The Base of the Upper Jurassic Morrison Formation in East-Central Utah

U.S. GEOLOGICAL SURVEY BULLETIN 1561

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By ROBERT B. O'SULLIVAN

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A review of the first description of the base of the Morrison Formation in east-central Utah and some later modifications

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THE BASE OF THE UPPER JURASSIC MORRISON FORMATION IN EAST-CENTRAL UTAH

By ROBERT B. O'SULLIVAN

ABSTRACT

The contact between the Middle Jurassic San Rafael Group and the overlying Upper Jurassic Morrison Formation in the San Rafael Swell of Utah was originally described as an unconformity that is both angular and erosional. This surface is now recognized as the J–5 unconformity, a widespread break in Jurassic rocks of the Western Interior of the United States. In east-central Utah, a sequence of channel sandstones—the Salt Wash Member of the Morrison Formation—lies 5–30 m above the J–5 unconformity. The basal contact of the Morrison has also been placed at the base of the Salt Wash Member, or somewhere between the Salt Wash and the J–5 unconformity. In east-central Utah, the base of the Morrison Formation is here placed at the widespread and consistent J–5 unconformity.

INTRODUCTION

The Morrison Formation of Late Jurassic age is present over large areas of east-central Utah. Throughout the region, the Morrison lies upon rocks of the San Rafael Group of Middle Jurassic age. Investigations by the author in eastern Utah indicate that geologists have selected different horizons as the base of the Morrison Formation. In introducing the term Morrison into the San Rafael Swell (fig. 1), Gilluly (1929, p. 111) described the lower contact as an unconformity that is both angular and erosional. In some areas the lower contact of the Morrison has been placed by many geologists at the base of a sequence of channel sandstones—the Salt Wash Member of the Morrison—which lies as much as 30 m above the unconformity observed by Gilluly. The base of the Morrison has also been placed by many geologists somewhere between the Salt Wash Member and the unconformity noted by Gilluly. This report reviews Gilluly's description of the base of the Morrison in east-central Utah and some later modifications. In addition, the basal contact of the Morrison is here placed at the unconformity described by Gilluly. The lithology and lateral stratigraphic relations of the various rock units above and below the unconformity are only briefly discussed in this report; more complete details may be found in publications cited throughout the text.

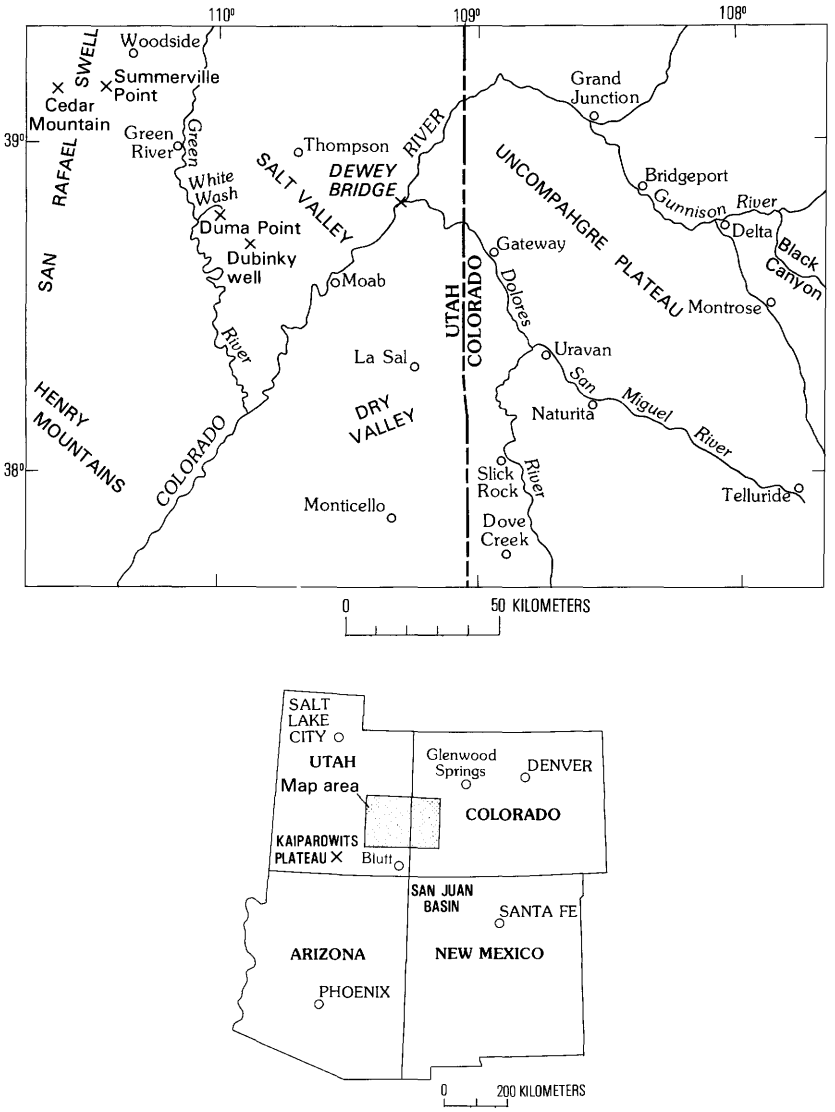

FIGURE 1.—Index map of east-central Utah and adjacent parts of Colorado.

The unconformity at the base of the Morrison Formation is one of several found in Jurassic rocks of east-central Utah. This surface that separates the Morrison Formation from the San Rafael Group is termed the J–5 unconformity and is recognized over much of the Western Interior of the United States. The unconformities found in

Jurassic rocks and their regional stratigraphic significance are discussed in a report by Pipiringos and O'Sullivan (1978).

George N. Pipiringos first introduced me to the Jurassic rocks of the San Rafael Swell in 1964. Subsequently, he shared with me his extensive knowledge of the Jurassic in the Western Interior, and contributed materially to my understanding of the contact relations described herein.

STRATIGRAPHY

The San Rafael Group, its subdivisions, and the Morrison Formation were established in east-central Utah in a press memorandum and four reports released over a period of 6 years. The San Rafael Group was defined in a report by Gilluly and Reeside (1928, p. 73) to include in ascending order the Carmel Formation, Entrada Sandstone, Curtis Formation, and Summerville Formation. The names and lithologies of the divisions of the San Rafael Group and the Morrison Formation were described in a U.S. Department of the Interior Memorandum for the Press, number 6064, dated March 30, 1926. A description of the San Rafael Group, its divisions, and the Morrison Formation and a diagram showing stratigraphic relations were included in a report by Baker and others (1927). The type sections of the Entrada Sandstone and the Curtis and Summerville Formations were given by Gilluly (1929, p. 104–110). The Carmel Formation was later defined and described by Gregory and Moore (1931, p. 72–76).

Geologic investigations in the San Rafael Swell produced the reports mentioned above. Field work in the San Rafael Swell was begun in July 1924 under the direction of E. M. Spieker. In August 1924, the investigations were assumed by James Gilluly, who then completed the field work in September 1925. In December 1925, oil was discovered in a drill hole on the Cane (Kane) Creek anticline about 15 km southwest of Moab. This discovery caused considerable interest in the petroleum potential of east-central Utah. Consequently, some of the results of the field work in the San Rafael Swell were incorporated in the Memorandum for the Press in 1926, the summary report by Baker and others (1927), and the regional study by Gilluly and Reeside (1928). The detailed description of the geology of the San Rafael Swell by Gilluly (1929) was undoubtedly delayed because the report contained a multi-colored geologic map that took some time to prepare. This report by Gilluly (1929) is treated herein as the principal reference because it includes the type sections of the Summerville and related formations.

The four formations (fig. 2) included in the San Rafael Group by Gilluly (1929, p. 99–110) are well exposed in the San Rafael Swell.

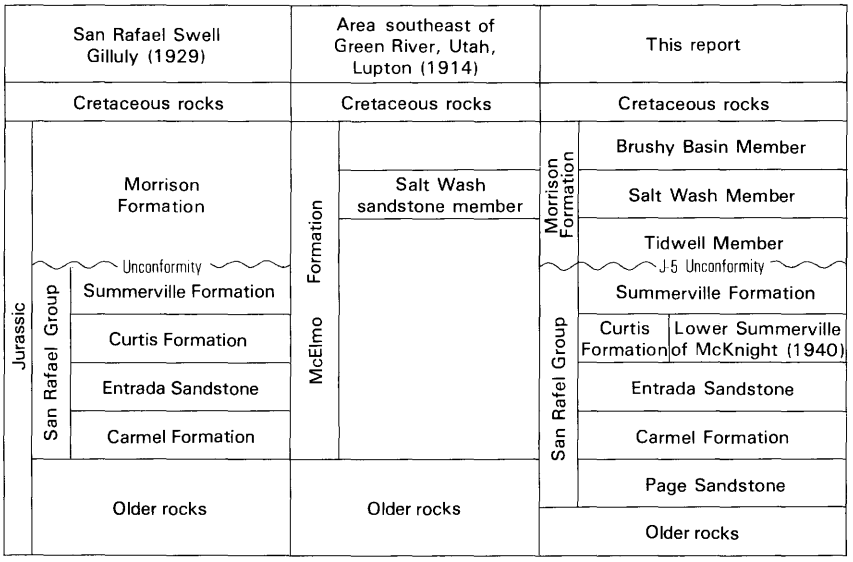

FIGURE 2.—Some Jurassic nomenclature used in east-central Utah.

On Cedar Mountain, the thickness of the group totals about 325 m (Wright and others, 1979, p. 26–42). The San Rafael Group shows a variety of lithologies including red and green siltstone and shale, red earthy sandstone, gray clean sandstone, glauconitic sandstone, and minor amounts of limestone and gypsum. The Carmel and Curtis Formations are of marine origin as indicated by marine fossils. The Entrada Sandstone and Summerville Formation are most likely marginal-marine deposits. The uppermost division of the San Rafael Group, the Summerville Formation, at Summerville Point (the type locality) is 49.6 m thick (Gilluly, 1929, p. 109). The Summerville consists of red siltstone and lesser amounts of sandstone and shale, all in very thin beds. Gypsum is present particularly in the upper part of the Summerville as thin beds, nodules, and seams that cut across bedding.

The assignment of some units of the San Rafael Group has recently been somewhat changed. The Page Sandstone, named by Peterson and Pipiringos (1979, p. B20–B30), is a gray crossbedded sandstone about 30 m thick near Cedar Mountain, which was formerly assigned to older Jurassic rocks. The Page is now assigned as the basal formation of the San Rafael Group. East of the Green River, equivalents of the Curtis Formation extending towards Moab beneath the Summerville are recognized as the lower Summerville of McKnight (1940), a unit now known to be entirely older than the Summerville Formation above the Curtis in the San Rafael Swell. (See O'Sullivan, 1980a.)

The Morrison Formation rests unconformably on the San Rafael

Group. In east-central Utah, the formation is 180–245 m thick (Craig and others, 1955, fig. 30). The Morrison consists of three parts. The Tidwell Member at the base is successively overlain by the Salt Wash and Brushy Basin Members. Strata forming the Tidwell have previously been assigned to the lower beds of the Salt Wash Member (O'Sullivan, 1981c) or included as an undivided part of the Salt Wash Member (L. C. Craig, written commun., 1980) in regional studies of the Morrison Formation (Craig and others, 1955).

A terrestrial origin for most of the Morrison is generally accepted. The fossil flora and fauna together with sedimentary bedding features support this environmental interpretation. Locally, however, some of the basal part of the Morrison may be marine or quasi marine. Imlay (1980, p. 95), for instance, stated, "* * * the presence of massive gypsum at the base of the Morrison Formation in the San Rafael Swell * * * suggests deposition in lagoons at the margin of a shallow sea * * *." Similarly Holt (1940) noted that near Grand Junction, Colo., adjacent to east-central Utah, "* * * basal beds of the Morrison Formation * * * were deposited in lagoons on the borders of the Upper Jurassic * * * sea." The marine or marginal-marine beds, just described, in the basal part of the Morrison Formation above the J–5 unconformity correlate with the quasi-marine Windy Hill Sandstone Member of the Sundance Formation overlying the J–5 unconformity in north-central Colorado.

The Tidwell Member is at the base of the Morrison Formation throughout east-central Utah. The Tidwell forms a siltstone slope that extends from the J–5 unconformity up to the base of the Salt Wash Member. The thickness of the Tidwell at 24 measured sections in east-central Utah averages 17.2 m and ranges from as little as 4.8 m to as much as 28.6 m. There is a pronounced color shift in the Tidwell from gray in the San Rafael Swell to red in the Moab area. As will be explained, this color shift probably accounts for some of the different placements of the basal contact of the Morrison.

The lithology of the Tidwell Member is somewhat varied. Siltstone is the dominant rock type. Chert beds as much as 1.5 m thick, rounded limestone nodules, and gray limestone beds are conspicuous lithologic features of the Tidwell Member. Gypsum is also present in some abundance from the San Rafael Swell to just east of the Green River. Gray ledge-forming sandstones as much as 2 m thick, in which bedding is absent or not apparent, crop out at many localities; light-gray cross-bedded channel sandstone beds typical of the overlying Salt Wash Member are absent at most places, but where present form a minor lithology in the slope-forming Tidwell Member. At places, the Tidwell contains persistent thin ledge-forming sandstone beds, generally less than 1 m thick, which are blocky, ripple marked, and commonly carry

coarse grains of chert. A widespread sandstone, termed for convenience bed A, marks the base of the Tidwell Member at most places. Throughout large areas of east-central Utah, bed A is generally less than 0.5 m thick but locally is as much as 2.5 m thick. Here and there the bed contains coarse grains, is ripple marked, and tends to form a resistant ledge that overhangs the J–5 unconformity and underlying rocks.

The Tidwell is overlain in ascending order by the Salt Wash and Brushy Basin Members. In east-central Utah, the Salt Wash ranges in thickness from 60 to 110 m, and the Brushy Basin ranges in thickness from 90 to 125 m (Craig and others, 1955, figs. 21 and 29). The Salt Wash is made up of a sequence of light-colored lenticular sandstone ledges interspersed with red and gray siltstone and sandstone. The sandstone beds, of fluviatile origin, are generally crossbedded and locally are coarse grained and conglomeratic. The Salt Wash forms high impressive cliffs, ledgy slopes, and broad benches. The lower boundary of the Salt Wash is at the base of the lowest channel sandstone that is a part of a continuous zone of channel sandstones (fig. 4). The stratigraphic position of the contact varies considerably from place to place because of intertonguing with the underlying Tidwell Member. Above the Salt Wash, the slope-forming Brushy Basin Member consists mostly of gray, green, and red siltstone, shale and minor limestone, and conglomeratic sandstone.

All the strata now assigned to the San Rafael Group and Morrison Formation were once included in the McElmo Formation near Green River (fig. 2). In an area southeast of the town of Green River and extending through Duma Point, Lupton (1914, p. 127) noted, "A gray coarse-grained sandstone, conglomeratic in places * * * about 350 feet below the top of the McElmo formation * * *" for which he proposed the name Salt Wash Sandstone Member of the McElmo Formation. In a general section of rocks in the area southeast of Green River, Lupton (1914, p. 124) recognized a Salt Wash Sandstone Member 46–53 m thick; the thicknesses of the underlying and overlying unnamed parts of the McElmo were about 213 m and 99–107 m, respectively. The Salt Wash Sandstone Member was positioned somewhere above the middle of the McElmo Formation (figs. 2 and 4).

In the later work of Gilluly and Reeside (1928) and Gilluly (1929), the newly defined San Rafael Group replaced the lower part of the McElmo Formation and the Morrison Formation replaced the upper part. In discussing the Morrison Formation, Gilluly (1929, p. 118) noted, "The rocks here correlated with the Morrison formation have * * * been hitherto referred to the "McElmo" formation. * * * There has been so wide diversity in the usage of the term "McElmo" * * * that it has seemed advisable to use the term Morrison for these

beds rather than to attempt to restrict the usage of McElmo. There seems ample lithologic and fossil evidence for the extension of the term Morrison formation * * * [into the San Rafael Swell]."

BASE OF MORRISON FORMATION

PREVIOUS USAGE

The contact between the San Rafael Group and the Morrison Formation was carefully described in the San Rafael Swell by Gilluly (1929, p. 111): "There is an unconformity, both angular and erosional, at the top of the Summerville formation. * * * Above this unconformity lie the clay, sandstone, and conglomerate of the Morrison formation." This unconformity that is both angular and erosional is now recognized as the J–5 unconformity.

In the San Rafael Swell, the Salt Wash has heretofore been recognized as the basal member of the Morrison. In describing the Morrison, Gilluly (1929, p. 111) noted, "The basal portion of this formation on the east flank of the Swell, is a series of conglomeratic sandstone lenses of the channel type, interbedded with far subordinate amounts of clay and some gypsum and limestone. * * * From the descriptions given by Lupton * * * this series is very probably his Salt Wash sandstone member * * *." It is clear from the description and measured sections that Gilluly (1929, p. 111–118) believed the Salt Wash extended down to the J–5 unconformity in the San Rafael Swell. Summerville Point makes a convenient locality to show the J–5 surface and its relationships to associated strata inasmuch as it includes the type section of the Summerville Formation—the youngest unit of the San Rafael Group beneath the J–5 unconformity. The Summerville Formation is overlain by the Morrison Formation that was extended somewhat casually into east-central Utah, consequently the Morrison lacks a nearby reference section. At Summerville Point, where the Morrison is well displayed, the lowest gray channel sandstone in the Morrison lies 9–16 m above the J–5 unconformity (fig. 3). These channel sandstones are lithologically the same as and are equivalent to the gray channel sandstones assigned by Lupton (1914) to the Salt Wash along White Wash (fig. 4) in the area east of the Green River where the Salt Wash was named. The sequence between the lowest channel sandstone and the J–5 unconformity is now recognized as the Tidwell Member. The Tidwell in the Swell is mostly gray siltstone with some thin gray limestone ledges. At Summerville Point, the gray bed A at the base of the Tidwell is 0.15 m thick, makes a slight ledge, and contains sparse coarse grains as much as 1.5 mm across. About 1.2 m above bed A is a gray persistent ripple-marked sandstone

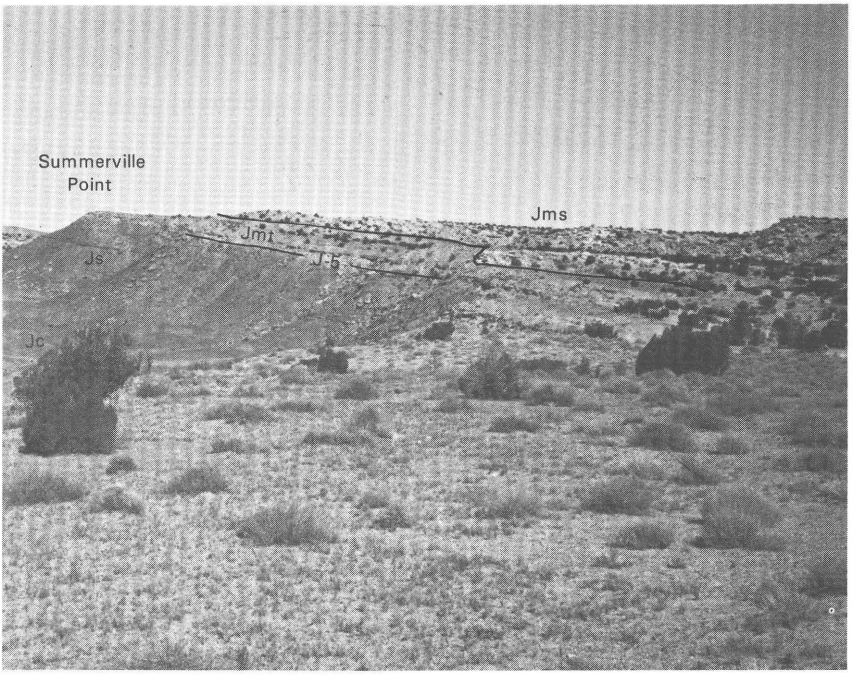

FIGURE 3.—View northwest of Jurassic rocks at Summerville Point. Upper part of Curtis Formation (Jc) makes the flat at base of steep slope of the Summerville Formation (Js). Tidwell Member about 15 m thick (Jmt); Salt Wash Member (Jms). The J–5 unconformity (J–5) separates the San Rafael Group and Morrison Formation. Summerville Point is in SE¼ sec. 9 (unsurveyed) T. 19 S., R. 13 E.

about 1 m thick that can be traced for several kilometers to the north and south of Summerville Point. The sandstone just described is typical of the Tidwell Member but is unlike the lenticular sandstone beds in the Salt Wash.

The J–5 unconformity was miscorrelated from the San Rafael Swell eastward towards the Green River. The detailed stratigraphy of the San Rafael Swell was extended eastward in the report by Gilluly and Reeside (1928). Measured sections in the San Rafael Swell were correlated with a section measured by Lupton (1914, p. 126) along White Wash (Gilluly and Reeside, 1928, plate 15). The unconformity at the base of the Morrison in the Swell was correlated with the base of the Salt Wash along White Wash rather than with the J–5 unconformity about 18 m below the Salt Wash along White Wash. The miscorrelation from the Swell eastward occurs partly because the Tidwell Member between the J–5 unconformity and the Salt Wash was overlooked at Summerville Point and along White Wash. Consequently, what was regarded as Salt Wash in the Swell, which included the

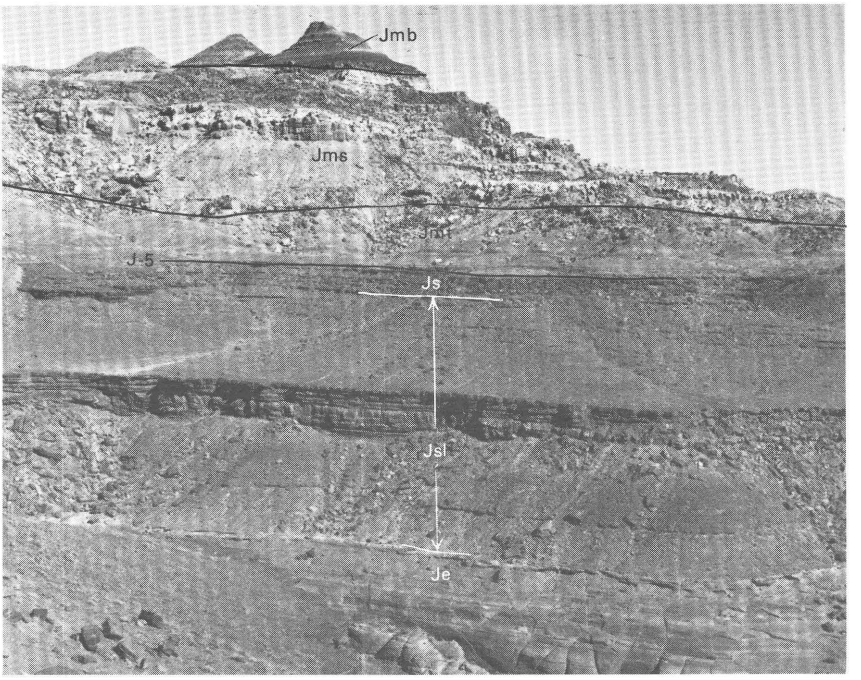

FIGURE 4.—View eastward of Jurassic rocks along White Wash at type locality of Salt Wash Member of Morrison Formation. Tidwell Member (Jmt) is about 18 m thick. Summerville Formation (Js) is only about 5 m thick here because most of it has been beveled out by the J–5 unconformity (J–5) at the base of the Morrison Formation. Entrada Sandstone (Je); the lower Summerville of McKnight (1940), a Curtis Formation equivalent, (Jsl); Salt Wash Member (Jms); and Brushy Basin Member (Jmb). Topographic high points in picture are in NW¼ sec. 19, T. 23, S., R. 18 E.

Tidwell Member, was correlated with what was defined by Lupton as Salt Wash along White Wash. In addition, the Tidwell Member underlying the Salt Wash is gray in the Swell and mostly red along White Wash. The red Tidwell along White Wash might be confused at first glance with the red Summerville Formation beneath the J–5 unconformity.

The Summerville Formation has been recognized east of White Wash and the Duma Point area. Gilluly and Reeside (1928, plate 15) traced the Summerville eastward to Dewey Bridge. However, recent stratigraphic studies (O'Sullivan, 1980a) show that all of the Summerville that overlies the Curtis Formation in the San Rafael Swell is truncated beneath the J–5 unconformity near Dubinky well not far east of White Wash. The strata previously treated as Summerville east of Dubinky well are now assigned to the Tidwell Member. In

selected parts of east-central Utah, the base of what was termed Morrison Formation has been variously described by Baker (1933) in the Moab area, by Dane (1935) in the Salt Valley and adjacent areas, and by Stokes (1952) in the Thompson area. Each author recognized a Salt Wash Sandstone Member underlain by what was termed Summerville Formation. Each seemed somewhat perplexed by the gradational nature of their selected base of the Morrison inasmuch as the base of the Morrison in the San Rafael Swell was described as an unconformity that is both angular and erosional.

In describing the Moab area, Baker (1933, p. 51) wrote: "The top of the Summerville is placed at the base of the first ledge of white sandstone in the Morrison formation, which was deposited on an uneven surface that may represent an erosional unconformity of more than local extent. The red sandstones and mudstones interbedded with the white sandstone ledges of the lower Morrison are similar to the material forming the body of the Summerville formation, and this apparent unconformity may be of no more significance than several other irregular contacts in the irregularly bedded overlying material. Elsewhere in southeastern Utah * * * this contact is marked by a pronounced unconformity, and it is inferred, therefore, that the unconformity at this horizon in the Moab district is more significant than is indicated by local evidence."

In his discussion of the Salt Valley and adjacent areas, Dane (1935, p. 112) stated: "The contact between the Morrison formation and the underlying Summerville is locally difficult to locate with precision, because of some resemblances in lithology between the formations. In most places it can be ascertained precisely and is a sharp, slightly irregular contact regardless of whether the basal bed of the Morrison is gray limestone, shale, or crossbedded sandstone. Within the area mapped no angular unconformity was observed, and the continuity and slight variation in thickness of the underlying Summerville formation suggest that there was not a significant erosional interval between the periods of deposition of the two formations. Angular unconformity has been reported at this contact in the San Rafael Swell * * *."

In the Thompson area, Stokes (1952, p. 11) found that: "The Morrison-Summerville contact * * * is somewhat gradational and difficult to determine. In general, the sediments involved in the transition zone reflect a gradual change from deposition in shallow, still, or slowly moving water to deposition under changing fluvial conditions which resulted in better sorting and greater lateral variation in sediments. The contact has been drawn where red, shaly, thin-bedded sediments give way upward to predominantly gray or brownish, sandy, lenticular types with distinct cross-bedding and less limestone and chert. Locally, however, sandstones of Morrison lithology cut into

the Summerville and conversely, red Summerville-type rocks occur in the lower part of the Morrison." Stokes (1952, p. 14) further noted, in describing the uppermost part of the San Rafael Group, "* * * slight angular unconformities are found in the San Rafael area (Gilluly and Reeside, 1928, p. 81) * * *."

The puzzling absence of an unconformity near the base of the Salt Wash is due to a misunderstanding of the position of the J–5 unconformity with respect to the Salt Wash Member. The J–5 unconformity in the Moab area, in the Salt Valley and adjacent areas, and in the Thompson area is well below the Salt Wash and is at the base of what was described as Summerville Formation but which is instead the Tidwell Member. The Tidwell is red and, superficially at least, resembles the red Summerville Formation in the San Rafael Swell. The Tidwell is completely gradational with the overlying Salt Wash; no sharp contact separates the two stratigraphic units.

The base of the Morrison Formation has also been placed at a horizon that indicates a change in environment of deposition. Craig and others (1955, p. 134) stated: "The base of the Morrison formation is defined * * * as the base of the terrestrial, fluvial Jurassic deposits overlying beds of the marine or marginal marine San Rafael group." In detail, according to L. C. Craig (written commun., 1980), the basal contact of the Morrison is selected at the lowest indication of terrestrial deposition, a contact that lies at the base of the lowest channel sandstone or lowest limestone or lowest lenticular bed of sandstone, mudstone, or siltstone. In east-central Utah, this contact is beneath the Salt Wash Member and lies 1 m or more above the J–5 unconformity.

PRESENT USAGE

The selection of any horizon but the J–5 unconformity as the base of the Morrison Formation in east-central Utah constitutes a departure from the horizon specified by Gilluly (1929, p. 111–118) when he extended the Morrison into east-central Utah. The base was clearly described in the San Rafael Swell as an unconformity that is both angular and erosional between the Summerville and Morrison Formations.

The base of the Morrison over wide areas has obviously been put by many geologists above the horizon selected by Gilluly (1929). Accordingly, the base of the Morrison is here placed at the unconformity described by Gilluly—now recognized as the J–5—throughout east-central Utah and adjacent parts of western Colorado. Moreover, this returns the base of the Morrison to the unconformity defined by Gilluly (1929, p. 111) as the top of the San Rafael Group. The Salt Wash

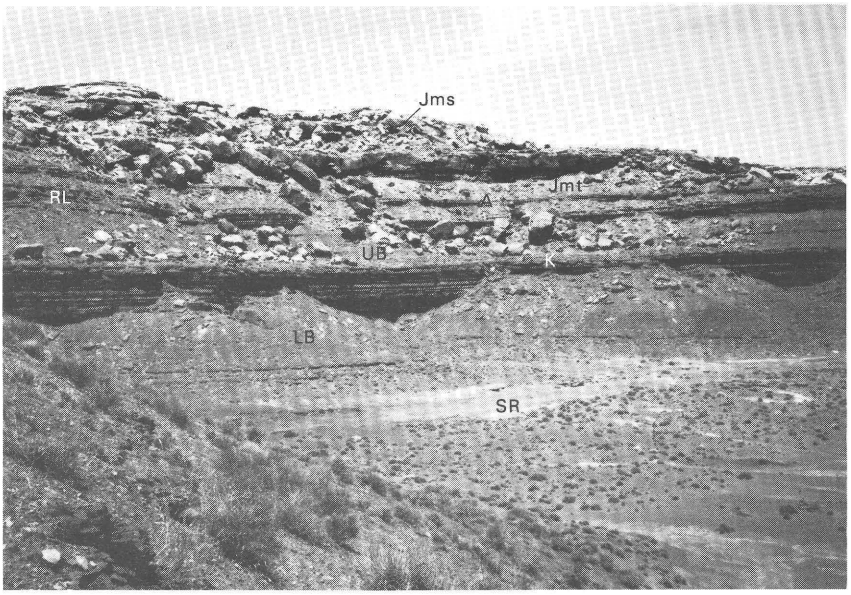

FIGURE 5.—View northward of Jurassic rocks at the section near Duma Point. Top of Slick Rock Member (SR) of Entrada Sandstone; lower Summerville of McKnight (1940) includes lower beds (LB), bed at Black Steer Knoll (K), and upper beds (UB); the basal red ledge (RL) of Summerville Formation. Morrison Formation here includes Tidwell Member (Jmt) and Salt Wash Member (Jms). Tidwell Member is 10.8 m thick. Bed A (A) at base of Tidwell overlies J–5 unconformity. Section is exposed mostly in NW¼ sec. 30, T. 23 S., R. 18 E.

Member as described and defined by Lupton (1914, p. 126) lies above the J–5 unconformity throughout east-central Utah. Strata between the Salt Wash and the base of the Morrison in east-central Utah now make up the Tidwell Member.

A section (fig. 5) near Duma Point is presented in the following to show the lithology and stratigraphic arrangement of units associated with the J–5 unconformity. The section is easily accessible by dirt road and lies about 2.3 km south of the locality on White Wash where Lupton (1914, p. 126) measured what is commonly regarded as the type section of the Salt Wash Member. Strata at the Duma Point section include in ascending order the uppermost part of the Entrada Sandstone, the lower Summerville of McKnight (1940), the Summerville Formation, and the Morrison Formation. The correlation of the various stratigraphic units to the east and west of the Duma Point section is shown in a report by O'Sullivan (1980a).

Duma Point Section

[Measured in NE¼NE¼SW¼ and SE¼SE¼NW¼ sec. 30, T. 23 S., R. 18 E.]

	Thickness in meters
Morrison Formation:	
Salt Wash Member:	
Sandstone, gray, crossbedded; forms a cliff; only basal part of Salt Wash measured	4.6+
Incomplete thickness of Salt Wash Member	4.6+
Tidwell Member:	
Siltstone and shale; reddish-brown in lower 3 m, upper part is bluish gray; 0.3-m white sandstone makes a ledge 3.6 m above base of unit; limestone nodules and small bits of chert and gray limestone litter surface; forms a slope	8.8
Sandstone, brown, flat to slightly wavy and thinly bedded; coarse grains as much as 2.4 mm across; minor interbedded reddish-brown siltstone; forms a conspicuous ledge. This sandstone is bed A	2.0
Total thickness of Tidwell Member	10.8
J–5 unconformity.	
Summerville Formation:	
Siltstone, reddish-brown; poorly exposed in a slope	4.6
Red ledge:	
Sandstone and interbedded siltstone, reddish-brown; makes a conspicuous ledge-forming marker bed in White Wash–Dubinky well area	3.0
Total thickness of Summerville Formation	7.6
Lower Summerville of McKnight (1940):	
Upper beds:	
Siltstone, reddish-brown; 0.4-m reddish-tan sandstone 3 m above base of unit makes a ledge and contains rounded medium grains less than 0.4 mm across; upper 8 m of unit contains at least three thin reddish-tan sandstone beds that form ledges; unit mostly forms a poorly exposed slope	12.5
Total thickness of upper beds	12.5
Bed at Black Steer Knoll:	
Sandstone, reddish-brown, flatbedded; forms a ledge	.8
Siltstone, reddish-brown; forms a re-entrant	.3
Sandstone, reddish-tan, flatbedded; forms a conspicuous ledge	.7
Total thickness of bed at Black Steer Knoll	1.8
Lower beds:	
Sandstone, silty, reddish-brown mottled gray, evenly bedded; in eight or nine beds; four very thin reddish-brown clay beds at 2.6, 3.6, 4.0, and 5.2 m above base of unit; forms a slope	5.5
Siltstone, reddish-brown mottled gray; 0.1-m light-greenish-gray sandstone 1.1 m above base of unit; thin purple clay bed 3.2 m above base of unit, another thin purple clay bed at top of unit; on vertical cliffs unit weathers to rounded spheroidal forms; elsewhere unit forms slope	3.4
Sandstone and siltstone, reddish-brown; interbedded in thin beds less than 0.15 m thick; four thin purple clay beds at base and at 0.24, 1.5, and 1.7 m above base of unit; forms a slope	2.4

	Thickness in meters
Lower Summerville of McKnight (1940)—Continued	
Lower beds—Continued	
Sandstone, reddish-tan mottled gray; contains dark reddish-brown clay galls; forms ledge	.2
Siltstone, reddish-brown; six thin reddish-brown or purple clay beds at 0.06, 0.3, 0.4, 0.5, 0.9, and 1.1 m above base of unit, thin reddish-brown clay at top of unit; forms slope	1.3
Sandstone, reddish-brown, irregularly to flatbedded; thin reddish-brown siltstone bed in middle of unit contains a very thin reddish-brown clay bed; forms a slight ledge	.3
Siltstone, reddish-brown; thin reddish-brown clay 0.2 m above base of unit; forms a slope	.6
Sandstone, reddish-brown, streaked white, flatbedded; forms ledge	.2
Siltstone, reddish-brown; contains a few thin reddish-brown locally mottled gray sandstone beds; thin reddish-brown clay at base, three other thin reddish-brown or purple clay beds at 0.15, 1.9, and 2.3 m above base of unit; forms slope	2.5
Sandstone, brown, flatbedded; slightly overhangs underlying Entrada Sandstone, weathers unevenly; forms thin reworked zone at base of lower beds	.2
Total thickness of lower beds	16.6
Total thickness of lower Summerville of McKnight (1940)	30.9
Entrada Sandstone:	
Slick Rock Member:	
Sandstone, reddish-brown, flatbedded	2.6
Sandstone, reddish-tan, crossbedded	3.5
Sandstone, reddish-tan, flatbedded	1.6
Sandstone, gray, crossbedded	1.0
Sandstone, reddish-tan, flatbedded	2.1
Sandstone, reddish-tan, crossbedded	1.1
Sandstone, reddish-tan, flatbedded	.9
Sandstone, reddish-tan, crossbedded	.8
Sandstone, reddish-tan, flatbedded	.7
Sandstone, reddish-brown, flatbedded	3.0+
Base of measured section. Base of Entrada Sandstone not exposed in area where section was measured.	
Incomplete thickness of Slick Rock Member of Entrada Sandstone	17.3+

In the Duma Point area, strata that form the Tidwell Member have been recognized previously as beds that are younger than the San Rafael Group. The area was investigated in the summer of 1940 by Baker and others (1952) not long after the work by Gilluly and Reeside (1928). The report was not published until 1952 because of World War II. In describing the base of the Morrison in the Duma Point area, they (Baker and others, 1952, p. 81) noted, "* * * typical red beds of the Summerville are overlain by gray and lavender shale and mudstone, thin beds of sandstone, and some blue-gray limestone, and these in turn are overlain by the Salt Wash sandstone member * * *." The description of the beds between the Summerville and the Salt Wash aptly applies to the Tidwell Member. Later, however,

Baker and others (1952, p. 81) described these strata as follows, "* * * the basal unit of the Salt Wash sandstone member of the Morrison consists of 35 feet of gray to variegated shale and mudstone containing many thin beds of sandstone and some nodular limestone. These are overlain by highly lenticular sandstone beds 30 feet or more thick, interbedded with shale and mudstone." The inclusion of these beds as a "basal unit" of the Salt Wash in the Duma Point area constitutes a change of the Salt Wash as designated by Lupton (1914) in the same area. A comparison of a measured section by Baker and others (1952, pl. 3) with sections measured by O'Sullivan (1980a) in the same Duma Point area show that the basal contact of the Morrison Formation as used by Baker and others coincides with the J–5 unconformity or nearly so.

The Tidwell Member is found over wide areas of Utah and Colorado. It has been traced from the San Rafael Swell eastward to Bridgeport and Uravan in western Colorado. South and southwest of the Swell, the Tidwell is recognized in the Kaiparowits Plateau and Henry Mountains area (Peterson, 1980, fig. 4). In southeastern Utah between Monticello and Bluff, the Tidwell is replaced laterally by the Bluff Sandstone Member of the Morrison. Near Glenwood Springs in western Colorado, the overlying Salt Wash Member wedges out and the Tidwell merges eastward with an undivided Morrison Formation.

The J–5 unconformity forms a consistent and widespread base of the Morrison Formation. At some places the J–5 is angular on underlying rocks. Generally, the beds above and below the unconformity are parallel or nearly so and the J–5 unconformity shows only slight relief. Regionally, however, the unconformity bevels progressively across older rocks from the San Rafael Swell eastward into Colorado. Along the Gunnison River east of Black Canyon, the Morrison Formation rests on Precambrian rocks (Hedlund and Olson, 1973); Jurassic strata beneath the surface of unconformity are absent. The specific stratigraphic position of the J–5 at many localities in eastern Utah and western Colorado is shown in reports cited in following text.

The J–5 unconformity is recognized over large areas of Utah and adjacent States. It has been traced from the San Rafael Swell through the Moab area to Bluff (O'Sullivan and Pierce, 1983). It is recognized from the Moab area southeastward to Slick Rock, Colo. (O'Sullivan, 1981a). The J–5 unconformity has been traced from the Moab area to Dewey Bridge (O'Sullivan, 1981b). From Dewey Bridge, the J–5 has been followed around the Uncompahgre Plateau through the Grand Junction area to Bridgeport, Colo. (O'Sullivan and Pipiringos, 1983), and from Dewey Bridge to Uravan (O'Sullivan, 1984). In northwestern New Mexico, a regionally extensive disconformity has been identified by R. D. Lupe (U.S. Geological Survey, 1980, p. 48) at

the base of the Morrison throughout the subsurface of the San Juan Basin. This surface, which "* * * likely corresponds to the J–5 unconformity * * *" (Lupe, 1983), forms an important datum and has been traced westward in the subsurface to near Bluff, Utah. At Bluff, the datum used by R. D. Lupe does indeed coincide with the J–5 unconformity traced into that area from the north (O'Sullivan, 1980b). Consequently, the unconformity recognized by Lupe in New Mexico enlarges the areal extent of the surface beyond Utah and Colorado.

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