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Molecular Fossil Constraints on the Water Column Structure of the Cenomanian-Turonian Western Interior Seaway, North America

Dirk-Jan H. Simons (dsimon1@uic.edu) & **Fabien Kenig**

University of Illinois at Chicago, Dept. of Earth & Environmental Sciences, M/C 186, 845 W. Taylor Street, Chicago, IL, 60607, USA

Cenomanian-Turonian sediments of the Western Interior Basin, North America were deposited in an epeiric sea (the Western Interior Seaway, WIS) that connected the Boreal Sea to the warmer waters of the Tethyan Ocean. Several palaeobiological and geochemical studies suggested anoxic water column conditions during parts of the Greenhorn Cyclothem (e.g. Kauffman and Caldwell, 1993; Schröder-Adams et al., 1996), however detailed molecular fossil records were not available. Therefore, samples from two cross-basinal transects in southern Canada and south-western USA were analysed in detail for their molecular fossils. The transects span approximately 900 km across the basin and are 1400 km apart (Figure1). Rock-Eval pyrolysis data, total organic carbon content, and biomarker analysis were used to evaluate thermal maturity and source of organic matter, and to select samples for further detailed study. The total organic carbon content of the US samples varies between 0.1 to 5.1% for beds with >65% carbonate carbon content, and varies between 0.3 and 6.4% for beds with low carbonate content (<65% carbonate carbon content). Canadian samples are more organic rich, with TOC values between 0.7 and 15.6%. The organic matter is essentially algal derived with minor terrestrial contribution, and is immature (Bunker Hill and Pasquaia Hills samples) to early mature (Pueblo, Red Wash, and Mill Creek river samples). Among the numerous biomarkers extracted and separated from the Greenhorn Cyclothem samples, isorenieratane and its derivatives (diagenetic products of isorenieratene, a photosynthetic pigment of the brown strain of the green sulfur bacteria Chlorobiaceae) were identified in shales (both laminated and burrowed) and carbonate beds. The presence of diagenetic products originating from the green sulfur bacteria in the environment of deposition is an unambiguous indicator of photic zone anoxia and therefore of stratification of the water column with anoxic waters reaching up into the photic zone (Kenig et al., 1995; Koopmans et al., 1996). The presence of isorenieratene derivatives at all locations indicates that the entire WIS experienced events of photic zone anoxia. At maximum transgression, sedimentary features indicative of water column oxygenation (bioturbation and fossil assemblage) occur within single beds with geochemical evidence of photic zone anoxia (isorenieratene derivatives). These so-called 'intermittent anoxic events' underline the high variability in redox conditions in the WIS. The distribution of isorenieratene derivatives shows a dynamic water column structure of the WIS during the Greenhorn Cyclothem. A stratified water column with bottom water anoxia reaching into the photic zone is especially prominent at Pasquaia Hills and Mill Creek River throughout the Greenhorn Cyclothem. Photic zone anoxic events and, thus, pronounced water column stratification is also observed during transgression and late regression at Bunker Hill and Pueblo, but only during highstand at Red Wash. At maximum transgression, oxygenated bottom water conditions alternated with intermittent anoxic events, more so in the southern part of the WIS than the northern. In turn, the structure of the water column and its evolution during deposition of the Greenhorn Cyclothem provide strong constraints on paleoceanographic circulation in the seaway.

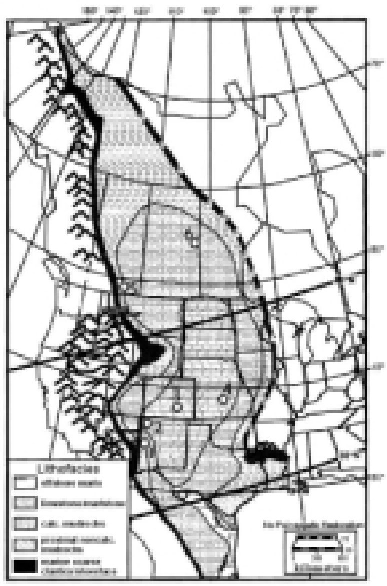

Figure 1: Lithofacies map of the Western Interior Seaway at maximum transgression (Early Turonian; adapted from Dean and Arthur, 1998). Numbers indicate sampling locations: (1) Mueses Canyon, New Mexico; (2) Red Wash, New Mexico; (3) Pueblo, Colorado; (4) Bunker Hill, Kansas; (5) Mill Creek River, Alberta; (6) Pasquia Hills, Saskatchewan

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