Chapter 5

Stratigraphic Cross Sections of the Eocene Green River Formation in the Green River Basin, Southwestern Wyoming, Northwestern Colorado, and Northeastern Utah

Click here to return to
Volume Title Page

By Jesse G. Self, Robert T. Ryder, Ronald C. Johnson, Michael E. Brownfield, and Tracey J. Mercier

Chapter 5 of 6
Oil Shale Resources of the Eocene Green River Formation, Greater Green River Basin, Wyoming, Colorado, and Utah

By U.S. Geological Survey Oil Shale Assessment Team

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

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2011

Suggested citation:
Self, J.G., Ryder, R.T., Johnson, R.C., Brownfield, M.E., and Mercier, T.J., 2011, Stratigraphic cross sections of the Eocene Green River Formation in the Green River Basin, southwestern Wyoming, northwestern Colorado, and northeastern Utah, *in* U.S. Geological Survey Oil Shale Assessment Team, ed., Oil shale resources of the Eocene Green River Formation, Greater Green River Basin, Wyoming, Colorado, and Utah: U.S. Geological Survey Digital Data Series DDS–69–DD, chap. 5, 7 p., 24 plates.

Contents

Plates

Figures

Table

Stratigraphic Cross Sections of the Eocene Green River Formation in the Green River Basin, Southwestern Wyoming, Northwestern Colorado, and Northeastern Utah

By Jesse G. Self, Robert T. Ryder, Ronald C. Johnson, Michael E. Brownfield, and Tracy J. Mercier

Introduction

For several decades, the U.S. Geological Survey (USGS) has collected cores, drill cuttings, and other subsurface data from boreholes drilled to evaluate the oil shale deposits in the Eocene Green River Formation, as well as from oil and gas tests, in the Greater Green River Basin of southwestern Wyoming, northwestern Colorado, and northeastern Utah (fig. 1). The Greater Green River Basin (GGRB) is the name given to a group of five sub-basins. The names of these sub-basins and their locations within the Greater Green River Basin are as follows: (1) the Hoback Basin in northwestern portion of the GGRB; (2) the Green River Basin in the western portion of the GGRB; (3) the Great Divide Basin in the north eastern portion of the GGRB; (4) the Washakie Basin in the east-central portion of the GGRB; and (5) the Sand Wash Basin in the southeastern portion of the GGRB (figs. 1 and 2). The Greater Green River Basin is one of three basins in the western United States that contains oil shale of the Green River Formation. The other two are the Piceance Basin in western Colorado and the Uinta Basin in eastern Utah and western Colorado (fig. 2). It was from these areas that data were collected and preserved for use by researchers and private industry in anticipation of the time when Green River oil shale deposits would become an economically viable alternate source of fossil fuel. In southwestern Wyoming, the Green River Formation was deposited in Lake Gosiute during early to middle Eocene time, with the majority of oil shale deposits accumulating in what is defined as the Tipton Shale Member, the Wilkins Peak Member, and the LaClede Bed of the Laney Member (fig. 3).

The types of data collected within the Greater Green River Basin include: (1) Fischer (shale oil) assays (American Society for Testing and Materials, 1980) on cores from wells drilled to assess oil shale and drill cuttings from oil and gas tests, (2) geophysical and lithologic logs of drill holes, and (3) measured sections from outcrops. Twenty-three subsurface stratigraphic cross sections were constructed using these various types of data for basinwide correlations and as a basis for the in-place assessment of the oil shale resources in the basin carried out by the USGS. These cross sections are presented on plates 1–23 in this report.

Stratigraphy of the Green River Formation, Wyoming

The Green River Formation consists of lacustrine and fluvial-lacustrine rocks that were deposited in and adjacent to the Eocene Lake Gosiute that covered much of southwestern Wyoming, northwestern Colorado, and northeastern Utah from roughly 52.5 to 47.5 Ma (Smith and others, 2008). The lake formed in a structural and sedimentary basin that formed during the Laramide orogeny, a major mountain-building episode in the western United States, which extended from Late Cretaceous through Eocene time. Lake Gosiute underwent two major expansions represented by the Tipton Shale Member and the LaClede Bed of the Laney Member of the Green River Formation (fig. 3). These units contain the richest and most persistent oil shale zones in the Greater Green River Basin.

The oldest rocks of the Green River Formation in the Greater Green River Basin are known as the Tipton Shale Member. This member is divided into the freshwater Scheggs Bed and the overlying saline Rife Bed (Roehler, 1991a). A northward-thickening wedge of marginal lacustrine deposits known as the Farson Sandstone Member of the Green River Formation (fig. 3) (Roehler, 1992b) separates the Scheggs and Rife Beds in the Green River Basin portion (western) of the Greater Green River Basin (figs. 1, 2). In the northeastern portion of the Greater Green River Basin, the Farson Sandstone Member is overlain by the Alkali Creek Tongue of the Wasatch Formation (Roehler, 1991a). These units are not distinguishable in the subsurface, therefore they are labeled together in the cross sections that were constructed covering the northeastern portion of the Greater Green River Basin.

After the deposition of the Tipton Shale Member of the Green River Formation, Lake Gosiute regressed to cover a much smaller area of the Greater Green River Basin, as well as becoming much shallower. It was during this regressive period of the lake's history that the Wilkins Peak Member of the Green River Formation was deposited (fig. 3) (Bradley, 1959). Although the Wilkins Peak Member contains significant oil shale, it is present in a much more restricted area than the underlying Tipton Shale Member and the overlying LaClede

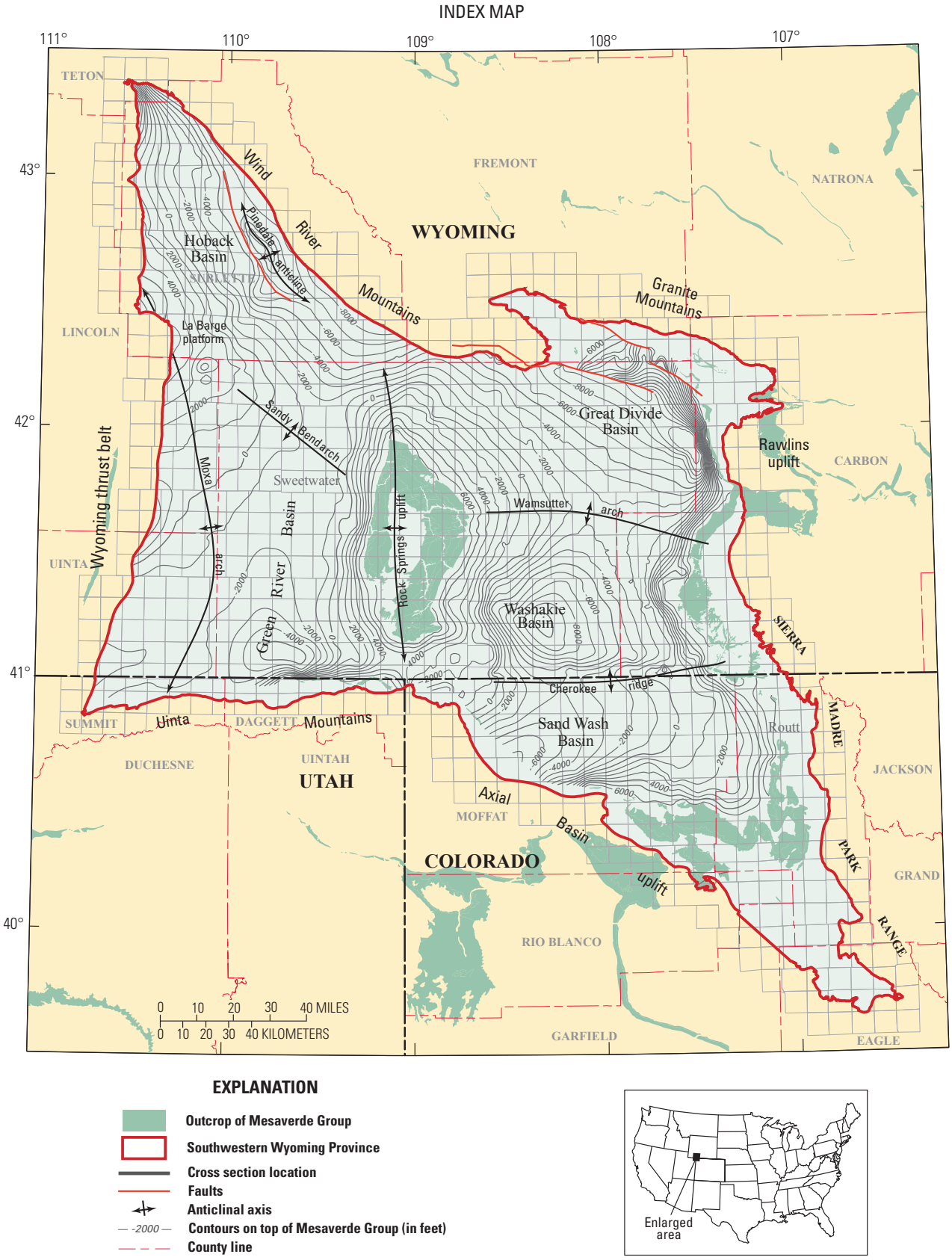

Figure 1. Structure map of the Greater Green River Basin, southwestern Wyoming and adjacent areas, showing major basinal areas and adjoining uplifts. Modified after Johnson and others (2005).

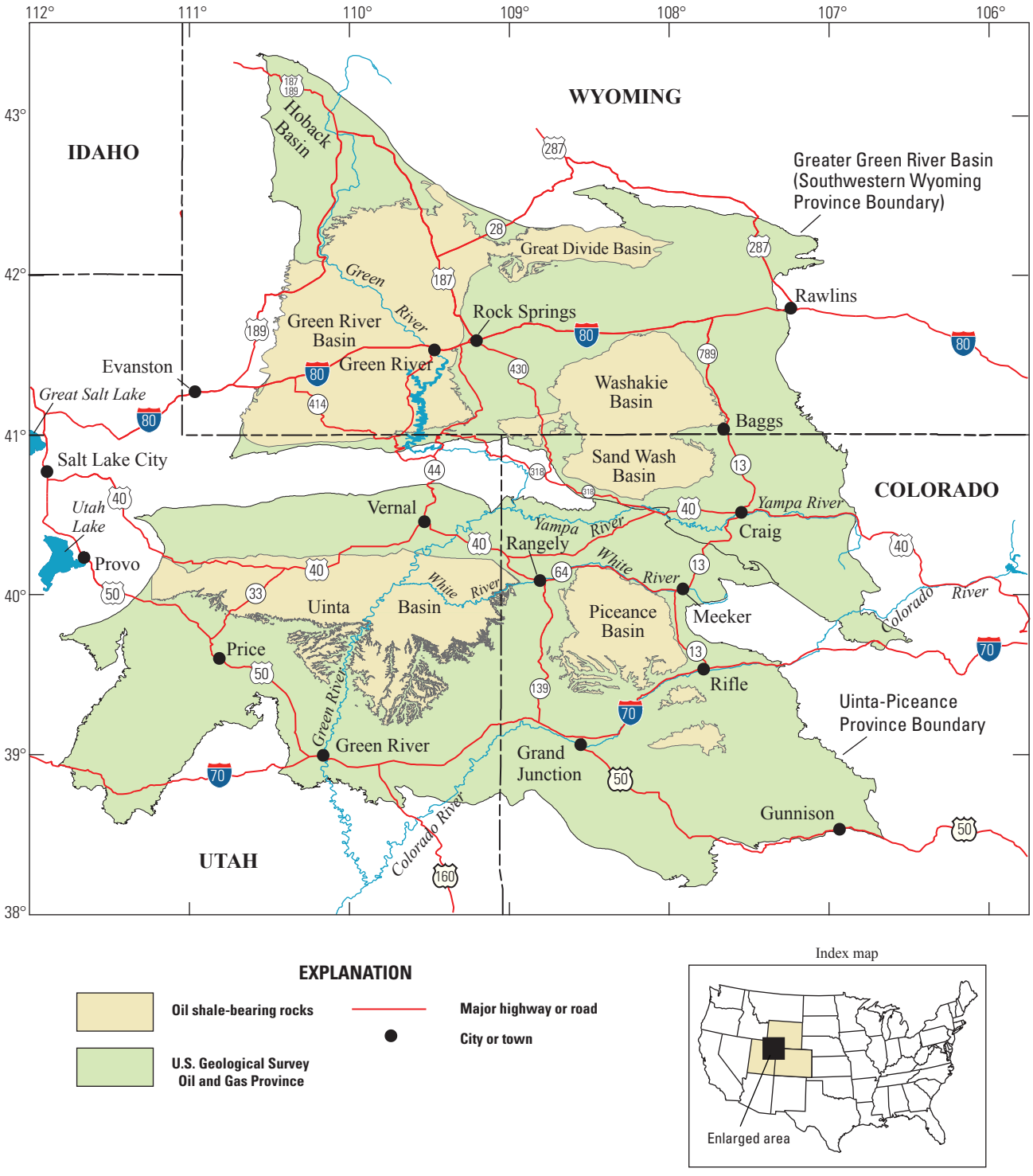

Figure 2. Distribution of oil shale-bearing rocks in the Eocene Green River Formation in southwestern Wyoming, northwestern Colorado, and northeastern Utah.

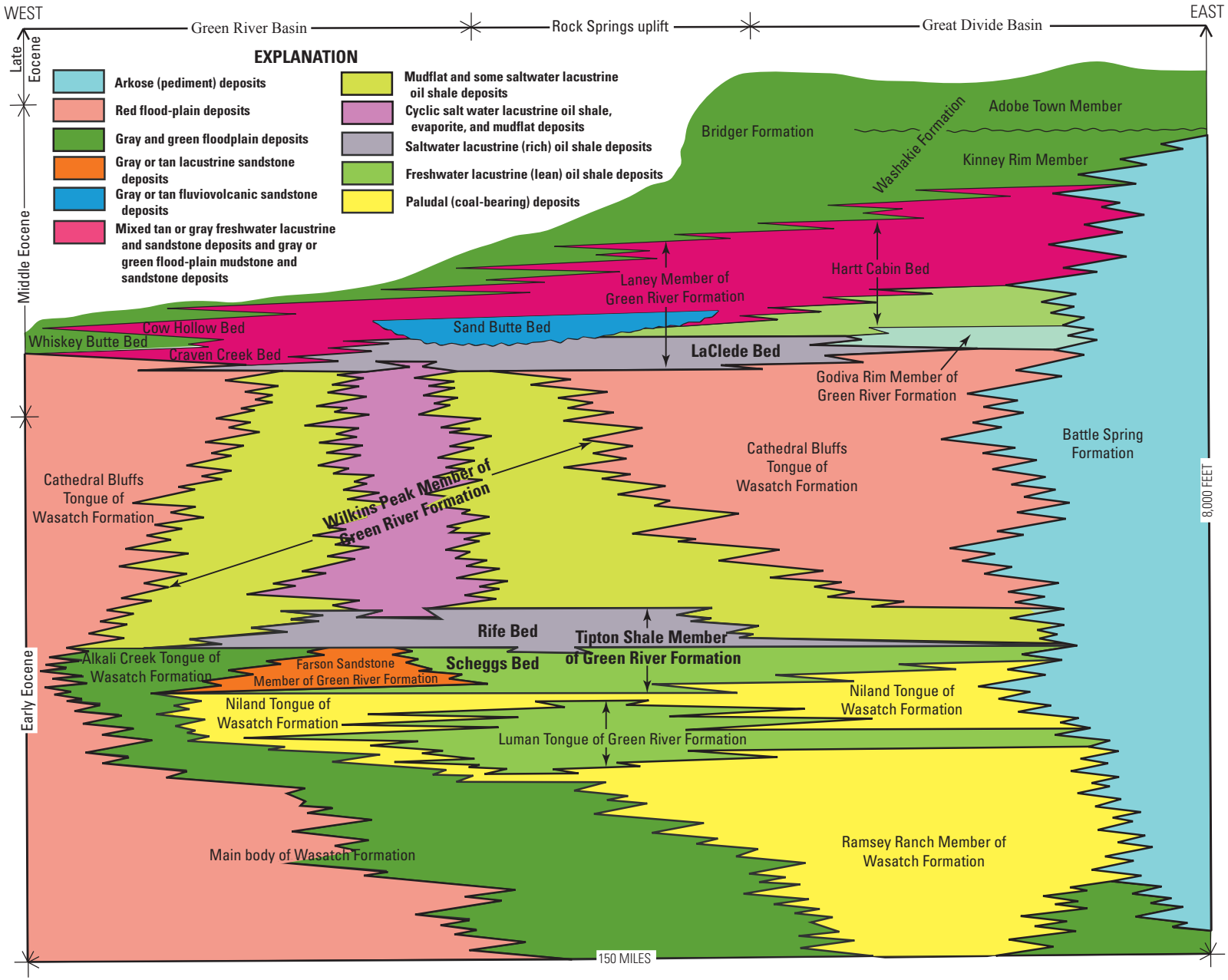

Figure 3. Stratigraphic relations of Eocene rocks within the Greater Green River Basin, southwestern Wyoming.

Bed of the Laney Member. It is also interbedded with higher amounts of sandstone and mudstone.

Following this regressive period, and subsequent deposition of the Wilkins Peak Member of the Green River Formation, Lake Gosiute expanded again. During this expansion, the lake covered a much larger area of the Greater Green River Basin than during Wilkins Peak time, as well as becoming much deeper. This expansion is recorded in the rock record, and is known as the Laney Member of the Green River Formation, named by Roehler (1973). The Laney Member contains the youngest oil shale-bearing strata that are included in the USGS oil shale assessment; the richest oil shale beds are found in the basal part of the member, known as the LaClede Bed. In the eastern portion of the Greater Green River Basin, the LaClede Bed grades into the laterally equivalent Godiva Rim Member of the Green River Formation (Roehler, 1991e). The rich oil shale deposits of the LaClede Bed are interbedded in some portions of the Greater Green River Formation by a tuffaceous siltstone layer informally known as the Buff Marker bed (Roehler, 1973).

Cross Sections

Of the 23 cross sections prepared for this assessment, 10 were created from data in the Green River Basin west of the Rock Springs Uplift (pls. 1–10), 7 were created from data in the Washakie Basin east of the Rock Springs Uplift (pls. 11–17), and 6 were modified from previously published cross sections by Roehler (1990, 1991b, 1991c, 1991d, 1992a) (pls. 18–23). All plates use the same formation tops that were used in the oil shale assessment of the Greater Green River Basin (see Johnson and others, chapter 1, this report).

The cross sections (pl. 24) were constructed using 201 of the existing 427 Fischer Assay oil-yield histograms, 11 geophysical logs collected from wells drilled for oil and gas exploration, and 38 surface sections measured from outcrops within the Greater Green River Basin; table 1 provides an explanation of the types of data that are presented in the spreadsheet that accompanies this report (Spatial_Information.xlsx). In a few cases, both oil-yield histograms and geophysical logs were available for the same well. The true tops and bases of oil shale intervals, such as for the LaClede Bed and Tipton Shale Member, can commonly be picked on geophysical logs. However, when these identified well depths are compared to those reported for cuttings, there is commonly a discrepancy owing to the difficulty in accurately compensating for the time delay between when a particular interval is being drilled and when the cuttings from that interval reach the surface. For this assessment, we chose to use the reported tops at which the oil shale units were encountered in the cuttings, because using the geophysical log data would have resulted in portions of rich oil shale units being excluded in many of the holes. The correlation datum for the cross sections was the bottom of the LaClede Bed of the Laney Member of the Green River Formation, or laterally equivalent strata. A horizontal scale of 1 in = 2 mi and a vertical scale of 1.3 in = 100 ft were selected to best accommodate the lateral distances covered and to serve the need for stratigraphic detail. Sources of stratigraphic data for surface sections include (1) Roehler (1981) for Section 27, Section 28, and Section 29 (pl. 15); (2) Roehler (1989a) for the Twenty Mile, Six Mile, Wilkins Peak, and Red Creek #1 sections (pls. 4 and 15); (3) Roehler (1989b) for the Vermillion Creek, Northeast Hiawatha, East Pioneer, Trail Dugway, Salt Wells, Salt Wells Axis, Eocene Reference, Laney Point, West U.P. Springs, Luman Point, South Antelope, LaClede Station, West Bitter Creek, Laney Dugway, Northeast Table Rock, West Tipton, and Alkali Creek sections (pls. 11, 12, 13, 15, and 19); (4) Roehler (1989c) for the Agate Quarry, Barrel Springs Draw, Tipton Point, Red Creek #2, and Ridge Road sections (pls. 3, 14, 15, and 16); (5) Roehler (1990) for the Boar's Tusk and Fontenelle Creek sections (pls. 4 and 20);

Table 1. Names and definitions for the column headers for the spatial-data spreadsheet (Spatial_Information.xlsx).

Column name	Column definition
USGSID	Unique ID assigned by staff geologist
COMPANY	Name of the company or agency that drilled the borehole
NAME	Name of the borehole assigned by the company or agency that drilled it
SECTION	Section
TOWNSHIP	Township
RANGE	Range
LATITUDE	Latitude, in decimal degrees, North American Datum 1927, software-calculated, original record
LONGITUDE	Longitude, in decimal degrees, North American Datum 1927, software-calculated, original record
COUNTY	Name of county in Wyoming
DEPTH	Total depth of the borehole, in ft
CROSS SECTION	The Green River Basin cross section where that piece of data can be found

(6) Roehler (1991d) for the North Sage Creek and Northeast Piedmont sections (pl. 21); (7) Roehler (1991c) for the Little Robber's Gulch, East Flat Top, Flat Top, and East Salt Wells Axis sections (pls 22); and (8) Roehler (1992a) for the Little Mountain section (pl. 23). Drill holes and measured sections used in the plates are listed in the Spatial_Information.xlsx file (chap. 5 folder)

References Cited

American Society for Testing and Materials, 1980, Standard method of test for oil from oil shale: Annual Book of ASTM Standards, Part 25, Designation D 3904-80, p. 513–515.

Bradley, W.H., 1959, Revision of stratigraphic nomenclature of Green River Formation of Wyoming: American Association of Petroleum Geologists Bulletin, v. 43, no. 5, p. 1072–1075.

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.

Johnson, R.C., Finn, T.M., and Roberts, L.N., 2005, The Mesaverde Total Petroleum System, Southwestern Wyoming Province, *in* U.S. Geological Survey Southwestern Wyoming Province Assessment team, ed., Petroleum systems and geologic assessment of oil and gas in he southwestern Wyoming Province, Wyoming, Colorado, and Utah: U.S. Geological Survey Digital Data Series DDS–69–D, Chapter 8, 38 p.

Johnson, R.C., and Roberts, L.N., 2003, Depths to selected stratigraphic horizons in oil and gas wells for Upper Cretaceous and Lower Tertiary strata of the Uinta Basin, Utah, *in* U.S. Geological Survey Southwestern Wyoming Province Assessment team, ed., Petroleum systems and geologic assessment of oil and gas in he southwestern Wyoming Province, Wyoming, Colorado, and Utah: U.S. Geological Survey Digital Data Series DDS–69–B, chapter 13, 30 p.

Love, J.D., and Christensen, A.C., 1985, Geologic Map of Wyoming: U.S. Geological Survey, scale 1:500,000.

Roehler, H.W., 1973, Stratigraphic divisions and geological history of the Laney Member of the Green River Formation in the Washakie Basin in southwestern Wyoming: U.S. Geological Survey Bulletin 1372–E, 28 p.

Roehler, H.W., 1981, Correlation of Eocene rocks in measured sections in the southeast and west parts of the Rock Springs Coalfield, Wyoming: U.S. Geological Survey, Oil and Gas Investigations Chart OC–111.

Roehler, H.W., 1989a, Correlation of surface section of the intertongued Eocene Wasatch and Green River Formations along the west flank of the Rock Springs uplift in southwest Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF–2104.

Roehler, H.W., 1989b, Correlation of surface sections of the intertongued Eocene Wasatch and Green River Formations along the western margins of the Sand Wash Basin, northwest Colorado, and Washakie Basin, southwest Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF–2105.

Roehler, H.W., 1989c, Correlation of surface sections of the intertongued Eocene Wasatch and Green River Formations along the central part of the Sand Wash Basin, northwest Colorado, and eastern part of the Washakie Basin, southwest Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF–2106.

Roehler, H.W., 1990, West-east stratigraphic correlations of surface and subsurface sections of the intertongued Eocene Wasatch and Green River formations, northern Green River basin, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF–2149.

Roehler, H.W., 1991a, Revised stratigraphic nomenclature for the Wasatch and Green River Formations of Eocene age, Wyoming, Utah, and Colorado: U.S. Geological Survey Professional Paper 1506–B, 38 p.

Roehler, H.W., 1991b, Correlation and depositional analysis of oil shale and associated rocks in the Eocene Green River Formation, Greater Green River Basin, southwest Wyoming: U.S. Geological Survey Miscellaneous Investigations Map I–2226.

Roehler, H.W., 1991c, East-west surface and subsurface correlations of the intertongued Eocene Wasatch and Green River Formations, Washakie basin, southwest Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF–2164.

Roehler, H.W., 1991d, West-east stratigraphic correlations of surface and subsurface sections of the intertongued Eocene Wasatch and Green River formations, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF–2159.

Roehler, H.W., 1991e, Godiva Rim Member—A new stratigraphic unit of the Green River Formation in Southwest Wyoming and Northwest Colorado: U.S. Geological Survey Professional Paper 1506–C, 17 p.

Roehler, H.W., 1992a, North-south correlation of oil-shale and trona beds in the Eocene Green River Formation, southwest Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF–2192.

Roehler, H.W., 1992b, Correlation, composition, areal distribution, and thickness of Eocene stratigraphic units, Greater Green River Basin, Wyoming, Utah, and Colorado: U.S. Geological Survey Professional Paper 1506–E, 49 p.

Rowley, P.D., Hansen, W.R., Tweto, Ogden, and Carrara, P.E., 1985, Geologic Map of the Vernal 1° × 2° quadrangle, Colorado, Utah, and Wyoming: U.S. Geological Survey Miscellaneous Investigations Map I–1526, scale: 1:250,000.

Smith, M.E., Carroll, A.R., and Singer, B.S., 2008, Synoptic reconstruction of a major ancient lake system—Eocene Green River Formation, western United States: Geological Society of America Bulletin v. 120, no. 1, 2, p. 54–84.

Tweto, Ogden, 1979, Geologic Map of Colorado: U.S. Geological Survey, scale: 1:500,000.

U. S. Geological Survey Uinta-Piceance Assessment Team, 2003, The Uinta-Piceance Province—Introduction to a geologic assessment of undiscovered oil and gas resources in U. S. Geological Survey Uinta-Piceance assessment team, compilers, Petroleum systems and geologic assessment of oil and gas in the Utah and Colorado: U.S. Geological Survey Digital Data Series DDS–69–B, 27 p.

U. S. Geological Survey Southwestern Wyoming Province Assessment Team, 2005, The Southeastern Wyoming Province—Introduction to a geological assessment of undiscovered oil and gas resources *in* U.S. Geological Survey Southwestern Wyoming Province Assessment team, ed., Petroleum systems and geologic assessment of oil and gas in the southwestern Wyoming Province, Wyoming, Colorado, and Utah: U.S. Geological Survey Digital Data Series DDS–69–B, chapter 13, 30 p.

Witkind, I.J., 1995, Geologic map of the Price 1° × 2° quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I–2462.

Click here to return to
Volume Title Page