Chapter 3

Petroleum Systems of the Uinta and Piceance Basins—Geochemical Characteristics of Oil Types

Click here to return to
Volume Title Page

By Paul G. Lillis, Augusta Warden, *and* J. David King

Chapter 3 *of*
Petroleum Systems and Geologic Assessment of Oil and Gas in the Uinta-Piceance Province, Utah and Colorado
By USGS Uinta-Piceance Assessment Team

U.S. Geological Survey Digital Data Series DDS–69–B

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
Charles G. Groat, Director

Version 1.0 2003

For sale by U.S. Geological Survey, Information Services
Box 25286, Denver Federal Center
Denver, CO 80225

Published in the Central Region, Denver, Colorado
Manuscript approved for publication July 24, 2002

ISBN=0-607-99359-6

Contents

Figures

Table

Petroleum Systems of the Uinta and Piceance Basins—Geochemical Characteristics of Oil Types

By Paul G. Lillis, Augusta Warden, *and* J. David King

Abstract

As a part of the U.S. Geological Survey's (USGS) petroleum resource assessment of the Uinta-Piceance Province in the year 2000, over 170 oils, oil stains, and oil seeps were geochemically characterized and divided into genetic types using stable carbon isotopes, API gravity, sulfur content, and biomarker composition. Several oil types were identified that, in many cases, could be linked to previously proposed oil types or source rocks. Recognized petroleum systems include the Minturn, Phosphoria, Mancos, Mesaverde, and Green River. The most important sources of oil are the Lower Permian Phosphoria Formation or stratigraphically equivalent rocks, the Upper Cretaceous Mancos Group, and the Paleocene and Eocene Green River Formation. New data from the Cisco area, Utah, show that the Phosphoria petroleum system extends throughout much of the Uinta Basin. The proposed Minturn petroleum system is hypothetical based on the geologic similarities to the Paradox petroleum system.

Introduction

A petroleum system is a classification scheme identifying all the essential geologic elements and processes necessary for the creation of a family of petroleum accumulations in a sedimentary basin (Magoon, 1988). The essential elements include source rock, reservoir rock, seal, and trap. The level of certainty of the source rock identity in a petroleum system is expressed as known, hypothetical, or speculative depending on the amount of available geochemical, geophysical, and geologic evidence. The first step in characterizing petroleum systems is identifying and mapping the areal extent of oil and gas genetic types. The second step is to identify and map the extent of the effective source rock for each petroleum type. The geographic extent of a petroleum system is defined by the line that circumscribes the pod of active source rock and the locations of all petroleum shows, seeps, and accumulations that originated from that pod (Magoon and Dow, 1994). Because the petroleum system definition includes only known petroleum occurrences, the term "total petroleum system" was proposed to include genetically related undiscovered petroleum occurrences that may exist outside of the mapped petroleum system (Magoon and Schmoker, 2000). The maximum geographic extent of the total petroleum system includes the geographic extent of the petroleum system as well as areas where geologic evidence indicates that undiscovered petroleum accumulations may exist (Magoon and Schmoker, 2000).

In the year 2000, the USGS conducted a petroleum resource assessment of the Uinta-Piceance Province (fig. 1), which approximately coincides with the Uinta and Piceance Basins, and total petroleum system maps were used as a basis for defining assessment units. This report summarizes the crude oil characteristics of each petroleum system within the assessment area based on previous studies as well as new oil data and interpretation. Gas and source-rock analyses and the Ferron/Wasatch Plateau Total Petroleum System (Henry and Finn, Chapter 8, this CD-ROM) are not discussed in this report.

Methods

Over 170 oils, oil stains, and oil seeps from the Uinta-Piceance Province and surrounding areas were geochemically characterized (table 1). Oils were analyzed for bulk properties including sulfur content, API gravity, and the C_{15+} concentration of saturated and aromatic hydrocarbons, resins, and asphaltenes. Hydrocarbon compound distributions (for example, n-alkanes and acyclic isoprenoids) were determined by gas chromatography using a flame ionization detector. Stable carbon isotopes of the saturated and aromatic hydrocarbon fractions were determined by placing the products of sealed-tube combustion into a dual inlet isotope ratio mass spectrometer. For samples analyzed in the year 2000 (lab number beginning with 00, table 1), stable carbon isotopes were measured using an elemental analyzer interfaced with a continuous flow isotope ratio mass spectrometer. The relative concentrations of molecular fossils or biomarkers were determined by combined gas chromatography/mass spectrometry using selected-ion monitoring at mass-to-charge (*m/z*) ratios of 191.1800 (terpanes) and 217.1956 (steranes). Results were

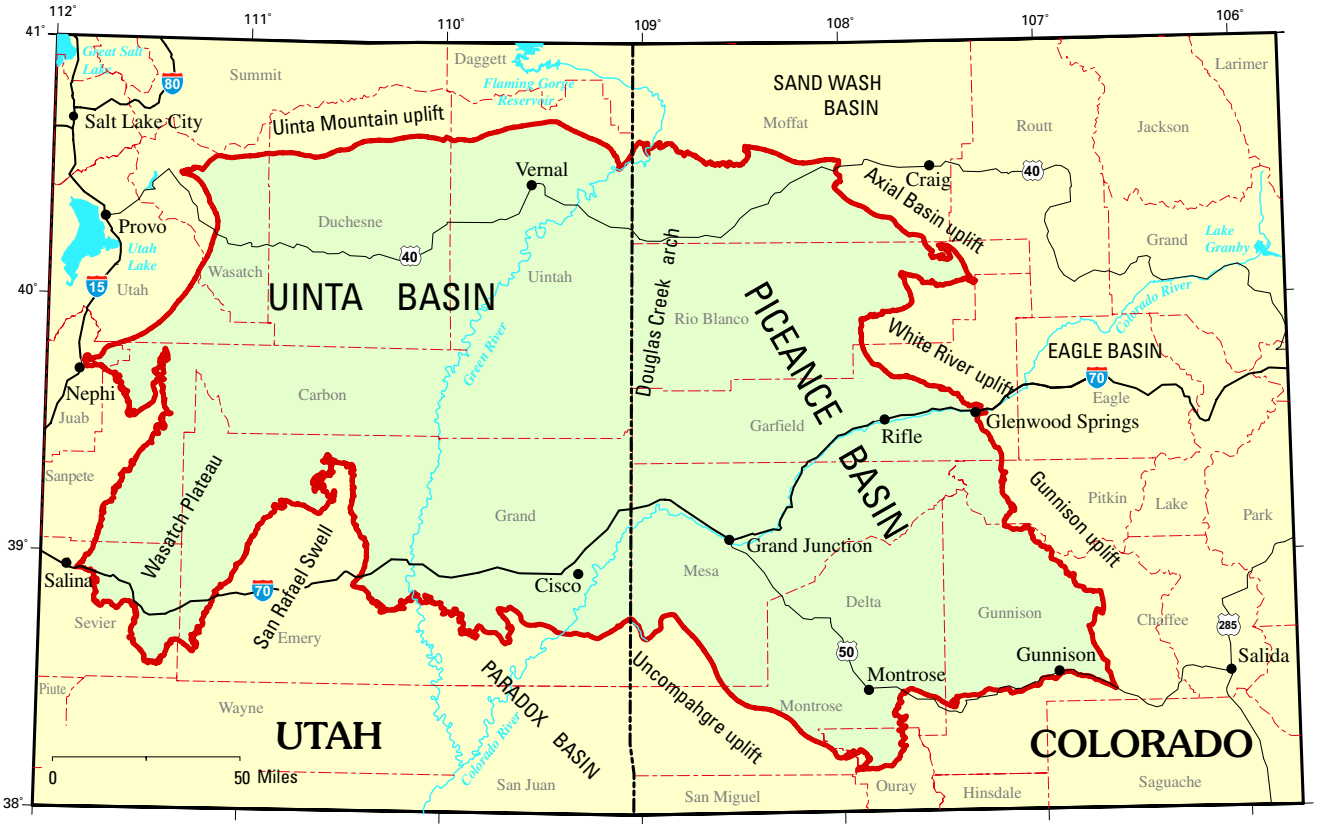

Figure 1. Index map of the Uinta-Piceance Province (red line). Province boundary roughly coincides with the geologically defined Uinta and Piceance Basins.

characterized and compared with data generated from previous USGS studies. For a more detailed description of the analytical methods, see Lillis and others (1999) and Lillis and others (2001).

The latitude/longitude for most of the well samples in table 1 is the latitude and longitude of the centroid (center point) of a quarter square mile (about 2,640 ft^2) cell that contains the well location (Laura Biewick, USGS, written commun., 2002). The cell grid was created in ESRI ARC/Info using North American Datum of 1983, Albers projection, and a cell side length of 804.5 m (2,639.4 ft). The maximum difference between the latitude/longitude of the cell's centroid and that of the actual well location should not exceed 569 m (1,866 ft).

The pour point data and some of the gravity and sulfur data in this report were taken from the U.S. Department of Energy Crude Oil Analysis database (COADB) version 2.0. The COADB contains the digital data compilation of 9,076 crude oil analyses from samples collected from 1920 through 1983, and analyzed by the U.S. Department of the Interior, Bureau of Mines (Sellers and others, 1996). Data include specific gravity, API gravity, pour point, viscosity, sulfur content, nitrogen content, color, and bulk properties of the distillation cuts. The COADB is currently available from the Department of Energy National Institute for Petroleum and Energy Research in Bartlesville, Okla. (http://www.npto.doe.gov/Software/dbindx.html).

Results and Discussion

Results of the analyses from the current study, as well as from previous studies, are listed in table 1. Sulfur content, stable carbon isotope values, and biomarker composition are the most useful geochemical parameters for the characterization of oil types. Several oil types are recognized within the Uinta-Piceance Province, and in many cases they can be linked to previously proposed oil types or source rocks. Recognized oil types include Minturn, Phosphoria, Grassy Trail Creek, Mancos, Mesaverde, and Green River. With the exception of Grassy Trail Creek, the oil types have been named after their presumed source rock units (fig. 2). Each oil type and its associated source rock provide substantiation for the identification and geographic extent of a petroleum system (of the same name). The Phosphoria, Mancos, Mesaverde, and Green River petroleum systems are components of the total petroleum systems that were assessed in the year 2000 by the USGS including Phosphoria, Mancos/Mowry, Mesaverde, and Green River, respectively. The most important sources of oil are the Lower Permian Phosphoria Formation or stratigraphically equivalent rocks, the Upper Cretaceous Mancos Group, and the Paleocene and Eocene Green River Formation.

Paleozoic, Cretaceous, and Tertiary petroleum systems are effectively distinguished based on stable carbon isotope values and the related canonical variable (CV) devised by

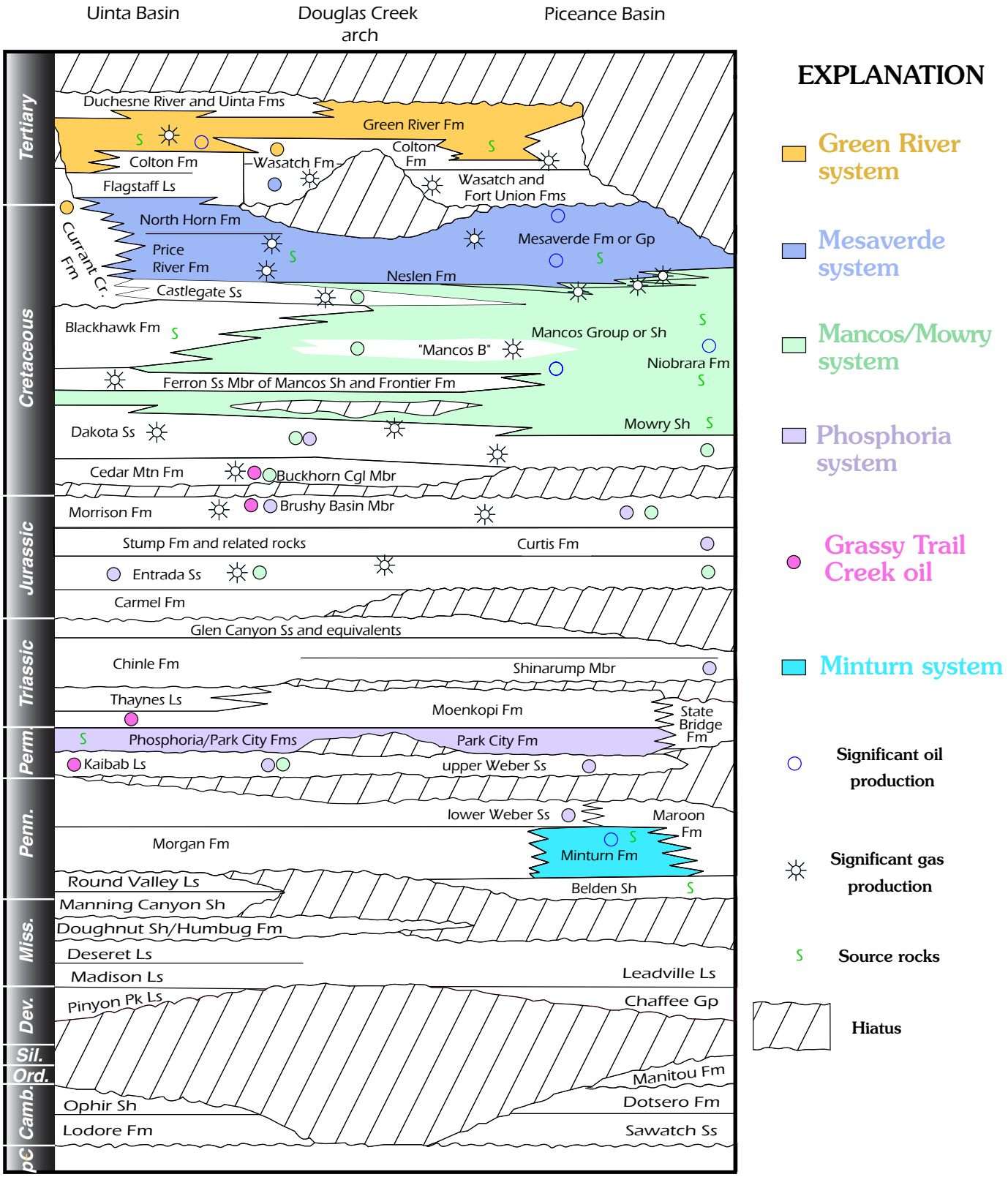

Figure 2. Generalized stratigraphic column of the Uinta-Piceance Province showing the distribution of petroleum system source rocks and associated oil types [modified from Sanborn (1977) and Spencer and Wilson (1988)].

Sofer (1984). Paleozoic oils in the Uinta-Piceance Province generally have CV values less than –1.3 whereas Cretaceous oils have CV values greater than –1.3 (table 1). The line where CV equals –1.3 is shown on figure 3. Sofer (1984) also defined a line equal to a CV of 0.47, which best separates waxy oils from nonwaxy oils (fig. 3). Waxy oils are usually derived from terrigenous organic matter, whereas nonwaxy oils are usually derived from marine organic matter. Based on this criterion all of the Paleozoic oils and most of the Mancos oils are derived from marine source rocks, whereas the Green River and Mesaverde oils are derived from terrigenous (nonmarine) source rocks.

Paleozoic Oil Types

Minturn

High-gravity (42°–70°API) oils and condensates are produced from the Middle Pennsylvanian Minturn Formation (Morgan Formation to the west) in fields in the northeastern part of the Piceance Basin (samples 3–5, fig. 4). These oils are herein called Minturn oil type because they have a distinctive heavy carbon isotopic signature (δ^{13}C saturated hydrocarbon values greater than –26 per mil) (fig. 3) and pristane/phytane (pr/ph) values between 1.6 and 1.9 (table 1). The low biomarker concentration and high oil gravity indicate a high thermal maturity.

The Minturn Formation, the Lower and Middle Pennsylvanian Belden Formation, and the Upper Cretaceous Mancos Group (or Shale) have been considered possible sources of the Minturn oil type (fig. 2). The Belden Formation has been recognized as a potential petroleum source rock in the Eagle Basin (Nuccio and Schenk, 1986; Waechter and Johnson, 1986) and was proposed as a possible source for oils in the Minturn Formation (Dodge and Bartleson, 1986) and for oil stains in the Schoolhouse Member of the Maroon Formation (Waechter and Johnson, 1986; Johnson and others, 1990). However, a Belden oil stain (sample 6) reported by Johnson and others (1990) does not appear to be genetically related to the Minturn oil type. For example, the δ^{13}C saturated hydrocarbon value of the Belden oil stain (–29.32 per mil) is more than 3 per mil lighter than the Minturn oils. Stone (1986a, 1990, 1994) believed that the oils in Minturn reservoirs are derived from the Upper Cretaceous Mancos Group (or Shale) based on pristane/phytane values and geologic considerations.

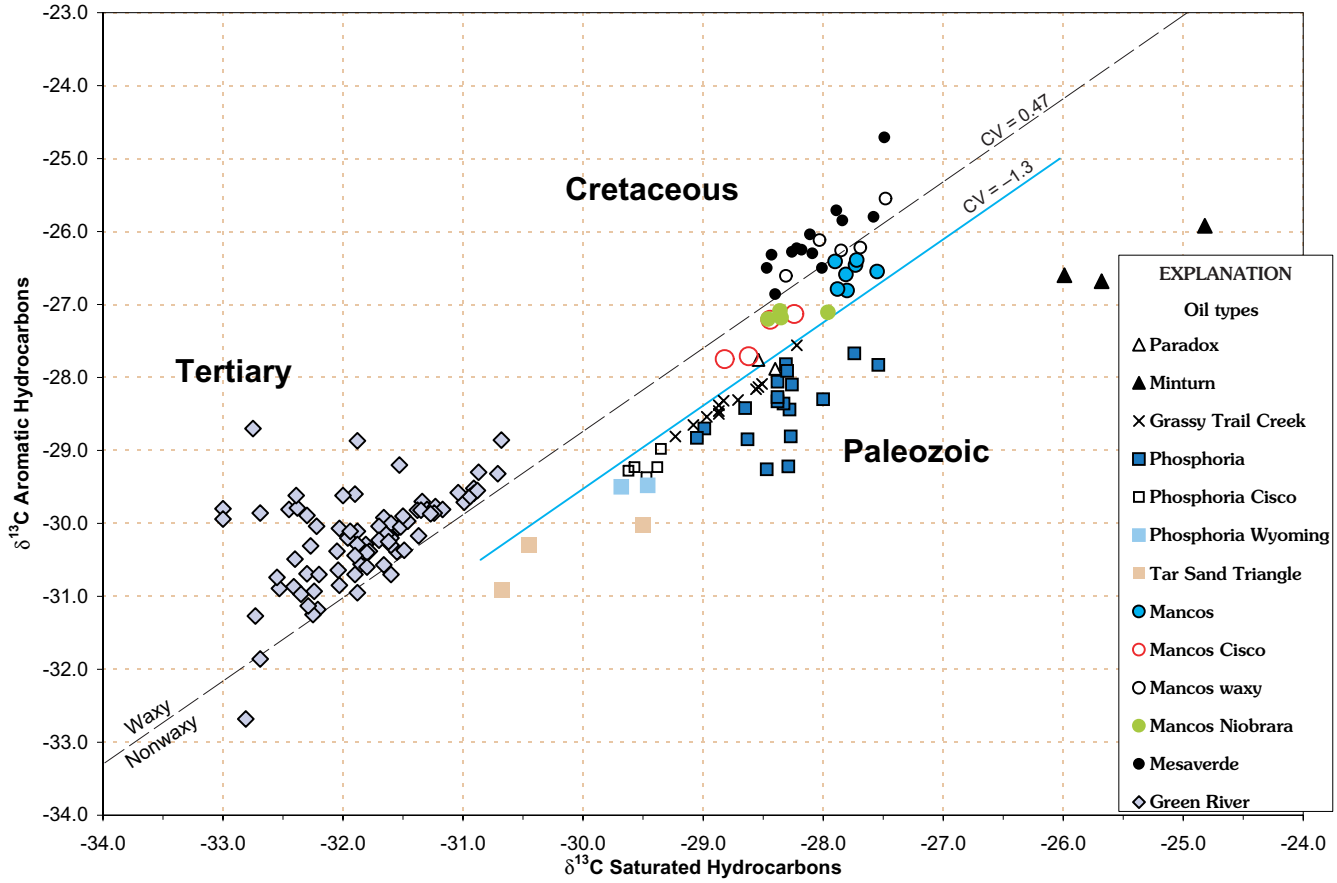

Figure 3. Stable carbon isotope values of oils, oil stains, and seeps from the Uinta-Piceance Province and adjacent areas. Dashed black line [canonical variable (CV) = 0.47] separates waxy (terrigenous source) from nonwaxy (marine source) oils (Sofer, 1984). Light-blue line (CV=–1.3) separates Cretaceous from Paleozoic oils.

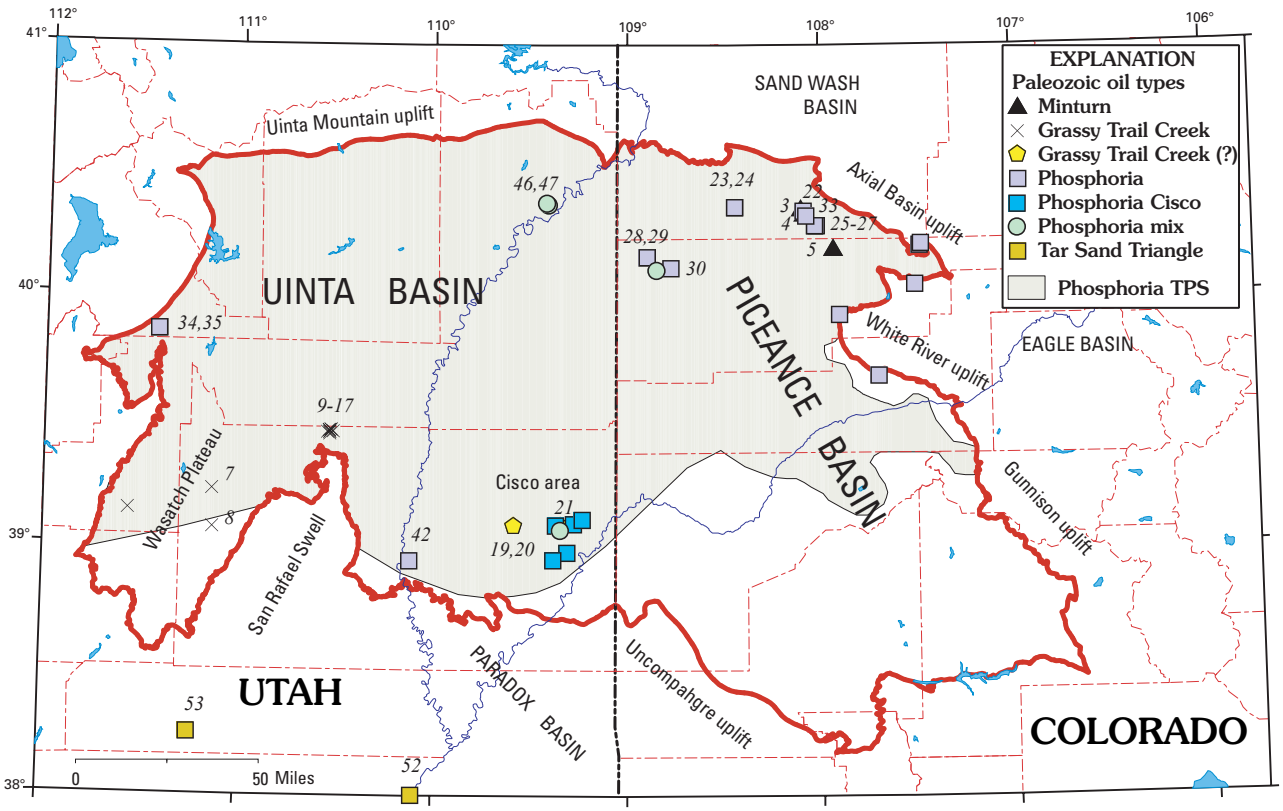

Figure 4. Paleozoic oil sample localities of the Uinta-Piceance Province (red line). Selected sample numbers are referred to in text. See table 1 for sample number key. Phosphoria Total Petroleum System from Johnson (Chapter 9, this CD-ROM).

However, the Minturn oil type can be distinguished from the Mancos oil type based on stable carbon isotope values (fig. 3) and C_{28} sterane and diasterane concentrations (fig. 5). Source-rock potential of the Minturn Formation was suggested by Nuccio and Schenk (1986), Dodge and Bartleson (1986), and Stone (1986a, 1990, 1994) although Nuccio and Schenk believed the Minturn to be gas-prone. The thick sequence of cyclically deposited rocks of the Minturn Formation and intertonguing Eagle Valley Evaporite (Eagle Basin) is possibly analogous to the Paradox Formation (Dodge and Bartleson, 1986; Waechter and Johnson, 1986; Spencer and Wilson, 1988; Stone, 1990). The Minturn petroleum system is proposed here with the Minturn Formation as the hypothetical source based on the Paradox petroleum system analogy (see further discussion of Paradox system below).

Grassy Trail Creek

The Grassy Trail Creek (GTC) oil type was previously recognized by Dembicki and others (1986) in the Grassy Trail Creek field (samples 9–17), but the oil type also occurs in the Buzzard Bench (sample 7) and Ferron (sample 8) fields in the western Uinta Basin and possibly in the Cisco area fields of the southeastern Uinta Basin (fig. 4). The oils are found in the Lower Permian Kaibab Limestone and Lower Triassic Moenkopi Formation and have high oil gravities (36°–42°API) and low sulfur contents (0.18–0.34 weight percent S). The pr/ph values of the GTC oil type range between 0.8 and 1.1, and the biomarker composition is characterized by a high diasterane content and a low hopanoid content. These oils are similar in composition to the Paradox oil type (see below) in the Paradox Basin except that Paradox oils have slightly higher pr/ph values (1.0–1.3) and hopanoid content and a lower sulfur content. However, it is difficult to determine whether the GTC oil type is genetically related to the Paradox oil type because of significant thermal alteration of both oil types. The stable carbon isotope values and limited biomarker data of the GTC oil type indicate an unknown anoxic marine Paleozoic source rock. Sprinkel and others (1997) have proposed that Grassy Trail Creek oil is derived from the Lower Permian Phosphoria Formation or equivalent strata.

Oil samples from the Brushy Basin Member of the Morrison Formation (Upper Jurassic) in the Cisco Dome field (samples 19, 20) and from the Buckhorn Conglomerate Member of the Cedar Mountain Formation (Lower Cretaceous) in the Cisco Springs field (sample 21) are similar to GTC and to Paradox oil types. More study is needed to determine if these oils are genetically related to the GTC oils or to some other oil type. Young (1983) proposed that the Cisco oils are nearly identical to those from the Pennsylvanian Paradox Formation of the Paradox Basin.

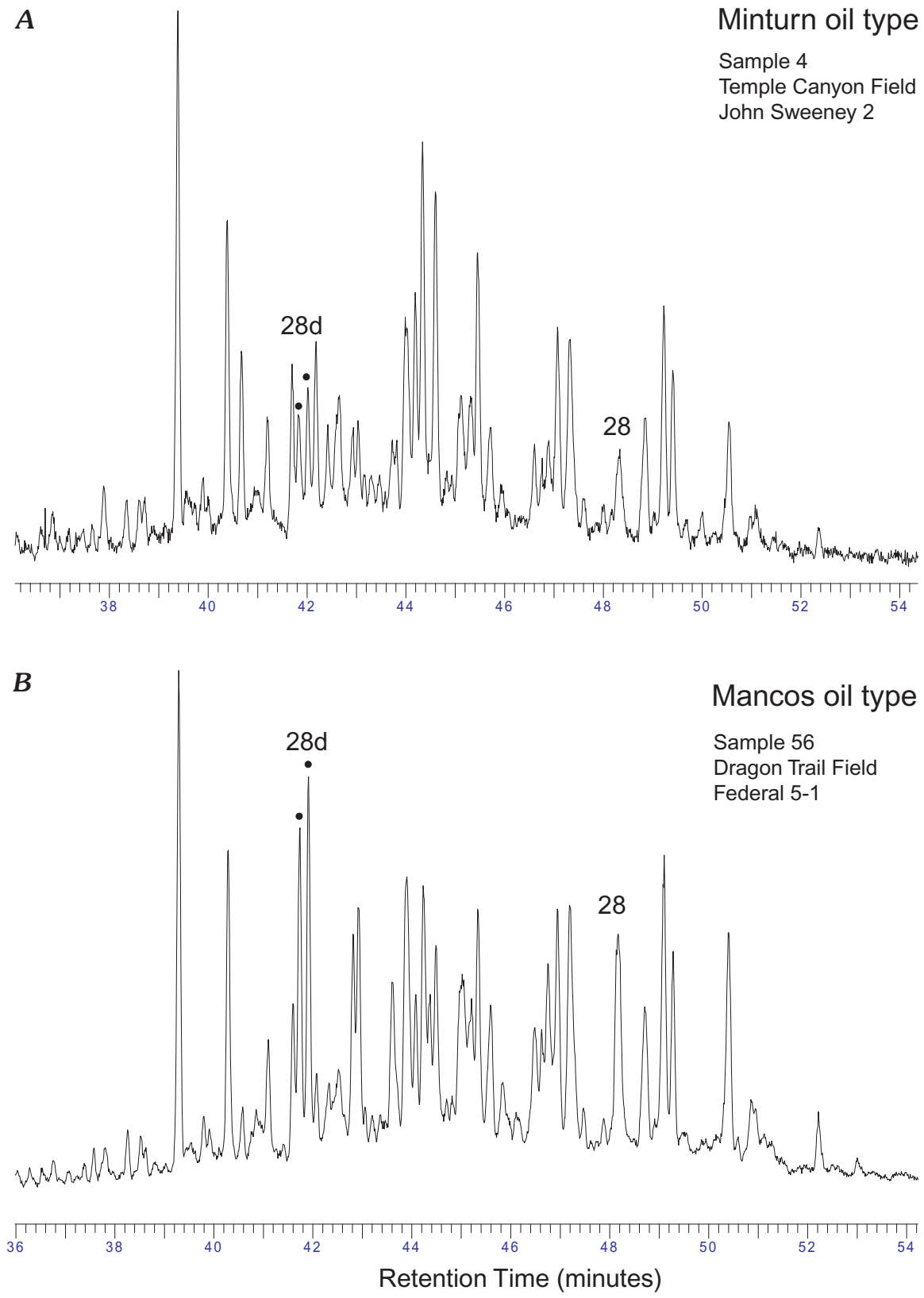

Figure 5. Sterane mass chromatograms (*m/z* 217) of *A*, Minturn and *B*, Mancos oil types, showing the differences in the C_{28} steranes (28) and diasteranes (28d).

Phosphoria

The Phosphoria oil type is widely distributed in fields throughout the northern Piceance and eastern Uinta Basins, including Rangely (samples 28–30), Ashley Valley (samples 46, 47), Elk Springs (samples 23, 24), Maudlin Gulch (samples 25–27), Temple Canyon (sample 33), and Danforth Hills (sample 22), and a number of Cisco area fields (fig. 4). Oil reservoirs include the Middle Pennsylvanian to Lower Permian Weber Sandstone, Upper Triassic Shinarump Member of the Chinle Formation, Middle Jurassic Entrada Sandstone, Middle Jurassic Curtis Formation, and Upper Jurassic Morrison Formation (fig. 2). Phosphoria oils are characterized by low to moderate diasterane content, higher sulfur content (0.5–1.4 weight percent S), and pr/ph values less than 1. The Permian Phosphoria Formation has previously been recognized as the source for oils in this area as well as in western Wyoming (Brenneman and Smith, 1958; Cheney and Sheldon, 1959; Sheldon, 1967; Stone, 1967; Barbat, 1967; Whitaker, 1975; Claypool and others, 1978; Seifert and Moldowan, 1981; Maughan, 1984; Stone, 1986b; Michael and others, 1990; Hefner and Barrow, 1992; Sprinkel and others, 1997) and the Phosphoria-Weber petroleum system has been proposed by Magoon (1988) with a known level of certainty. However, Waechter and Johnson (1986) and Johnson and others (1990) suggested a Belden source for oil in the Weber Sandstone at Rangely field. Phosphoria oils from the study area can be distinguished from the Phosphoria-derived oils in western Wyoming in that the Wyoming oils have a lower diasterane content, higher sulfur content, and more negative (lighter) stable carbon isotope values. This may be due to slight differences in source-rock thermal history or kerogen composition between the two areas.

Localities of Phosphoria oil type in the Uinta Basin (fig. 4) include Ashley Valley field (samples 46, 47), the Browns Peak well test (samples 34, 35), Cisco area fields, and a seep in Little Grand Wash near Green River, Utah (sample 36). Our analyses indicate that the oil in the Weber Sandstone at Ashley Valley field is a mixture of Phosphoria and Cretaceous oil. Stone (1986b) and Sprinkel and others (1997) reached a similar conclusion although Hefner and Barrow (1992) proposed a Cretaceous Mancos source. We believe that Cretaceous oil has charged the Jurassic Entrada Sandstone at Ashley Valley field based on the oil characteristics (low sulfur and high pour point) reported by Otto and Picard (1975). Our analysis of the Browns Peak oil (sample 34, 35) confirms the report by Dembicki and others (1986) that the oil correlates with Rangely oil (samples 28–30, Phosphoria oil type). High sulfur oils (0.7–1.3 weight percent S) in the Cisco area fields (Sieber Nose, Agate, Cisco Townsite, and Cisco Springs fields) are named Phosphoria Cisco oil type because the Cisco oils have slightly lower (more negative) stable carbon isotope values (fig. 3).

Cretaceous Oil Types

Mancos

The Mancos oil type is widely distributed throughout the northern Piceance, eastern Uinta, and southern Sand Wash Basins (fig. 6). The reservoir rocks include the Middle Jurassic Entrada Sandstone, Upper Jurassic Morrison Formation, Lower Cretaceous Dakota Sandstone and Cedar Mountain Formation, and Upper Cretaceous Niobrara Formation, Mancos A sand (Castlegate Sandstone Member of the Mancos Shale), and Mancos B sand (Emery Sandstone Member of the Mancos Shale). Stone (1986b) reported Mancos oil in a Weber reservoir in Moffat dome (Sand Wash Basin). Mancos oils are characterized by low sulfur content (less than 0.4 weight percent S), low to moderate pour point, medium gravity, and pr/ph values between 1.5 and 2.4. Mancos oils can be further subdivided based on stable carbon isotopes (fig. 3) and saturated/aromatic hydrocarbon values (sat/aro, table 1) into Mancos Cisco, Mancos waxy, and Mancos Niobrara oil groups. The Mancos Cisco group includes oils from the Entrada Sandstone and Buckhorn Conglomerate Member of the Cedar Mountain Formation in the Cisco Dome field (samples 63–66). These oils have low isotope values and high saturated/aromatic hydrocarbon values. Mancos waxy oils are located in Dakota Sandstone reservoirs in the northeastern Uinta-Piceance Province (fig. 6). These oils have isotope values that generally plot above the Sofer (1984) line on figure 3, suggesting a waxy (higher plant) source.

The Mancos Niobrara oil group occurs in the fractured shales of the Upper Cretaceous Niobrara Formation in a region from the northern Piceance to southern Sand Wash Basins. Although Niobrara fracture production has been exploited at Rangely field since the early 1900's (Turner, 1962), the concept of self-sourced fractured shale was not proposed until later (Mallory, 1977; Hefner and Barrow, 1992; Vincelette and Foster, 1992). As a result, the concept was assessed as the Cretaceous Self-Sourced Fractured Shales Play (2009) in the 1995 USGS assessment (Spencer, 1995).

The Cretaceous Mancos Group (or Shale) is a previously recognized source for oil in the area (Meissner and others, 1984; Stone, 1986a, b; Michael and others, 1990; Hefner and Barrow, 1992; Sprinkel and others, 1997) and is likely the source of the Mancos oil type. The Mancos is also proposed to be a source of nonassociated gas in the Piceance Basin (Johnson and Rice, 1990). The slightly older Aspen Formation/Mowry Shale is a source of oils in southwestern Wyoming (Rosenfeld and others, 1980; Seifert and Moldowan, 1981; Warner, 1982) and may be the source of Mancos waxy oils in the northeastern part of the Uinta-Piceance Province. For the purposes of the 2000 assessment, the Mancos and Mowry are considered together as the Mancos/Mowry Total Petroleum System (Kirschbaum, Chapter 6, this CD-ROM).

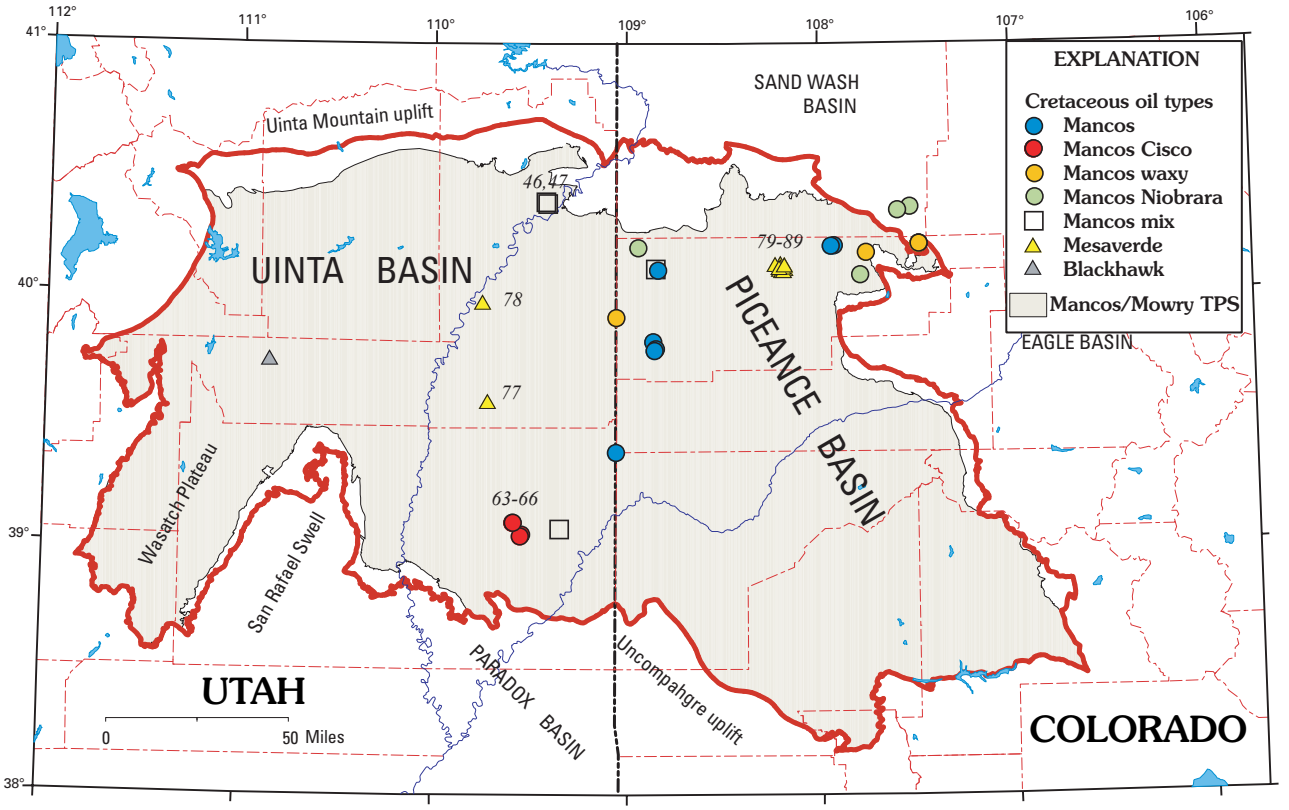

Figure 6. Cretaceous oil sample localities of the Uinta-Piceance Province (red line). Selected sample numbers are referred to in text. See table 1 for sample number key. Mancos/Mowry Total Petroleum System from Kirschbaum (Chapter 6, this CD-ROM).

Mesaverde

Widely scattered occurrences of Mesaverde oil type have been identified in the Uinta and Piceance Basins (fig. 6) in the Flat Rock (sample 77), Natural Buttes (sample 78), and White River Dome (samples 79–89) fields. Reservoirs include the Upper Cretaceous Mesaverde Group sandstones and the Paleocene and Eocene Wasatch Formation (fig. 2). The Mesaverde oil type is characterized by waxy (terrigenous) carbon isotope values (fig. 3), high pr/ph values (greater than 3.5), and high saturated/aromatic hydrocarbon values (table 1). These geochemical characteristics indicate that the source rock is coal or sediments with coaly organic matter (Clayton, 1993, and references therein) and we propose that Mesaverde Group rocks are the source. The Mesaverde Group was previously recognized as a possible oil source in northwest Colorado (Michael and others, 1990; Johnson and others, 1995). Pitman and others (1986) proposed that the Upper Cretaceous Tuscher and Farrer Formations of the Mesaverde Group may be a source for gas and possibly oil in eastern Uinta Basin. However, the Mesaverde Group is the presumed source of large quantities of nonassociated gas throughout the Piceance and Uinta Basins (Johnson and Rice, 1990; Rice and others, 1992; Johnson and Roberts, Chapter 7, this CD-ROM). We surmise that the hypothetical Mesaverde petroleum system is predominantly a gas system but has widely scattered areas of oil-prone source rocks that generated Mesaverde oil.

Tertiary Oil Types

Green River

The Green River oil type is widely distributed throughout the Uinta Basin (fig. 7). However, one oil sample is located in the Piceance Basin from Sulphur Creek field, Colorado (sample 164). Oils are found predominantly in the Paleocene and Eocene Wasatch and Green River Formations, but Green River oil has also migrated into Cretaceous and older strata along the strongly folded and faulted north flank of the Uinta Basin. Green River oil occurrences analyzed in this study include outcrop samples from the Asphalt Ridge (sample 165), Chinese Wax mine (sample 171), Tabiona (sample 166), Whiterocks (samples 169, 170), and Thistle (samples 167, 168) localities. Green River oil has a distinctive carbon isotope composition (fig. 3), high wax content (pour point greater than 55°F), and a low sulfur content (generally less than 0.3 weight percent S).

Most of the Green River oils fall into two subtypes (Green River A or Green River B) based on the odd or even carbon number predominance of the n-alkanes and the relative abundance of β-carotane. The carbon preferential index or CPI (Bray and Evans, 1961; Hunt, 1979, p. 303) approaches unity with increasing thermal maturity but also can be used to

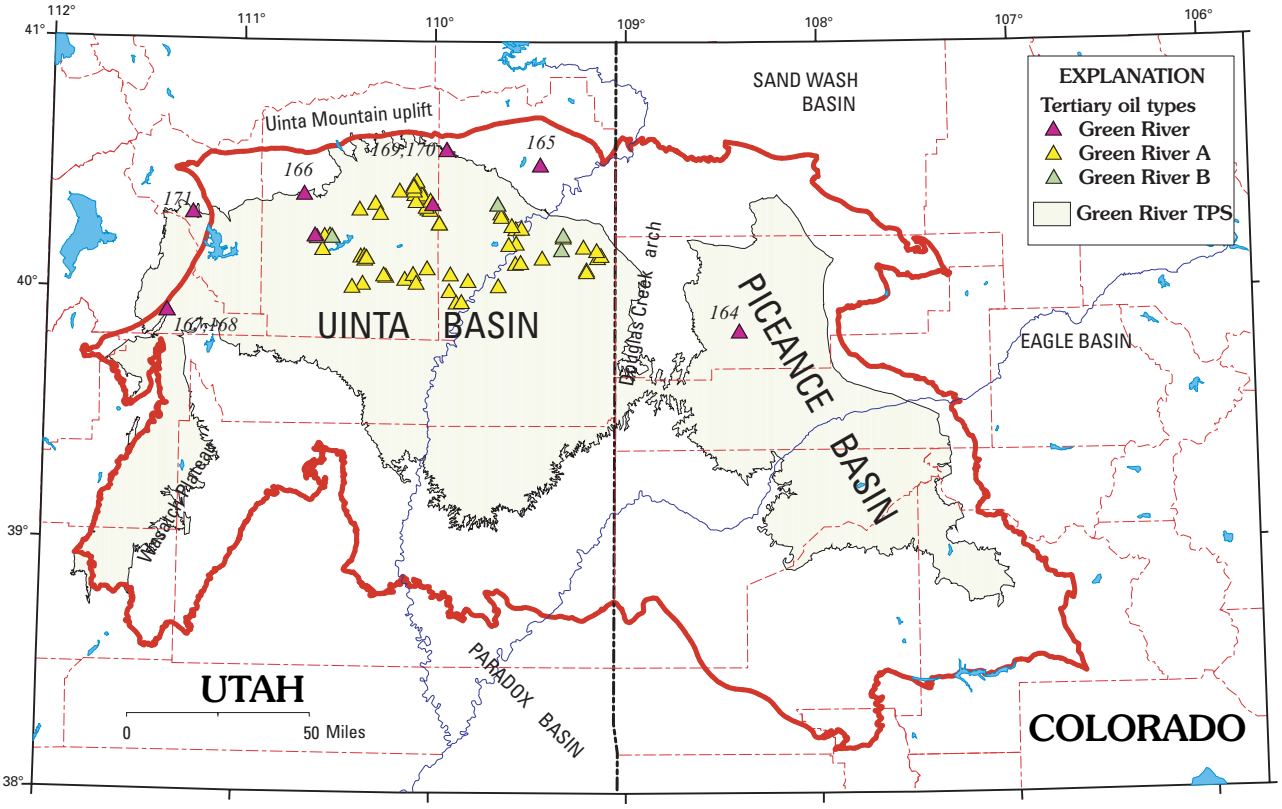

Figure 7. Tertiary oil sample localities of the Uinta-Piceance Province (red line). Selected sample numbers are referred to in text. See table 1 for sample number key. Green River Total Petroleum System from Dubiel (Chapter 5, this CD-ROM).

characterize organic facies within the Green River Formation (Tissot and others, 1978; Ruble and others, 2001). Green River A oils, by far the most common subtype, have a higher wax content, CPI less than 1.10, and low β-carotane content, whereas the less common Green River B oils generally have higher odd-carbon predominance (CPI greater than 1.2) and higher β-carotane content. The Paleocene and Eocene Green River Formation is a previously recognized source rock for oil in the Uinta Basin (Hunt and others, 1954; Forsman and Hunt, 1958; Silverman and Epstein, 1958), and the Green River petroleum system has been defined by Fouch and others (1994). The lower part of the Green River Formation is considered to be the primary source of Green River oil, whereas the mahogany shale facies (oil-shale) of the upper part of the Green River is a secondary source (Picard, 1962; Bell and Hunt, 1963; Reed and Henderson, 1972; Tissot and others, 1978; Anders and others, 1992; Fouch and others, 1994; Ruble, 1996; Mueller, 1998; Ruble and others, 2001). Based on a comparison of oil data in this report with published source-rock and oil data (Tissot and others, 1978; Ruble and others, 2001), we believe that Green River A oils are most likely derived from the lower black shale facies (nomenclature after Ruble, 1996) of the lower part of the Green River Formation whereas Green River B oils are derived from the mahogany shale facies or similar organic facies present in the Green River Formation. The Sulphur Creek oil (sample 164) has a distinct sulfur and stable carbon isotopic composition (table 1) and may be derived from a high salinity facies of the Green River Formation.

Oil Types Adjacent to the Assessment Area

The Tar Sand Triangle (TST) oils and Paradox oils are two major oil types adjacent to the current assessment area south of the Uinta Basin (fig. 1) that may have migrated into the assessment area or may be genetically related to petroleum systems within the assessment area. The TST oil type is widely distributed throughout south-central Utah, including outcrops of tar sands in the Tar Sand Triangle, Circle Cliffs, and San Rafael Swell areas (samples 52, 53, fig. 4), as well as the oil (sample 51) in Upper Valley field (Dembicki and others, 1986; Wenrich and Palacas, 1992; Lillis and Palacas, 1998). TST oils are found in the Lower Permian White Rim Sandstone Member of the Cutler Formation, Lower Permian Kaibab Limestone, Lower and Middle Triassic Moenkopi Formation, Upper Triassic Chinle Formation, Lower Jurassic Navajo Sandstone, and Middle Jurassic Entrada Sandstone. TST oils are similar in composition to the Phosphoria oil type in the Uinta-Piceance Province except that TST oils have a higher sulfur content (greater than 1.5 weight percent S), lower diasterane content, and lower stable carbon isotope values

(Lillis and Palacas, 1998). The source of TST oil is unknown, but many sources have been proposed, including the Lower and Middle Triassic Moenkopi Formation (Baars and Seager, 1970; Spencer, 1975; Mitchell, 1984; Spencer and Wilson, 1988), Lower Permian Phosphoria Formation (Dana and others, 1984; Sprinkel and others, 1997; Peterson, 1997; Lillis and Palacas, 1998), Mississippian Chainman Shale (Magoon, 1988), and the Mississippian Delle Phosphatic Member of the Deseret Limestone (Huntoon and others, 1999).

The Paradox oil type is widely distributed throughout the Paradox Basin and may extend northward into the Uinta Basin. The oils, which are generally found within the Middle and Upper Pennsylvanian Hermosa Group, have high gravity (over 40°API), low sulfur content (less than 0.2 weight percent S), lean biomarker concentrations, and stable carbon isotope values similar to those of other Paleozoic oils (fig. 3). The Middle Pennsylvanian Paradox Formation is the most likely source for most of the oils in the Paradox Basin (Barbat, 1967; Hite and others, 1984; Nuccio and Condon, 1996), hence the hypothetical Paradox-Hermosa petroleum system has been proposed (Magoon, 1988). As mentioned above, the Paradox oil type is similar in composition to the Grassy Trail Creek oil type and two oils from the Cisco Dome and Cisco Springs fields, but more study is needed to determine any genetic relationships between these oils.

Conclusions

Based on previous studies and new data presented in this report several oil types and petroleum systems are recognized within the Uinta-Piceance Province and adjacent areas. Identified oil types may be grouped into Paleozoic, Cretaceous, and Tertiary petroleum systems based on stable carbon isotope composition. The most prominent source of oil from Paleozoic rocks is the Lower Permian Phosphoria Formation. New data from the Cisco area in Utah show that the Phosphoria petroleum system extends much farther south than previously mapped by Fouch and others (1994). However, Sprinkel and others (1997) proposed a single Permian oil type that includes the Phosphoria, Grassy Trail Creek, and Tar Sand Triangle (TST) oil types of this study. We agree that the composition of the TST oil type is similar to that of the Phosphoria oil type and may be genetically related. However, the distinct chemical differences (discussed above) prevent us from including the Tar Sand Triangle oils in the Phosphoria petroleum system at this time.

Because of the distinctive $\delta^{13}C$ values of the Minturn oil type and the geologic similarities between the Minturn and the Paradox Formations, the Minturn petroleum system is proposed. The areal extent of this system is limited to the northeastern Piceance, Sand Wash, and Eagle Basins.

The source of the previously recognized Grassy Trail Creek oil type is unknown but could be related to either the Paradox or Phosphoria petroleum systems. The areal extent of the GTC oil type has been enlarged based on new data.

The Upper Cretaceous Mancos Group (and equivalent rocks) is the main source of Cretaceous oil in the Uinta-Piceance Province, whereas the Upper Cretaceous Mesaverde Group is a minor source of oil. However, both the Mancos and the Mesaverde are major sources of nonassociated gas in the province. Organic facies variations within the Mancos Group are reflected in the composition of the Mancos oil subtypes. The Lower Cretaceous Mowry Shale may be the source of the waxy oils in Dakota Sandstone reservoirs in the northeastern part of the Uinta-Piceance Province.

The lower black shale facies of the Green River Formation is the main source of Tertiary oil, and new data presented herein extend the size of the Green River petroleum system. Other facies of the Green River Formation such as the mahogany zone have contributed oil to the area and may warrant treatment as a separate petroleum system in the future.

Acknowledgments

Many of the oil samples used for this report originated from Robert Carlson of Chevron Oil Company and Lee Allison, Tom Chidsey, and Dave Tabet of the Utah Geological Survey; we thank these organizations for their cooperation. Samples were also provided by Robert Weimer, Newt Burkhalter, Warren Dickenson, Dietmar Schumacher, Kurt Constenius, Bob Grabb, Paula Hansley, Gary Mitchell, Karen Wenrich, Samuel Johnson, Dudley Rice, Jim Palacas, Joe Dyk, Walter Broadhead, Robert Reynolds, Charles Spencer, Ronald Johnson, and Jerry Clayton. Analyses were performed by the authors and by other past and present personnel of the USGS Organic Geochemistry Laboratory in Denver, Colo. These include Don Anders, Eric Michael, April Vuletich, Charles Threlkeld, Mike Pribil, Mark Monk, and Sara Rudzik. Laura Biewick provided derived latitude/longitude data and GIS support. The manuscript was greatly improved by reviews from Christopher Schenk, Mark Kirschbaum, Katharine Varnes, and Richard Keefer (USGS). We also thank James Palacas, Michael Lewan, and Tim Ruble for their comments on the manuscript and detailed discussions on Utah petroleum systems and geology.

References Cited

Anders, D.E., Palacas, J.G., and Johnson, R.C., 1992, Thermal maturity of rocks and hydrocarbon deposits, Uinta Basin, Utah, *in* Fouch, T.D., Nuccio, V.F., and Chidsey, T.C., eds., Hydrocarbon and mineral resources of the Uinta Basin, Utah and Colorado: Utah Geological Association Guidebook 20, p. 53–76.

Baars, D.L., and Seager, W.R., 1970, Stratigraphic control of petroleum in White Rim Sandstone (Permian) in and near Canyonlands National Park, Utah: American Association of Petroleum Geologists Bulletin, v. 54, p. 709–718.

Barbat, W.N., 1967, Crude-oil correlations and their role in exploration: American Association of Petroleum Geologists Bulletin, v. 51, p. 1255–1292.

Bell, K.G., and Hunt, J.M., 1963, Native bitumens associated with oil shales, *in* Berger, I.A., ed., Organic geochemistry: New York, Macmillan, p. 333–366.

Bray, E.E., and Evans, E.D., 1961, Distribution of n-paraffins as a clue to recognition of source beds: Geochimica et Cosmochimica Acta, v. 22, p. 2–15.

Brenneman, M.C., and Smith, P.V., 1958, The chemical relationships between crude oils and their source rocks, *in* Weeks, L.G., ed., Habitat of oil: American Association of Petroleum Geologists, p. 818–849.

Cheney, T.M., and Sheldon, R.P., 1959, Permian stratigraphy and oil potential, Wyoming and Utah, *in* Intermountain Association of Petroleum Geologists 10th Annual Field Conference: Intermountain Association of Petroleum Geologists, p. 90–100.

Claypool, G.E., Love, A.H., and Maughan, E.K., 1978, Organic geochemistry, incipient metamorphism, and oil generation in black shale members of Phosphoria Formation, Western Interior United States: American Association of Petroleum Geologists Bulletin, v. 62, p. 98–120.

Clayton, J.L., 1993, Composition of crude oils generated from coals and coaly organic matter in shales, *in* Law, B.E., and Rice, D.D., eds., Hydrocarbons from coal: American Association of Petroleum Geologists Studies in Geology 38, p. 185–201.

Dana, G.F., Oliver, R.L., and Elliott, J.R., 1984, Geology and resources of the Tar Sand triangle, southeastern Utah: U.S. Department of Energy Report DE-FC-83FE60177, 50 p.

Dembicki, H., Anderson, M.J., and Diedrich, R.P., 1986, Oil-to-oil correlation in northwestern Colorado Plateau [abs.]: American Association of Petroleum Geologists Bulletin, v. 70, p. 1036–1037.

Dodge, C.N., and Bartleson, B.L., 1986, The Eagle basin—A new exploration frontier, *in* Stone, D.S., and Johnson, K.S., eds., New interpretations of northwest Colorado geology: Rocky Mountain Association of Geologists, p. 113–121.

Forsman, J.P., and Hunt, J.M., 1958, Insoluble organic matter (kerogen) in sedimentary rocks of marine origin, *in* Weeks, L.G., ed., Habitat of oil: American Association of Petroleum Geologists, p. 747–778.

Fouch, T.D., Nuccio, V.F., Anders, D.E., Rice, D.D., Pitman, J.K., and Mast, R.F., 1994, Green River(!) petroleum system, Uinta Basin, Utah, U.S.A., *in* Magoon, L.B., and Dow, W.G., eds., The petroleum system—From source to trap: American Association of Petroleum Geologists Memoir 60, p. 399–421.

Hefner, T.A., and Barrow, K.T., 1992, Rangely Field—U.S.A., Uinta/Piceance Basins, Colorado, *in* Beaumont, E.A., and Foster, N.H., eds., Structural traps III, Tectonic fold and fault trap: American Association of Petroleum Geologists, Treatise of Petroleum Geology, Atlas of Oil and Gas Fields, v. A–25, p. 29–56.

Hite, R.J., Anders, D.E., and Ging, T.G., 1984, Organic-rich source rocks of Pennsylvanian age in the Paradox Basin of Utah and Colorado, *in* Woodward, J., Meissner, F.F., and Clayton, J.L., eds., Hydrocarbon source rocks of the greater Rocky Mountain region: Rocky Mountain Association of Geologists, p. 255–274.

Hunt, J.M., 1979, Petroleum geochemistry and geology: San Francisco, W.H. Freeman and Company, 617 p.

Hunt, J.M., Stewart, F., and Dickey, P.A., 1954, Origin of hydrocarbons of Uinta basin, Utah: American Association of Petroleum Geologists Bulletin, v. 38, p. 1671–1698.

Huntoon, J.E., Hansley, P.L., and Naeser, N.D., 1999, The search for a source rock for the giant Tar Sand Triangle accumulation, southeastern Utah: American Association of Petroleum Geologists Bulletin, v. 83, p. 467–495.

Johnson, R.C., and Rice, D.D., 1990, Occurrence and geochemistry of natural gases, Piceance basin, northwest Colorado: American Association of Petroleum Geologists Bulletin, v. 74. p. 805–829.

Johnson, R.C., Rice, D.D., and Finn, T.M., 1995, Coal-bed gas plays of the Piceance Basin, *in* Gautier, D.L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., eds., 1995 National assessment of United States oil and gas resources—Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDS–30, p. 44–49.

Johnson, S.Y., Schenk, C.J., Anders, D.E., and Tuttle, M.L., 1990, Sedimentology and petroleum occurrence, Schoolhouse Member, Maroon Formation (Lower Permian), northwestern Colorado: American Association of Petroleum Geologists Bulletin, v. 74, p. 135–150.

Lillis, P.G., Lewan, M.D., Warden, A., Monk, S.M., and King, J.D., 1999, Identification and characterization of oil types and their sources, *in* The oil and gas resource potential of the Arctic National Wildlife Refuge 1002 area, Alaska: U.S. Geological Survey Open-File Report 98–34, p. OA1–OA101.

Lillis, P.G., Magoon, L.B., Stanley, R.G., McLaughlin, R.J., and Warden, A., 2001, Characterization of Northern California petroleum by stable carbon isotopes: U.S. Geological Survey Open-File Report 99–164, 13 p.

Lillis, P.G., and Palacas, J.G., 1998, Oil families in the Grand Staircase–Escalante National Monument, Utah, *in* Hill, L.M., ed., Learning from the land—Grand Staircase–Escalante National Monument Science Symposium proceedings, November 4–5, 1997, Southern Utah University: U.S. Department of the Interior, Bureau of Land Management, p. 319–320.

Magoon, L.B., 1988, The petroleum system—A classification scheme for research, exploration, and resource assessment: U.S. Geological Survey Bulletin 1870, p. 2–15.

Magoon, L.B., and Dow, W.G., 1994, The petroleum system, *in* Magoon, L.B., and Dow, W.G., eds., The petroleum system—From source to trap: American Association of Petroleum Geologists Memoir 60, p. 3–24.

Magoon, L.B., and Schmoker, J.W., 2000, The total petroleum system—The natural fluid network that constrains the assessment unit, *in* U.S. Geological Survey world petroleum assessment 2000—Description and results: U.S. Geological Survey Digital Data Series DDS–60, p. PS1–PS20.

Mallory, W.W., 1977, Fractured shale hydrocarbon reservoirs in southern Rocky Mountain basins, *in* Veal, H.K., ed., Exploration frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, p. 89–94.

Maughan, E.K., 1984, Geological setting and some geochemistry of petroleum source rocks in the Permian Phosphoria Formation, *in* Woodward, J., Meissner, F.F., and Clayton, J.L., eds., Hydrocarbon source rocks of the greater Rocky Mountain region: Rocky Mountain Association of Geologists, p. 281–294.

Meissner, F.F., Woodward, J., and Clayton, J.L., 1984, Stratigraphic relationships and distribution of source rocks in the greater Rocky Mountain region, *in* Woodward, J., Meissner, F.F., and Clayton, J.L., eds., Hydrocarbon source rocks of the greater Rocky Mountain region: Rocky Mountain Association of Geologists, p. 1–34.

Michael, G.E., Anders, D.E., and Dickinson, W., 1990, Crude oil and source rock correlation, Northwest Colorado [abs.]: American Association of Petroleum Geologists Bulletin, v. 74, p. 1337.

Mitchell, G.C., 1984, Permo-Triassic of Northwestern Paradox Basin area, Utah: American Association of Petroleum Geologists Bulletin,

v. 68, p. 943.
Mueller, E., 1998, Temporal and spatial source rock variations and the consequence on crude oil composition in the Tertiary petroleum system of the Uinta Basin, Utah, U.S.A.: Norman, Okla., University of Oklahoma Ph.D. dissertation, 264 p.
Nuccio, V.F., and Condon, S.M., 1996, Burial and thermal history of the Paradox Basin, Utah and Colorado, and petroleum potential of the Middle Pennsylvanian Paradox Basin: U.S. Geological Survey Bulletin 2000–O, p. O1–O41.
Nuccio, V.F., and Schenk, C.J., 1986, Thermal maturity and hydrocarbon source-rock potential of the Eagle Basin, northwestern Colorado, *in* Stone, D.S., ed., New interpretations of northwest Colorado geology: Rocky Mountain Association of Geologists, p. 259–264.
Otto, E.P., and Picard, M.D., 1975, Stratigraphy and oil and gas potential of Entrada Sandstone (Jurassic), northeastern Utah, *in* Bolyard, D.W., ed., Deep drilling frontiers of the central Rocky Mountains: Rocky Mountain Association of Geologists, p. 129–139.
Peterson, J.A., 1997, The Carboniferous-Permian (late Paleozoic) hydrocarbon system, Rocky Mountains, U.S. region, with analysis of evidence for origin of the central Utah tar and heavy oil deposits [abs.]: American Association of Petroleum Geologists Bulletin, v. 81, p. 1231.
Picard, M.D., 1962, Source beds in Red Wash–Walker Hollow field, eastern Uinta Basin, Utah: Bulletin of the American Association of Petroleum Geologists, v. 46, p. 690–694.
Pitman, J.K., Anders, D.E., Fouch, T.D., and Nichols, D.J., 1986, Hydrocarbon potential of nonmarine Upper Cretaceous and Lower Tertiary rocks, Eastern Uinta Basin, Utah, *in* Spencer, C.W., and Mast, R.F., eds., Geology of tight gas reservoirs: American Association of Petroleum Geologists Studies in Geology 24, p. 235–251.
Reed, W.E., and Henderson, W., 1972, Proposed stratigraphic controls on the composition of crude oils reservoired in the Green River Formation, Uinta Basin, Utah, *in* Gaertner, H.R., and Wehner, H., eds., Advances in organic geochemistry, 1971: New York, Pergamon, p. 499–515.
Rice, D.D., Fouch, T.D., and Johnson, R.C., 1992, Influence of source rock type, thermal maturity, and migration on composition and distribution of natural gases, Uinta basin, Utah, *in* Fouch, T.D., Nuccio, V.F., and Chidsey, T.C., eds., Hydrocarbon and mineral resources of the Uinta basin, Utah and Colorado: Utah Geological Association Guidebook 20, p. 95–109.
Rosenfeld, J.K., Ho, T.T.Y., and Dembicki, H., 1980, Oil-to-source correlation—Pineview field, Overthrust Belt, Utah [abs.]: American Association of Petroleum Geologists Bulletin, v. 64, p. 776.
Ruble, T.E., 1996, Geochemical investigation of the mechanisms of hydrocarbon generation and accumulation in the Uinta Basin, Utah: Norman, Okla., University of Oklahoma Ph.D. dissertation, 333 p.
Ruble, T.E., Philp, R.P., and Lewan, M.D., 2001, New insights on the Green River petroleum system in the Uinta basin from hydrous pyrolysis experiments: American Association of Petroleum Geologists Bulletin, v. 85, p. 1333–1371.
Sanborn, A.F., 1977, Possible future petroleum of Uinta and Piceance basins and vicinity, Northeast Utah and Northwest Colorado, *in* Veal, H.K., ed., Exploration frontiers of the central and southern Rockies: Rocky Mountain Association of Geologists, p. 151–166.
Seifert, W.K., and Moldowan, J.M., 1981, Paleoreconstruction by biological markers: Geochimica et Cosmochimica Acta, v. 45, p. 783–794.
Sellers, C., Fox, B., and Pautz, J., 1996, Bartlesville Project Office crude oil analysis user's guide: U.S. Department of Energy DOE/BC-96/3/SP, 23 p.
Sheldon, R.P., 1967, Long-distance migration of oil in Wyoming: Mineral Resources Development Series, v. 26, p. 113–117.
Silverman, S.R., and Epstein, S., 1958, Carbon isotopic compositions of petroleums and other sedimentary organic materials: American Association of Petroleum Geologists Bulletin, v. 42, p. 998–1012.
Sofer, Z., 1984, Stable carbon isotope compositions of crude oils—Application to source depositional environments and petroleum alteration: American Association of Petroleum Geologists Bulletin, v. 68, p. 31–49.
Spencer, C.W., 1975, Petroleum geology of east-central Utah and suggested approaches to exploration: Four Corners Geological Society 8th Field Conference Guidebook, p. 263–275.
———1995, Uinta-Piceance Basin Province (020), *in* Gautier, D.L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., eds., 1995 National assessment of United States oil and gas resources—Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDS–30, 57 p.
Spencer, C.W., and Wilson, R.J., 1988, Petroleum geology and principal exploration plays in the Uinta-Piceance-Eagle Basins Province, Utah and Colorado: U.S. Geological Survey Open-File Report 88–0450–G, 35 p.
Sprinkel, D.A., Castano, J.R., and Roth, G.W., 1997, Emerging plays in central Utah based on a regional geochemical, structural, and stratigraphic evaluation [abs.]: American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists Annual Meeting Abstracts, v. 6, p. 110.
Stone, D.S., 1967, Theory of Paleozoic oil and gas accumulation in Big Horn basin, Wyoming: American Association of Petroleum Geologists Bulletin, v. 51, p. 2056–2114.
———1986a, Geology of the Wilson Creek Field, Rio Blanco County, Colorado, *in* Stone, D.S., and Johnson, K.S., eds., New interpretations of Northwest Colorado geology: Rocky Mountain Association of Geologists, p. 229–246.
———1986b, Rangely Field summary, 2, Seismic profile, structural cross section, and geochemical comparisons, *in* Stone, D.S., and Johnson, K.S., eds., New interpretations of Northwest Colorado geology: Rocky Mountain Association of Geologists, p. 226–228.
———1990, Wilson Creek Field U.S.A., Piceance Basin, northern Colorado, *in* Beaumont, E.A., and Foster, N.H., compilers, Structural traps III, Tectonic fold and fault traps: American Association of Petroleum Geologists Treatise of Petroleum Geology, Atlas of Oil and Gas Fields, v. A–019, p. 57–101.
———1994, New geochemical data bearing on the source of the oils in Wilson Creek Field, northwest Colorado: The Mountain Geologist, v. 31, no. 4, p. 115–118.
Tissot, B., Deroo, G., and Hood, A., 1978, Geochemical study of the Uinta Basin; formation of petroleum from the Green River Formation: Geochimica et Cosmochimica Acta, v. 42, no. 10, p. 1469–1486.
Turner, D.S., 1962, Controls of oil and gas accumulation, *in* Exploration for oil and gas in Northwestern Colorado: Rocky Mountain Association of Geologists, p. 29–33.
Vincelette, R.R., and Foster, N.H., 1992, Fractured Niobrara of northwest Colorado, *in* Schmoker, J.W., Coalson, E.B., and Brown, C.A., eds., Geological studies relevant to horizontal drilling—Examples from western North America: Rocky Mountain Association of Geologists, p. 227–240.
Waechter, N.B., and Johnson, W.E., 1986, Pennsylvanian-Permian paleostructure and stratigraphy as interpreted from seismic data in the Piceance Basin, northwest Colorado, *in* Stone, D.S., and Johnson, K.S., eds., New interpretations of Northwest Colorado geology: Rocky Mountain Association of Geologists, p. 51–64.

Warner, M.A., 1982, Source and time of generation of hydrocarbons in the Fossil basin, Western Wyoming thrust belt, *in* Powers, R.B., ed., Geologic studies of the Cordilleran thrust belt: Rocky Mountain Association of Geologists, p. 805–815.

Wenrich, K.J., and Palacas, J.G., 1992, Organic matter and uranium in solution-collapse breccia pipes of northern Arizona and San Rafael swell, Utah, *in* Dickinson, K.A., ed., Short papers of the U.S. Geological Survey Uranium Workshop, 1990: U.S. Geological Survey Circular 1069, p. 36–50.

Whitaker, R.M., 1975, Upper Pennsylvanian and Permian strata of northeast Utah and northwest Colorado, *in* Bolyard, D.W., ed., Deep drilling frontiers of the central Rocky Mountains: Rocky Mountain Association of Geologists, p. 75–85.

Young, R.G., 1983, Petroleum in Northeastern Grand County, Utah, *in* Averett, W.R., ed., Northern Paradox basin–Uncompahgre Uplift, Field Trip October 1–2, 1983: Grand Junction Geological Society, p. 1–7.

Table 1. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

[Area, other than Uinta-Piceance; area abbreviations: PB=Paradox Basin, EB=Eagle Basin, WRU=White River uplift, B=Big Horn Basin, W=Wind River Basin, SCU=south-central Utah, OV=Overthrust, SWB=Sand Wash Basin. Sec-T-R=section-township-range. Source=source of latitude/longitude; source abbreviations: cell=derived from a 1/4 square mile grid (see Methods), topo=calculated from a topographic map, GPS=measured with a global positioning satellite unit. Comments abbreviations: COADB=Crude Oil Analysis database (see Methods), DST=drill-stem test, TD=total depth. $\delta^{13}C$ in per mil relative to PDB standard. CV=canonical variable (Sofer, 1984) equal to $-2.53\delta^{13}Csat + 2.22\delta^{13}Caro - 11.65$. Gravity=oil gravity in degrees API. Sulfur=weight percent sulfur. Pr/Ph=pristane/phytane. CPI=carbon preferential index (Hunt, 1979, p. 303). β C=β carotane abundance; abundance abbreviations: 0=none, tr=trace, +=minor, ++=minor, +++=moderate, ++++=high. Sat/Aro=saturated/aromatic hydrocarbons. Lab Number=USGS Organic Geochemistry laboratory number, Denver, Colo.]

Sample	Area	Oil type	Field name	Well or sample name	Unit age	Unit name	Depth (ft)
1	PB	Paradox	Aneth Greater	Navajo D 1	Pennsylvanian	Paradox Fm. - Desert Creek zone	---
2	PB	Paradox	Ismay	Navajo-J 1	Pennsylvanian	Paradox Fm. - Ismay zone	5585 - 5625
3	---	Minturn	Danforth Hills	Govt-Treleaven 11	Pennsylvanian	Minturn Fm.	9698 - 9752
4	---	Minturn	Temple Canyon	John Sweeney 2	Pennsylvanian	Minturn Fm.	9354 - 9686
5	---	Minturn	Wilson Creek	tank battery - Minturn fm	Pennsylvanian	Minturn Fm.	---
6	EB	Belden	outcrop oil stain	Belden McCoy stain	Pennsylvanian	Belden Fm.	surface
7	---	Grassy Trail Creek	Buzzard Bench	Federal 41-33	Triassic	Moenkopi Fm.	9462 - 9472
8	---	Grassy Trail Creek	Ferron	Ferron Unit 42-21 3	Permian	Kaibab Ls.	7154 - 7176
9	---	Grassy Trail Creek	Grassy Trail Creek	Federal 11-23	Triassic	Sinbad Ls. Mbr.	3910 - 3940
10	---	Grassy Trail Creek	Grassy Trail Creek	Federal 11-33	Triassic	Moenkopi Fm.	3420 - 3906
11	---	Grassy Trail Creek	Grassy Trail Creek	Federal 1-14	Triassic	Moenkopi Fm.	3687 - 4010
12	---	Grassy Trail Creek	Grassy Trail Creek	Federal 11-41	Triassic	Moenkopi Fm.	3540 - 3911
13	---	Grassy Trail Creek	Grassy Trail Creek	Federal 11-41	Triassic	Moenkopi Fm.	3540 - 3911
14	---	Grassy Trail Creek	Grassy Trail Creek	Federal 11-42	Triassic	Moenkopi Fm.	3453 - 3654
15	---	Grassy Trail Creek	Grassy Trail Creek	Federal 11-43	Triassic	Moenkopi Fm.	3382 - 3966
16	---	Grassy Trail Creek	Grassy Trail Creek	Federal 12-32	Triassic	Moenkopi Fm.	3627 - 3970
17	---	Grassy Trail Creek	Grassy Trail Creek	State 2-43X	Triassic	Moenkopi Fm.	3669 - 4162
18	---	Grassy Trail Creek	wildcat well	United States E 1	Triassic	Sinbad Ls. Mbr.	16115 - 16425
19	---	Grassy Trail Creek(?)	Cisco Dome	Cisco-Federal 3	Jurassic	Brushy Basin Mbr.	2814 - 2824
20	---	Grassy Trail Creek(?)	Cisco Dome	Cisco-Federal 3	Jurassic	Brushy Basin Mbr.	2814 - 2824
21	---	Grassy Trail Creek(?)	Cisco Springs	Levon-Federal 1	Cretaceous	Buckhorn Cgl. Mbr.	1895 - 1918
22	---	Phosphoria	Danforth Hills	Federal Exxcel 1-8	Triassic	Shinarump Mbr.	6954 - 6965
23	---	Phosphoria	Elk Springs	Elk Springs Unit 3	Perm.-Penn.	Weber Ss.	6259 - 6335
24	---	Phosphoria	Elk Springs	Elk Springs Unit 3	Perm.-Penn.	Weber Ss.	6259 - 6335
25	---	Phosphoria	Maudlin Gulch	Maudlin Gulch 15	Jurassic	Curtis Fm.	6795 - 6804
26	---	Phosphoria	Maudlin Gulch	Maudlin Gulch Unit 26	Perm.-Penn.	Weber Ss.	7924 - 7926
27	---	Phosphoria	Maudlin Gulch	Maudlin Gulch Unit 26	Perm.-Penn.	Weber Ss.	7924 - 7926
28	---	Phosphoria	Rangely	Equity Federal 1-7	Perm.-Penn.	Weber Ss.	6505 - 6535
29	---	Phosphoria	Rangely	Equity Federal 1-7	Perm.-Penn.	Weber Ss.	6505 - 6535
30	---	Phosphoria	Rangely	Pennell-Hayes 1-31	Perm.-Penn.	Weber Ss.	6175 - 6345
31	---	Phosphoria	Scott Hill	Govt-Trinity 1	Perm.-Penn.	Weber Ss.	6051 - 6105
32	---	Phosphoria	Scott Hill	Seely Land & Livestock 1	Perm.-Penn.	Weber Ss.	6096 - 6151
33	---	Phosphoria	Temple Canyon	Federal 17-1	Jurassic-Triassic	Morrison Fm. - Shinarump Mbr.	5984 - 7087
34	---	Phosphoria	wildcat well	Browns Peak Unit 1-G24	Jurassic	Entrada Ss.	5788 - 5812
35	---	Phosphoria	wildcat well	Browns Peak Unit 1-G24	Jurassic	Entrada Ss.	5788 - 5812
36	---	Phosphoria	oil seep	Little Grand Wash Fault oil seep	---	---	surface
37	WRU	Phosphoria	outcrop oil stain	SJ85-62 Fawn Creek stain	Perm.-Penn. (?)	Schoolhouse Mbr.	surface
38	WRU	Phosphoria	outcrop oil stain	SJ86-129 East Rifle Creek stain	Perm.-Penn. (?)	Schoolhouse Mbr.	surface
39	WRU	Phosphoria	outcrop oil stain	SJ88-39 Flag Creek stain	Perm.-Penn. (?)	Schoolhouse Mbr.	surface
40	---	Phosphoria Cisco	Agate	Eppie C-Fee 2	Jurassic	Brushy Basin Mbr.	1562 - 1580
41	---	Phosphoria Cisco	Cisco Springs	Federal 5	Jurassic	Morrison Fm.	---
42	---	Phosphoria Cisco	Cisco Townsite	Murray 2	Jurassic	Morrison Fm.	558 - 610
43	---	Phosphoria Cisco	Cisco Townsite	Owen 1	Cretaceous	Ferron Ss. Mbr.	1286 - 1300
44	---	Phosphoria Cisco	Seiber Nose	Larsen State 1	Jurassic	Morrison Fm.	1429 - 1445
45	---	mix - Phosphoria Cisco and Mancos	Cisco Springs	Federal 14-03	Cretaceous	Dakota Ss.	1329 - 1342
46	---	mix - Phosphoria and Mancos	Ashley Valley	Ashley Valley (unknown well)	Perm.-Penn.	Weber Ss.	---

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	Field name	Well or sample name	Unit age	Unit name	Depth (ft)
47	---	mix - Phosphoria and Mancos	Ashley Valley	Ashley Valley 5	Perm.-Penn.	Weber Ss.	4147 - 4290
48	---	mix - Phosphoria and Mancos	Rangely	McLaughlin Stuart 2	Jurassic	Morrison Fm.	3225 - 3237
49	B	Phosphoria Wyoming	Cottonwood Creek	tank battery - Cottonwood Creek	Perm.-Penn.	Tensleep Ss.	---
50	W	Phosphoria Wyoming	Steamboat Butte	Tribal E 5	Perm.-Penn.	Tensleep Ss.	6843
51	SCU	Tar Sand Triangle	Upper Valley	Upper Valley 31	Permian	Kaibab Ls.	6644 - 6748
52	SCU	Tar Sand Triangle	well core oil stain	LETC/DOE TST-3	Permian	White Rim Ss.	1471
53	SCU	Tar Sand Triangle	outcrop oil stain	Teasdale limestone stain 8B	Permian	Kaibab Ls.	surface
54	OV	Aspen (Mowry)	Anschutz Ranch	Anschutz Ranch W36-16	Jurassic	Nugget Ss.	13776 - 14158
55	OV	Aspen (Mowry)	Lodgepole	Conoco UPRR 33-1	Jurassic	Twin Creek Ls.	11376 - 11524
56	---	Mancos	Dragon Trail	Federal 5-1	Cretaceous	Mancos B zone	3729 - 3926
57	---	Mancos	Rangely	Carney 3-4	Cretaceous	Mancos Shale	1225 - 1632
58	---	Mancos	San Arroyo	Federal 33-13	Cretaceous	Dakota Ss.	3598 - 3665
59	---	Mancos	Texas Mountain	Govt 16-1	Cretaceous	Mancos A zone	3044 - 3059
60	---	Mancos	Texas Mountain	Govt 20-2	Cretaceous	Mancos A zone	3177 - 3223
61	---	Mancos	Wilson Creek	tank battery - Entrada	Jurassic	Entrada Ss.	---
62	---	Mancos	Wilson Creek	tank battery - Morrison fm	Jurassic	Morrison Fm.	---
63	---	Mancos Cisco	Cisco Dome	Calf Canyon Federal 7	Cretaceous	Buckhorn Cgl. Mbr.	2834 - 2869
64	---	Mancos Cisco	Cisco Dome	Federal 25-1	Jurassic	Entrada Ss.	2588 - 2592
65	---	Mancos Cisco	Cisco Dome	Federal 25-2	Jurassic	Entrada Ss.	2606 - 2625
66	---	Mancos Cisco	Cisco Dome	Federal 675 1	Cretaceous	Buckhorn Cgl. Mbr.	2784 - 2812
67	---	Mancos waxy	Hells Hole Canyon	Hell's Hole State 1-36-10-25	Cretaceous	Dakota Ss.	6467 - 6505
68	---	Mancos waxy	Nine Mile	McBride-Govt 1	Cretaceous	Dakota Ss.	7266 - 7300
69	---	Mancos waxy	Scott Hill	Govt Trinity 1	Cretaceous	Dakota Ss.	4164 - 4178
70	---	Mancos waxy	Scott Hill	Govt Trinity 1	Cretaceous	Dakota Ss.	4170 - 4180
71	---	Mancos waxy	Scott Hill	Govt Trinity 1	Cretaceous	Dakota Ss.	---
72	---	Mancos Niobrara	McHatton	MH Moore 2-11	Cretaceous	Niobrara Fm.	2990 - 3120
73	---	Mancos Niobrara	wildcat well	Federal 1-34	---	---	---
74	SWB	Mancos Niobrara	Waddle Creek	Beaver-Durham 12-32	Cretaceous	Niobrara Fm.	2900 - 2961
75	SWB	Mancos Niobrara	Moffat	Yenom-Govt 1	Cretaceous	Niobrara Fm.	2910 - 3103
76	---	Blackhawk	oil seep	Willow Creek Mine oil seep	Cretaceous	Castlegate Ss.	---
77	---	Mesaverde	Flat Rock	Flat Rock 30-2A	Eocene-Paleocene	Wasatch Fm.	3594 - 4018
78	---	Mesaverde	Natural Buttes	Island Unit 26	Eocene-Paleocene	Wasatch Fm.	5978 - 6522
79	---	Mesaverde	White River Dome	Federal 1	Cretaceous	Mesaverde Gp.	5284 - 6950
80	---	Mesaverde	White River Dome	Federal A-30-2-96	Cretaceous	Williams Fork Fm.	5999 - 6849
81	---	Mesaverde	White River Dome	Federal A-31-2-96	Cretaceous	Williams Fork Fm.	5829 - 6700
82	---	Mesaverde	White River Dome	Federal A-32-2-96	Cretaceous	Williams Fork Fm.	5993 - 6792
83	---	Mesaverde	White River Dome	Federal B-25-2-97	Cretaceous	Williams Fork Fm.	5592 - 6369
84	---	Mesaverde	White River Dome	Fee A-29-2-96N	Cretaceous	Williams Fork Fm.	6398 - 7156
85	---	Mesaverde	White River Dome	Fee M-32-2-96N	Cretaceous	Williams Fork Fm.	5718 - 6484
86	---	Mesaverde	White River Dome	White River Dome Federal 2-M	Cretaceous	Mesaverde Gp.	7264 - 7340
87	---	Mesaverde	White River Dome	White River Dome Federal Unit 3-M	Cretaceous	Mesaverde Gp.	6176 - 7392
88	---	Mesaverde	White River Dome	White River Dome Govt Unit 3	Cretaceous	Mesaverde Gp.	5598 - 6273
89	---	Mesaverde	White River Dome	White River Dome Unit 1	Cretaceous	Mesaverde Gp.	6040 - 6932
90	---	Green River A	Altamont	Lamicq 2-6B1	Eocene-Paleocene	Green River Fm.	---
91	---	Green River A	Altamont	Miles 1	Eocene-Paleocene	Green River Fm.	12341 - 12575
92	---	Green River A	Altamont	Miles 1	Eocene-Paleocene	Green River Fm.	12910 - 12942
93	---	Green River A	Altamont	Potter 2-6B4	Eocene-Paleocene	Wasatch Fm.	12953 - 14032
94	---	Green River A	Altamont	Shell etal 1-13-B4	Eocene-Paleocene	Wasatch Fm.	10661 - 13102
95	---	Green River A	Altamont	Ute Tribal D-1	Eocene-Paleocene	Wasatch Fm.	10217 - 10317
96	---	Green River A	Altamont	Ute Tribal D-1	Eocene-Paleocene	Wasatch Fm.	8569 - 8632
97	---	Green River A	Antelope Creek	Ute Tribal 3-8	Eocene-Paleocene	Green River Fm.	4041 - 4066
98	---	Green River A	Antelope Creek	Ute Tribal 7-1	Eocene-Paleocene	Green River Fm.	4533 - 6182
99	---	Green River A	Bluebell	Blanchard 33-3 1	Eocene-Paleocene	Green River Fm.	9039 - 9056
100	---	Green River A	Bluebell	Chevron L Boren Unit 3-15	Eocene-Paleocene	Wasatch Fm.	13900 - 14020
101	---	Green River A	Bluebell	Chevron Mobil Ute 2	Eocene-Paleocene	Green River Fm.	11935 - 12060

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	Field name	Well or sample name	Unit age	Unit name	Depth (ft)
102	---	Green River A	Bluebell	Cook 1-26B1	Eocene-Paleocene	Green River Fm.	10044 - 10049
103	---	Green River A	Bluebell	Cook 1-26B1	Eocene-Paleocene	Wasatch Fm.	11340 - 11346
104	---	Green River A	Bluebell	Cook 1-26B1	Eocene-Paleocene	Wasatch Fm.	14636
105	---	Green River A	Bluebell	Cook 1-26B1	Eocene-Paleocene	Green River Fm.	8476 - 8486
106	---	Green River A	Bluebell	Fay Mecham-Fee 4-2C 1	Eocene-Paleocene	Green River Fm.	10400 - 10525
107	---	Green River A	Bluebell	Fay Mecham-Fee 4-2C 1	Eocene-Paleocene	Green River Fm.	10999 - 11033
108	---	Green River A	Bluebell	Freston 2-8B1	Eocene-Paleocene	Wasatch Fm.	11232 - 11720
109	---	Green River A	Bluebell	John Lamicq State 1-6-B1	Eocene-Paleocene	Green River Fm.	8500 - 9000
110	---	Green River A	Bluebell	L Boren Unit 1-24	Eocene-Paleocene	Green River Fm.	10500
111	---	Green River A	Bluebell	LL Pack 1-33A1	Eocene-Paleocene	Green River Fm.	8466
112	---	Green River A	Bluebell	Powell Fee 3	Eocene-Paleocene	Wasatch Fm.	10915 - 10992
113	---	Green River A	Bluebell	R G Dye 1-29A1	Eocene-Paleocene	Green River Fm.	9804 - 10004
114	---	Green River A	Bluebell	Shaw 2-27	Eocene-Paleocene	Wasatch Fm.	14700
115	---	Green River A	Bluebell	Springfield Marine 1-10-A2	Eocene-Paleocene	Wasatch Fm.	13360 - 13517
116	---	Green River A	Bluebell	Ute Tribal 1-34B	Eocene-Paleocene	Wasatch Fm.	14189 - 14612
117	---	Green River A	Bluebell	Victor Brown 1	Eocene-Paleocene	Green River Fm.	9042 - 9499
118	---	Green River A	Bluebell	Walker Brown Unit 1	Eocene-Paleocene	Green River Fm.	10568 - 10724
119	---	Green River A	Brennan Bottom	Federal 5-21	Eocene-Paleocene	Green River Fm.	6660 - 6720
120	---	Green River A	Brennan Bottom	Joan Federal 1	Eocene	Uinta Fm.	---
121	---	Green River A	Brundage Canyon	South Cottonwood 1-19	Eocene-Paleocene	Green River Fm.	5421 - 5641
122	---	Green River A	Brundage Canyon	Sowers Canyon Ute Tribal 3-26	Eocene-Paleocene	Green River Fm.	4112 - 4164
123	---	Green River A	Castle Peak	Federal 23-5-G	Eocene-Paleocene	Green River Fm.	4851 - 5746
124	---	Green River A	Cedar Rim	Cedar Rim 21	Eocene-Paleocene	Green River Fm.	5298 - 5358
125	---	Green River A	Cedar Rim	Cedar Rim 5	Eocene-Paleocene	Wasatch Fm.	7287 - 10260
126	---	Green River A	Cedar Rim	Ute Fee 2-33C6	Eocene-Paleocene	Wasatch Fm.	6935 - 8765
127	---	Green River A	Coyote Basin	Coyote Basin 21-7	Eocene	Uinta Fm.	4403 - 4416
128	---	Green River A	Coyote Basin	East Red Wash 1	Eocene-Paleocene	Green River Fm.	4495 - 4501
129	---	Green River A	Coyote Wash	Federal 1-27	Eocene-Paleocene	Green River Fm.	3867 - 3872
130	---	Green River A	Duschesne	Ute Tribal 1-7D	Eocene-Paleocene	Wasatch Fm.	7503 - 7553
131	---	Green River A	Duschesne	Ute Tribal 2-8D	Eocene-Paleocene	Wasatch Fm.	7500 - 7562
132	---	Green River A	Duschesne	Ute Tribal 4-17D	Eocene-Paleocene	Wasatch Fm.	6730 - 6738
133	---	Green River A	Duschesne	Ute Tribal 6-16D	Eocene-Paleocene	Wasatch Fm.	6116 - 6124
134	---	Green River A	Duschesne	Ute Tribal 6-16D	Eocene-Paleocene	Wasatch Fm.	7140 - 7170
135	---	Green River A	Eight Mile Flat N	Federal 32-29	Eocene-Paleocene	Green River Fm.	4524 - 4625
136	---	Green River A	Eight Mile Flat N	NGC 33-32	Eocene-Paleocene	Wasatch Fm.	4678 - 6554
137	---	Green River A	Gusher	Gusher 3	Eocene-Paleocene	Green River Fm.	7748 - 7995
138	---	Green River A	Horseshoe Bend	Federal 33-7-L	Eocene-Paleocene	Green River Fm.	6852 - 7183
139	---	Green River A	Horseshoe Bend	Horseshoe Bend Federal 2 /22-34/	Eocene-Paleocene	Green River Fm.	6670 - 6690
140	---	Green River A	Horseshoe Bend	L C K 30-1-H	Eocene-Paleocene	Green River Fm.	6922 - 6998
141	---	Green River A	Monument Butte	Federal 15-20	Eocene-Paleocene	Green River Fm.	5789 - 5846
142	---	Green River A	Monument Butte	Federal 23-34-B	Eocene-Paleocene	Green River Fm.	---
143	---	Green River A	Monument Butte	Goates-Federal 1	Eocene-Paleocene	Green River Fm.	4624 - 4631
144	---	Green River A	Natural Buttes	Natural Duck 4-21GR	Eocene-Paleocene	Green River Fm.	3760 - 4799
145	---	Green River A	Pariette Bench	Pariette Bench Unit 2	Eocene-Paleocene	Green River Fm.	4864 - 4923
146	---	Green River A	Red Wash	E. Redwash State 1/41-36C/	Eocene-Paleocene	Green River Fm.	4900 - 4920
147	---	Green River A	Red Wash	Gypsum Hills Federal 3	Eocene-Paleocene	Green River Fm.	5241
148	---	Green River A	Red Wash	Red Wash Unit 201 32-28C	Eocene-Paleocene	Green River Fm.	5160 - 5233
149	---	Green River A	Red Wash	USA Broadhurst 1	Eocene-Paleocene	Green River Fm.	4693 - 5413
150	---	Green River A	Red Wash	White River Unit 17-10	Eocene-Paleocene	Green River Fm.	5533 - 5552
151	---	Green River A	unnamed	East Gusher 15-1-A	Eocene-Paleocene	Green River Fm.	7694 - 7736
152	---	Green River A	unnamed	Federal 34-1	Eocene-Paleocene	Green River Fm.	3865 - 3936
153	---	Green River A	Uteland Butte	River Bend Unit 2-10D	Eocene-Paleocene	Green River Fm.	4890 - 4898
154	---	Green River A	Uteland Butte	River Bend Unit 8-11D	Eocene-Paleocene	Green River Fm.	4744 - 4752
155	---	Green River A	Wonsits Valley	Wonsits Valley Unit 133(24-15)	Eocene-Paleocene	Green River Fm.	5192 - 5217
156	---	Green River B	Altamont	Ute Tribal D-1	Eocene-Paleocene	Green River Fm.	4700

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	Field name	Well or sample name	Unit age	Unit name	Depth (ft)
157	---	Green River B	Blacktail Ridge	Ute Tribal 2/22-18/	Eocene-Paleocene	Green River Fm.	4689 - 4715
158	---	Green River B	Red Wash	Red Wash Unit 120 23-28B	Eocene-Paleocene	Green River Fm.	5521 - 5557
159	---	Green River B	Twelve Mile Wash	Twelve Mile Federal 1	Eocene-Paleocene	Green River Fm.	6956 - 6960
160	---	Green River B	Twelve Mile Wash	Twelve Mile Federal 1	Eocene-Paleocene	Green River Fm.	7396 - 7426
161	---	Green River B	Walker Hollow	Broadhurst 18	Eocene-Paleocene	Green River Fm.	5379 - 5409
162	---	Green River	Bluebell	LL Pack 1-33A1	Eocene-Paleocene	Green River Fm.	8272 - 8276
163	---	Green River	Cedar Rim	Caloil Ute Tribal 11-18 1-A	Eocene-Paleocene	Green River Fm.	4042 - 4082
164	---	Green River	Sulphur Creek	Government 29-3	Eocene-Paleocene	Wasatch A	4078 - 4090
165	---	Green River	outcrop oil stain	Asphalt Ridge deposit	Cretaceous	Rim Rock Ss.	surface
166	---	Green River	outcrop oil stain	Tabiona deposit	Cretaceous	Currant Creek Fm.	surface
167	---	Green River	outcrop oil stain	Thistle deposit	Eocene-Paleocene	Green River Fm.	surface
168	---	Green River	outcrop oil stain	Thistle deposit	Eocene-Paleocene	Green River Fm.	surface
169	---	Green River	outcrop oil stain	Whiterocks stain 1	Jurassic	Nugget Ss.	surface
170	---	Green River	outcrop oil stain	Whiterocks stain 2	Jurassic	Nugget Ss.	surface
171	---	Green River	solid hydrocarbons	Chinese Wax mine 1	Perm.-Penn.	Oquirrh Fm.	surface

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	Sec-T-R	Longitude	Latitude	Source	Comments	Biodegradation	$\delta^{13}C_{SAT}$	$\delta^{13}C_{ARO}$
1	PB	Paradox	22-40S-24E	-109.26866	37.29381	cell	Gravity and sulfur data from COADB 57088	none	-28.54	-27.76
2	PB	Paradox	20-40S-26E	-109.07557	37.30042	cell	Gravity and sulfur data from COADB 57012	none	-28.40	-27.88
3	---	Minturn	31-5N-95W	-108.09477	40.34817	cell	---	none	-25.99	-26.60
4	---	Minturn	8-4N-95W	-108.08166	40.32771	cell	---	none	-25.68	-26.68
5	---	Minturn	34-3N-94W	-107.92900	40.18900	topo	---	none	-24.82	-25.92
6	EB	Belden	6-2S-83W	-106.72500	39.91500	topo	location McCoy, Colo. Sample from Johnson and others (1990)	minor	-29.32	-28.95
7	---	Grassy Trail Creek	33-18S-7E	-111.13562	39.21785	cell	gas field near Ferron	none	-28.71	-28.31
8	---	Grassy Trail Creek	21-20S-7E	-111.13217	39.06560	cell	---	minor	-29.23	-28.81
9	---	Grassy Trail Creek	11-16S-12E	-110.54443	39.44865	cell	Moenkopi Fm.	none	-28.97	-28.54
10	---	Grassy Trail Creek	11-16S-12E	-110.53511	39.44974	cell	---	none	-29.08	-28.65
11	---	Grassy Trail Creek	1-16S-12E	-110.52722	39.45793	cell	---	none	-28.87	-28.46
12	---	Grassy Trail Creek	11-16S-12E	-110.53654	39.45684	cell	different sample than 92107056 (sample 13)	none	-28.51	-28.09
13	---	Grassy Trail Creek	11-16S-12E	-110.53654	39.45684	cell	different sample than 89094007 (sample 12)	none	-28.83	-28.32
14	---	Grassy Trail Creek	11-16S-12E	-110.53511	39.44974	cell	---	none	-28.54	-28.13
15	---	Grassy Trail Creek	11-16S-12E	-110.53367	39.44265	cell	---	none	-28.56	-28.16
16	---	Grassy Trail Creek	12-16S-12E	-110.51646	39.45193	cell	---	none	-28.87	-28.38
17	---	Grassy Trail Creek	2-16S-12E	-110.52722	39.45793	cell	---	none	-28.87	-28.50
18	---	Grassy Trail Creek	27-19S-3E	-111.56558	39.13525	cell	Moenkopi Fm., west of Ferron	none	-28.22	-27.56
19	---	Grassy Trail Creek(?)	10-20S-21E	-109.58588	39.08275	GPS	sample collected in 2000, Morrison Fm.	none	-29.07	-28.10
20	---	Grassy Trail Creek(?)	10-20S-21E	-109.58588	39.08275	GPS	sample collected in 1992, Morrison Fm.	none	-28.81	-28.22
21	---	Grassy Trail Creek(?)	11-20S-23E	-109.34372	39.08295	GPS	Cedar Mountain Fm.	none	-28.66	-28.05
22	---	Phosphoria	8-4N-95W	-108.08287	40.33483	cell	Chinle Fm.	none	-28.28	-28.44
23	---	Phosphoria	30-5N-98W	-108.44198	40.35050	cell	rerun of 89047011	none	-28.29	-29.22
24	---	Phosphoria	30-5N-98W	-108.44198	40.35050	cell	rerun as 00024001	none	-28.27	-28.81
25	---	Phosphoria	35-4N-95W	-108.01518	40.27617	cell	equivalent to the Sundance Fm.	none	-28.33	-28.36
26	---	Phosphoria	35-4N-95W	-108.02465	40.27526	cell	rerun of 89047013	none	-28.63	-28.85
27	---	Phosphoria	35-4N-95W	-108.02465	40.27526	cell	rerun as 00024002	none	-28.38	-28.33
28	---	Phosphoria	7-2N-102W	-108.89759	40.15235	cell	rerun of 89047033	none	-28.99	-28.70
29	---	Phosphoria	7-2N-102W	-108.89759	40.15235	cell	rerun as 00024003	none	-28.38	-28.27
30	---	Phosphoria	31-2N-101W	-108.77408	40.10703	cell	---	none	-28.26	-28.10
31	---	Phosphoria	27-3N-90W	-107.48287	40.19572	cell	1 of 4 samples, different depths, DST#4	none	-28.31	-27.82
32	---	Phosphoria	26-3N-90W	-107.47455	40.20371	cell	---	none	-28.38	-28.06
33	---	Phosphoria	17-4N-95W	-108.06976	40.31437	cell	---	none	-28.00	-28.30
34	---	Phosphoria	24-11S-4E	-111.42392	39.85139	cell	rerun of 91045003	none	-29.05	-28.83
35	---	Phosphoria	24-11S-4E	-111.42392	39.85139	cell	rerun as 00024015	none	-28.65	-28.42
36	---	Phosphoria	35-21S-16E	-110.11956	38.93570	GPS	near Crystal Geyser, Green River, Utah	moderate	-28.47	-29.26
37	WRU	Phosphoria	20-1N-90W	-107.50700	40.04100	topo	sample from Johnson and others (1990)	none	-27.74	-27.67
38	WRU	Phosphoria	27-4S-92W	-107.70000	39.67700	topo	sample from Johnson and others (1990)	moderate	-28.30	-27.91
39	WRU	Phosphoria	36-1S-94W	-107.90000	39.92000	topo	sample from Johnson and others (1990), remeasured pr/ph	minor	-27.54	-27.83
40	---	Phosphoria Cisco	8-20S-24E	-109.27731	39.08571	GPS	Morrison Fm.	none	-29.35	-28.98
41	---	Phosphoria Cisco	10-20S-23E	-109.36954	39.08053	cell	probably Brushy Basin Member, TD=2448ft	none	-29.57	-29.23
42	---	Phosphoria Cisco	24-21S-23E	-109.31139	38.97083	cell	probably Brushy Basin Member	none	-29.62	-29.28
43	---	Phosphoria Cisco	33-21S-23E	-109.38168	38.94147	cell	Ferron production unusual, may be Morrison	none	-29.47	-29.37
44	---	Phosphoria Cisco	2-20S-24E	-109.23140	39.10266	cell	possibly Brushy Basin Member	none	-29.38	-29.23
45	---	mix - Phosphoria Cisco and M	14-20S-23E	-109.34701	39.06122	cell	pr/ph indicates Cretaceous mix	none	-28.24	-27.64
46	---	mix - Phosphoria and Mancos	??-5S-22E	-109.41000	40.36000	topo	pr/ph indicates Cretaceous mix	none	-28.15	-27.85

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	Sec-T-R	Longitude	Latitude	Source	Comments	Biodegradation	$\delta^{13}C_{SAT}$	$\delta^{13}C_{ARO}$
47	---	mix - Phosphoria and Mancos	22-5S-22E	-109.41881	40.36595	cell	pr/ph and waxy GCsats indicates Cretaceous mix	none	-28.74	-28.15
48	---	mix - Phosphoria and Mancos	33-2N-102W	-108.84955	40.09931	cell	pr/ph indicates Cretaceous mix	none	-28.18	-28.00
49	B	Phosphoria Wyoming	---	-107.70000	44.00000	topo	---	none	-29.68	-29.50
50	W	Phosphoria Wyoming	5-3N-1W	-108.90334	43.26516	cell	gravity and sulfur data from COADB 49120	none	-29.46	-29.48
51	SCU	Tar Sand Triangle	14-36S-1E	-111.75131	37.67800	cell	gravity and sulfur data from COADB 66003	none	-30.45	-30.30
52	SCU	Tar Sand Triangle	2-31S-16E	-110.10000	38.00000	topo	Dept. of Energy (?) core hole	moderate	-29.50	-30.02
53	SCU	Tar Sand Triangle	35-29S-6E	-111.24138	38.24444	topo	rerun of 92005008	minor	-30.67	-30.92
54	OV	Aspen (Mowry)	36-4N-7E	-111.09749	41.03335	cell	---	none	-26.79	-25.12
55	OV	Aspen (Mowry)	33-2N-6E	-111.26505	40.86040	cell	---	none	-27.23	-25.96
56	---	Mancos	5-3S-102W	-108.86419	39.80796	cell	Emery Ss. Mbr. of the Mancos Sh.	none	-27.55	-26.55
57	---	Mancos	4-1N-102W	-108.83884	40.09317	cell	---	none	-27.81	-26.59
58	---	Mancos	33-16S-26E	-109.05611	39.36662	GPS	probably Cedar Mountain Formation	none	-27.90	-26.41
59	---	Mancos	16-3S-102W	-108.84969	39.78048	cell	Castlegate Ss. Mbr. of the Mancos Sh.	none	-27.73	-26.46
60	---	Mancos	20-3S-102W	-108.85780	39.77239	cell	Castlegate Ss. Mbr. of the Mancos Sh.	none	-27.72	-26.39
61	---	Mancos	34-3N-94W	-107.92390	40.19170	topo	---	none	-27.80	-26.81
62	---	Mancos	33-3N-94W	-107.93940	40.18870	topo	---	none	-27.88	-26.79
63	---	Mancos Cisco	3-20S-21E	-109.58858	39.08562	cell	Cedar Mountain Formation	none	-28.24	-27.13
64	---	Mancos Cisco	25-20S-21E	-109.54319	39.03948	GPS	originally a Morrison gas well	none	-28.82	-27.75
65	---	Mancos Cisco	25-20S-21E	-109.55003	39.03184	cell	---	none	-28.62	-27.71
66	---	Mancos Cisco	10-20S-21E	-109.58500	39.08640	GPS	Cedar Mountain Formation	none	-28.44	-27.21
67	---	Mancos waxy	36-10S-25E	-109.05403	39.90420	cell	---	none	-28.31	-26.61
68	---	Mancos waxy	6-2N-92W	-107.75604	40.16319	cell	---	none	-27.48	-25.55
69	---	Mancos waxy	27-3N-90W	-107.48287	40.19572	cell	1 of 4 samples, different depths	none	-27.69	-26.22
70	---	Mancos waxy	27-3N-90W	-107.48287	40.19572	cell	1 of 4 samples, different depths	none	-28.03	-26.12
71	---	Mancos waxy	27-3N-90W	-107.48287	40.19572	cell	1 of 4 samples, different depths Depth and fm uncertain	none	-27.85	-26.26
72	---	Mancos Niobrara	11-1N-93W	-107.78916	40.07325	cell	---	none	-27.96	-27.11
73	---	Mancos Niobrara	34-3N-103W	-108.94181	40.18403	cell	well ID uncertain	none	-28.46	-27.20
74	SWB	Mancos Niobrara	32-5N-90W	-107.52602	40.34368	cell	East of Moffat	none	-28.35	-27.18
75	SWB	Mancos Niobrara	34-5N-91W	-107.59123	40.33046	cell	---	none	-28.36	-27.09
76	---	Blackhawk	31-12S-10E	-110.84800	39.73600	topo	---	none	-26.81	-25.28
77	---	Mesaverde	30-14S-20E	-109.71892	39.57170	cell	---	none	-27.58	-25.80
78	---	Mesaverde	2-10S-19E	-109.74709	39.96762	cell	---	none	-27.49	-24.71
79	---	Mesaverde	31-2N-96W	-108.20598	40.09849	cell	---	none	-28.09	-26.30
80	---	Mesaverde	30-2N-96W	-108.20020	40.12077	cell	---	none	-28.18	-26.25
81	---	Mesaverde	31-2N-96W	-108.19776	40.10653	cell	---	none	-28.43	-26.32
82	---	Mesaverde	32-2N-96W	-108.17765	40.10124	cell	---	none	-28.47	-26.50
83	---	Mesaverde	25-2N-97W	-108.22853	40.11801	cell	---	none	-28.11	-26.04
84	---	Mesaverde	29-2N-96W	-108.18009	40.11548	cell	---	none	-28.22	-26.23
85	---	Mesaverde	32-2N-96W	-108.19532	40.09228	cell	---	none	-28.26	-26.28
86	---	Mesaverde	32-2N-96W	-108.18588	40.09320	cell	---	none	-27.84	-25.85
87	---	Mesaverde	29-2N-96W	-108.18831	40.10744	cell	---	none	-27.89	-25.71
88	---	Mesaverde	30-2N-96W	-108.20720	40.10561	cell	---	none	-28.01	-26.50
89	---	Mesaverde	28-2N-96W	-108.18009	40.11548	cell	---	none	-28.40	-26.86
90	---	Green River A	6-2S-1W	-110.03075	40.33534	cell	---	none	-31.34	-29.70
91	---	Green River A	35-1S-4W	-110.30520	40.35518	cell	1 of 2 samples, different depths	none	-32.30	-30.69
92	---	Green River A	35-1S-4W	-110.30520	40.35518	cell	1 of 2 samples, different depths	none	-33.00	-29.80
93	---	Green River A	6-2S-4W	-110.38732	40.33126	cell	---	none	-31.66	-29.92
94	---	Green River A	13-2S-4W	-110.27773	40.31473	cell	---	none	-31.30	-29.81
95	---	Green River A	14-3S-6W	-110.52889	40.22049	cell	deepest of 3 samples	none	-30.68	-28.86
96	---	Green River A	14-3S-6W	-110.52889	40.22049	cell	middle of 3 samples, DST 1, isotopes suspect	none	-28.70	-28.10
97	---	Green River A	8-5S-3W	-110.24669	40.06409	cell	---	none	-31.55	-30.39
98	---	Green River A	7-5S-3W	-110.25753	40.07011	cell	---	none	-31.54	-30.06
99	---	Green River A	3-1S-2W	-110.09634	40.42238	cell	---	none	-30.90	-29.54
100	---	Green River A	15-1S-2W	-110.10014	40.39291	cell	---	none	-32.75	-28.70
101	---	Green River A	12-1S-3W	-110.18003	40.40570	cell	---	none	-31.60	-30.00

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	Sec-T-R	Longitude	Latitude	Source	Comments	Biodegradation	$\delta^{13}C_{SAT}$	$\delta^{13}C_{ARO}$
102	---	Green River A	26-2S-1W	-109.97092	40.27668	cell	1 of 4 samples, different depths	none	-32.21	-31.18
103	---	Green River A	26-2S-1W	-109.97092	40.27668	cell	1 of 4 samples, different depths	none	-32.41	-30.87
104	---	Green River A	26-2S-1W	-109.97092	40.27668	cell	1 of 4 samples, different depths	none	-32.35	-30.97
105	---	Green River A	26-2S-1W	-109.97092	40.27668	cell	1 of 4 samples, different depths	none	-31.52	-30.05
106	---	Green River A	2-1S-2W	-110.07601	40.41740	cell	1 of 2 samples, different depths	none	-31.60	-30.20
107	---	Green River A	2-1S-2W	-110.07601	40.41740	cell	1 of 2 samples, different depths	none	-32.53	-30.89
108	---	Green River A	8-2S-1W	-110.01990	40.32929	cell	---	none	-32.55	-30.74
109	---	Green River A	6-2S-1W	-110.04161	40.34138	cell	---	none	-30.91	-29.52
110	---	Green River A	24-1S-2W	-110.05950	40.38295	cell	---	none	-32.03	-30.07
111	---	Green River A	33-1S-1W	-110.00521	40.35271	cell	1 of 2 samples, different depths	none	-31.60	-30.70
112	---	Green River A	13-1S-2W	-110.06091	40.39005	cell	---	none	-31.90	-29.60
113	---	Green River A	29-1S-1W	-110.01747	40.36586	cell	---	none	-31.23	-29.77
114	---	Green River A	27-1S-2W	-110.09449	40.36450	cell	no GCsats, A type based on depth and sat/aro	---	-31.53	-29.20
115	---	Green River A	10-1S-2W	-110.10297	40.40712	cell	---	none	-31.88	-28.87
116	---	Green River A	34-1N-2W	-110.09112	40.44475	cell	---	none	-32.22	-30.04
117	---	Green River A	3-1S-2W	-110.10721	40.42842	cell	---	none	-30.91	-29.59
118	---	Green River A	4-1S-2W	-110.10580	40.42132	cell	---	none	-30.99	-29.71
119	---	Green River A	21-7S-21E	-109.56997	40.19736	cell	---	none	-30.94	-29.63
120	---	Green River A	19-7S-21E	-109.60771	40.19326	cell	---	none	-30.88	-29.55
121	---	Green River A	19-5S-4W	-110.36612	40.03589	cell	---	none	-31.86	-30.44
122	---	Green River A	26-5S-5W	-110.42109	40.02229	cell	---	none	-32.03	-30.85
123	---	Green River A	5-9S-16E	-110.14836	40.05347	cell	---	none	-31.46	-29.97
124	---	Green River A	10-3S-6W	-110.53976	40.22649	cell	---	none	-31.66	-30.57
125	---	Green River A	16-3S-6W	-110.56804	40.22320	cell	---	none	-31.17	-29.81
126	---	Green River A	33-3S-6W	-110.57669	40.17133	cell	---	none	-32.81	-32.68
127	---	Green River A	7-8S-25E	-109.14555	40.14108	cell	---	none	-31.70	-30.04
128	---	Green River A	5-8S-25E	-109.12800	40.15017	cell	---	none	-31.96	-30.20
129	---	Green River A	27-8S-24E	-109.20368	40.09146	cell	---	none	-31.88	-30.11
130	---	Green River A	7-4S-4W	-110.37822	40.14345	cell	---	none	-31.88	-30.95
131	---	Green River A	8-4S-4W	-110.35938	40.14561	cell	---	none	-32.69	-31.86
132	---	Green River A	17-4S-4W	-110.35652	40.13141	cell	---	none	-31.24	-29.86
133	---	Green River A	16-4S-4W	-110.34853	40.13959	cell	1 of 2 samples, different depths	none	-30.71	-29.32
134	---	Green River A	16-4S-4W	-110.34853	40.13959	cell	1 of 2 samples, different depths	none	-31.04	-29.58
135	---	Green River A	29-9S-18E	-109.91800	40.00675	cell	---	none	-31.81	-30.29
136	---	Green River A	32-8S-18E	-109.91167	40.07277	cell	---	none	-32.27	-30.31
137	---	Green River A	10-6S-20E	-109.65114	40.31914	cell	---	none	-31.38	-29.82
138	---	Green River A	33-6S-21E	-109.57138	40.25524	cell	---	none	-31.35	-29.82
139	---	Green River A	34-6S-21E	-109.54305	40.25830	cell	---	none	-31.90	-30.70
140	---	Green River A	30-6S-21E	-109.59299	40.26741	cell	---	none	-31.37	-30.17
141	---	Green River A	20-8S-17E	-110.03162	40.09567	cell	---	none	-31.85	-30.56
142	---	Green River A	34-8S-16E	-110.10413	40.07299	cell	---	none	-31.64	-30.15
143	---	Green River A	11-9S-16E	-110.08769	40.03854	cell	---	none	-31.49	-30.37
144	---	Green River A	21-9S-20E	-109.66257	40.02768	cell	---	none	-31.78	-30.38
145	---	Green River A	7-9S-19E	-109.82002	40.04665	cell	---	none	-32.04	-30.64
146	---	Green River A	36-7S-24E	-109.15081	40.16952	cell	---	none	-32.25	-31.25
147	---	Green River A	20-8S-21E	-109.57391	40.11713	cell	---	none	-31.70	-30.23
148	---	Green River A	28-7S-24E	-109.22084	40.18391	cell	---	none	-31.94	-30.11
149	---	Green River A	9-7S-23E	-109.32454	40.22369	cell	carotane abundance like type B	none	-31.83	-30.39
150	---	Green River A	10-8S-22E	-109.43384	40.13949	cell	---	none	-31.80	-30.40
151	---	Green River A	15-6S-20E	-109.64841	40.30493	cell	---	none	-31.27	-29.87
152	---	Green River A	34-8S-24E	-109.20236	40.08435	cell	---	none	-31.88	-30.29
153	---	Green River A	10-10S-18E	-109.88009	39.96016	cell	---	none	-32.24	-30.93
154	---	Green River A	11-10S-18E	-109.85189	39.96330	cell	---	none	-32.29	-31.13
155	---	Green River A	15-8S-21E	-109.54563	40.12019	cell	---	none	-31.90	-30.44
156	---	Green River B	14-3S-6W	-110.52889	40.22049	cell	1 of 3 samples, different depths, oil from pit	none	-30.87	-29.30

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	Sec-T-R	Longitude	Latitude	Source	Comments	Biodegradation	$\delta^{13}C_{SAT}$	$\delta^{13}C_{ARO}$
157	---	Green River B	18-3S-6W	-110.60574	40.21881	cell	---	none	-32.20	-30.70
158	---	Green River B	28-7S-23E	-109.33409	40.17191	cell	---	none	-32.05	-30.38
159	---	Green River B	27-5S-20E	-109.66743	40.35365	cell	1 of 2 samples, different depths	none	-31.80	-30.60
160	---	Green River B	27-5S-20E	-109.66743	40.35365	cell	1 of 2 samples, different depths	none	-31.50	-29.90
161	---	Green River B	9-7S-23E	-109.32587	40.23080	cell	---	none	-32.40	-30.49
162	---	Green River	33-1S-1W	-110.00521	40.35271	cell	1 of 2 samples, different depths, probably A type	---	-31.60	-30.30
163	---	Green River	18-3S-6W	-110.61662	40.22481	cell	probably type A based on low carotane	moderate	-31.62	-30.25
164	---	Green River	29-2S-98W	-108.41172	39.84654	cell	high sulfur, waxy	none	-32.73	-31.27
165	---	Green River	4-4S-22E	-109.44638	40.50972	topo	---	severe	-33.00	-29.94
166	---	Green River	16-1S-7W	-110.67700	40.39000	topo	may be Paleocene in part, conglomerate	severe	-32.45	-29.81
167	---	Green River	28-10S-5E	-111.37800	39.91680	topo	rerun as 92118001	severe	-32.30	-29.89
168	---	Green River	28-10S-5E	-111.37800	39.91680	topo	rerun as 91056001, probably type B based on carotane	severe	-32.69	-29.86
169	---	Green River	18-2N-1E	-109.93472	40.56945	topo	---	severe	-32.38	-29.79
170	---	Green River	18-2N-1E	-109.93500	40.56972	topo	---	severe	-32.39	-29.62
171	---	Green River	10-6S-6E	-111.25472	40.31111	topo	---	severe	-32.00	-29.62

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	CV	Gravity	Sulfur	Pr/Ph	CPI	β C	Sat/Aro	Lab number
1	PB	Paradox	-1.07	41.5	0.02	1.09	1.05	tr	4.1	92107026
2	PB	Paradox	-1.69	44.1	0.05	1.25	1.02	0	4.1	92107025
3	---	Minturn	-4.95	56.1	---	1.71	1.08	0	2.5	89047010
4	---	Minturn	-5.91	43.7	---	1.56	1.02	tr	3.1	89047014
5	---	Minturn	-6.40	57.8	---	1.88	---	---	3.7	89055004
6	EB	Belden	-1.74	---	---	1.00	---	---	6.6	88002003
7	---	Grassy Trail Creek	-1.86	---	---	0.83	0.99	0	7.5	90126002
8	---	Grassy Trail Creek	-1.66	---	---	0.94	0.97	tr	7.2	90082003
9	---	Grassy Trail Creek	-1.71	---	---	0.89	0.98	0	4.8	89094002
10	---	Grassy Trail Creek	-1.68	---	---	0.97	1.01	tr	4.8	92107001
11	---	Grassy Trail Creek	-1.79	---	---	0.90	0.98	0	5.6	89094006
12	---	Grassy Trail Creek	-1.88	---	---	1.00	1.00	0	5.4	89094007
13	---	Grassy Trail Creek	-1.58	36.5	0.33	1.12	0.97	0	6.1	92107056
14	---	Grassy Trail Creek	-1.89	---	---	1.00	0.99	0	5.5	89094005
15	---	Grassy Trail Creek	-1.91	---	---	0.91	0.99	0	5.3	89094004
16	---	Grassy Trail Creek	-1.61	---	---	0.93	0.98	0	6.4	89094003
17	---	Grassy Trail Creek	-1.88	---	---	0.88	0.99	0	4.8	89094001
18	---	Grassy Trail Creek	-1.44	---	---	0.95	0.98	tr	30.6	90126003
19	---	Grassy Trail Creek(?)	-0.48	39.4	0.15	1.37	1.02	tr	4.6	00024018
20	---	Grassy Trail Creek(?)	-1.41	40.4	0.31	1.30	1.00	tr	5.2	92107005
21	---	Grassy Trail Creek(?)	-1.41	38.9	0.31	1.27	1.02	tr	6.2	00024019
22	---	Phosphoria	-3.24	33.8	0.55	0.75	1.01	0	2.0	89047044
23	---	Phosphoria	-4.94	30.5	1.32	0.84	1.02	tr	2.8	00024001
24	---	Phosphoria	-4.09	30.7	---	1.00	1.02	tr	1.4	89047011
25	---	Phosphoria	-2.93	35.6	---	0.78	1.00	0	2.9	89047012
26	---	Phosphoria	-3.26	36.6	0.40	0.77	0.99	tr	5.4	00024002
27	---	Phosphoria	-2.74	36.0	---	0.78	0.99	0	3.6	89047013
28	---	Phosphoria	-2.02	33.1	0.73	0.95	1.02	tr	4.6	00024003
29	---	Phosphoria	-2.61	32.8	---	0.96	1.00	tr	1.9	89047033
30	---	Phosphoria	-2.53	34.5	---	1.06	1.00	tr	3.2	89047032
31	---	Phosphoria	-1.79	30.9	---	0.77	0.99	tr	2.4	89047023
32	---	Phosphoria	-2.14	34.1	0.77	0.76	0.97	tr	2.0	89047021
33	---	Phosphoria	-3.64	33.6	0.50	0.74	1.02	tr	2.0	89047045
34	---	Phosphoria	-2.16	30.8	0.74	0.91	1.00	tr	4.9	00024015
35	---	Phosphoria	-2.26	35.5	---	0.91	0.97	0	4.7	91045003
36	---	Phosphoria	-4.58	20.7	1.44	---	---	0	3.3	00011001
37	WRU	Phosphoria	-2.90	---	---	0.80	---	0	10.3	88002001
38	WRU	Phosphoria	-2.01	---	---	---	---	0	1.9	88002002
39	WRU	Phosphoria	-3.76	---	---	1.06	---	0	1.5	89066001
40	---	Phosphoria Cisco	-1.73	36.9	0.70	0.97	0.98	tr	2.4	00024020
41	---	Phosphoria Cisco	-1.73	34.8	0.84	1.01	1.03	tr	5.9	00011002
42	---	Phosphoria Cisco	-1.71	33.7	1.30	1.04	1.00	tr	4.3	00011005
43	---	Phosphoria Cisco	-2.29	34.0	1.23	1.02	1.01	tr	4.2	00011004
44	---	Phosphoria Cisco	-2.21	34.0	1.10	0.96	1.02	tr	4.6	00011003
45	---	mix - Phosphoria Cisco and Mancos	-1.56	32.0	0.43	1.58	1.03	tr	3.6	92107008
46	---	mix - Phosphoria and Mancos	-2.26	36.2	---	2.21	1.03	0	1.7	89047040

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	CV	Gravity	Sulfur	Pr/Ph	CPI	β C	Sat/Aro	Lab number
47	---	mix - Phosphoria and Mancos	-1.43	---	---	1.94	1.27	tr	2.2	92107046
48	---	mix - Phosphoria and Mancos	-2.51	33.3	---	1.25	1.01	tr	2.4	89047034
49	B	Phosphoria Wyoming	-2.05	21.6	2.68	0.64	1.04	tr	2.1	00024006
50	W	Phosphoria Wyoming	-2.56	28.2	2.20	0.56	0.99	tr	2.6	00024013
51	SCU	Tar Sand Triangle	-1.88	26.4	1.79	0.56	1.00	tr	3.3	00024007
52	SCU	Tar Sand Triangle	-3.66	---	---	0.66	0.96	tr	1.4	91023006
53	SCU	Tar Sand Triangle	-2.70	---	---	0.45	0.97	0	1.4	00024010
54	OV	Aspen (Mowry)	0.36	---	---	2.24	1.02	0	---	92107055
55	OV	Aspen (Mowry)	-0.39	---	---	2.12	1.04	tr	5.3	92107010
56	---	Mancos	-0.89	44.0	---	1.98	1.01	tr	4.5	89047037
57	---	Mancos	-0.32	41.4	---	2.14	1.02	tr	4.2	89047036
58	---	Mancos	0.31	39.4	0.00	2.16	1.05	tr	13.8	00024021
59	---	Mancos	-0.23	39.4	0.07	2.45	1.09	---	2.1	89047038
60	---	Mancos	-0.10	44.1	---	2.23	---	---	3.3	89047039
61	---	Mancos	-0.83	43.6	---	1.61	1.02	tr	2.5	89055002
62	---	Mancos	-0.59	45.6	---	1.63	1.01	tr	2.3	89055001
63	---	Mancos Cisco	-0.43	36.0	0.23	1.71	1.05	tr	7.2	92107009
64	---	Mancos Cisco	-0.34	41.3	0.14	1.51	1.02	tr	7.8	00024016
65	---	Mancos Cisco	-0.76	41.5	0.28	1.49	1.05	tr	4.5	92107007
66	---	Mancos Cisco	-0.10	37.0	0.10	1.68	1.03	tr	8.3	00024017
67	---	Mancos waxy	0.90	---	---	1.99	1.02	0	3.7	92107053
68	---	Mancos waxy	1.15	39.3	---	1.62	1.02	tr	3.6	89047026
69	---	Mancos waxy	0.20	39.6	0.00	2.22	1.03	0	1.9	89047022
70	---	Mancos waxy	1.28	43.1	---	2.14	1.03	tr	3.2	89047024
71	---	Mancos waxy	0.51	38.1	---	---	---	---	1.9	89055003
72	---	Mancos Niobrara	-1.10	31.4	0.15	1.87	1.01	tr	2.0	89047035
73	---	Mancos Niobrara	-0.03	39.4	---	2.09	0.98	tr	1.9	89047041
74	SWB	Mancos Niobrara	-0.26	35.1	---	1.98	1.00	0	2.0	89047005
75	SWB	Mancos Niobrara	-0.04	33.7	---	1.89	0.99	tr	2.2	89047043
76	---	Blackhawk	0.06	35.5	0.00	7.26	1.06	0	8.7	00027001
77	---	Mesaverde	0.85	---	---	5.35	1.04	0	7.0	92109076
78	---	Mesaverde	3.04	---	---	3.50	1.06	0	10.2	92107047
79	---	Mesaverde	1.03	51.4	---	6.17	1.08	tr	3.4	89047030
80	---	Mesaverde	1.37	49.3	---	5.50	1.05	0	6.3	91064001
81	---	Mesaverde	1.85	47.5	---	6.18	1.06	0	4.8	91064004
82	---	Mesaverde	1.55	43.2	---	8.70	1.05	0	6.5	91064005
83	---	Mesaverde	1.66	51.1	---	7.37	1.08	0	6.8	91064006
84	---	Mesaverde	1.52	46.1	---	7.05	1.12	0	7.1	91064003
85	---	Mesaverde	1.51	55.5	---	7.98	1.07	0	7.5	91064002
86	---	Mesaverde	1.40	40.6	---	4.24	1.05	tr	2.4	89047031
87	---	Mesaverde	1.84	45.7	---	4.83	1.04	tr	2.5	89047028
88	---	Mesaverde	0.39	46.6	---	6.60	1.07	0	2.1	89047029
89	---	Mesaverde	0.57	45.0	---	4.21	1.15	tr	4.5	89047027
90	---	Green River A	1.71	---	---	0.98	1.08	tr	4.4	92107045
91	---	Green River A	1.94	---	---	1.97	1.00	tr	48.3	90103015
92	---	Green River A	5.68	---	---	1.97	1.03	tr	34.1	90103016
93	---	Green River A	2.03	---	---	2.00	1.01	tr	12.9	92107040
94	---	Green River A	1.36	---	---	1.06	1.02	+	4.4	92107041
95	---	Green River A	1.90	---	---	2.36	1.00	tr	30.2	90103020
96	---	Green River A	-1.42	42.6	---	1.49	0.98	tr	9.8	90103018
97	---	Green River A	0.71	---	---	1.05	1.08	tr	2.6	92110024
98	---	Green River A	1.41	---	---	1.25	1.06	0	10.7	92109009
99	---	Green River A	0.95	---	---	1.09	1.06	+	7.3	90103008
100	---	Green River A	7.49	---	---	2.40	1.04	tr	20.7	90103012
101	---	Green River A	1.70	---	---	1.46	1.04	tr	15.5	90103014

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	CV	Gravity	Sulfur	Pr/Ph	CPI	β C	Sat/Aro	Lab number
102	---	Green River A	0.62	---	---	2.35	1.03	tr	9.3	93018001
103	---	Green River A	1.82	---	---	2.17	0.98	tr	22.4	93013002
104	---	Green River A	1.44	---	---	2.36	1.02	tr	30.5	93013003
105	---	Green River A	1.38	---	---	1.15	1.03	tr	3.1	93013001
106	---	Green River A	1.25	---	---	1.33	1.04	+	7.8	90103006
107	---	Green River A	2.08	---	---	1.50	1.05	tr	13.2	90103007
108	---	Green River A	2.46	---	---	2.15	1.01	tr	13.1	92107039
109	---	Green River A	1.02	---	---	0.89	0.98	tr	7.2	90103017
110	---	Green River A	2.63	---	---	1.92	0.95	tr	22.1	90103013
111	---	Green River A	0.14	---	---	0.78	0.97	+	3.9	90103005
112	---	Green River A	3.34	---	---	1.54	0.99	tr	23.3	90103002
113	---	Green River A	1.27	---	---	1.21	1.00	tr	12.0	90103003
114	---	Green River A	3.30	---	---	---	---	---	16.0	93013004
115	---	Green River A	4.91	---	---	2.33	0.93	+	22.0	90103011
116	---	Green River A	3.18	---	---	1.89	1.01	tr	13.5	90103001
117	---	Green River A	0.86	---	---	1.23	1.02	+	8.0	90103009
118	---	Green River A	0.80	---	---	1.38	1.01	tr	16.5	90103010
119	---	Green River A	0.85	---	---	1.04	0.99	+	4.0	92109022
120	---	Green River A	0.88	---	---	1.08	0.98	tr	4.8	92110008
121	---	Green River A	1.38	---	---	2.51	1.06	0	6.7	92109011
122	---	Green River A	0.90	---	---	1.96	1.04	tr	2.9	92110039
123	---	Green River A	1.41	---	---	1.20	1.04	tr	7.2	92109047
124	---	Green River A	0.58	---	---	1.81	0.98	0	6.7	92107044
125	---	Green River A	1.03	---	---	2.28	1.03	tr	16.2	92107038
126	---	Green River A	-1.19	---	---	2.46	1.01	0	21.9	92110002
127	---	Green River A	1.86	---	---	1.68	1.03	0	5.3	92107048
128	---	Green River A	2.16	---	---	1.54	1.00	0	4.5	92107052
129	---	Green River A	2.16	---	---	1.73	1.03	tr	5.9	92109040
130	---	Green River A	0.30	---	---	2.09	1.03	tr	27.3	92107034
131	---	Green River A	0.33	---	---	1.95	0.98	0	24.8	92107035
132	---	Green River A	1.10	---	---	2.07	1.03	tr	11.0	92107036
133	---	Green River A	0.96	---	---	1.09	1.07	0	4.9	92109005
134	---	Green River A	1.21	---	---	1.17	1.03	tr	4.3	92107037
135	---	Green River A	1.59	---	---	1.06	1.07	+	3.8	92109056
136	---	Green River A	2.70	---	---	1.10	1.04	+	4.3	92109033
137	---	Green River A	1.54	---	---	1.22	1.04	+	3.9	92109013
138	---	Green River A	1.47	---	---	1.37	1.06	+	3.9	92107051
139	---	Green River A	0.90	---	---	1.22	1.05	+	5.1	90103027
140	---	Green River A	0.74	---	---	1.26	1.03	tr	2.7	92110011
141	---	Green River A	1.09	---	---	1.25	1.04	tr	4.1	92110035
142	---	Green River A	1.47	---	---	1.16	1.08	+	5.4	92107042
143	---	Green River A	0.60	---	---	1.01	1.05	+	4.3	92109049
144	---	Green River A	1.31	---	---	1.28	1.09	+	6.8	92107054
145	---	Green River A	1.39	---	---	1.04	1.07	+	3.4	92109059
146	---	Green River A	0.57	---	---	0.73	1.07	+	4.3	90103031
147	---	Green River A	1.44	---	---	1.19	1.05	tr	3.8	92110009
148	---	Green River A	2.31	---	---	1.56	1.03	tr	6.2	92109027
149	---	Green River A	1.41	---	---	1.16	1.06	+	3.2	92110005
150	---	Green River A	1.32	---	---	0.94	1.05	+	6.9	90103026
151	---	Green River A	1.15	---	---	1.26	1.04	tr	3.4	92110046
152	---	Green River A	1.76	---	---	1.70	1.01	tr	6.3	92109041
153	---	Green River A	1.25	---	---	1.52	1.03	tr	8.2	92109069
154	---	Green River A	0.94	---	---	1.52	1.01	tr	7.2	92109070
155	---	Green River A	1.48	---	---	1.20	1.11	+	3.2	92107050
156	---	Green River B	1.41	23.0	---	1.55	1.36	++++	5.9	90103021

Table 1—Continued. Geochemistry of oils, oil stains, and seeps from Uinta-Piceance Province and adjacent area, Utah and Colorado.

Sample	Area	Oil type	CV	Gravity	Sulfur	Pr/Ph	CPI	β C	Sat/Aro	Lab number
157	---	Green River B	1.66	---	---	1.66	1.20	++++	5.5	90103024
158	---	Green River B	1.99	---	---	1.13	1.05	++	2.9	92109026
159	---	Green River B	0.87	---	---	1.36	1.24	+++	5.1	90103028
160	---	Green River B	1.67	---	---	1.29	1.33	+++	8.8	90103030
161	---	Green River B	2.63	---	---	1.09	1.04	++	2.4	92109025
162	---	Green River	1.03	---	---	---	---	---	6.1	90103004
163	---	Green River	1.19	---	---	1.24	---	tr	1.9	90103023
164	---	Green River	1.74	27.2	0.79	0.58	1.16	++	3.6	00013001
165	---	Green River	5.37	---	---	---	---	0	1.0	92005024
166	---	Green River	4.27	---	---	---	---	+	1.2	92117001
167	---	Green River	3.71	---	---	---	---	0	2.4	91056001
168	---	Green River	4.77	---	---	---	---	++++	1.4	92118001
169	---	Green River	4.14	---	---	---	---	0	1.4	91023010
170	---	Green River	4.54	---	---	---	---	0	1.3	91023011
171	---	Green River	3.55	---	---	---	---	0	0.8	92005023

Click here to return to
Volume Title Page