Upper Cretaceous marine strata in the Little Hatchet Mountains, southwestern New Mexico

Spencer G. Lucas and Lawton, Timothy, F.

New Mexico Geology, v. 27, n. 3 pp. 63-68, Print ISSN: 0196-948X, Online ISSN: 2837-6420.
https://doi.org/10.58799/NMG-v27n3.63

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

Upper Cretaceous marine strata in the Little Hatchet Mountains, southwestern New Mexico

Spencer G. Lucas, New Mexico Museum of Natural History and Science,
1801 Mountain Road NW, Albuquerque, NM 87104, slucas@nmmnh.state.nm.us,
and *Timothy F. Lawton*, Department of Geological Sciences,
New Mexico State University, Las Cruces, NM 88003, tlawton@nmsu.edu

Abstract

Upper Cretaceous marine strata with age-diagnostic middle Cenomanian bivalve and ammonite fossils are preserved in the Little Hatchet Mountains of southwestern New Mexico. These strata, long assigned to the upper part of the Lower Cretaceous Mojado Formation, are approximately 100 m (328 ft) thick and are mostly dark gray shale with a few thin interbeds of limestone and sandstone and some limestone septarian concretions. We assign these marine strata to the Mancos Shale; they are unconformably overlain by nonmarine sandstone at the base of the Upper Cretaceous (Campanian) Ringbone Formation. Fossil localities in the Mancos Shale that are 11–30 m (36–98 ft) below the Ringbone base yield the following bivalve and ammonite taxa: *Ostrea beloiti* Logan, *Inoceramus arvanus* Stephenson, *Inoceramus prefragilis* Stephenson, cf. *Acanthoceras* sp., cf. *Tarrantoceras* sp., *Desmoceras* sp., *Hamites* cf. *H. simplex* d'Orbigny, and *Turrilites acutus acutus* Cobban and Scott. These fossils indicate the ammonite zone of *Acanthoceras amphibolum* Morrow and thus a middle Cenomanian age.

In the Little Hatchet Mountains, marine strata of the Mancos Shale overlie a thick succession of quartzarenite strata of the Mojado Formation that contain hummocky cross-lamination and a few marine bivalves. The Mancos was deposited in a shelfal setting below storm wave base and thus records post-Mojado transgression across the axis of the former Bisbee rift basin. The presence of shelfal deposits and Western Interior inoceramids in the New Mexico bootheel implies that the former highland of the Mogollon–Burro uplift was completely submerged by the middle Cenomanian transgression. These biostratigraphic data support previous interpretations, based on post-Cenomanian sandstone composition and fluvial sediment dispersal, that transgression of the Cenomanian seaway took place from the northeast, across the trend of the former Mogollon–Burro uplift.

Introduction

Lower Cretaceous strata of the Bisbee Group are exposed in most of the mountain ranges of southwestern New Mexico, but the distribution of Upper Cretaceous strata in these ranges is much more limited. Lower Cretaceous rocks crop out in the Big and Little Burro, Peloncillo, Animas, Big Hatchet, Little Hatchet, West Potrillo, East Potrillo, and Victorio Mountains, in the Cooke's Range and at Cerro de Cristo Rey, whereas Upper Cretaceous strata are exposed only in the Cooke's Range and northeast of Virden (Fig. 1).

Here, we report on recently discovered Upper Cretaceous marine strata and fossils in the Little Hatchet Mountains, first mentioned briefly by Lucas and Lawton (2000). Our purpose is to document middle Cenomanian marine fossils from these strata and to discuss their stratigraphic, paleo-

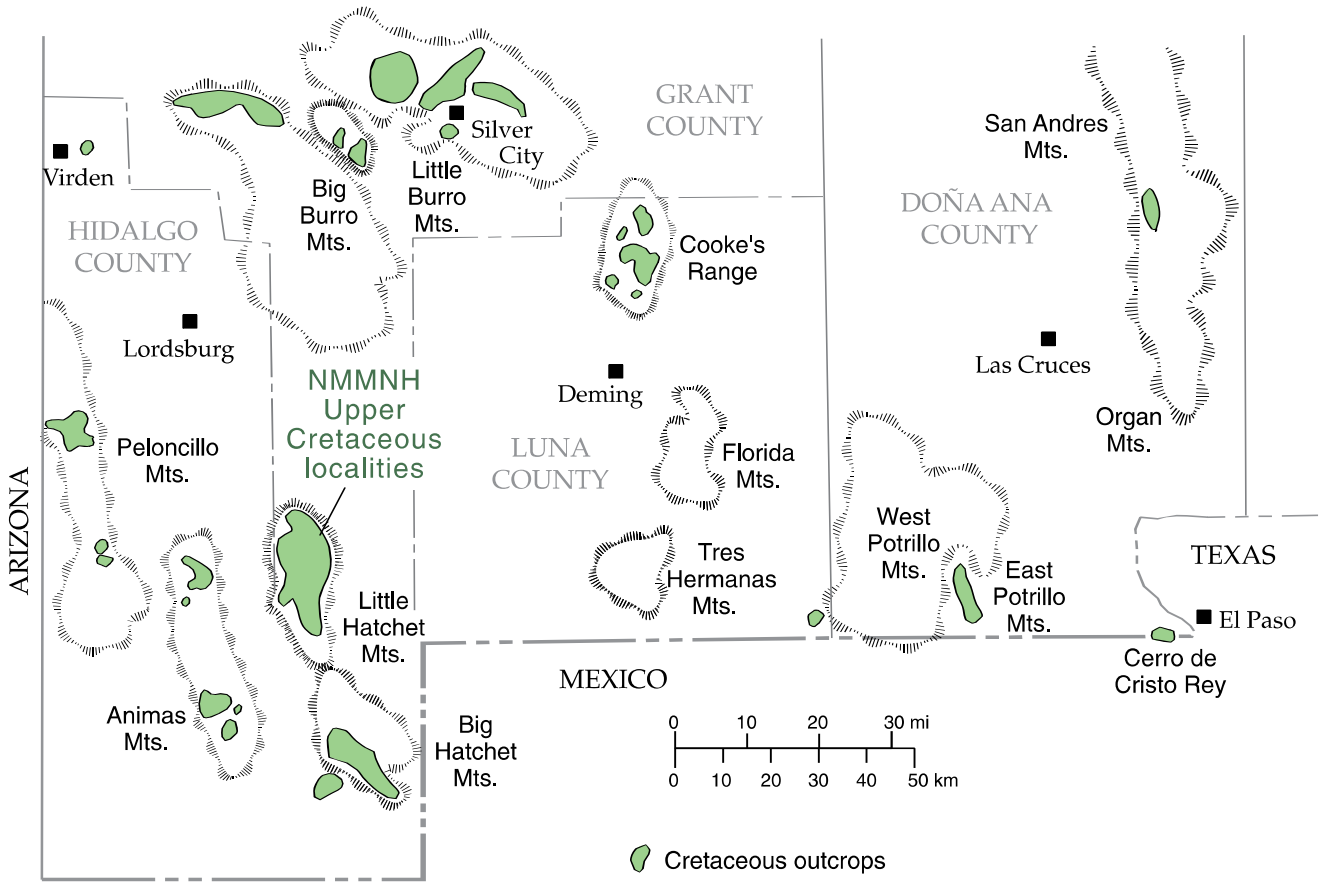

FIGURE 1—Map showing distribution of Cretaceous strata in southwestern New Mexico and NMMNH localities of Upper Cretaceous invertebrates in the Little Hatchet Mountains.

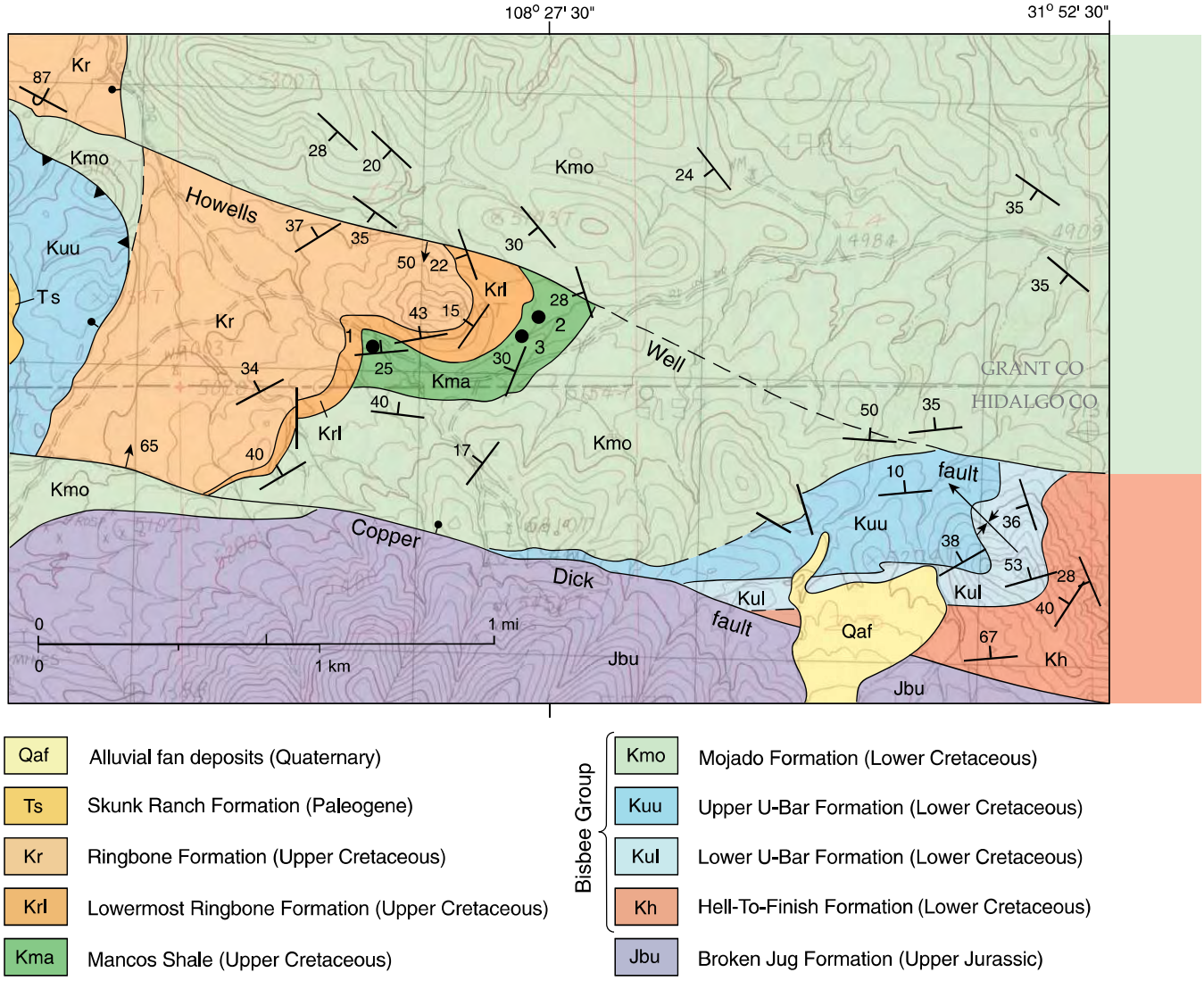

FIGURE 2— Geologic map of part of the Howells Well syncline, showing distribution of the Mancos Shale in the Little Hatchet Mountains. Bold numerals are NMMNH localities: 1, 4488; 2, 5597; 3, 5598. Hachita Peak, NM 1:24,000 quadrangle.

geographic, and tectonic significance. In this article, NMMNH refers to the New Mexico Museum of Natural History and Science, Albuquerque.

Location and lithostratigraphy

In the Little Hatchet Mountains, Upper Cretaceous marine strata are exposed in sec. 15 T28S R16W in the hinge of the Howells Well syncline (Lasky 1947; Zeller 1970; Fig. 2). The marine strata consist mostly of thin heterolithic beds of silty shale and very fine to medium-grained chert-lithic sandstone. Meter-scale intervals of streaky bedding, composed of millimeter-thick sandstone beds in black shale, alternate with wavy to flaser-bedded sandstone. Sandstone bedsets are as much as 80 cm (31 in) thick and consist of amalgamated beds with wave ripples, low-angle lamination, and trough crossbeds. Bed tops are sharp and broadly undulose to rippled. Intraclasts of shale are common at sandstone bed bases and form disklike impressions on some sharp bed tops. Sandstone bed surfaces reveal abundant fine-grained detrital muscovite. Burrowing is conspicuously rare to absent except on some thicker sandstone beds. White to pale-green laminated tuff beds as much as 15 cm (6 in) thick are present in shale-rich intervals. Uncommon limestone is present. Near NMMNH locality 4488, a single 65-cm-thick (26-in-thick) bed of black laminated limestone is present on the south limb of the syncline. In the hinge of the syncline, brown laminated limestone with entire inoceramid valves was observed. The brown limestone overlies a conspicuous interval of silty, very fine grained, black quartzarenite that contains ammonites and inoceramids. We interpret these strata to have been deposited in lower shoreface and shelfal environments.

Structural complexity and poor exposure preclude a precise determination of the thickness of the Upper Cretaceous marine strata. From its map distribution and attitude, we estimate the interval to be approximately 100 m (328 ft) thick. The original thickness is not preserved because the unit is erosionally truncated beneath the Ringbone Formation.

Three fossil localities are present (Fig. 2):

1. NMMNH locality 4488 is in an arroyo in the SW¼ sec. 15 in steeply dipping, dark-gray, metamorphosed shale (argillite) approximately 30 m (98 ft) below the base of the Ringbone Formation.

2. NMMNH locality 5597 is in the SE¼ sec. 15 in two gray ledges of sandy limestone 11–12 m (36–39 ft) below the base of the Ringbone Formation (Fig. 3).

3. NMMNH locality 5598 is approximately 80 m (262 ft) southwest of locality 5597 at the same stratigraphic level (Fig. 3).

Paleontology

Ostrea beloiti Logan

At localities 5597 and 5598, valves of a

small, smooth-shelled oyster are common. The right valve illustrated here (Fig. 4B) is characteristic and is slightly convex and smooth, except around its margin where there are many chromata. These oysters closely resemble illustrated specimens of *Ostrea beloiti* (e.g., Kauffman et al. 1977, pl. 8, figs. 9–10; Cobban 1977, pl. 7, fig. 7; Cobban and Hook 1980, fig. 2; Kennedy et al. 1988, figs. 2f–g).

***Inoceramus prefragilis* Stephenson**

One inoceramid from locality 5598 has a prominent terminal beak that is strongly incurved, has a straight anterior margin, and has ornamentation of closely spaced, low, narrow, concentric ridges that are most prominent umbonally (Fig. 4A). It closely resembles illustrated specimens of *Inoceramus prefragilis* (e.g., Stephenson 1952, pl. 12, figs. 10–12; Cobban 1977, pl. 19, figs. 1–2, 4; Lucas et al. 1988, fig. 11A; Lucas 2002 fig. 2D–E).

***Inoceramus arvanus* Stephenson**

The most common inoceramid from localities 5597 and 5598 is a prosoclinal form characterized by a subquadrate outline, distinct auricles and sulci, and fine growth lines between irregularly spaced concentric folds (Fig. 4C–D). It closely resembles illustrated specimens of *Inoceramus arvanus* (e.g., Stephenson 1952, pl. 12, figs. 6–9, 1955, pl. 4, figs. 1–3; Cobban 1977, pl. 6, fig. 27; Kauffman 1977, pl. 4, fig. 5; Akers and Akers 2002, fig. 87).

***Inoceramus* cf. *I. crippsi* Mantell**

An inoceramid from locality 4488 (Fig. 4E) is at least 90 mm (3.5 in) high, much more than 50 mm (2 in) long, slightly prosoclinal, and has an elongate-ovate shape, a terminal subrounded beak, and concentric raised folds with somewhat irregular spacing. It closely resembles specimens of *Inoceramus crippsi* Mantell (e.g., Kauffman 1977, pl. 4, fig. 5; Kauffman et al. 1977, pl. 5, fig. 1; Akers and Akers 2002, fig. 87), but in view of its poor preservation, we tentatively assign it to *I.* cf. *I. crippsi*.

Cf. *Acanthoceras* sp.

Fragmentary specimens of an evolute ammonite with prominent, widely spaced flank ribs and strong inner ventrolateral tubercles and weaker outer ventrolateral tubercles are present at localities 5597 and 5598. They are too poorly preserved for certain identification but probably represent the common Cenomanian genus *Acanthoceras*.

Cf. *Tarrantoceras* sp.

Only two ammonite fossils were recovered from locality 4488. NMMNH P-31793 is the impression of a shell in shale, and we have produced a silicon rubber peel of this specimen (Fig. 4K) to establish morphological details not obvious on the original. P-37065 is the natural cast of a partial outer whorl of an ammonite (Fig. 4J) that has greater three dimensionality than does P-31793, but both specimens do not preserve details of venter morphology. In addition, P-42369 from locality 5598 (Fig. 4I) preserves part of a flank near the umbilicus.

P-31793 has a diameter of ~ 45 mm (~1.75 in) and is a somewhat evolute ammonite with flattened flanks and many closely spaced, nearly straight (rectiradiate) ribs. On the outer whorl, these ribs become slightly curved, and there are distinct ventrolateral tubercles, except on the outer part of the last whorl. There are also conspicuous umbilical tubercles. P-37065 so closely resembles the outer whorl of P-31793 that we believe both specimens represent the same taxon. P-42369 also

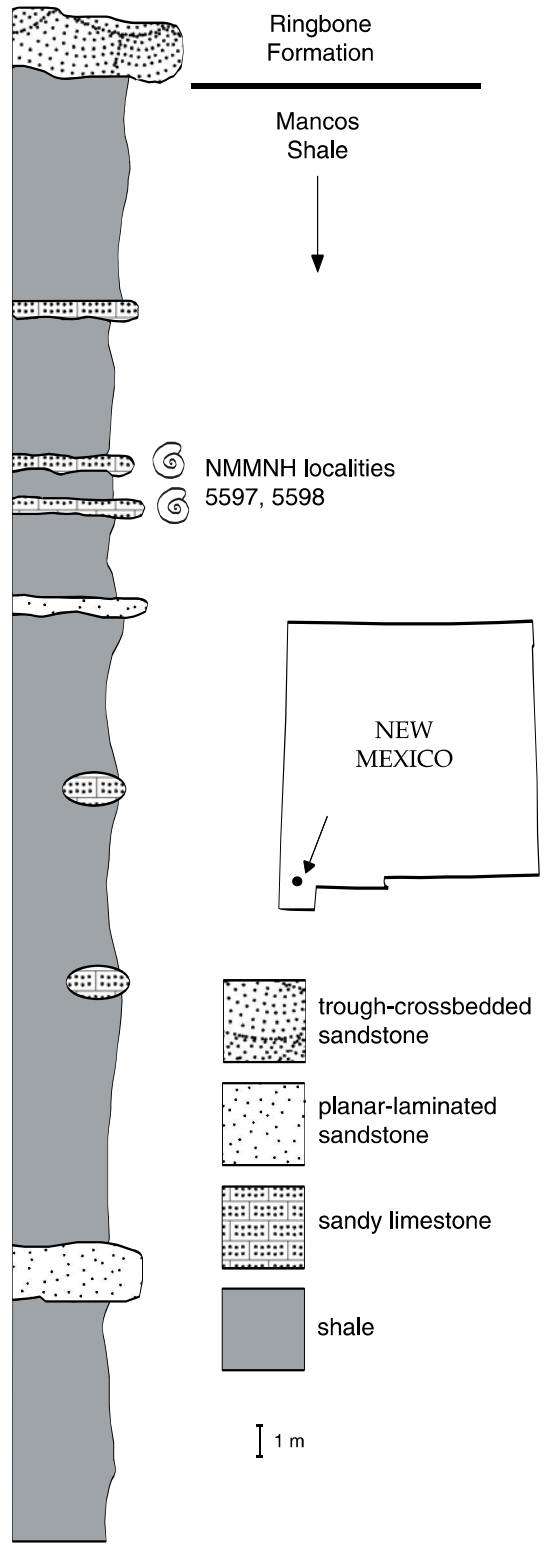

FIGURE 3—Measured stratigraphic section of Mancos Shale at NMMNH localities 5597 and 5598.

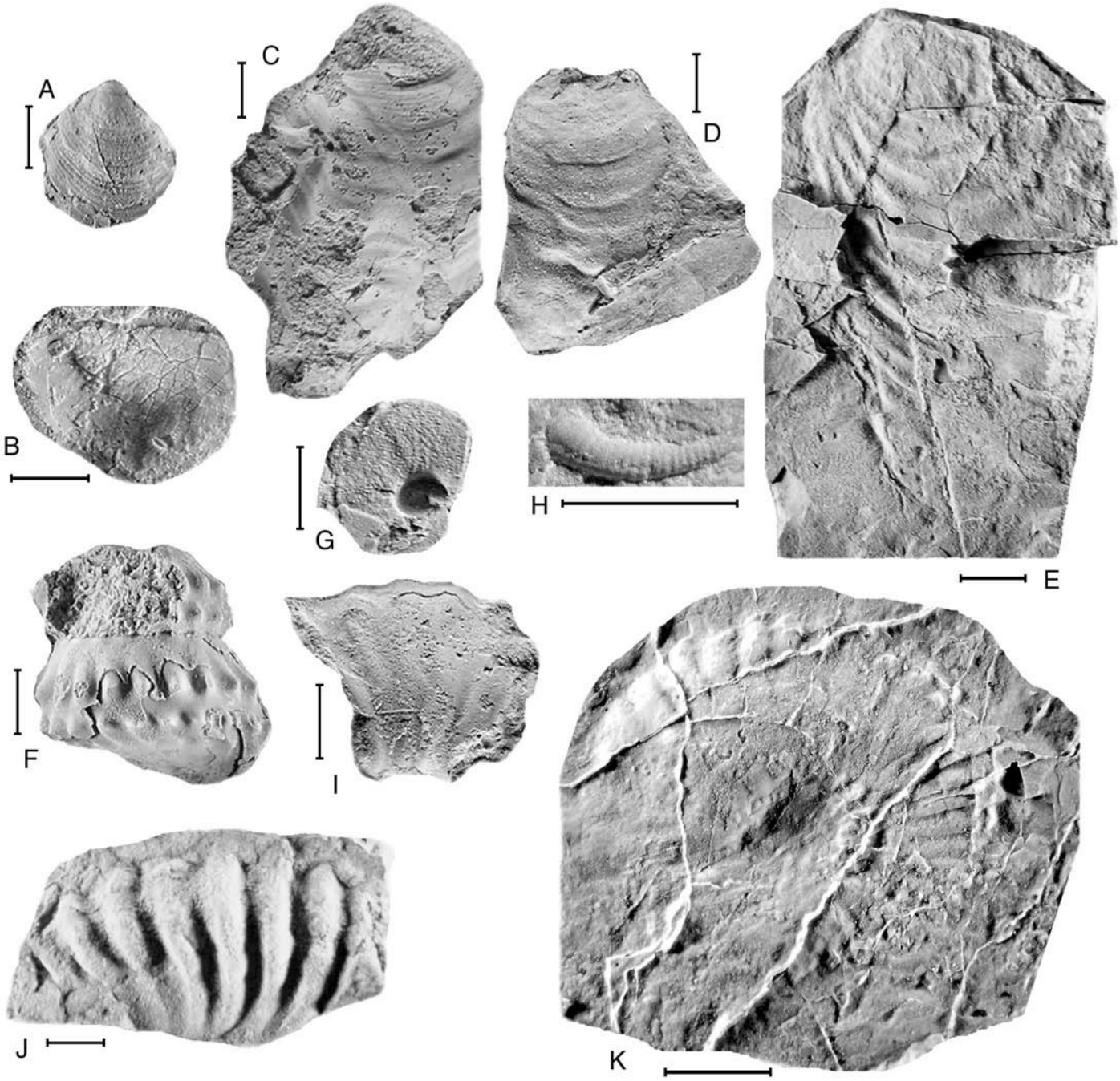

FIGURE 4—Selected middle Cenomanian invertebrate fossils from the Little Hatchet Mountains. **A**, NMMNH P-42363, *Inoceramus prefragilis*. **B**, P-42358, *Ostrea beloiti*. **C**, P-42860, *Inoceramus arvanus*. **D**, P-42359, *I. arvanus*. **E**, P-31792, *I.* cf. *I. crippsi*. **F**, P-42372, *Turrilites acutus acutus*. **G**, P-42365, *Desmoceras* sp. **H**, P-42368, *Hamites* cf. *H. simplex*. **I**, P-42369, cf. *Tarrantoceras* sp. **J**, P-37065, cf. *Tarrantoceras* sp. **K**, P-31793, cf. *Tarrantoceras* sp., silicon rubber peel from shell impression. Specimens **A**, **F–I** from NMMNH locality 5598; **B–D** from locality 5597; and **E, J–K** from locality 4488. Scale bars are 1 cm long.

appears to belong to the same taxon and well displays slightly flexuous primary and secondary ribs near the umbilical margin.

All three ammonites closely resemble *Tarrantoceras* or *Eucalycoceras* (see especially Cobban 1988). These two genera are very similar and are distinguished primarily on sutural characteristics not visible on the Little Hatchet Mountains specimens. Therefore, we cannot with certainty assign these specimens to either *Tarrantoceras* or *Eucalycoceras*, but they clearly belong to one of these genera, and we refer to them as cf. *Tarrantoceras* sp. for convenience.

Desmoceras sp.

Several small (<30 mm diameter) ammonites from localities 5597 and 5598 are very involute, have flattened flanks, a smooth rounded venter, and lack ornamentation (Fig. 4G). They closely resemble specimens assigned to *Desmoceras* (e.g., Cobban 1977, pl. 11, figs. 1–6, 9, 10; Kennedy et al. 1988, fig. 1u–v; Lucas et al. 1998, fig. 6L) but are too poorly preserved to be assigned to a species.

Hamites cf. *H. simplex* d'Orbigny

A single specimen of a very small (approximately 13 mm long, maximum whorl height = 3 mm) heteromorph ammonite from locality 5598 is an open planispiral coil ornamented with many, closely spaced rectiradiate ribs (Fig. 4H). Rib count is 4 to

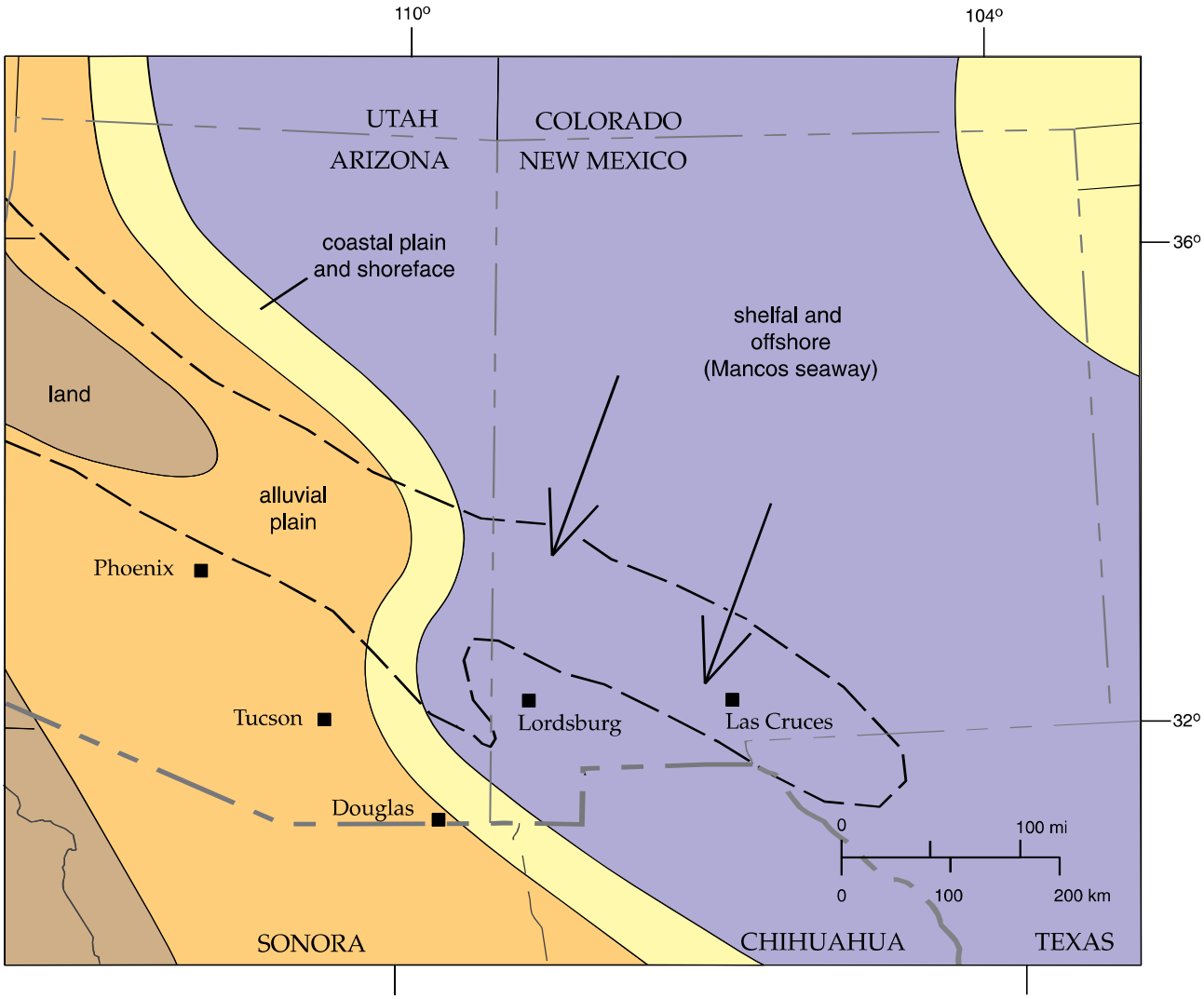

FIGURE 5—Cenomanian paleogeography of New Mexico, Arizona, and surrounding region, modified from Molenaar (1983) and Roberts and Kirschbaum (1995). Arrows represent inferred transgression directions (see text for discussion). Dashed line is outline of Mogollon–Burro uplift (Late Jurassic–Early Cretaceous), which formed the rift shoulder of the Bisbee Basin. The uplift is illustrated as having some influence on sedimentation trends but was generally submerged in its eastern extent. The shoreline and coastal plain facies tracts tended to shift laterally during the Cenomanian as a result of eustatic rise and fall; therefore, the boundaries between facies tracts should be regarded as approximate.

5 per whorl. This specimen closely resembles illustrated specimens assigned to *Hamites* cf. *H. simplex* (e.g., Cobban and Scott 1972, pl. 13, figs. 5–10, pl. 17, figs. 3-4; Cobban et al. 1989, fig. 92A–K).

***Turrilites acutus acutus* Scott and Cobban**

The most common ammonites at localities 5597 and 5598 are helical heteromorphs with two rows of essentially equal-sized tubercles on the whorl flanks (Fig. 4F). They closely resemble specimens of *Turrilites acutus acutus* illustrated by Cobban and Scott (1972, pl. 14, fig. 6) and Cobban (1977, pl. 4, figs. 4–5), and specimens of *Turrilites acutus* illustrated by Kennedy et al. (1988, figs. 1h, 2d, 2l), who did not make subspecies distinctions.

Age

The inoceramid and ammonite fossils described here from NMMNH localities 4488, 5597, and 5598 in the Little Hatchet Mountains are certainly of middle Cenomanian age. *Acanthoceras*, *Tarrantoceras* (or *Eucalycoceras*), *Desmoceras*, *Hamites*, and *Turrilites* are characteristic middle to late Cenomanian ammonites in Texas and the Western Interior. Indeed, most of these taxa are known from middle Cenomanian strata of the Mancos Shale ("Colorado Formation") in the Cooke's Range (Lucas et al. 1988; Cobban et al. 1989) and the middle Cenomanian Boquillas Formation at Cerro de Cristo Rey (Kennedy et al. 1988). The heteromorph ammonite *Turrilites acutus acutus* is particularly important, as it first appears in the middle Cenomanian and is restricted to the middle Cenomanian zones of *Conlinoceras tarrantense* and *Acanthoceras amphibolum* (Kennedy et al. 1988).

Ostrea beloiti is a middle to late Cenomanian taxon and is particularly abundant in strata of the middle Cenomanian *Acanthoceras amphibolum* zone (Cobban and Hook 1980; Kennedy et al. 1988). The inoceramid bivalves *I. crippsi*, *I. prefragilis*, and *I. arvanus* are also well-known middle to late Cenomanian (*I. crippsi* and *I. prefragilis*) or middle Cenomanian (*I. arvanus*) taxa in Texas and the Western Interior (Kauffman et al. 1993). *I. arvanus* is known from the middle Cenomanian Boquillas Formation at Cerro de Cristo Rey and is a strong indicator of the *Acanthoceras amphibolum* zone (Kennedy et al. 1988).

The middle Cenomanian marine fossils from the NMMNH localities in the Little Hatchet Mountains indicate the zone of *Acanthoceras amphibolum* and thus are correlative to that zone in the Boquillas Formation at Cerro de Cristo Rey and the lower part of the Mancos Shale to the northeast in the Cooke's Range and to the northwest at Virden (Lucas et al. 1988, 2000; Kennedy et al. 1988; Cobban et al. 1989).

Discussion

The discovery of Upper Cretaceous marine strata in the Little Hatchet Mountains is of stratigraphic, paleogeographic, and tectonic significance. These middle Cenomanian strata were previously considered the upper part of the Mojado Formation, but this succession of dark-gray shale is lithologically similar to and age equivalent to strata assigned to the Mancos Shale in the Cooke's Range and northward. Therefore, we recommend removing the shale-dominated Upper Cretaceous strata in the Little Hatchet Mountains from the Mojado Formation and assigning them to the Mancos Shale. Although this outcrop of the Mancos Shale is small, it can be mapped as a formation-rank unit distinct from the Mojado Formation (Fig. 2).

Because of the local folding and discontinuous outcrops, it is impossible to trace individual beds for more than a few tens of meters; the location of the basal contact is controlled by structural attitudes and the general boundary between quartzite- and argillite-rich outcrops. Although the Beartooth–Mancos contact is sharp in the vicinity of Silver City, the quartzite-argillite contact in the Little Hatchet Mountains appears to be gradational through a thick interval of dark-gray, medium-bedded quartzarenite with subordinate argillite beds.

The Cenomanian strata described here represent the youngest known pre-Laramide strata in the region of the former Bisbee Basin in New Mexico. The inoceramid forms, previously described from the Western Interior Basin (Kauffman 1977), and the location and thickness of these strata indicate that marine conditions may have been widespread south of the Burro uplift in Cenomanian time, and moreover, that the Burro uplift had ceased to act as an important paleogeographic barrier in the early Late Cretaceous.

The presence of the Mancos Shale in the Little Hatchet Mountains has an important bearing on the paleogeography of the middle Cenomanian seaway in the Western Interior. Molenaar (1983) inferred general southwestward migration of the Cenomanian shoreline of the Western Interior seaway across the former Mogollon–Burro uplift of Early Cretaceous age, such that his late Cenomanian shoreline trended northwestward through the bootheel of New Mexico. This direction of transgression is supported by southward onlap of the Dakota Formation onto progressively older units on the north flank of the Mogollon uplift of Arizona (Dickinson et al. 1989). Transgression across a northeast-sloping surface is further supported by northeast-directed paleocurrent indicators and volcanic lithic fragments in post-Mancos fluvial strata near Silver City (Fig. 1) and in south-central New Mexico, both of which indicate the existence of a northeast-oriented paleoslope by early Late Cretaceous time (Mack et al. 1988). Roberts and Kirschbaum (1995) inferred that the relict highland influenced sedimentation in the Cenomanian and was the site of alluvial sedimentation along its axis into southwestern New Mexico, but that the former Bisbee Basin was a marine embayment that extended west along the international border to about Nogales, Arizona. Our data suggest that the former Mogollon–Burro uplift was completely submerged by middle Cenomanian time and support the shoreline trends and positions of Molenaar (1983). Southwestward marine transgression and submergence of the uplift mark the demise of the former rift shoulder of the Bisbee Basin as a paleogeographic element in the Southwest and imply an important transition in the region from extensional to contractional tectonics (Mack 1987; Mack et al. 1988)

In southwestern New Mexico, the upper part of the Mojado Formation (Rattlesnake Ridge Member) records the last marine transgressions of the latest Albian–earliest Cenomanian in the Bisbee Basin. The base of the middle Cenomanian marine transgression across much of New Mexico represents a significant reorganization of the depositional system at about the beginning of Late Cretaceous time. This is the initiation of the Cretaceous Western Interior Basin and, in most of New Mexico, its middle Cenomanian Dakota transgression.

Acknowledgments

Jerry Harris, Yami Lucas, Betty Quintairos, and Pete Reser assisted in the field. William R. Dickinson and Stephen C. Hook provided helpful reviews of the manuscript.

References

Akers, R. E., and Akers, T. J., 2002, Texas Cretaceous bivalves 2: Houston Gem and Mineral Society, Texas Paleontology Series, Publication 7, 516 pp.

Cobban, W. A., 1977, Characteristic marine molluscan fossils from the Dakota Sandstone and intertongued Mancos Shale, west-central New Mexico: U.S. Geological Survey, Professional Paper 1009, 30 pp.

Cobban, W. A., 1988, *Tarrantoceras* Stephenson and related ammonoid genera from Cenomanian (Upper Cretaceous) rocks in Texas and the Western Interior of the United States: U.S. Geological Survey, Professional Paper 1473, 29 pp.

Cobban, W. A., and Hook, S. C., 1980, Occurrence of *Ostrea beloiti* Logan in Cenomanian rocks of Trans-Pecos Texas; *in* Dickerson, P. W., Hoffer, J. M., and Callender, J. F. (eds.), Trans-Pecos region (west Texas): New Mexico Geological Society, Guidebook 31, pp. 169–172.

Cobban, W. A., and Scott, G. R., 1972, Stratigraphy and ammonite fauna of the Graneros Shale and Greenhorn Limestone near Pueblo, Colorado: U.S. Geological Survey, Professional Paper 645, 108 pp.

Cobban, W. A., Hook, S. C., and Kennedy, W. J., 1989, Upper Cretaceous rocks and ammonite faunas of southwestern New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 45, 137 pp.

Dickinson, W. R., Fiorillo, A. R., Hall, D. L., Monreal, R., Potochnik, A. R., and Swift, P. N., 1989, Cretaceous strata of southern Arizona; *in* Jenney, J. P., and Reynolds, S. J. (eds.), Geologic evolution of Arizona: Arizona Geological Society, Digest 17, pp. 447–461.

Kauffman, E. G., 1977, Illustrated guide to biostratigraphically important Cretaceous macrofossils, Western Interior Basin, U.S.A.: The Mountain Geologist, v. 14, pp. 225–274.

Kauffman, E. G., Hattin, D. E., and Powell, J. D., 1977, Stratigraphic, paleontologic, and paleoenvironmental analysis of the Upper Cretaceous rocks of Cimarron County, Oklahoma: Geological Society of America, Memoir 149, 150 pp.

Kauffman, E. G., Sageman, B. B., Kirkland, J. I., Elder, W. P., Harries, P. J., and Villamil, T., 1993, Molluscan biostratigraphy of the Cretaceous Western Interior Basin, North America: Geological Association of Canada, Special Paper 39, pp. 397–434.

Kennedy, W. J., Cobban, W. A., and Hook, S. C., 1988, Middle Cenomanian (Late Cretaceous) molluscan fauna from the base of the Boquillas Formation, Cerro de Muleros, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 114, pp. 35–44.

Lasky, S. G., 1947, Geology and ore deposits of the Little Hatchet Mountains, Hidalgo and Grant Counties, New Mexico: U.S. Geological Survey, Professional Paper 208, 101 pp.

Lucas, S. G., 2002, Invertebrate fossil assemblage from Galisteo Dam and the correlation of the Cretaceous Dakota–Mancos succession in north-central New Mexico: New Mexico Geology, v. 24, no. 1, pp. 15–18.

Lucas, S. G., and Lawton, T. F., 2000, Stratigraphy of the Bisbee Group (Jurassic–Cretaceous), Little Hatchet Mountains, New Mexico; *in* Lawton, T. F., McMillan, N. J., and McLemore, V. T. (eds.), Southwest passage—a trip through the Phanerozoic: New Mexico Geological Society, Guidebook 51, pp. 175–194.

Lucas, S. G., Anderson, O. J., and Estep, J. W., 1998, Stratigraphy and correlation of middle Cretaceous rocks (Albian–Cenomanian) from the Colorado Plateau to the southern High Plains, north-central New Mexico: New Mexico Museum of Natural History and Science, Bulletin 14, pp. 57–66.

Lucas, S. G., Estep, J. W., Boucher, L. D., and Anderson, B. G., 2000, Cretaceous stratigraphy, biostratigraphy, and depositional environments near Virden, Hidalgo County, New Mexico: New Mexico Museum of Natural History and Science, Bulletin 16, pp. 107–119.

Lucas, S. G., Kues, B. S., Hayden, S. N., Allen, B. D., Kietzke, K. K., Williamson, T. E., Sealey, P., and Pence, R., 1988, Cretaceous stratigraphy and biostratigraphy, Cooke's Range, Luna County, New Mexico; *in* Mack, G. H., Lawton, T. F., and Lucas, S. G. (eds.), Cretaceous and Laramide tectonic evolution of southwestern New Mexico: New Mexico Geological Society, Guidebook 39, pp. 143–167.

Mack, G. H., 1987, Mid-Cretaceous (late Albian) change from rift to retroarc foreland basin in southwestern New Mexico: Geological Society of America, Bulletin, v. 98, pp. 507–514.

Mack, G. H., Galemore, J. A., and Kaczmarek, E. L., 1988, The Cretaceous foreland basin in southwestern New Mexico; *in* Mack, G. H., Lawton, T. F., and Lucas, S. G. (eds.), Cretaceous and Laramide tectonic evolution of southwestern New Mexico: New Mexico Geological Society, Guidebook 39, pp. 135–141.

Molenaar, C. M., 1983, Major depositional cycles and regional correlations of Upper Cretaceous rocks, southern Colorado Plateau and adjacent areas; *in* Reynolds, M. W., and Dolly, E. D. (eds.), Symposium 2—Mesozoic paleogeography of the west-central United States: SEPM, Rocky Moun-

tain Section, pp. 201–224.
Roberts, L. N. R., and Kirschbaum, M. A., 1995, Paleogeography of the Late Cretaceous of the Western Interior of middle North America—coal distribution and sediment accumulation: U.S. Geological Survey, Professional Paper 1561, 115 pp.
Stephenson, L. W., 1952, Larger invertebrate fossils of the Woodbine Formation (Cenomanian) of Texas: U.S. Geological Survey, Professional Paper 242, 226 pp.
Stephenson, L. W., 1955, Basal Eagle Ford fauna (Cenomanian) in Johnson and Tarrant Counties, Texas: U.S. Geological Survey, Professional Paper 274-C, pp. 53–67.
Zeller, R. A., 1970, Geology of Little Hatchet Mountains, Hidalgo and Grant Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 96, 26 pp.