ALONG A PROMINENT BLOYD FORMATION EXPOSURE: *ASTEROSOMA* MORPHOLOGY AND DISPERSION

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Abstract:
Asterosoma traces are exposed among Bloyd Formation outcroppings in the Big Piney District of the Ozark National Forest, Arkansas. One prominent exposure is along a waterfall where fallen blocks bare bedding surfaces with the densely-clustered traces. The strata were measured at this exposure to assist in discovery of more *Asterosoma* in the region. From clear photographs of the block faces, a series of measurements were taken from each trace using vector-based image editing software. The *Asterosoma* tracemakers produced a clear radial pattern of lobes with some additional sprieten textures, each cataloged with measurements from clear photos using the software. Location of trace centers, the number of lobes on each trace, angle between each lobe, and trace center spacing were determined to interpret the conditions and potential biodiversity of the ancient environment the tracemakers inhabited. The shallow marine conditions represented in this section of the Bloyd Formation strata were active enough to host this community of organisms, persistently, indicated by the presence of these traces through multiple layers of the exposure. More work will determine if this particular type of community is present in other portions of the Bloyd Formation in the region.

Background:
The Pennsylvanian-age Bloyd Formation is exposed from central Arkansas towards Oklahoma on a west-northwest line. While not as widely exposed in the central portion of this tract, there are a number of localities where the Bloyd Formation is well exposed due to fault or stream erosion.
About ~30 km North of Arkansas Tech's Campus in the Boston Mountains region of the Ozark Mountains, and in the Big Piney District of the National Forest there exists a famous "hidden" waterfall. There are tens of meters of Bloyd strata exposed along the entirety of the waterfall. The coarse thick-bedded sandstones of the Middle Bloyd Sandstone offer a strong caprock to the shale layers below. Weathering along this sharp contact has produced a rather expansive clean section of Bloyd strata below the Middle Bloyd sandstone.
One feature present in the lower strata is the density of the trace fossil *Asterosoma*. The multi-lobed star-shaped radial burrows are readily found in fallen blocks, or in the base of intact overhanging layers. *Asterosoma* have been found in the region, but the waterfall exposure presents the best location to study the ancient tracemaker's environment and community characteristics. Measurable aspects of the *Asterosoma* presence along this exposure is the focus of this research poster.

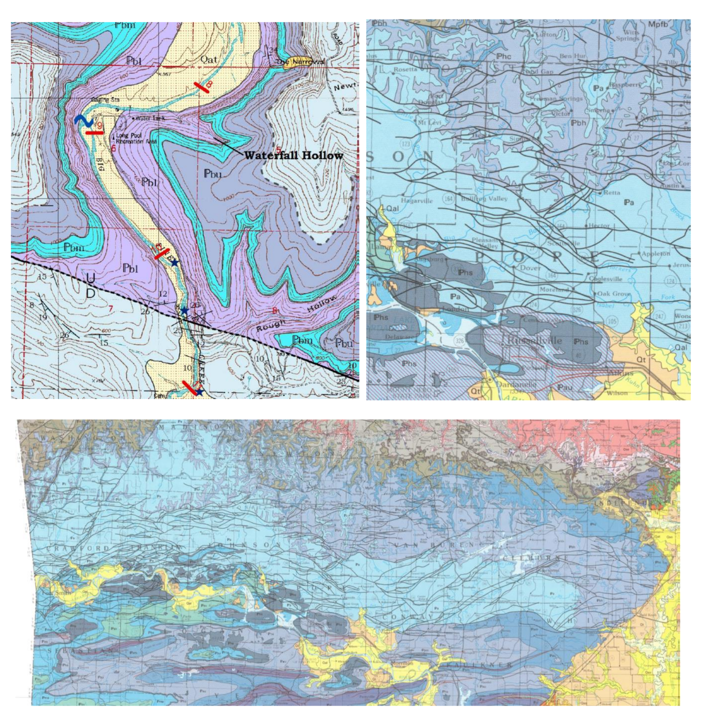
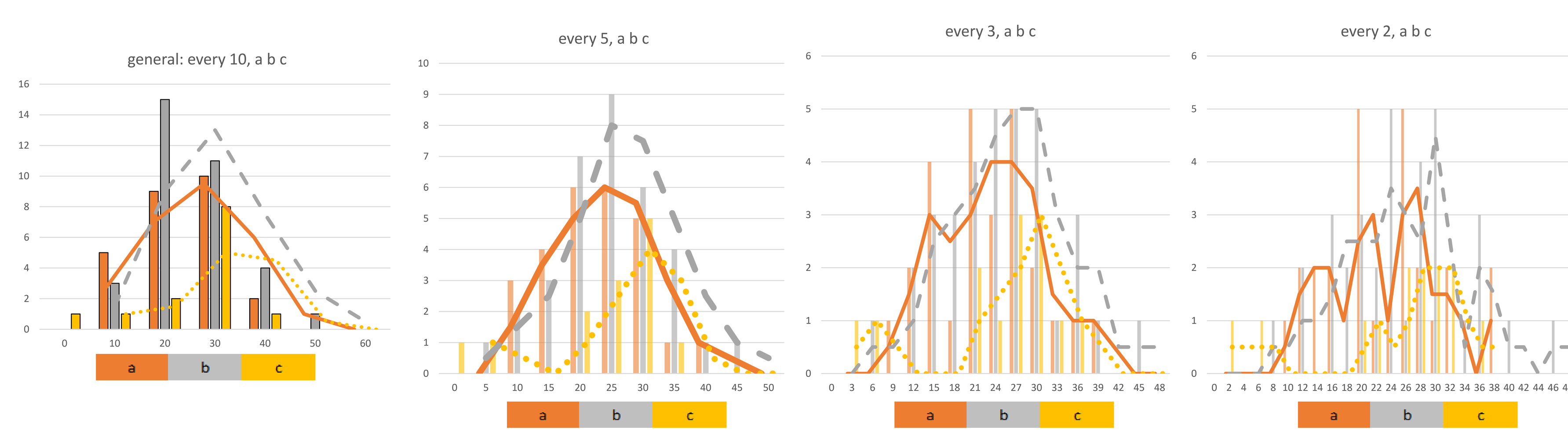


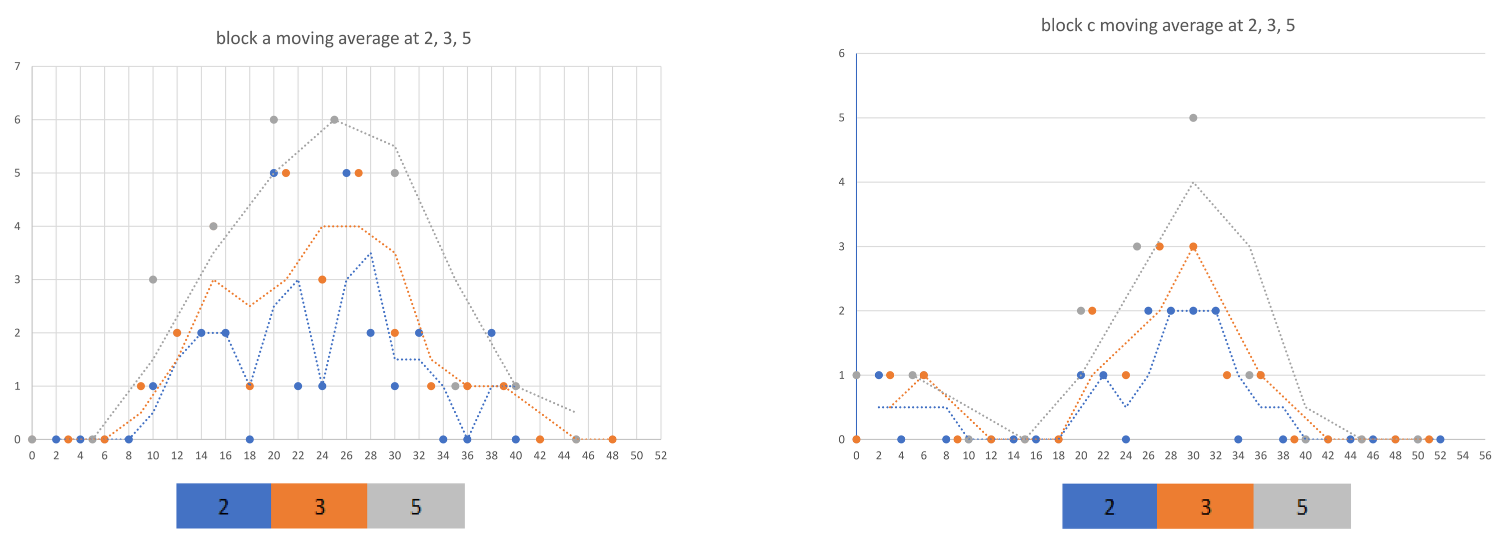
Figure 1: Geologic map of the exposure area (Haley, B.R. and Arkansas Geological Commission personnel. 1993. Geologic Map of Arkansas 1:500,000. Revised from 1976 ed. Arkansas Geological Survey State Map Series, Arkansas Geological Survey, Little Rock, AR); **Figure 2**: Photographs taken by John M. Thomas of the field site in the Bloyd Formation *Asterosoma* traces are found.

Research Goals:
A) Build detailed stratigraphic column to more readily locate these traces in the poorer quality exposures of the surrounding region; determine what beds the traces are mainly produced from
B) Carefully photograph traces present on fallen blocks, and import those photos into a vector-based image editing program in order to
B.1) examine the trace size and shape characteristics and interpret tracemaker(s) morphology
B.2) determine the density of the traces to interpret paleoenvironmental conditions

Methods:
Inkscape, a vector image editing software was used to determine trace centers, angles between lobes, and trace density of three slabs that were photographed clearly and possessed traces. A spreadsheet was used to gather data and calculate average angles between the trace lobes and create histograms to further study the angles between lobes, and to determine trace density of each slab using measurements taken in Inkscape. Trace centers were marked, and their lobe separation angles were measured in Inkscape.
For calculating trace density of each slab, a random point was picked on the photographic image and the distance to the nearest trace center (called **Line 1**) was calculated using the pixel-distance dimension of a box and its hypotenuse. The box width and height were recorded and reported, the hypotenuse and true distance between the traces was calculated from those values. The next step of determining distance to the next nearest trace center (called **Line 2**) was calculated in the same manner.
Results from this procedure could represent trace density ranging from uniform (indicated by *Line 1 < Line 2*), clumped (indicated by *Line 1 > Line 2*), or random (indicated by *Line 1 and Line 2 being about equal in length*). After these average distances were calculated in pixels, they were converted to actual (real life, cm) distances for applied interpretation.

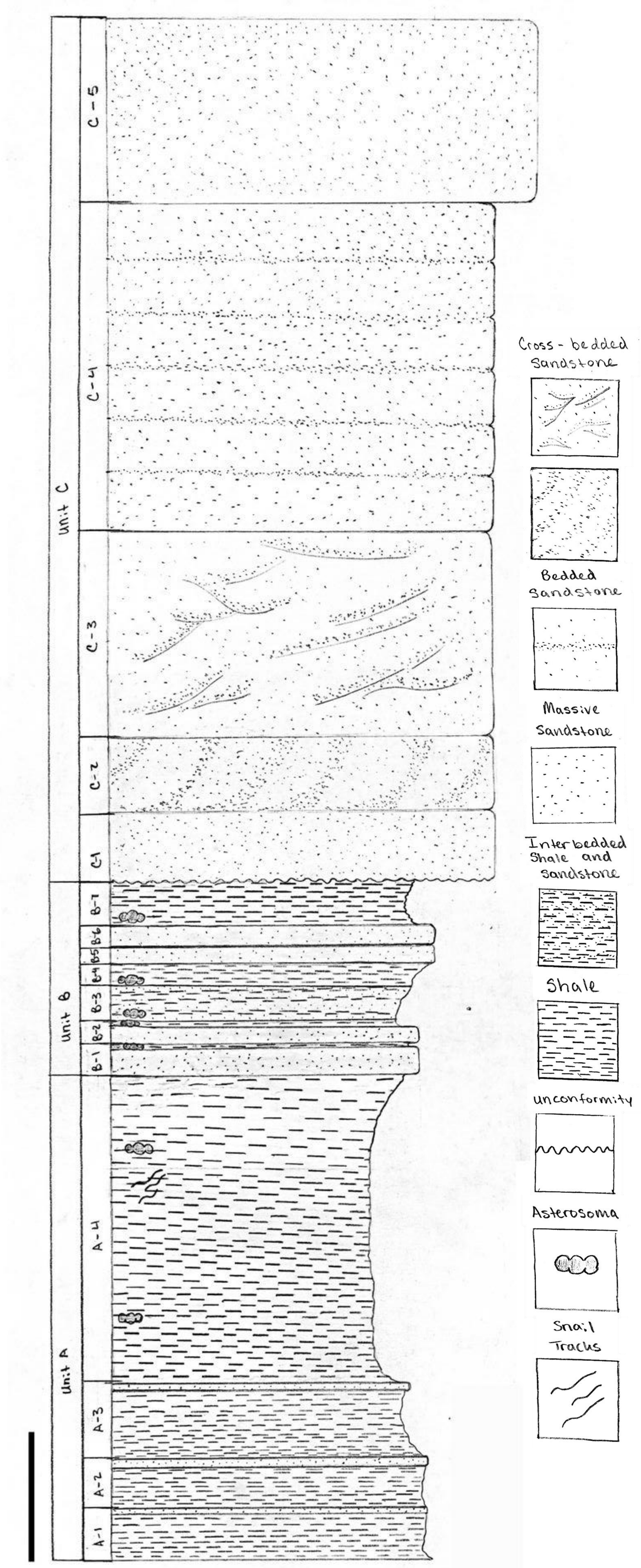
Figure 3: The image to the left is the unedited Photo A, and the image to the right is Photo A after edits were made in Inkscape. The red circles represent trace centers, and the red line represents a scale bar (10 cm). This was the first step in editing the images using Inkscape.





Trace morphology: Average angle between lobes
Determining if lobes on a 3D trace fossil were on the same surface proved difficult. With the most conservative interpretation, 73 measurements were made across three blocks that possessed many *Asterosoma*.
The average angle between lobes was 23.8 degrees, with a standard deviation of 8.35 degrees. Further investigation into the trace morphology revealed a deviation from the expected based on the normal range of organism body plans. Morphologies of organism populations tend to vary on a normal distribution, there was a deviation to this measured distribution respective to a smaller angle between lobes.
Angle between lobes measurements were rounded into 5 degree categories and counted for total traces possessing a matching lobe spread each category. Most traces measured had a lobe separation angle of around 25–30 degrees. The categories were further expanded by grouping lobe spread angles to roundings of 2 and 3 degrees, where the deviation from the norm was easily noticed. Slabs A and C were examined at these finer-degree separation, as they seem to have the most deviation.

This finding implies that the traces preserved in the Bloyd Formation could have been produced by a community of organisms that made the same trace due to dwelling and feeding behaviors consistent with the environment, but may have been composed of different species (not monospecific).



Unit	Subunit	Description
Unit C	C-5	Massive sandstone capping the entire waterfall exposure (1.29 m est.)
	C-4	Thick sandstone beds (2.58 m total thickness, est.). Bed thickness average 43cm.
	C-3	Very thick bedded sandstone (1.60 m) containing cross-beds of varying orientations and steepnesses.
	C-2	Very thick bedded uniformly cross-bedded sandstone(59 cm)
	C-1	Massive sandstone bed (54 cm). Rip up clast inclusions embedded in wavy base.
Unit B	B-7	Very thinly bedded shale (33 cm). Unconformity at top. Last major shale layer and layer where *Asterosoma* can be found.
	B-6	Thick sandstone bed that extends 16 cm.
	B-5	Thick sandstone bed that extends 12 cm.
	B-4	Thinly bedded shale that extends 17 cm. Contains the largest abundance of *Asterosoma* observed throughout entire exposure.
	B-3	Interbedded shale and sandstone beds, with the avg shale bed g 5 cm and avg sandstone bed 8 cm. *Asterosoma* can be found within each shale bed in layer.
	B-2	Thick sandstone bed (13 cm) capped by very thinly bedded shale (4 cm). *Asterosoma* present throughout shale cap.
	B-1	Thick sandstone bed (20 cm) capped by very thinly bedded shale (3 cm). *Asterosoma* present throughout shale cap.
Unit A	A-4	Base: thinly bedded shale that (164 cm) transitions to medium to thinly bedded shale (Top, 73cm). Snail tracks observed at bedding transition (73 cm). First presence of *Asterosoma*.
	A-3	Thinly bedded shale (57 cm) capped by thin sandstone bed (4 cm).
	A-2	Thinly bedded shale (36 cm avg), capped by a thin sandstone bed (6 cm)
	A-1	Thinly bedded shale (35 cm avg), capped by thin sandstone (4 cm)

Results/Interpretation:
The data was collected by looking at the most recently made lobes and interpreting the angle data based on those assumptions. For example, some of the traces were clear indicators of an organism's behavior, however, they were too damaged to discern the center but were good evidence of a trace such that they were labeled but the lobes were not measured, some had centers that had to be interpreted to measure the angle between lobes, and others may have been traces overlain and thus were labeled but not measured. After calculating the angles between lobes and determining the trace density of each slab, averages were recorded, and grouping determined. The average angle between lobes was 23.03°, 24.94°, & 24° for blocks A, B & C, respectively. The dispersal of organisms tested using point to trace, and trace to trace measurements was analyzed using Eberhardt's index (I_E;1967) of dispersion (good for populations with low dispersion), and Hines and Hines (h_T;1979) test. Different blocks possessed different trace dispersion types. For instance, Block A has one test, with a result of $I_E = 1.127$ indicated a uniform pattern of traces, and with the other result $h_T = 1.147$, was too close to consider "not random" at $\alpha = 0.01$, but is considered "not random" at less statistically significant alpha values.

Block	I_E	h_T ($\alpha \leq 0.01$)	h_T ($\alpha > 0.01$)
A	Uniform	Random	Not Random
B	Uniform	Random	Random
C	Uniform	Not Random	Not Random

The average distance from trace center to trace center (**Line 1** to **Line 2**—trace density) was 5.52 cm, 6.11 cm, and 9.25 cm for blocks A, B & C, respectively. The environment was rich in oxygen and nutrition to support this community, with organisms potentially closely spaced as the radial burrow's peripheral outline.

Conclusions:
-Strata below the Middle Bloyd Sandstone are well-exposed at a popular "hidden" waterfall

-Certain horizons in this exposure possess densely packed *Asterosoma* in a uniform and random type dispersal arrangement

-Evidence suggests there is a mixed community of trace makers

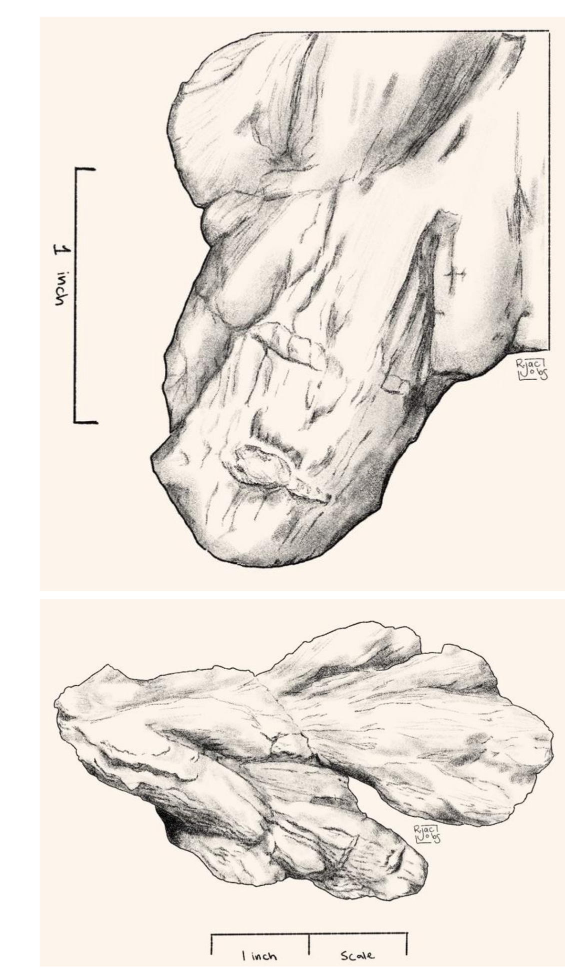


Figure 4: Artistic rendition of a well-preserved trace fossil to exhibit the detail by Rachel Jacobs. Note the nodes enhanced on the top image are the same as the ones in the lower-most lobe of the bottom image.

References and Acknowledgements:
Chandler, A., and Hutto, R. 2010. Geologic Float Guide to Big Piney Creek Helton's Farm to Twin Bridges, Pope County, Arkansas. Arkansas Geological Survey Guidebook, GB 2010-1, 27p.
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Hines, W.G.S. and Hines, R.J. 1979. The Eberhardt statistic and the detection of nonrandomness of spatial point distributions. *Biometrika*, **66**, 73–79.
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