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

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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 Manos Shale; they are unconformably overlain by nonmarine sandstone at the base of the Upper Cretaceous (Campanian) Ringbone Formation. Fossil localities in the Manos Shale that are 11–30 m (36–98 ft) below the Ringbone base yield the following bivalve and ammonite taxa: Ostrea belatti Logan, Ioceramus arvensis Stephenson, Ioceramus prefragiis Stephenson, cf. Acanthoceras sp., cf. Tarrantoceras sp., Desmoeras sp., Hamites cf. H. simplex d’Orbigny, and Terrilites acutus acutus Cobban and Scott. These fossils indicate the ammonite zone of Acanthoceras amphiphylum Morrow and thus a middle Cenomanian age.

In the Little Hatchet Mountains, marine strata of the Manos Shale overlie a thick succession of quartzarenite strata of the Mojado Formation that contain hummocky cross-lamination and a few marine bivalves. The Manos 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 ineoceramids in the New Mexico booteel 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.
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 beds 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 beloi**

**Ostrea beloi**

At localities 5597 and 5598, valves of a
small, smooth-shelled oysters 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 beloitii (e.g., Kauflman 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 unambonally (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 arvatus** Stephenson
The most common inoceramid from localities 5597 and 5598 is a prosoclinal form characterized by a subquadrangular outline, distinct auricles and sulci, and fine growth lines between irregularly spaced concentric folds (Fig. 4C–D). It closely resembles illustrated specimens of *Inoceramus arvatus* (e.g., Stephenson 1952, pl. 12, figs. 6–9, 1955, pl. 4, figs. 1–3; Cobban 1977, pl. 6, fig. 27; Kauflman 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., Kauflman 1977, pl. 4, fig. 5; Kauflman 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. Turractoceras 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. 4D) 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
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
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 NMNH 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 *Ostrea beloitii* and *Acanthoceras amphibolum* (Kennedy et al. 1988).

**Ostrea beloitii** 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. arvatus* are also well-known middle to late Cenomanian (*I. crippsi* and *I. prefragilis*) or middle Cenomanian (*I. arvatus*) taxa in Texas and the Western Interior (Kauffman et al. 1993). *I. arvatus* 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 NMNH 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 northwest. 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-ranking 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 quartizite-argillite contact in the Little Hatchet Mountains appears to be gradational through a thick interval of dark-gray, medium-bedded quartzarenite with subordinated 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 incoeramid 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. Molenar (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. However, the 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 Molenar (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.

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References
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