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MAGNETIC SUSCEPTIBILITY OF BEDS FROM THE UPPER LOWER ATOKA FORMATION

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INTRODUCTION

The Pennsylvanian-age Lower Atoka Formation is exposed along an I-49 roadcut north of the Highway 74 intersection. The section is composed of repeating shale and sandstone units that appear to be cyclical.

A gamma-ray well-log correlated to this outcrop tracks the lithologic changes well, with shale units indicating high API values, while sandstone units represent lower values relative to the shale units. API values are controlled by concentration of clay content due to those clays bearing the radioactive isotope ^{40}K, and Th and U that may be trapped interstitially.

Clays are concentrations of terrigenous materials that are paramagnetic, and more paramagnetic than other marine sediments such as carbonates and quartz-rich silts and sands.

Magnetic susceptibility (χ) is a cost-effective geophysical analysis on rock samples that detects concentrations of paramagnetic materials in an induced magnetic field, and should therefore reproduce a gamma-ray curve. If collected at short, repeated intervals, χ data may detail more information on conditions of sedimentation than a section sampled at coarse intervals with a gamma-ray spectrometer.

The purpose of this project is to determine if χ values of these samples and curve produced from these samples collected at this roadcut can reproduce the gamma-ray curve from well-log.

Research questions include:

1) Which unit contacts are apparent in the χ curve?

2) Which contacts correlate well between both curves?

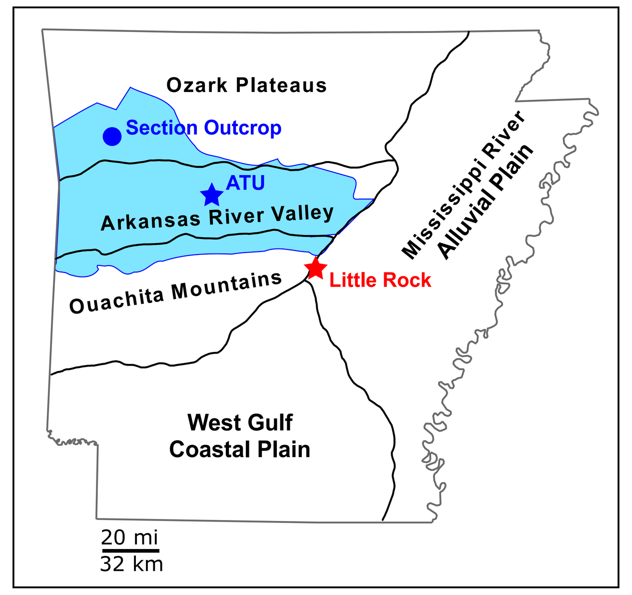
3) Are there any new units/contacts evidenced in the χ curve?

4) Is there an apparent sediment accumulation rhythmicity expressed in the χ curve?

5) What sampling resolution is needed to apply this technique at other Atoka Formation outcrops?

METHODS

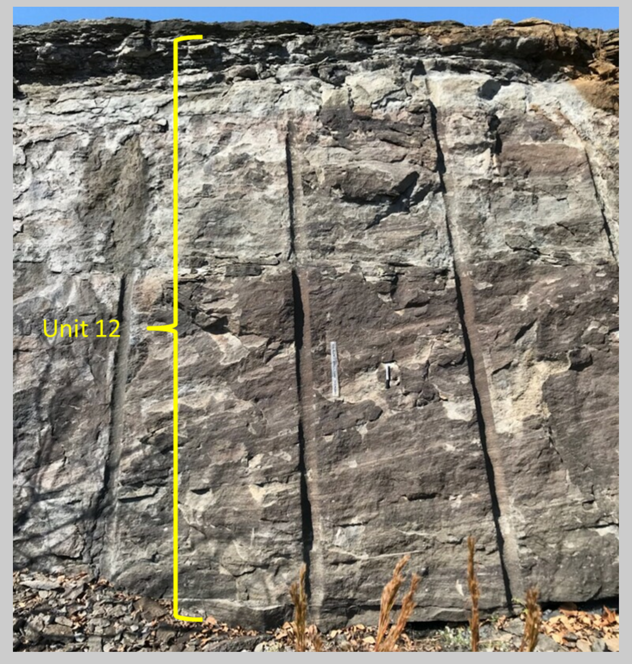
Samples were collected every 10 cm, which was adjusted to account for dipping strata. The section starts 0.50 m below the base of a Unit 1. Samples were processed into pellet-sized pieces to remove effects of anisotropy. χ was measured using the Williams Magnetic Susceptibility Bridge at Louisiana State University, and mass of the sample.



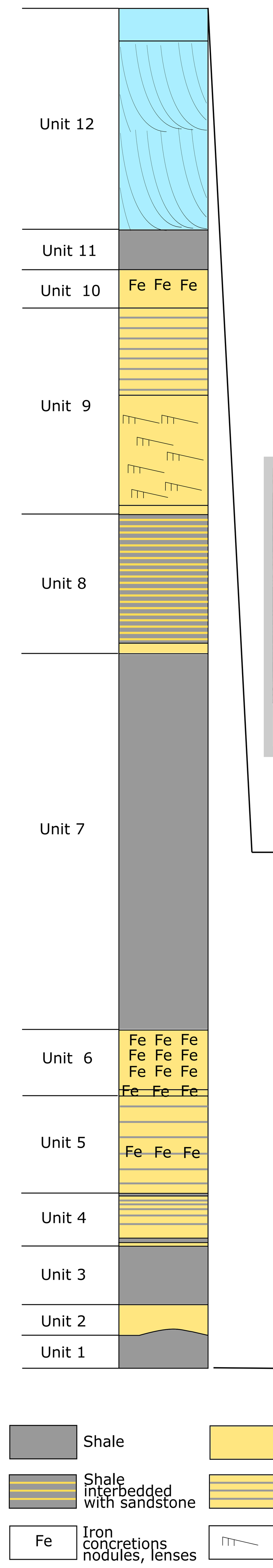
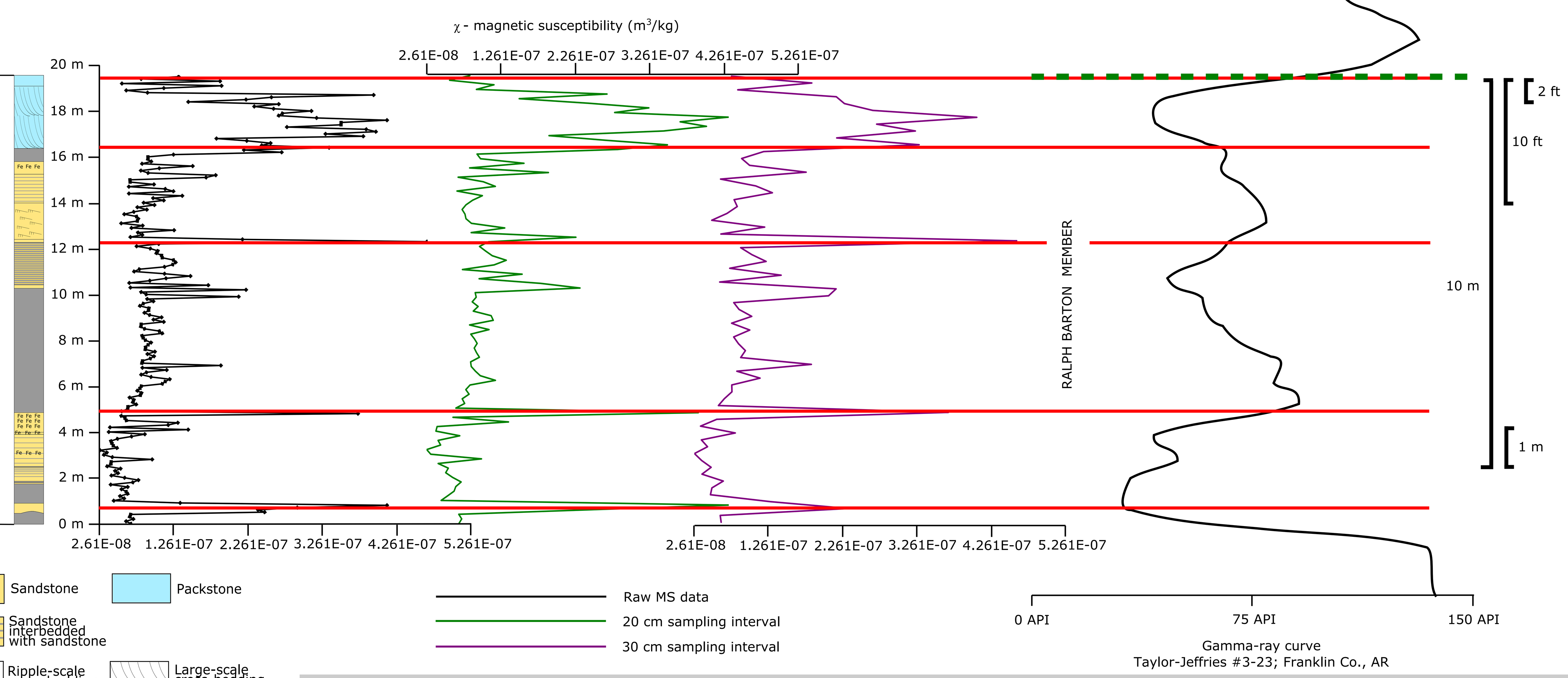
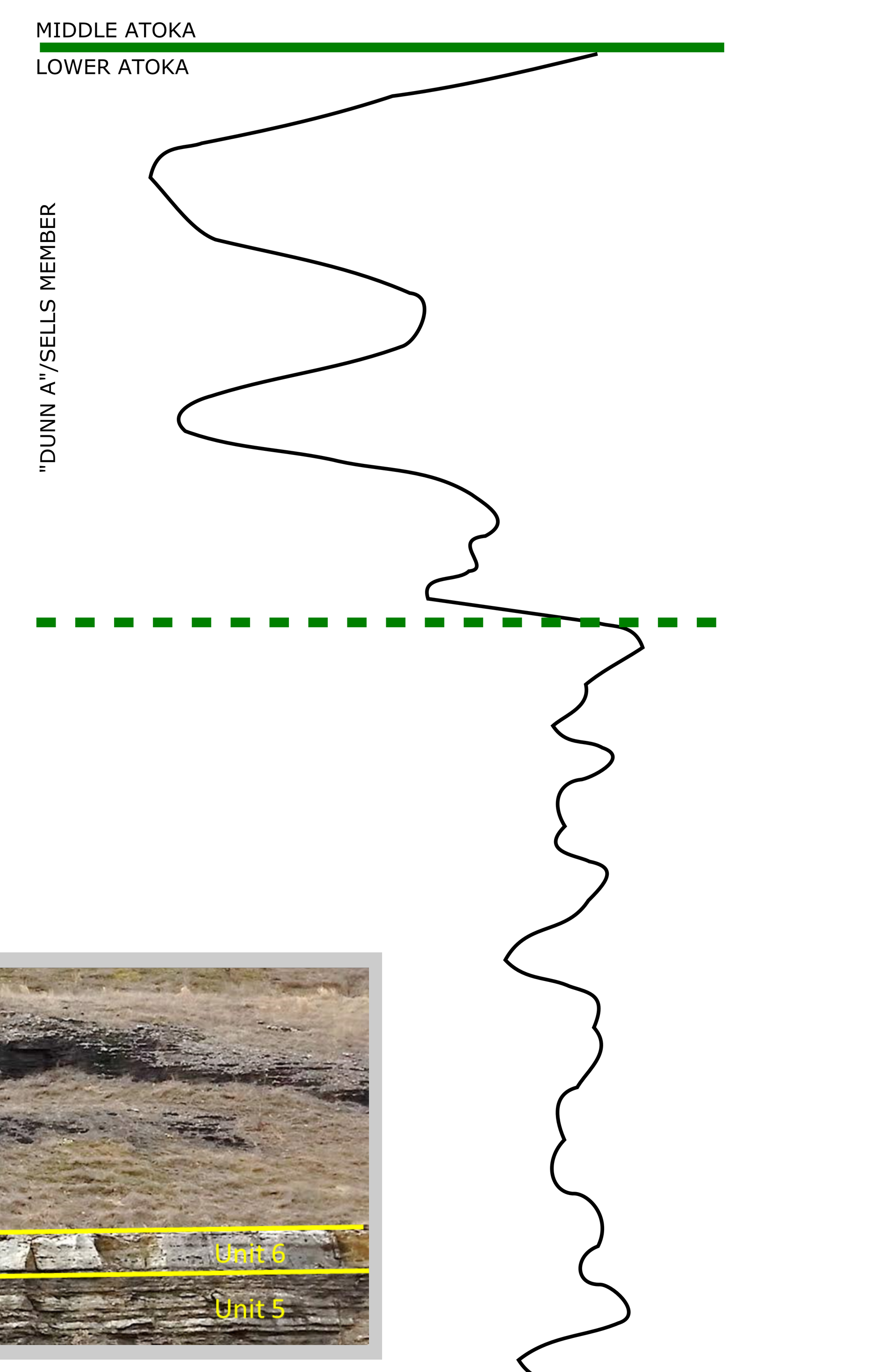
Left. Physiographic map of Arkansas with study site and other notable locations marked. Extent of Atoka Formation bedrock potentially exposed is indicated by light blue fill. Modified from Arkansas Geological Survey Physiographic Regions Map and Geologic Map.

Right. Bed description and unit number for stratigraphic column below. Unit 12 "packstone" is a mix of bioclasts that have been replaced, calcite cement, and coarse quartz grains. Due to the mix of various compositions, determining a single lithology ID/name is rather enigmatic.

Unit	Bed #	Thickness	Description
12	20	51 cm	Thinly bedded packstone.*
	19	286 cm	Packstone with broken fossils, cross-beds, and iron. Fossil concentration increased 160 cm up from the base of the layer.*
11	18	61 cm	Shale.
10	17	57 cm	Massive sandstone at the top of the layer with some bioturbation and iron concentrations at the bottom.
9	16	135 cm	Sandstone interbedded with shale. The sandstone beds start at 10 cm up from the bottom of this layer and get finer moving up the layer while displaying ripples and lensing.
	15	167.5 cm	Ripple, cross-bedded sandstone with coherent layers ranging from 8 cm thick.
	14	14 cm*	Sandstone layer that displays lensing. *Average thickness.
8	13	195 cm	Shale with sandstone lenses and beds that range from 4 cm to less than 0.5 cm in thickness interbedded throughout the layer.
	12	16.5 cm	Sandstone.
7	11	569 cm	Shale.
6	10	90.7 cm	Completely bioturbated sandstone with horizontal trace fossils, and three horizons of iron lenses 30 cm apart.
	9	10.25 cm	Bioturbated sandstone with 2.5 cm iron lens bed near the top.
5	8	148 cm	Indurated sandstone with layers of lensed iron concretions. Broad alternation between 16 cm to 40 cm in thickness.
4	7	4.5 cm	Shale.
	6	64.5 cm	Sandstone and shale with thin beds being at the top that get thicker moving down the layer.
	5	7.5 cm	Shale.
	4	5.5 cm	Massive sandstone.
3	3	89 cm	Shale.
2	2	47 cm	Massive sandstone with channel fill/wavy contact at base.
1	1	50 cm	Shale.



Right. Various photographs of I-49 southbound outcrop annotated with unit numbers and contacts that match the stratigrpahic column. Jacob's staff is 6 ft; ruler is 12 inches. Photographs by A. Baker and J. Grosskopf

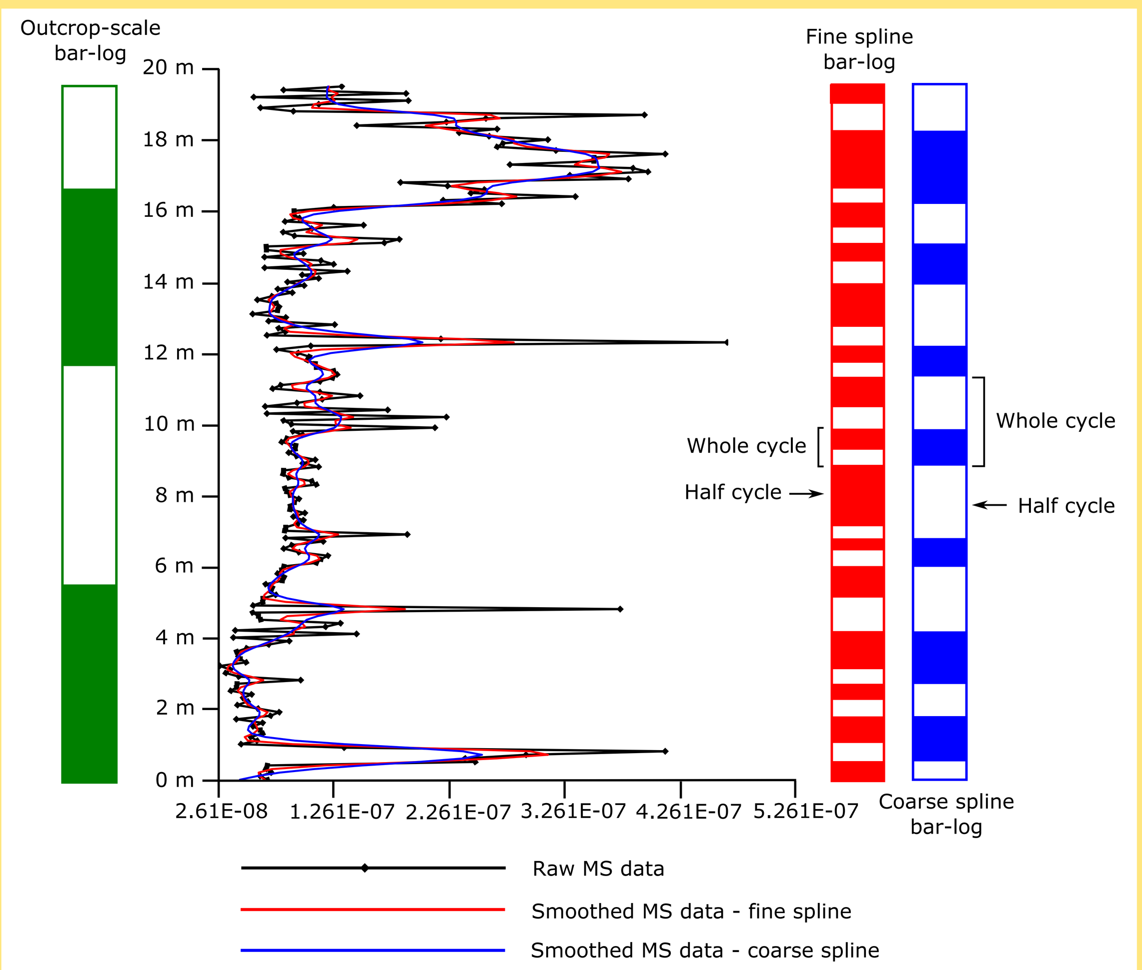
Above, from left to right:
Expanded stratigraphic column and lithologic patterns for the Atoka Formation roadcut, scaled stratigraphic column, χ curve at 10 cm collection interval, χ curve at 20 cm intervals, χ curve at 30 cm intervals, and scaled (see scale bars on right) gamma-ray curve from well-log. Horizontal red lines represent correlative horizons that can be traced at unit divisions, among the different collection intervals, and shifts in the gamma-ray curve from the well-log. Green lines on well-log indicate Middle/Lower Atoka Formation Member contacts.

RESULTS AND DISCUSSION

Represented in the χ curve are various unit contacts and horizons that correlate well with the gamma-ray log.

Quartz-rich sandstone units should produce low χ values due to lack of paramagnetic materials; the χ curve depicts the opposite. Hematite lenses present in the sandstone units are responsible for the positive spike (paramagnetic) in readings. Similarly, in Unit 12 an unidentified iron oxide was present, and coated/replaced bioclasts and was concentrated at bounding surfaces between cross-beds. While this might seem destructive to the signal for the section, it serves as a good marker for correlation among other outcrop-scale datasets or curves.

Sampling at 20 cm and 30 cm maintains a good correlation with the gamma-ray log. This result establishes that coarse sampling intervals may be used for correlation among outcrops comprising the Atoka Formation.



Above. Raw x curve and smoothed χ curves, and bar-logs produced from shifts in th curve. Fine and coarse splines calculated using JMP software cubic spline function at 10000 and 100000 for fine and coarse splines, respectively.

Sediment accumulation rates for the Lower Atoka Formation at this position in the Arkoma Basin are interpreted to be 11 cm/Kyr. The total time represented in the 19.20 m section collected is 174.5 Kyr. Bar-logs produced from smoothed χ curve depict cycles of sedimentation. Coarse- and fine-splined χ data represent different interpretations of the number of cycles present in the outcrop. A bar-log depicting the coarsest interpretation of depositional cycles matches expected results for the eccentricity cycle at 100 Kyr, with 1.75 cycles.

Duration of obliquity and precessional cycles, when corrected for the age of the strata, do not match expected sedimentation rates . It is expected that precessional cycles would be preserved at the paleoequator. Incorrect smoothing spline or sampling interval, and chaotic depositional conditions may have influenced this result.

CONCLUSIONS

Magnetic susceptibility (χ) is a robust tool for correlation and interpretation of depositional conditions, which can be applied Atoka Formation outcrops in the region.

- χ data produce a curve that shares correlative horizons with gamma-ray well-logs.

- A coarse sampling interval up to and perhaps past 30 cm (~1 ft) is good enough to correlate sections of Atoka Formation using χ.

- Sediment accumulation rates depicted in χ data curve match interpretations of Lower Atoka sediment accumulation rates.

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