



## ***Turonian ammonites from the Upper Cretaceous D-Cross Member of the Mancos Shale, Cebollita Mesa, Cibola County, New Mexico***

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# TURONIAN AMMONITES FROM THE UPPER CRETACEOUS D-CROSS MEMBER OF THE MANCOS SHALE, CEBOLLITA MESA, CIBOLA COUNTY, NEW MEXICO

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**ABSTRACT.**—At Cebollita Mesa southeast of Grants in Cibola County (T6N, R10W), the D-Cross Member of the Mancos Shale is ~50 m thick and is underlain by the Tres Hermanos Formation and overlain by the Gallup Sandstone. We collected the following ammonoids from the D-Cross Member: *Prionocyclus wyomingensis* Meek, *Coilopoceras inflatum* Cobban and Hook, *Scaphites ferronensis* Cobban and *Prionocyclus novimexicanus* (Marcou). *P. wyomingensis* is fairly common from near the base of the D-Cross to up to ~10 m above its base. *C. inflatum* is common and is restricted to the lowermost 5-6 m of the D-Cross Member. This is the first confirmed report of *P. wyomingensis* associated with *C. inflatum* in the D-Cross Member at Cebollita Mesa. The adult robust specimens of *C. inflatum* are characterized by a distinctive inflated appearance with a prominently ribbed shell possessing radial swellings; all but one specimen collected at Cebollita Mesa are the robust form of *C. inflatum*. *S. ferronensis* is locally abundant in the D-Cross Member of the Mancos Shale at Cebollita Mesa, and specimens are clustered in small concretions low in the section, ~8 m above the base of the D-Cross. *P. novimexicanus* is fairly common in the D-Cross Member at Cebollita Mesa and occurs throughout most of the D-Cross Member's thickness, from ~10 m above its base to up to ~9 m below the D-Cross-Gallup contact. *Scaphites whitfieldi* Cobban has not been recovered by us from the D-Cross at Cebollita Mesa, but the middle-upper part of the member there should be in that zone. Likewise, *Scaphites warreni* Meek and Hayden has not been recovered by us from this section, but the lower part of the D-Cross Member there should be in that zone. Ammonoid distribution in the D-Cross Member at Cebollita Mesa is concentrated in three intervals and provides a better range zone biostratigraphy than an assemblage zone biostratigraphy.

## INTRODUCTION

At Cebollita Mesa southeast of Grants in Cibola County, New Mexico, strata of the D-Cross Member of the Mancos Shale yield Turonian ammonoids from several stratigraphic levels (Fig. 1). Previous reports on the ammonoid biostratigraphy of the D-Cross Member at Cebollita Mesa (e.g., Hook et al., 1983) did not provide detailed documentation of the ammonoid faunas. We provide such detailed documentation here, based on recent collecting and stratigraphic study. This documentation confirms the overall conclusions of Hook et al. (1983) and further refines the ammonoid biostratigraphy of the D-Cross Member at Cebollita Mesa.

NMMNH refers to the New Mexico Museum of Natural History, Albuquerque. All measurements are in millimeters; U = umbilical diameter, Wh = whorl height, and Wb = whorl breadth. For measurement of *Scaphites* we follow Crick (1978, p. 6): Dg = maximum diameter of conch, Ds = minimum diameter of conch and WW = whorl width at base of body chamber.

## LOCALITIES AND STRATIGRAPHY

Pike (1947, p. 71-74) first presented a measured section and listed several fossil localities from strata he termed the "Pescado Tongue of the Mancos Shale" at Cebollita Mesa. The name D-Cross Tongue was proposed by Dane et al. (1957) for the shale member of the Mancos underlying the Gallup Sandstone in west-central New Mexico and thus encompassed the strata Pike termed Pescado. Cobban (1951, p. 23-24) mentioned *Scaphites ferronensis* occurring at "Cebolleta" (Cebollita) Mesa, and Cobban and Hook (1980, p. 4, 19) listed fossil localities at Cebollita Mesa and described the holotype of *Coilopoceras inflatum*, which was collected there.

Hook et al. (1983, sheet 1) described a section at Cebollita Mesa (their section 56A in the SE1/4 sec. 17 and NW1/4 sec. 21,

T6N, R10W) similar to ours and reported *Coilopoceras inflatum* from near the base of the D-Cross, *Scaphites warreni* and *S. ferronensis* a few meters higher and *Prionocyclus novimexicanus* in the middle of the member. Although Hook et al. (1983, sht. 1) listed *Scaphites whitfieldi* Cobban and *Scaphites warreni* Meek and Hayden in their measured section at Cebollita Mesa, they have not been recovered by us from there.

Our collecting confirms that the collignoniceratid zones of *Prionocyclus wyomingensis* and *Prionocyclus novimexicanus* and the standard zone of *Scaphites ferronensis* are present in the D-Cross Member of the Mancos Shale on the southwest side of Cebollita Mesa at NMMNH localities 4701-4704 and 5170-5176, all located in sections 17, 21, 34, T6N, R10W and section 7, T5N, R10W. We measured two complete sections of the D-Cross Member of the Mancos Shale at these locations (Fig. 1).

At these sections (Fig. 1), the D-Cross Member is 48 to 52 m thick. Most of the unit (95% of the measured sections) is gray to grayish black shale; some shale beds have numerous yellowish brown to dark yellowish orange, sandy limestone concretions. A minor component of the D-Cross Member is calcareous, ledge-forming sandstone. In general, the D-Cross section can be divided into four intervals (in ascending stratigraphic order): (1) lower 7-10 m of gray shale with numerous ammonoid-bearing limestone concretions; (2) overlying shale slope devoid of ammonoids; (3) a prominent, 1-2 m thick, medial sandstone ledge/bench; and (4) upper shale slope with sparse ammonoid-bearing concretions. Unit 1 belongs mostly to the *Prionocyclus wyomingensis* Zone; the base of the *P. novimexicanus* Zone is near the top of unit 1. Units 2-4 belong to the *P. novimexicanus* Zone.

Unit 3 is the sandstone unit Molenaar (1983) informally named "unit F," and is equivalent to a bed in the lower part of the Gallup Sandstone to the west. Below the sandstone, the lower shale interval of the D-Cross is equivalent to the Pescado Tongue of the Mancos Shale to the west. The shale above the sandstone

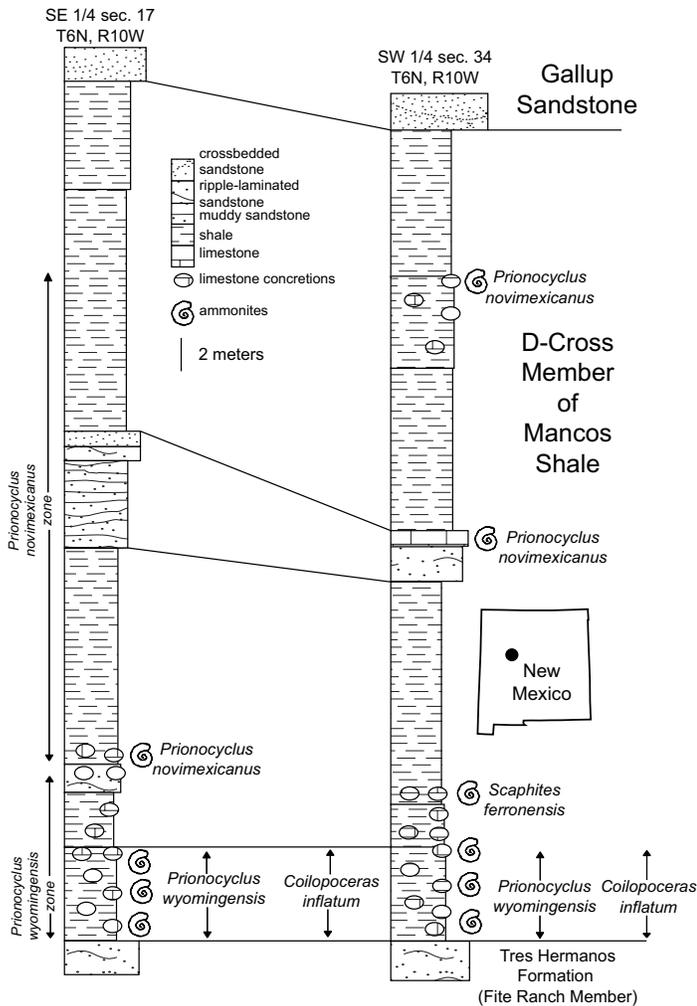


FIGURE 1. Index map and measured stratigraphic sections of the D-Cross Member of the Mancos Shale underlain by the Fite Ranch Sandstone Member of the Tres Hermanos Formation and overlain by the Gallup Sandstone on the southwestern side of Cebollita Mesa.

is equivalent to part of the lower Gallup Sandstone to the west. What we term the Gallup Sandstone (Fig. 1) thus is "unit E" of Molenaar's (1983) informal terminology of sandstone beds in the Gallup Sandstone.

## PALEONTOLOGY

### *Prionocyclus wyomingensis* Zone

#### *Prionocyclus wyomingensis* Meek, 1876

NMMNH P-36691 (Fig. 2A-B) from locality L-5176 is a fragment of a middle whorl section of an adult of *Prionocyclus wyomingensis*. It is semi-quadrangular in shape, with prominent prorsiradial ribs that are fairly widely spaced and curve forward after crossing the ventrolateral shoulder. The prominent primary ribs are separated by weak secondaries. The whorl section is compressed (higher than wide), but not as compressed as NMMNH P-33804, an equivalent whorl section of *P. novimexicanus* (see Fig. 4E-F). It also possesses bullate outer and nodate inner ven-

tro-lateral tubercles, long bullate umbilical tubercles, siphonal clavi and a fairly prominent keel. *P. wyomingensis* differs from *P. novimexicanus* in possessing a less compressed whorl section and by retaining the outer ventrolateral tubercles (Kennedy et al., 2001, p. 117). The suture pattern is poorly exposed. The dimensions of NMMNH P-36691 are Wh = 57.2 and Wb = 48.4.

*P. wyomingensis* is fairly common in the study area, sometimes in association with *C. inflatum*. *P. wyomingensis* was previously collected from Cebollita Mesa in association with *Scaphites warreni* and *Inoceramus dimidius* White (Cobban and Hook, 1980, p. 22). *P. wyomingensis* also occurs in the Juana Lopez Member of the Mancos Shale northeast of Thoreau, New Mexico (Cobban and Hook, 1989, p. 254), in the D-Cross Member at D-Cross Mountain (Hook et al., 1983, sht. 1), in the type section of the Juana Lopez Member northwest of Cerrillos, New Mexico (Hook and Cobban, 1980, p. 20-21) and at several other localities in New Mexico.

#### *Coilopoceras inflatum* Cobban and Hook, 1980

NMMNH P-36688 (not illustrated) from locality L-5171 is a relatively medium sized phragmocone, partially weathered and concreted, that is the robust form of *Coilopoceras inflatum*. The shell is inflated, and the venter is sharp on the inner whorl, becoming more broad toward the outer part of the whorl. It possesses distinct ribbing that is more closely spaced on the younger part of the whorl, with the older part possessing radial swellings that are more widely spaced and less distinct. On the younger portion, the primary ribs are separated by possibly four secondaries, but because of preservation this is difficult to discern. The suture is not well exposed. NMMNH P-36688 is 236 mm in diameter, at which Wh = 124.3, Wb = 71.6, and U = 18.6.

NMMNH P-36683 (Fig. 2C-D) from locality L-5174 is a fairly well preserved phragmocone that is not exceptionally robust but is assigned to the robust form of *C. inflatum*. It has secondary ribs separating the primaries, with all ribs possessing ventrolateral swellings on the younger part of the whorl. It possesses a sharp venter on the younger part of the whorl, with the outer part becoming less sharp. The ribs are rectiradial and become wider spaced swellings on the outer part of the whorl. The suture is not well exposed, but the lateral lobe appears to be bifid. NMMNH P-36683 is 193.4 mm in diameter, at which Wh = 113, Wb = 56.3 and U = 13.1.

A partially weathered medium sized, partly concreted phragmocone (NMMNH P-36684; Fig. 2E) from locality L-5173 is the robust form of *C. inflatum*. The shell is very stout and possesses rectiradial ribs on the younger portion, becoming prominent radial swellings on the older portion. *C. inflatum* differs from the stout form of *Coilopoceras colleti* Hyatt in having a more inflated whorl section (Cobban and Hook, 1980, p. 19-20). The venter is sharp on the younger part, possesses ventrolateral swellings, and then becomes much broader on the older part. The suture is difficult to discern. NMMNH P-36684 is 215.8 mm in diameter, at which Wh = 109.1, U = 19.8.

NMMNH P-36690 (Fig. 2F-H) from locality L-5176 is a fairly well preserved, laterally compressed inner whorl that was removed for study from a larger, robust and highly weathered partial specimen of *C. inflatum*. Part of a lateral side and part of the venter are crushed. It is lightly ribbed, with weak primaries

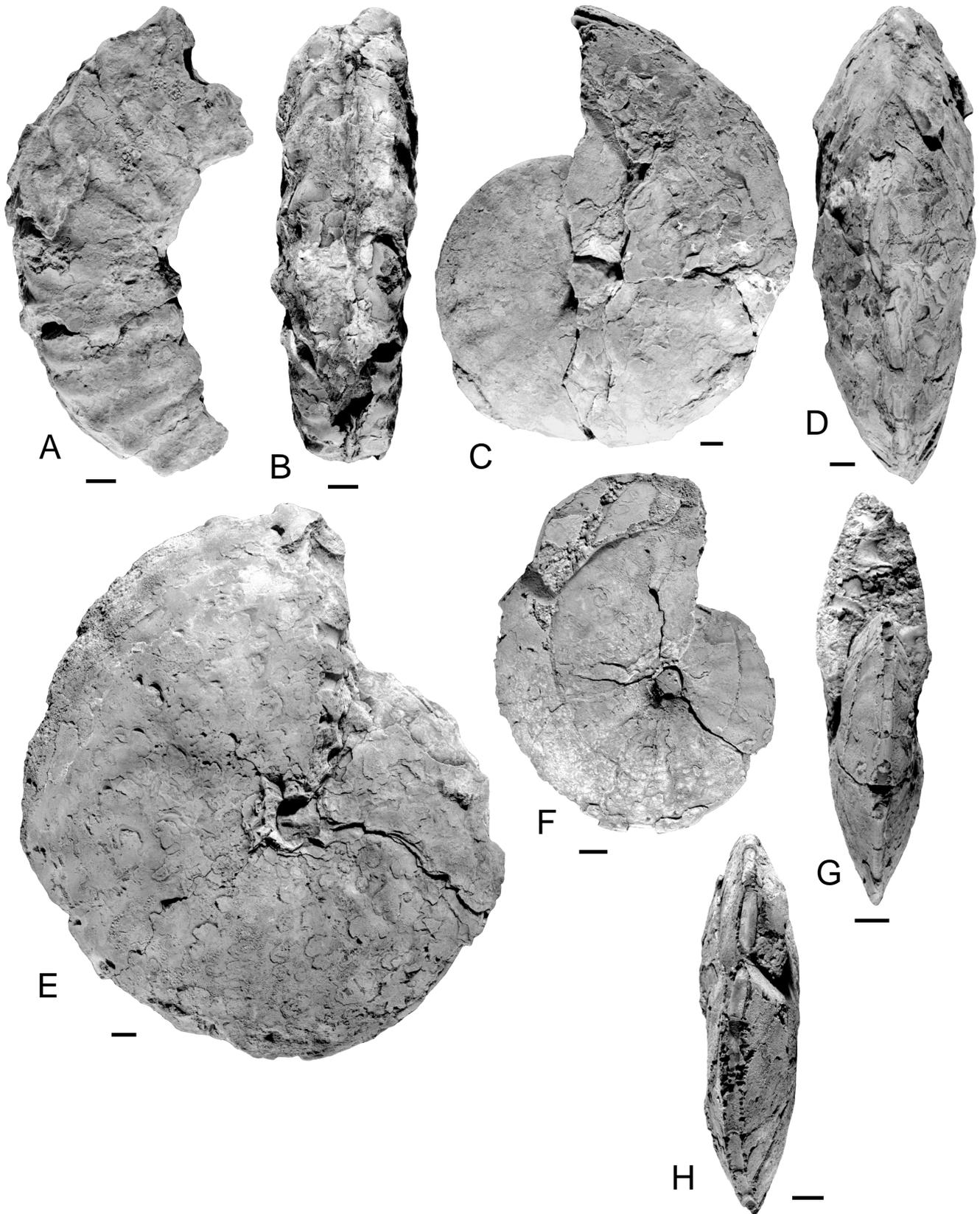


FIGURE 2. Ammonites from the *Prionocyclus wyomingensis* Zone in the D-Cross Member of the Mancos Shale at Cebollita Mesa. A-B. *Prionocyclus wyomingensis* Meek, lateral (A) and ventral (B) views of fragment of adult, NMMNH P-36691 from locality L-5176; C-D. *Coilopoceras inflatum* Cobban and Hook, lateral (C) and ventral (D) views of a not very robust juvenile, NMMNH P-36683 from locality L-5174; E. *Coilopoceras inflatum* Cobban and Hook, lateral view of very robust adult, NMMNH P-36684 from locality L-5173; F-H. *Coilopoceras inflatum* Cobban and Hook, lateral (F), anterior (G) and ventral (H) views of a slender inner whorl, NMMNH P-36690 from locality L-5176. Scale bars equal 1 cm.

and still weaker secondaries, and possesses a sharp venter. The umbilical tubercles are bullate and relatively strong, and the ventrolateral swellings are weak. A partial suture line reveals a bifid lateral lobe. NMMNH P-36690 is 116.3 mm in diameter, at which  $Wh = 61.6$ ,  $Wb = 33$  and  $U = 10.9$ .

*C. inflatum* is common in the study area, and we collected 12 specimens. The type specimen of *C. inflatum* was collected from the D-Cross Member of the Mancos Shale at the southern end of Cebollita Mesa in section 34 (Cobban and Hook, 1980, p. 4, 19, pl. 11). *C. inflatum* has also been reported occurring at the base of the D-Cross Tongue in the Oscura area in Lincoln County, New Mexico (Cobban, 1986, p. 81), at and near the base of the D-Cross Member at D-Cross Mountain (Cobban and Hook, 1980, p. 20), in the Carlile Member of the Mancos Shale (just below the base of the Juana Lopez Member) in the Rio Puerco Valley (Sealey and Lucas, 2000, p. 138, 141-142) and at several other localities in New Mexico.

#### ***Scaphites ferronensis* Cobban, 1951**

NMMNH P-36689 (Fig. 3A-C) from locality L-5175 is a fairly complete slender shell that is weathered on one side. The living chamber is relatively smooth, with widely spaced broad, weak ribs, and possesses, together with the phragmocone, moderately pronounced umbilical bullae. On internal molds of *Scaphites ferronensis* the curved portion of the living chamber possesses weak ribbing or can be entirely smooth (Cobban, 1951, p. 23). This is one feature that distinguishes *S. ferronensis* from *S. warreni*. The phragmocone possesses ribs that are dense and evenly spaced, but not as dense as in *Scaphites whitfieldi*. On the middle of the phragmocone, the primary ribs extend from the umbilicus to about halfway up the flank, where they split into two ribs with two secondaries between them. It possesses a pseudoceratitic suture that is simple, with short lobes and saddles that are weakly incised. NMMNH P-36689 was collected by Wright on February 6, 1980 for the New Mexico Bureau of Mines and Mineral Resources in Socorro, NM. It was collected "in section 34 from limestone concretions, 30-35 ft. above the base of the D-Cross Shale." The dimensions of NMMNH P-36689 are  $Dg = 35.2$  and  $Ds = 31.9$ .

NMMNH P-33819 (Fig. 3D-E) from locality L-4703 is a nearly complete, fairly well preserved, slender shell with body chamber imbedded in matrix. It possesses dense, evenly spaced ribs, but not as dense as in *S. whitfieldi*. *S. ferronensis* is distinguished from *S. warreni* in possessing much denser ribs on the venter of the living chamber (Cobban, 1951, p. 23). Primaries split mid-flank and are separated by one secondary. The straight part of the body chamber is less densely ribbed than the latter part of the phragmocone, but almost as densely ribbed as near the end of the body chamber. Fragments of suture show saddles that are typical of *S. ferronensis*. The dimensions of NMMNH P-33819 are  $Dg = 33.6$  and  $WW = 12.5$ .

A well preserved inner whorl of *S. ferronensis* (NMMNH P-36685; Fig. 3F-H) from locality L-5170 possesses fairly dense, evenly spaced ribbing that is denser than the inner whorls of *S. warreni*. The whorl is small and fairly robust and lacks umbilical bullae. The primaries split in two mid-flank and are divided by one secondary rib. The suture is poorly exposed. The dimension of NMMNH P-36685 is  $Dg = 23.7$ .

A fairly robust, complete, adult whorl of *S. ferronensis* (NMMNH P-36686; Fig. 3I-J) from locality L-5170, well preserved but weathered on one side, possesses fairly dense ribbing on the venter of the curved part of the living chamber and primaries with one or two secondaries between them on the phragmocone. NMMNH P-36686 has less dense and less evenly spaced ribbing on the venter of the living chamber than *S. whitfieldi*, but denser ribbing than *S. warreni* (Cobban, 1951, p. 23-24). The primaries begin at the umbilicus as umbilical bullae, then split mid-flank into two ribs. The umbilical bullae are sharp on the phragmocone and become more broad and widely spaced on the living chamber. The suture pattern resembles both *S. ferronensis* and *S. whitfieldi*. The saddles appear more like *S. ferronensis*, but the lobes are longer and therefore resemble *S. whitfieldi*. The dimensions of NMMNH P-36686 are  $Dg = 45$ ,  $Ds = 39.2$  and  $WW = 21.7$ . Among other differences of form and sculpture, the large, robust, more involute shells (macroconchs) of *Scaphites* have been interpreted as females, whereas the smaller, slender, more evolute shells (microconchs) have been interpreted as males (Cobban, 1969, p. 7; Crick, 1978, p. 7-9).

At Cebollita Mesa, *S. ferronensis* is very abundant locally. *S. ferronensis* also occurs in the D-Cross Member at Puertecito (Hook and Cobban, 1979, p. 41, fig. 5) and the type section of the Juana Lopez Member of the Mancos Shale northwest of Cerrillos, New Mexico (Dane et al., 1966, p. H14).

#### ***Prionocyclus novimexicanus* Zone**

##### ***Prionocyclus novimexicanus* (Marcou, 1858)**

NMMNH P-36687 (Fig. 4A-B) from locality L-5170 is a slightly weathered inner whorl of *Prionocyclus novimexicanus* with a conspicuous, finely serrate keel and small siphonal tubercles. The whorl section is compressed (higher than wide) and subquadrangular. The inner part of the whorl is very densely ribbed, with the outer part still dense but less so than the inner part. The presence of a single row of ventrolateral tubercles easily distinguishes *P. novimexicanus* from the gracile form of *Prionocyclus hyatti* (Stanton) as does its higher whorl (Kennedy, 1988, p. 83). NMMNH P-36687 possesses a single row of clavate inner ventrolateral tubercles, sinuous primary and secondary ribs that curve forward after crossing the ventrolateral shoulder, and bullate umbilical tubercles that are elongate. *P. novimexicanus* differs from *Prionocyclus wyomingensis* chiefly by the loss of the outer ventrolateral tubercles at an early stage (Kennedy et al., 1989, p. 94). NMMNH P-36687 is 54.2 mm in diameter, at which  $Wh = 19$ ,  $Wb = 15.6$  and  $U = 21.7$ .

NMMNH P-33802 (Fig. 4C-D) from locality L-4704 is a well preserved juvenile whorl of *P. novimexicanus* that possesses a serrated keel, prominent sinuous ribs that curve forward after crossing the ventrolateral shoulder, siphonal tubercles, elongated umbilical bullae and clavate inner ventrolateral tubercles. It is assigned to the gracile form of *P. novimexicanus* on the basis of the closely spaced flexuous primary ribs and relatively narrow umbilicus (Kennedy et al., 2001, p. 117-118). The whorl section is quadrangular in shape and compressed. No suture is visible on this specimen. NMMNH P-33802 is 97.1 mm in diameter, at which  $Wh = 38.8$ ,  $Wb = 24.5$  and  $U = 32.4$ .

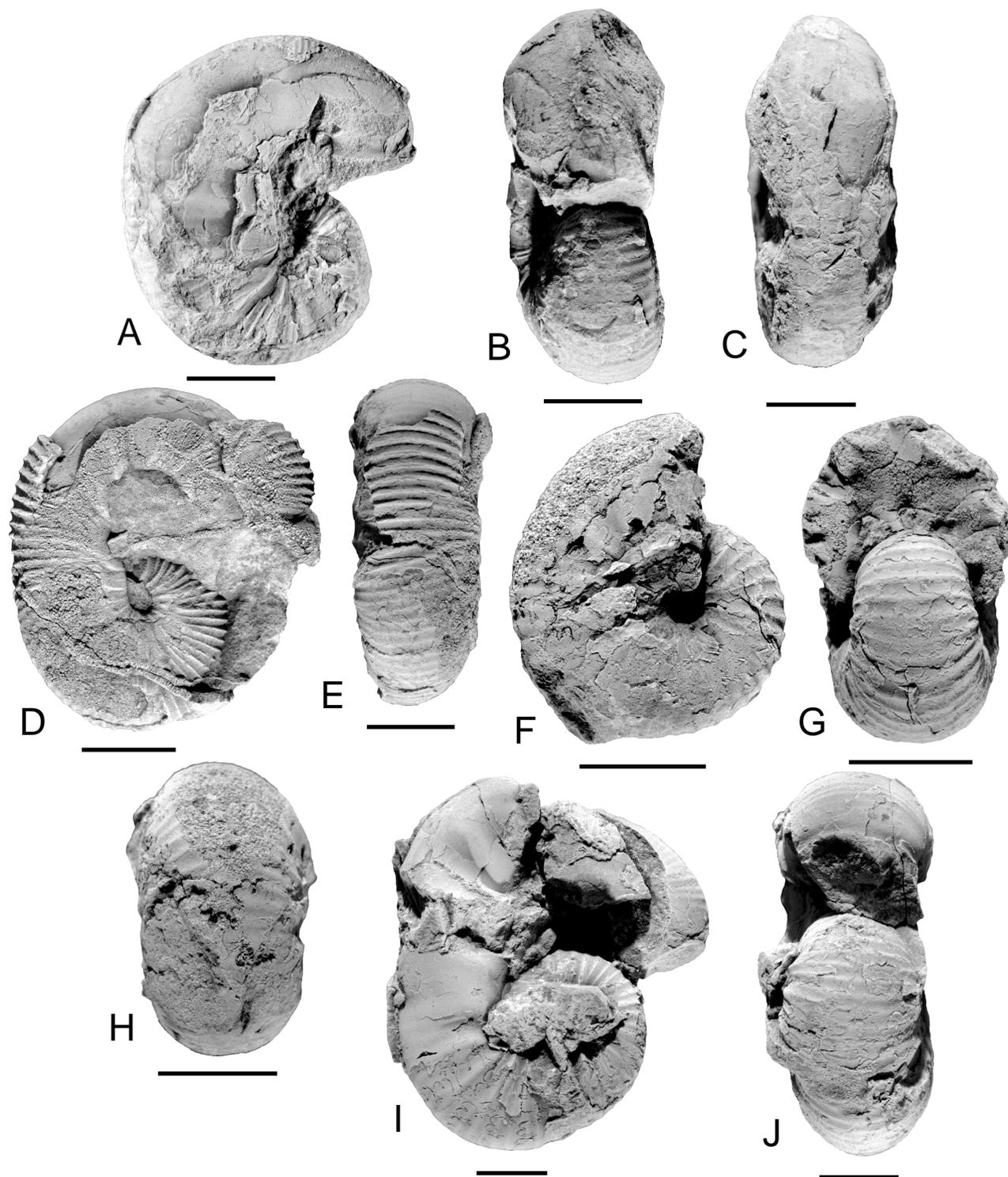


FIGURE 3. *Scaphites ferronensis* from the *Prionocyclus wyomingensis* Zone in the D-Cross Member of the Mancos Shale at Cebollita Mesa. A-C. *Scaphites ferronensis* Cobban, lateral (A), anterior (B) and ventral (C) views of a slender adult, NMMNH P-36689 from locality L-5175; D-E. *Scaphites ferronensis* Cobban, lateral (D) and ventral (E) views of slender adult, NMMNH P-33819 from locality L-4703; F-H. *Scaphites ferronensis* Cobban, lateral (F), anterior (G) and ventral (H) views of a fairly robust inner whorl, NMMNH P-36685 from locality L-5170; I-J. *Scaphites ferronensis* Cobban, lateral (I) and anterior (J) views of a fairly robust adult, NMMNH P-36686 from locality L-5170. Scale bars equal 1 cm.

A fragmentary, partly weathered whorl section of an adult *P. novimexicanus* (NMMNH P-33804; Fig. 4E-F) from locality L-4704 possesses prominent arcuate bullae on primary ribs that

start at the umbilical shoulder, two to three secondaries that start below mid-flank, ventrolateral tubercles that have been sheared off and a conspicuous keel that is mostly broken off. Siphonal

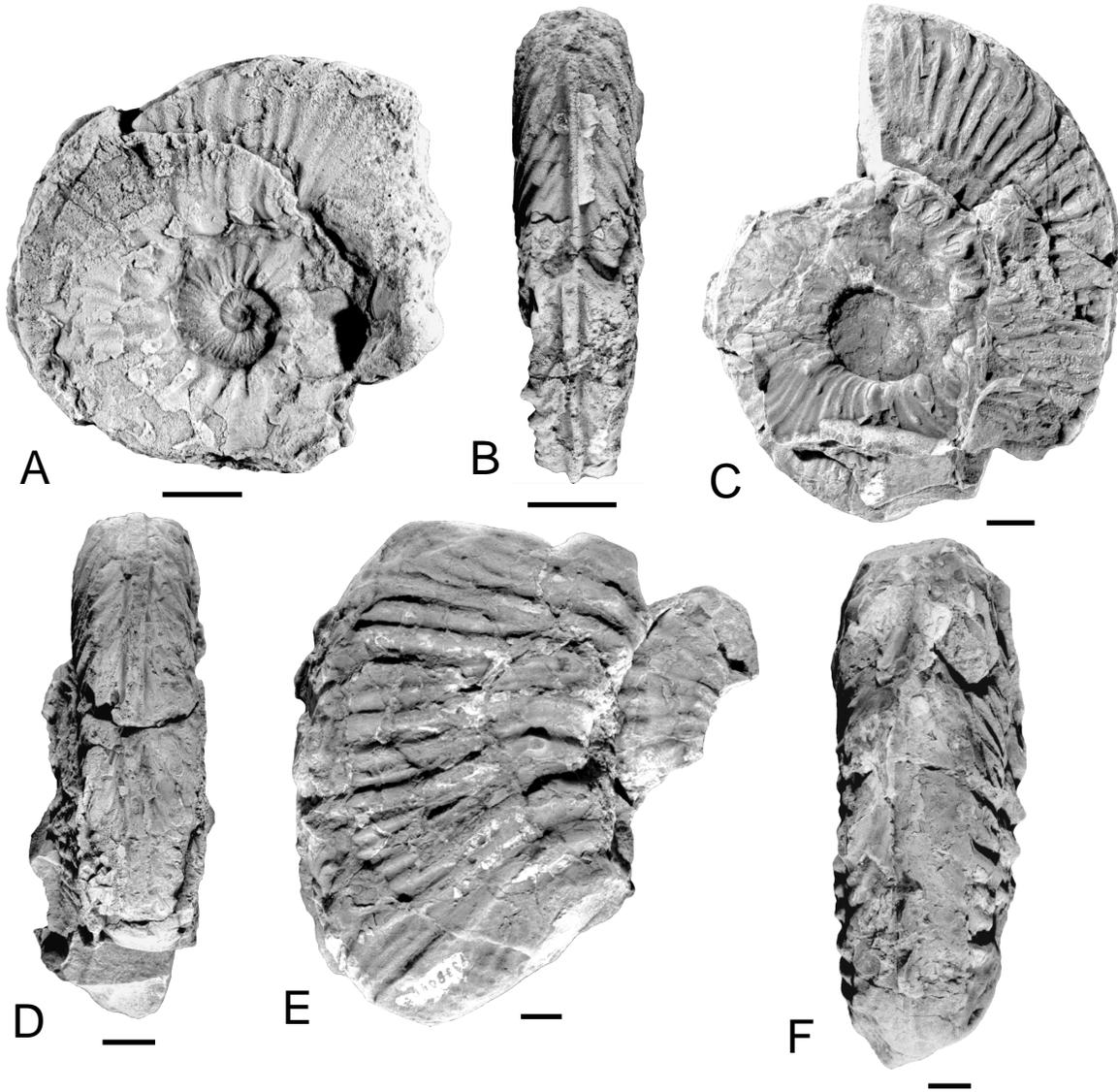


FIGURE 4. *Prionocyclus novimexicanus* from the *Prionocyclus novimexicanus* Zone in the D-Cross Member of the Mancos Shale at Cebollita Mesa. A-B, *Prionocyclus novimexicanus* (Marcou), lateral (A) and ventral (B) views of an inner whorl, NMMNH P-36687 from locality L-5170; C-D, *Prionocyclus novimexicanus* (Marcou), lateral (C) and ventral (D) views of a juvenile whorl, NMMNH P-33802 from locality L-4704; E-F, *Prionocyclus novimexicanus* (Marcou), lateral (E) and ventral (F) views of a whorl fragment of an adult, NMMNH P-33804 from locality L-4704. Scale bars equal 1 cm.

tubercles appear to be present but are difficult to discern. The ribs are closely spaced and flexuous. The outer whorl section, which has part of an earlier whorl attached, is very compressed. The dimensions of NMMNH P-33804 are  $Wh = 72.3$  and  $Wb = 41.6$ .

*P. novimexicanus* is fairly common at Cebollita Mesa. It has also been reported from the D-Cross Member at D-Cross Mountain (Hook et al., 1983, sht. 1), the D-Cross Member at Puertecito, New Mexico (Hook and Cobban, 1979, p. 41, fig. 5), the D-Cross Member at Carthage, New Mexico (Hook et al., 1983, sht. 1) and as *Prionocyclus wyomingensis* Meek var. *elegans* Haas in the Juana Lopez Member at the type and reference sections (Dane et al., 1966, p. H11 and H13).

## DISCUSSION

Here, we follow the ammonite zonation of Kennedy et al. (2001, p. 6, fig. 2). The occurrence of the collignoniceratid zone of *P. wyomingensis* at Cebollita Mesa indicates correlation with the Juana Lopez Member of the Mancos Shale northeast of Thoreau, New Mexico, the upper part of the type section of the Juana Lopez Member northwest of Cerrillos, New Mexico and the lower part of the D-Cross Member at D-Cross Mountain. The occurrence of the standard zone of *Scaphites ferronensis* at Cebollita Mesa indicates correlation of the lower part of the D-Cross there with the upper part of the Juana Lopez Member of

the Mancos Shale at the type section and the lowest part of the D-Cross Member of the Mancos Shale at Puertecito. The occurrence of the collignoniceratid zone of *P. novimexicanus* at Cebollita Mesa indicates correlation with the lower part of the D-Cross Member at D-Cross Mountain, Riley, and Carthage and most of the section of the D-Cross Member at Puertecito and with the top of the Juana Lopez Member at the type and reference sections.

Although Hook et al. (1983, sht. 1) listed *Scaphites whitfieldi* and *Scaphites warreni* in a measured section from the D-Cross at Cebollita Mesa, we did not recover *S. whitfieldi* from there, but the middle-upper part of the member should be in that zone since the collignoniceratid zone of *P. novimexicanus* occurs in that interval. Likewise, *S. warreni* has not been recovered by us from there, but the lower part of the member there should be in that zone since the collignoniceratid zone of *P. wyomingensis* occurs in that interval. The *P. wyomingensis* and *S. ferronensis* Zones are of late middle Turonian age and the *P. novimexicanus* Zone is of late Turonian age (Kennedy et al., 2001, p. 6-7, figs. 2, 3).

Hook et al. (1983) presented evidence for an unconformity between the D-Cross Member of the Mancos Shale and the underlying Fite Ranch Member of the Tres Hermanos Formation. We agree with this assertion—the D-Cross base is a transgressive surface followed by a flooding zone of relatively deep water in which ammonoids are abundant. This is the *Prionocyclus wyomingensis* zone of the lowermost D-Cross. Significantly, our data place the base of the *P. novimexicanus* Zone low in the D-Cross, ~ 10 m above its base. Above that, ammonoids occur in two narrow intervals in the D-Cross Member (Fig. 1). Thus, the ammonoid distribution in the D-Cross Member at Cebollita Mesa is best used for a range zone biostratigraphy, not an assemblage zone biostratigraphy. Zone boundaries are marked by the highest occurrence of *Prionocyclus wyomingensis* (= top of *P. wyomingensis* Zone) and by the lowest occurrence of *P. novimexicanus* (= base of *P. novimexicanus* Zone).

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Small folds in limestone of the Jurassic Todilto Formation in Todilto Park have long been mistaken for algal stromatolites.