Chapter 11

Northwest to Southeast Cross Section of Cretaceous and Lower Tertiary Rocks Across the Eastern Part of the Uinta Basin, Utah

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By Ronald C. Johnson

Chapter 11 *of*

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By USGS Uinta-Piceance Assessment Team

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Introduction

The primary purpose of this report is to portray and describe the stratigraphic relations of Cretaceous and Tertiary rocks along a subsurface cross section extending from the central trough of the Uinta Basin, where it intersects a previously published east-west cross section (Johnson, 1989), southeastward to San Arroyo anticline, at the southeast margin of the basin (Index map, pl. 1). Resistivity and gamma-ray logs are shown for 20 drill holes, and the included intervals extend stratigraphically upward from the base of the undivided Jurassic Morrison Formation and Cretaceous Cedar Mountain Formation and Dakota Sandstone into the Eocene Green River Formation. Datum is the top of the Upper Cretaceous Castlegate Sandstone. Ten different depositional settings were recognized: (1) offshore mudrock; (2) marine sandstone and mudrock; (3) shoreface sandstone; (4) braided stream sandstone and minor mudstone; (5) estuarine sandstone, siltstone, and mudstone; (6) coastal plain sandstone, mudstone, carbonaceous mudstone, and coal; (7) fluvial sandstone and mudstone (Cretaceous); (8) fluvial sandstone and mudstone (Tertiary); (9) marginal-lacustrine clastic and carbonate rock; and (10) offshore lacustrine shale and carbonate rock. These depositional settings were identified using geophysical logs, sample description logs, and by correlations with previously published studies of nearby outcrops.

The cross section (pl. 1) generally parallels an earlier cross section by Fouch and Cashion (1979), but correlations in the Eocene Green River Formation have been extensively modified largely because of the recognition of a key marker bed, the Long Point Bed of the Douglas Creek Member, which was not recognized at the time that that cross section was published. The Long Point Bed was originally defined in the Piceance Basin in western Colorado and later traced into the Uinta Basin (Johnson, 1989). Correlation has also improved because of careful tracing of rich and lean oil-shale zones defined by Cashion and Donnell (1972). The base of the R-4 rich oil-shale zone is shown on the north end of the cross section (pl. 1). In particular, recognition of these stratigraphic markers has improved correlation between offshore lacustrine rocks, near the basin trough, and marginal-lacustrine rocks around the basin margins.

Cretaceous Stratigraphy Along the Line of Section

The Upper Jurassic Morrison Formation, Lower Cretaceous Cedar Mountain Formation, and Upper and Lower Cretaceous Dakota Sandstone are the oldest units shown on the cross section. The Cedar Mountain was deposited in a nonmarine setting and the Dakota was deposited in a marginal-marine setting during the first incursion of the Cretaceous epicontinental seaway into the Uinta Basin area in Early Cretaceous Aptian through Late Cretaceous early Cenomanian time (Young, 1960). They are separated from the overlying marine Mancos Shale by an unconformity (Molenaar and Cobban, 1991). The Mowry Shale, which was deposited in an offshore marine setting during this incursion, appears to be largely absent in the area along the transect of the section due to nondeposition and (or) later erosion (see Francyzk and others, 1992, their fig. 5).

The Mancos Shale overlies the Dakota Sandstone. It was deposited in an offshore marine setting during an extended period when the Cretaceous seaway covered the area of the Uinta Basin from Late Cretaceous Turonian through late Campanian time. Four members are recognized; they are, in ascending order: (1) the Tununk Member, (2) the Juana Lopez Member, (3) the Blue Gate Member, and (4) the Buck Tongue. The thin Tununk and Juana Lopez Members consist largely of offshore marine shales except for the Coon Springs Sandstone bed of the Tununk Member, which is a marine shelf to coastal sandstone (Molenaar and Cobban, 1991). The top of the Coon Springs was identified along the southern part of the cross section (pl. 1). The Tununk and Juana Lopez Members, of late Cenomanian to late Turonian age, grade into the Frontier Formation to the northwest in the Uinta Basin (Molenaar and Cobban, 1991). The Bluegate Member forms the bulk of the Mancos Shale, extending from the top of the Juana Lopez Member to the base of the Castlegate Sandstone. The Buck Tongue extends from the top of the Castlegate Sandstone to the base of the Sego Sandstone (pl. 1).

The Mancos Shale consists largely of offshore marine shales with a sandy interval in the middle part. On geophysical logs, the base of the sandy interval is marked by an abrupt shift from low-resistivity shale below to higher resistivity silty and sandy shales above. This interval was originally referred to as the Mancos "B" zone of the Mancos Shale by Kopper (1962) and later as the Mancos B Formation by Kellogg (1977). More recently, the Mancos "B" of Kopper (1962) and Kellogg (1977) was included in the Prairie Canyon Member (new name) of the Mancos Shale by Cole and others (1997), who then subdivided that member into lower, middle, and upper parts. The top of the middle part corresponds approximately to the top of the Mancos B Formation as used by Kellogg (1977). Thus, the Prairie Canyon Member as defined by Cole and others (1997) includes a considerable thickness of strata above the Mancos "B" of Kellogg (1977). The Mancos B Formation of Kellogg (1977) and Prairie Canyon Member of Cole and others (1997), however, occur entirely within the Blue Gate Member of the Mancos Shale. Such units are therefore considered in the present report to be informal zones within the Blue Gate Member.

The age of the Mancos "B" of Kopper (1962) is latest Santonian to late-early Campanian (Fouch and others, 1983; Chan and others, 1991; Cole and others, 1997). Kellogg (1977) interpreted the Mancos "B" to have been deposited in an offshore marine environment, on an east-west-trending-northward-prograding "fore slope" that trended nearly at a right angle to the north-south-trending shoreline of the Cretaceous seaway that lay about 100 mi to the west in central Utah. Subsequent workers have had difficulties tracing the Prairie Canyon in outcrop along the Book Cliffs into nearshore and nonmarine rocks farther to the west in the Uinta Basin (Swift and others, 1987; Chan and others, 1991; Hampson and others, 1999). The northward progradation of the Prairie Canyon Member has recently been documented in greater detail by Johnson (Chapter 10, this CD-ROM). The cross section presented here (pl. 1) is oblique to the direction of progradation; hence the inclination on this prograding slope, which can be seen on the right side of the cross section between wells 13 and 20, is considerably less than the inclination that is apparent on a more north-south-trending cross section (see Johnson, Chapter 10, this CD-ROM). The Prairie Canyon Member appears to die out to the northwest as indicated on plate 1.

Environments of deposition of the upper part of the Prairie Canyon Member were studied in outcrop by Cole and Young (1991) and Cole and others (1997), who interpreted this interval as entirely marine in origin. However, Hampson and others (1999) identified several erosion surfaces within this interval and also cited some evidence for paleosol development. Channels filled with what they interpreted as tidally influenced fluvial deposits occur along these surfaces, and they (Hampson and others, 1999) suggested that such surfaces were developed during relative sea level falls whereas the channel fills were deposited during the subsequent sea level rises. The lower part of the Prairie Canyon zone is poorly exposed and has not been studied in as much detail in outcrop.

The Upper Cretaceous Castlegate Sandstone, the lowest formation in the Mesaverde Group, overlies the Mancos Shale along the entire line of section. The name Castlegate Sandstone was applied by Forrester (1918), Spieker and Reeside (1926), and Clark (1928) to the prominent cliff-forming sandstone sequence of Late Cretaceous age that locally forms a topographic feature called the Castle Gate in Price Canyon, about 10 mi northwest of the town of Price (Index map, pl. 1). The Castlegate was made a member of the Price River Formation by Spieker and Reeside (1925) and was later elevated to formation rank by Fisher and others (1960). Within the study area, the Castlegate Sandstone was probably deposited during the time (late Campanian) represented by the *Baculites asperiformis* through *Baculites perplexu*s zones (Gill and Hail, 1975; Fouch and others, 1983). The formation was deposited in braided stream and estuarine environments in an incised valley in areas toward the central and northwestern parts of the cross section and in a marginal-marine setting toward the southeastern part (Fouch and others, 1983; Francyzk and others, 1992; Van Wagoner, 1995).

The Castlegate Sandstone is overlain by the Buck Tongue of the Mancos Shale along the southeastern part of the cross section, and the Buck Tongue is in turn overlain by the Sego Sandstone of the Upper Cretaceous Mesaverde Group. The names Buck Tongue and Sego were first used by Erdmann (1934) and were formally named by Fisher (1936). The Sego was deposited in a variety of marginal-marine environments in a predominantly estuarine setting (Francyzk and others, 1990). The Neslen Formation of the Mesaverde Group occurs along the entire line of cross section and overlies both the Castlegate Sandstone and the Sego Sandstone where it is present. Fisher (1936) originally named the Neslen a member in the Price River Formation. It was elevated to formation rank by Cobban and Reeside (1952) and Fisher and others (1960).

The Farrer and Tuscher Formations of the Mesaverde Group (undifferentiated on the cross section) occur above the Neslen. Both of these formations were deposited in a largely fluvial setting. The contact between the coal-bearing Neslen Formation and the overlying sandier, less coaly Farrer Formation is generally easy to recognize in outcrops (Francyzk and others, 1990). In the subsurface cross section presented here (pl. 1), the contact was generally placed at the base of first major sandstone above the uppermost coal bed. Fisher (1936) named the Tuscher Formation and described it as being composed largely of light-gray to white, cliff-forming sandstones. The contact between the Farrer and overlying Tuscher, however, is largely gradational and not well defined (Francyzk and others, 1990); hence the two formations were lumped during the present study.

An unconformity occurs between the Upper Cretaceous Mesaverde Group and the overlying lower Tertiary strata along the line of cross section. Weathering during the time gap represented by the unconformity kaolinized sandstones in the uppermost part of the underlying Mesaverde Group, producing a distinctive white zone recognizable in outcrops throughout much of the eastern Uinta Basin east of the San Rafael Swell, including the area of the cross section (Francyzk and Pitman, 1987). This weathered zone extends eastward over the Douglas Creek arch and across much of the Piceance Basin

Click on image below to bring up high-resolution image of plate 1.

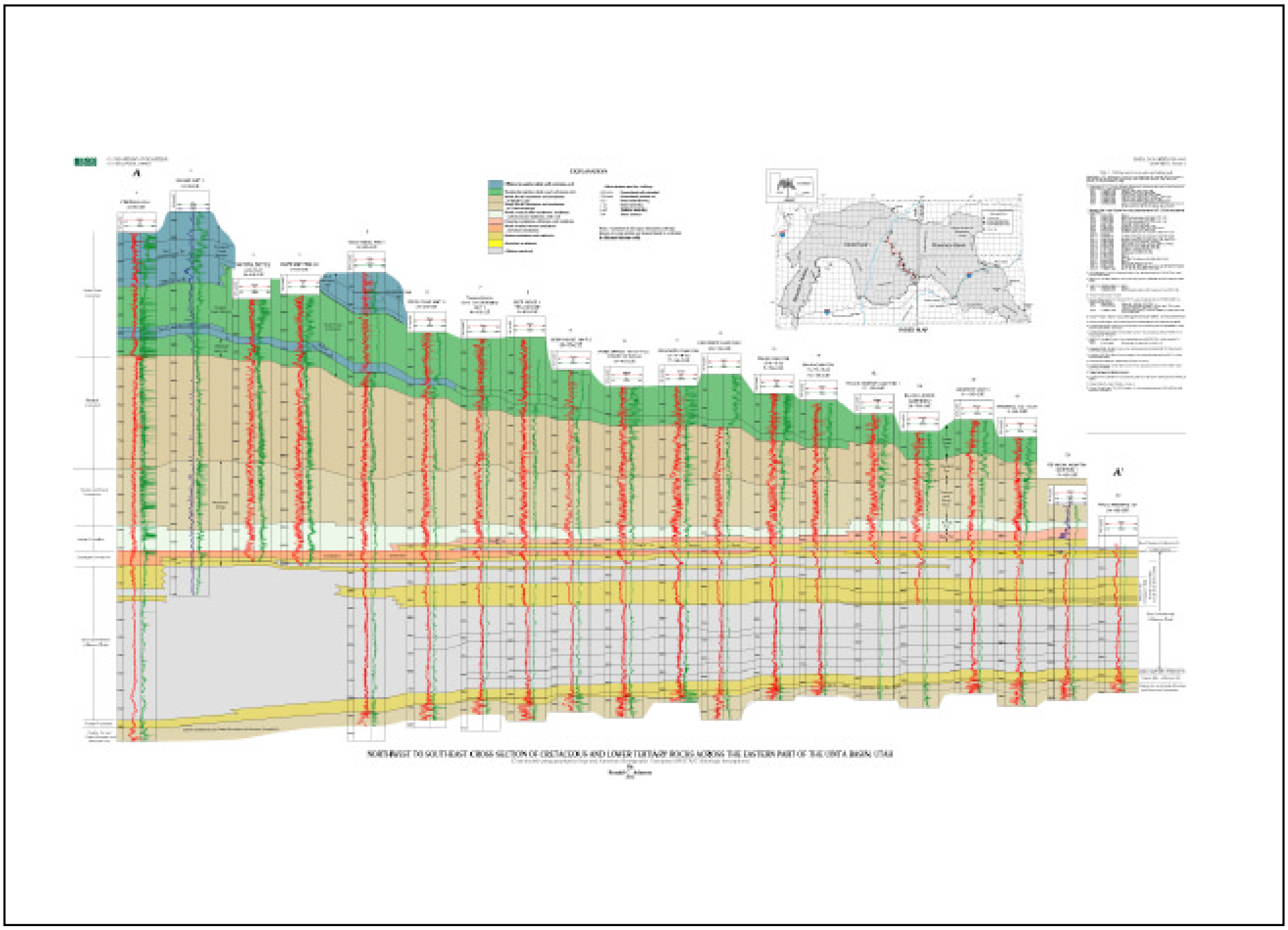

Plate 1. Northwest to southeast cross section of Cretaceous and lower Tertiary rocks across the eastern part of the Uinta Basin, Utah.

(Johnson and May, 1978, 1980). Discontinuous conglomerates derived mainly from Paleozoic and Mesozoic sedimentary rocks occur in lower Tertiary rocks above the weathered zone in the eastern Uinta Basin. These conglomerates were first described by Fisher and others (1960) and have been referred to as "beds at Dark Canyon" (Fouch and Cashion, 1979), "conglomerate at Dark Canyon" (Keighin and Fouch, 1981), and "Dark Canyon sequence" (Francyzk and Pitman, 1987). A similar conglomeratic sequence has been described in many areas of the Piceance Basin (Johnson and May, 1980). The conglomerates, included in the Wasatch Formation, occur in some but not all wells for which sample descriptions were obtained. Where conglomerates are absent, the top of the Mesaverde Group is generally placed at the top of the highest white sandstone or the first major sandstone below the lowest occurrence of red or green mudstone, both of which are confined almost exclusively to lower Tertiary rocks in the area. In wells for which sample descriptions were not obtained, the contact is generally placed at a horizon that is consistent with that of nearby wells where sample descriptions are available.

Tertiary Stratigraphy

The upper Paleocene to lower Eocene Wasatch Formation occurs above the Mesaverde Group. It consists predominantly of sandstones and variegated red, green, and gray shale deposited in a fluvial setting, and is distinguished from the underlying Tuscher Formation by the presence of varicolored shales and general lack of white, kaolinitic sandstone. The Wasatch Formation is overlain by the Eocene Green River Formation, which is subdivided into three members: an unnamed freshwater lacustrine member at the base, the medial Douglas Creek Member, and the Parachute Creek Member at the top (pl. 1). The lower fresh-water member has been informally called the Willow Creek interval by Roberts (1964) and the "basal lacustrine phase" by Bradley (1931, pl. 3) where it is exposed in Indian Canyon in the western part of the Uinta Basin. Abundant fresh-water mollusks occur in this interval where it crops out on the Douglas Creek arch along the east margin of the Uinta Basin (Johnson and others, 1988). A similar fresh-water unit, named the Cow Ridge Member of the Green River Formation (Johnson, 1985), is present in the Piceance Basin to the east. These two fresh-water lacustrine units may have once been connected across the Douglas Creek arch, but erosion has since removed such strata for a 10- to 20-mi-wide area along the crest of the arch (Johnson, 1985). A persistent ostracodal limestone zone occurs at the base of the fresh-water lacustrine unit; it is recognized as a high-resistance interval on well logs and was traced in the subsurface in an east-west direction across much of the Uinta Basin (Johnson, 1989). Osmond (1992, fig. 7) referred to this ostracodal limestone informally as the Uteland Butte limestone where it occurs in the Greater Natural Buttes gas field.

The Long Point Bed, a thin, fossiliferous unit at the base of the overlying Douglas Creek Member of the Green River Formation, was deposited during a major transgression of Eocene Lake Uinta (Johnson, 1984) and is the lowest lacustrine unit that can be traced between the Uinta and Piceance Basins across the intervening Douglas Creek arch (Johnson, 1985). The Long Point Bed marks a shift from fresh- to brackish-water lacustrine conditions. Fresh-water mollusks are abundant in the unit but are seldom found in overlying strata. Although the Long Point Bed is time transgressive, the time represented by the transgression is thought to be fairly brief (Johnson, 1985). A 250- to 350-ft-thick unit of offshore lacustrine shale occurs above the Long Point Bed in the vicinity of the cross section (pl. 1). The top of a distinctive carbonate-rich zone called the carbonate marker occurs in this offshore lacustrine shale interval about 200 ft above the base of the Long Point Bed. The carbonate marker, which was described by Ryder and others (1976), is a carbonate-rich mudstone unit, averaging about 50 ft thick, that was deposited throughout the entire offshore area of Lake Uinta. Above this carbonate unit, the Douglas Creek Member consists of marginal-lacustrine clastic and carbonate rocks.

A shift from marginal-lacustrine rocks to offshore lacustrine carbonate-rich mudstones and carbonate-rich oil shales marks the base of the overlying Parachute Creek Member of the Green River Formation. This member was originally named by Bradley (1931) for exposures along Parachute Creek in the southern part of the Piceance Basin in western Colorado. The base of the R-4 rich oil-shale zone approximately marks the base of the Parachute Creek Member along the line of section. The R-4 rich oil-shale zone was originally named by Cashion and Donnell (1972) and can be traced across much of the Uinta and Piceance Basins (see Johnson, 1989). The Mahogany oil-shale bed is the richest oil-shale bed in the Mahogany zone or Mahogany ledge of the Parachute Creek Member. The term Mahogany ledge was first used by Bradley (1931) for exposures along Parachute Creek in the southern part of the Piceance Basin where the weathered appearance of the oil-shale beds resembles antique, unfinished mahogany. The Mahogany bed is the most widespread marker bed in the Green River Formation. It was deposited during the most expansive stage of Eocene Lake Uinta (Johnson, 1985) and occurs throughout much of the Uinta and Piceance Basins.

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