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THE JURASSIC SECTION ALONG McELMO CANYON IN SOUTHWESTERN COLORADO

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Abstract—In McElmo Canyon, Jurassic rocks are 1500–1600 ft thick. Lower Jurassic rocks of the Glen Canyon Group include (in ascending order) Wingate Sandstone, Kayenta Formation and Navajo Sandstone. Middle Jurassic rocks are represented by the San Rafael Group, which includes the Entrada Sandstone and overlying Wanakah Formation. Upper Jurassic rocks comprise the Junction Creek Sandstone overlain by the Morrison Formation. The Burro Canyon Formation, generally considered to be Lower Cretaceous, may be Late Jurassic in the McElmo Canyon area and is discussed with the Jurassic. The Upper Triassic Chinle Formation in the subsurface underlies, and the Upper Cretaceous Dakota Sandstone overlies, the Jurassic section. An unconformity is present at the base of the Glen Canyon Group (J-O), at the base of the San Rafael Group (J-2), and at the base of the Junction Creek Sandstone (J-5). Another unconformity of Cretaceous age is at the base of the Dakota Sandstone. Most of the Jurassic rocks consist of fluviatile, lacustrine and eolian deposits. The basal part of the Entrada Sandstone and the Wanakah Formation may be of marginal marine origin.

INTRODUCTION

McElmo Creek (Fig. 1A) cuts a deep canyon on the north side of Sleeping Ute Mountain near Cortez, Colorado. Elevations in the Canyon range from a low of 5375 ft near Battle Rock School to 7240 ft on Goodman Point to the north; Ute Peak, an igneous intrusion, to the south rises to 9977 ft. About 1500 to 1600 ft of Jurassic rocks are exposed in the canyon walls (Fig. 2A). Jurassic rocks comprise the Glen Canyon Group of Early Jurassic age, the San Rafael Group of Middle Jurassic age and the Junction Creek Sandstone and Morrison Formation of Late Jurassic age. Although the Burro Canyon Formation is generally considered Early Cretaceous in age, it may be of Jurassic age in the McElmo Canyon area, and is here discussed with the Jurassic section. The Glen Canyon Group is underlain in the subsurface by continental deposits of the Chinle Formation of Late Triassic age. Cretaceous rocks overlie the Jurassic section.

Four unconformities are associated with the rocks in McElmo Canyon. The J-O unconformity, which is not exposed, forms an erosional hiatus between the Glen Canyon Group and the underlying Chinle Formation. The J-2 unconformity occurs between the Glen Canyon and San Rafael Groups. The J-5 unconformity forms an erosional break between the San Rafael Group and the overlying Junction Creek Sandstone. The fourth unconformity is found at the base of the Dakota Sandstone.

The exposures along McElmo Canyon form a convenient bridge for correlation of Jurassic rocks in southwestern Colorado and adjacent areas. Most Jurassic rocks are concealed in the subsurface in all directions from McElmo Canyon. The San Rafael Group, for example, partly reappears in Salter Canyon 22 mi to the northeast. The group is completely exposed at Stoner, 30 mi distant, and in the La Plata Mountains 40 mi to the northeast. The San Rafael Group reappears around Bluff, Utah, 40 mi to the west and in the Carrizo Mountains area of Arizona, 40 mi to the southwest.

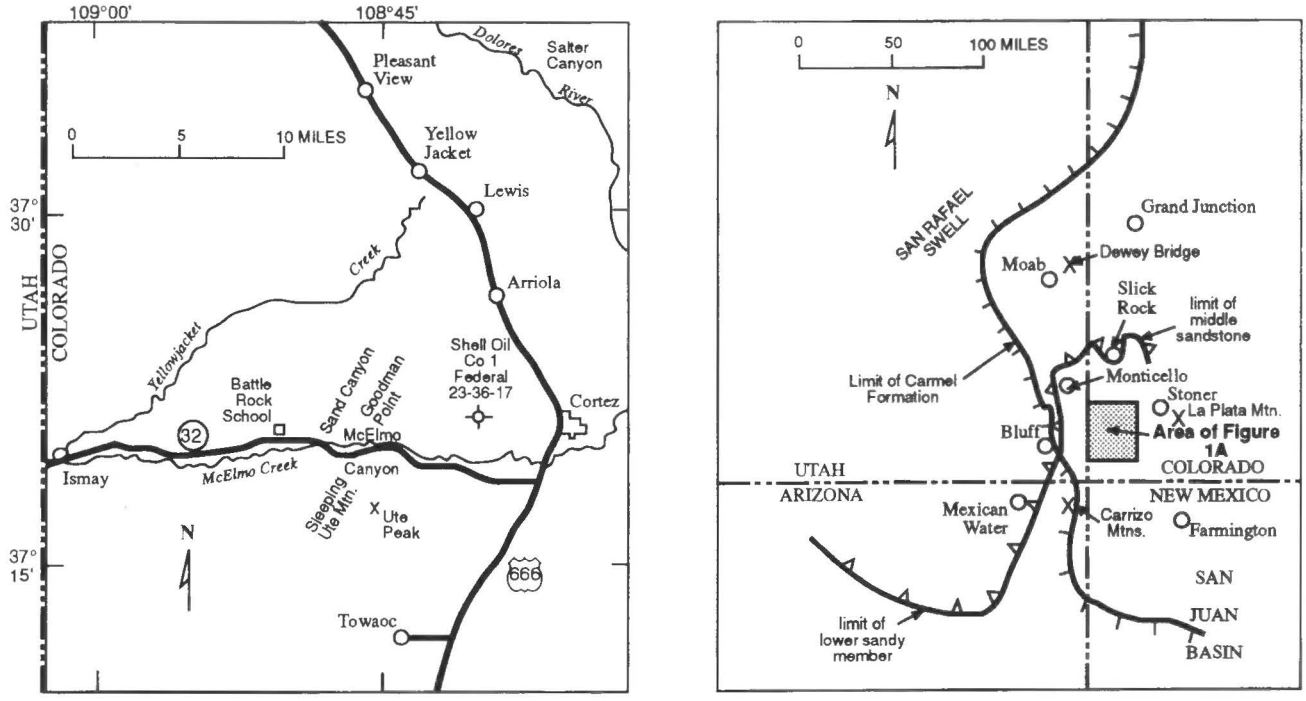
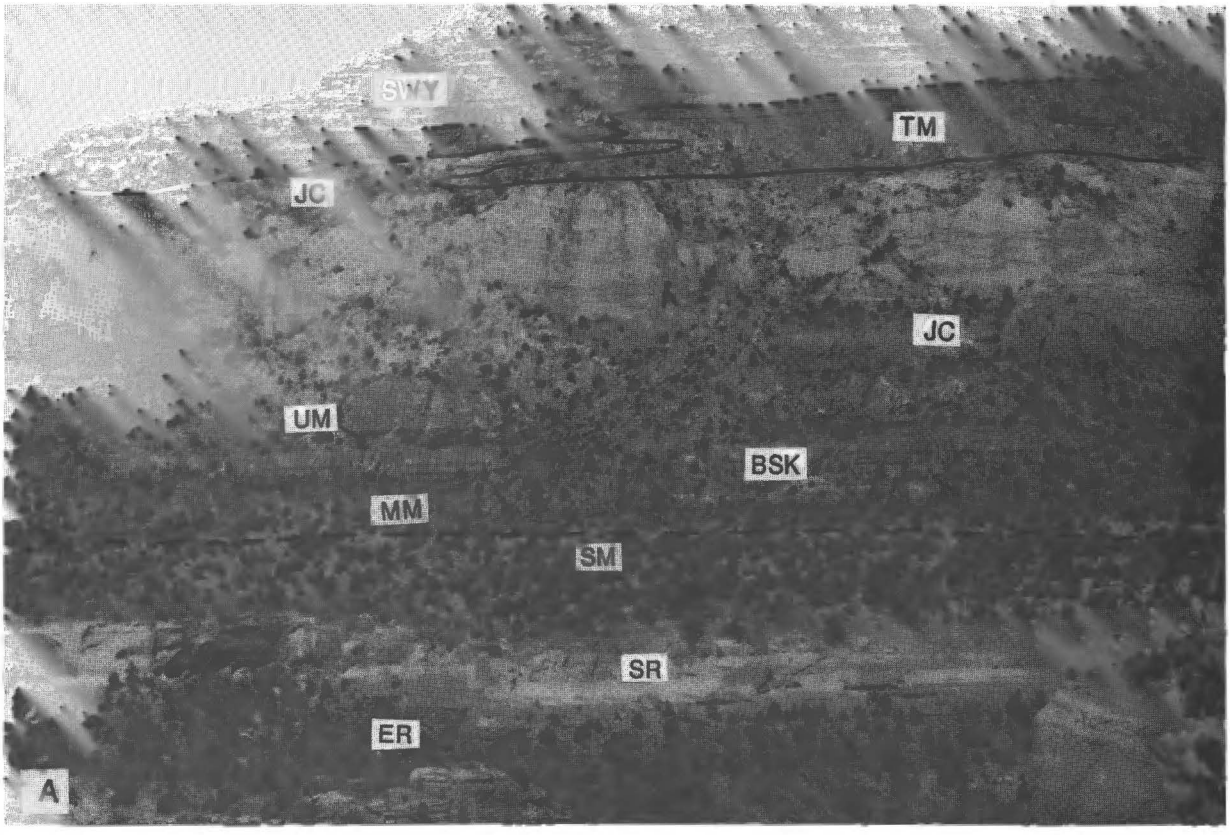
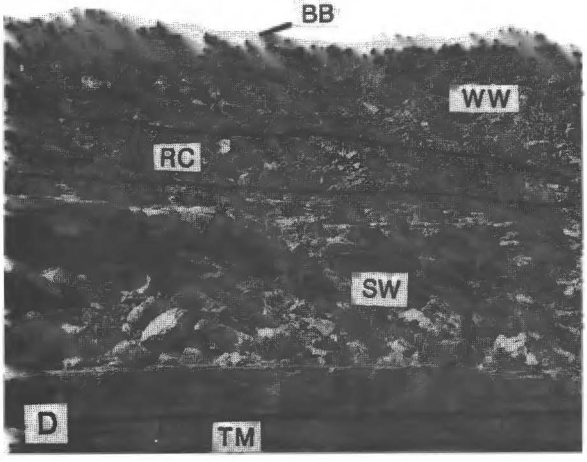


FIGURE 1. Maps of southwestern Colorado and adjacent areas. Depositional limits of Carmel Formation from O'Sullivan and Craig (1973, fig. 2), O'Sullivan (1996), Pipiringos and O'Sullivan (1978, pl. 1), and Wright et al. (1962, figs. 1, 2). Limits of middle sandstone of Entrada in Utah from O'Sullivan (1996). Limits of lower sandy member of Entrada Sandstone in the northeastern Arizona area from Harshbarger et al. (1957, fig. 25). Unit lies on ornamented side of boundary.


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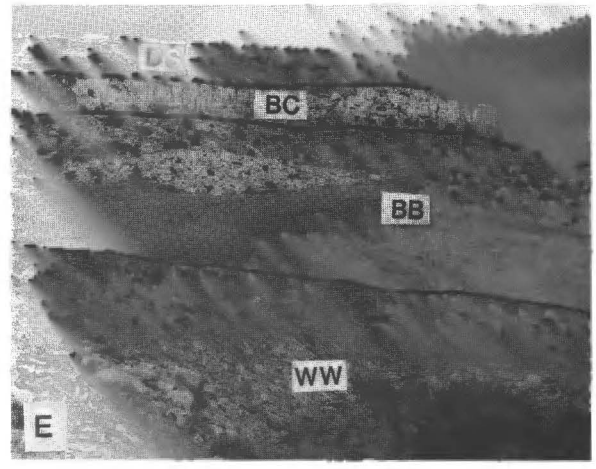

BC
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FIGURE 2. Views of Jurassic rocks in McElmo Canyon area. A, West wall of Sand Canyon. Entrada Sandstone includes red member (ER) and Slick Rock Member (SR). Wanakah Formation is made up of siltstone member (SM), middle member (MM), bed at Black Steer Knoll (BSK), and upper member (UM). Junction Creek Sandstone (JC). Morrison Formation includes Tidwell Member (TM), and Salt Wash Member and younger parts of the Morrison Formation (SWY). Note stratigraphic rise of the base of the Salt Wash Member and intertonguing of Junction Creek and Tidwell. B, The J-5 unconformity on west side of Sand Canyon in NW¼ sec. 23, T36N, R18W separates Junction Creek Sandstone (JC) from upper member (UM) of Wanakah Formation. Arrows point to J-5 unconformity. Note hammer (circled) for scale. C, Tidwell Member (TM), underlying lowest channel sandstone of Salt Wash Member (SW). Tidwell weathers to hoodoos at this locality. Photograph by R. A. Cadigan. D, Morrison Formation 1 mi west of Battle Rock School. Tidwell Member (TM), Salt Wash Member (SW), Recapture Member (RC), Westwater Canyon Member (WW) and Brushy Basin Member (BB) on the skyline. Photograph by Ekren and Houser (1965, fig. 4). E, Burro Canyon Formation (BC) in western McElmo Canyon. Note color contrast with Dakota Sandstone (DS). Upper part of Morrison Formation includes Westwater Canyon (WW) and Brushy Basin (BB) Members. Photograph by Ekren and Houser (1965, fig. 5)

The interpretations discussed in this report are based on a stratigraphic study of the San Rafael Group, Junction Creek Sandstone and lower part of the Morrison Formation from Salter Canyon to McElmo Canyon (O'Sullivan, 1995), and from unpublished measured sections and subsurface studies. Details on other Jurassic and related rocks are from reports by Ekren and Houser (1965), Condon (1991) and Aubrey (1996). Further details on lithology, thickness and stratigraphic relationships may be found in reports cited.

STRATIGRAPHY

Glen Canyon Group

The Glen Canyon Group consists of, in ascending order, Wingate Sandstone, Kayenta Formation and Navajo Sandstone. The Navajo and Wingate Sandstones are eolian deposits and the Kayenta Formation is largely a fluviatile deposit. In the McElmo Canyon area, the entire Glen Canyon Group is about 350 to 425 ft thick (Condon, 1992, fig. 22). The following description of the Glen Canyon Group along Sand Canyon (Fig. 3) is derived from Condon (1991). The Wingate Sandstone is dark to light reddish-brown, very fine- to fine-grained crossbedded sandstone. The Wingate is about 175 ft thick in lower Sand Canyon, but the base is not exposed. The Kayenta Formation, 20 to 30 ft thick, is yellowish-gray to pinkish-gray, very fine- to fine-grained sandstone and clay-clast conglomerate. Sandstone beds are lenticular and have the geometry of laterally amalgamated fluvial channels. The Navajo Sandstone is about 90 ft thick and consists of light gray, very fine- to fine-grained crossbedded and flatbedded sandstone.

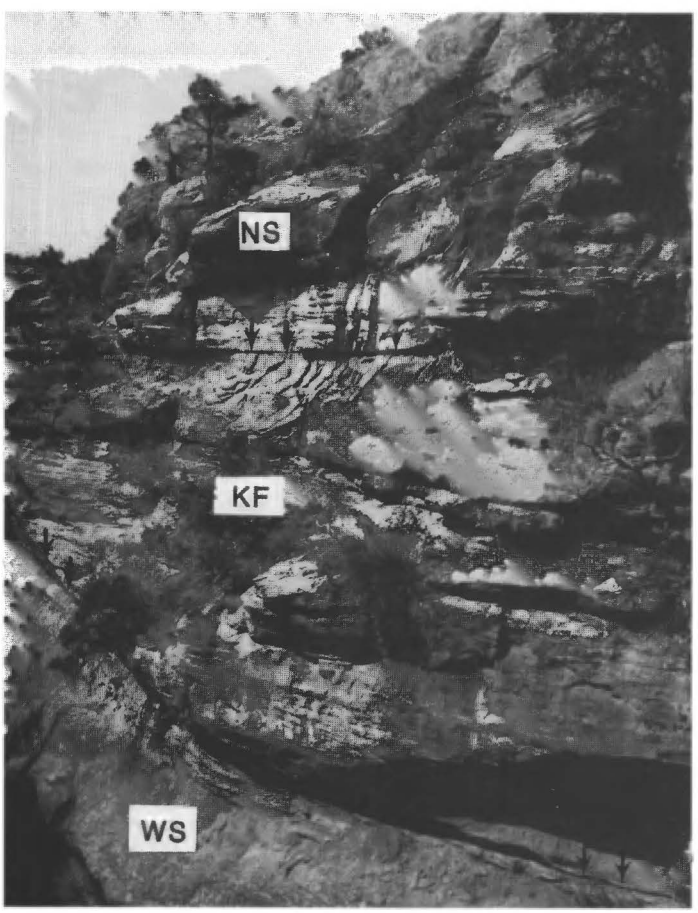


FIGURE 3. Glen Canyon Group in upper Sand Canyon. View south in NE¼ sec. 23, T36N, R18W. Wingate Sandstone (WS). Arrows point to base of Kayenta Formation (KF) and Navajo Sandstone (NS). Note channel sandstone at base of Kayenta Formation. Photograph by S.M. Condon.

Entrada Sandstone

The Entrada Sandstone, which is the basal formation of the San Rafael Group in McElmo Canyon, consists of the informal red member and the overlying Slick Rock Member. The red member consists of reddish-brown siltstone and silty sandstone, parts of which tend to form spheroidal-weathering features known as hoodoos, stone babies, or goblins. The red member averages about 27 ft thick along McElmo Canyon and is possibly of marginal marine origin.

Different names have been applied to the red member in McElmo Canyon. Lupe (1983) and Harshbarger et al. (1957, pl. 3) referred to it as Carmel Formation. Ekren and Houser (1965, p. 8) termed it the Dewey Bridge Member of the Entrada. The Carmel Formation of marine or marginal marine origin is widespread in Utah below the Entrada Sandstone (Fig. 4). West of Moab, Utah, the Carmel Formation grades eastward into reddish-brown siltstone of the Dewey Bridge Member of the Entrada Sandstone (Wright et al., 1962, p. 2062). The red member can be traced in the subsurface from McElmo Canyon into Dry Valley, north of Monticello, Utah, where it grades into the Slick Rock Member and is separated from the Dewey Bridge Member by the middle sandstone of the Entrada (Fig. 4). The red member, therefore, is clearly younger than the Dewey Bridge Member or equivalent Carmel Formation. At Bluff, Utah, the red member lies within the Entrada Sandstone and stratigraphically overlies the Carmel Formation. From Bluff, the Entrada Sandstone can be followed to Mexican Water, Arizona. The red member and middle sandstone at Bluff are equivalent at Mexican Water to the medial silty and lower sandy members, respectively, of Harshbarger et al. (1957, fig. 2) and lie above the Carmel. The Carmel Formation and the middle sandstone of the Entrada in Utah lap out in various directions (Fig. 1B) toward southwest Colorado and are not present at McElmo Canyon (O'Sullivan, 1996, p. 194). Southward from Bluff and in northeastern Arizona the lower sandy member of the Entrada thins out in a depositional wedge above the Carmel Formation (Harshbarger et al., 1957, pl. 3). Only the red member is present at McElmo Canyon; it is

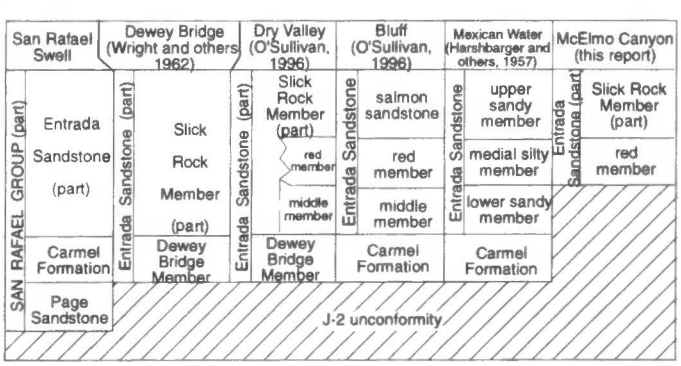


FIGURE 4. Selected nomenclature used in southeastern Utah and adjacent areas.

also widespread in northwestern New Mexico as the medial siltstone member of the Entrada Sandstone.

The Slick Rock Member of the Entrada forms a conspicuous cliff (Fig. 2A) above the red member in McElmo Canyon, where it averages 82 ft in thickness and consists of reddish-tan and gray, fine- to very fine-grained sandstone arranged in a sequence of alternating crossbedded and flatbedded units. The crossbedded units are eolian deposits; the flatbedded units are interpreted as interdune or sabkha deposits.

Wanakah Formation

The Wanakah Formation, probably of marginal marine origin, makes up the upper part of the San Rafael Group. In McElmo Canyon, the Wanakah Formation averages 135 ft thick. Several informal subdivisions are recognized. These include the siltstone, middle and upper members, which are lithologically similar and are characteristic of the Wanakah. The members are largely a red-bed sequence of sandstone and siltstone in beds generally less than 3 ft thick. The beds are mostly reddish brown, locally mottled or banded gray, and commonly form a slope (Fig. 2A). Gray and red ledge-forming sandstone beds, usually less than 2 ft thick, and thin red clay beds are present at many localities. In McElmo Canyon, the siltstone member averages 33 ft thick, the middle member averages 34 ft thick and the upper member averages 20 ft thick.

A thin sandstone, arbitrarily termed bed V, is at the top of the siltstone member and separates it from the overlying middle member. Bed V in McElmo Canyon is about 1.5 ft thick and consists of fine- to very fine-grained, hard, resistant, flatbedded sandstone. Bed V is mostly gray, but is reddish tan mottled or streaked gray at some localities. At many exposures, bed V forms a prominent ledge that tends to overhang underlying strata of the siltstone member.

A distinctive sandstone layer—the bed at Black Steer Knoll—lies between the middle and upper members of the Wanakah Formation. The bed at Black Steer Knoll has been traced into McElmo Canyon from the north (O'Sullivan, 1995). The bed averages about 48 ft in thickness along McElmo Canyon, forms a prominent ledge (Fig. 2A) or cliff, and consists of gray and reddish-tan, fine-grained, flatbedded sandstone. Locally, thin crossbedded strata, less than 3 ft thick, are found at various levels in the bed at Black Steer Knoll.

The Wanakah Formation has been traced in the subsurface from the San Juan Basin of New Mexico into the McElmo Canyon area. In New Mexico, the Wanakah, above the Entrada Sandstone, consists of, in ascending order, Todilto Limestone Member, Beclabito Member and Horse Mesa Member. Condon and Huffman (1994) included the Wanakah in a line of section extending from the San Juan Basin to the Shell Oil Co. 1 Federal 23-26-17 drill hole at the east end of McElmo Canyon (well 77 on their line of section G-G'). Comparing outcrop to drill hole 77, Condon and Huffman (1994) assigned both the bed at Black Steer Knoll and the upper member to the Horse Mesa Member, and assigned the siltstone and middle members, of this report, to the Beclabito Member. The Todilto Limestone Member is absent in McElmo Canyon.

The Wanakah Formation overlying the Entrada Sandstone in McElmo Canyon has previously been termed Summerville Formation (Craig et al., 1959, sec. 124, 214; Ekren and Houser, 1965, p. 10–12; Lupe, 1983). The Summerville Formation at the type locality in the San Rafael Swell in Utah, is separated from the Entrada Sandstone by the Curtis Formation—a marine sandstone about 200 ft thick. The Wanakah Formation, however, was defined by Burbank (1930, p. 171–177) as beds directly overlying the Entrada Sandstone. Stratigraphic studies show that the siltstone and middle members of the Wanakah grade into the Entrada Sandstone (Moab Tongue) in the Dry Valley area of Utah (O'Sullivan, 1991). The Moab Tongue, the uppermost part of the Entrada, grades into the Curtis Formation between Moab and the San Rafael Swell (Caputo and Pryor, 1991, figs. 1, 3). Consequently, much of the Wanakah Formation in the McElmo Canyon area correlates with the Curtis and not with the Summerville. However, the upper part of the Wanakah (beds at Black Steer Knoll and upper member) is truncated north of McElmo Canyon in Dry Valley by the J-5 unconformity (O'Sullivan, 1991) so its relationship to the Curtis and Summerville Formations is uncertain.

The strata assigned to the Wanakah Formation in this report have been interpreted differently by Anderson and Lucas (1992, 1994). The Todilto Limestone Member is considered by Anderson and Lucas (1992, p. 81) to be a homotaxial correlative of the Curtis Formation and the beds overlying the Todilto are thought to be equivalent to the Summerville Formation. Where the Todilto Limestone Member is absent, as in McElmo Canyon and in southeast Utah, Anderson and Lucas (1992, p. 81) envision a paraconformity that separates the Entrada Sandstone and overlying beds in the area from Moab southward to the southwest corner of Colorado. In their view the paraconformity, or hiatus, represents the Todilto or Curtis Formation. I have been unable to find such an unconformity. Instead I find evidence of continuous lateral and vertical deposition between the Entrada and Wanakah Formation from Bluff northwards towards Moab (O'Sullivan, 1996). Furthermore, Peterson (1994, p. 248–249) believes that the Todilto Limestone Member correlates with the upper part of the Entrada Sandstone in south-central Utah and not with the Curtis Formation. Until some of the stratigraphic problems are resolved it seems expedient, at least to some geologists, to use Wanakah Formation for beds directly above the Entrada in southwestern Colorado. The Wanakah Formation has been recognized in southwest Colorado since it was named by Burbank (1930) over 65 years ago.

Junction Creek Sandstone

The Junction Creek Sandstone, of eolian origin, unconformably overlies the Wanakah Formation. The Junction Creek Sandstone was first recognized in the McElmo Canyon area by Goldman and Spencer (1941, fig. 6), who named the formation, and it was later mapped in the area by Ekren and Houser (1965, pl. 1). Along McElmo Canyon the Junction Creek averages about 250 ft thick and can be divided into lower and upper units. As described by Ekren and Houser (1965, p. 12): "The lower unit, 30 to 50 feet thick, is composed of alternating beds of flat-stratified and cross-stratified sandstone. The cross-strata dip at low angles and are truncated by planar surfaces of erosion. A few of the horizontal surfaces of erosion may be continuous across all the exposures in McElmo Canyon." The lower unit tends to form a prominent ledge at the base of the Junction Creek. Although flat beds are characteristic of the lower unit, they also occur in the overlying upper unit. The contact between the upper and lower units is arbitrary. The upper unit, as much as 220 ft thick, consists primarily of large scale crossbeds with some minor flat beds. The top of the upper unit shows flat beds at many exposures; locally, along Sand Canyon, they are 70 ft thick.

The J-5 unconformity, traced into the canyon (O'Sullivan, 1995 and unpublished subsurface studies) at the top of the Wanakah Formation, is mostly obscured in the McElmo Canyon area. Where exposed (Fig. 2B) the unconformity is a sharp, slightly wavy surface showing only about 1 in. of relief in 6 in. laterally. The basal sandstone of the overlying Junction Creek commonly contains concentrations of coarse grains. In McElmo Canyon, the J-5 unconformity coincides with a "datum" used by Lupe (1983) to trace Jurassic rocks from New Mexico into Colorado. In northwestern New Mexico the "datum" is a regional disconformity showing relief that is "...locally more than 10 m [and] apparently represents a time of abrupt change in deposition" from thinly bedded siltstone below the "datum" to thick sandstone bodies above (U.S. Geological Survey, 1980, p. 48).

Morrison Formation

The Morrison Formation, which overlies the Junction Creek Sandstone, consists of the Tidwell Member at the base overlain successively by Salt Wash, Recapture, Westwater Canyon and Brushy Basin Members. They contain mainly fluvial, flood plain and lacustrine deposits that range in the McElmo Canyon area from 500 to 650 ft thick (Ekren and Houser, 1965, p. 14).

The Tidwell Member consists of red siltstone and thin gray or red sandstone; the sandstone tends to weather to a slope or, locally, to hoodoos (Fig. 2C). The Tidwell Member, locally, interfingers with the underlying Junction Creek Sandstone and the overlying Salt Wash Member. An excellent example of this relationship is exposed on the west side of Sand Canyon (Fig. 2A), where basal channel sandstones of the Salt Wash that rest directly on the Junction Creek Sandstone rise stratigraphically northward about 35 ft by passing laterally into the Tidwell Member. At the same

locality, about 20 ft of basal beds of the Tidwell pass laterally southward into the Junction Creek Sandstone. A tongue of the Junction Creek, about 10 to 12 ft thick, wedges out northward into the Tidwell Member, which thickens to about 65 ft.

The Salt Wash, Recapture and Westwater Canyon Members (Fig. 2D), according to Ekren and Houser (1965, p. 13) "... are composed predominantly of lenticular light tan and light gray sandstone which is interstratified with thin red or green siltstone and claystone. The Brushy Basin, a bentonitic mudstone, is mainly green, but is subordinately red, purple, and gray." In the McElmo Canyon area there is considerable variation in thickness of individual members probably because of interfingering among the units. Ekren and Houser (1965, p. 14) found that "Where one member is thin, generally, another is correspondingly thick. The Brushy Basin Member and overlying Burro Canyon Formation have a similar nearly constant total thickness." The Salt Wash Member ranges from 90–250 ft thick, the Recapture Member from 0–260 ft, the Westwater Canyon Member from 40–200 ft, and the Brushy Basin Member from 150–300 ft (Ekren and Houser, 1965, p. 14–16).

The Morrison Formation has recently been interpreted in a different way by Anderson and Lucas (1995). The Morrison Formation is rearranged to consist of a Salt Wash Member overlain by a Brushy Basin Member. The base of the Morrison is placed at the base of the Salt Wash Member. The Westwater Canyon Member is not recognized; the name Recapture Member is restricted to the lower part of the member as originally defined by Gregory (1938, p. 58), near Bluff, and the member is assigned to the Bluff Sandstone (an equivalent of the Junction Creek Sandstone). The Tidwell Member is placed in the Summerville Formation (Anderson and Lucas, 1995, fig. 6). In this report I use most of the Morrison Formation stratigraphy as mapped by Ekren and Houser (1965, pl. 1). The Tidwell Member was traced into the McElmo Canyon area from the north in the subsurface (O'Sullivan, 1995) and is the same as the upper unit of the Junction Creek Sandstone as used by Ekren and Houser (1965, p. 12).

Burro Canyon Formation

The Burro Canyon Formation (Fig. 2E) consists largely of fluvial deposits, which overlie the Morrison Formation. According to Ekren and Houser (1965, p. 18) the Burro Canyon in the McElmo Canyon area "... ranges from 30 to 200 feet in thickness and consists of green, predominantly nonbentonitic mudstone interbedded with lenses of conglomerate and conglomeratic sandstone that vary considerably in number and thickness. Red mudstone occurs sporadically in the lower part of the formation." The lowest unit of the Burro Canyon is the Karla Kay Conglomerate Member named locally by Ekren and Houser (1959), which is only present in a small area on the north side of McElmo Creek. The Karla Kay is a system of shoestring channel fillings of dark brown conglomerate in lenses usually 500 to 800 ft wide and as much as 65 ft deep (Ekren and Houser, 1965, p. 18). The Karla Kay and basal beds of the overlying parts of the Burro Canyon Formation contain abundant colorful chert pebbles (Ekren and Houser, 1965, p. 19) that are also characteristic of the Brushy Basin Member of the Morrison.

The Burro Canyon Formation is currently considered to be Early Cretaceous in age. However, a recent report suggests that the formation is more likely Jurassic in the McElmo Canyon area. Aubrey (1996) found that at the type locality near Slick Rock, Colorado, the Burro Canyon Formation consists of lower and upper units or members. The upper member contains Lower Cretaceous fossils and is confined to east-central Utah and west-central Colorado (Fig. 5). The unfossiliferous lower member is more widespread and extends into southwestern Colorado. In the McElmo Canyon area, the Burro Canyon Formation is represented only by the undated lower member and the locally present Karla Kay Member (Fig. 5).

The Burro Canyon Formation succeeds the Morrison Formation with little break in deposition (Ekren and Houser, 1965, p. 19). Extensive intertonguing between the Burro Canyon (lower member of Aubrey above the Karla Kay Conglomerate Member) and the underlying Brushy Basin Member of the Morrison Formation has been mapped in the McElmo Canyon area by Ekren and Houser (1965, pl. 1). The upper part of the Brushy Basin Member (to within 3 ft of its top) has been dated radiometrically (see Aubrey, 1996, p. 216) as Late Jurassic (Tithonian) in nearby Utah. Consequently, the intertongued parts and possibly all, of the Burro Canyon is the same Late Jurassic age as the Brushy Basin Member. However, an isotope age study for the Brushy Basin Member has not been done in the McElmo Canyon area and the age of the Burro Canyon is not changed in this report.

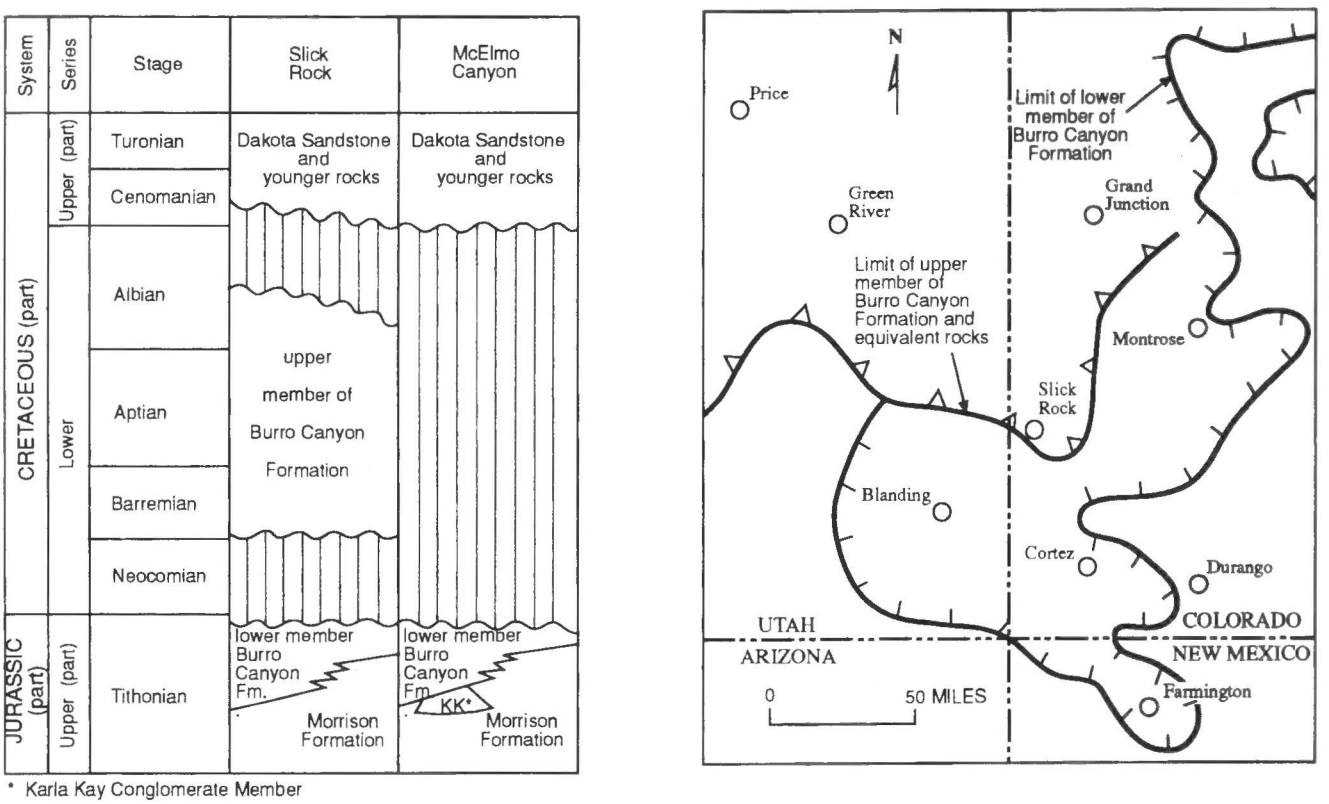


FIGURE 5. Correlation chart and distribution of Burro Canyon Formation. Modified from Aubrey (1996, figs. 1, 2, 4).

Cretaceous Rocks

The Dakota Sandstone of Late Cretaceous age unconformably overlies the Burro Canyon Formation. The Dakota ranges in thickness from 95 to 140 ft (Ekren and Houser, 1965, p. 20) and consists of sandstone, conglomerate, gray shale and coal deposited in fluvial, swamp and near shore conditions. Relief on the base of the Dakota "... ranges from a few inches to more than 40 feet within a distance of 300 feet" (Ekren and Houser, 1965, p. 19). Carbonaceous shale, locally containing thin coal beds, readily distinguishes the Dakota from the underlying Burro Canyon Formation.

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