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Updated Tops File for Cretaceous and Lower Tertiary Units, Piceance Basin, Northwest Colorado

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Introduction

Depths to selected Cretaceous and lower Tertiary stratigraphic units in the Piceance Basin, northwestern Colorado (fig. 1) are presented here for 1,563 wells (table 1, fig. 2). This file is updated from the Piceance Basin Oil Shale Database (http://pubs.usgs.gov/dds/dds-069/dds-069-y/) with data for additional new drill holes. Also included in this report are elevations for the base of the Long Point Bed of the Eocene Green River Formation (figs. 3–5) for 347 surface locations obtained by determining locations and elevations from published 7 ½-minute quadrangle maps for the Piceance Basin listed in the "Geologic Maps Used to Generate Long Point Control Points" section.

Each entry for the base of the Long Point Bed was obtained at a location where the mapped Long Point Bed intersects a contour line on the published maps. Precision of each elevation is therefore dependent on the precision of the maps and the placement of the mapped contact by the authors.

Cretaceous Units

The top of the Lower to Upper Cretaceous Dakota Sandstone (fig. 3) is the lowest stratigraphic horizon included in the database (TOPDKTA). The Dakota was deposited during the initial transgression of the Cretaceous seaway into the Rocky Mountain region (Currie, 1998) and consists of fluvial, shoreface, and tidally influenced rocks. The top of the Lower Cretaceous Mowry Shale (fig. 3) is the next highest stratigraphic unit in the database (TOPMRY). The Mowry Shale was deposited in an offshore marine setting, and consists of hard, dark-gray siliceous mudstone containing abundant bentonite beds and fish scales and is a possible source rock for hydrocarbons in the Piceance Basin (Burtner and Warner, 1984). The Mowry Shale is recognized mainly in the northernmost part of the basin and only one Mowry pick is included in the database, the Phillips No. 1 Mannel well in that part of the basin (entry C1017R). The Upper Cretaceous Frontier Formation (TOPFRON), the next youngest unit in the database, is a complex unit deposited in nearshore marine and coastal plain settings (fig. 3) (Molenaar and Wilson, 1990). TOPFRON was identified in only a few wells in the northern and central part of the basin. The Upper Cretaceous Castlegate Sandstone (TOPCSGT) is a persistent offshore marine sandstone in the basin except in the southeast where it grades into Upper Cretaceous Mancos Group (Johnson, 1986). The Castlegate Sandstone is the stratigraphically oldest unit in the database for which a large number of picks were made (Johnson 1986). A structure contour map on the top of the Castlegate Sandstone was published by Johnson (1986).

The Upper Cretaceous Mesaverde Formation (or Group) (fig. 3) was deposited in coastal plain, nearshore marine, and shallow marine settings. It is the youngest Cretaceous unit preserved in the basin. The lower part of the Mesaverde Group is a complex series of regressive marine cycles interbedded with marine shale generally referred to as the Iles Formation (fig. 3), where the overlying Rollins/Trout Creek Sandstone Member exists. The upper part consists of mainly nonmarine rocks and is generally referred to as the Williams Fork Formation where the underlying Rollins/Trout Creek Sandstone Member exists. Where the Rollins/Trout Creek does not exist, the Mesaverde is considered a Formation. The top of the Mesaverde Formation/Group or top of the Williams Fork Formation is listed as TOPKMV. At least seven member names have been applied to individual regressive marine cycles in the Iles Formation (for a summary, see Johnson, 1989). The Iles Formation is capped regionally by the Rollins Sandstone and Trout Creek Sandstone Member (fig. 3). In the accompanying database, the Rollins and Trout Creek Sandstone Members are treated separately from the rest of the Iles Formation. Thus, there is a top listed for the Rollins and Trout Creek Sandstone Members (TOPRLNS) and a top listed for the next oldest regressive marine cycle in the Illes Formation (TOPILES).

Lower Tertiary Units

Top of Cretaceous to Long Point Bed Interval

The majority of the stratigraphic horizons listed in the database are from the lower Tertiary interval in the basin. In general, they are subdivided into two intervals: (1) those deposited prior to the development of Eocene Lake Uinta (top of Cretaceous to base of Long Point Bed) (fig. 3), and (2) those deposited after Lake Uinta formed (Long Point Bed to Bed 76) (figs. 3–6). During deposition of the first interval, the central part of the basin was first occupied by a large marsh or paludal system (Fort Union Formation, figs. 3, 4), and then by a large freshwater lake (Cow Ridge Member of the Green River Formation, figs. 3, 4). A distinctive marker occurs at the top of the paludal interval referred to as the I-marker in the central part of the basin (figs. 3, 4) (Chancellor and others, 1974) and is listed as IMARKR in the database. Several persistent marker beds (fig. 4) occur in the overlying freshwater lacustrine Cow Ridge Member in ascending order: (1) F-marker (FMARKR), (2) D-marker base (DMARKRBS), (3) D-marker top (DMARKRTP), (4) C-marker base (CMARKRBS), (5) C-marker top (CMARKRTP), (6) B-marker base (BMARKRBS), and (7) B-marker top (BMARKRTP). The marker beds were originally described by Chancellor and others (1974). The D, C, and B markers are typically tens of feet thick, and their tops are shown on figure 4. F-marker is the base of the Cow Ridge Member.

Long Point Bed and Above Interval

The base of the Long Point Bed of the Green River Formation marks a major transition in the Piceance Basin and the Uinta Basin to the west. During the Long Point transgression, represented by the Long Point Bed, the freshwater lakes in the Piceance and Uinta Basins expanded and coalesced across the Douglas Creek arch to form one large lake, Lake Uinta (Johnson, 1985a). Lake Uinta increased in salinity through time, ultimately depositing large amounts of the sodium carbonate mineral nahcolite along with halite in the central part of the basin. The interval above (fig. 5) the Long Point Bed is subdivided into four members: (1) Garden Gulch Member (Bradley, 1931), for illite-rich oil shale interval deposited early in the

history of Lake Uinta and prior to the onset of saline mineral deposition (figs. 3–5), (2) Parachute Creek Member (Bradley, 1931), for dolomite-rich oil shale interval deposited during saline mineral deposition (figs. 3–5), (3) Douglas Creek Member (Bradley, 1931), for marginal lacustrine rocks around the western margins of Lake Uinta (figs. 3, 4), and (4) Anvil Points Member (Donnell, 1953), for marginal lacustrine rocks around the eastern margin (fig. 3). The Douglas Creek and Anvil Points Members are the marginal equivalents of both the Garden Gulch and Parachute Creek Members.

Cashion and Donnell (1972) recognized that the entire Parachute Creek Member and Garden Gulch Member could be subdivided into a sequence of oil-rich zones, in ascending order R-0 through R-6 zones and Mahogany zone; and oil-lean zones, in ascending order L-0 through L-5, B-groove, and A-groove that could be recognized throughout much of the central part of the Piceance Basin and eastern part of the Uinta Basin (fig. 4). A- and B-grooves are thin lean zones that bracket the Mahogany zone, the most widespread and richest oil shale zone in the Piceance Basin and the primary target of most surface mining operations in the basin. These zones appear to approximately form time-stratigraphic units representing changing rates of organic matter production and preservation that occurred simultaneously throughout Lake Uinta in both basins. The rich- and lean-zone stratigraphy form the basis of the recent assessment of in-place oil shale resources in the Piceance Basin, provided by the U.S. Geological Survey (Johnson and others, 2010). Tops for all the rich and lean zones are included in this database. The rich and lean zones are listed in the database, in ascending order: R0, L0, R1, L1, R2, JDL2, JDR3, JDL3, JDR4, JDL4, JDR5, JDL5, JDR6, JDBGROOV, OMAHOG, JDMAHOGZN, JDAGROOV. Picks for zones that begin with JD were originally made by John Donnell and later modified. An organic-poor, clastic-rich interval is present in many drill holes in the southwest part of the basin, and the top (CLASTCR1TP) and base (CLASTCR1BS) of this interval is included in the database. The R0 through L1 zones are clay-rich and contain little carbonate, and form the Garden Gulch Member (fig. 4). All zones above L1 zone are dolomitic and form the Parachute Creek Member (fig. 4). In addition, Donnell (2008) traced individual oil shale beds above the Mahogany zone across large areas of the Piceance and Uinta Basins numbering them bed 2 through bed 76 (fig. 6). Tops for many of these numbered beds are also included in the database (JD2 through JD76). A persistent tuff bed, the informal Porcupine tuff bed (fig. 5), occurs between bed 70 (JD70) and bed 72 (JD72), and the top (JDTPPORCTF) and base (JDBSPORCTF) of that tuff are also included in the database.

References Cited

Bradley, W.H., 1931, Origin and microfossils of the oil shale of the Green River Formation of Colorado and Utah: U.S. Geological Survey Professional Paper 168, 58 p.

Burtner, R.L., and Warner, M.A., 1984, Hydrocarbon generation in Lower Cretaceous Mowry and Skull Creek Shales of the Northern Rocky Mountain area, in Woodward, Jane, Meissner, F.F., and Clayton, J.L., eds. Hydrocarbon source rocks of the greater Rocky Mountain region: Rocky Mountain Association of Geologists, p. 449–467.

Cashion, W.B., 1973, Geologic and structure map of the Grand Junction quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-736, scale 1:250,000.

Cashion, W.B., and Donnell, J.R., 1972, Chart showing correlation of selected key units in the organic-rich sequence of the Green River Formation, Piceance Creek Basin, Colorado, and Uinta Basin, Utah: U.S. Geological Survey Oil and Gas Investigations Chart OC-65.

Chancellor, R.E., Barksdale, W.L., and Dolezal, George, Jr., 1974, Occurrence of oil and gas in the Tertiary system, Rio Blanco unit, Rio Blanco County, Colorado, *in* Murray, D. Keith, ed., Guidebook to the Energy Resources of the Piceance Creek Basin, Colorado: Rocky Mountain Association of Geologists, 25th Field Conference, p. 225–233.

Currie, B.S., 1998, Upper Jurassic–Lower Cretaceous Morrison and Cedar Mountain Formations, NE Utah–NW Colorado—Relationships between nonmarine deposition and early Cordilleran foreland basin development: Journal of Sedimentary Research, v. 68, p. 632–652.

Donnell, J.R., 1953, Columnar section of rocks exposed between Rifle and DeBeque Canyon, Colorado, *in* Rocky Mountain Association of Geologists Guidebook, Field Conference, Northwestern Colorado: Denver, Colo., Rocky Mountain Association of Geologists, p. 14.

Donnell, J.R., 2008, Intertonguing of the lower part of the Uinta Formation with the upper part of the Green River Formation in the Piceance Creek Basin during the late stages of Lake Uinta: U.S. Geological Survey Scientific Investigation Report SIR 2008–5237, 25 p.

Donnell, J.R., and Blair, R.W., 1970, Resource appraisal of three rich oil-shale zones in the Green River Formation, Piceance Creek Basin, Colorado: Colorado School of Mines Quarterly, v. 65, p. 73-87.

Johnson, R.C., 1985a, Early Cenozoic history of the Uinta and Piceance Creek basins, Utah and Colorado, with special reference to the development of Eocene Lake Uinta, *in* Flores, R.M., and Kaplan, S.S., eds., Cenozoic Paleogeography of the West-Central United States, Rocky Mountain Paleography Symposium 3: The Rocky Mountain Section, Society of Economic Paleontologists and Mineralogists, p. 247–276.

Johnson, R.C., 1985b, Preliminary geologic map of the Winter Flats quadrangle, Garfield and Mesa Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1777, scale: 1:24,000, available at http://pubs.er.usgs.gov/usgspubs/mf/mf1777.

Johnson R.C., 1986, Structure contour map of the top of the Castlegate Sandstone, eastern part of the Uinta basin and the western part of the Piceance Creek Basin, Utah and Colorado: U.S. Geological Survey Miscellaneous Field Investigations Map MF-1826, scale, 1:253,440. [Two large foldouts]

Johnson, R.C., 1989, Geologic history and hydrocarbon potential of Late Cretaceous-age, low-permeability reservoirs, Piceance basin, western Colorado: U.S. Geological Survey Bulletin 1787-E, 51 p. and 2 large foldouts.

Johnson, R.C., and Roberts, L.N., 2003a, Depths to selected stratigraphic horizons in oil and gas wells for Upper Cretaceous and lower Tertiary strata of the Uinta Basin, Utah, chap. 13 *of* Petroleum systems and geologic assessment of oil and gas in the Uinta-Piceance Province, Utah and Colorado: U.S. Geological Survey Digital Data Series 69–B, 30 p.

Johnson, R.C., and Roberts, S.B., 2003b, The Mesaverde total petroleum system, Uinta-Piceance province, Utah and Colorado, chap. 7 *of* Petroleum systems and geologic assessment of oil and gas in the Uinta-Piceance Province, Utah and Colorado: U.S. Geological Survey Digital Data Series 69–B, 63 p.

Johnson, R.C., Mercier, T.J., Brownfield, M.E., Pantea, M.P., and Self, J.G., 2010, An assessment of in-place oil shale resources in the Green River Formation, Piceance Basin, Colorado, chap. 1 *of* U.S. Geological Survey Oil Shale Assessment Team, Oil Shale and Nahcolite Resources of the Piceance Basin, Colorado: U.S. Geological Survey Digital Data Series DDS–69–y, 187 p., available at http://pubs.usgs.gov/dds/dds-069/dds-069-y/.

Kellogg, H.E., 1977, Geology and petroleum of the Mancos B Formation, Douglas Creek arch area, Colorado and Utah, *in* Veal, H.K., ed., Exploration frontiers of the central and southern Rockies, Rocky Mountain Association of Geologists 1977 Symposium, p. 167–179.
Love, J.D., and Christiansen, A.C., 1985, Geologic map of Wyoming: U.S. Geological Survey and the Geological Survey of Wyoming, scale 1:500,000.
Molenaar, C.M., and Wilson, B.W., 1990, The Frontier Formation and associated rocks of northeastern Utah and northwestern Colorado: U.S. Geological Survey Bulletin 1787-M, 21p.
Rowley, P.D., Hansoe, W.R., Tweto, Ogden, and Carrara, P.E., 1985, Geologic map of the Vernal 1^{o} x 2^{o} quadrangle Colorado, Utah, and Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-1526, scale 1:250,000.
Southwestern Wyoming Province Assessment Team, 2005, The Southwestern Wyoming Province—Introduction to a geologic assessment of undiscovered oil and gas resources: U.S. Geological Survey Digital Data Series DDS–69-D, 36 p.
Tweto, Ogden, 1979, Geologic map of Colorado: U.S. Geological Survey and the Colorado Geological Survey, scale 1:500,000.
Uinta-Piceance Assessment Team, 2003, The Uinta-Piceance Province, introduction to a geologic assessment of undiscovered oil and gas resources: U.S. Geological Survey Digital Data Series DDS-69-B, 27 p.
Witkind, I.J., 1995, Geologic map of the Price 1^{o} x 2^{o} quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-2462.

Geologic Maps Used to Generate Long Point Control Points

Barnum, B.E., and Hail, W.J., Jr., 1996, Geologic map of the Gillam Draw Quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2314, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf2314.
Barnum, B.E., Scott, R.W., Jr., and Pantea, M.P., 1997, Geologic map of the Texas Mountain Quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2321, scale: 1:24,000.
Cashion, W.B., 1969, Geologic map of the Black Cabin Gulch quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-812, scale: 1:24,000.
Cullins, H.L., 1968, Geologic map of the Banty Point quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-703, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/gq/gq703.
Donnell, J.R., Hail, W.J., 1984, Preliminary geologic map of the Calamity Ridge quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-690, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1690.
Donnell, J.R., Schmitt, L.J., and Smith, M.C., 1992a, Geologic map of the Red Pinnacle quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2202, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf2202.
Donnell, J.R., Yeend, W.E., Schmitt, L J., and Smith, M.C., 1992b, Geologic map of the De Beque quadrangle, Garfield and Mesa counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2201, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf2201.
Donnell, J.R., Yeend, W.E., and Smith, M.C., 1984, Preliminary geologic map of the Mesa quadrangle, Mesa County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1698, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1698.

Donnell, J.R., Yeend, W.E., and Smith, M.C., 1985, Preliminary geologic map of the Collbran quadrangle, Mesa County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1825, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1825.
Donnell, J.R., Yeend, W.E., and Smith, M.C., 1985, Preliminary geologic map of the Molina quadrangle, Mesa County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1784, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1784.
Donnell, J.R., Yeend, W.E., and Smith, M.C., 1986, Preliminary geologic map of the Grand Valley quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1883, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1883.
Donnell, J.R., Yeend, W.E., and Smith, M.C., 1987, Geologic map of the Housetop Mountain quadrangle, Garfield and Mesa counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1965, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1965.
Donnell, J.R., Yeend, W.E., and Smith, M.C., 1988, Geologic map of the Hawxhurst Creek quadrangle, Garfield and Mesa counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2026, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf2026.
Donnell, J.R., Yeend, W.E., and Smith, M.C., 1989, Geologic map of the North Mamm Peak quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2093, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf2093.
Donnell, J.R., Yeend, W.E., and Smith, M.C., 1990, Geologic map of the South Mamm Peak quadrangle, Garfield and Mesa Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2113, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf2113.
Hail, W.J., Jr., 1972, Preliminary geologic map of the Barcus Creek SE quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-347, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf347.
Hail, W.J., Jr., 1973, Geologic map of the Smizer Gulch quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1131, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/gq/gq1131.
Hail, W.J., Jr., 1974a, Geologic map of the Rough Gulch quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1195, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/gq/gq1195.
Hail, W.J., Jr., 1974b, Preliminary geologic map and section of the Barcus Creek quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map 619, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf619.
Hail, W.J., Jr., 1978, Preliminary geologic map of the Mount Blaine quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-984, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf984.
Hail, W.J., Jr., 1982, Preliminary geologic map of the Circle Dot Gulch quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1293, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1293.
Hail, W.J., Jr., 1984, Geologic map of the Barcus Creek quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1578, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/gq/gq1578.
Hail, W.J., Jr., 1988, Geologic map of the Barcus Creek SE quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Geologic Quadrangle GQ-1613, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/gq/gq1613.

Hail, W.J., Jr., and Duncan, D.C., 1984, Revised preliminary geologic map of the northern half of the Square S Ranch quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Open-File Report 84–202, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/ofr/ofr84202.

Hail, W.J., Jr., and Barnum, B.E., 1993, Geologic map of the Divide Creek quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2232, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf2232.

Johnson, R.C., 1975, Preliminary geologic map, oil shale yield histograms and stratigraphic sections, Long Point Quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-688, 2 sheets, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf688.

Johnson, R.C., 1977a, Preliminary geologic map and cross section of The Saddle quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-829, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf829.

Johnson, R.C., 1980, Preliminary geologic map of the Middle Dry Fork quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1215, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1215.

Johnson, R.C., 1981b, Preliminary geologic map of the Desert Gulch quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1328, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1328.

Johnson, R.C., and Douglas, B.J., 1980, Preliminary geologic map of the Wagon Track Ridge Quadrangle, Garfield and Mesa Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1182, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1182.

Johnson, R.C., and Smith, M.C., 1993, Geologic map of the Philadelphia Creek quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2216, scale: 1:24,000.

Nuccio, V.F., 1985, Preliminary geologic map of the Douglas Pass quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1772, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1772.

O'Sullivan, R.B., 1985, Preliminary geologic map of the Rio Blanco quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1816, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1816.

O'Sullivan, R.B., 1986, Preliminary geologic map of the Anvil Points quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1882, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1882.

O'Sullivan, R.B., and Smith, M.C., 1985, Preliminary geologic map of the west half of the Thirteenmile Creek quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1789, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1789.

O'Sullivan, R.B., and Hail, W.J., 1987, Preliminary geologic map of the Forked Gulch quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1953, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf1953.

Pantea, M.P., 1993, Preliminary geologic map of the East Evacuation Creek quadrangle, Garfield and Rio Blanco Counties Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2220, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf2220.

Pipiringos, G.N., and Johnson, R.C., 1975, Preliminary geologic map of the Buckskin Point quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-651, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf651.

Pipiringos, G.N., and Johnson, R.C., 1976, Preliminary geologic map and correlation diagram of the White River City quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF 76–736, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf736.

Pipiringos, G.N., and Rosenlund, G.C., 1977, Preliminary geologic map of the Indian Valley quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-836, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf836.

Pipiringos, G.N., and Rosenlund, G.C., 1977, Preliminary geologic map of the White Rock quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-837, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf837.

Roehler, H.W., 1972a, Geologic map of the Brushy Point quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1018, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/gq/gq1018.

Roehler, H.W., 1972b, Geologic map of the Razorback Ridge quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1019, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/gq/gq1019.

Roehler, H.W., 1973a, Geologic map of the Calf Canyon quadrangle, Garfield County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1086, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/gq/gq1086.

Yeend, W.E., Donnell, J.R., and Smith, M.C., 1988, Geologic map of the Rulison quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2060, scale: 1:24,000, http://pubs.er.usgs.gov/usgspubs/mf/mf2060.

Figures

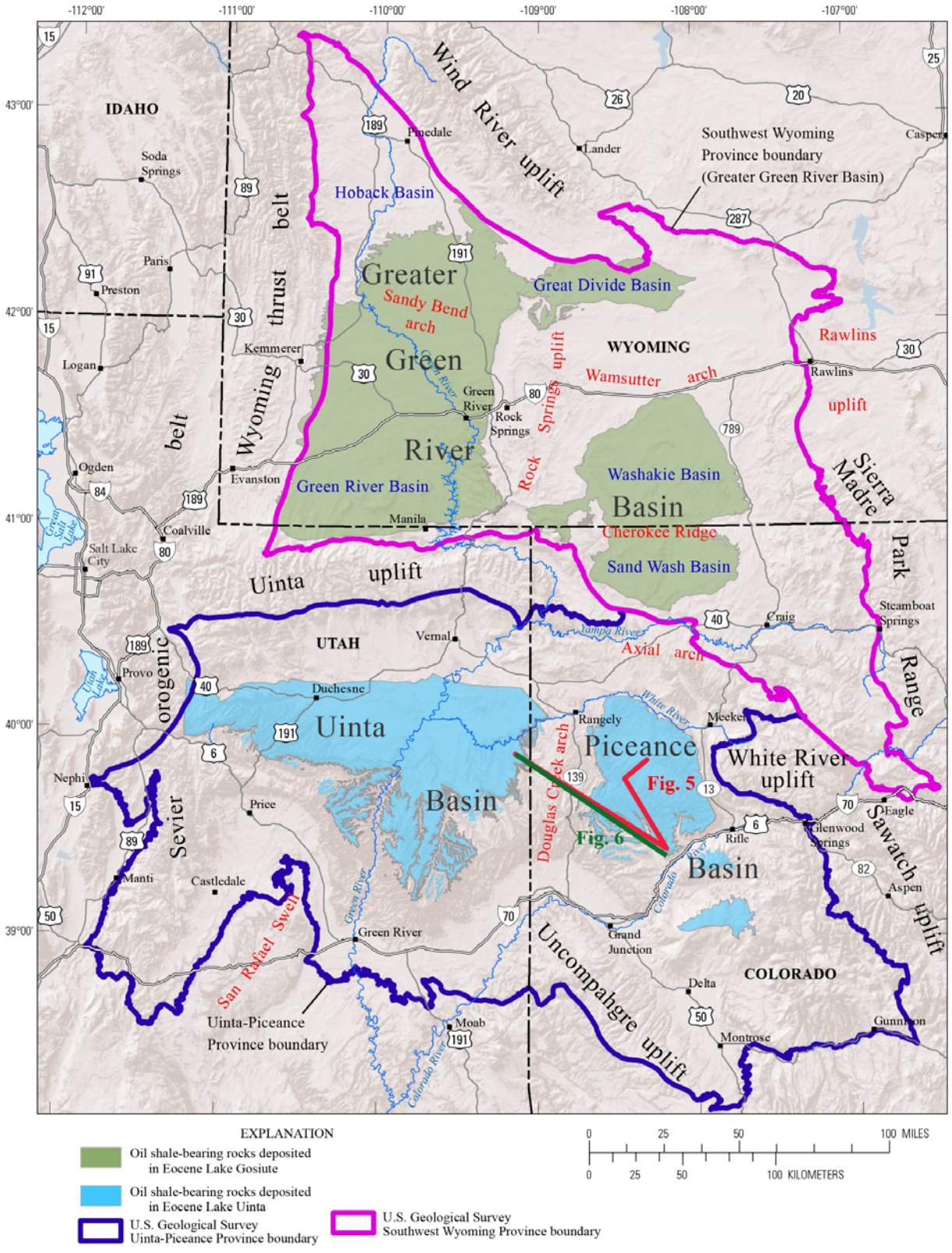
-112°00'
-111°00'
-110°00'
-109°00'
-108°00'
-107°00'
43°00'
42°00'
41°00'
40°00'
39°00'
IDAHO
UTAH
WYOMING
COLORADO
Wind River uplift
Hoback Basin
Greater Green River Basin
Sandy Bend arch
Great Divide Basin
Southwest Wyoming Province boundary (Greater Green River Basin)
Wamsutter arch
Rawlins uplift
Rock Springs uplift
Washakie Basin
Sand Wash Basin
Cherokee Ridge
Sierra Madre uplift
Park Range
Axial arch
Douglas Creek arch
Piceance Basin
White River uplift
Fig. 5
Fig. 6
Uinta Basin
Uinta uplift
Uinta-Piceance Province boundary
San Rafael Swell
Uncompahgre uplift
Sawatch uplift
thrust belt
Wyoming belt
orogenic belt
Sevier
Pinedale
Lander
Casper
Rawlins
Kemmerer
Logan
Paris
Preston
Soda Springs
Ogden
Evanston
Coalville
Salt Lake City
Manila
Rock Springs
Green River
Vernal
Craig
Steamboat Springs
Meeker
Rangely
Rifle
Glenwood Springs
Eagle
Aspen
Duchesne
Provo
Nephi
Manti
Castledale
Price
Green River
Grand Junction
Delta
Montrose
Gunnison
Moab
Yampa River
White River
Colorado River
Great Salt Lake
Utah Lake
EXPLANATION
Oil shale-bearing rocks deposited in Eocene Lake Gosiute
Oil shale-bearing rocks deposited in Eocene Lake Uinta
U.S. Geological Survey Uinta-Piceance Province boundary
U.S. Geological Survey Southwest Wyoming Province boundary
0 25 50 100 MILES
0 25 50 100 KILOMETERS

Figure 1. Extent of the Uinta and Piceance Basins, the Greater Green River Basin, and approximate extent of oil shale in the Eocene Green River Formation. Extent of the Uinta and Piceance Basins is the same as the Uinta-Piceance Province boundary (Uinta and Piceance Assessment Team, 2003). Extent of the Greater Green River Basin is the same as the Southwest Wyoming Province boundary (Southwest Wyoming Province Assessment Team, 2005). For the extent of oil shale in the Piceance Basin, the base of the Parachute Creek Member of the Green River Formation as mapped by Tweto (1979) was used for all but the northwest part of the basin where the base of the lower member of the Green River Formation is used. For the extent of oil shale in the eastern part of the Uinta Basin, the base of the Parachute Creek Member of the Green River Formation as mapped by Cashion (1973) and Rowley and others (1985) was used. In the western part of the basin the top of the Mahogany bed as mapped by Witkind (1995) was used. In the northern part of the Uinta Basin, only those areas where oil shale is at a depth of 6,000 ft or less are shown, based on a structure contour map of the top of the Mahogany oil shale bed compiled by Johnson and Roberts (2003a). For the Sand Wash, Washakie, and Great Divide Basins and southeastern part of the Green River Basin, the base of the Tipton Shale Member of the Green River Formation as mapped by Tweto (1979) and Love and Christiansen (1985) was used as the extent of oil shale. For the western part of the Green River Basin, the base of the Wilkins Peak Member of the Green River Formation as mapped by Love and Christiansen (1985) was used, and for the northern part of the Green River Basin, the base of the Laney Shale Member of the Green River Formation as mapped by Love and Christiansen (1985) was used. Location of cross section in figure 5 shown in red, location of cross sections shown in figure 6 shown in green.

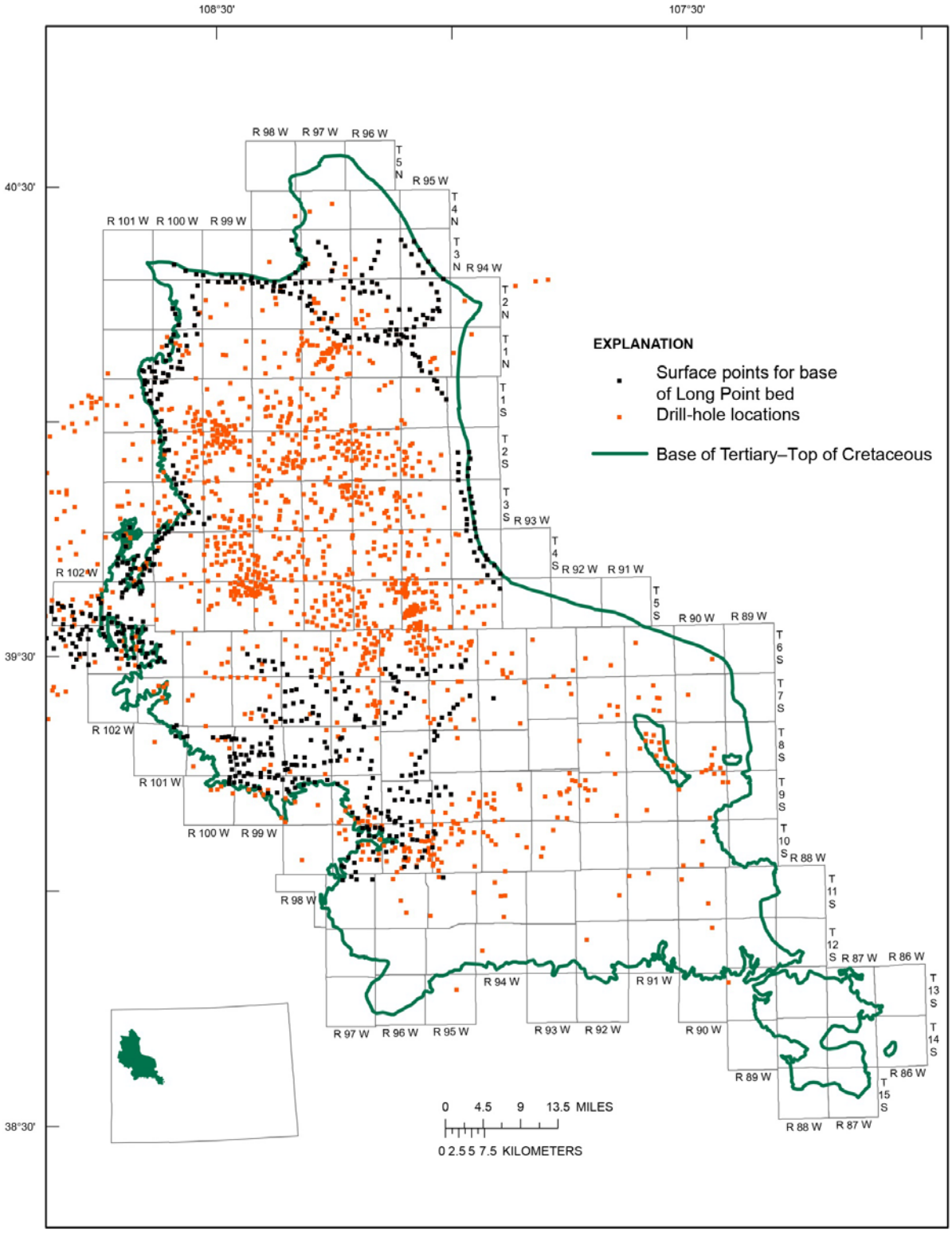

Figure 2. Map of the Piceance Basin showing locations of drill holes (orange and surface elevations on the base of the Long Point Bed of the Eocene Green River Formation (black) included in this database. Top of Upper Cretaceous Mesaverde Formation or Williams Fork Formation—base of Tertiary shown in dark green.

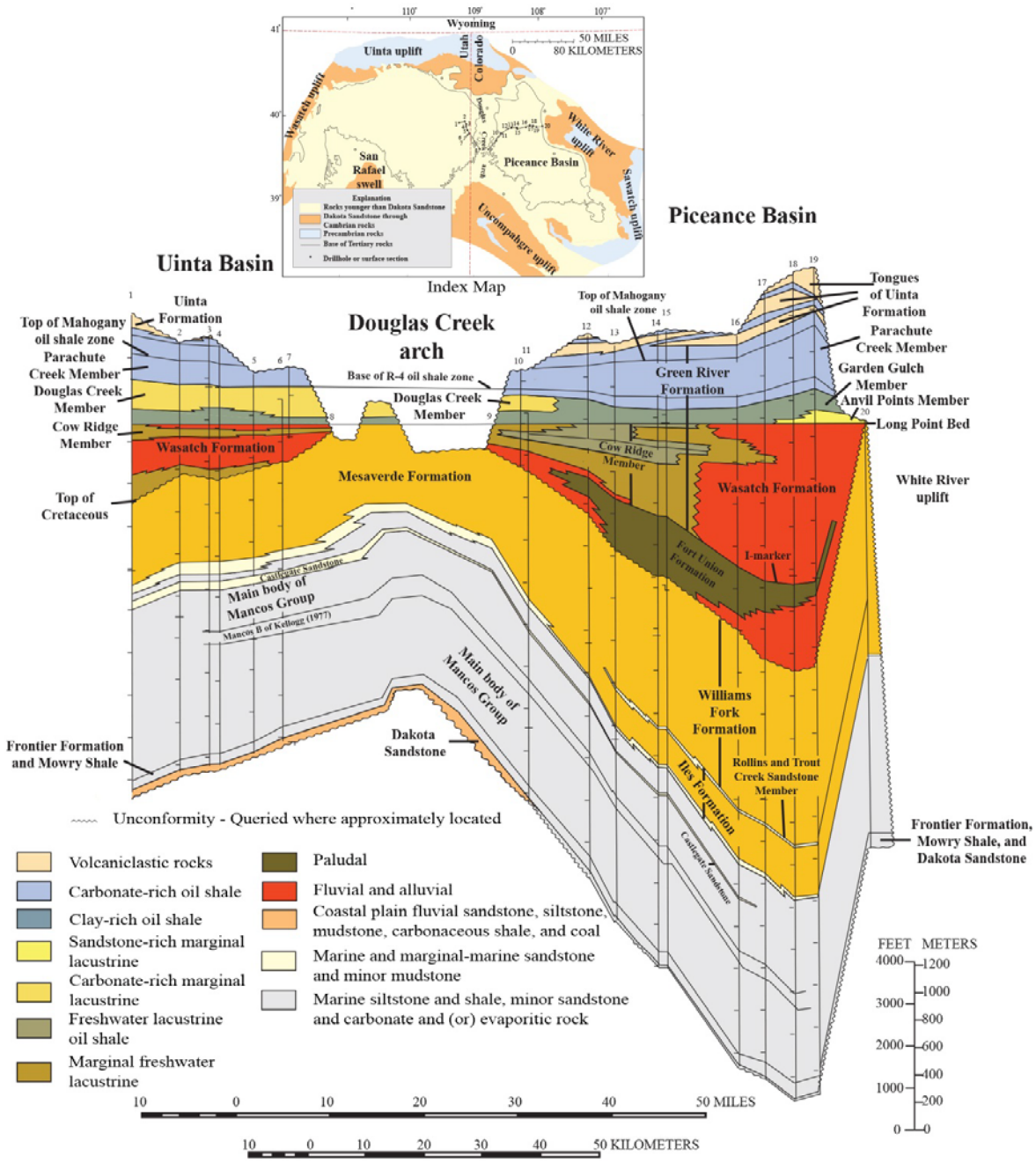

Figure 3. East-west cross section through the Piceance Basin, the Douglas Creek arch, and the eastern part of the Uinta Basin showing stratigraphic units in the Cretaceous and lower Tertiary. Modified from Johnson and Roberts (2003b, their Plate 1).

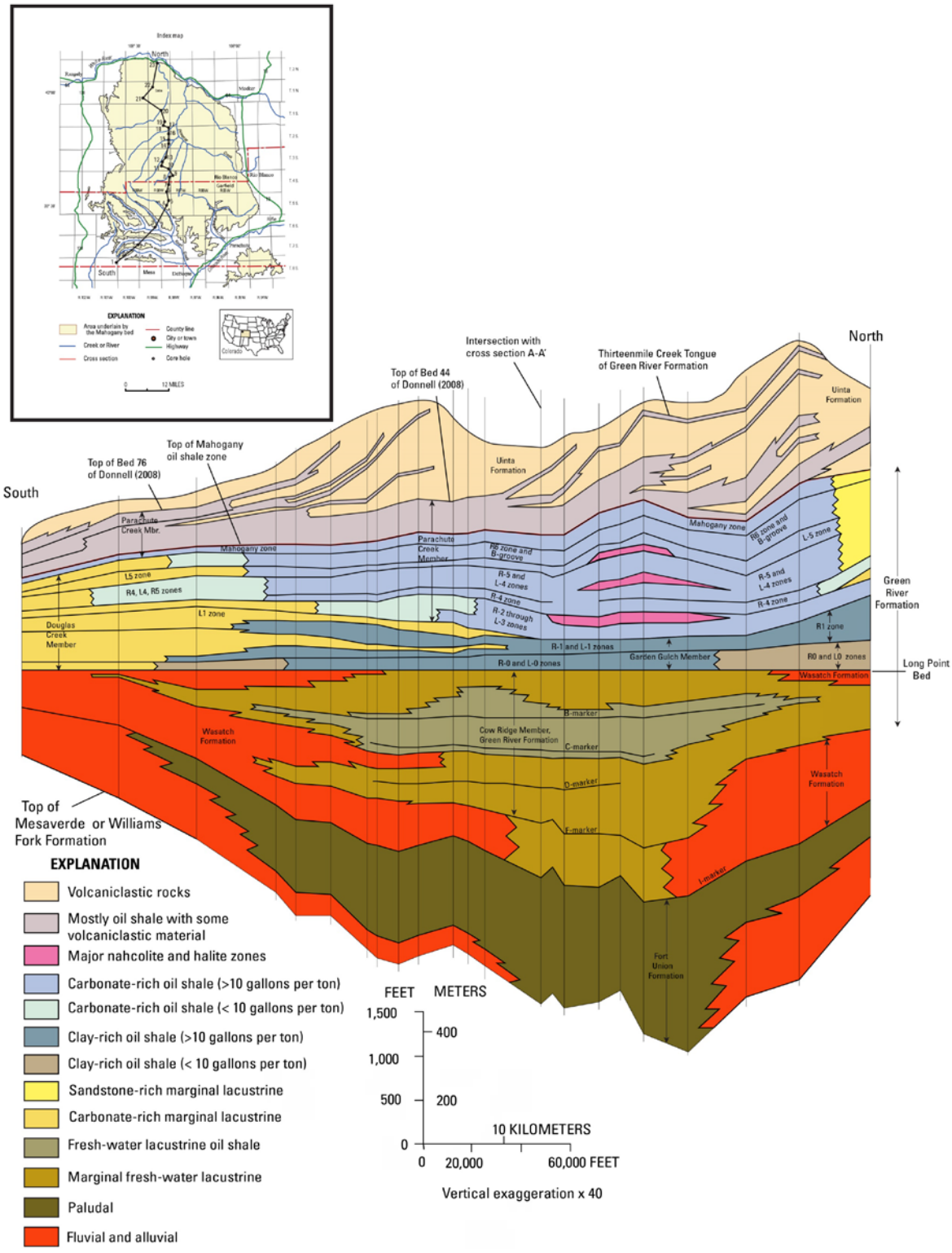

Figure 4. North-south cross section through the Piceance Basin, northwest Colorado showing members, stages of Lake Uinta as defined by Johnson (1985a), and some of the rich and lean zones defined by Cashion and Donnell (1972). (>, greater than; <, less than)

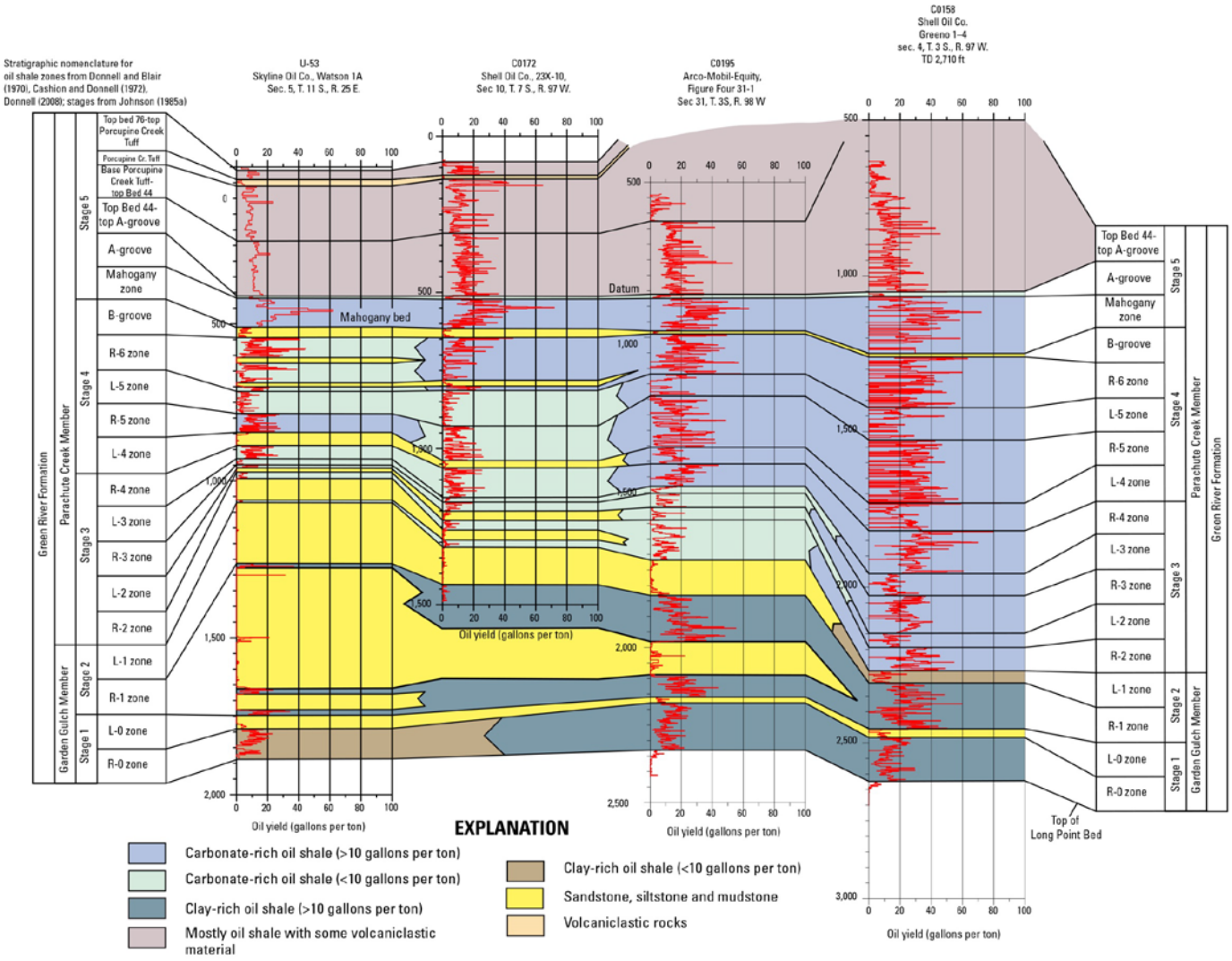

Figure 5. Cross section showing members of the Eocene Green River Formation, stages in the evolution of Lake Uinta, correlation of rich and lean oil shale zones of Cashion and Donnell (1972), and oil-yield histograms. U-53 is in the northeast corner of the Uinta Basin and core holes CO172 and CO195 are in the southeastern and central parts of the Piceance Basin respectively. Location shown on figure 1. (>, greater than; <, less than)

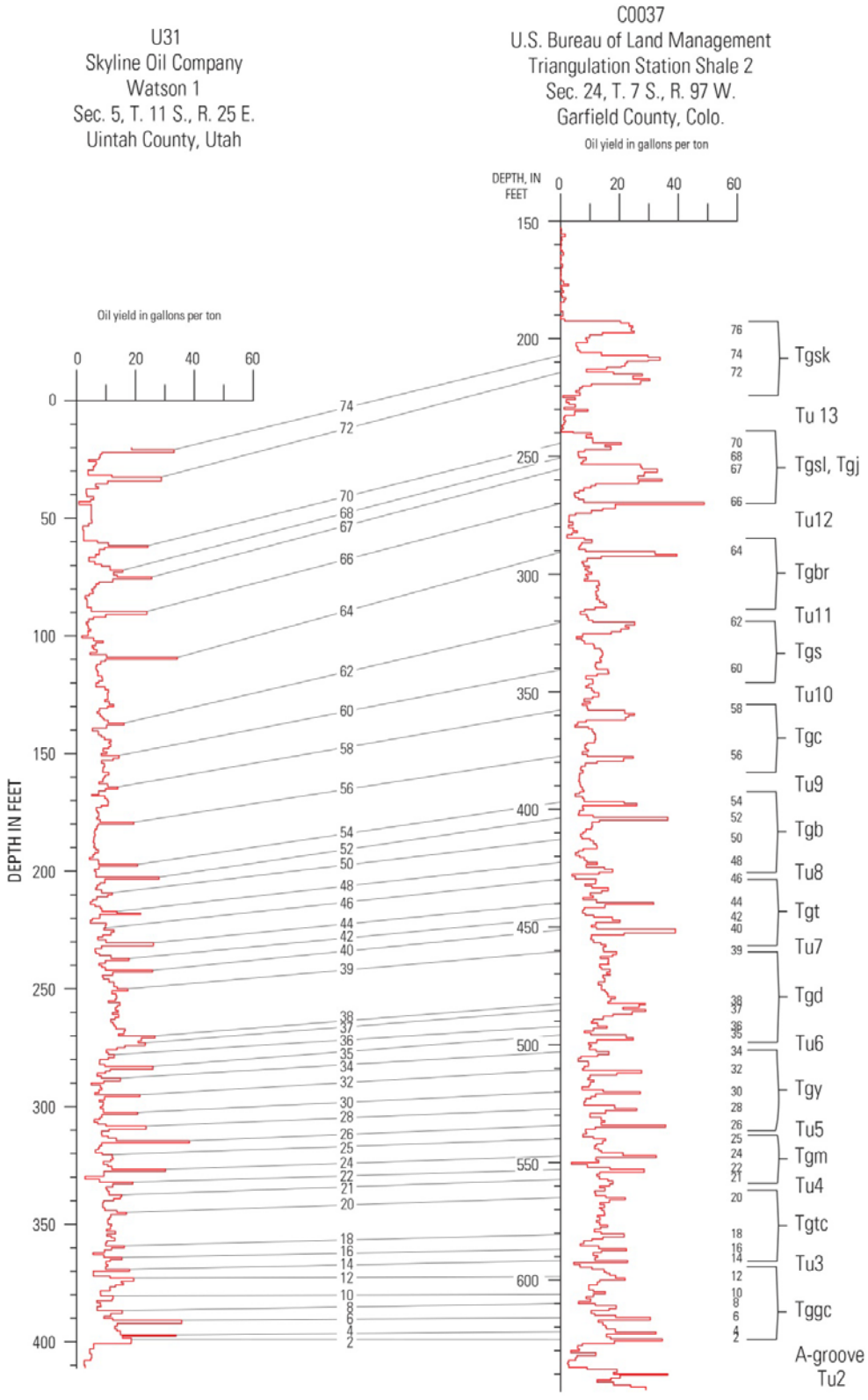

Figure 6. Cross section showing correlation of individual oil shale beds between two coreholes: *A*, U31 in the eastern part of the Uinta Basin, and *B*, C0037 in the southern part of the Piceance Basin for the

interval above A-groove (modified from Donnell, 2008, his figure 4). Locations of coreholes shown on figure 1. A, base of A-groove; Tggc, Marlstone at Greasewood Creek; Tgtc, Marlstone at Trail Canyon; Tgm, Marsltone at Mare Canyon; Tgy, Yellow Creek Tongue; Tgd, Dry Fork Tongue; Tgt, Thirteenmile Creek Tongue; Tgb, Black Sulfur Tongue; Tgc, Cough's Creek Tongue; Tgs, Stewart Gulch Tongue; Tgsl, Tgi, Marlstone at Barnes Ridge and Marlstone bed at Bull Fork; Tgsk, Marlstone at Skinner Ridge.] Numbers between C0333 and C0037 are persistent oil shale beds defined by Donnell (2008).