Ichnology of the Upper Cretaceous Greenhorn and Niobrara Formations of the Amoco Production Company Rebecca K Bounds #1 Well, Greeley County, KS

Adam M. Jackson, and Stephen T. Hasiotis

STATUS: Project expanding on previous work.
TIMING: Data being collected; results to be reported.
FUNDING: Seeking funding

Purpose
Rhythmically bedded marlstone and limestone in the Greenhorn and Niobrara Formation contain distinctly different trace-fossil assemblages (ichnocoenoses). Marlstone is often laminated with bioturbation fabrics of 1–2 (ichnofabric index; ii) or 0–1 (bioturbation intensity; bi), whereas limestone is highly bioturbated commonly with ii and bi of 3–4. Marlstone ichnocoenoses consists of small Planolites, Chondrities, and Teichichnus. Limestone ichnocoenoses consists of Planolites, Zoophycos, Teichichnus, and Thalassinoides. The purpose of this study is understand the distribution bioturbation patterns and coupled with sedimentary structures in the Upper Cretaceous Greenhorn and Niobrara Formations of the Amoco Production Company Rebecca K Bounds #1 to (1) interpret environments of deposition, (2) reconstruction oxygenation profiles in the basin (e.g., alternation of oxic [limestone] and dysoxic [marlstone] conditions), and (3) investigate differences in micro- and macropermeability produced by the variety of trace fossil morphologies in core.

Project Description
Organic carbon-rich shale, marlshale, and marlstone can host significant hydrocarbon resources. Although trace fossils and bioturbation patterns have been used as benthic oxygen indicators in these lithologies, a high-resolution study of changes in depositional conditions using ichnology has not been done for the Niobrara and Greenhorn formations. The goal of this project is to ichnologically assess the depositional conditions for the Upper Cretaceous Greenhorn and Niobrara formations of western Kansas. The purpose of this project is to describe the ichnology of the Greenhorn Formation, with emphasis on the (Cenomanian–Turonian) Bridge Creek Limestone Member.

The Upper Cretaceous Greenhorn Formation has been studied due to its organic carbon content, up to 5.1% (Pratt, 1984), and distinct traceable beds across the Western Interior Seaway (Hattin, 1971). The major traceable beds are bentonites, which have been used to erect lithochronozones and estimate rates of deposition (Hattin, 1985; Elder et al., 1994). This study uses the Amoco Production Company Rebecca K. Bounds #1 Well, from Greeley County, Kansas (Figure 1), where the Bridge Creek Limestone Member (BCLM) of the Bounds core is 26.2 m thick with 99.9% recovery.
The Greenhorn Formation, deposited during a transgressive systems tract, consists of the BCLM that overlies the Heartland Shale Member and basal Lincoln Limestone Member. In western Kansas, the BCLM is dominated by marlstone with decimeter-scale limestone beds. The marlshale and marlstone are laminated with little to no bioturbation, whereas the limestone is highly bioturbated. Intense bioturbation, that in a few limestone beds, produces mottled patterns in which distinct burrow morphologies are unrecognizable. The laminated units have been interpreted as zones where the benthic oxygen content was very low (Pratt, 1984; Savrda, 1998).

The lower half of the BCLM (from ~289 to 302 m) contains well-developed, rhythmically bedded cycles of marlstone and limestone that show distinct differences in type, size, and intensity of bioturbation. In the thinly laminated marlstone, trace fossils are often sparsely distributed with a $ii$ of 1–2 and a $bi$ of 0–1, and are limited to a few ichnogenera. The marlstone ichnocoenoses consist commonly of small Planolites, Chondrities, and Teichichnus (Figure 2). This is in contrast to the highly bioturbated limestone, with a $ii$ and $bi$ of 3–4. A few limestone beds appear massive due to bioturbation ($ii$ and $bi$ of 6). The limestone ichnocoenoses contain Planolites, Zoophycos, Teichichnus, and Thalassinoides (Figure 3).
Figure 2: Common trace fossils of the marlstone of the Bridge Creek Limestone Member of the Greenhorn Formation. A) Laminated bedding with few to rare burrows in marlstone. B) Planolites. C) Chondrites. D) Teichichnus. From the Amoco Production Company Rebecca K. Bounds #1 well. Ruler ticks are 0.5 cm.

Figure 3: Common trace fossils of the limestone of the Bridge Creek Limestone Member of the Greenhorn Formation. A) Burrow mottling common in limestone. B) Planolites. C) Zoophycus. D) Teichichnus. From the Amoco Production Company Rebecca K. Bounds #1 well. Ruler ticks are 0.5 cm.
To further this preliminary research, we will analyze the \textit{ii} and \textit{bi} of the Greenhorn and Niobrara formations in Amoco Production Company Rebecca K Bounds #1 housed in the Core Barn at the Kansas Geological Survey in Lawrence, Kansas. We will make a bed-by-bed assessment of the trace fossil diversity, tiering depth, and intensity with respect to the lithofacies in which they occur, including differences in grain-size distribution, size, and sorting and facies relations. Sediment from burrow fills will be compared to the surrounding matrix to determine how burrow fills affect local porosity and permeability. We will also perform minipermeameter analysis of the bioturbated intervals vs. nonbioturbated intervals. As part of this analysis we will also explore the permeability of different trace fossil morphologies with respect to the \textit{ii} and \textit{bi}, in comparison to the background texture of the host sediment vs. similar lithofacies with no bioturbation. The purpose of this is to determine the effects of bioturbation on postdepositional modification of effective porosity and vertical permeability. All of these data on bioturbation patterns will be tied to the stratigraphic variation in lithofacies in each formation to build ichnocoenoses (trace fossil communities) and ichnofacies models to understand the relationship between grain size, lithofacies, biogenically mediated porosity and permeability trends. Through this systematic analysis, we expect to find subtle though marked differences in grain size, sorting and type, and sedimentary structures and ichnology.

References


Hattin, D.E., 1985, Distribution and significance of widespread, time-parallel pelagic limestone beds in Greenhorn Limestone (Upper Cretaceous) of the Central Great Plains and southern Rocky Mountains: SEPM Field Trip Guidebook No. 4, p. 28–37.
