A Faunal and Sedimentological Analysis of Upper Ordovician Strata, Grant Lake Formation, northern Kentucky

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Introduction

The Cincinnatian strata of the Upper Ordovician are some of the most fossiliferous beds in the world. Other Ordovician workers such as Li and Droser (1999) and McFarland et al. (1999) have found predictable shell-bed sequences in Ordovician deposits, and it was hoped that from sampling a two meter section of Upper Ordovician strata in the Grant Lake Formation of northern Kentucky, that I might find similar shell beds. Many of the beds were indeed composed largely of fossils, but not usually of only one particular type. Where Li and Droser (1999) found beds made primarily of brachiopods, beds made primarily of trilobites, and so on, the Grant Lake Formation sampled here contained primarily beds with several different fauna mixed together, mostly brachiopods, trilobites, echinoderms, gastropods, pelecypods, ostracods, and bryozoans.

Outcrops

Samples were collected from two road cuts in the Maysville, Kentucky, area: Maysville West and Highway 11 (see figure 1). The two collection areas are believed to be nearly stratigraphically equivalent because of a marker bed of seismites approximately 20 meters below. The beds in this area are all nearly horizontal, having dips of 0 degrees, making correlation more certain. Two 2-meter sections were measured at each outcrop, thirteen meters apart horizontally but at the same vertical position. It soon became apparent that, although the measured sections in the two different outcrops may be stratigraphically equivalent, their rocks have differences.

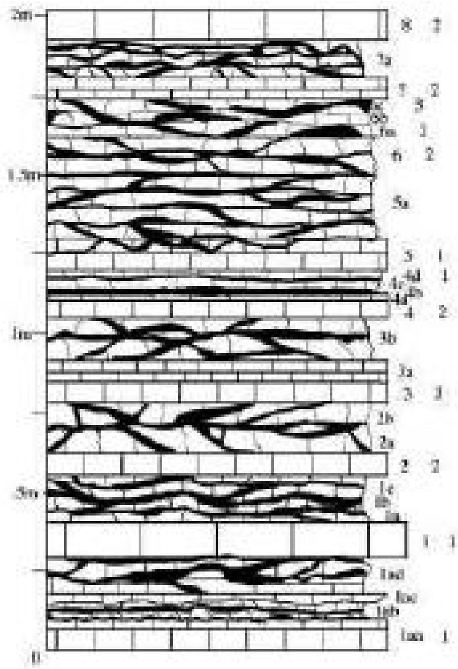
Rock Fabric and Composition

The thin sections were analyzed and categorized based on a number of different factors, including fossil assemblage, fossil size and abrasion, cements, orientations, and presence of phosphates or algal oncoids. Two main categories based on these data became quickly apparent: the finer-grained layers with no large fossils and common horizontal fossil and sediment orientations, making up only about 15% of the measured sections, and then the other 85%, mostly containing larger fossils and less commonly horizontally oriented. The second category can then be further broken down into two smaller groups. The first is a "higher current action" group, containing those layers with some degree of horizontal orientations, spar cements more common than micrite, and generally a lack of phosphates and oncoids. The second, the "low current action" group, contains mostly layers with frequent large, unbroken fossils with no discernable orientation, frequent thick micrites filling in around shells and less common spars, and often the presence of phosphates and oncoids.   These three designations were then assigned numbers (see figure 1).

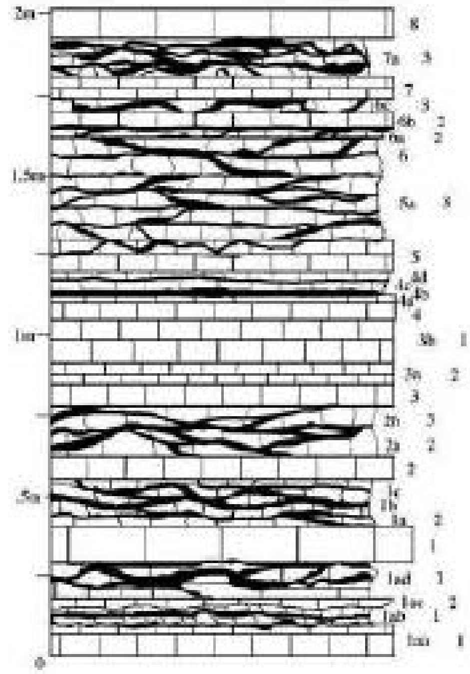
Other workers in this area have proposed that the alternation of resistant limestone beds and nodular limestones/clays of the Grant Lake Formation are storm bed sequences (Schumacher et al., 1991), so one of the first things investigated was the possibility of graded bedding. In all of the beds from both outcrops, there is only one good example of graded bedding, however, from layer 1 of the D and E sections. This thick, resistant limestone layer which contains burrows, grades from large fossils in the bottom 10 cm to very fine grains in the upper portion.

Maysville West Outcrops

Section A

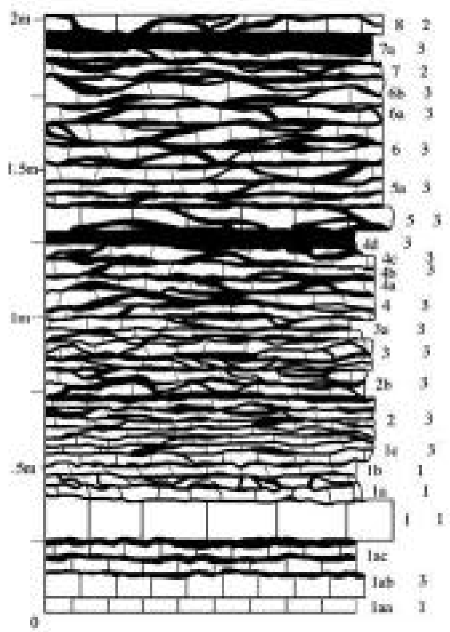


Section C



Highway 11 Outcrops

Section D



Section E

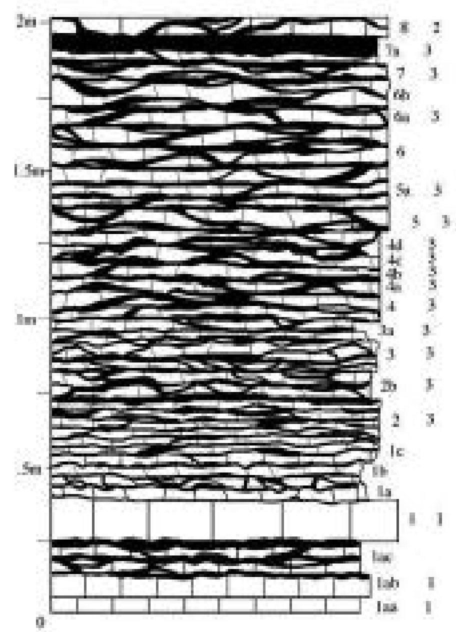


Figure 1. Stratigraphic columns of the four measured sections. Numbers to the right are bed designations and then depositional environment assignment. Notice the increased prevalence of both shale beds and of depositional environment 3 in the Highway 11 outcrop.

Implications for Depositional Environment

After analysis of over 80 thin sections from the four measured sections, it is apparent that the sequence is not merely made up of storm bed after storm bed. Instead, there are a few distinct storm beds, those layers classified as "1", containing fine-grained broken shells, which only make up 15-25% of sections in both outcrops. The remaining layers contain varying amounts of small, broken shell material, from moderate amounts in the Maysville West outcrops to very little in the Highway 11 outcrop.

Coarse-grained terrigenous material is absent in the measured sections as well as in most of the rest of the deposits of the Cincinnatian basin. A carbonate ramp depositional scheme best fits the observed deposits (James et al., 1994). This is illustrated in figure 2.

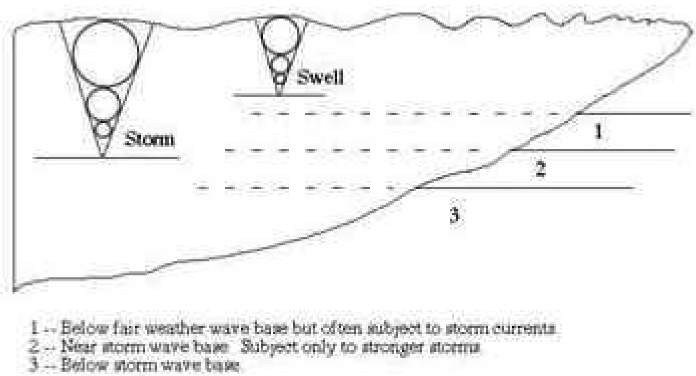


Figure 2. Relative position of depositional environment classifications in a slope system.

Classification 1 -- Shallow water, near-fair weather wave base:

These layers contain primarily biosparites with small grain sizes and a high degree of abrasion of fossil contents. This is indicative of strong currents, reworking and allochthonous deposition. In many of these layers the only fossils present are very small trilobite and ostracod fragments. Current ripple cross-bedding of fine-grained fossil fragments, burrowing, and graded bedding, as stated before, were observed in layer 1 of sections D and E at the Highway 11 outcrop, making this 17cm thick layer an idealized storm sequence. This layer is an exception, however, as no other layers reach such thicknesses or contain graded bedding.

Classification 2 -- Deeper water, but above storm wave base:

The contents of these layers vary from biosparite as in the previous classification, to some packed biomicrites and poorly washed biosparites. The occurrence of both large, whole fossils, and small fragments, as well as varying degrees of horizontal alignment of fossils, indicates that these layers were influenced by occasional strong current action, but were too deep to be affected substantially by most storms, and sometimes went long periods of time without being affected by swift currents. In this class, there is a large amount of variability in layer composition as observed in thin section. Small broken trilobite pieces and ostracods are fairly common, but unlike in class 1, in these layers they occur together with larger fossils. Burrowing, indicative of fairly shallow water, is rare. Deposition is interpreted as being variable, but in general, in deeper water than the first class, but still shallow enough for the occasional introduction of large amounts of broken, reworked shell pieces.

Classification 3 – Below storm wave base, but still in photic zone:

The predominance of large, whole fossils, with less frequent smaller fragments, and lack of order, suggest that these layers were deposited in somewhat deeper water than the previous two. Contents are primarily packed biomicrites and poorly washed biosparites. Currents were not strong enough to bring broken shells from shallower areas. The frequent presence of oncoids, however, means that deposition was not too deep, as these algal growths around shells are known to occur only in the photic zone (Selting and Schmitt, 1999). This is supported also by the fact that they grow through the rolling around of shells, which is more likely in shallower water. Layers in this class sometimes have stained shells, possibly from the presence of phosphate or magnesium (uncertain because no XRD analysis was done). If the staining is due to phosphates, it would imply possible deeper deposition (Pope and Read, 1994). This depositional zone is most likely deeper than the previous two, somewhat below storm wave base, but not in a deep-ocean area. The high abundance of mud in many of the layers with this classification is likely because of a very muddy environment, not because currents were only strong enough to move very small particles.

Conclusions

The layers in the measured two-meter sections of the Grant Lake Formation in northern Kentucky give many clues toward depositional environment, which have allowed for their classification into three possible depositional environments. If time and effort were not a factor, it would be interesting to do a similar survey on a twenty-meter section with more frequent sampling. Such a survey would possibly validate my work and give a better perspective on the depositional conditions over a larger time period.

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