Stratigraphy and Regional Relationships of a Reference Section for the Juana Lopez Member, Mancos Shale, in the San Juan Basin, New Mexico

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CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1224-H

The lithology and faunal zonation of a well-exposed surface section are described, and the section is compared with the abnormally thin section at the type locality

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1966

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 15 cents

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STRATIGRAPHY AND REGIONAL RELATIONSHIPS OF A REFERENCE SECTION FOR THE JUANA LOPEZ MEMBER, MANCOS SHALE, IN THE SAN JUAN BASIN NEW MEXICO

By CARLE H. DANE, WILLIAM A. COBBAN, and ERLE G. KAUFFMAN [1]

ABSTRACT

The Juana Lopez is a member of the Mancos Shale in northwestern New Mexico and southwestern Colorado and a member of the Carlile Shale in central and southeastern Colorado and northeastern New Mexico. The member is characterized by ridge-forming hard thin platy layers of orange-brown-weathering calcarenite, which are interbedded with dark-gray noncalcarenitic clay shale.

The member is only 3 feet 10 inches thick at its type locality near Santa Fe, N. Mex., where it is predominantly calcarenite. Along the east side of the San Juan Basin, N. Mex., however, the thickness of the member ranges from 90 to 135 feet (the maximum known thickness of the member), and it contains much more shale than calcarenite. A well-exposed stratigraphic section near La Ventana, N. Mex., is presented as a reference section for the member in the San Juan Basin, and its relationship to the unusually thin sequence at the type locality is discussed.

Abundant pelecypods and ammonites indicate that the Juana Lopez Member is of early late Turonian age (Upper Cretaceous). In New Mexico ribbed oysters (*Lopha lugubris*), *Inoceramus*, and the ammonites *Prionocyclus*, *Baculites*, *Coilopoceras*, and *Scaphites* dominate the faunas. Fossils in the Juana Lopez Member on the east side of the San Juan Basin are distributed in distinct laterally persistent faunal zones.

INTRODUCTION

The Upper Cretaceous Juana Lopez Member is one of the most laterally persistent and lithologically distinctive divisions of the Mancos Shale in northwestern New Mexico and southwestern Colorado and of the upper part of the Carlile Shale in central and southeastern Colorado and northeastern New Mexico. It is characterized by numerous thin, slabby to platy resistant calcarenite beds separated by varying amounts of dark-gray clay shale. The calcarenite beds

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weather pale to moderate yellowish brown or orange brown and are composed largely of bioclastic debris, predominantly calcite needles or rounded grains of calcite derived chiefly from the prismatic layer of *Inoceramus* shells, and oyster-shell fragments, worn fish teeth, and bone fragments.

During the past 5 years the writers have measured more than 15 surface sections of the Juana Lopez Member in the type area and along the eastern and northern flanks of the San Juan Basin from Seboyeta, N. Mex., north to Pagosa Springs, Colo., and west to the vicinity of Ship Rock, N. Mex. Large collections of fossils were made from many of the sections. It is apparent from these studies that the Juana Lopez Member at the type section southwest of Santa Fe is abnormally thin (3 ft, 10 in.) compared with sections exceeding a hundred feet in thickness over much of the San Juan Basin. In advance of more detailed reports on the extent, lithology, stratigraphy, and faunal zonation of the Juana Lopez Member, we herein describe the member as it occurs on the east side of the San Juan Basin, establish an outcrop reference section of the member that is substantially representative of its occurrence there, and discuss the relationships of this section to the type section. The reference section is in the SE¼SW¼ sec. 14, T. 19 N., R. 1 W., northeast of La Ventana, Sandoval County, N. Mex. (La Ventana quad.).

STRATIGRAPHIC HISTORY OF THE JUANA LOPEZ MEMBER

Rankin (1944, p. 12, 19, and 20) applied the name "Juana Lopez sandstone member" to 10 feet of "very calcareous sandstone" which lies "near the top of the Carlile Shale" on the Mesita Juana Lopez Grant, in sec. 32, T. 15 N., R. 7 E., 6 miles northwest of Cerrillos, Santa Fe County, N. Mex. (fig. 1). Long before Rankin's work the distinctive nature and wide extent of the beds that he included in his "Juana Lopez sandstone member" had been noted by other authors (Newberry, 1876, p. 87, 107; Stanton, 1893, p. 29, 32). Rankin, however, emphasized the lateral extent and continuity of the member by identifying it in measured stratigraphic sections around the margins of the San Juan Basin from near Ship Rock, N. Mex., northeast to Mancos, Colo., east to Pagosa Springs, Colo., and south to the Rio Puerco, northeast of Seboyeta, N. Mex.

Three years after Rankin's work, Pike (1947, p. 22, 29, 30 and pl. 6) described the member as the "late Carlile zone" and noted its distinct fauna and lateral persistence in the northwestern part of the San Juan Basin. In the same paper (p. 23) he mentioned in a footnote that since his paper had been written Rankin had applied the name "Juana

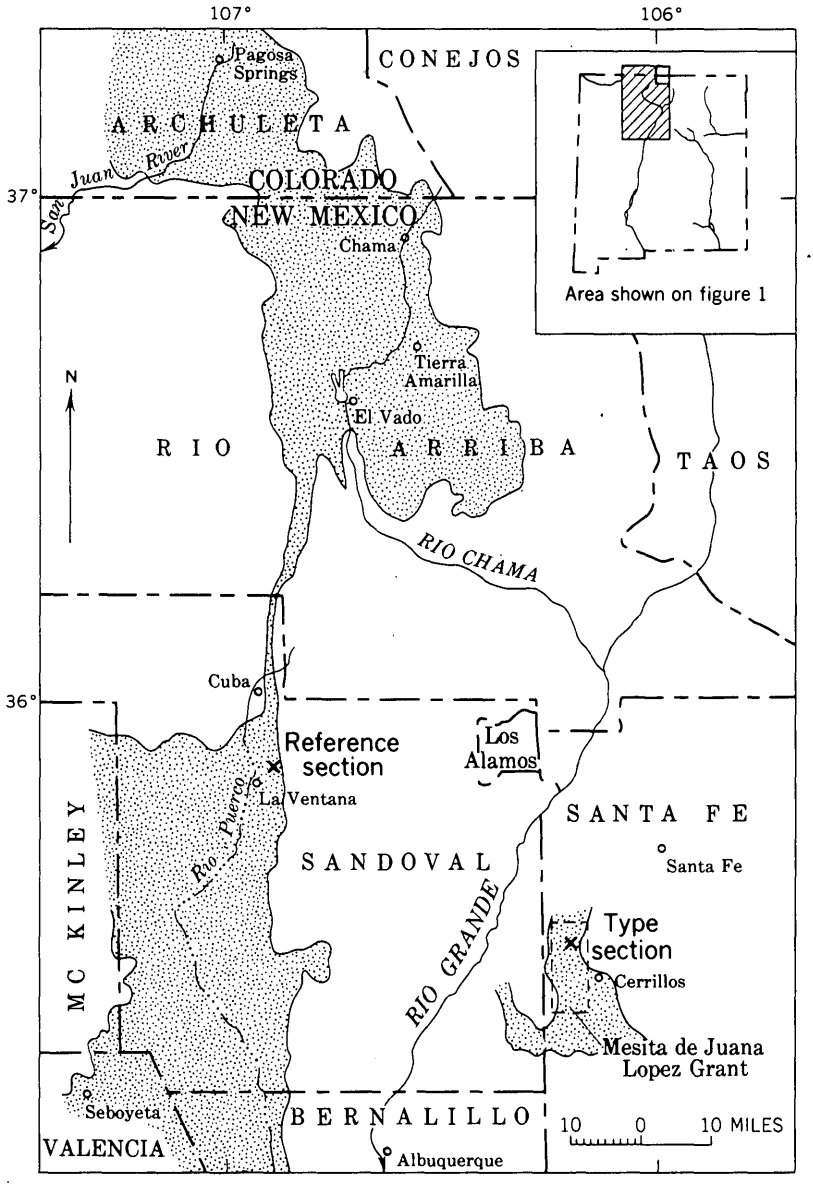

FIGURE 1.—Location of the type and reference sections of the Juana Lopez Member of the Mancos Shale, Sante Fe and Sandoval Counties, N. Mex. (Stippling shows much-generalized area of outcrop of Upper Cretaceous rocks.)

Lopez Sandstone Member of the Carlile Shale" to his "late Carlile zone" in areas where it was a distinct lithologic unit. The name Juana Lopez has since been applied to the member in the type area by Stearns (1953, p. 968) and along the east side of the San Juan Basin by Dane (1960, p. 72), and it has been mentioned in regional papers by Cobban and Reeside (1952, chart 10b) and Young (1960, p. 178). Juana Lopez has recently been accepted by the U.S. Geological Survey as a member of the Mancos Shale in the Ute Mountains area of southwestern Colorado (Ekren and Houser, 1965, p. 23) and as a member of the Carlile Shale in the Pueblo area of eastern Colorado (Scott, 1964). Kauffman (1965) applied the name widely in southern Colorado and northern New Mexico.

Subsequent to its definition by Rankin (1944) two other stratigraphic names have been applied to rocks now incorporated in the Juana Lopez Member. The name "Sanastee" was applied to part or all of the Juana Lopez in a road log of the New Mexico Geological Society Second Field Conference (1951, p. 46). The name was apparently derived from the trading post of Sanostee (present spelling), 18 miles south of Ship Rock, and was in use by petroleum geologists and drillers long before its publication. Bozanic (1955, p. 91) noted the priority of Juana Lopez over "Sanastee" and stated "As a matter of priority the term Sanastee should be discarded in favor of Juana Lopez, but in actual practice such a change is not easily made, inasmuch as the Sanastee name is deeply entrenched in petroleum usage." Nevertheless, as Bozanic noted, the name Juana Lopez has unquestioned priority, and its formal description predates the first published usage of "Sanastee" by 7 years.

In southeastern and south-central Colorado, the term "Niobenton sand" has been applied informally by drillers to a very thin sequence of massive to slabby calcarenite beds that cap the Codell Sandstone Member of the Carlile Shale (Dane, Pierce, and Reeside, 1937, p. 217). Inasmuch as the derivation of the name does not allow it to be used formally in stratigraphy, and Scott (1964) and Kauffman (1965) correlated this unit with the Juana Lopez Member of New Mexico, the name "Niobenton" has been abandoned in favor of Juana Lopez in this area.

LITHOLOGY AND THICKNESS

The most characteristic lithologic feature of the Juana Lopez Member in outcrop in the San Juan Basin and elsewhere is its content of numerous hard dense slabby, platy, rarely massive beds of calcarenite which range from a fraction of an inch to several inches in thickness. The thickest beds normally occur near the top of the member; massive calcarenite beds, some of them exceeding a foot in thickness, are most

common in areas where the member is abnormally thin, as at the type section. The thinnest calcarenite beds are ordinarily lenses of very limited extent. Small-scale crossbedding and extensively ripple-marked surfaces are common, particularly in the upper part of the member. Bedding surfaces, especially within and at the margins of massive calcarenite beds, are generally irregular, possibly reflecting small-scale scouring in an environment of vigorous wave or current agitation of the sea bottom.

In New Mexico, Juana Lopez calcarenite beds are light olive gray and, less commonly, medium gray, purplish gray, and grayish red on fresh fracture. They characteristically weather pale to moderate yellowish brown or orange brown. The beds are fine to coarse grained; the thinnest beds are generally finer grained than the slabby and massive units. The rock is dense, and the grains are tightly cemented with calcium carbonate. Many calcarenite beds are abundantly fossiliferous; most of the fossil material is broken and worn. The grains of calcarenite are predominantly bioclastic debris. The carbonate grains of most beds are predominantly fragmented calcareous needles from the prismatic layer of *Inoceramus* shells (inoceramite of Hattin, 1962, p. 41) together with small percentages of broken oyster shells, worn fish teeth and bone fragments, and shell fragments of other invertebrates. Some beds, particularly in the lower part of the member, include a conspicuous, though fractional, amount of greatly abraded grains of fish bone, teeth, and scales. Locally these beds have been described as "fish-tooth conglomerates," "fish-bone beds," "fish-tooth beds," or simply "fish beds."

Although the calcarenite beds are composed predominantly of carbonate with small percentages of phosphatic material (fish debris), a few beds, mostly in the lower part of the member, contain an appreciable percentage of silt- to sand-size grains of silica and some clay. Petrographic observation of calcarenite in measured sections has been random, and only a few thin sections have been studied, but the designation of almost all hard beds as calcarenite in these sections appears warranted.

Although the calcarenite beds constitute only a small fraction of the total thickness of the member in the San Juan Basin, they are resistant to erosion, and plates, ranging from a few inches to more than a foot in diameter, litter the surface of the outcrops and creep long distances down shale slopes where they are more conspicuous than the associated shales.

The dominant lithology of the Juana Lopez Member in the San Juan Basin is fissile medium-dark-gray to black noncalcareous clay shale that weathers light gray and is easily eroded. The shale in-

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cludes, especially in the upper part of the member, limestone and limestone-siderite concretions that are light to medium gray on fresh fracture and weather gray to grayish orange. Some of the concretions are septarian. They occur either isolated in the shale or localized in zones and range from a few inches to several feet in diameter. Bentonite beds as much as several inches in thickness are present at many places. Owing to the generally poor soft-shale exposures in the Juana Lopez Member and the marked downslope creep of bentonitic material, the precise position and thickness of bentonite beds in many sections were not determined. On the eastern and southeastern

FIGURE 2.—Outcrop of reference section of the Juana Lopez Member of the Mancos Shale, northeast of La Ventana, N. Mex.

flanks of the San Juan Basin, the Juana Lopez Member ranges in thickness from 90 to 135 feet. In the reference section it is nearly 107 feet thick, which seems to be only slightly below the average for this part of the basin (fig. 2).

Reexamination of the type section in 1963 demonstrated that: (1) although Rankin's (1944) measured section of Coloradoan sediments started in sec. 32, the Juana Lopez is exposed in sec. 33, T. 15 N., R. 7 E., (2) the thickness of the Juana Lopez at the type section is only 3 feet, 10 inches, the rest of Rankin's original estimate of 10 feet being made up of baked resistant shale of earliest Niobrara age (latest Turonian) overlying the Juana Lopez and a massive brown-weathering sill of hornblende monzonite porphyry (Disbrow and Stoll, 1957)

that caps the ridge, (3) the Juana Lopez at the type section is composed predominantly of calcarenite and limestone, in view of which, the term "Sandstone" has been dropped from the member name, and (4) the Juana Lopez Member at the type section is abnormally thin and contains an unusually small percentage of shale as compared with sections more than 100 feet thick in the eastern San Juan Basin which are predominantly shale.

Subsurface data in the San Juan Basin corroborate outcrop observations. Bozanic (1955, p. 91) recognized the Juana Lopez Member in the subsurface of the northern San Juan Basin as "a persistent discernible interval of roughly 120 feet, which will vary somewhat due to occasional arbitrarily chosen boundaries. In some areas, two distinct units are present, whereas in other parts of the basin the lower part is transitional with and not distinctly separable from the upper development". McPeek (1965, fig. 2, sec. B–B′) identified the Juana Lopez Member in electric logs of 12 wells on the east side of the San Juan Basin as an interval ranging from 115 to 135 feet in thickness. Other subsurface information and similarity of intervals from the bottom and top of the Juana Lopez to lower and higher horizons in the Mancos Shale indicate that the member, as identified in the subsurface, includes the same stratigraphic sequence as it does in surface exposures.

FAUNAL ZONES, AGE, AND CORRELATION

Calcarenite, shale, and concretions in the Juana Lopez Member at the reference section and throughout the San Juan Basin are fossiliferous. The calcarenite beds indicate periods of abundant invertebrate life on the shallow sea floor, favorable living conditions for sharks and other fish, and long periods of negligible accumulation of terrigenous sediments or chemical carbonate deposits.

Seven genera of mollusks dominate the invertebrate faunas of the Juana Lopez almost to the exclusion of others. These are the ammonites *Prionocyclus*, *Scaphites*, *Baculites*, and *Coilopoceras*, and the pelecypods *Inoceramus*, *Lopha*, and *Lucina*. Many of the species are widely distributed in time-equivalent strata in the western interior and thus form a good basis for faunal zonation and correlation. Good faunal zoning can be recognized in the thick Juana Lopez sections in the San Juan Basin.

The ranges of the significant species insofar as they are now known are shown on the accompanying chart on which the Juana Lopez is divided arbitrarily into equal lower, middle, and upper parts (fig. 3). The regional applicability of this zoning has not yet been fully tested.

Coilopoceras colleti Hyatt is in the lower part of the member to-

gether with a form of *Prionocyclus macombi* Meek that has a well-arched venter, but only *P. macombi* persists into the middle and upper parts, where it becomes more flat ventered, in marked contrast to the earlier form. *Prionocyclus wyomingensis wyomingensis* Meek is restricted to the basal and middle parts of the upper third of the member and *P. wyomingensis elegans* Haas to the uppermost ledges. In the upper part of the member distinct species of *Scaphites* occur at three levels: *Scaphites warreni* Meek and Hayden in the lower beds, *Scaphites ferronensis* Cobban in the middle part, and the more delicately

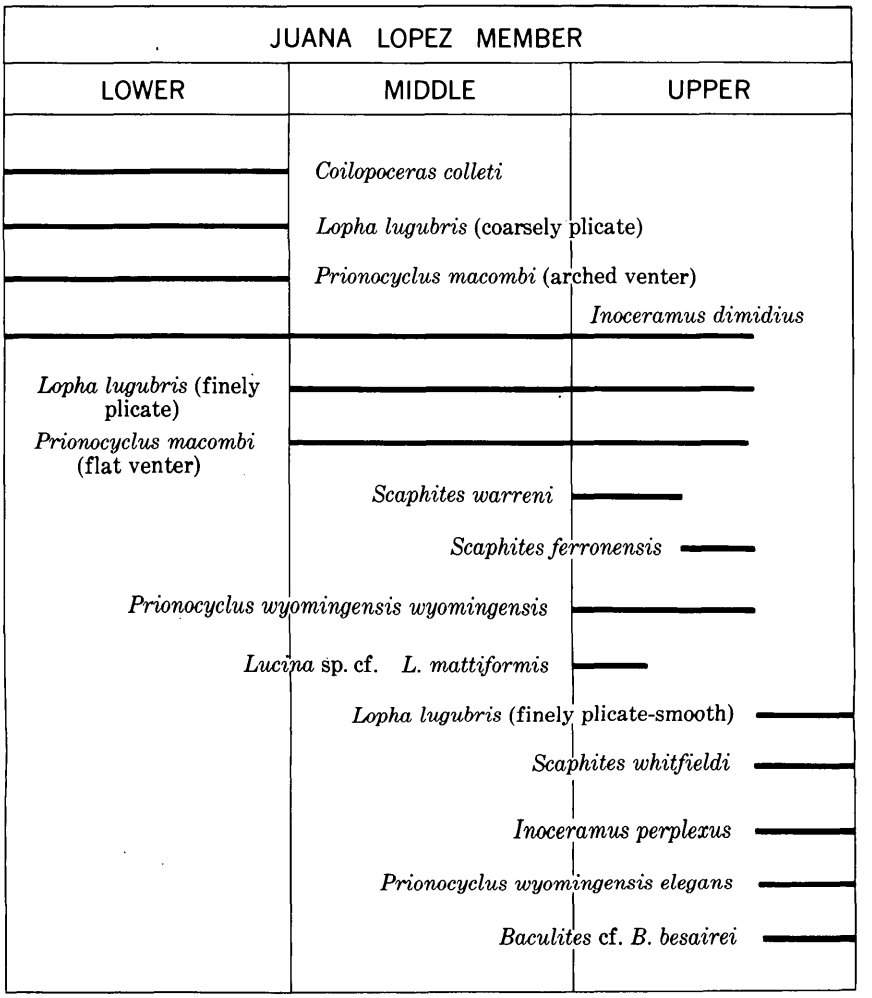

FIGURE 3.—Generalized stratigraphic ranges of some fossils occurring in the Juana Lopez Member of the Mancos Shale on the east side of the San Juan Basin, N. Mex. The member is divided arbitrarily into equal lower, middle, and upper parts which have no lithologic significance.

ribbed *Scaphites whitfieldi* Cobban in the highest beds associated with *Inoceramus perplexus* Whitfield, *Prionocyclus wyomingensis elegans*, and a small smooth baculite, *Baculites* cf. *B. besairei* Collignon. *Inoceramus dimidius* White ranges from the base nearly to the top of the member, where it is replaced by *Inoceramus perplexus*. *Lucina* sp. cf. *L. mattiformis* Stephenson has been found thus far only in the lower part of the upper third of the member. Varieties of *Lopha lugubris* (Conrad) occur throughout the member, and this is perhaps the most abundant species. A coarsely plicate form is restricted to the basal third of the member; more finely plicate forms are found in the middle third and in the lower part of the upper third; and, in the topmost layers, smooth to very finely plicate forms are rare or apparently absent locally.

In a general way the ranges of the fossils are such that five faunal zones can be recognized in ascending order as follows: (1) Zone of *Coilopoceras colleti*, coarsely plicate *Lopha lugubris*, and *Prionocyclus macombi* with well-arched venter, (2) zone of finely plicate *Lopha lugubris* and *Prionocyclus macombi* with flatter venter, (3) zone of *Prionocyclus wyomingensis wyomingensis* and *Scaphites warreni*, together with finely plicate *Lopha lugubris* and *Prionocyclus macombi*, (4) zone of *Scaphites ferronensis* along with *Prionocyclus wyomingensis wyomingensis*, *P. macombi* (flat venter), and *Inoceramus dimidius* in the highest part of their range, (5) zone of *Scaphites whitfieldi*, *Inoceramus perplexus*, and *Prionocyclus wyomingensis elegans*.

The distinctive aspect of the Juana Lopez Member facilitates its recognition and lithologic correlation, but time correlation of the unit is more difficult. The progression of ammonites and pelecypods noted in the thick sections of the San Juan Basin is not fully represented at the type section of the member where the lowest recognizable faunal zone, occurring near the base of the member, is that of *Scaphites ferronensis*. The older zones of *Scaphites warreni*, *Prionocyclus macombi* (late form) with finely plicate *Lopha lugubris*, and *Prionocyclus macombi* (early form) with coarsely plicate *Lopha lugubris* are absent. This suggests that the Juana Lopez of the type section is the lithologic and time equivalent of only the upper part of the reference section on the eastern flank of the San Juan Basin. It seems therefore that the abrupt eastward thinning of the Juana Lopez in north-central New Mexico is caused by facies change in the lower half of the section. The lower part of the Juana Lopez of the reference section apparently grades laterally into dark-bluish-gray clay shale that lacks calcarenite and lies below the Juana Lopez of

the type section. Unfortunately the shale is unfossiliferous in the upper part, and no definite faunal correlations can be made.

Throughout the San Juan Basin the Juana Lopez Member rests on shale of middle Carlile (Blue Hill, Codell) age. The contact between the Juana Lopez Member and the underlying Mancos Shale is gradational and conformable. Lateral gradation between the basal Juana Lopez and the top of the underlying shale unit has been established.

The beds above the Juana Lopez Member on the eastern and southern flanks of the San Juan Basin in New Mexico are of latest Carlile age, where an age has been established, and are composed predominantly of dark clay shale. On the south side of the San Juan Basin the Juana Lopez Member is overlain by shale of late Carlile age that lies below one of the tongues of the Gallup Sandstone of the Mesaverde Group. For the present, it seems practicable to consider the Juana Lopez throughout the San Juan Basin as a member of the Mancos Shale rather than to attempt to apply Colorado Front Range nomenclature to the sequence. Even in the northeastern part of the basin in New Mexico, where the name "Carlile shale member" was used by Dane and Bryson (1938), it appears that Carlile is of debatable value as a lithologic unit because of the uncertainty of the upper contact south of the geographic extent of the Fort Hays Limestone Member.

At its type section the Juana Lopez Member is succeeded disconformably by rocks equivalent to the basal part of the Niobrara Formation in southeast Colorado, and the younger Carlile rocks of the east and south sides of the San Juan Basin are missing.

Stratigraphic sections of the Juana Lopez Member at the new reference section and at the type locality follow.

STRATIGRAPHIC SECTIONS

Reference section of the Juana Lopez Member of the Mancos Shale, SE¼SW¼ sec. 14 T. 19 N., R. 1 W.

[Measured 3 miles southeast of San Miguel School and just east and northeast of Ruben Tafoya detention dam, in La Ventana quad., Sandoval County, N. Mex., by C. H. Dane, October 1959, and C. H. Dane, W. A. Cobban, and E. R. Landis, Aug. 1963. Additional fossil collections made by Erle G. Kauffman and G. R. Paulson in June 1964]

	Ft	in.
Mancos Shale (part):		
Shale, dark-gray.		
Juana Lopez Member (top):		
Siltstone, calcareous, with minutely comminuted fish remains		2
Shale, dark-gray		10
Bentonite, thickness only determinable approximately		6
Shale, dark-gray		5

Reference section of the Juana Lopez Member of the Mancos Shale, SE¼SW¼ sec. 14 T. 19 N., R. 1 W.—Continued

	Ft	in.
Mancos Shale (part)—Continued		
Juana Lopez Member (top)—Continued		
Calcarenite, fine-grained, in beds ½ to 2 in. thick, and thin-bedded very fine grained calcarenite. Unit thickens along outcrop to as much as 2 ft 8 in	2	2
USGS D3672:		
Inoceramus perplexus Whitfield		
Lopha lugubris (Conrad)?		
Anisomyon apicalis Sidwell		
Baculites cf. *B. besairei* Collignon		
Scaphites whitfieldi Cobban		
Prionocyclus wyomingensis Meek var. *elegans* Haas		
Shale	2	2
Calcarenite, very silty		5
Shale, dark-gray	1	8
Bentonite		1
Shale, dark-gray		3
Calcarenite, in beds ½ to 1 in. thick; unit thins along outcrop to as little as 2 in		8
Shale, dark-gray	1	6
Calcarenite, lenses out within 100 ft along outcrop		2½
Shale, dark-gray	1	3
Bentonite		4
Shale, dark-gray		9
Calcarenite, fine-grained, very slightly silty, with some comminuted fish remains; in beds 1/10 to ¾ in. thick; unit as much as 6 in. thick locally		3
Shale, dark-gray	6	8
Zone of concretions, large, rounded, yellowish-gray-weathering; dense carbonate but with dusky-brown crystalline carbonate patches. Concretions are 1 to 2 ft thick and 1 to 3 ft long	2	0
Shale, dark-gray	4	10
Limestone, very finely granular, in two beds each ½ in. thick with intervening shale		2
Shale, dark-gray	10	0
Bentonite		1
Shale, dark-gray	7	0
Calcarenite, very fine grained, hard, in two beds each ½ in. thick with intervening shale		2½
USGS D4411: *Lucina* sp.		
Shale, dark-gray		3
Bentonite		½
Shale, dark-gray	14	6
Calcarenite, very fine grained, in irregular bed ½ to 2 in. thick with associated tan-weathering limestone concretions		2
USGS 4410: *Lopha lugubris* Conrad, finely plicate variety		
Shale, dark-gray	8	0

Reference section of the Juana Lopez Member of the Mancos Shale, SE¼SW¼ sec. 14 T. 19 N., R. 1 W.—Continued

	Ft	in.
Mancos Shale (part)—Continued		
Juana Lopez Member (top)—Continued		
Shale, dark-gray; contains gray septarian limestone concretions near the top with finely plicate oysters	26	0
USGS D4409: *Lopha lugubris* Conrad, finely plicate variety		
Shale, black; in the upper part contains rounded yellowish-gray carbonate concretions weathering pale brown to grayish orange; from 1 to 2 ft thick and 1 to 2 ft long	3	4
Calcarenite, very fine-grained, in beds ½ to 4 in. thick; contains coarsely plicate oysters and other fossils		4
USGS D3671:		
Lopha lugubris Conrad, coarsely plicate variety		
Inoceramus dimidius White		
Prionocyclus macombi Meek		
Concealed	3	0
Calcarenite, thin-bedded, lenticular		1
Shale, black	1	10
Bentonite		½
Shale, black		10
Bentonite		½
Shale, black		3
Calcarenite, fine-grained, silty, with some comminuted fish remains in beds ¼ to 1½ in. thick; crossbedded; contains coarsely plicate oysters and other fossils		8
USGS D4408:		
Lopha lugubris Conrad, coarsely plicate variety		
Inoceramus dimidius White		
Prionocyclus macombi Meek		
Shale, black	1	8
Calcarenite, hard		½
Shale, black	1	1
Siltstone, calcareous, hard, crossbedded, with abundant grayish-brown to dusky-brown minutely fragmented fish remains		2
(Base of member.)		
Total Juana Lopez Member	106	11
Shale, black	1	9
Bentonitic zone; includes one bed about 1 in. thick and several thinner beds		4½
Shale, black	6	0
Shale, black; at the top is a zone of concretions that weather grayish orange and pale brown; up to 1 ft thick and several feet long. Concretions are mostly dense gray carbonate but have some dark-brown crystalline carbonate patches.		

Type section of Juana Lopez Member of the Mancos Shale, NW¼SE¼ sec. 33, T. 15 N., R. 7 E.

[Measured on property of Sam Brown, realtor, Albuquerque, Madrid quad., Santa Fe County, N. Mex., by E. G. Kauffman and G. R. Paulson, July 1963. This is section at type locality originally stated by Rankin (1944) to be in sec. 32, T. 15 N., R. 7 E., on the Mesita Juana Lopez Grant 6 miles northwest of Cerrillos]

	Ft	in.
Massive sill (mapped by Disbrow and Stoll, 1957, as Ti 1, which includes principally hornblende monzonite porphyry)	3	0
Mancos Shale (part):		
Niobrara Shale equivalent:		
Shale, baked, thin-bedded to platy, brittle, resistant, dark-gray, light-gray-weathering; contains a fauna of earliest Niobrara age (late Turonian)	2	6
USGS 28766:		
Scaphites sp. aff. *S. geinitzi* d'Orbigny		
Prionocyclus wyomingensis elegans Haas		
Worthoceras? sp.		
Baculites sp. (smooth)		
Trace of ammonite with constrictions		
Inoceramus ex. gr. *I. labiatus* (Schlotheim) (=*problematicus* Schlotheim of Meek; *aviculoides* Meek and Hayden)		
Pycnodonte? sp. aff. *P.*? *congesta* (Conrad)		
Nuculana sp.		
Hoploparia sp.		
Hamulus? sp.		
Solitary coral, indet.		
fish bone, teeth, scales		
Juana Lopez Member (top):		
Calcarenite, dark-gray, brown- and rusty-weathering, fine- to medium-grained, granular, very dense and hard; in 3 distinct massive beds separated by 1 in. layers of shaly calcarenite and calcareous shale; forms a ledge and has a petroliferous odor	1	4½
USGS 28765:		
Inoceramus perplexus Whitfield		
Ostrea sp.		
Scaphites whitfieldi Cobban		
Prionocyclus wyomingensis elegans Haas		
fish debris		
Calcarenite, dark-gray, rusty- and tan-weathering, fine-grained, granular, well-cemented, moderately resistant, platy to shaly; interbedded with dark-gray calcarenitic shale		6
USGS 28764:		
Inoceramus perplexus Whitfield		
Lopha lugubris (Conrad)? (smooth right valves)		
Scaphites whitfieldi Cobban		
Calcarenite, dark-gray, rusty-brown-weathering, fine-grained, petroliferous; grades to bioclastic limestone and forms a hard ledge		3½

Type section of Juana Lopez Member of the Mancos Shale, NW¼SE¼ sec. 33, T. 15 N., R. 7 E.—Continued

	Ft	in.
Mancos Shale (part)—Continued		
Juana Lopez Member (top)—Continued		
Calcarenite, dark-gray, fine-grained, slabby to platy, interbedded with dark-gray thin-bedded calcareous shale		4
USGS 28763:		
Inoceramus sp. aff. *I. dimidius* White		
Lopha? sp. aff. *L. lugubris* (Conrad) (smooth valves only)		
Prionocyclus wyomingensis Meek subsp. indet.		
Scaphites whitfieldi Cobban		
fish debris		
Limestone, dark-gray, brown-weathering, bioclastic, massive, hard, fine-grained, petroliferous		4
USGS 28762:		
Inoceramus dimidius White		
Scaphites ferronensis Cobban		
Prionocyclus wyomingensis Meek subsp. indet.		
fish scales and bone and tooth debris		
Limestone, medium-gray, fine-grained, resistant		1
Siltstone, soft, granular, and silty, sandy hard calcarenite; interbedded dark-gray carbonaceous platy to fissile shale. Entire unit calcareous and petroliferous		9
Limestone, medium-gray, brown-weathering, bioclastic, fine-grained, granular, dense, slabby		1–2
Total Juana Lopez Member	3	10
Shale, black, bluish-black-weathering, thin-bedded, soft, noncalcareous; weathers papery. Poorly exposed but complete fresh section dug out in gully	3	4
Bentonite, orange and buff, clayey		1
Shale, black, blue-black- and dark-gray-weathering, soft, noncalcareous, thin-bedded; weathers thin-bedded to papery. Lies on a zone of septarian limestone concretions. Well exposed at base, poorly exposed at top, but completely dug out in a gully	29	5

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U.S. GOVERNMENT PRINTING OFFICE: 1966 O—798–003