Reinterpretation of type section of Juana Lopez Member of Mancos Shale

Stephen C. Hook and W. A. Cobban

New Mexico Geology, v. 2, n. 2 pp. 17-22, Print ISSN: 0196-948X, Online ISSN: 2837-6420.
https://doi.org/10.58799/NMG-v2n2.17

This page is intentionally left blank to maintain order of facing pages.

New Mexico GEOLOGY
• Science and Service
Volume 2, Number 2, May 1980

Reinterpretation of type section of Juana Lopez Member of Mancos Shale

by Stephen C. Hook, Paleontologist, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM, and William A. Cobban, Paleontologist, U.S. Geological Survey, Denver, CO

The Juana Lopez Member (Upper Cretaceous) of the Mancos Shale (San Juan Basin), Carlile Shale (Denver and Raton Basins) or Benton Shale (North Park Basin) is one of the most distinctive and laterally persistent lithostratigraphic units in New Mexico, Colorado, Utah, and southwestern Kansas. The member contains an abundant late Turonian (middle Cretaceous) invertebrate fauna whose elements have restricted vertical ranges and are widely distributed in time-equivalent rocks throughout the Western Interior of North America (Dane and others, 1966).

On the east side of the San Juan Basin, where Dane and others (1966) established a 107-ft-thick (32.6 m) well-exposed reference section (fig. 1), the Juana Lopez Member ranges in thickness from 90 to 135 ft (27.4 to 41.1 m). Here, and at other localities, the member consists of thin beds of rusty-brown-weathering, highly fossiliferous calcarenite interbedded with dark-gray noncalcareous clay shale. The calcarenites occur as both continuous beds and discontinuous lenses, range from a fraction of an inch to 2 ft (0.6 m) thick, are fine to coarse grained, and are composed of bioclastic debris. This debris generally consists of the fragmented prismatic layer of *Inoceramus* shells. Fragmented remains of fish teeth, bones, and scales are common and led early workers to describe these beds as "fish-tooth conglomerates" or "fish- bone beds." Gray septarian limestone concretions are common in the lower and middle parts of the member. Although shale is the dominant lithology, the hard, platy-weathering calcarenites are more conspicuous in outcrop, often littering the slopes with debris, and generally stand in topographic relief above the softer shales (Dane and others, 1966).

In the subsurface the calcarenites produce a distinctive "kick" (resistive deflection) on electric logs (Lilly, 1952, fig. 2; Bozanic, 1955, pls. 1-3; Lamb, 1968, fig. 5; Molenaar, 1973, p. 94). The top of this resistive zone (referred to by oil-company geologists as Sanostee or Sanastee Member of the Mancos Shale) has long been considered a time-synchronous surface (Dane, 1960; Molenaar, 1973; Campbell, 1979). Microfossil studies by Lamb (1968) and Thompson (1972), however, indicate that this surface may be younger toward the northern edge of the San Juan Basin. Outcrop sections we visited indicate that the top of the Juana Lopez Member lies in a lower faunal zone along the south side of the San Juan Basin than it does along the east side. In the southern San Juan Basin near Hosta Butte, 32 mi (52 km) east of Gallup, the top of the Juana Lopez Member lies in the *Prionocyclus macombi* Zone, whereas on the east side near Cuba, the top lies two zones higher in the *Prionocyclus novimexicanus* Zone.

The distinctive lithologic and faunal nature of the Juana Lopez was first noted by Newberry (1861) near Las Vegas, New Mexico. In a later publication, Newberry (1876, p. 33) presented a detailed measured section of Cretaceous rocks along the Canadian River south of Taylor Springs, New Mexico; it included the Juana Lopez as a distinct lithology characterized as ". . . ferruginous, laminated, sandy limestone . . . [that is] a great store-house of fossils." Newberry (1876, p. 107) also noted that "this ferruginous stratum marks a distinct horizon and may be traced over an immense area in New Mexico." However, Rankin (1944, p. 12, 19, 20) was the first to formally name the unit and identified it (often incorrectly) in a number of measured sections in northern New Mexico and southern Colorado. Rankin (1944, p. 12, 19, 20) applied the name "Juana Lopez sandstone member of the Carlile shale" to 10 ft (3 m) of very calcareous sandstone containing *Prionocyclus wyomingensis* near the top of the Carlile Shale. The type section for this new unit was given as " . . . sec. 32, T. 15 N., R. 7 E., on the Mesita Juana Lopez Grant, six miles northwest of Cerrillos, Santa Fe County, New Mexico" (Rankin, 1944, p. 19).

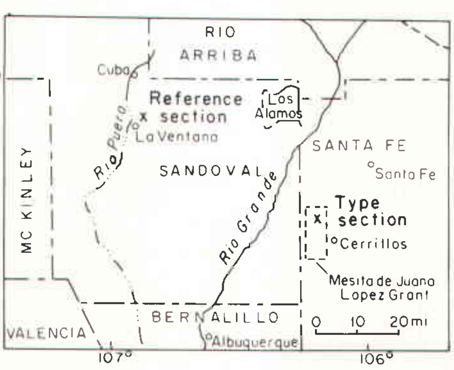

FIGURE 1—LOCATIONS OF THE TYPE AND REFERENCE SECTIONS OF THE JUANA LOPEZ MEMBER OF THE MANCOS SHALE, SANTA FE AND SANDOVAL COUNTIES, NEW MEXICO (modified from Dane and others, 1966, fig. 1).

Kauffman (*in* Dane and others, 1966, p. H6, H7, H13, H14) examined the type section of the Juana Lopez Member in 1963 and concluded that 1) the type section of the member was actually in sec. 33, T. 15 N., R. 7 E.; 2) the thickness of the type section was only 3 ft 10 inches, the remainder of Rankin's estimated 10 ft being composed of baked shale of Niobrara age; 3) the member at the type section was composed predominantly of calcarenite and limestone (hence, the term sandstone was dropped from the member name); 4) the member at the type section was abnormally thin and contained an unusually small percentage of shale compared with sections more than 100 ft (30 m) thick in the San Juan Basin; 5) the member at the type section was succeeded disconformably by rocks equivalent to the basal part of the Niobrara Formation; and 6) the Juana Lopez at the type section was the lithologic and time equivalent of only the upper part of the member at the reference section.

In connection with work on the Juana Lopez Member of the Carlile Shale in the Taylor Springs area of northeast New Mexico, 109 mi (175 km) northeast of the type section (Hook and Cobban, 1980, fig. 6), we visited the type section of the Juana Lopez. After remeasuring the type section of the member in a 1965 railroad cut of the Atchison, Topeka, and Santa Fe Railway Company in NW¼SE¼ sec. 33, T. 15 N., R. 7 E., we suggest modification of all but the first of Kauffman's conclusions. This paper presents our measured type section of the Juana Lopez Member (table 1) and compares this newly remeasured section with the reference section established by Dane and others (1966) on the east side of the San Juan Basin.

Lithology and thickness

A 1965 railroad cut of the Atchison, Topeka, and Santa Fe Railway Company exposes not only the entire type section of the

Juana Lopez Member of the Mancos Shale, but also several hundred feet of Mancos Shale both above and below this member (fig. 2). Two points are readily apparent from a cursory examination of this cut. First, the ledge-forming calcarenites in the upper part of the member (fig. 3) are approximately 10 ft (3 m) thick and therefore closely match Rankin's (1944, p. 20) original estimate. In fact, these upper beds are probably all Rankin intended to include in his definition, although he shows the Juana Lopez to be 50 ft thick on his graphic section no. 6 (Rankin, 1944, fig. 5). Second, the basal calcarenites, although thin and rather inconspicuous on the south side of the cut (fig 2), are well exposed on the north side (fig. 4) and can be traced laterally (to the south) in outcrop. These basal calcarenites also carry the *Lopha lugubris–Prionocyclus macombi* fauna characteristic of the lower Juana Lopez in the San Juan Basin and are separated from the upper, ledge-forming beds by approximately 90 ft (27 m) of shale. Hook measured the Juana Lopez in this railroad cut on July 16–18, 1979 (table 1) and obtained a thickness of 106 ft (32.3 m). This measured thickness is almost identical to that obtained by Dane and others (1966, p. H10–H12) for the reference section (fig. 5). The Juana Lopez was measured at the type locality by the Jacob's staff method (Kottlowski, 1965, p. 61–75). The thickness obtained is thought to be accurate to within 10 percent of true thickness. Several factors other than those listed by Kottlowski (1965, p. 122) may contribute some error. First, a reliable dip and strike measurement could be obtained only on the uppermost calcarenites (fig. 3); this measurement was then used to measure the thickness of the entire member. Second, several minor faults with displacements of less than 5 ft (1.5 m) cut the member; in unit 19 (table 1) it was impossible to offset on a key bed to avoid one of these faults. Third, at least two igneous dikes, which weather to small chips and are covered by shale talus, cut unit 31 (table 1).

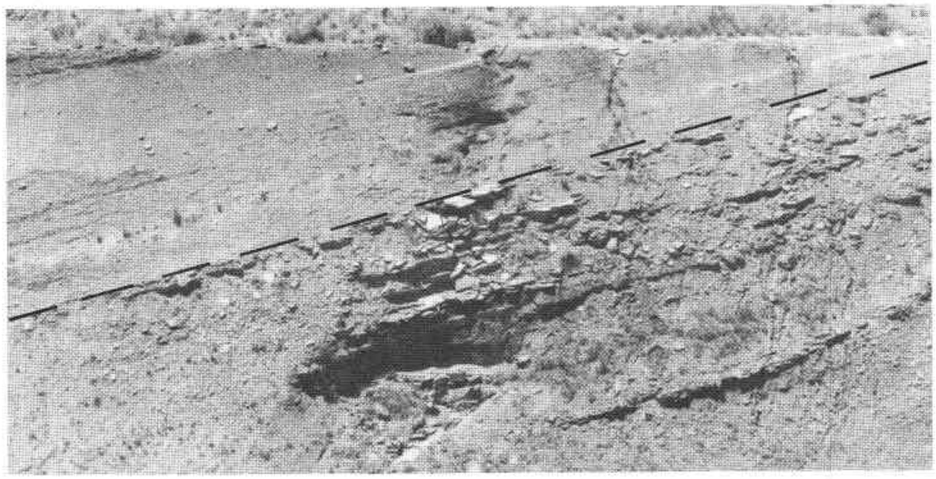

FIGURE 3—CLOSE-UP VIEW OF FIG. 2 SHOWING UPPER LEDGE-FORMING CALCARENITE UNIT OF JUANA LOPEZ MEMBER. Upper contact of Juana Lopez Member shown as dashed line; 5-ft-long (1.5 m) Jacob's staff for scale.

The Juana Lopez Member at its type section can be subdivided into three informal units similar in lithology and thickness to those at the reference section: a lower calcarenite unit with interbedded shales, approximately 10 ft (3 m) thick; a middle shale unit with scattered lenses of calcarenite that hosts septarian limestone concretions, approximately 81 ft (24.7 m) thick; and an upper calcarenite unit with interbedded shales, approximately 15 ft (4.5 m) thick. These same informal subdivisions at the reference section are approximately 11 ft (3.3 m), 83 ft (25.3 m), and 12 ft (3.7 m) thick (fig. 5).

The calcarenites are hard, brittle, thin-bedded, platy-weathering rocks that range from a fraction of an inch to 9 inches (0.2 m) thick. Bedding surfaces are generally irregular and highly burrowed and bioturbated. The calcarenites are generally fine grained, with most grains being bioclastic debris derived from *Inoceramus* and *Lopha* shells; comminuted fish remains are common. These calcarenites range in color from medium to dark to brownish gray on fresh surface and weather from slightly darker gray to dark yellowish

ALSO IN THIS ISSUE:

Chinle Formation	p. 22
Proterozoic tectonic setting	p. 27
Service/News	p. 30

COMING SOON:

- Red Rock talc deposits
- Geology and paleontology, Tortugas Mtn.
- Kirtland crocodile
- Dakota-Mancos, Zuni Basin

New Mexico GEOLOGY

• Science and Service

Volume 2, Number 2, May 1980

Acting Editor: Joan C. Pendleton

published quarterly by
New Mexico Bureau of Mines & Mineral Resources
a division of New Mexico Institute of Mining & Technology

Subscriptions: Issued quarterly, February, May, August, November; subscription price $3.00/yr.
Editorial matter: Contributions of possible material for consideration in future issues of NMG are welcome. Materials cannot be returned unless accompanied by return postage. Address inquiries to the Editor, New Mexico Geology, New Mexico Bureau of Mines & Mineral Resources, Socorro, NM 87801
Circulation: 1,200
Printer: University of New Mexico Printing Plant

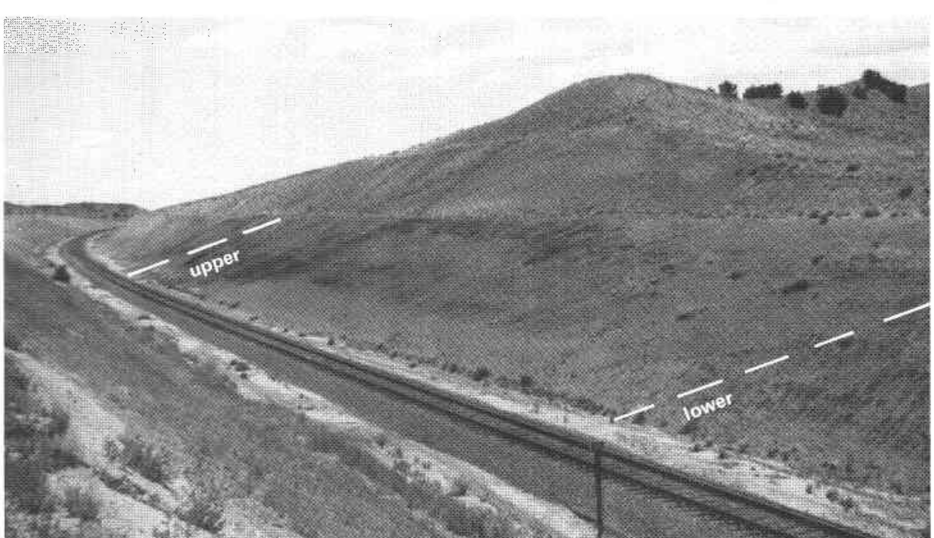

FIGURE 2—RAILROAD CUT OF ATCHISON, TOPEKA, AND SANTA FE RAILWAY COMPANY AT TYPE SECTION OF THE JUANA LOPEZ MEMBER OF THE MANCOS SHALE. View is southeast toward south side of cut; upper and lower contacts of Juana Lopez Member shown as dashed lines.

orange where iron content is higher. Most have a petroliferous odor, especially in the upper calcarenite unit.

Dark-gray fissile noncalcareous shale is the dominant lithology at the type section. These shales are conspicuously darker than those of the overlying calcareous shale member of the Mancos (fig. 3). Limestone concretions, common throughout the shales, occur both as isolated bodies and in zones a few feet thick (fig. 6) and are usually septarian. Scattered thin lenses of more resistant calcarenite are also common. Bentonite beds occur throughout the upper two informal divisions of the type section of the Juana Lopez and range from a fraction of an inch to 6 inches thick (0.15 m). The bentonites are white (fig. 6), weather dark yellowish orange, and are often secondarily gypsiferous. The thickest bentonites occur in the upper part of the Juana Lopez.

The contact between the Juana Lopez Member and the underlying shale member of the Mancos is conformable at the type section; Dane and others (1966, p. H10) established that there was a lateral gradation between the basal Juana Lopez and the underlying shale in the San Juan Basin. The upper contact of the Juana Lopez at its type section is conformable and gradational. Not only are the shales interbedded in the upper calcarenite unit calcareous (table 1, units 43, 45, 47, 50), but also the base of the overlying shale unit is silty, with the silt content decreasing upward. No physical evidence of an unconformity was observed at either the lower or upper contacts of the Juana Lopez at its type section. However, we have recorded an unconformity at the base of the Juana Lopez Member in the Taylor Springs area of northeast New Mexico (Hook and Cobban, 1980, fig. 4).

Fauna and age

Fossils were collected throughout the Juana Lopez Member at the type section (fig. 5). With the exception of the D10814 collection and one concretion from the D10811 level, all fossils shown on fig. 5 were collected in place from the railroad cut (fig. 2). Although all lithologies in the Juana Lopez are fossiliferous, fossils are generally more abundant and better preserved in the calcarenites.

The invertebrate fauna at the type section, like that at the reference section (fig. 5; Dane and others, 1966, p. H7–H10), is dominated by a few species of mollusks. The lower calcarenite unit is dominated by the oyster *Lopha lugubris* (Conrad), the bivalve *Inoceramus dimidius* White, and the ammonite, *Prionocyclus macombi* Meek; the middle shale by *Lopha lugubris;* and the upper calcarenite by the bivalves *Inoceramus dimidius* and *I. perplexus* Whitfield, and the ammonites *Scaphites warreni* Meek and Hayden, *S. whitfieldi* Cobban, *Prionocyclus wyomingensis* Meek, and *P. novimexicanus* (Marcou). A concretion in unit 10 (D10811 level) also contained a new species of the ammonite *Coilopoceras* and a rare occurrence of the ammonite *Hourcquia,* previously reported only from Madagascar, Japan, Russia, and possibly France. The ranges and occurrences of these species compare very favorably with those in the reference section (fig. 5).

The fauna collected at the railroad cut indicates that the type section of the Juana Lopez Member lies entirely within the upper Turonian (middle Cretaceous) zones of *Prionocyclus macombi, Prionocyclus wyomingensis, and Prionocyclus novimexicanus.* These three prionocyclid species serve as name bearers for the basal three faunal zones of the upper Turonian in the Western Interior (Obradovich and Cobban, 1975; Hook and Cobban, 1979; and Cobban and Hook, 1979). The zone of *Prionocyclus macombi* probably extends at least 10 ft (3 m) below the base of the Juana Lopez into the underlying shale (USGS Mesozoic locality D10810), and the zone of *Prionocyclus novimexicanus* extends a few feet into the overlying shale (USGS Mesozoic locality D10820; fig. 5; and Kauffman *in* Dane and others, 1966, p. H13, as *Prionocyclus wyomingensis elegans* Haas). Thus, faunally, it is not possible to recognize an unconformity at either the top or the base of the Juana Lopez Member at its type locality.

Descriptions and illustrations of *Lopha lugubris, Inoceramus dimidius, Prionocyclus macombi, Prionocyclus novimexicanus,* and *Scaphites whitfieldi* can be found in Hook and Cobban (1979, 1980). Illustrations of most of the fauna appear in Kauffman (1977).

Historical note

Although the name Juana Lopez is geologically well known, little is known about the historical person. She was apparently Juana Lopez del Castillo (Myra Ellen Jenkins, oral communication, 1979), whose family is thought to have come from Bernalillo in 1706 to help found Albuquerque (Pearce, 1965, p. 90). The Mesita de Juana Lopez has simply been a place name since at least 1746, but there is no documentary evidence concerning Juana Lopez or why the area bears her name (Myra Ellen Jenkins, oral communication, 1979). The Mesita de Juana Lopez Grant was granted to Domingo Romero, Miguel Ortiz, and Manuel Ortiz in January 1782 (Pearce, 1965, p. 100).

Conclusions

1) The Juana Lopez Member of the Mancos Shale at its type section in a 1965 railroad cut of the Atchison, Topeka, and Santa Fe Railway Company in the NW¼SE¼ sec. 33, T. 15 N., R. 7 E., Santa Fe County, New Mexico is 106 ft (32.3 m) thick and composed primarily of dark-gray noncalcareous fissile shale with interbedded calcarenite beds and lenses; the thickest calcarenites occur at the top of the member; thin beds of laterally persistent calcarenite mark the base of the member. 2) The member is succeeded conformably by calcareous shales of late Turonian (middle Cretaceous) age and conformably succeeds noncalcareous shales of early late Turonian age. 3) The Juana Lopez is the lithologic and time equivalent of the entire member at the reference section established by Dane and others (1966) on the east side of the San Juan Basin. 4) The Juana Lopez Member lies entirely within the late Turonian (middle Cretaceous) ammonite zones of *Prionocyclus macombi, Prionocyclus wyomingensis,* and *Prionocyclus novimexicanus.*

In addition, it appears that Rankin's (1944) original definition of the Juana Lopez was restricted to the upper calcarenite unit (approximately the upper 10 ft—3m—of the Juana Lopez Member as presently recognized and mapped). The expanded scope of the Juana Lopez apparently originated with

FIGURE 4—BASAL CALCARENITE UNIT OF JUANA LOPEZ MEMBER EXPOSED ON NORTH SIDE OF RAILROAD CUT. Contact of Juana Lopez Member with underlying lower shale member of Mancos Shale shown as dashed line; 5-ft-long (1.5 m) Jacob's staff for scale.

Bozanic (1955) and was carried to its logical conclusion in surface sections by Dane and others (1966).

ACKNOWLEDGMENTS—We thank the Atchison, Topeka, and Santa Fe Railway Company for permission to measure the type section of the Juana Lopez and Myra Ellen Jenkins, Chief, Historical Services Division, State Records Center and Archives, and State Historian, Santa Fe, New Mexico, for historical information on Juana Lopez. C. M. Molenaar and E. R. Landis, both of the U.S. Geological Survey, Denver, Colorado, critically reviewed this manuscript.

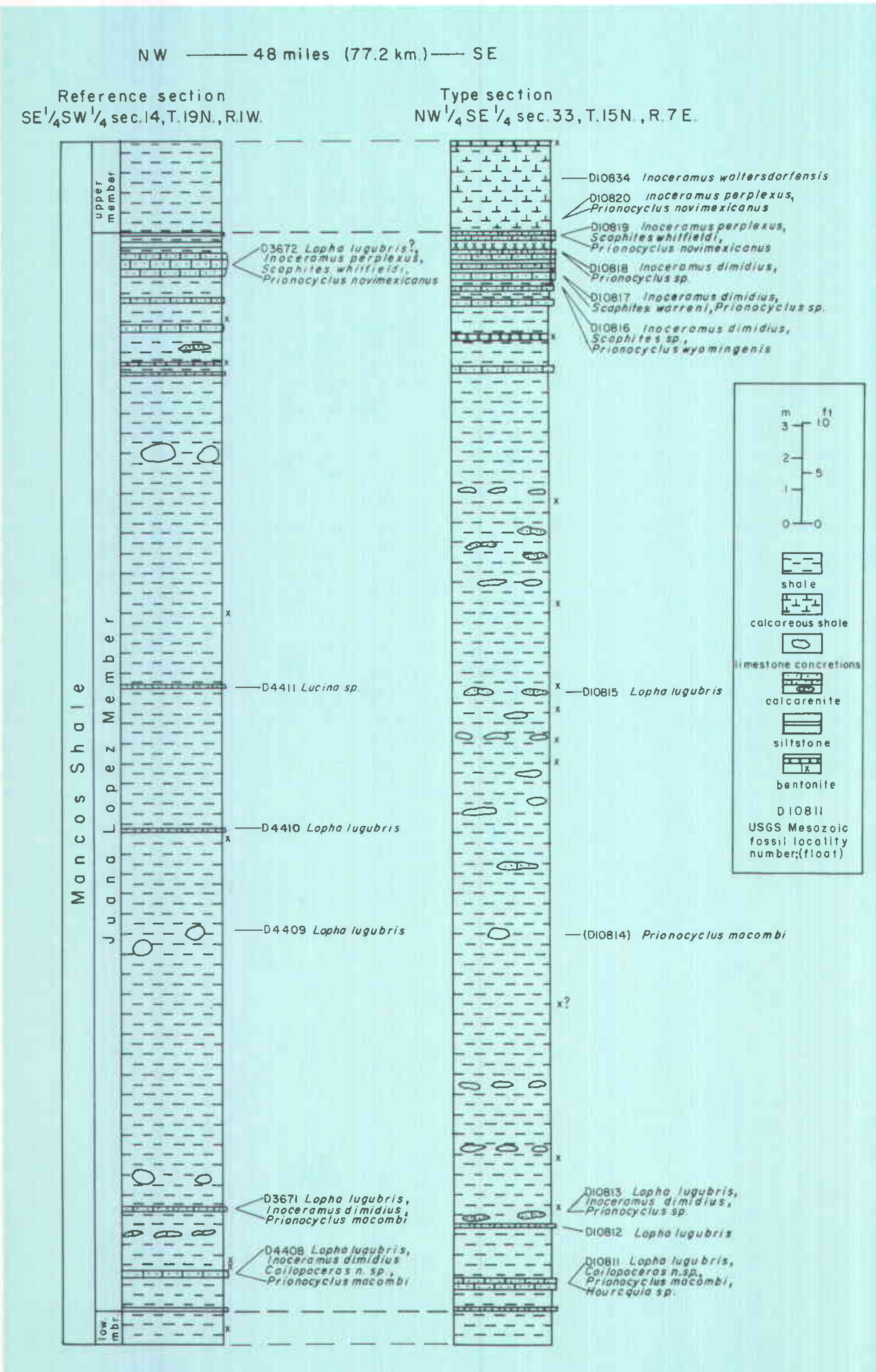

FIGURE 5—OUTCROP SECTIONS OF THE JUANA LOPEZ MEMBER AT ITS REFERENCE AND TYPE SECTIONS SHOWING OCCURRENCES OF FOSSILS. Reference section from Dane and others (1966, p. H10-H12) with faunal names undated; upper member of Mancos Shale not measured or described.

TABLE 1—TYPE SECTION OF THE JUANA LOPEZ MEMBER OF THE MANCOS SHALE NW¼SE¼ sec. 33, T. 15 N., R. 7 E., Santa Fe County, New Mexico, exposed in railroad cut of Atchison, Topeka, and Santa Fe Railway Company. Measured by S. C. Hook on July 16–18, 1979, using a Jacob's staff, Abney hand level, and tape. Fossil collections made on June 28, 1979, by W. A. Cobban and S. C. Hook, and by Hook on July 16–18, 1979.

Unit	Description	Thickness ft	in.
	Mancos Shale		
	Upper shale member (part):		
	Top of measured section		
54	Bentonite, white	0	2
53	Shale, calcareous, olive-gray; weathers slightly lighter	6	0
	USGS Mesozoic locality D10834: *Inoceramus waltersdorfensis* Andert		
52	Bentonite, white; weathers dark yellowish orange	0	2
51	Shale, olive-gray, calcareous, silty; silt content decreases upward; weathers slightly lighter	2	6
	USGS Mesozoic locality D10820: *Inoceramus perplexus* Whitfield, *Baculites yokoyamai* Tokunaga and Shimizu, *Prionocyclus novimexicanus* (Marcou)		
	Total measured thickness, upper shale member	8	10
	Top of Juana Lopez Member:		
50	Calcarenite, olive-gray; weathers light olive brown and dark yellowish orange; fine-grained, wavy bedded, in beds ½ to 2 inches thick (1.3 to 5 cm); petroliferous odor; hard resistant unit, basal 6 inches (15 cm) forms ledge; contains abundant fragmented fossils	0	9
	USGS Mesozoic locality D10819: *Inoceramus perplexus* Whitfield, *Prionocyclus novimexicanus* (Marcou)		
49	Shale, dark-gray, calcareous	0	1
48	Bentonite, white; weathers dark yellowish orange	0	9
47	Calcarenite, olive-gray; weathers light olive brown and dark yellowish orange; fine-grained, in beds as much as 3 inches thick (3.7 cm); petroliferous odor; hard resistant unit; contains abundant fragmented fossils	0	9
	USGS Mesozoic locality D10818: *Inoceramus dimidius* White, *Prionocyclus* sp.		
46	Shale, dark-gray, calcareous	0	3
45	Calcarenite, olive-gray; weathers light olive brown to dark yellowish orange; fine-grained, thin-bedded; petroliferous odor; hard, resistant unit; contains abundant fragmented *Inoceramus* shells and comminuted fish remains	0	7
	Inoceramus sp., *Prionocyclus* sp.		
44	Shale, dark-gray, calcareous, hard, platy-weathering	0	5
43	Calcarenite, olive-gray; weathers light olive brown to dark yellowish orange; fine-grained, thin-bedded, hard resistant unit	0	6

	USGS Mesozoic locality D10817: *Inoceramus dimidius* White; *Scaphites warreni* Meek and Hayden; *Prionocyclus* sp.		
42	Shale, dark-gray calcareous, silty, hard, platy-weathering	0	5
41	Bentonite; weathers dark yellowish orange; gypsiferous	0	1
40	Calcarenite, olive-gray; weathers to light olive brown to dark yellowish orange; fine-grained, thin-bedded; petroliferous odor; hard resistant unit	0	5
	USGS Mesozoic locality D10816: *Inoceramus dimidius* White; *Scaphites* sp.; *Prionocyclus wyomingensis* Meek		
39	Shale, dark-gray, calcareous, silty	0	9
38	Calcarenite, olive-gray; weathers to light olive brown and dark yellowish orange; fine-grained, wavy bedded, in beds ½ to 2 inches (1.3 cm to 5 cm) thick; petroliferous odor; hard resistant unit; only scraps of *Inoceramus* observed	0	6
37	Shale, dark-gray, noncalcareous	0	11
36	Siltstone, olive-gray; weathers dark yellowish brown; slightly calcareous, micaceous, very thin bedded, resistant unit	0	1½
35	Shale, dark-gray, noncalcareous	1	10
34	Bentonite, white	0	6
33	Shale, dark-gray, noncalcareous	2	6
32	Calcarenite, olive-gray; weathers slightly darker; fine-grained, burrowed, in wavy, irregular beds as much as 1 inch (2.5 cm) thick; hard, resistant unit; contains abundant fragmented *Inoceramus*	0	8
31	Shale, dark-gray, noncalcareous; contains zone of flat limestone concretions 1 ft (0.3 m) in diameter and 2 inches (5 cm) thick, that are 1 ft (0.3 m) above base; also has two basaltic dikes 1 ft thick	13	0
30	Bentonite, white	0	1
29	Shale, dark-gray, noncalcareous; contains a zone of gray septarian limestone concretions as much as 3 ft (1 m) in diameter and 1 ft (0.3 m) in thickness, 2 ft (0.6 m) above base, and also several calcarenite lenses as much as 1 inch (2.5 cm) thick in middle of unit	10	0
28	Bentonite, white	0	1½
27	Shale, dark-gray, noncalcareous	8	0
26	Bentonite, white	0	½
25	Shale, dark-gray, noncalcareous; calcarenite lens 1 ft (0.3 m) from top	2	0
	USGS Mesozoic locality D10815: *Lopha lugubris* (Conrad)		
24	Bentonite, orange-weathering	0	1
23	Shale, dark-gray, noncalcareous, with zone of poorly fossiliferous concretions as much as 2 ft (0.6 m) long and 6 inches (15 cm) high developed at base, and scattered concretions in upper half	3	6
22	Bentonite, orange-weathering	0	2
21	Shale, dark-gray, noncalcareous	2	0
20	Bentonite, orange-weathering	0	1
19	Shale, olive-black, noncalcareous, with minor thin calcarenites in upper half; one limestone concretion 1 ft (0.3 m) long, 2 inches (5 cm) thick observed 20 ft (6.1 m) above base; crossed minor fault of unknown displacement (probably less than 5 ft (1.5 m)) at 22 ft (6.7 m)	24	0
	USGS Mesozoic locality D10814 (float): *Prionocyclus macombi* Meek		
18	Bentonite?, orange-weathering; gypsiferous zone	0	¾
17	Shale, olive-black, noncalcareous, with zone of gray-weathering septarian limestone concretions as much as 1 ft (0.3 m) in diameter and 6 inches (15 cm) thick that lie 2–3 ft (0.6–1 m) above base of unit	15	6
16	Bentonite, white; weathers vivid dark yellowish orange	0	1½
15	Shale dark-gray, noncalcareous	4	6
14	Bentonite, white; weathers vivid dark yellowish orange	0	3
13	Shale, dark-gray, noncalcareous, with minor calcarenite lenses as much as 2 inches (5 cm) thick	1	8
	USGS Mesozoic locality D10813: *Lopha lugubris* (Conrad); *Inoceramus dimidius* White; *Prionocyclus* sp.		
12	Calcarenite, light-brownish-gray; weathers brownish gray; fine-grained, in irregular thin burrowed beds; hard resistant unit	0	2
	USGS Mesozoic locality D10812: *Lopha lugubris* (Conrad)		
11	Shale, dark-gray, noncalcareous, with scattered lenses of calcarenite	5	0
10	Calcarenite, light-brownish-gray; weathers brownish gray; fine-grained, with minor interbedded noncalcareous shale, in irregular beds as much as 2 inches (5 cm) thick; gray limestone concretions as much as 10 inches (25 cm) long and 4 inches (10 cm) thick occasionally developed at top of unit; resistant unit	1	0
	USGS Mesozoic locality D10811: *Lopha lugubris* (Conrad); *Coilopoceras* n. sp.; *Prionocyclus macombi* Meek; *Hourcquia* sp.		
9	Shale, dark-gray, noncalcareous	1	10
8	Calcarenite, medium-gray; weathers grayish red to dark yellowish brown; very fine grained, burrowed, irregular top and bottom; hard resistant unit.	0	1
	Base of member		
	Total thickness, Juana Lopez Member	106	¾
	Lower shale member (part):		
7	Shale, medium-dark-gray; weathers olive gray, noncalcareous, slightly silty; contains scattered septarian concretions throughout as much as 1 ft (0.3 m) in diameter and zone of concretions as much as 1½ ft (46 cm) in diameter in basal 5 ft (1.5 m)	60	0
	USGS Mesozoic locality D10810 10 ft (3 m) below top: *Prionocyclus* sp.		
	USGS Mesozoic locality D10809 20 ft (6 m) below top: *Prionocyclus hyatti* (Stanton)?		
1-6	Shale, with thin interbeds of sandstone (not described)	70	2½
	Total measured thickness, lower shale member	130	2½

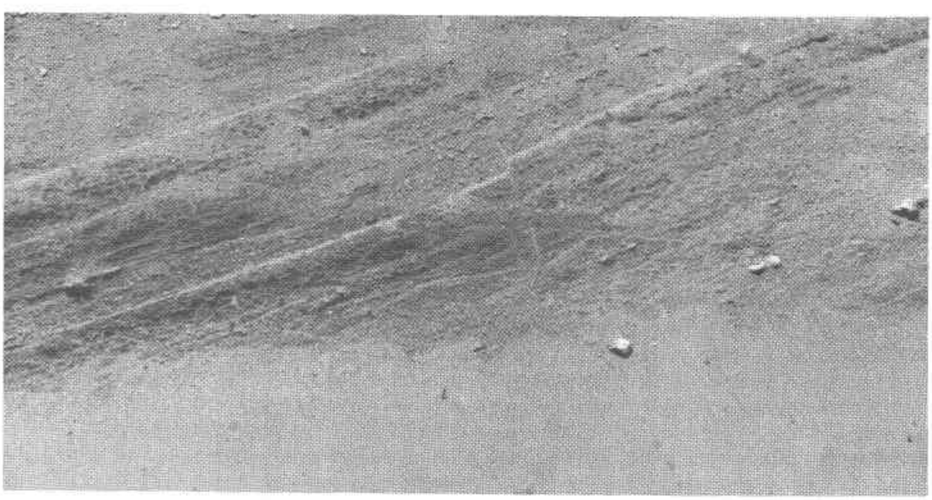

FIGURE 6—MIDDLE SHALE UNIT OF JUANA LOPEZ MEMBER ON SOUTH SIDE OF RAILROAD CUT showing interbedded lenses of calcarenite, zones of limestone concretions, and two prominent bentonite beds that are approximately 10 ft (3 m) apart. Note small fault offset of lower bentonite.

References

Bozanic, Dan, 1955, A brief discussion on the subsurface Cretaceous rocks of the San Juan Basin: Four Corners Geological Society, Guidebook 1st field conference, p. 89–107, 1 fig., 4 pls., 2 charts, 4 maps

Campbell, C. V., 1979, Model for beach shoreline in Gallup Sandstone (Upper Cretaceous) of northwestern New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circ. 164, 32 p., 32 figs., 1 table

Cobban, W. A., and Hook, S. C., 1979, *Collignoniceras woollgari woollgari* (Mantell) ammonite fauna from Upper Cretaceous of Western Interior, United States: New Mexico Bureau of Mines and Mineral Resources, Mem. 37, 52 p., 12 figs., 12 plates

Dane, C. H., 1960, The boundary between rocks of Carlile and Niobrara age in San Juan Basin, New Mexico and Colorado: American Journal of Science (Bradley volume), v. 258–A, p. 46–56, 3 figs.

Dane, C. H., Cobban, W. A., and Kauffman, E. G., 1966, Stratigraphy and regional relationships of a reference section for the Juana Lopez Member, Mancos Shale, in the San Juan Basin, New Mexico: U.S. Geological Survey, Bull. 1224–H, 15 p., 3 figs.

Hook, S. C., and Cobban, W. A., 1979, *Prionocyclus novimexicanus* (Marcou)—Common Upper Cretaceous guide fossil in New Mexico: New Mexico Bureau of Mines and Mineral Resources, Annual Report 1977–78, p. 34–42, 5 figs.

———, 1980, Some guide fossils to the Upper Cretaceous Juana Lopez Member of the Mancos and Carlile Shales, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Annual Report 1978–79, p. 38–49, 7 figs.

Kauffman, E. G., 1977, Illustrated guide to biostratigraphically important Cretaceous macrofossils, Western Interior Basin, U.S.A.: The Mountain Geologist, v. 3 and 4, p. 225–274, 32 pls.

Kottlowski, F. E., 1965, Measuring stratigraphic sections: New York, Holt, Rinehart, and Winston, 253 p.

Lamb, G. M., 1968, Stratigraphy of the lower Mancos Shale in the San Juan Basin: Geological Society of America, Bull., v. 79, p. 827–854, 5 figs.

Lilly, O. J., 1952, The Doswell oil field, Rio Arriba County, New Mexico, *in* Geological Symposium of the Four Corners Region: Four Corners Geological Society, p. 99–103, 4 figs.

Molenaar, C. M., 1973, Sedimentary facies and correlation of the Gallup Sandstone and associated formations, northwestern New Mexico, *in* Cretaceous rocks of the southern Colorado Plateau, J. E. Fassett, ed.: Four Corners Geological Society, Mem., p. 85–110, 19 figs., 1 table

Newberry, J. S., 1861, Geological report, *in* Ives, J. C., Report upon the Colorado River of the west: U.S. 36th Congress, 1st session, Senate Executive Document and House Executive Document 90, pt. 3, 154 p.

———, 1876, Geological report, *in* Macomb, J. N., Report of the exploring expedition from Santa Fe, New Mexico, to the junction of the Grand and Green Rivers of the Great Colorado of the West in 1859: U.S. Army Engineer Department, p. 9–118, 11 pls.

Obradovich, J. D., and Cobban, W. A., 1975, A time-scale for the Late Cretaceous of the Western Interior of North America: Geological Association of Canada, Spec. Paper 13, p. 31–54, 3 figs.

Pearce, T. M., ed., 1965, New Mexico place names: Albuquerque, University of New Mexico Press, 187 p.

Rankin, C. H., 1944, Stratigraphy of the Colorado Group, Upper Cretaceous, in northern New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bull. 20, 27 p., 6 figs.

Thompson, G. G., 1972, Palynologic correlation and environmental analysis within the marine Mancos Shale of southwestern Colorado: Journal of Sedimentary Petrology, v. 42, p. 287–300 □

Depositional environments and paleocurrents of Chinle Formation (Triassic), eastern San Juan Basin, New Mexico

by Dennis D. Kurtz and John B. Anderson, Department of Geology, Rice University, Houston, TX

Strata of the Chinle Formation (Upper Triassic) crop out in the Nacimiento Mountains of Rio Arriba and Sandoval Counties on the eastern side of the San Juan Basin. The strata are exposed in the San Pedro–Nacimiento uplift, on the French Mesa-Archuleta arch, and in the Chama Basin (fig. 1). As elsewhere in the Southwest, the Chinle in north-central New Mexico was deposited under terrestrial conditions consisting of two cycles of fluvial-to-marshland or lacustrine sedimentation (Stewart and others, 1972). These cycles reflect the uplift and erosion of nearby highlands and can be used to decipher the effects of these uplifts on sedimentation.

Although the Chinle Formation has been mapped and studied principally to locate and assess sedimentary copper deposits near its base, relatively little work has been done concerning the details of its depositional history. In describing the lithostratigraphic sequence and the possible depositional history of the Chinle in north-central New Mexico, this report analyzes changes in sediment paleotransport directions between fluvial cycles and pebble lithologies to document changes in sediment source areas and dispersal patterns. These changes and concomitant changes in depositional energy form the basis for a discussion of the tectonic significance of the unit.

Methods

Paleocurrent measurements were taken from small (less than 4 cm), medium (4–15 cm), and large (more than 15 cm) crossbeds. Data were grouped according to the size of the crossbedding and were statistically analyzed using the von Mises distribution (Till, 1974). Though relatively few measurements were analyzed, each of these directions represents an average for a set of several tens of individual crossbeds. The mean vector directions are thus reasonable estimates of paleotransport direction and paleoslope.

Sediment texture was analyzed by settling tube. Thirty rock samples were disaggregated by dissolution of carbonate cement in hydrochloric acid or by pounding. This technique is suitable only for an approximation of mean grain size and particle-size distribution but is adequate for examining general textural trends within a given unit or gross changes between units. A sampling bias is present because only rocks with a calcareous cement were analyzed and because only the sand-sized fraction (0.0ϕ to 4.0ϕ) was used. This bias affects samples from the lowest unit, where only fine-grained beds have a calcareous cement, and from the uppermost member, where sandstone beds contain varying amounts of silt-sized material. Interpretations concerning the remainder of the formation, however, and those regarding overall textural trends are not significantly affected.

Unit descriptions

Wood and Northrop (1946) correlated Triassic strata in the Nacimiento Mountains with the Chinle Formation (Upper Triassic) in Arizona, named by Gregory (1917). The Chinle is the only representative of the Triassic in north-central New Mexico. Vertebrate remains (Reeside and others, 1957) and plant fossils (Daugherty, 1941) found in Chinle strata of the Nacimiento Mountains provide paleontologic evidence for Upper Triassic age.

The Chinle Formation in the eastern San Juan Basin has been divided into four lithostratigraphic units (Wood and Northrop, 1946), listed in ascending order: Agua Zarca Sandstone Member, Salitral Shale Tongue, Poleo Sandstone Lentil, and the upper shale member. In the present study the Poleo Sandstone Lentil is further divided into upper and lower portions.

The *Agua Zarca Sandstone Member,* first described by Wood and Northrop (1946), crops out in a northeast-southwest-trending belt, thickest (approximately 30 m) near San Miguel Canyon (fig. 2, section 1). Where present, it is a prominent ridge former. The Agua Zarca is thin or absent on the French Mesa–Archuleta arch and in the southeastern Chama Basin (fig. 3, sections 6, 7, 8). Erosional remnants of thick channels are present in the south-central Chama Basin.

The *Salitral Shale Tongue,* also first described by Wood and Northrop (1946), oc-

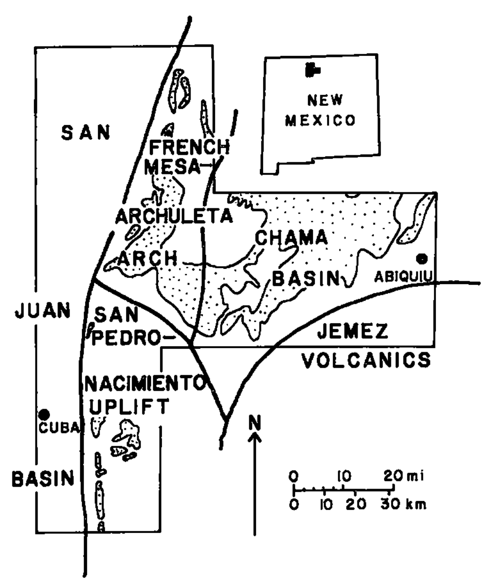

FIGURE 1—Location of eastern San Juan Basin–Chama Basin, showing major tectonic features, outcrops of Chinle Formation are delineated and stippled.