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Detailed Cross Sections of the Eocene Green River Formation along the North and East Margins of the Piceance Basin, Western Colorado, Using Measured Sections and Drill Hole Information

Scientific Investigations Map 3276

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

Front cover. Green River Formation at the mouth of Yellow Creek in the northern Piceance Basin. Yellow Creek is one of the measured sections on sheet 1. Photograph by R.C. Johnson, 2007.

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Pamphlet to accompany
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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Volume	
gallon (gal)	3.785	liter (L)
	Mass	
ton, short (2,000 lb)	0.9072	megagram (Mg)

SI to Inch/Pound

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Volume	
liter (L)	0.2642	gallon (gal)
	Mass	
megagram (Mg)	1.102	ton, short (2,000 lb)

Altitude, as used in this report, refers to distance above the vertical datum.

Detailed Cross Sections of the Eocene Green River Formation along the North and East Margins of the Piceance Basin, Western Colorado Using Measured Sections and Drill Hole Information

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Introduction

The Eocene Green River Formation was deposited in Lake Uinta, a long-lived saline lake that covered much of the Piceance Basin in northwestern Colorado and the Uinta Basin in eastern Utah (fig. 1). This report presents 2 detailed cross sections of the Eocene Green River Formation in the Piceance Basin constructed from 8 detailed measured sections, 14 core holes, and 2 rotary holes. The cross sections extend across the northern and eastern margins of the basin and are intended to aid in correlating between surface sections and the nearby subsurface (fig. 1). Detailed measured sections new to this report are: (1) Smith Gulch, (2) Hay Gulch, and (3) Rio Blanco. Detailed measured sections that were previously published include: (1) Fletcher Gulch (Johnson and others, 1988), (2) Anvil Points (Self and others, 2010), (3) Spring Creek (Self and others, 2010), (4) Yellow Creek (Self and others, 2010), and (5) Lower Piceance Creek (Johnson, 2012).

Core holes and rotary holes used include oil-yield histograms from Fischer assay analysis, a standardized laboratory test for determining the oil yield from oil shale that has been almost universally used to determine oil yields for Green River Formation oil shales (Stanfield and Frost, 1949; ASTM, 1984). In addition, all measured sections except Anvil Points and Smith Gulch include estimates of oil yield based on appearance and density. According to Cashion (1967, p. 25) estimated oil yields from surface samples can give moderately accurate results when sampling is done by an experienced investigator, but should only be used if data are not available. These estimates are presented mainly as an aid to correlating oil shale units between surface sections and nearby drill holes, as sequences of oil shale beds have similar richness patterns.

Correlation of oil shale units in both the Piceance Basin and the Uinta Basin to the west uses a comprehensive time-stratigraphic system based on alternating rich and lean oil shale zones. This system, originally proposed by Cashion and Donnell (1972), has been used to subdivide the oil shale interval of the Green River Formation throughout much of both basins (fig. 2) and was recently used in the assessment of in-place oil shale in the two basins (Johnson and others, 2010a; b). The system assumes that rich- and lean-oil shale units were deposited during alternating periods of high- and low-organic productivity, respectively, that occurred simultaneously across the entire area of Lake Uinta.

The sequence of rich- and lean-oil shale zones, deposited in offshore areas of Lake Uinta, grade into marginal lacustrine clastic and carbonate sequences toward the lake margins. One of the purposes of this study is to better correlate these rich and lean zones into their largely marginal lacustrine equivalents. This was previously attempted by Johnson and others (1988) for the western margin of the Piceance Basin and the eastern margin of the Uinta Basin. Johnson (2012) used the 1988 study, along with early versions of the detailed cross sections presented here, to correlate each of the marginal lacustrine units mapped on published quadrangle maps in the basin into this time-stratigraphic system of rich and lean zones. Thus, this publication provides additional supporting data to that used in Johnson's 2012 study.

Stratigraphic Subdivisions of the Green River Formation.

The Green River Formation of the Piceance Basin was deposited in the Eocene Lake Uinta that formed when two much smaller fresh-water lakes, one in each the Piceance and Uinta Basins, expanded and merged into one large saline lake. Lake Uinta remained a single unbroken lake across both basins and the intervening Douglas Creek arch throughout most of its history, and as a result most stratigraphic units can be recognized in both basins (figs. 2 and 3). Several members of the Green River Formation are recognized, although the member designations have not always been applied consistently (figs. 3 and 4). For a recent compilation of how member names have been applied, see Johnson (2012). In the oil shale section deposited in the offshore areas of the lake, the name Garden Gulch Member is generally applied to the illitic oil shales that were deposited in the early history of Lake Uinta,

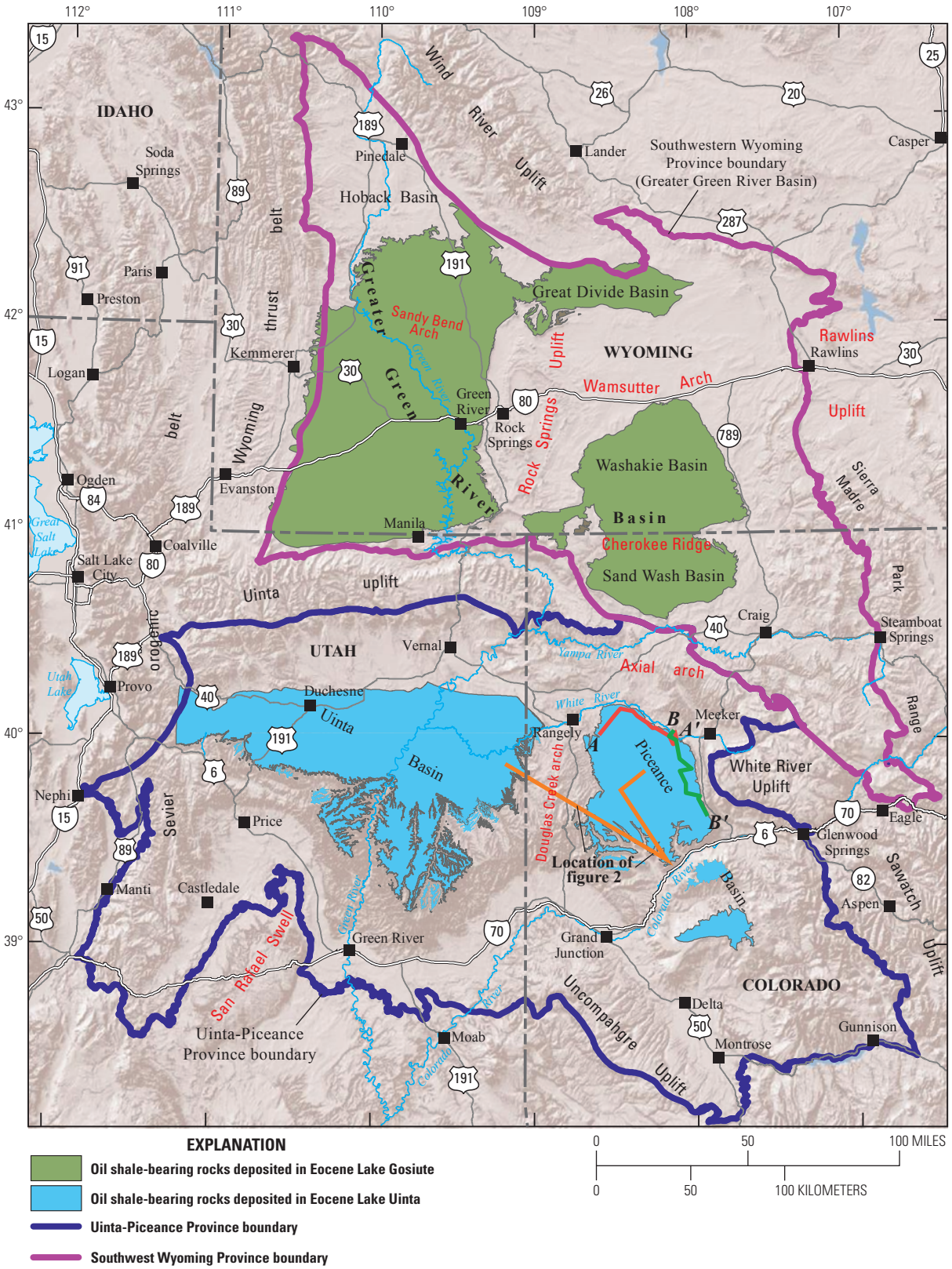

Figure 1. Map showing extent of Uinta, Piceance, and Greater Green River Basins and approximate extent of oil shale in the Green River Formation.

and the name Parachute Creek Member is applied to the dolomitic oil shales deposited later. The name Douglas Creek Member is applied to marginal lacustrine rocks along the west and southwest margins, and the name Anvil Points Member is applied to marginal lacustrine rocks along the east and southeast margins of the Piceance Basin. The names Garden Gulch Member, Parachute Creek Member, and Douglas Creek Member were first used by Bradley (1931), whereas Donnell (1953) was the first to use the name Anvil Points Member. The name Uinta Formation is applied to a sequence of sandstones and siltstones containing abundant volcanic debris that interfinger with the upper part of the Green River Formation (Cashion and Donnell, 1974).

Cashion and Donnell (1972) recognized that the entire oil shale interval in the Piceance and Uinta Basins could be subdivided into a series of oil-rich zones (R–1 through R–6) and oil-lean zones (L–1 through L–5) (fig. 2). Later, the names R–0 and L–0 zones were applied to the lowest oil shale units in the Green River Formation that was deposited just after the Long Point transgression (fig. 2) (see, for example, Johnson and others, 1988). Previously named oil shale units above the R–6 zone are, in ascending order: B–groove, Mahogany zone, and A–groove. The oil shale interval above A–groove was not named by Cashion and Donnell (1972), but they traced several oil shale marker beds through that interval. Donnell (2008) correlated 44 individual oil shale beds above A–groove across much of the Piceance Basin and eastern part of the Uinta Basin (fig. 2). All of these oil shale beds and zones appear to closely represent time-stratigraphic units that reflect changing rates of organic matter production and preservation that occurred simultaneously throughout Lake Uinta.

In the offshore areas of the lake, the boundary between clay-rich oil shale and carbonate-rich oil shale is near the base of the R–2 oil shale zone (fig. 2), however, the boundary between the Garden Gulch and Parachute Creek Members mapped in outcrop around the margins of the basin commonly does not correspond to that stratigraphic position. Johnson (2012) discusses the many reasons for these discrepancies, and it is suggested that the reader consult that report.

Constructing the Detailed Cross Sections

The individual measured sections include columns for color, lithology, grain size, bedding features, and in most cases, estimated oil yield based on the appearance and density of the oil shale in outcrop. The strata exposed at Anvil Points and Smith Gulch contain little oil shale, and estimates of oil yield in these two sections were not made. Datum for the two detailed cross sections is the base of the Long Point Bed of the Green River Formation (figs. 3 and 4), the basal transgressive bed that formed Lake Uinta. The detailed cross sections include the boundaries of stratigraphic units from published maps in the vicinity of each measured section (see Johnson, 2012) and correlate stratigraphic units to the rich- and lean-zone stratigraphy when it can be determined. Boundaries between various lithologic units shown may or may not correspond to the mapped outcrop boundaries of stratigraphic units or boundaries between the rich and lean zone.

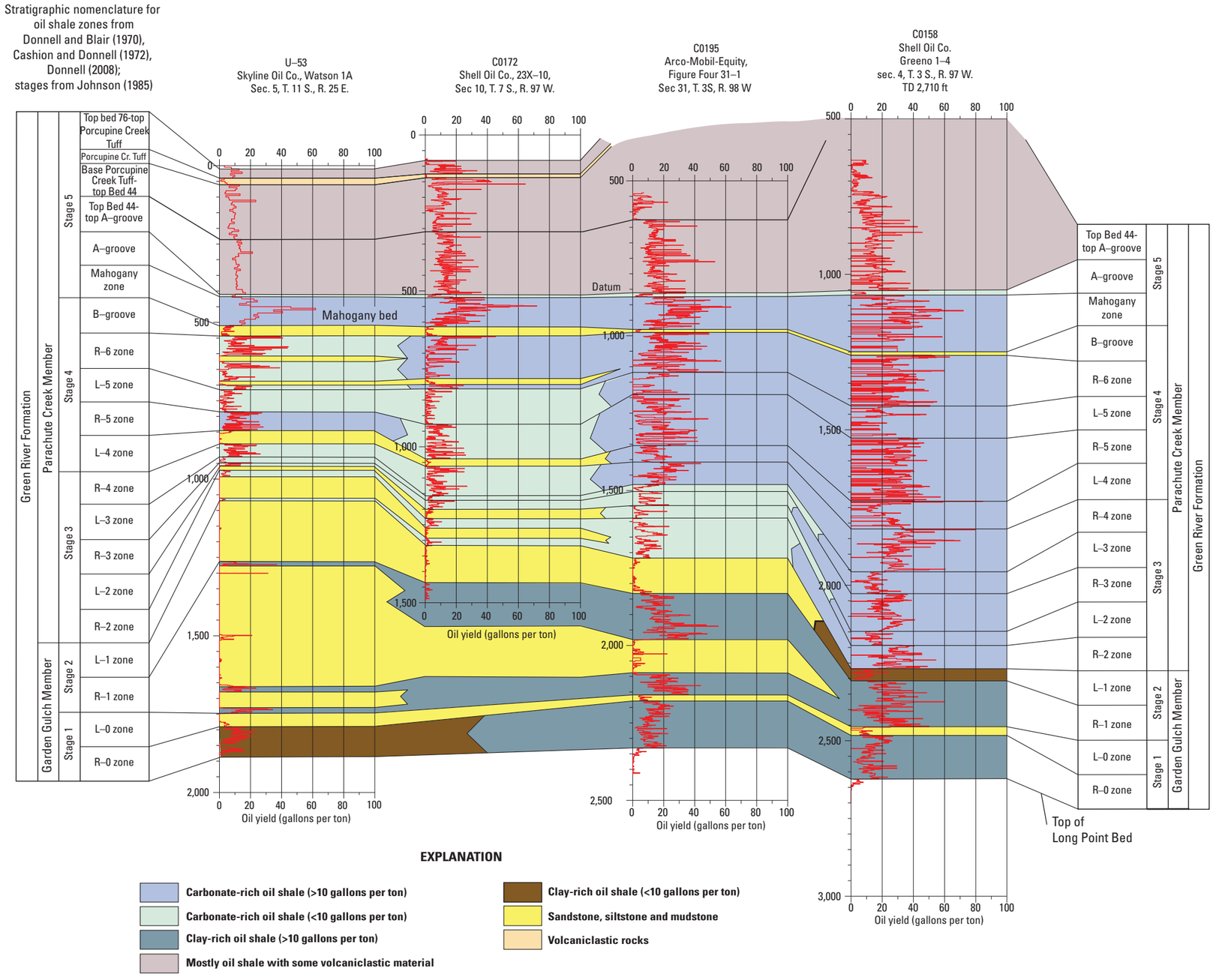

Figure 2. Cross section showing oil-yield histograms, members of the Eocene Green River Formation, correlation of rich- and lean-oil shale zones, and stages in the evolution of Lake Uinta.

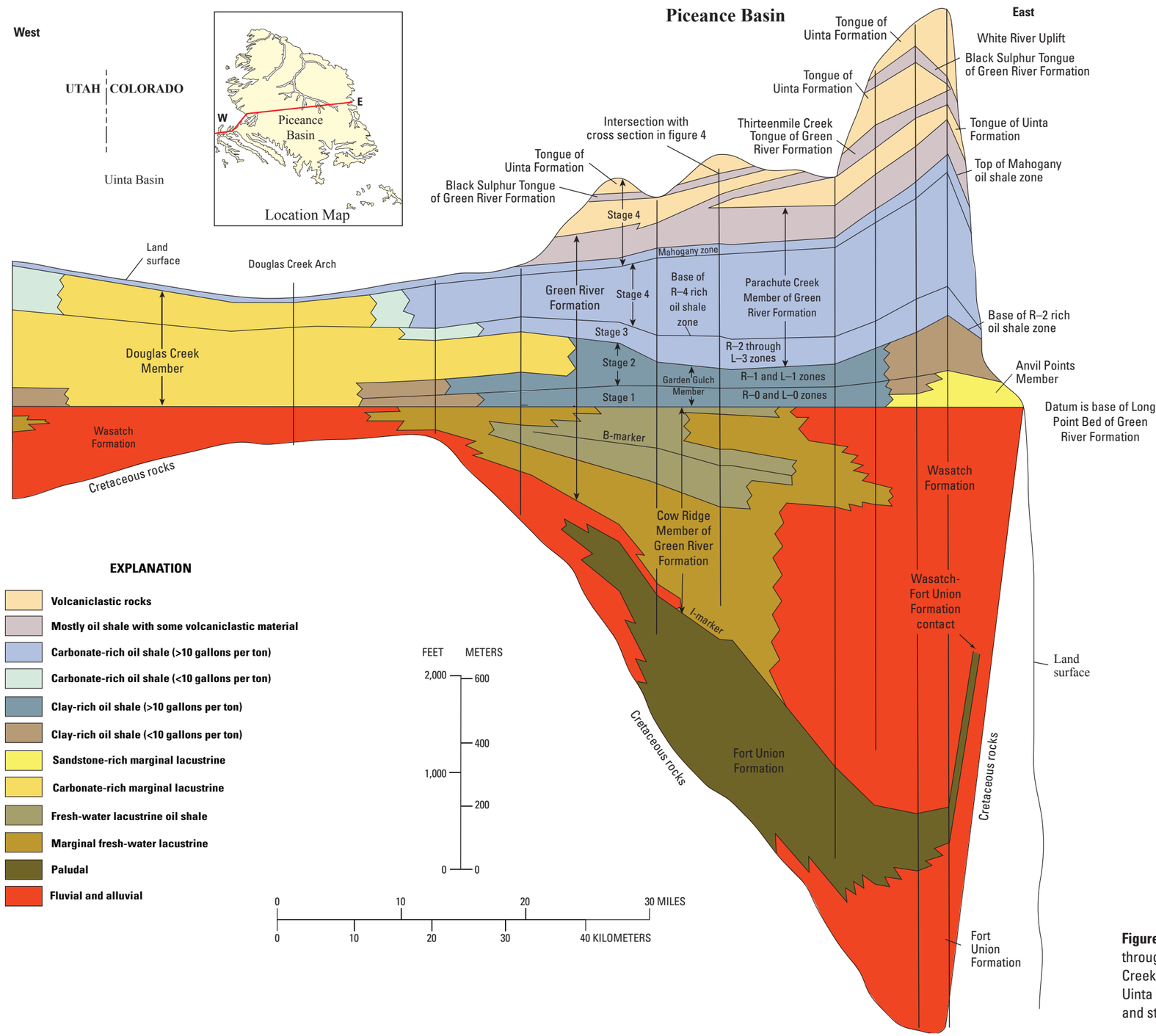

Figure 3. East-west cross section through the Piceance Basin, the Douglas Creek arch, and the eastern part of the Uinta Basin showing member subdivisions and stages of Lake Uinta.

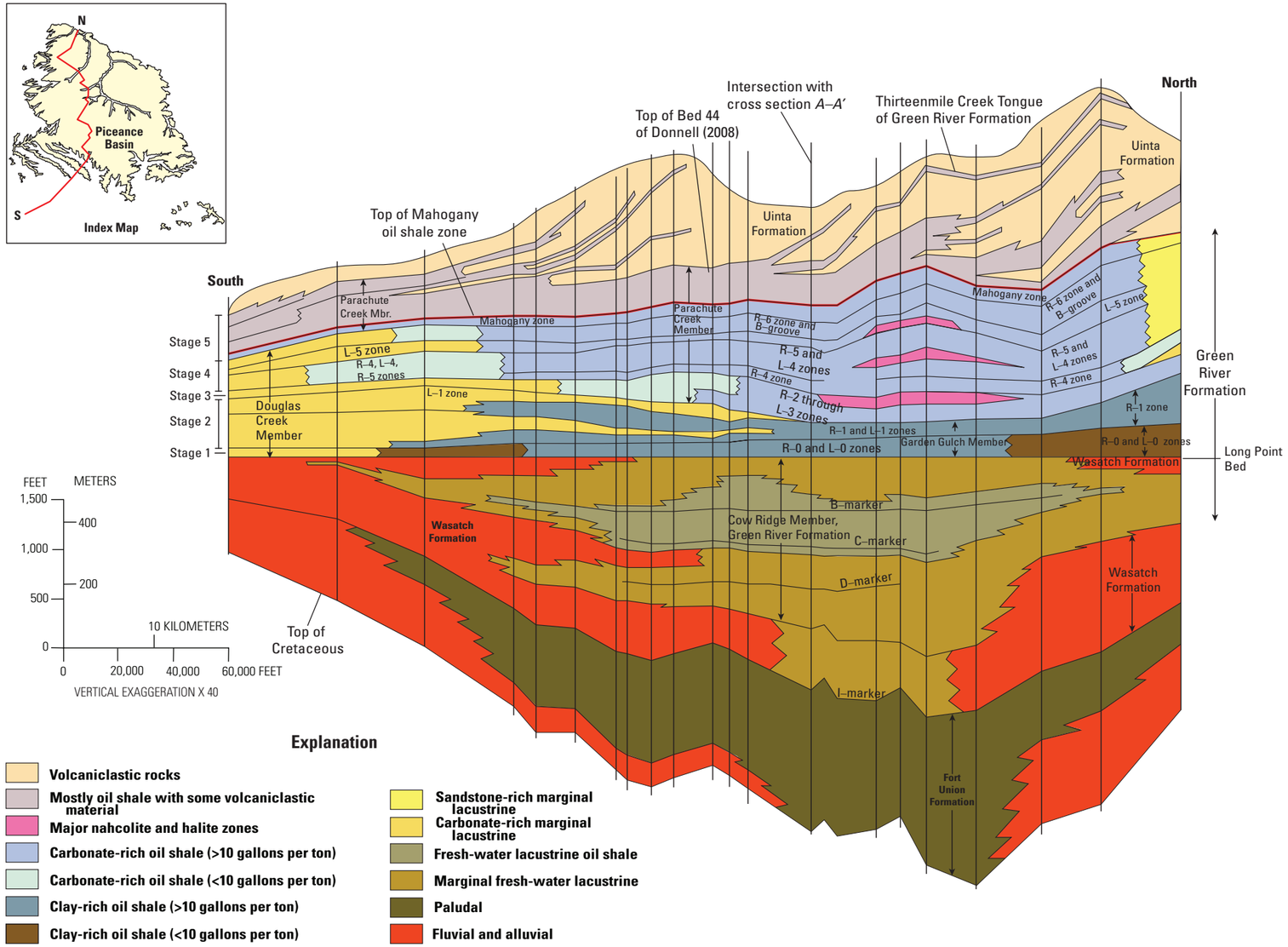

Figure 4. North-south cross section through the Piceance Basin, northwestern Colorado, showing member subdivisions and stages of Lake Uinta.

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