstone and carbonate. The sandstones have good reservoir quality at shallow depths (<8,000 feet). The carbonates are expected to be porous at least as deep as 12,000 feet. The shallow sandstones (Weber Sandstone) have about 11-14 percent porosity in the only two discovered fields in the play.

Source rocks: The source rocks for the discovered oil fields are not known, but the Park City (Phosphoria) Formation was probably the source, requiring long-range migration. Some local Pennsylvanian marine shales may also be a source.

Timing and migration: The hydrocarbons must have migrated prior to Tertiary tectonism, so generation was probably during the Upper Cretaceous.

Exploration status and resource potential: Only two fields have been found in the province, both of which are related to anticlinal closures, and both of which produce oil. The play is for oil with associated gas, but it is possible that some gas fields of less than minimum size (6 BCFG) may also be found. Several Pennsylvanian sandstone and carbonate reservoirs produce on closures just outside the province in the Maudlin Gulch Field area (Danforth Hills Anticline).

The two producing fields in the play are Ashley Valley Field in Utah (EUR 25.5 MMBO) and Rangely Field in Colorado (EUR 955 MMBO, 706 BCFG). Ashley Valley produces from about 4,000 feet and Rangely from 5,500 to more than 6,000 feet. The play depths for undiscovered accumulations range from 6,000 to 12,000 feet. The play below 8,000 feet is relatively unexplored by drilling, but is

Analog Example: Rangely

Figures: UO-18, 19, 32, 33

Location:	Rio Blanco County, Colorado, east of Reservation
Producing formations:	Weber Sandstone
Other significant shows:	None
Lithology:	Sandstone
Type of drive:	Combination
Net pay thickness:	275 feet
Porosity:	15%
Permeability:	25 mD
Estimated ultimate recovery:	904 MMBO
Other major analog fields:	Ashley Valley, Thornburg

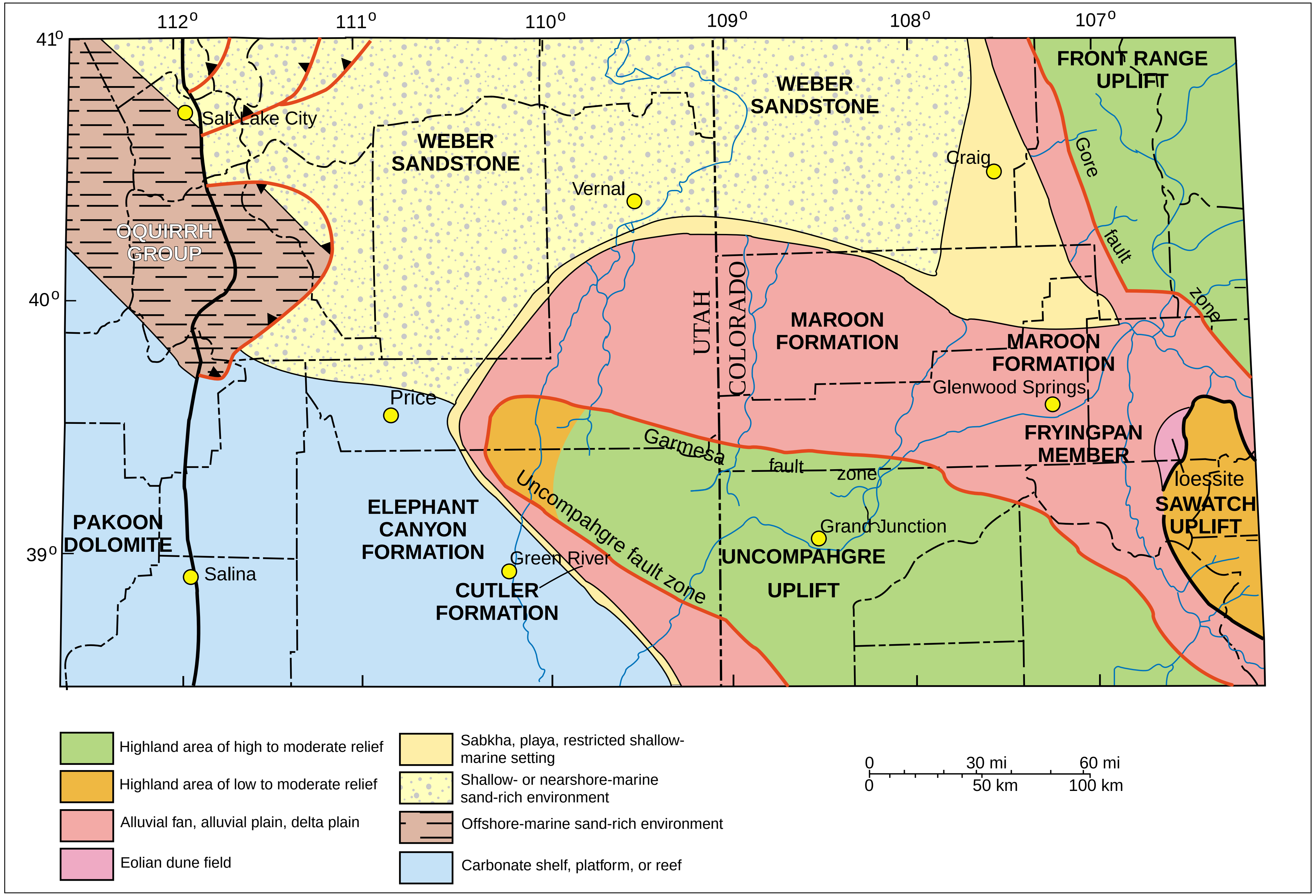


Figure UO-32. Map showing the Early Wolfcampian paleogeography of the Uinta-Piceance Basin Region during maximum transgression (modified after Johnson et al., 1992).

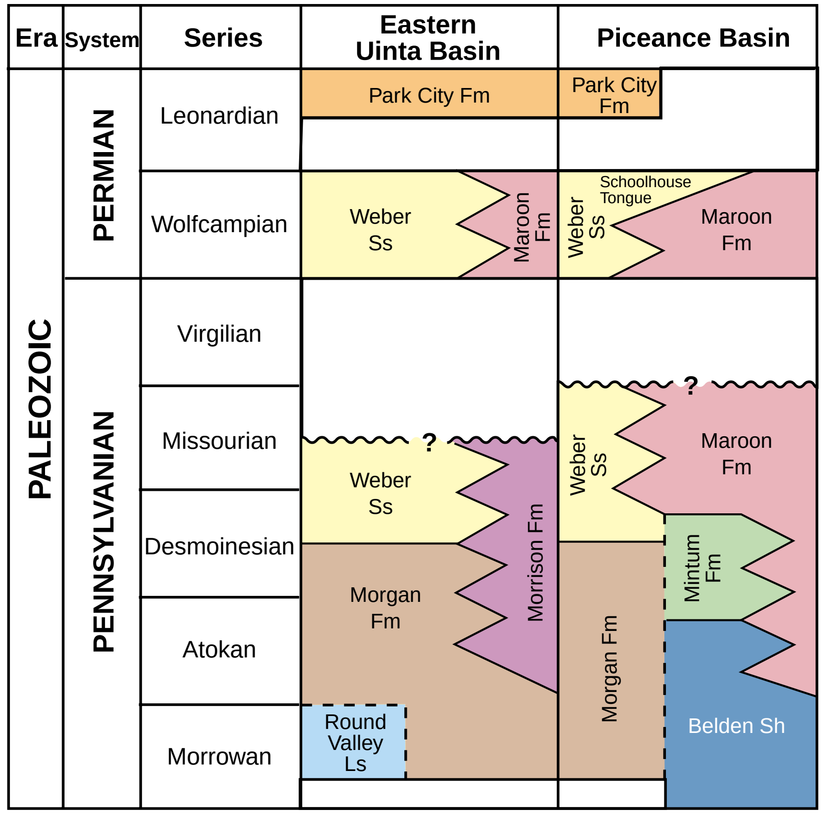


Figure UO-33. Nomenclature and correlation for the Weber Sandstone in the East Uinta and Piceance Basins. Unconformities indicated by white patches (modified after Hemborg, 1993).

PLAY TYPE 5
BASIN MARGIN SUBTHRUSTS PLAY (HYPOTHETICAL)

This play is primarily for closures beneath high- to low-angle thrusts. Figure UO-3 shows some of the flanking thrusts present along the northern to eastern part of the province. The play is hypothetical, and both oil and gas should be present. The only nearby analog is the Tepee Flats Field in the eastern Wind River Basin-Casper Arch area. Here, thick, unfractured Cretaceous marine shale provides a seal for an oil and gas accumulation in the Upper Cretaceous Frontier Formation.

Reservoirs: The reservoirs for this play range in age from Paleozoic to Tertiary. Reservoir quality may be poor, especially for prospects deeper than 12,000 feet. The Mississippian carbonates are expected to be porous in most parts of the play.

Source rocks: The source rocks are within the subthrust section. Possible source rocks containing more than 1 percent total organic carbon (TOC) are found in the Lower Tertiary, Upper Cretaceous, and Pennsylvanian Belden Shale (FIGURE UO-33). The Jurassic Curtis Formation may be a local source bed.

Timing and migration: The timing is uncertain, but most of the thrusting took place during the Laramide Orogeny.

Traps: Traps are most likely structural and structural-stratigraphic (FIGURES UO-34 and UO-35). Play depths should range from 5,000 feet to as much as 25,000 feet.

Exploration status and resource potential: The play is almost unexplored by drilling and only moderately explored by seismic mapping. Based on the abundant fields near the thrusts in the Uinta Basin, a median field size of 2 MMBO and 15 BCF of non-associated gas, and a maximum field size of approximately 50 MMBO and 150 BCFG are estimated for this play.

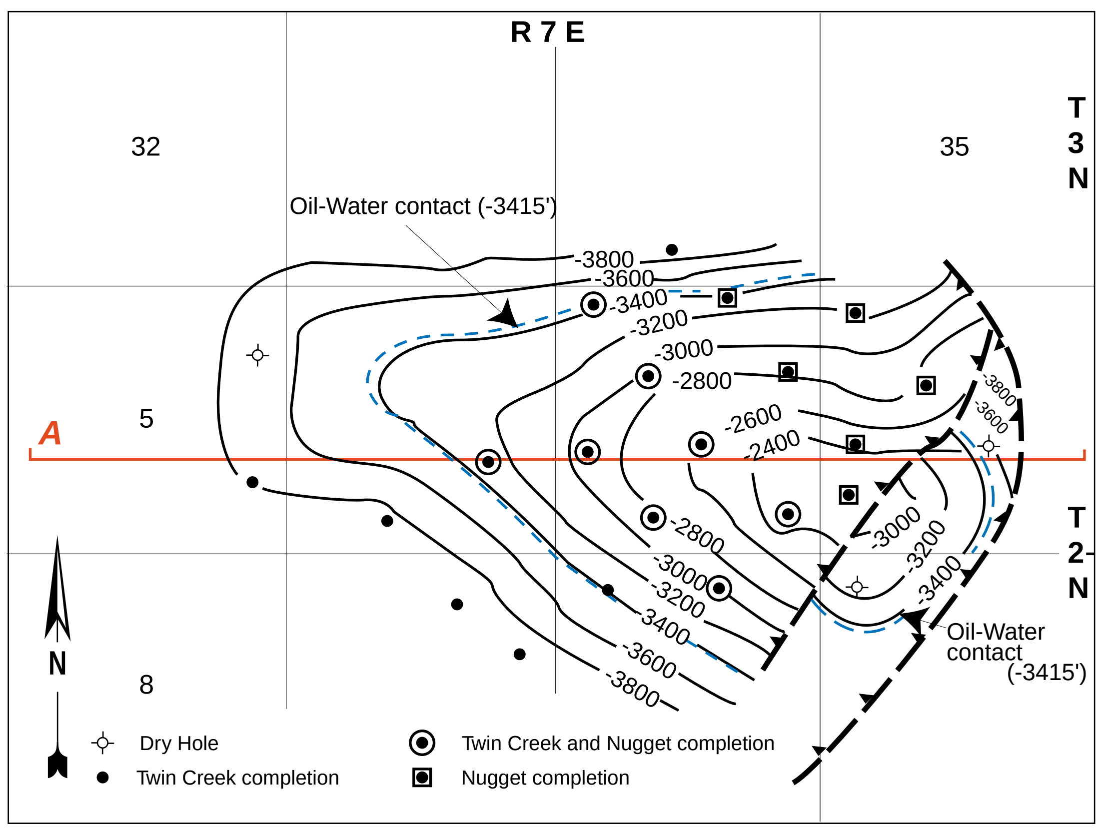


Figure UO-34. Typical geometry of a shallow east-trending structure, Pineview Nugget Reservoir, Summit County, Utah (not on reservation). Gas is trapped in an asymmetrical thrusted anticline in the hanging wall of the Absaroka Thrust system. Structure contour map of the top of the Nugget Sandstone (modified after Hjellming, 1993).

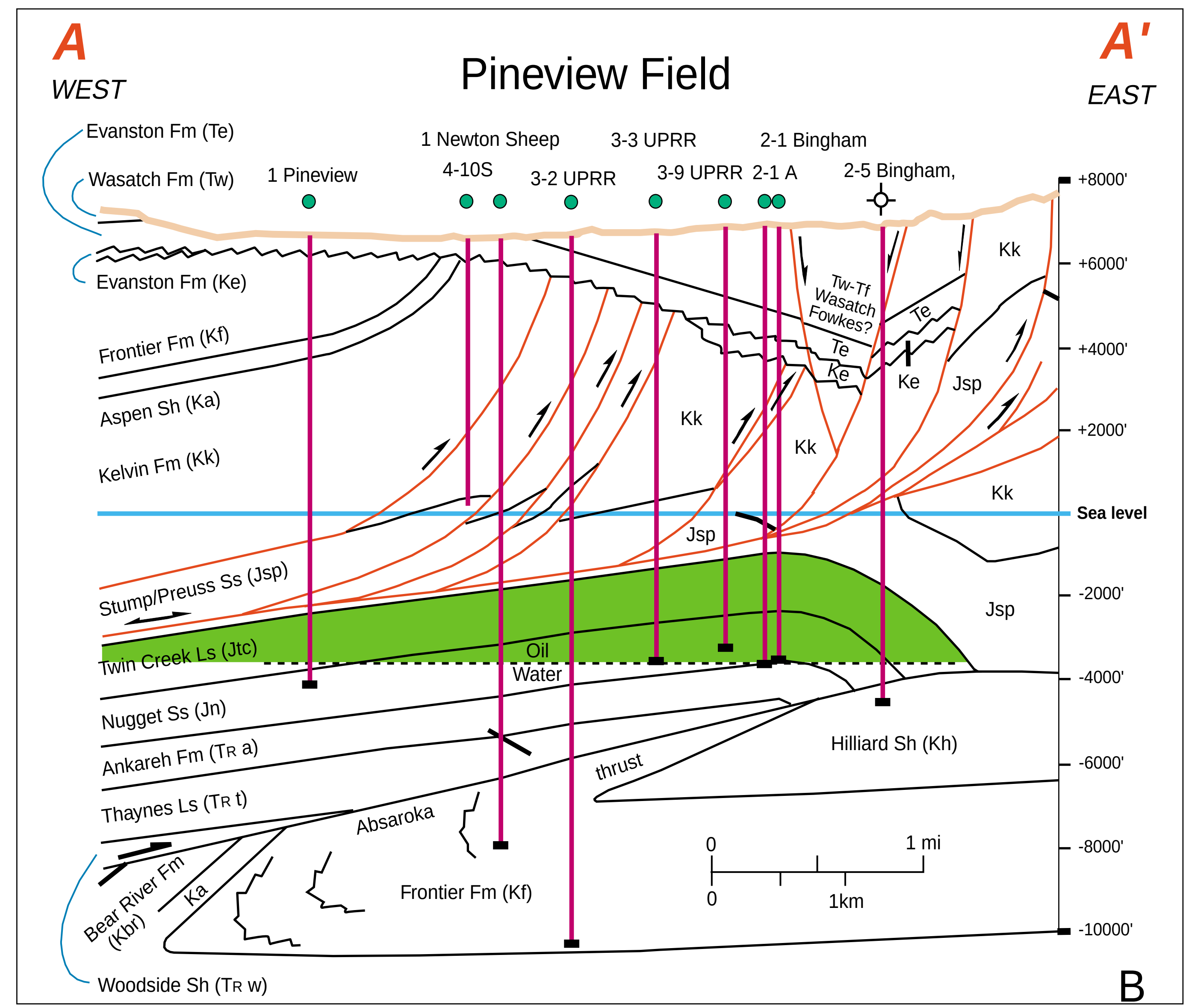


Figure UO-35. Cross section through the reservoir. Line of section shown in Figure UO-34 (modified after Hjellming, 1993).

DEFINITION: Unconventional Plays

Unconventional Play- A broad class of hydrocarbon deposits of a type (such as gas in "tight" sandstones, gas shales, and coal-bed gas) that historically has not been produced using traditional development practices. Such accumulations include most continuous-type deposits.

Cretaceous Self-Sourced Fractured Shales Play (Hypothetical)

Oil is produced from fractured Upper Cretaceous Mancos Shale and its equivalents. The best fracturing occurs in brittle siltstones, carbonates, and calcareous shales.

The play outline is based by the U.S.G.S. on the known occurrence of production and the tectonic features associated with known and suspected potential. In the play, the best open fractures occur at the maximum flexure on anticlines or monoclines. Fractures also produce well where shear zones or faults occur. The play boundary is fairly easy to define except in the area between Rangely and the Axial Uplift, where proprietary seismic data indicate the presence of several subsurface thrusts, including thrusts associated with the White River Field structure.

Reservoirs: The reservoirs are open fractures in brittle siltstones, carbonates, and calcareous and siliceous shales. The producing intervals vary from 10 feet to more than 50 feet thick. The fracturing is highly variable, and one well in the play has produced over 1 MMBO.

Source rocks: The enclosing marine shales are the source rocks. The richness varies from about one percent to more than four percent TOC, based on unpublished information.

Timing and migration: The oil was probably generated in the Late Tertiary during maximum burial.

Traps: The traps are formed by the enclosing unfractured, more plastic shale, which contains less silt and carbonate than the brittle facies. The largest accumulation in the play is found in Rangely Field (EUR 14 MMBO). The highest concentration of oil wells producing from the Mancos Shale at Rangely is along the south flank of the structure at the point of maximum flexure.

Exploration Status and Resource Potential: The play is moderately well explored by vertical wells but nearly unexplored by slant- and horizontal-hole drilling. The U.S.G.S. assumed a low success ratio for the overall play area. Although this play is classified as a continuous-type play (e.g., tight gas), production should be localized by individual fractured structures and fracture trends.

EUR estimates per well are extremely variable and, although the play is treated as a continuous-type occurrence, the U.S.G.S also simulated individual undiscovered fields or "sweet spots" within it to assist in assessment. On this basis, the success ratio in well-mapped structural flexures is considered quite high, perhaps more than 50 percent; also, there is high potential for finding many areas of small production, and perhaps as many as 10 larger fields (Table 1).

Analog Example: Greater Douglas Creek

FIGURES UO-13, UO-14

Location:	Rio Blanco County, Colorado west of Reservation
Producing formations:	Mancos, Mancos (B) Shale
Other significant shows:	Morapos Formation
Lithology:	Sandstone
Type of drive:	Pressure depletion and water drive
Net pay thickness:	30-250 feet
Porosity:	2-20%
Permeability:	0.01-100 mD

TIGHT GAS UINTA TERTIARY EAST PLAY

This play is based on well-established gas production from the Uteland Butte, Chapita, and Buck Canyon zones of the Tertiary Wasatch Formation. Updip to the south and east, the play limit is based on an increase in reservoir quality and a change to mostly conventional reservoirs that have gas-water contacts, which are included in the Uinta Tertiary Oil and Gas Play. Downdip to the north, the play boundary is defined as the point where it becomes predominantly an oil play and is included in Play Type 1. The western limit is along the Green River drainage, where the play becomes higher risk and has been assessed separately by the U.S.G.S. as Tight Gas Uinta Tertiary West Play (Play Type 8). The overall Wasatch tight gas plays (7 and 8) are based on vitrinite reflectance (Ro) levels in the underlying Cretaceous Mesaverde Group. Rice and others (1992) and Fouch and others (1992) showed that Wasatch gas has migrated upward from the Mesaverde Group and that the play occurs between the basal Mesaverde Ro limits at 1.1-1.5 percent.

Reservoirs: Reservoir rocks are generally medium- to fine-grained feldspathic litharenites and litharenites deposited primarily in fluvial environments. They are interbedded with mudstones, siltstones, shales, and some coal. Porosity ranges from less than 5 percent to more than 9 percent. The reservoirs range in depth from about 3,000 feet to about 10,500 feet, having a median depth of 6,400 feet.

Source rocks: The predominant source of the gas is in the underlying Mesaverde Group (Fouch and others, 1992; Nuccio and others, 1992; Rice and others, 1992).

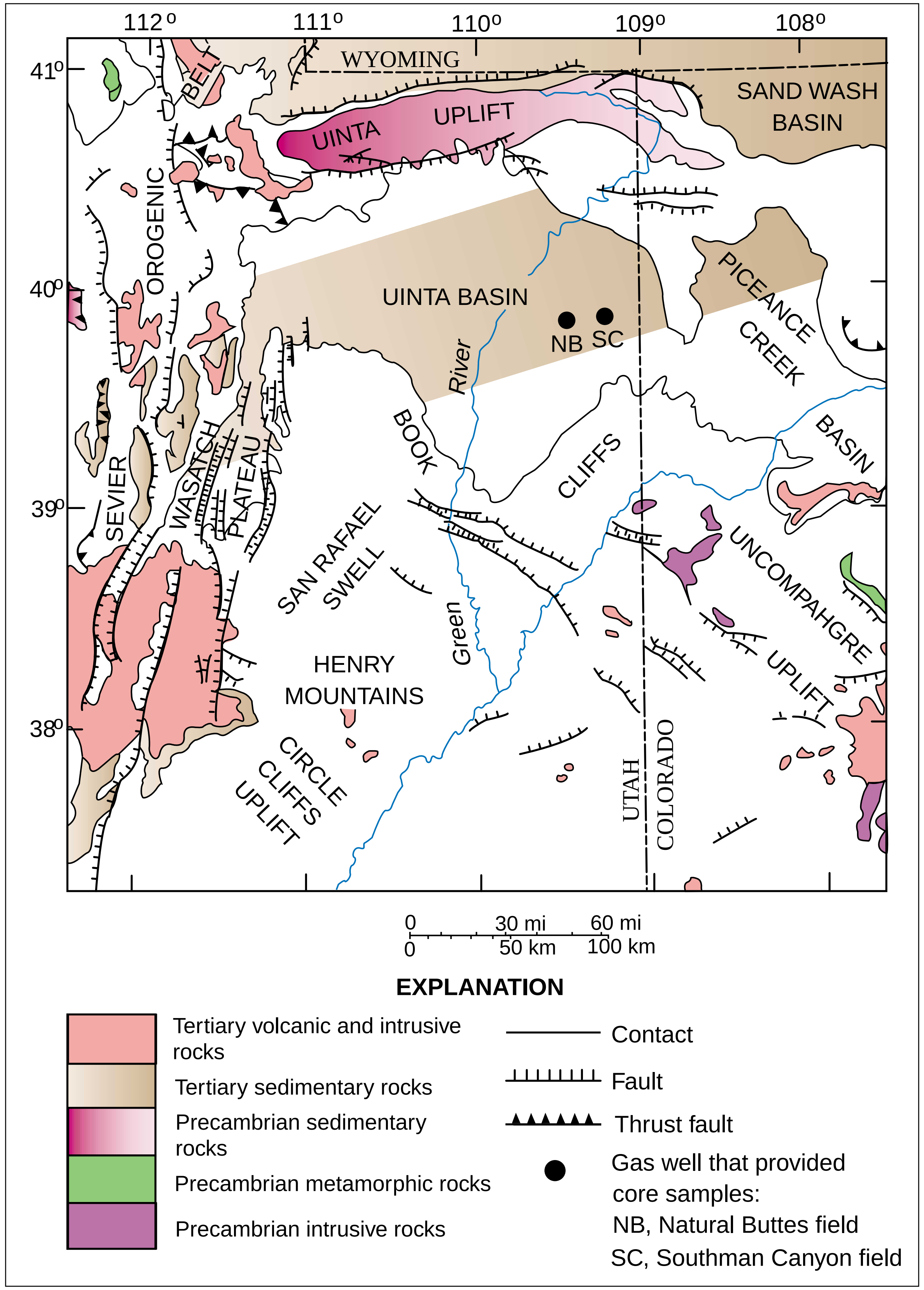


Figure UO-36. Generalized geologic map of the Uinta Basin Province showing location of cored wells (modified after Pitman et al., 1986)

Play 8: TIGHT GAS UINTA TERTIARY WEST PLAY
(HYPOTHETICAL)

This play is the western extension of Tight Gas Uinta Tertiary East Play (Play Type 7) and is separated from Play 7 along the Green River drainage. Although the river is a surface feature, it more or less coincides with a westward decrease in drilling activity and reservoir quality. It is higher risk than Play 7 and, on this basis, it was decided by the U.S.G.S to use separate assessment parameters.

Reservoirs: This play draws on the same reservoirs as Play 7, yet porosities are somewhat lower here, ranging from less than 4 percent to about 8 percent in reservoir sandstones. The play depths range from about 4,500 feet to 11,000 feet, with a median depth of 7,500 feet.

Source rocks: The underlying Mesaverde Group is the gas source. The play limits approximately coincide with maturation levels of R_o 1.1-1.5 percent in gas-prone source beds in the basal part of the Mesaverde Group.

Timing and migration: Gas generation began in the Late Tertiary and may be continuing presently in the Mesaverde in the deeper parts of the basin; however, it is possible that vertical gas migration from the Mesaverde may not be as effective as it is in Play 7.

Traps: Traps are both stratigraphic and diagenetic.

Exploration status: There is considerably less drilling activity in this play relative to Play 7. The play is only sparsely to moderately explored by drilling.

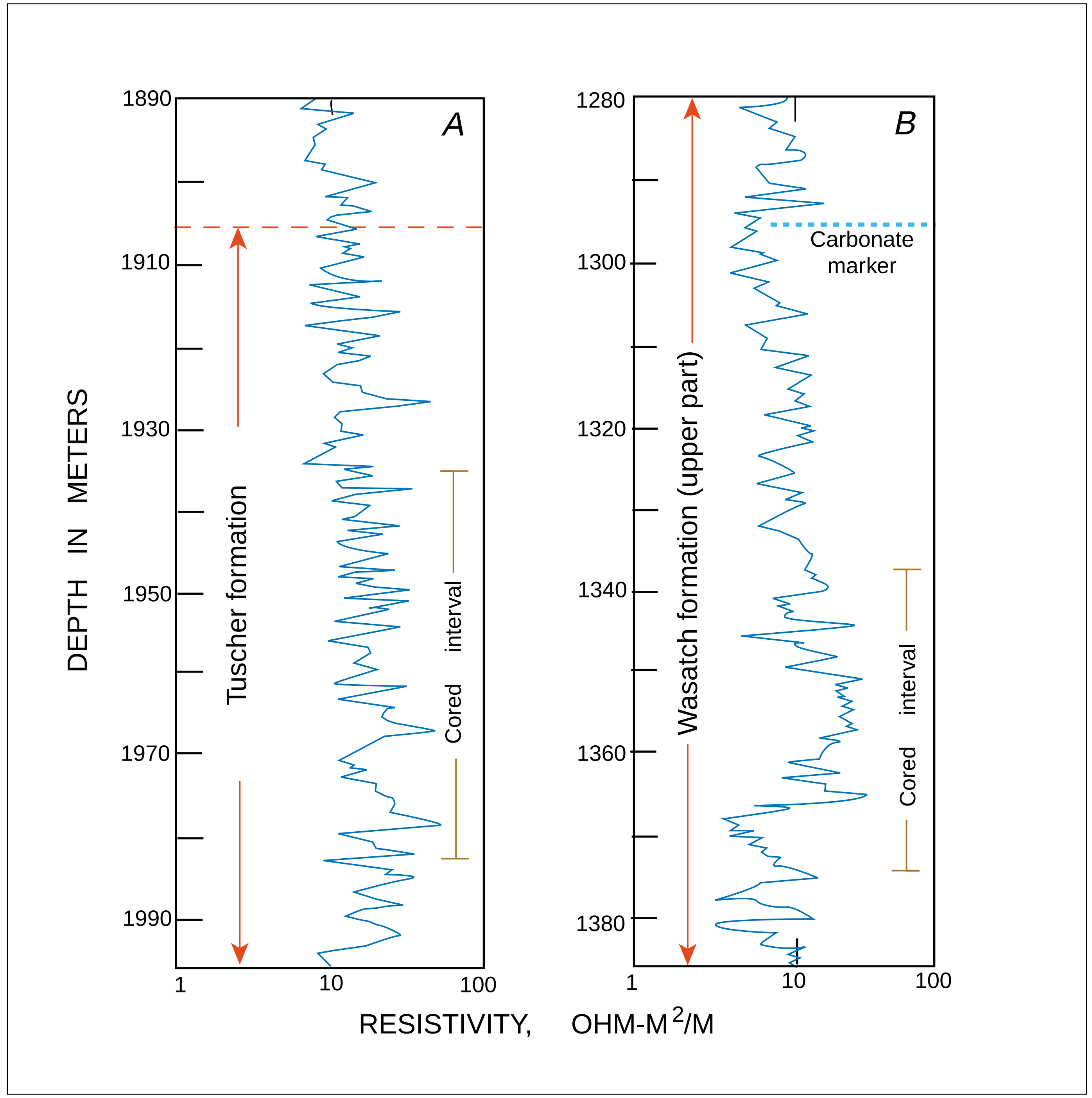


Figure UO-37. Electric log profile of cored wells (modified after Pitman et al., 1986).

Play 9: BASIN FLANK UINTA MESAVERDE PLAY
(HYPOTHETICAL)

This play is based on the widespread occurrence of tight, gas-saturated continental and marginal marine sandstone. The south, east, and west limits of the play are based on thermal maturation levels in the basal part of the Mesaverde Group. The reservoirs grade updip into more conventional Mesaverde reservoirs having gas-water contacts (see Upper Cretaceous Conventional Play Type 2). Mesaverde burial depths greater than 15,000 feet designate the downdip (north) play boundary (Fouch and others, 1994).

Reservoirs: The reservoirs are fine- to medium-grained litharenites to feldspathic litharenites, becoming coarser to the west. Most reservoir permeabilities are <0.1 md. Porosities range from <4 percent to >12 percent, averaging about 8 percent (FIGURES UO-11 and UO-12) (Nuccio and others, 1992). Play depth varies from 8,000 feet to 15,000 feet, having a median of 9,500 feet.

Source rocks: Source rocks are gas-prone, thermally mature coals, carbonaceous shales, and mudstones of the Mesaverde Group (FIGURES UO-11 and UO-12).

Timing and migration: Gas generation began in the Tertiary and may be continuing to the present in the deeper parts of the play. The basal Mesaverde has a thermal maturity greater than R_o 1.1 percent.

Traps: Traps are both stratigraphic and diagenetic.

Exploration status: The play is essentially unexplored due to depth, economics, poor reservoir quality, and the fact that it is mostly overlain by oil- and gas-producing rocks of the Tertiary Green River Formation.

DEEP SYNCLINAL UINTA MESAVERDE PLAY (HYPOTHETICAL)

This play is based on the expected occurrence of gas-saturated, tight Mesaverde sandstones at depths greater than 15,000 feet. The limits of the play are based on depth and reservoir quality. This play borders Play 9 and involves the same suite of rocks.

Reservoirs: Reservoir rocks are sandstones interbedded with mudstones, siltstones, shales, and some coals. Porosity is generally lower than in Play 9, and although there is almost no drilling, the U.S.G.S. expects porosity to be <8 percent to about 3 percent, having a median of 5-6 percent (Table 1). Reservoir depths are >15,000 feet, as deep as 25,000 ft, and have a median of 20,000 feet (FIGURES UO-42 through UO-44).

Source rocks: Gas-prone organic material interbedded with sandstone has generated large volumes of gas.

Timing and migration: Gas generation commenced in the Tertiary, and may be continuing at the present time. The thermal maturity of the Mesaverde is in excess of Ro 1.5 percent, and the deeper rocks exhibit >Ro 2.0 percent.

Traps: Traps are both stratigraphic and diagenetic.

Exploration status: The play is not well explored, due to the fact that primary interest in the area is in the overlying Tertiary reservoirs.

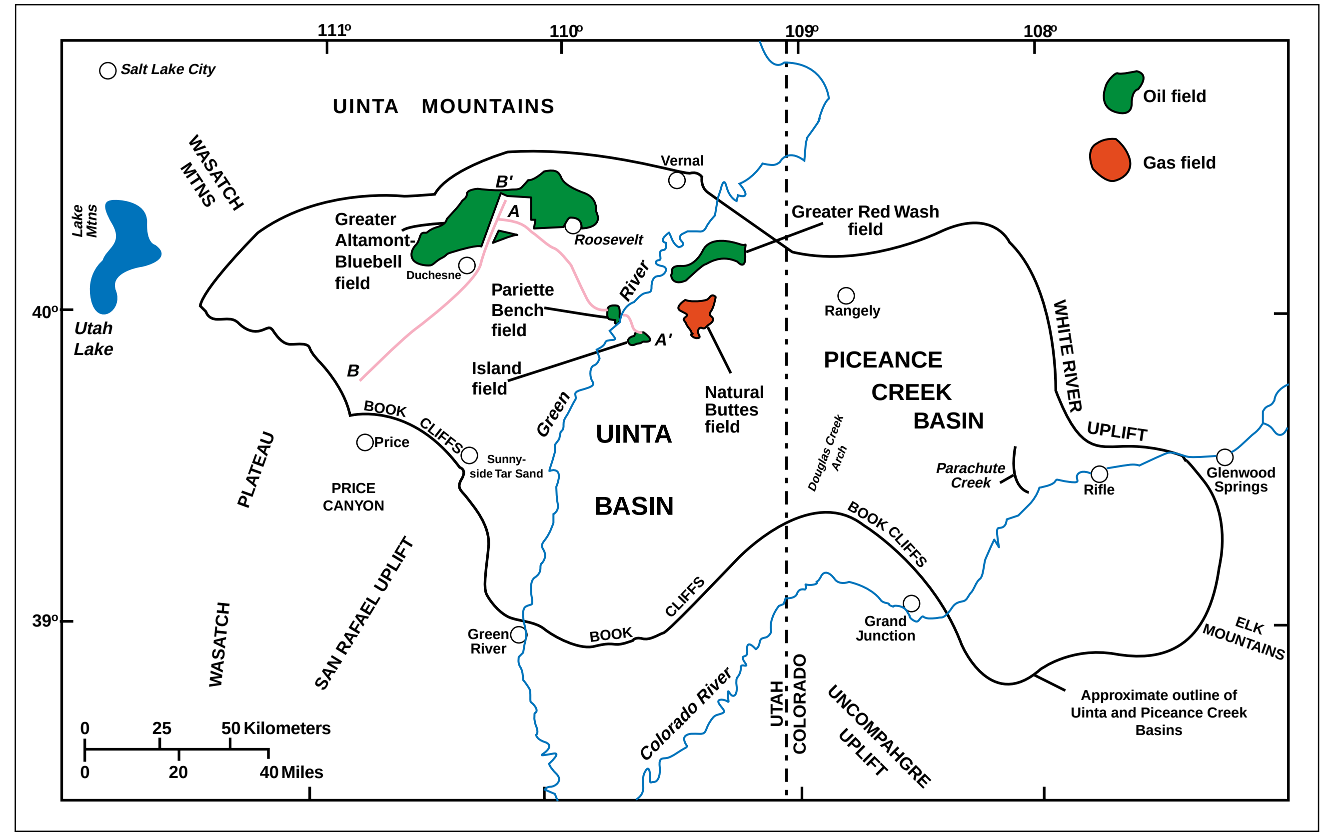


Figure UO-38. Index map of the Uinta and Piceance Creek Basins area showing location of cross-sections ***A-A'*** (Figure UO-43) and ***B-B'*** (Figure UO-44) (modified after Nuccio et al., 1992).

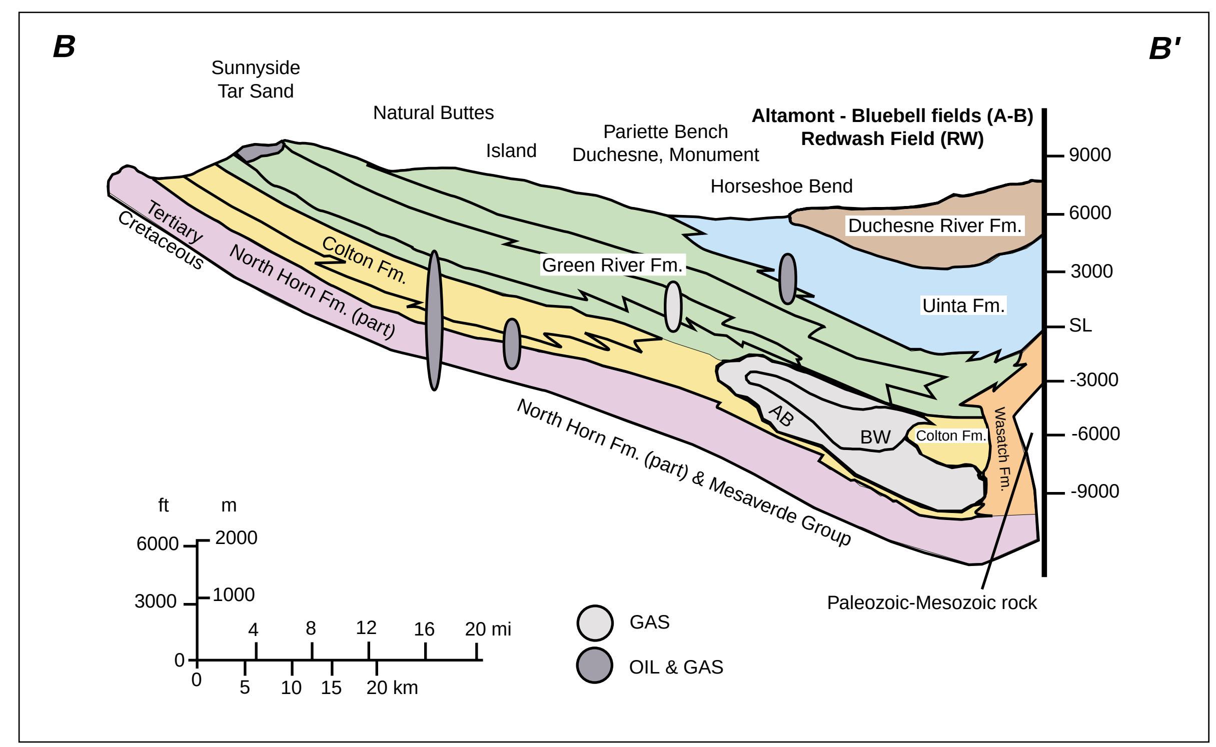


Figure UO-40. Cross section ***B-B'***, which extends from outcrops on the southwest flank of the Uinta Basin through the Altamont-Bluebell Field. Producing intervals for some of the basin's fields are projected into the line of section. See Figure UO-42 for line of section (modified after Nuccio et al., 1992).

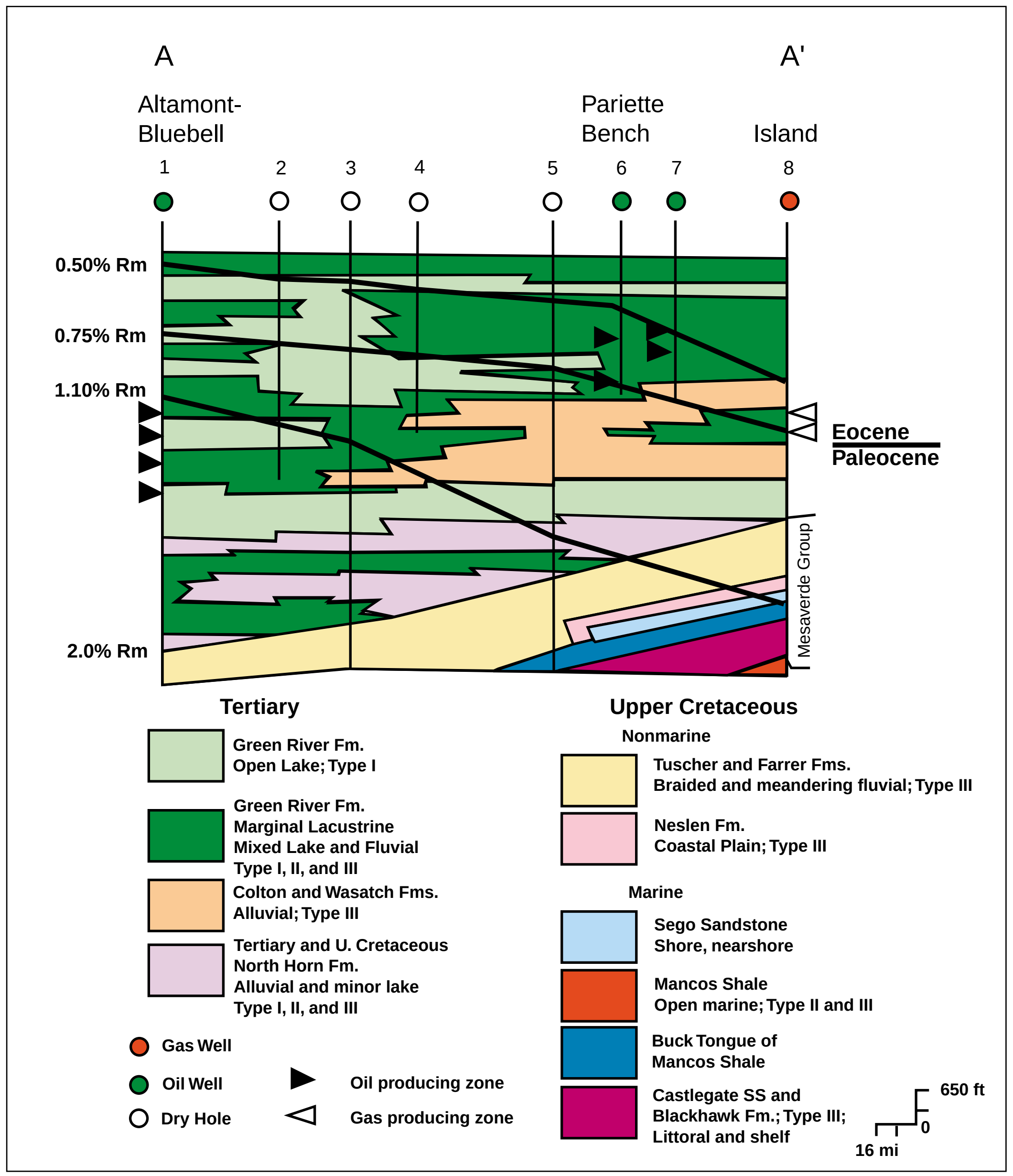


Figure UO-39. Cross section A-A' through the Uinta Basin, Utah, showing types of kerogen found at various stratigraphic intervals, levels of thermal maturity (Rm lines), and associated hydrocarbon producing zones. See Figure UO-42 for line of section (modified after Nuccio et al., 1992).

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