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W. A. Cobban, E. R. Landis, and C. H. Dane, 1974, pp. 279-282

in:

Ghost Ranch, Siemers, C. T.; Woodward, L. A.; Callender, J. F.; [eds.], New Mexico Geological Society 25th Annual Fall Field Conference Guidebook, 404 p.

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AGE RELATIONS OF UPPER PART OF LEWIS SHALE ON EAST SIDE OF SAN JUAN BASIN, NEW MEXICO

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INTRODUCTION

Fassett and Hinds (1971, fig. 7) have very clearly documented a southwestward increase in the age of the top of the Lewis Shale across the San Juan Basin. The change in age was determined by isopaching the interval between a persistent subsurface marker bed, the Huerfanito Bentonite Bed of the Lewis Shale, and the top of the Pictured Cliffs Sandstone. This interval is 1,250 feet (381 m) thick a few miles west of Dulce, on the northeast side of the San Juan Basin, and only 300-350 feet (91-107 m) thick near Cuba, about 12 miles south of Regina, on the southeast side.

The present study confirms the conclusions of Fassett and Hinds by relating the thickness changes to ammonite zones at the top of the Lewis. The uppermost part of the Lewis Shale in the Dulce area probably lies in the zone of *Baculites compressus,* whereas the uppermost part of the Lewis lies several zones lower in the Regina area about 50 miles (80 km) south of Dulce.

AMMONITE RECORD

Ammonites, especially *Baculites,* are common in many parts of the Lewis Shale. The same species are abundant in the age-equivalent part of the Pierre Shale of the Great Plains region where an excellent zonation has been determined (for example, Gill and Cobban, 1966, p. A28-A34, table 2). Collections from the Lewis Shale along the east side of the San Juan Basin are not numerous, but enough have been made to reveal the presence of many of the zones known from the Great Plains province. The following zones seem to be present in the Lewis Shale in a narrow north-south belt in New Mexico in Ranges 1 East and 1 West extending north from Township 23 North to the Colorado State boundary.

(Youngest)	*Baculites compressus* Say
	Didymoceras cheyennense (Meek and Hayden)
	Exiteloceras jenneyi (Whitfield)
	Didymoceras nebrascense (Meek and Hayden)
	Baculites scotti Co bban
	Baculites gregoryensis Co bban
	Baculites perplexus Cobban
	Baculites sp. (smooth)
	Baculites asperiformis Meek
	Baculites maclearni Landes
(Oldest)	*Baculites obtusus* Meek

Sketches of most of these ammonites were presented in a recent paper by Gill and Cobban (1973, figs. 2-6). Fossils indicative of the zone of *Didymoceras stevensoni* (Whitfield), which separates the zones of *D. nebrascense* and *Exiteloceras jenneyi* farther north, have not been found along the east side of the San Juan Basin. Rocks of *D. stevensoni* age are probably present, however, because *D. stevensoni* is known from the Lewis Shale in the Pagosa Springs-Durango area, Colo., on the north side of the San Juan Basin.

*Deceased

FOSSIL COLLECTIONS

The following collections from the Lewis Shale are important in documenting the presence of at least 11 ammonite zones on the east side of the San Juan Basin from Township 23 North to the Colorado State line (Fig. 1). Some of the collections contain many species of fossil mollusks, but only the most useful zone indicators are listed. The numbers are U.S. Geological Survey Mesozoic fossil localities.

Zone of *Baculites obtusus*

D4534. SW'/ NE *'A* sec. 11, T. 23 N., R. 1 W. From a thin brown-weathering sandstone bed about 200 feet above base. C. H. Dane, E. R. Landis, and W. A. Cobban, 1964.

Ostrea russelli Landes
Baculites cf. *B. obtusus* Meek

Zone of *Baculites maclearni*

D4546. SW 1/4 NW 1/4 sec. 4, T. 26 N., R. 1 E. Less than 300 feet above base. Dane, 1964.

Ostrea russelli Landes?
Baculites maclearni Landes?

Zone of *Baculites asperiformis*

D5096. NW NE sec. 5, T. 26 N., R. 1 E. From calcareous, ferruginous concretions and "tepee-butte limestones" about 300 feet above base. Dane, Landis, and Cobban, 1963.

Inoceramus subcompressus Meek and Hayden
Baculites cf. *B. asperiformis* Meek
Scaphites (Hoploscaphites) gill/ Cobban and Jeletzky

Zone of *Baculites* sp. (smooth)

D5090. North of the center of sec. 24, T. 29 N., R. 1 W. Lower part of Lewis Shale. Dane, 1965.

Baculites sp. (smooth)

D5091. Near center of west line of sec. 30, T. 29 N., R. 1 E. Lower part of Lewis Shale. Dane, 1965.

Baculites sp. (smooth)

Zone of *Baculites perplexus*

D5101. SE 1/4 NE 1/4 sec. 28, T. 26 N., R. 1 E. From orange-weathering limestone concretions. Cobban, 1965.

Inoceramus aff. 1, *proximus* Tuomey
Baculites perplexus Cobban

D5106. SE 1/4 SE 1/4 sec. 4, T. 25 N., R. 1 E. Dane, 1965.

Baculites cf. *B. perplexus* Cobban

Zone of *Baculites gregoryensis*

D4526. NW 'A NW 1/4 sec. 16, T. 25 N., R. 1 E. From a "tepee-butte limestone." Dane, Landis, and Cobban, 1964.

Inoceramus tenuilineatus Hall and Meek
Baculites gregoryensis Cobban

D4532. SE 1/4 SW 1/4 sec. 9, T. 25 N., R. 1 E. From a "tepee-butte limestone." Dane, Landis, and Cobban, 1964.

Inoceramus aff. I. *proximus* Tuomey
Baculites gregoryensis Cobban

D5093. NE' sec. 24, T. 28 N., R. 1 W. Dane, 1965.

Inoceramus aff. I. *proximus* Tuomey
Baculites cf. *B. gregoryensis* Cobban

D5102. SE 1/4 NE *1/4* sec. 28, T. 26 N., R. 1 E. From orange-weathering limestone concretions. Cobban, 1965.

Inoceramus aff. I. *proximus* Tuomey
Baculites gregoryensis Cobban

Zone of *Baculites scotti*

D4527. NW 1/4 NW 1/4 sec. 16, T. 25 N., R. 1 E. From a "tepee-butte limestone" about 20 feet above D4526. Dane, Landis, and Cobban, 1964.

Baculites aff. *B. scotti* Cobban
Oxybeloceras n. sp.
Didymoceras n. sp.

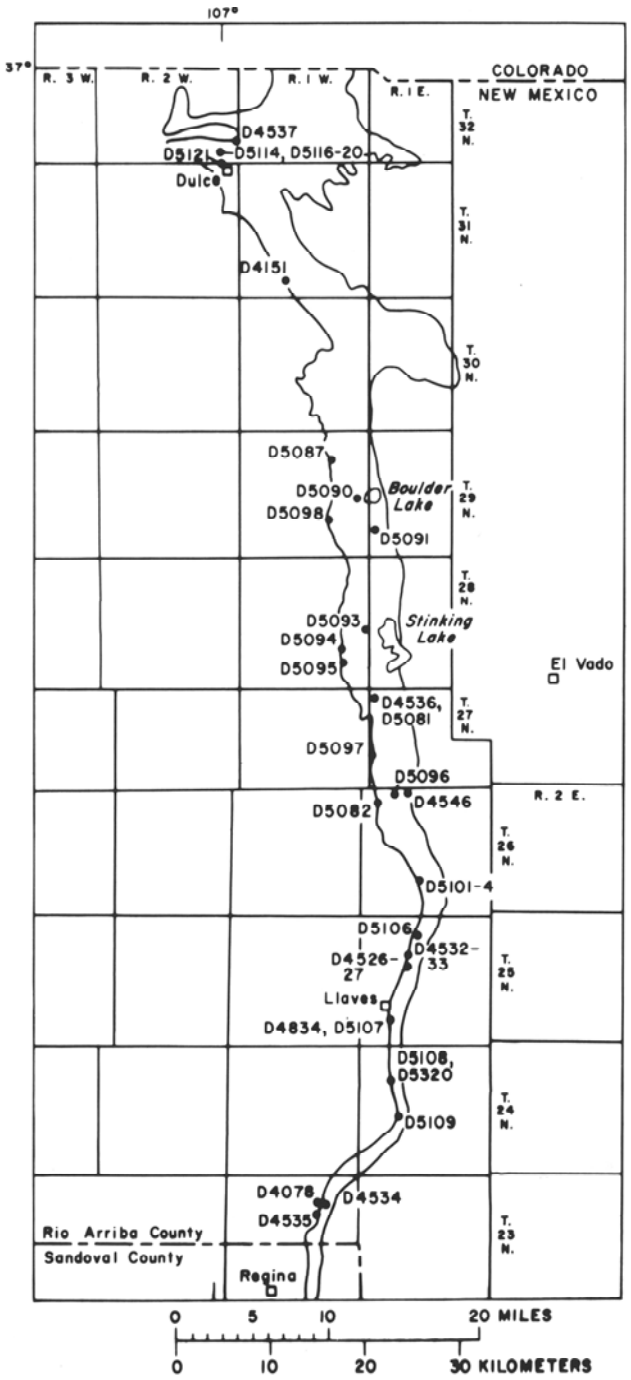

Figure 1. Map showing outcrop of Lewis Shale along the east edge of the San Juan Basin and localities of fossil collections. Outcrop distribution taken from Dane and Bachman (1965).

D4535. Center of north line of SW' sec. 11, T. 23 N., R. 1 W. From yellowish-orange-weathering limestone concretions. Landis and Cobban, 1964.

Didymoceras sp.

D5103. SE 1/4 NE 1/4 sec. 28, T. 26 N., R. 1 E. Float probably from a limestone concretion higher than D5102. Cobban, 1965.

Anapachydiscus sp.

D5104. SE 1/4 NE 1/4 sec. 28, T. 26 N., R. 1 E. From small orange-weathering sandy limestone concretions 70 feet above D5102. Cobban, 7/16/65.

Baculites scotti Cobban

Zone of *Didymoceras nebrascense*

D4078. SE 1/4 NW 1/4 sec. 11, T. 23 N., R. 1 W. From gray-weathering limestone concretions. G. R. Scott and family, 1963; Dane, Landis, and Cobban, 1963.

Inoceramus aff. /. *turgidus* Anderson
Baculites pseudovatus Elias?
Didymoceras nebrascense (Meek and Hayden)

D4533. Near center of SW % sec. 9, T. 25 N., R. 1 E. From orange-brown-weathering limestone concretions. Cobban, 1964.

Didymoceras nebrascense (Meek and Hayden)

D4834. SW 1/4 SW % sec. 29, T. 25 N., R. 1 E. From yellowish-gray-weathering limestone concretions about 50-100 feet below top. J. E. Fassett and J. S. Hinds, 1965.

Didymoceras nebrascense (Meek and Hayden)

D5107. SE SW 1/4 sec. 29, T. 25 N., R. 1 E. From silty limestone concretions. Dane and Cobban, 1965.

Inoceramus aff. I. *turgidus* Anderson
Didymoceras nebrascense (Meek and Hayden)

D5108. NE 1/4 NW'/ sec. 8, T. 24 N., R. 1 E. From gray-weathering nodular limestone concretions. Cobban, 1965.

Inoceramus aff. I. *turgidus* Anderson
Didymoceras nebrascense (Meek and Hayden)

D5109. SE 1/4 NE 1/4 sec. 20, T. 24 N., R. 1 E. From gray- and brown-weathering silty limestone concretions. Landis and Cobban, 1965.

Inoceramus aff. I. *turgidus* Anderson
Didymoceras nebrascense (Meek and Hayden)

D5320. Center of sec. 8, T. 24 N., R. 1 E. About same stratigraphic level as D5108. Dane and Landis, 1966.

Inoceramus aff. /. *turgidus* Anderson
Didymoceras nebrascense (Meek and Hayden)

Zone of *Exiteloceras jenneyi*

D5081. SE % SW 1/4 sec. 7, T. 27 N., R. 1 E. From silty limestone concretions. Dane, Landis, and Cobban, 1963.

Exiteloceras jenneyi (Whitfield)

D5082. NW % SE 1/4 sec. 6, T. 26 N., R. 1 E. From small gray-weathering silty limestone concretions 247 feet below cliff of sandstone of Animas Formation. Cobban, 1965.

Exiteloceras jenneyi (Whitfield)

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D5085. NW 1/4 SE 1/4 sec. 6, T. 26 N., R. 1 E. Float about 40-50 feet above D5082. Cobban, 1965.

Exiteloceras jenneyi (Whitfield)

D5097. NW NW 1/4 sec. 30, T. 27 N., R. 1 E. From silty limestone concretions. Cobban, 1965.

Exiteloceras jenneyi (Whitfield)

D5117. SW % NW 1/4 sec. 36, T. 32 N., R. 2 W. From small gray-weathering limestone concretions 350 feet below top. Cobban, 1965.

Exiteloceras jenneyi (Whitfield)

D5118. SW 1/4 NW 1/4 sec. 36, T. 32 N., R. 2 W. From ironstone concretions and orange-weathering limestone concretions 264 feet below top. Cobban, 1965.

Baculites rugosus Cobban

D5121. NE 1/4 SW % sec. 36, T. 32 N., R. 2 W. From orange- and red-weathering limestone and ironstone concretions. Cobban, 1965.

Baculites rugosus Cobban
Exiteloceras jenneyi (Whitfield)

Zone of *Didymoceras cheyennense*

D4151. NW 1/4 NW 1/4 sec. 33, T. 31 N., R. 1 W. From gray-weathering limestone concretions. Landis, 1963; Landis and Cobban, 1965.

Inoceramus vanuxemi Meek and Hayden
Inoceramus aff. I. *pertenuis* Meek and Hayden
Baculites aff. *B. rugosus* Cobban

D4536. Near center of SW 1/4 sec. 7, T. 27 N., R. 1 E. From gray- and brown-weathering silty limestone concretions. Dane, Landis, and Cobban, 1964.

Inoceramus vanuxemi Meek and Hayden
Inoceramus aff. I. *pertenuis* Meek and Hayden
Baculites aff. *B. rugosus* Cobban
Hoploscaphites nodosus (Owen)

D5087. Center of W 1/2 NW 1/4 sec. 11, T. 29 N., R. 1 W. From gray-weathering limestone concretions. Landis and Cobban, 1965.

Inoceramus vanuxemi Meek and Hayden
Inoceramus aff. I. *pertenuis* Meek and Hayden
Baculites aff. *B. rugosus* Cobban
Didymoceras cheyennense (Meek and Hayden)

D5094. SE 1/4 NE 1/4 sec. 26, T. 28 N., R. 1 W. About 145 feet below top. Dane, Landis, and Cobban, 1963.

Inoceramus aff. I. *pertenuis* Meek and Hayden
Didymoceras cheyennense (Meek and Hayden)

D5095. Near center of east line of SE 1/4 sec. 26, T. 28 N., R. 1 W. Same stratigraphic level as D5094. Dane and Cobban, 1963.

Inoceramus vanuxemi Meek and Hayden
Baculites aff. *B. rugosus* Cobban

D5098. NE 1/4 NW 'A sec. 26, T. 29 N., R. 1 W. From gray-weathering limestone concretions. Cobban, 1965.

Anomia tellinoides Morton
Baculites aff. *B. rugosus* Cobban

D5114. NW 1/4 NW sec. 36, T. 32 N., R. 2 W. Float from about 180 feet below top. Cobban, 1965.

Ostrea plumosa Morton
Didymoceras cheyennense (Meek and Hayden)

D5116. NW 1/4 NW 1/4 sec. 36, T. 32 N., R. 2 W. From limestone concretions 110 feet below top. Landis and Cobban, 1965.

Inoceramus vanuxemi Meek and Hayden
Anomia argentaria Morton
Baculites aff. *B. rugosus* Cobba n

D5119. SW 1/4 NW 1/4 sec. 36, T. 32 N., R. 2 W. F om limestone concretions 223 feet below top. Landis and Cobban, 1965.

Baculites n. sp.

Zone of *Baculites compressus?*

D4537. SE 1/4 SE 1/4 sec. 25, T. 32 N., R. 2 W. From uppermost part. Dane, 1964.

Inoceramus sagensis Owen
Placenticeras sp.

D5120. SW 1/4 NW 1/4 sec. 36, T. 32 N., R. 2 W. From a limestone concretion 29 feet below top. Landis, 1965.

Placenticeras meek! Boehm

AMMONITE ZONES IN UPPER PART OF LEWIS SHALE

Figure 2 shows how we believe the upper part of the Lewis Shale thins southward by a decrease in original thickness and by a drop in age of the uppermost beds. This diagrammatic cross section, from north to south along the eastern edge of the San Juan Basin, was constructed by projecting to the outcrop area the isopachs of Fassett and Hinds (1971, fig. 7) subsurface interval for the sequence from the Huerfanito Bentonite Bed to the top of the Pictured Cliffs Sandstone. An arbitrary thickness of 100 feet (30 m) was assigned by us to the Pictured Cliffs Sandstone in the few places where it crops out. Fassett and Hinds (1971, pl. 1) showed the Pictured Cliffs cropping out only in the Dulce area, in the Boulder Lake-Stinking Lake area, and possibly in the Llaves area. In the intervening areas, nonmarine Upper Cretaceous or Tertiary rocks rest unconformably on the Lewis. Hence, in Figure 2,

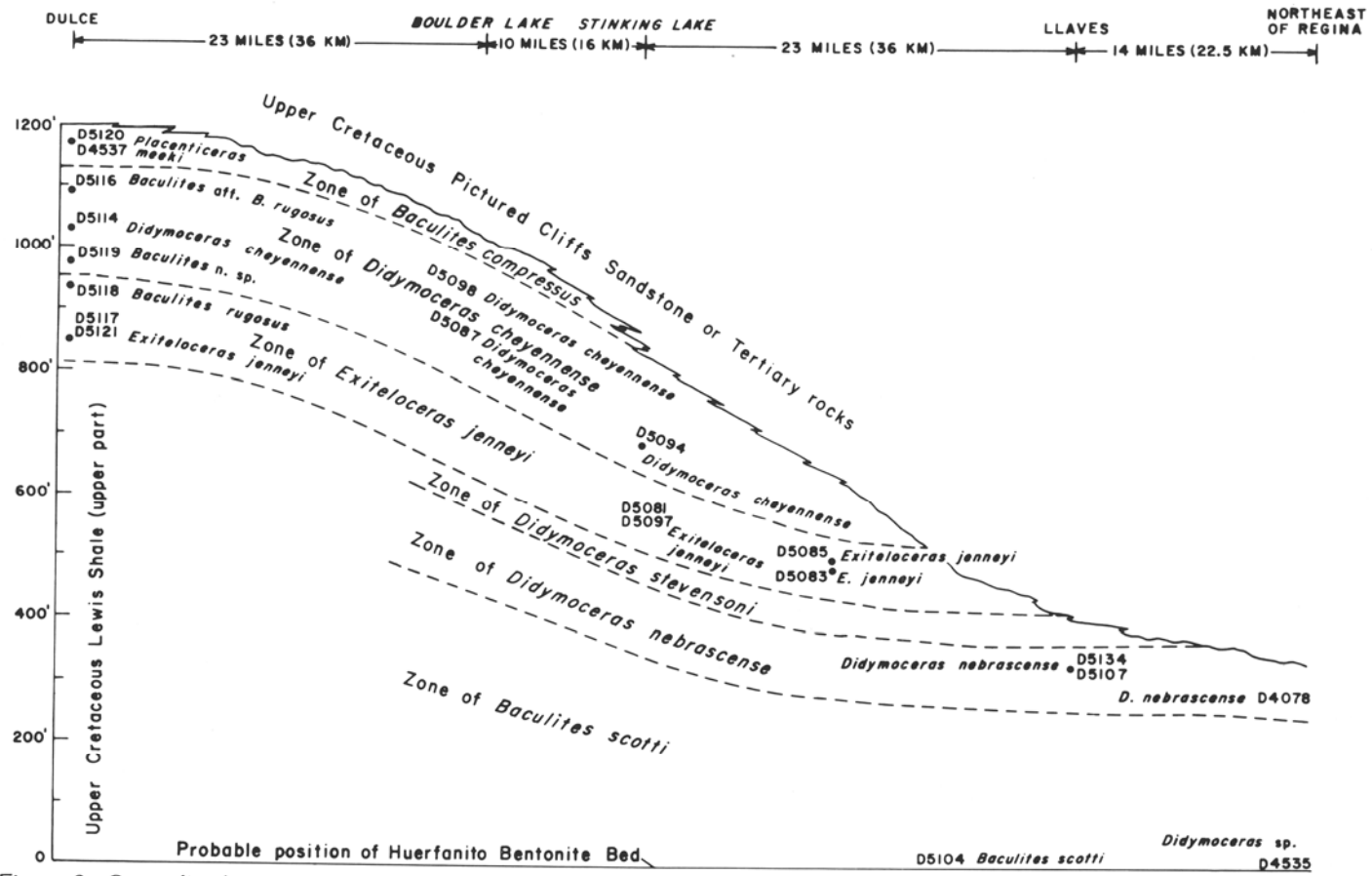

Figure 2. Generalized cross section of the upper part of the Lewis Shale between Dulce and Regina showing ammonite zones and occurrences of important fossil collections. (Each collection that can be related in feet to the top of the Lewis Shale is indicated by an X preceding the U.S. Geological Survey Mesozoic locality number.)

the top of the Lewis is shown as an interfingering contact where overlain by the Pictured Cliffs Sandstone, and as an unconformable contact where overlain by post-Pictured Cliffs rocks.

At Dulce, where many collections of fossils can be closely related to the top of the Lewis Shale, *Exiteloceras jenneyi* occurs 350 feet (107 m) below the top of the Lewis, and *Baculites rugosus,* which is restricted to the zone of *E. jenneyi,* occurs 264 feet (80 m) below the top. Consequently, the zone of *E. jenneyi* is at least 86 feet (26 m) thick. The *Baculites* aff. *B. rugosus* and the *B.* n. sp., both higher in the section, are undescribed species that seem to be restricted elsewhere to the zone of *Didymoceras cheyennense.* Accordingly, the zone of *D. cheyennense* is at least 115 feet (35 m) thick, and it may be nearly 200 feet (61 m). The uppermost collections, containing *Placenticeras meeki,* are questionably assigned to the zone of *Baculites compressus.* One of these collections (D4537) includes *Inoceramus sagensis,* a common associate of *B. compressus* in the Great Plains area.

In the Llaves-Regina area, 50-70 miles (80-113 km) south of Dulce, *Didymoceras nebrascense* has been found within 100 feet (30 m) of the top of the Lewis. The thickness of the zone of *Didymoceras nebrascense* along the east edge of the San Juan Basin was not determined by us. The nearest control point is Pueblo, Colorado, where the zone is 100 feet (30 m) thick (Scott, 1964). In the Llaves area the Huerfanito Bentonite Bed of the Lewis Shale lies about 400 feet (122 m) or less below the top of the Lewis, according to the projected isopachs of Fassett and Hinds (1971, fig. 7). Allowing about 100 feet (30 m) for the thickness of the *D. nebrascense* zone, the next older zone of *Baculites scotti* is possibly between 200 and 300 feet (61 and 91 m) thick. This zone is probably much thicker, perhaps as much as 600 feet (183 m), in the Dulce area (Fig. 2). The zone of *B. scotti* is consistently thick in eastern Colorado; it is more than 500 feet (152 m) thick at Pueblo (Scott, 1964) and 700 feet (213 m) thick near Boulder (Scott and Cobban, 1965).

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