Storm Deposits and Evidence of Synsedimentary Faulting in the Middle Ordovician Trenton Group Limestones, Central New York

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Introduction

The purpose of this study was to determine how the depositional environment of the lower Trenton Group changed over time. The Kings Falls and Sugar River formations, along with the Napanee Member of the Rockland Formation, were the stratigraphic units in which the study was conducted. Emphasis was placed on water depth and environmental conditions at the time of deposition and possible synsedimentary faulting.

Our area of study was a south-facing man-made outcrop along the eastern bank of East Canada Creek near Inghams Mills, New York. Approximately 16.7 meters of the lower Trenton Group was exposed. New graptolite and lithostratigraphic evidence introduced by Mitchell and Bergström (1991), along with descriptions from Kay (1937), indicates that the Trenton Group is uppermost Middle Ordovician (upper Champlanian series, and Rocklandian, Kirkfieldian, and Shermanian stages).

Methods

The project was evenly divided into field and lab work. In the field at Inghams Mills, we compiled a stratigraphic column of the outcrop. A base was established at a bentonite bed in the Rockland Formation. From this datum we measured and recorded the bedding units up section, taking samples at distinct lithologic changes. A portable rock drill provided excellent cores which could show the transition between units in cross section.

The analysis of the samples was done in the lab, which was located in the Smith College Geology Department. Acetate peels were made of the samples using the techniques outlined in Wilson and Palmer (1989). Thin sections were also made both by using the equipment at the Smith laboratory and by sending the billets to Pioneer Thin Section Company.

Observations and Discussion

Paleogeography:

During the Middle Ordovician, a tectonically active belt formed along the eastern edge of North America, culminating in the Taconic Orogeny. Cisne et al. (1982) proposed that an arc-continent collision caused the orogeny. Due to the uplift, the Taconic foreland basin formed to the west of the orogeny. The Trenton Bank, where the Kings Falls and Sugar River limestones were deposited, formed adjacent to this basin. Continual uplift took place during deposition of the limestones. New York state was approximately 20° south of the equator during deposition of the Trenton Group, thus having a tropical environment capable of producing carbonates.

Paleoenvironment:

The Trenton Group limestones consist mainly of interbedded shales, packstones, and grainstones. In the lower portion of the Kings Falls, the main lithologic units are interbedded packstones and shales. Grainstones appear midway through the Kings Falls and become the dominant unit upward into the upper Sugar River. Fossils are abundant throughout the section both whole and fragmented and include such types as brachiopods, bryozoans, trilobites, gastropods, echinoderms, and ostracodes. The grainstones generally contain more of the fossil hash and less mud supported matrix than the packstones and shales.

After intensely studying the lithologic units of the outcrop, a fluctuating environment of deposition was hypothesized. In the shaley Napanee Member, the environment was most likely a deep, subtidal one. In the Kings Falls, a rapid regression occurs into a shallow, above wavebase environment. Evidence of this is the appearance of megaripples and cobble-bearing grainstones in the unit. Increased concentrations of gastropods, commonly shallow water organisms, in the lithology also indicates a shallower environment. Upward into the Sugar River from the Kings Falls, a deepening environment is observed. Titus (1989) supports the idea of a transgressive sea depositing the Trentonian sediments. Although grainstones are the dominant unit in the Sugar River, the increased sparry calcite content is more of a diagenetic (J. White, pers. comm., 1992) rather than environmental feature. Disappearance of gastropods in the lithology also supports a transgressive environment.

Storm Deposits:

Sediments deposited during single storm events commonly occur in characteristic vertical sequences of lithologies and sedimentary structures (Kreisa, 1981). An idealized storm sequence has been proposed by Kreisa (1981) showing the vertical succession of sedimentary structures and lithologies in fining-upward sequences. Figure 1 shows this idealized sequence as a shale unit overlain successively by a whole fossil packstone unit and a laminated unit upon which lies another shale. Thicknesses of these sequences can range from 1 to 40 cm, with thicker units tending to be deposited in a deeper environment than thinner ones.

The whole fossil packstone unit has a sharp, usually planar base which truncates the underlying lithology. These idealized packstones have certain defining characteristics which were also observed in those of the lower Trenton Group. The fact that whole fossils are found in a storm deposit seems almost a paradox. With a high energy environment, it would seem that fossils would be fragmented. However, it is due to this high energy that the fossils are deposited and buried very quickly before they are highly fragmented. Fossil fragments are indeed found in the packstones, but they are generally large and not finely broken up. The dominant orientation of the fragments is convex-up and parallel to bedding. A fine matrix supports the fabric. These packstone layers are quite irregular and may pinch out completely in a horizontal direction.

The laminated unit is a fining upward sequence which is formed from a settling out of debris from the waning storm. A sharp base is seen, resulting from scouring during the storm. Infiltration textures such as shelter porosity also developed in these relatively thin beds (Kreisa, 1981). Although it is seen in a few instances in the section, the laminated unit is not a dominant feature of the storm cycles. Cause for this limited occurrence could be extensive bioturbation.

The shale unit is formed either as a result of a settling out of the finest storm debris or from fair weather processes. These fine-grained, moderately fissile units are not highly bioturbated; body fossils are present is lesser quantities than the other layers.

At Inghams Mills, storm deposits appear in the Rockland and lower Kings Falls limestones. These deposits were not observed in the upper portion of the Kings Falls and Sugar River. Thinning of the deposits up section shows evidence of a transgressive environment (Kreisa, 1981). The absence of such deposits in the Sugar River could denote a depositional environment below the wave and tidal base, where the sediment is not affected by storm processes.

Cobbles as evidence for faulting:

At 1.96 meters into the section, large exotic cobbles ranging in diameter from 1-20 cm, along with megaripples, appear within the unit. These cobbles are mainly carbonate in nature, but a few metamorphic quartz cobbles were also observed. They ranged in color from white to gray. Cobbles such as these also appear in other units up-section, but not in such numbers as they do in this 0.85 meter thick section. In an attempt to determine their origin, I mapped out the area of section in which the cobbles occurred by transposing the region onto graph paper. On the map I noted the position of each cobble in relation to each other and noted the alignment of their long axis with a Brunton compass. Their alignment was charted in an attempt to show any patterns in relation to each other and to the prevailing direction of the megaripples (Figure 2). A slight trend was seen with the long axis aligned just west of N-S, which is parallel to the current flow as seen in the ripples. Overall however, a generally random cobble distribution was seen. Kepper (1981) also used this technique in a syndepositional faulting study on an outer shelf margin in California and Nevada.

Active contemporaneous faulting in the region was proposed by Kay (1937), and later disputed by Titus (1988) due to lack of evidence in the facies patterns. Cisne et al. (1982) claims that faulting was episodically active throughout Trentonian time due in part to arc-continent convergence. A fault scarp was observed in the area of our study approximately 100 meters to the west. I propose the fault scarp was active during deposition of the Trenton limestones and is responsible for the presence of the cobbles in the area. The carbonate cobbles could have been brought up from the underlying Rockland and Lowville Limestones, while the metamorphic ones may have come from quartz patches in the Little Falls dolomite. These cobbles eroded off the scarp and were deposited into the sediment where some reworking and sorting took place due to current activity. A large slumping feature was also observed in Napanee Member which provides additional evidence for synsedimentary faulting.

Conclusions

1. As we move up-section through the Napanee and lower Trenton Group, there is a change in the depositional environment. Regression is followed by transgression. Evidence to support this includes the presence of gastropods in the lower Kings Falls and the thinning of storm deposits upward.

2. Storm deposits are present in our section and are more dominant in the shallower environment of the lower Kings Falls and Napanee Member. These became evident by comparing Kreisa's (1981) idealized storm sequence model to the units in our outcrop.

3. The appearance of cobbles and the slumping feature in the lithology indicates synsedimentary faulting in the region. The cobbles could possibly have eroded off of the nearby fault scarp and been deposited in the sediment, where some sorting took place due to current and wave action.

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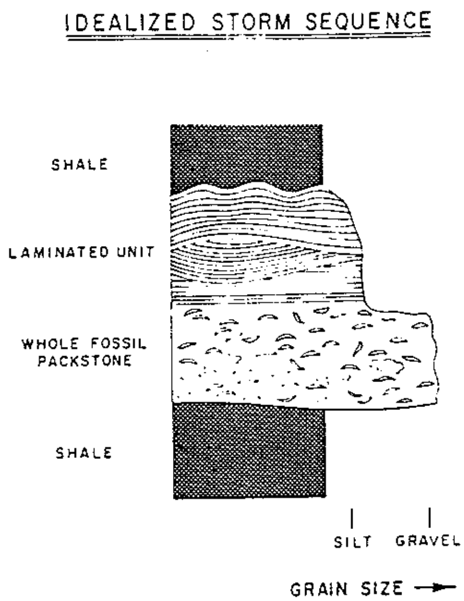

Figure 1. Idealized vertical succession of sedimentary structures and lithologies in fining upward sequences (Kreisa, 1981, fig. 3).

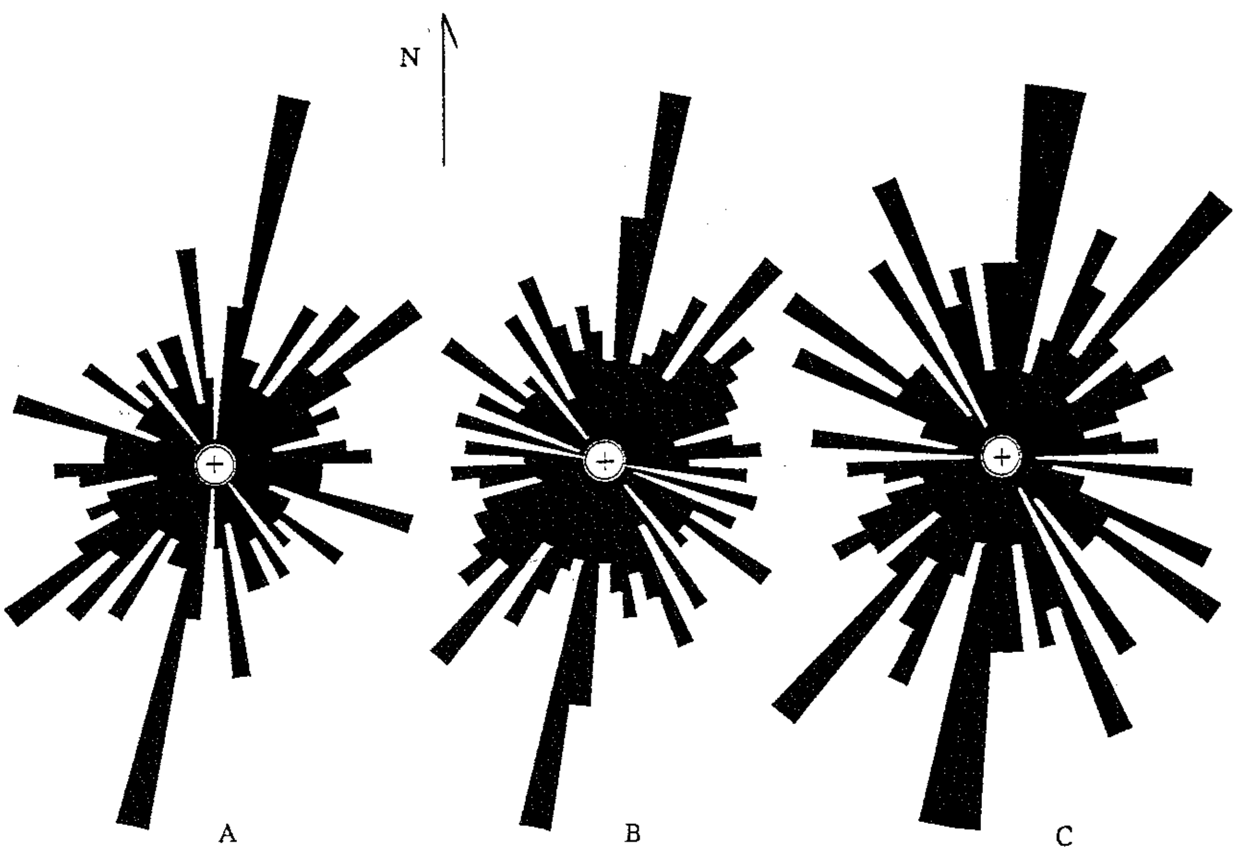

Figure 2. Rose diagrams showing alignment of long axis of cobbles 1.96 m into the section. A) Area 1 at 1.96 m. B) Area 2 at 1.96 slightly to the southwest of area 1. C) Combined plot of data from diagrams A and B.