Magnetic Susceptibility of Kettle Point Formation, Ontario, Canada

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Abstract

The Kettle Point Formation is an Upper Devonian black shale that preserves the Frasnian-Famennian boundary, which marks the most extreme of the three extinction events that comprise the Late Devonian mass extinction. The purpose of this study is to determine a high resolution location of the boundary within the Gore of Chatham core from Ontario, Canada. This determination will improve the understanding of the environmental conditions leading up to the Kellwasser event of the Late Devonian mass extinction. The specific location of the boundary will also improve the ability to correlate this rock unit to others that were deposited during the same time period in different locations. The Frasnian-Famennian boundary was determined to be located at a depth of 134.59 meters in the core. The boundary is observed to have taken place during a magnetic susceptibility decrease, and therefore indicates a sea level rise.

Introduction

The Gore of Chatham core contains a section of the Kettle Point Formation, taken from Ontario, Canada. The Kettle Point Formation is an Upper Devonian shale containing strata that preserves the Frasnian-Famennian boundary which is defined by the Kellwasser event, the most severe of the three stages which comprise the Late Devonian mass extinction (Bingham-Koslowski, 2015). Despite being one of the five most extreme mass extinction events during the Phanerozoic, little is understood about the factors responsible for causing this event. The magnetic susceptibility recorded in the samples was measured and used as a proxy to indicate sea level rise or fall and to identify unconformities within the strata as way to learn more about the climate during the Late Devonian mass extinction. Identifying the climate changes within the rock record through magnetic susceptibility can aid in understanding what factors may have caused the mass extinction.

Methods

- During the collection process samples were stored in small plastic bags and dried in a 50 degree oven overnight.
- The mass of each sample was measured to the nearest 0.01 g and labeled with the interval of strata from which they were collected.
- The AGICO MFK1-A was then used to measure the bulk-mass magnetic susceptibility of each sample (Figure 1).
- The magnetic susceptibility along with the spline-smoothed data was then plotted against the stratigraphic position to identify changes throughout the column.

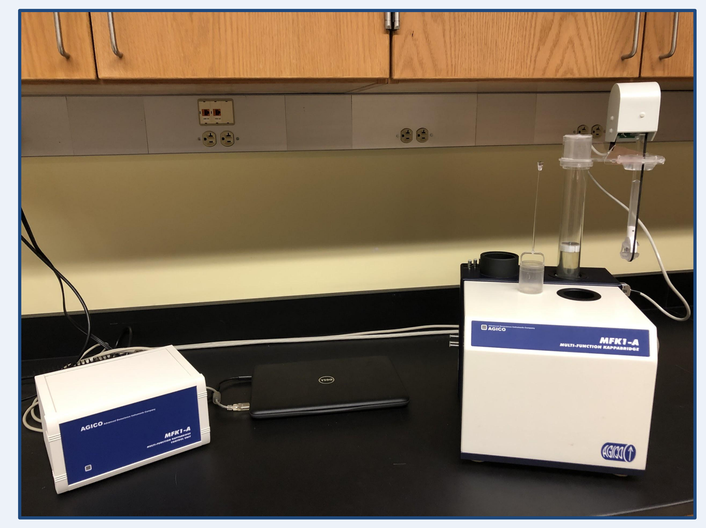

Figure 1. The AGICO MFK1-A is connected to a laptop and used to collect the bulk-mass magnetic susceptibility of the samples. Located on the main console is the plastic sample holder which is placed inside the unit three times for each sample in order to calculate an average value.

Results

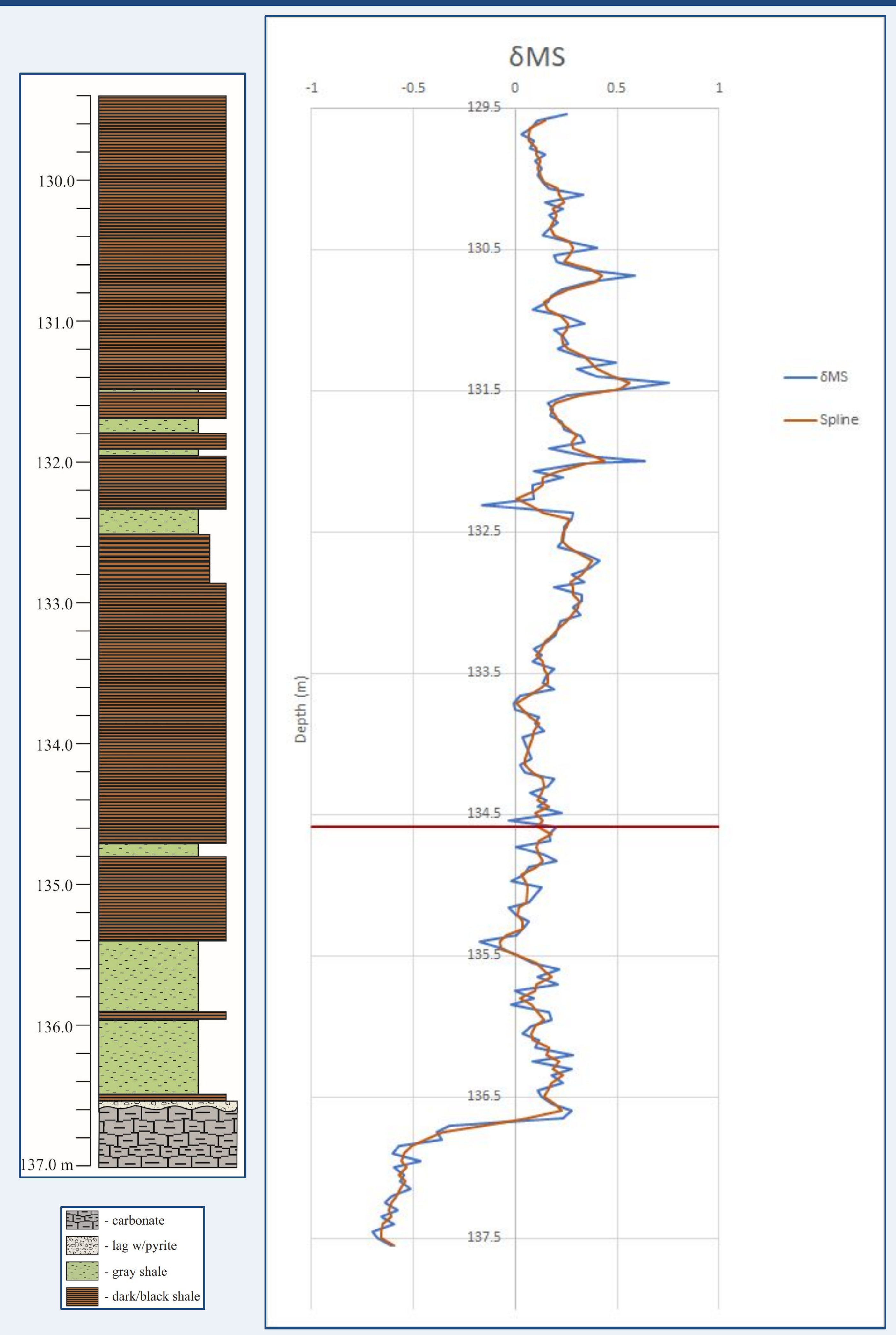

Figure 2. Magnetic susceptibility vs. stratigraphic position with increasing depth moving down the graph. The blue line represents the marine normalized data and the orange line represents the spline-smoothed data, calculated using a three-sample running average. The red line indicates the experimentally determined Frasnian-Famennian Boundary. A stratigraphic column showing lithology is displayed next to the MS data.

Discussion

Conodonts from both the Frasnian and the Famennian were recognized within the core and indicated a window between the depths of 134.4 meters and 134.94 meters for the occurrence of the boundary. The magnetic susceptibility graph was then used to pinpoint a more specific location of variation in sea level in this constrained section of rock. A rapid change in the magnetic susceptibility within this window of time would indicate a depositional facies shift due to the sea level change. Since the magnetic susceptibility is used as a proxy for sea level, a decrease in the MS represents a sea level rise and an increase in MS represents a sea level fall. The magnetic susceptibility changes observed in Figure 2 display many periods of sea level change but, using the constrained window of time we can pinpoint a decrease in magnetic susceptibility at 134.59 meters. This decrease in magnetic susceptibility indicates a rise in sea level thus confirming a change in the depositional facies at that time contributing to a deeper anoxic environment further from land. The Frasnian-Famennian boundary is generally defined by a negative shift in MS, and therefore our placement of the boundary is consistent with previous studies of different rock units (Over et al., 2019).

Conclusion

Understanding mass extinctions in the rock record is key to understanding potential mass extinctions of the future. Investigating the environment leading up to an extinction event may help recognize a modern mass extinction before it happens. The Frasnian-Famennian Boundary is typically defined by an unconformity and is recognized for a high magnitude change in the MS, but this unit doesn't appear to follow that trend. The boundary location was placed at a relatively low magnitude shift in the data and therefore suggests a simple facies shift rather than an unconformity representing a gap in time. Because this location preserves continuous strata through the boundary, more investigation into this unit may provide information about the Kellwasser event that has been unstudied because of the unconformity recognized in previous studies

References

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Over, D.J., Hauf, E., Wallace, J., Chiarello, J., Over, J., Gilleaudeau, G.J., Song, Y., Algeo, T.J., 2019, Conodont biostratigraphy and magnetic susceptibility of Upper Devonian Chattanooga Shale, eastern United States: Evidence for episodic deposition and disconformities: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 524, p. 137-149. doi: 10.1016/j.palaeo.2019.03.017