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STRATIGRAPHY AND BIOSTRATIGRAPHY OF AN UPPER CRETACEOUS OUTLIER NEAR ROY, HARDING COUNTY, NEW MEXICO

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Abstract.—Upper Cretaceous strata exposed as outliers near Roy in Harding County, New Mexico, are assigned to the Graneros Shale and the overlying Greenhorn Formation. The Greenhorn Formation locally consists of three members (in ascending order): Lincoln, Hartland, and Bridge Creek. The Lincoln Member is 8.3 m thick and dominated by yellowish gray and very pale orange calcareous shale and characteristic persistent beds of calcarenite. The Hartland Member is 11.0 m thick and consists mostly of medium and brownish gray bentonitic shale. The Bridge Creek Member here is erosionally truncated by the Neogene Ogallala Formation 4.1 m above its base and consists of interbeds of ledge-forming limestone and calcareous shale. Fossils from the Lincoln Member include numerous specimens of the bivalve *Ostrea beloiti* Logan and of the selachian *Ptychodus anonymus* Williston. The Hartland Member lacks biostratigraphically significant fossils. The Bridge Creek Member produces the ammonites *Euomphaloceras* sp. and *Sciponoceras gracile* (Shumard) near its base and *Watinoceras coloradoense* (Henderson) and *Vascoceras birchbyi* Cobban and Scott near its top. These fossils can be assigned to the upper Cenomanian *Sciponoceras gracile* ammonite zone and the lower Turonian *Vascoceras birchbyi* ammonite zone. Younger ammonite zones normally present in the Bridge Creek Member are not present at Roy, having been stripped off by Neogene erosion.

INTRODUCTION

Wanek (1962) mapped Upper Cretaceous strata along the edge of the Canadian Escarpment west and northwest of Roy in T20N, R25-26E, Harding County, New Mexico (Fig. 1). He assigned these strata to the Graneros Shale ("chiefly black fissile marine shale containing thin beds of dark brown-gray limestone," no thickness given) and the Greenhorn Limestone ("thin interbeds of marine limestone and shale and is 35 feet thick").

Subsequent statewide maps by Dane and Bachman (1965) and Clemons (1982) have indicated that the Upper Cretaceous strata near Roy are continuous with Graneros and Greenhorn strata to the north. However, the outcrops near Roy are actually isolated outliers, largely covered in the subdued local topography (Fig. 2). As no data beyond those provided by Wanek (1962) are available, we describe the lithostratigraphy and biostratigraphy of the best exposed Upper Cretaceous outlier near Roy, which is in sec. 12, T20N, R25E (Figs. 1, 2). Here, NMMNH refers to the New Mexico Museum of Natural History and Science, Albuquerque.

LITHOSTRATIGRAPHY

Wanek (1962) correctly assigned Upper Cretaceous strata exposed near Roy to the Graneros Shale and Greenhorn Limestone. The Graneros Shale, however, is so poorly exposed in this area that little can be said about it other than: (1) it conformably (?) overlies ledge-forming quartzarenite sandstone of the Romeroville Sandstone of the Dakota Group; (2) its estimated thickness is about 20 m; and (3) it consists primarily of dark gray, light brownish gray and grayish orange shale with minor, thin (<0.3 m) interbeds of calcarenite, siltstone and airfall bentonitic ash. Near Roy, the Graneros Shale forms covered slopes and plains.

The Greenhorn Formation conformably overlies the Graneros Shale near Roy and consists of three members (ascending): Lincoln, Hartland and Bridge Creek (Figs. 1, 2). Total Greenhorn thickness is approximately 23 m, but this is not a complete thickness as the top of the Bridge Creek Member has been removed by Neogene erosion (Fig. 1).

The Lincoln Member is 8.3 m thick and consists of a few persistent ledges of very pale orange calcarenite and several thin bentonite beds in slopes of yellowish gray and very pale orange calcareous shale. We pick the base of the Lincoln Member at a prominent calcarenite ledge full of shell debris of inoceramid bivalves, numerous valves of the small oyster *Ostrea beloiti* Logan and occasional sharks' teeth. This bed is 1.6 m above a prominent bentonite (correlated to the "x bentonite") in the uppermost Graneros Shale. We identify the top of the Lincoln Member as the highest persistent calcarenite ledge below slope-forming, bentonitic shale of the Hartland Member (Fig. 1).

Near Roy, the Hartland Member is 11.0 m thick and consists mostly of medium gray and yellowish gray bentonitic shale that includes three distinctive bentonites. Each of these bentonites is mottled yellowish gray, dark yellowish orange and very pale orange.

The base of the Bridge Creek Member is the first persistent ledge of light gray to very pale orange dense fossiliferous limestone. At least 4.1 m of Bridge Creek Member are present near Roy, and these strata are interbeds of ledge-forming limestone and medium-gray calcareous shale. Calcrete of the Neogene Ogallala Formation unconformably overlies the Bridge Creek Member.

PALEONTOLOGY

Fossils are present in virtually all of the calcarenite and limestone beds of the Greenhorn Formation near Roy. However, we collected identifiable and biostratigraphically significant fossils from only three beds: (1) NMMNH locality 4618, in the basal calcarenite of the Lincoln Member at UTM 569352E, 3980960N (Zone 13, NAD 27); (2) NMMNH locality 4619, in the lower part of the Bridge Creek Member at UTM 569670E, 3980844N (Zone 13, NAD 27); and (3) NMMNH locality 4620, near the top of the preserved Bridge Creek section at UTM 569304E, 3980533N (Zone 13, NAD 27) (Fig. 1). Fossils from these localities are of bivalves, ammonites and selachian teeth.

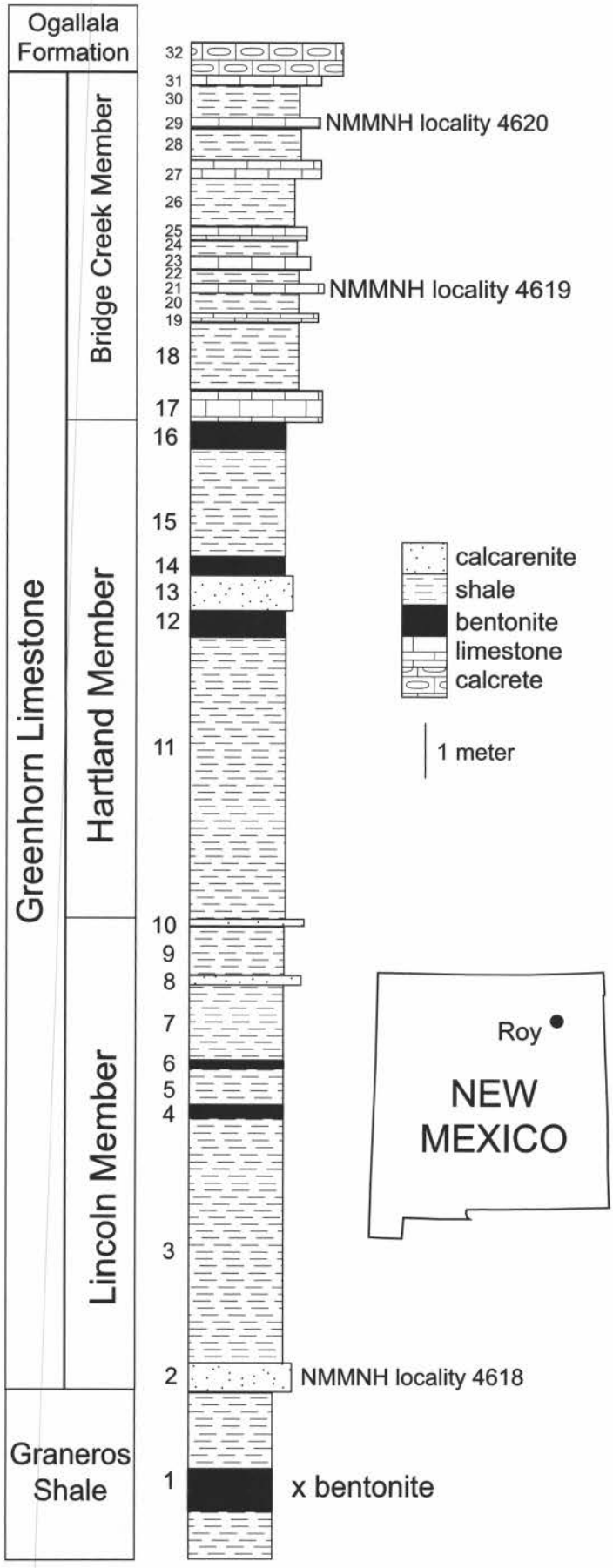

FIGURE 1. Measured section of the Greenhorn Formation near Roy, Harding County, New Mexico. See the Appendix for description of the numbered lithologic units.

Bivalves

We collected both oysters and inoceramids from the Greenhorn strata near Roy. The oysters (Fig. 3A-B) are from the basal Lincoln Member calcarenite and have small, irregularly convex valves that often show linear, closely set denticles around the inner shell margin. They are readily assigned to *Ostrea beloiti* Logan (cf. Hattin, 1975, pl. 2b-e; Kauffman et al., 1977, p. 92, pl. 8; Lucas et al., 2000, figs. 4A-B).

Inoceramids are abundant in the upper part of the Bridge Creek Member (locality 4620) and are mostly *Mytiloides* (Fig. 3C-D). Most common are specimens of *M. puebloensis* Walaszczyk and Cobban. These specimens have a slightly convex growth axis, maximum inflation at the umbo, a very small posterior auricle and regular rugae with rounded edges, separated by evenly spaced microrugae (cf. Kennedy et al., 2000, p. 321, pls. 6-8, 10). Some small inoceramids from locality 4620 have single rugae in the juvenile stage (Fig. 3D), so we tentatively refer them to *Mytiloides goppelnensis* Badillet and Sornay (cf. Kennedy et al., 2000, p. 323, pls. 9-10).

Ammonites

Ammonites are abundant as chalky molds and casts at NMMNH localities 4619 and 4620 (Fig. 3). Numerous specimens from locality 4619 (e.g., Fig. 3E) are readily assigned to *Euomphaloceras* sp. (cf. Cobban and Scott, 1972, p. 70-71, pls. 4, 5). These fairly evolute ammonites have straight, rectiradiate to prorsiradiate ribs. They have two tubercles on each rib, and the ribs are closely spaced and alternate as primaries and secondaries. One strong tubercle is on the ventrolateral shoulder, and the second is at the umbilicus. All specimens we collected are small, inner whorls, so we refrain from assigning them to a species.

A second common ammonite taxon from locality 4619 is the heteromorph *Sciponoceras gracile* (Shumard) (Fig. 3F). This taxon has a straight shell with a subcircular cross section. The shell surface has prorsiradiate ribs, and no suture is preserved (cf. Cobban and Scott, 1972, p. 47, pl. 17; Hattin, 1975, pl. 6).

The most common ammonite at NMMNH locality 4620 can be assigned to *Vascoceras (Greenhornoceras) birchbyi* Cobban and Scott (Fig. 3G-H). These subglobose ammonites are moderately involute with a deep umbilicus and have an essentially smooth body chamber. There are strong ribs and umbilical tubercles on the later inner whorls (cf. Cobban and Scott, 1972, p. 85, pls. 22-25).

A less common ammonite from locality 4620 is *Watinoceras coloradoense* (Henderson) (Fig. 3I-J). These are relatively large (diameter ~80 mm), moderately involute with a steep umbilical wall and have strong, rectiradiate ribs, each with a bullate umbilical tubercle, a clavate lower ventrolateral tubercle and a clavate upper ventrolateral tubercle that is the largest of the three tubercles (cf. Cobban and Scott, 1972, p. 76, pls. 27-28).

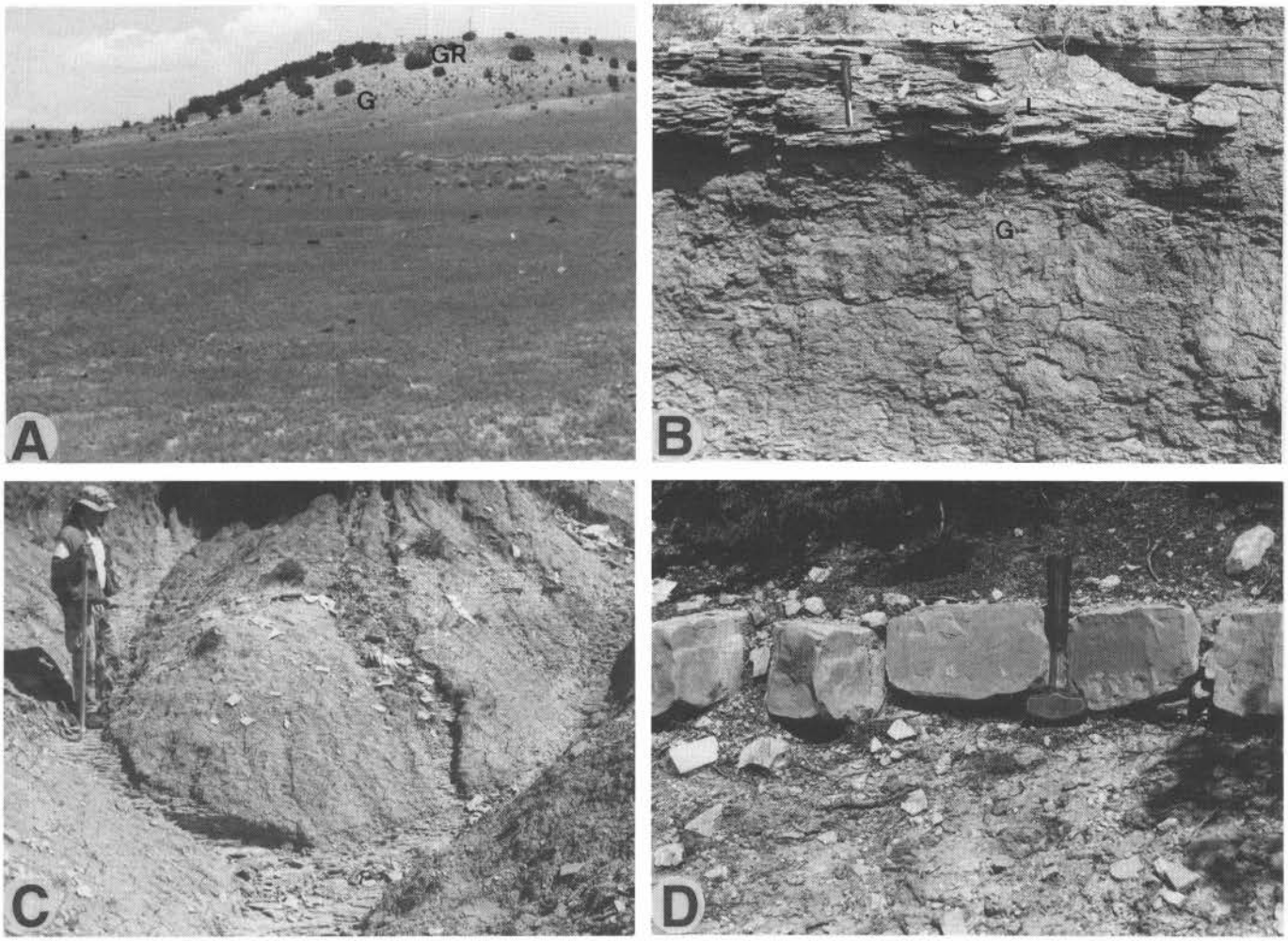

FIGURE 2. Selected Upper Cretaceous outcrops near Roy, Harding County. A. Overview of Graneros Shale (G) and Greenhorn Formation (GR) outcrop along border of secs. 12 and 13, T20N, R25E. B. Basal *Ostrea beloiti*-bearing calcarenite bed of Lincoln Member of Greenhorn Formation (L) above Graneros Shale (G) (bed 2 of measured section in Figure 1). C. Typical calcareous shale and thin calcarenite of Hartland Member of Greenhorn Formation (beds 11-12 of measured section in Figure 1). D. Characteristic limestone bed of Bridge Creek Member of Greenhorn Formation (bed 23 of measured section in Figure 1).

Selachian Teeth

Selachian teeth from the basal calcarenite of the Lincoln Member at NMMNH locality 4618 resemble those described by Lucas et al. (2000) from the same unit in Quay County, New Mexico. Near Roy, the most common teeth are of *Ptychodus anonymus* Williston. These teeth are relatively small, have a weakly conical high cusp, fine transverse ridges and a gentle transition between the cusp and granular marginal area. *P. anonymus* is a common Cenomanian and Turonian taxon (Welton and Farish, 1993, p. 57).

BIOSTRATIGRAPHY

Ammonites from the Bridge Creek Member of the Greenhorn Formation near Roy identify two of the ammonite zones characteristic of that unit elsewhere (e.g., Kennedy et al., 2000), the uppermost Cenomanian *Sciponoceras gracile* zone and the earliest Turonian *Vascoceras birchbyi* zone. Therefore, the Cenomanian-Turonian boundary is between localities 4619 and 4620 in the Bridge Creek Member near Roy. The younger ammonite zones normally present in the Bridge Creek Member—*Mammites nodosoides* and *Collignoniceras woollgari* zones—are not present at Roy, having been stripped off by Neogene erosion.

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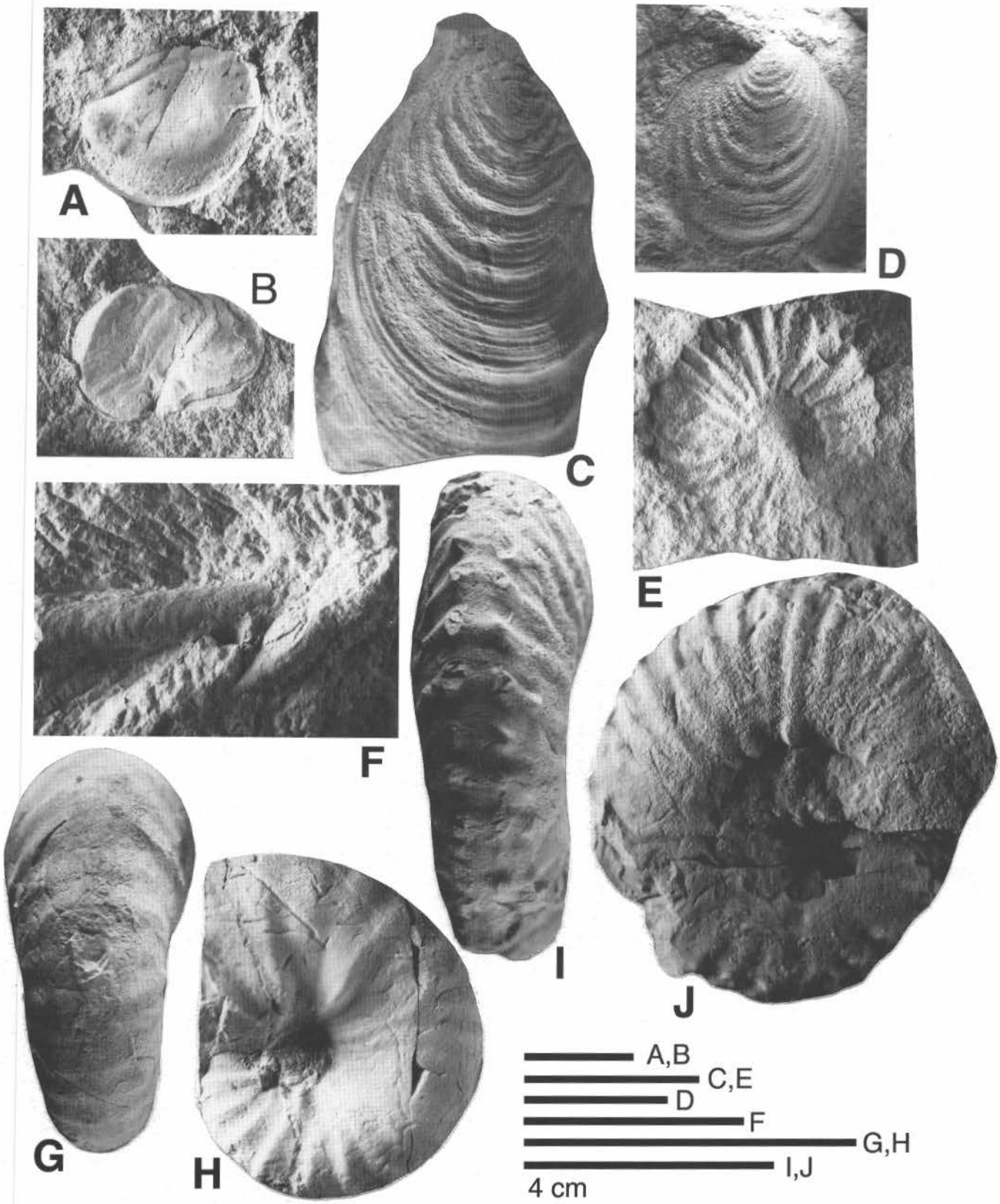

FIGURE 3. Selected fossils from the Greenhorn Formation near Roy, New Mexico. A-B. *Ostrea beloiti* Logan, NMMNH P-33150 from locality 4618. C. *Mytiloides puebloensis*, NMMNH P-33159 from locality 4620. D. *Mytiloides goppelnensis*, NMMNH P-33161 from locality 4620. E. *Euomphaloceras* sp., NMMNH P-33154 from locality 4619. F. *Sciponoceras gracile* (Shumard), NMMNH P-33152 from locality 4619. G-H. *Vascoceras* (*Greenhornoceras*) *birchbyi* Cobban and Scott, NMMNH P-33162 from locality 4620. I-J. *Watinoceras coloradoense*, NMMNH P-33157 from locality 4620.

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APPENDIX—DESCRIPTION OF MEASURED SECTION

Stratigraphic section measured in two segments. Base of the first segment (unit 1) is at UTM 569352E, 3980960N, ending with unit 17 at UTM 569571E, 3980813N. The second segment begins with unit 18 at UTM 569257E, 3980494N and ends at 569300E, 3980495N. All UTM coordinates are in zone 13, NAD27. Rock colors follow Goddard et al. (1984). Section measured 8 July, 2000.

unit	lithology	thickness (m)
Ogallala Formation:		
32	White and red calcrete.	**Not measured**
unconformity		
Greenhorn Formation: Bridge Creek Member:		
31	Limestone, same color and lithology as unit 21.	**0.1**
30	Shale; calcareous; mostly covered.	**0.7**
29	Limestone, same color and lithology as unit 21; NMMNH locality 4620.	**0.1**
28	Shale; calcareous; mostly covered.	**0.6**
27	Limestone, same color and lithology as unit 21. Stratigraphic horizon of NMMNH locality 4620.	**0.2**
26	Shale; calcareous; mostly covered.	**0.9**
25	Limestone, same color and lithology as unit 21.	**0.3**
24	Shale; calcareous; mostly covered.	**0.3**
23	Limestone, same lithology as unit 21. Stratigraphic horizon of NMMNH locality 4619.	**0.1**
22	Shale, same lithology as unit 20.	**0.2**
21	Limestone; light greenish gray (5GY8/1) to light gray (N7); NMMNH locality 4619.	**0.1**
20	Shale; calcareous; mostly covered.	**0.4**
19	Limestone, bioclastic; yellowish gray (5Y8/1) to very pale orange (10YR8/2).	**0.1**
18	Shale and calcarenite; shale medium gray (N5) and calcareous; calcarenite is grayish orange (10YR7/4).	**1.2**
17	Limestone; light gray (N7) to very pale orange (10YR8/2); forms a ledge.	**0.4**
Greenhorn Formation: Hartland Member:		
16	Bentonite.	**0.5**
15	Silty shale; grayish orange (10YR7/4); calcareous; bentonitic.	**1.9**
14	Bentonite.	**0.2**
13	Calcarenite; pale yellowish brown (10YR6/2) and yellowish gray (5Y8/1); clasts are shell hash.	**0.7**
12	Bentonite.	**0.1**
11	Calcareous shale; mostly covered.	**6.0**
Greenhorn Formation: Lincoln Member:		
10	Calcarenite; same color and lithology as unit 8.	**0.1**
9	Shale, same colors and lithology as unit 5.	**0.8**
8	Calcarenite; very pale orange (10YR8/2); calcareous.	**0.8**
7	Shale, same colors and lithology as unit 5.	**1.5**
6	Bentonitic claystone; mottled yellowish gray (5Y8/1), dark yellowish orange (10YR6/6) and very pale orange (10R8/2); calcareous.	**0.1**
5	Shale; yellowish gray (5Y8/1) and very pale orange (10YR8/2); calcareous.	**0.7**
4	Bentonitic claystone; mottled yellowish gray (5Y8/1), dark yellowish orange (10YR6/6) and very pale orange (10R8/2); calcareous.	**0.1**
3	Shale; mostly covered.	**4.5**
2	Calcarenite; very pale orange (10R8/2); laminated; locally coquinoid; forms a ledge; NMMNH locality 4618.	**0.4**
Graneros Shale:		
1	Shale and siltstone, pale yellowish brown (10YR6/2); shale is very calcareous; includes 0.9-m-thick bentonite bed (x bentonite) about 1.6 m below top of unit.	**3.0+**

The spillway at Clayton Lake in Union County exposes sandstone and siltstone beds in the Lower Cretaceous Mesa Rica and Pajarito formations that are covered with dinosaur tracks. Here, volunteers from the New Mexico Museum of Natural History are working on a map of the tracksite.