Biostratigraphy of the Turonian-Coniacian boundary interval in Western Saskatchewan: Micropaleontological analysis of the contact between the Carlile and Niobrara formations

Juan F. Diaz & Maria I. Velez
Department of Geology, University of Regina
juanfdiazt@gmail.com

Introduction

The Turonian-Coniacian boundary in the Western Interior Basin (WIS) of Canada is marked by the deposition of the upper Carlile Formation and the overlying Govenlock Member of the Niobrara Formation (Figure 1). These two units were accumulated during the regressive phase of the Greenhorn cycle (Late Turonian) and the transgressive phase of the Niobrara cycle (Lower Coniacian), respectively (Figure 2). Although the boundary between these two cycles has been broadly studied in WIB of USA (e.g. Walaszczyk and Cobban, 1998), little is known about this interval in the Canadian portion. The only three cores that cut the contact between the Carlile and Niobrara formations in Western Saskatchewan were examined in order to evaluate the paleoecological and paleogeographical changes that took place during the Turonian-Coniacian boundary interval (Figure 3). The micropaleontological analysis of this interval is based mainly on foraminifera, radiolarians and sporadic diatoms.

Figure 1. Stratigraphic and biostratigraphic framework of the Carlile and Niobrara formations in the WIB of Canada

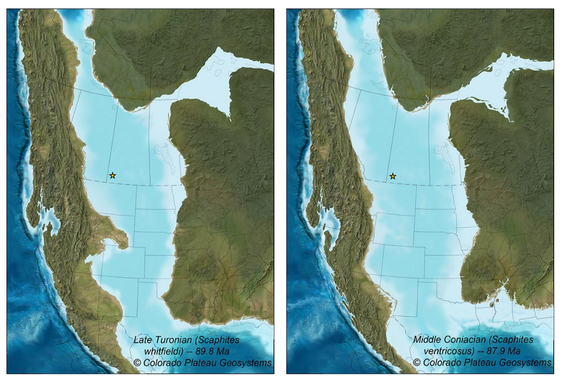

Figure 2. Western Interior Seaway paleogeography maps. Left: Late Turonian; Right: Middle Coniacian. Taken from Blakey, Colorado Plateau Geosystems 2014 (http://cpgeosystems.com/paleomaps.html)

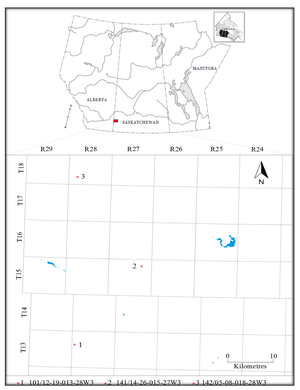

Figure 3. Geographical location of the three cores analyzed

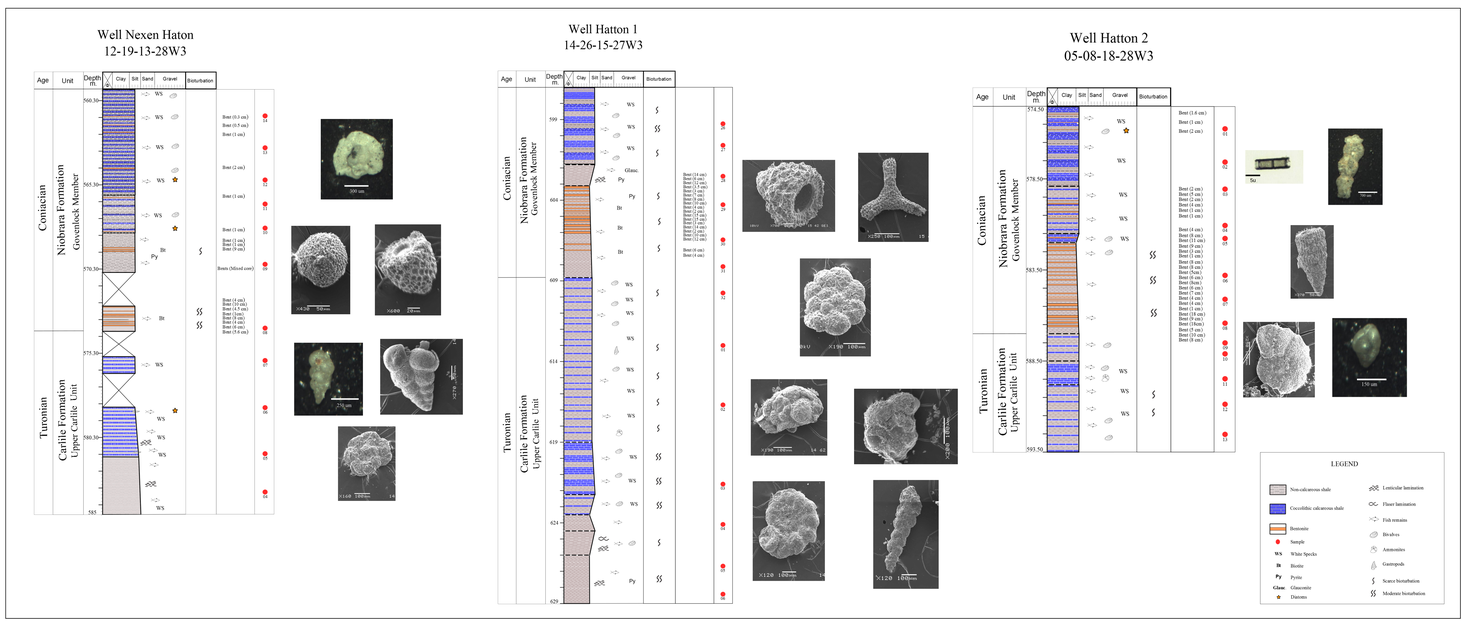

Figure 4. Stratigraphic columns of the Carlile/Niobrara contact in the studied cores with images of some species

Methods

Microfossils were prepared using a variation of the Freeze-Thaw method of Kennedy and Coe (2014). The procedure is as follows: 1) an aliquot of 5-6 g of each sample was saturated in distilled water for 24 hours. 2) The sample was washed with 250 µm and 63 µm sieves stacked together. The residue over sieve 250 µm was placed in a sealed plastic container and frozen for 4 hours. 3) The sample was removed from the freezer and covered with boiled water for ten minutes. 4) The sample was washed out again using 250 µm and 63 µm sieves. 5) The process was repeated until almost all the sample was disaggregated (from 3 to 12 cycles). 6) The sediment on sieve 63 µm was subsequently placed in a beaker with 30 ml distilled water and 30 ml household bleach and heated up on an oscillating hot plate for 40 minutes. 7) The solution was washed out again on sieve 63 µm and left overnight to dry.

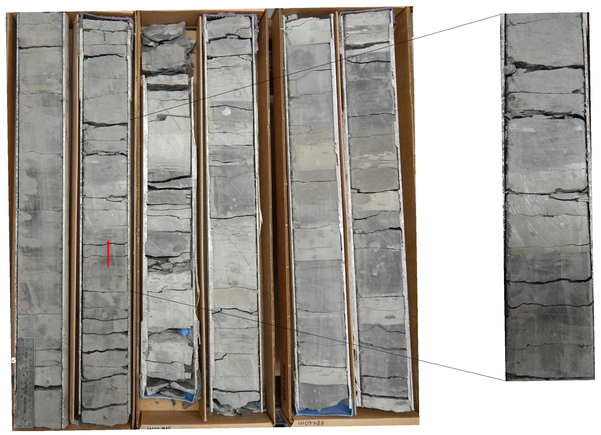

Figure 5. Carlile/Niobrara contact in core Apache Hatton 2 (05-08-18-28W3), Interval from 587,5 m. to 584,5m.

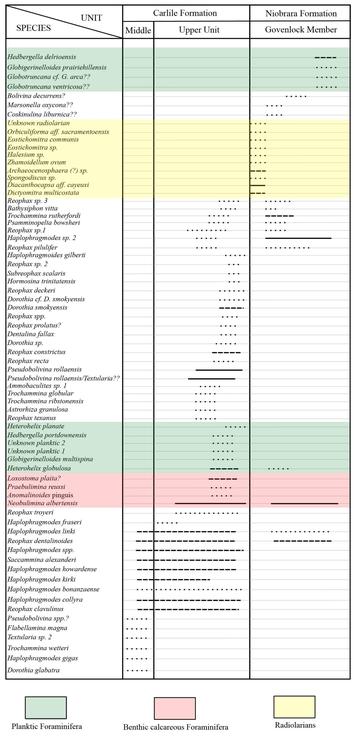

Figure 6. Biostratigraphic chart of the studied cores. Dotted line: Rare abundance; Dashed line: Moderate abundance; Solid line: Abundant species

Results

In southwestern Saskatchewan, the uppermost part of the Carlile Formation and the lowermost part of the Niobrara Formation (Govenlock Member) are lithologically very similar, but slightly differ in the foraminiferal assemblages (Figure 4). The upper Carlile Formation consist of a mix of benthic (agglutinated and calcareous) and planktic foraminifera, the latter being present only a few meters below the contact. The contact with the overlying Niobrara Formation is marked by the disappearance of foraminifera and the appearance of radiolarians. These siliceous microfossils are found just in a four- meter bentonitic interval in the lowermost part of the Govenlock Member of the Niobrara Formation (Figure 5). Above this interval there is a significant reduction in diversity and abundance of most of the foraminifera with the exception of the benthic calcareous species *Neobulimina albertensis*.

Figure 6 shows the distribution of foraminifera and radiolarians recovered from the three cores. Abundances were defined as follows: Rare (0-10), Moderate (10-100) and Abundant (> 100). The Upper Carlile Formation represents a transition from relatively shallow marine environments to upper bathyal settings close to the Turonian/Coniacian boundary. The presence of benthic calcareous and planktic foraminifera in this interval indicates transgressive stages at the end of the regressive Greenhorn Cycle in this part of the WIS. The faunal changes in the Turonian/Coniacian boundary in the WIS have been associated to a warming trend in the world oceans (Kauffman, 1994), however it seems that in western Saskatchewan these variations are probably related to volcanic activity and subsequent ash-falling into the basin. This phenomenon changed the oxygen content of the bottom water and/or the nutrient availability, while provided enough silica material for the radiolarians to build up their skeletons. Various benthic agglutinated species of *Reophax* and *Trochammina* recolonized the first centimeters of sediment after the volcanic event. The proportion of benthic calcareous and planktic foraminifera increases gradually upwards as the epicontinental seaway extends in the WIS during the Coniacian.

Acknowledgments

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