

Inoceramid fauna and biostratigraphy of the upper Middle Coniacian–lower Middle Santonian of the Pueblo Section (SE Colorado, US Western Interior)

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Abstract

The Middle Coniacian to Middle Santonian inoceramid succession of the Pueblo section, southeastern Colorado, US Western Interior, is reviewed in the context of the zonal scheme applied in Europe. The Middle Coniacian record starts with the upper Middle Coniacian *Volviceramus involutus* Zone, because the base of the succession is characterised by a hitherto unsuspected stratigraphical gap, spanning the topmost Lower and lower Middle Coniacian in European inoceramid terms. The base of the Upper Coniacian is recognised by the entry of *Magadiceramus*; this substage is divided into a *Magadiceramus subquadratus* Interval Zone and a *Magadiceramus crenelatus* Taxon Range Zone. The base of the Santonian is taken at the base of the *Cladoceramus undulatoaplicatus* Taxon Range Zone. The Middle Santonian is assigned to the *Cordiceramus bueltenensis* Zone, and the base of the Upper Santonian is placed at the base of the zone of *Cordiceramus muelleri*. The inoceramid faunas of the Pueblo succession are similar to those known from southern Europe, south of the regular occurrence of sphenoceramids. The apparent differences reported in the previous literature between the inoceramid faunas of Europe and of the Western Interior at this level resulted mainly from differences in the taxonomic concepts applied. The new data enable correlation between the proposed inoceramid zonal scheme and the scaphitid ammonite zones.

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1. Introduction

In recent years the Pueblo section (Fig. 1) has attracted considerable attention of stratigraphers due mostly to its expanded Cenomanian–Turonian boundary succession (e.g. Cobban and Scott, 1972; Cobban, 1985, 1988; Kennedy and Cobban, 1991; Kennedy et al., 1999, 2000), as well as its proposal as the boundary stratotype for the base of the Turonian (Bengtson, 1996; Kennedy et al., 2000). As demonstrated by Scott and Cobban (1964) in their original survey on the Niobrara

Formation near Pueblo, the succession continues with a similarly well exposed and fossiliferous Turonian–Coniacian transition (e.g. Scott and Cobban, 1964; Walaszczyk and Cobban, 2000) and also with the boundary interval between the Coniacian and Santonian (Scott and Cobban, 1964; see also Kauffman and Pratt (1985). Although the Middle Coniacian through Middle Santonian interval possesses a rather poor ammonite record, it yields relatively common and diverse inoceramid faunas, providing the means for obtaining a comprehensive picture of the inoceramid succession and of establishing an inoceramid zonation applicable to the southern US Western Interior.

It is not our intention to propose the Pueblo section as a candidate Santonian basal boundary stratotype. The main

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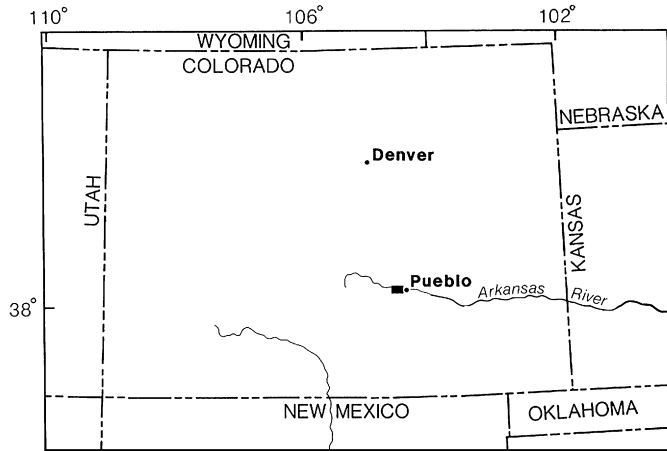


Fig. 1. The location of the Pueblo section (black square), near the town of Pueblo, Colorado, in the US Western Interior.

disadvantage of this section is the lack of numerous macro- and microfossil groups, and the endemic nature of the ammonite fauna. However, the very good inoceramid record and the apparently continuous succession, make the Pueblo succession a useful US Western Interior reference section for the Middle Coniacian through Middle Santonian interval.

This paper documents the inoceramid record and biostratigraphy of the Middle Coniacian through Middle Santonian (Fig. 2). The section was described in detail by Scott and Cobban (1964) and is presented here only in skeletal form. The present study is based primarily on a revision of their original collections. In particular, it should be noted that inoceramids assigned by Scott and Cobban (1964) to various morphotypes of *Inoceramus stantoni* Sokolov, 1914 are here assigned to the genus *Magadiceramus* Heinz, 1932. The palaeontological description of the Pueblo inoceramids is given in a separate paper on the Middle Coniacian and Santonian inoceramids of the Western Interior (Walaszczyk and Cobban, 2006).

The Middle Coniacian through Middle Santonian interval of the Rock Canyon Anticline in Pueblo encompasses the lower shale, lower limestone, and middle shale units of the Smoky Hill Member of the Niobrara Formation (Fig. 2). It should be noted that each unit has its own set of bed numbers. The Middle Coniacian record begins in the topmost bed of the shale and limestone unit, and the base of the Santonian is located a short distance above the base of the middle shale unit (Fig. 2).

All inoceramid specimens illustrated and/or referred to in this paper are housed in the United States National Museum of Natural History in Washington DC, and are described in detail in Walaszczyk and Cobban (2006).

2. Stage and substage boundaries

The stage and substage definitions used here follow the proposals from the Brussels Symposium (Rawson et al., 1996). The Coniacian substage division, as provisionally accepted

(Kauffman et al., 1996), is based on the European inoceramid zonation, with the FO (first occurrence) of *Volviceramus koeneni* (Müller, 1888) defining the base of the Middle Coniacian and the FO of *Magadiceramus subquadratus* (Schlüter) defining the base of the Upper Coniacian. The scheme seems to be readily applicable, at least in the Euramerican biogeographic region.

The general consensus during the Brussels Symposium was that the Santonian Stage should also be subdivided into three substages. As provisionally accepted (Lamolda and Hancock, 1996), the base of the Santonian is taken at the FO of the inoceramid *Cladoceramus undulatoplicatus* (Roemer, 1852). A possible datum for the base of the Middle Santonian was taken at the top of the range of the latter taxon, and a possible datum for the base of the Upper Santonian could be the first occurrence of the crinoid species *Uintacrinus socialis* Grinnell (Lamolda and Hancock, 1996). In inoceramid terms, this latter horizon approximates to the level of the FO of the inoceramid *Cordiceramus muelleri* (Petrascheck) (see Tröger, 1989; Walaszczyk and Wood, 1999).

3. Inoceramid sequence

3.1. Shale and limestone unit

This unit yields Early Coniacian *Cremnoceramus* ex gr. *deformis* throughout. The topmost bed (bed 37 of Scott and Cobban, 1964) yielded *Cremnoceramus deformis deformis* (Meek) at USGS locality D3470 and, some distance away at Wild Horse Park (USGS locality D3471), a large *Volviceramus involutus* (J. de C. Sowerby), indicative of the upper Middle Coniacian *Volviceramus involutus* Zone (Scott and Cobban, 1964). The occurrence of this *Volviceramus* in the same bed as *Cremnoceramus deformis* (Fig. 2), albeit at widely separate localities in the same general area, indicates a hitherto totally unsuspected stratigraphical gap, spanning the topmost Lower Coniacian and lower Middle Coniacian (see below).

3.2. Lower shale unit

The first *Magadiceramus*, referable to the basal Upper Coniacian index taxon *Magadiceramus subquadratus* (Schlüter), appears in bed 19 of this unit (USGS locality D3473) (Fig. 3C), where it occurs together with *Volviceramus involutus* (see Scott and Cobban, 1964, pl. 3, fig. 4) and *Platyceramus* ex gr. *mantelli* (Barrois).

In the American literature, specimens of *Platyceramus* ex gr. *mantelli* (Barrois) were previously referred to the North American taxon *Platyceramus platinus* (Logan). However, Logan's species is actually impossible to identify; the specimen illustrated (Logan, 1898, pl. 116, fig. 2, left-hand lower figure) does not match the description in the text, and the specimen on which he based his description has not been found and is possibly lost. Moreover, even if Logan applied his name to the same form as Barrois, it is the European taxon that would have priority (Walaszczyk and Cobban, 2006).

The middle part of the unit contains single volviceramids as well as fragments of platyceramids (localities D3475). The

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