Age and Correlation of Cretaceous Rocks Previously Assigned to the Morrison (?) Formation, Sanpete-Sevier Valley Area, Central Utah

U.S. GEOLOGICAL SURVEY BULLETIN 1584

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By IRVING J. WITKIND, LARRY A. STANDLEE,
and KEVIN F. MALEY

In central Utah, rocks previously assigned to
the qualified Morrison (?) Formation of Late
Jurrassic age are now believed to be part to
the Cedar Mountain Formation of Early Cretaceous age

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Age and Correlation of Cretaceous Rocks Previously Assigned to the Morrison(?) Formation, Sanpete-Sevier Valley Area, Central Utah

By Irving J. Witkind,[1] Larry A. Standlee,[2] *and* Kevin F. Maley[3]

Abstract

Beds of conglomerate, sandstone, mudstone, and freshwater limestone exposed in the Sanpete-Sevier Valley area of central Utah have been assigned, in the past, to the qualified Morrison(?) Formation, of Late Jurassic age. In our view these beds are neither part of the Morrison Formation nor of Jurassic age. We divide these beds into an upper unit that consists primarily of beds of reddish-brown coarse conglomerate, and a lower unit that consists of variegated mudstone containing interleaved thin beds of limestone, sandstone, and conglomerate. The two units intertongue. Diagnostic plant microfossils of Early Cretaceous age have been recovered from our upper unit, and bivalves, also of Early Cretaceous age, have been found in our lower unit. In addition, well-rounded, polished stones, considered by some geologists to be gastroliths, indicative of the Lower Cretaceous Cedar Mountain Formation, are plentiful in the lower unit. Our lower unit is lithologically much like the upper member of the Cedar Mountain Formation as exposed in the San Rafael Swell to the east. We believe that our upper and lower units are Early Cretaceous in age. We are uncertain about the correlation of the conglomerate beds that form our upper unit; they may be a newly recognized lithofacies at the top of the Cedar Mountain Formation, a conglomeratic facies of the undivided Indianola Group, or in part Cedar Mountain and in part Indianola Group. We do not assign a formal name to this upper unit. We believe that our lower unit is correlative with the upper member of the Cedar Mountain Formation, exposed elsewhere on the Colorado Plateaus. Consequently, we propose that in the Sanpete-Sevier Valley area, the strata composing our lower unit henceforth be assigned to the Lower Cretaceous Cedar Mountain Formation.

INTRODUCTION

Two of the more troublesome stratigraphic problems in the Sanpete-Sevier Valley area of central Utah (fig. 1) are the age and correlation of a series of sedimentary beds that have been assigned, in the past, to the Jurassic Morrison(?) Formation. Despite the fact that each of us interprets the structural history of this sector of central Utah in different ways, we are in firm agreement that the beds in question are neither Jurassic in age nor part of the Morrison Formation. On the basis of evidence presented in this paper we believe the beds are of Early Cretaceous age and that some of them are correlative with the upper member of the Cedar Mountain Formation of the San Rafael Swell, Utah.

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PREVIOUS WORK

E. M. Spieker, originally with the U.S. Geological Survey and later a member of the faculty at Ohio State University, was among the early workers in central Utah. During his early studies in and near the Wasatch Plateau (Spieker and Reeside, 1926; Spieker, 1931), Spieker identified a series of "variegated shales, sandstones, and conglomerates" as being "possibly Morrison" (1946, p. 125). Subsequently, as a result of additional field work, Spieker decided that these beds were indeed Morrison. He was influenced by the fact that these strata were lithologically much like the Morrison strata exposed to the east in the San Rafael Swell and, moreover, were in the stratigraphic position commonly occupied by the Morrison Formation. As his field mapping progressed and his work extended westward into the Sanpete-Sevier Valley sector of central Utah, he became less certain about his identification. Two factors disturbed him: First, some units in these Morrison strata are lithologically like units in the overlying undivided Indianola Group of earliest Late Cretaceous age. And second, he became concerned about the gradational relations between the Morrison and the Indianola strata; the units apparently intertongue. Seemingly the entire Early Cretaceous sequence was missing. Despite a diligent search, Spieker and his colleagues failed to find an unconformity at the top of the presumed Morrison Formation. He was also unable to find any fossils that might help resolve the dilemma. Thus, in spite of some cogent reasons for retaining the unqualified Morrison assignment, Spieker (1946, p. 126) decided:

> Review of the evidence leads to no satisfactory conclusion, * * * it seems best to designate the beds by the qualified term Morrison(?).

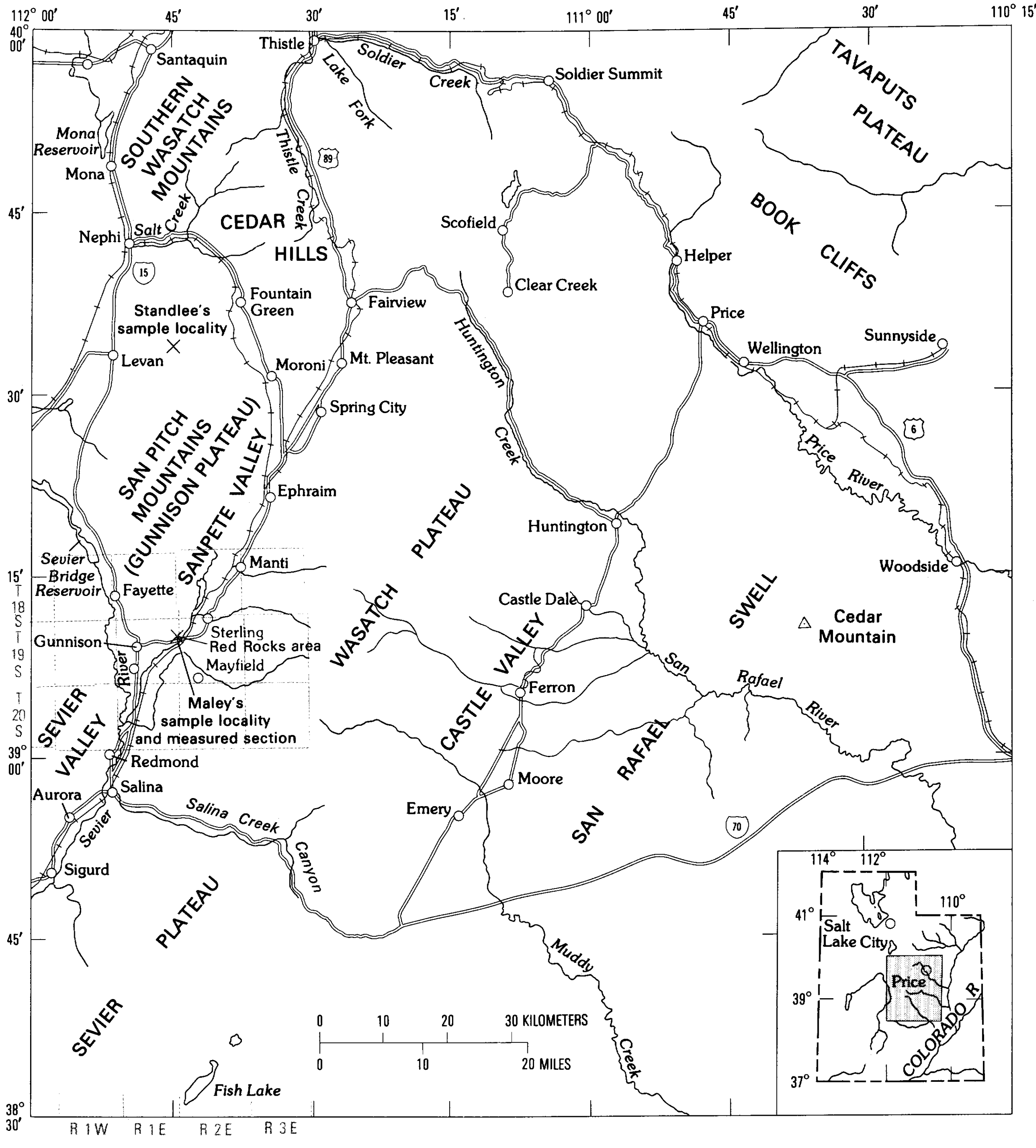

Figure 1. Map of central Utah showing geographic features mentioned in text, sample localities (X), and location of measured section.

Stokes (1944, p. 965–966) was the first to recognize that the beds originally grouped as Morrison Formation on the San Rafael Swell included units of both Late Jurassic and Early Cretaceous age (table 1). He assigned the Upper Jurassic beds to the Morrison Formation, and divided the Lower Cretaceous beds into an upper "Cedar Mountain shale" and a lower "Buckhorn conglomerate." Subsequently both units were combined to form the Cedar Mountain Formation (Hale and Van De Graff, 1964). Stokes (1972, p. 26) inferred that the Morrison Formation of the San Rafael Swell pinched out to the west beneath the Wasatch Plateau, and that the Lower Cretaceous upper "shale" member of the Cedar Mountain Formation persisted westward beyond the Wasatch Plateau into the Sanpete-Sevier Valley area.

In the intervening years subsequent workers, also unable to establish firmly the age and correlation of the qualified Morrison(?) beds in the Sanpete-Sevier Valley

Table 1. History-of-usage chart; correlation not implied. Stokes (1944) was the first to recognize that Spieker's qualified Morrison(?) Formation (1931, 1946) contained units of both Jurassic and Cretaceous age. The Buckhorn Conglomerate Member is confined essentially to the San Rafael Swell. We believe that the Morrison Formation pinches out west of the San Rafael Swell, and that the upper unit of this paper pinches out east of the Sanpete-Sevier Valley area. Both pinchouts are concealed beneath the Wasatch Plateau. We are uncertain about the age of the Twist Gulch Formation. In central Utah, the Twist Gulch appears to grade into the overlying Cedar Mountain Formation of Early Cretaceous age. We infer, thus, that the Twist Gulch, although dated as Middle Jurassic, may extend into the Late Jurassic. We know of no fossil evidence, however, to support this younger age, and so show a hiatus between the Twist Gulch and Cedar Mountain Formations

		Witkind and Maley interpretation (This paper)	Standlee interpretation (This paper)		Hale and Van De Graff (1964)		Stokes (1944)	Spieker (1946)
		Central Utah	Central Utah		San Rafael Swell		San Rafael Swell	San Rafael Swell and central Utah
CRETACEOUS	Upper Cretaceous	Indianola Group, undivided (Includes upper unit of this paper)	Indianola Group undivided		Tununk Shale (Mancos Shale)		Mancos Shale	Mancos Shale
					Dakota Sandstone		Dakota Sandstone	Dakota Sandstone
	Lower Cretaceous		Upper unit of this paper	Cedar Mountain Formation		Cedar Mountain Formation	Cedar Mountain Shale	Morrison (?) Formation
		Cedar Mountain Formation (Consists of lower unit of this paper)	Lower unit of this paper					
					Buckhorn Conglomerate Member		Buckhorn Conglomerate	
JURASSIC	Upper Jurassic				Morrison Formation		Morrison Formation	
		?	?					
	Middle Jurassic	Twist Gulch Formation	Twist Gulch Formation		Summerville Formation			
					Curtis Formation			
					Entrada Formation			

area, have continued to refer to them as "Morrison(?)," and to assign them either to the Late Jurassic (Witkind, 1983, p. 47) or Early Cretaceous (Stuecheli and Collinson, 1984). We suspect that this hesitancy in accepting Stokes' views reflects the fact that Stokes, although he found a few dinosaur bones, was unable to find age-specific index fossils within Cedar Mountain strata (1944, p. 967).

STRATIGRAPHIC RELATIONS

Lithology

Spieker (1949, p. 18) recognized four distinct lithologies in the units he assigned to the Morrison(?) Formation: conglomerate, sandstone, shale (we believe these "shale" beds are best described as variegated calcareous mudstone), and freshwater limestone. Only rarely are all these lithologies represented in any one exposure. In places, as along the west flank of the San Pitch Mountains—known to geologists as the Gunnison Plateau (fig. 1)—the Morrison(?) strata consist chiefly of coarse conglomerates (Spieker, 1946, p. 18), but also include, according to Standlee (1982, p. 367), "thin-grey-green shale beds interbedded with red shales, [and] sandstones * * * ." Elsewhere, as in the Red Rocks area (near Sterling, at the southeast corner of the Gunnison Plateau, fig. 1), where the Morrison(?) is perhaps best exposed, the beds consist of variegated calcareous mudstone rich in light-gray limestone nodules (commonly about 5–8 cm (2–3 in) in diameter), with interleaved thin beds of freshwater light-gray limestone, light-brown sandstone, and reddish-brown conglomerate. The variegated mudstone beds are conformably overlain by, and interfinger with, a thick sequence of coarsely conglomeratic reddish-brown beds.

Spieker (1949, p. 18) tentatively assigned all these units to the Morrison(?) Formation. He noted:

Elsewhere [the Morrison(?) Formation] seems to be thinner, excepting possibly the southeastern part of the Gunnison Plateau [the Red Rocks area], where a problematic section of red conglomerates and variegated beds about 1,800 feet thick is tentatively assigned to the formation.

To facilitate our discussion we divide the above sequence of beds into two informal units—a lower unit composed of the variegated mudstone with intercalated thin beds of freshwater limestone, sandstone, and conglomerate, and an upper unit composed primarily of the coarse conglomerate beds. Figure 2 shows the general appearance of the units. Appendix A gives a measured section of strata of the lower and upper units, formerly called Morrison(?), that are exposed in the Red Rocks area.

Lower unit

Where exposed in the Sanpete-Sevier Valley area the lower unit consists of variegated calcareous mudstone beds that contain variable amounts of conglomerate, sandstone, and limestone nodules. The limestone nodules appear to be characteristic; in places where Morrison(?) strata are concealed beneath detritus, the strata are identified on the basis of a profusion of these nodules in the float. In the Red Rocks area a thin bed of aphanic light-gray limestone is interlayered in the mudstone sequence.

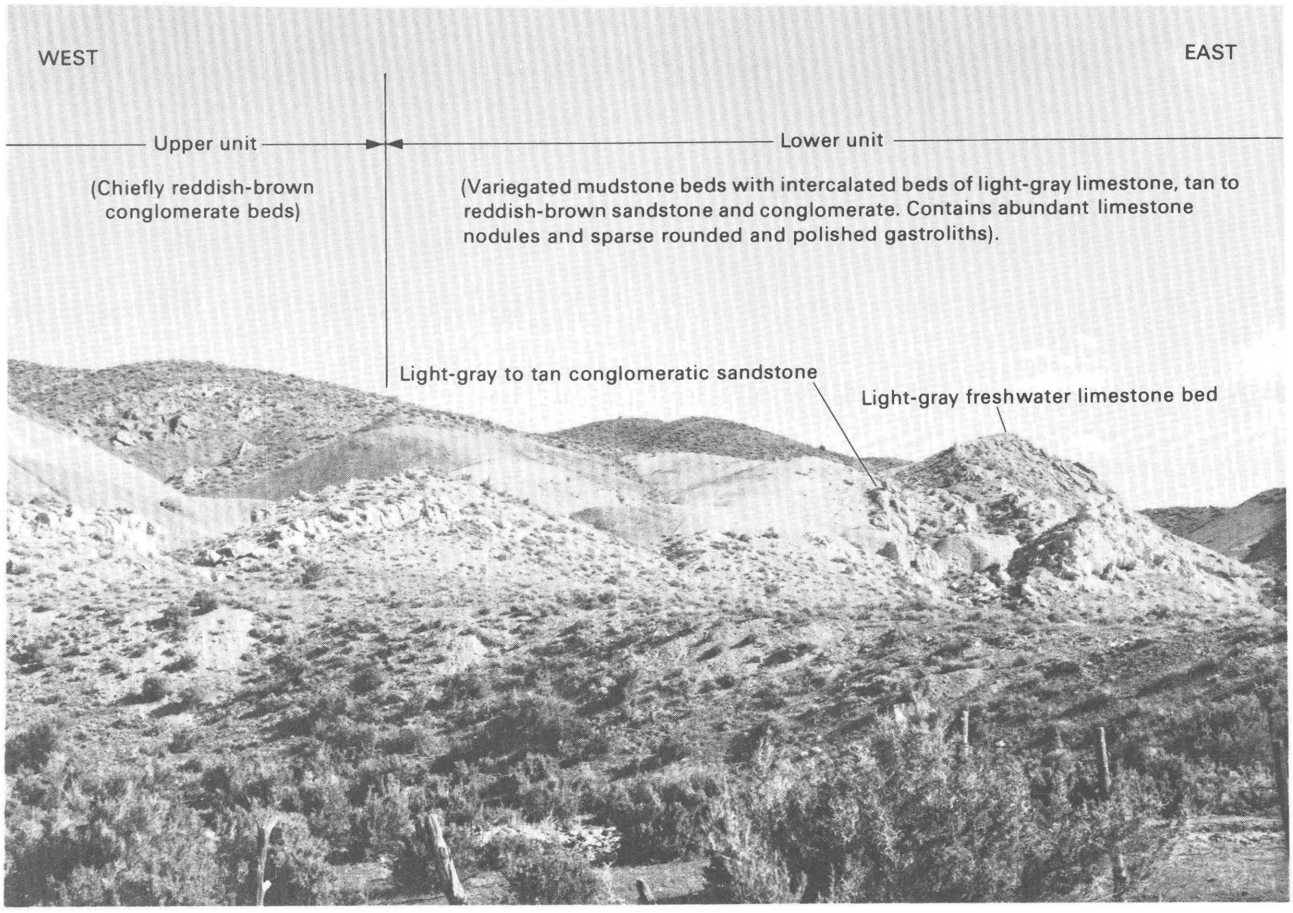

Figure 2. View northward of lower and upper units (formerly called Morrison(?) Formation) as exposed in the Red Rocks area, southeast flank of the Gunnison Plateau, near Sterling, Utah. Strata range in attitude from vertical to overturned to the west.

Upper unit

Our upper unit is indistinguishable lithologically from conglomerate beds that belong to the Indianola Group (Spieker, 1946, p. 125). We suspect that our upper unit, on the basis of its lithology and stratigraphic position, is either part of the Indianola Group, part of the Cedar Mountain Formation, or part of both. Although we are uncertain about its correlation, we are certain that it is not part of the Upper Jurassic Morrison Formation of the Colorado Plateaus.

In the Red Rocks area, the conglomerate beds that form our upper unit locally have been folded into a tight isoclinal syncline. These conglomerate beds are conformably overlain, in the axial part of the syncline, by a thin light-brown sandstone bed. Two factors favor assigning these conglomerate beds to the Lower Cretaceous Cedar Mountain Formation (Spieker's qualified Morrison(?) Formation): They contain fossils of Early Cretaceous age (page 6 and table 2), and the thin, light-brown sandstone bed that rests on them is lithologically much like beds of the Sanpete Formation, the basal unit of the overlying Indianola Group (where the group can be differentiated farther to the east near the mouth of Sixmile Canyon, fig. 1). In this interpretation, then, the conglomerate beds could be considered as a newly recognized lithology of the Cedar Mountain Formation. Craig (1981) has shown that the Cedar Mountain Formation thickens to the northwest across the San Rafael Swell, and that sediment transport was generally from the west. This suggests that in Early Cretaceous time our study area was near the Sevier orogenic highlands in west-central Utah; thus, the coarse conglomerate beds of our upper unit may be contemporaneous in part with the upper shale member of the Cedar Mountain Formation to the east. Co-author Standlee favors this interpretation.

Another interpretation, favored by co-authors Witkind and Maley, suggests that the conglomerate beds, rather than being restricted to the Cedar Mountain Formation, are part of the overlying undivided Indianola Group. Several factors favor this interpretation: the conglomerates are lithologically similar to conglomerates in the overlying Indianola Group; and some of the shales within the conglomerate beds of our upper unit (table 2) contain fossils that range up into the Late Cretaceous. Late Cretaceous is the accepted age of the Indianola Group. Moreover, the conglomerate beds clearly represent a drastic change in stream regimen, and thus are best viewed as synorogenic deposits derived from newly formed mountains to the west—the generally accepted origin of the Indianola Group (Spieker, 1946; Harris, 1959; Armstrong, 1968; Lawton, 1982).

The fluvial deposits that compose the Cedar Mountain Formation seemingly were derived from source areas not far west of the Sanpete-Sevier Valley area. Stokes (oral commun., 1984) interprets the Buckhorn Conglomerate Member of the Cedar Mountain Formation, as exposed in the San Rafael Swell, to be local flash-flood deposits that were spread eastward across terrain of low relief. After deposition of the Buckhorn Conglomerate Member, eastward-flowing streams, heading in the newly formed uplands west of the Sanpete-Sevier Valley area, deposited the mudstone beds that now form the upper member of the Cedar Mountain Formation. Rejuvenation of those streams, presumably as a result of the growth of thrust-related mountains, resulted in deposition of the eastward-pointing wedge of conglomerate that forms our upper unit.

Unable to determine whether these conglomerate beds of our upper unit are Cedar Mountain or part of the undivided Indianola, we have agreed to disagree pending further work. Co-author Standlee, influenced by the Early Cretaceous age assigned to the taxa contained within the conglomerate beds, proposes that these beds be considered a new—and the uppermost—lithologic unit of the Cedar Mountain Formation. Co-authors Witkind and Maley propose that our upper unit be provisionally assigned to the undivided Indianola Group. They are strongly influenced by the fact that the change from mudstone to conglomerate is distinct and easily recognized and thus forms an excellent contact for mapping purposes. Inherent in this interpretation is a change of age for the Indianola Group from "Late Cretaceous" to "Early and Late Cretaceous" in the Sanpete-Sevier Valley area.

Other Exposures

In Lake Fork, near Thistle, Spieker's Morrison(?) strata appear as thick beds of light-gray and reddish-brown mudstone that contain limestone nodules and thin beds of sandstone and conglomerate. These beds, possibly correlative with our lower unit, are overlain by reddish-brown, fine- to medium-grained beds of quartzose sandstone that intertongue with the light-gray sandstone beds of the Sanpete Formation of the Indianola Group. These reddish-brown sandstone beds may be correlative with our upper unit.

In the Cedar Hills, co-author Witkind, unable to distinguish Morrison(?) conglomerate beds from other similar conglomerate beds assigned to the Indianola, grouped all conglomerate beds as part of the undivided Indianola Group. He included in the Morrison(?) Formation only the pink and variegated calcareous mudstone beds that contain abundant light-gray limestone nodules.

In the northern part of the Gunnison Plateau, early workers, such as Hunt (1950), seemingly included the mudstone beds (our lower unit) with the Middle Jurassic Twist Gulch Formation, and the overlying conglomerate beds (our upper unit) with the Upper Cretaceous Indianola Group.

Thickness

Spieker (1949, p. 18) indicated that the Morrison(?) is about 550 m (1,800 ft) thick east of Thistle (in Lake Fork), of equal thickness in the southeastern part of the Gunnison Plateau, and about 400 m (1,300 ft) thick in Salina Creek Canyon (east of Salina). Co-author Witkind believes that the Morrison(?) Formation is about 245 m (800 ft) thick along the Middle Fork of Pole Creek (in the Cedar Hills). Co-author Maley has measured a thickness of 368 m (1,206 ft) of Spieker's Morrison(?) strata in the Red Rocks area (appendix A). Although our thicknesses differ from Spieker's, these differences may reflect our differing interpretations of which units should be included in the Morrison(?) Formation.

Contact relations

Throughout the Sanpete-Sevier Valley area all units grade into one another or intertongue. In the Red Rocks area the variegated mudstone beds of our lower unit intertongue with the overlying conglomerate beds of our upper unit. In the Gunnison Plateau the conglomerate beds of our upper unit are lithologically like and to us indistinguishable from the conglomerate beds of the overlying Indianola Group. Thus, we concur with Spieker (1949, p. 19) that these Morrison(?) strata grade into and apparently intertongue with both the overlying beds of the Indianola Group and the underlying beds of the "Arapien shale". (Spieker originally divided the Arapien Shale into two members, a Twist Gulch Member at the top and a Twelvemile Canyon Member at the base. Since Spieker's work, the Twist Gulch has been raised to formational rank and the term Twelvemile Canyon Member abandoned and replaced by the term Arapien Shale (Witkind and Hardy, 1983). The lower intertonguing referred to by Spieker, therefore, involves our lower unit and the Twist Gulch Formation).

CURRENT STUDIES

In 1980, W. L. Stokes visited the Red Rocks area and examined the sequence of Morrison(?) beds that makes up our lower unit. He reiterated his views that these specific beds were most likely correlative with the upper "shale" member of the Lower Cretaceous Cedar Mountain Formation. His identification was based on: (1) gross lithologic similarities with units in the upper member of the Cedar Mountain Formation exposed to the east in the San Rafael Swell, (2) the abundant limestone nodules, and (3) most significantly, the presence in these beds of distinctive well-rounded and polished stones which are probably gastroliths. Stokes (oral commun., 1980) suggested that these distinctive stones could serve as "index fossils" for Cedar Mountain strata.

Paleontologic data

Although Stokes was firm in his identification of the beds, we, along with others, have hesitated to accept his views pending supporting paleontologic evidence. We believe that we now have some evidence to support Stokes' identification of our lower unit as part of the Cedar Mountain Formation.

Co-author Maley extensively sampled both our lower and upper units in the Red Rocks area for microfossils (fig. 1). Palynologist Gerald Waanders of Waanders Palynology Consulting, Inc., San Marcos, California identified and assigned ages to the forms listed in tables 2 and 3. Palynologist R. H. Tschudy of the U.S. Geological Survey reviewed the fossil lists.

Most of the plant microfossils found in both units (tables 2 and 3) are long ranging; their assigned ages range from Jurassic to Cretaceous. Tschudy, who has just completed a comprehensive study of the Cedar Mountain and Burro Canyon Formations, reports (oral commun., 1984) that of the palynomorphs that came from our lower unit (table 2), none are diagnostic of an Early Cretaceous age. On the other hand, Tschudy notes (oral commun., 1984) that three of the plant microfossils found in mudstone and black shale lenses interleaved in the coarse conglomerate beds that make up our upper unit (table 3) are indeed indicative of an Early Cretaceous age. Two forms, attributed by Waanders to *Concavissimisporites punctatus* and *Pilosisporites trichopapillosus*, range from Barremian to Aptian-Albian. In addition, Tschudy suggests that the microfossil identified by Waanders as *Costatoperforosporites foveolatus* is also diagnostic of the Early Cretaceous, and assigns this form an Aptian-Albian Age.

Co-author Standlee sampled mudstone lenses intercalated in conglomerate beds exposed along the northwest flank of the Gunnison Plateau (fig. 1); they contained non-marine palynomorphs of late Albian age (Standlee, 1982, p. 367). We believe that these conglomerate beds are correlative, in part, with the coarse conglomerate beds that make up our upper unit.

Thus, our samples reveal that our upper unit contains plant microfossils unquestionably of Early Cretaceous age; diagnostic microfossils have not been found, as yet, in our lower unit.

Although we have been unable to use plant microfossils to demonstrate an unequivocal Early Cretaceous age for our lower unit, some macrofossils found in Morrison(?) strata in the Red Rocks area do indicate that these strata are of that age. Bivalves, collected by P. J. Stuecheli, a graduate student at Ohio State University, were identified and dated by J. H. Hanley of the U.S. Geological Survey. Stuecheli (1984, p. 71) reports that:

> Bivalve specimens * * * collected * * * about 10 m below the lowest of the major coarse conglomerate beds * * * have been identified as belonging to the freshwater Genus

PROTELLIPTIO, a form which ranges from the Barremian (Early Cretaceous) to the early Cenomanian (earliest Late Cretaceous)."

The implication is strong, thus, that our lower unit is no older than Early Cretaceous.

Consequently, we consider that both our units are Early Cretaceous in age. This coincides with the views of Stuecheli and Collinson (1984) who also believe that all Morrison(?) strata (that is, both our lower and upper units) are Early Cretaceous in age. Stuecheli and Collinson, however, retain the qualified term, "Morrison(?)," for these units, while recognizing that the Lower Cretaceous "Morrison(?) Formation" of central Utah is probably unrelated to the Upper Jurassic Morrison Formation of the Colorado Plateaus.

Figure 1 shows our sample localities; tables 2 and 3 contain our paleontologic data. As the site where coauthor Maley collected the microfossils is structurally complex and about 200 meters (600 ft) from his measured section (Appendix A), we are unable to designate, on the measured section, beds that are correlative with those that contained the microfossils. In general, however, the fossiliferous units were in the lower part of our upper unit.

CONCLUSIONS

We cite below the factors that strongly influence us in our belief that our lower unit (of Spieker's Morrison(?) Formation) is correlative with the upper member of the Cedar Mountain Formation of Early Cretaceous age.

The strata that compose our lower unit:

1. Are strikingly similar, lithologically, to units that form the upper member of the Cedar Mountain Formation, as exposed in the San Rafael Swell,
2. Contain distinctive, well-rounded and polished stones, possibly gastroliths—Stokes' "index fossils" of the Cedar Mountain Formation, and
3. Contain macrofossils that range from Barremian to Cenomanian (Steucheli, 1984, p. 71), implying that our lower unit is of Early Cretaceous age.

If the variegated mudstone beds and intercalated units that make up our lower unit are indeed of Early Cretaceous age, many of the stratigraphic problems that so puzzled Spieker (1946, p. 125–126; 1949, p. 18–20) are resolved. Moreover, assigning these beds to the Cedar Mountain Formation rather than the Morrison Formation suggests that Morrison strata pinch out east, rather than west, of the Sanpete-Sevier Valley area, presumably somewhere beneath the Wasatch Plateau, as inferred by Stokes (1972, p. 26) and Standlee (1982, p. 367).

Although we are uncertain about the correlation of the beds of coarse conglomerate that make up our upper unit, we believe, as do Stuecheli and Collinson (1984), that these conglomerate beds are not correlative with the Upper Jurassic Morrison Formation as exposed on the San Rafael Swell to the east. We believe that these conglomerate beds are of Early Cretaceous age, and either are a newly recognized lithologic unit at the top of the

Table 2. Fossil content of samples collected from lower unit (variegated mudstones), Red Rocks area, southwest of Sterling, Utah

[Samples collected by K. F. Maley. Paleontologic determinations by G. Waanders, Waanders Palynology Consulting, Inc., San Marcos, Calif., 92069]

Sample No.	Fossils identified	Abundance	Inferred age of sample	Environment of deposition
1	*Classopollis classoides*......	Rare.....	Jurassic to Early Cretaceous.	Nonmarine.
	?*Eucommiidites minor*.........	...do....	....do.....	Do.
	Exesipollenites tumulus......	...do....	....do.....	Do.
2	*Classopollis classoides*......	Rare.....	Jurassic to Early Cretaceous.	Nonmarine.
3	Undifferentiated bisaccates..	Rare.....	Indeterminate.	Indeterminate.
4	Sample not collected.........			
5	*Classopollis classoides*......	Rare.....	Jurassic to Early Cretaceous.	Nonmarine.
6	*Classopollis classoides*......	Rare.....	Jurassic to Early Cretaceous.	Nonmarine.

Table 3. Fossil content of samples collected from upper unit (conglomerate beds), Red Rocks area, southwest of Sterling, Utah

[Samples collected by K. F. Maley. Paleontologic determinations by G. Waanders, Waanders Palynology Consulting, Inc., San Marcos, Calif., 92069]

Sample No.	Fossils identified	Abundance	Inferred age of sample	Environment of deposition
2c	Apiculatisporis spp.	Rare....	Aptian to early Albian.	Nonmarine.
	Appendicisporites spp..............	...do...	......do......	Do.
	Araucariacites australis...........	...do...	......do......	Do.
	Cicatricosisporites australiensis..	...do...	......do......	Do.
	Cicatricosisporites hallei.........	...do...	......do......	Do.
	Concavissimisporites punctatus.....	...do...	......do......	Do.
	Deltoidospora spp..................	...do...	......do......	Do.
	Gleicheniidites senonicus..........	...do...	......do......	Do.
	Lycopodiumsporites spp.............	...do...	......do......	Do.
	Osmundacidites spp.................	...do...	......do......	Do.
	Pilosisporites trichopapillosus....	...do...	......do......	Do.
	Undulatisporites sp................	...do...	......do......	Do.
3c	Araucariacites australis	Rare....	Probable Aptian to ?early Albian.	Nonmarine.
	Costatoperforosporites foveolatus..	...do...	......do......	Do.
4	Cicatricosisporites venustus.......	Rare....	Early to Late Cretaceous.	Nonmarine.
	Deltoidospora spp..................	...do...	......do......	Do.
	Perotrilites sp....................	...do...	......do......	Do.
	?Sphagnum spp......................	...do...	......do......	Do.
	Triporolites sp....................	...do...	......do......	Do.
4a	Deltoidospora spp..................	Rare....	Indeterminate	Nonmarine.
	?Schizosporis reticulata...........	...do...	......do......	Do.
	?Sphagnum spp......................	...do...	......do......	Do.
7	Deltoidospora spp..................	Rare....	Cretaceous	?Marginal marine.
	Spiniferites ramosus.(Microplankton)	...do...	......do......	Do.
7a	Chomotriletes fragilis.............	Rare....	Indeterminate	Indeterminate.

Cedar Mountain Formation, a conglomeratic facies of the undivided Indianola Group, or in part Cedar Mountain Formation and in part Indianola Group.

The fossils collected from our lower unit indicate that it is no older than Early Cretaceous. Furthermore, all data suggest strongly that our lower unit is correlative with the upper part of the Cedar Mountain Formation. Consequently, we recommend that the strata that form our lower unit, previously assigned to the Upper Jurassic Morrison(?) Formation, henceforth be assigned to the Lower Cretaceous Cedar Mountain Formation.

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Appendix A

Section of Morrison(?) Formation in the Red Rocks area near Sterling, Utah (fig. 1)

[Section extends northwestward from the NW 1/4, sec. 18, T. 19 S., R. 2 E. into the SE 1/4, sec. 12, T. 19 S., R. 1 E. Measured by K. F. Maley]

	Thickness Meters	Thickness Feet
Sanpete(?) Formation, Indianola Group		
Sandstone, tan to yellowish-tan, thin-bedded, fine-grained, quartzose; grains chiefly subangular. Well sorted. Cemented by calcite; friable. Few well-rounded quartzite and limestone cobbles and boulders in basal part	23	75
Morrison(?) Formation		
(Upper unit)		
Conglomerate and conglomeratic sandstone, reddish-brown. Composed chiefly of well-rounded cobbles and boulders of light-tan quartzite, reddish-purple quartzite, and dark-blue limestone. Matrix is reddish-brown, fine- to coarse-grained sandstone and mudstone. Few interleaved thin sandstone lenses. Cemented by limonite and calcite. Forms moderate to steep slopes, thinly veneered with loose well-rounded cobbles and boulders	236	775
Total thickness of upper unit	236	775
Morrison(?) Formation—*Continued*		
(Lower unit)		
Mudstone, light-reddish-brown to reddish-brown, forms smooth rounded slopes	14	45
Conglomerate, reddish-brown. Interbedded thin lens of light reddish-brown shale	2	5
Mudstone, reddish-brown and variegated	9	30
Conglomerate, reddish-brown	2	5
Mudstone, light-reddish-brown to reddish-brown	9	30
Sandstone, light-reddish-brown, thin-bedded, quartzose, fine- to medium-grained	3	10
Mudstone, light-reddish-brown and variegated. Contains small, round, light-gray limestone nodules that also mantle surface	12	40
Shale, sandy, dark-gray to black	2	7
Mudstone, light-reddish-brown and variegated. Forms rounded slope partly covered by scree	53	174
Limestone, light-gray to white, massive, aphanic	20	65
Sandstone, light-tan to white, fine- to very fine grained; well sorted. Cemented by calcite. Cross-bedded. Few thin conglomerate lenses at base	6	20
(Base of section covered by unconsolidated deposits of sand and gravel.)		
Total thickness of lower unit	132	431
Total thickness of exposed Morrison(?) Formation	368	1,206

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