



Structural Analysis of the Bigfork Chert in Crystal Springs, AR



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Abstract

This project aims to generate a photogrammetric virtual outcrop model (VOM) to digitally analyze the geometry and structural features of folded beds. Using a DJI MAVIC 2 drone, 401 images were collected and processed to construct a high-resolution 3D model, enabling remote measurement and structural interpretation. The study area is in the Ouachita Mountains, south of Crystal Springs, Arkansas, and consists of a former chert quarry. Given the limited accessibility of the physical outcrop, this method provides a valuable alternative for structural analysis. The resulting structural data is then compared to regional deformation associated with the Ouachita Orogeny. This is done in attempt to assess the structural role of the Crystal Springs locality within the broader tectonic framework. This study highlights the utility of VOMs in expanding geologic accessibility and supporting detailed structural interpretations in challenging field environments.

Geologic Background

The study area lies ~0.3 miles south of the unincorporated community of Crystal Springs, Arkansas on Crystal Springs Rd. The site is home to a former Chert Quarry which is solely outcropped by the Bigfork Chert Fm. Deposited around the mid Ordovician, ~470-445 million years ago (Ethington, et. al, 1989) and formed in a deep marine basin. The Ouachita orogeny was characterized by complex folds which can be seen in the study location. Deformation took place in the Mississippian through early Pennsylvanian periods (~330–300 Ma) and was the result of the Laurentia and Gondwana plates colliding (Viele & Thomas, 1989).

Study Area: Crystal Springs Chert Quarry

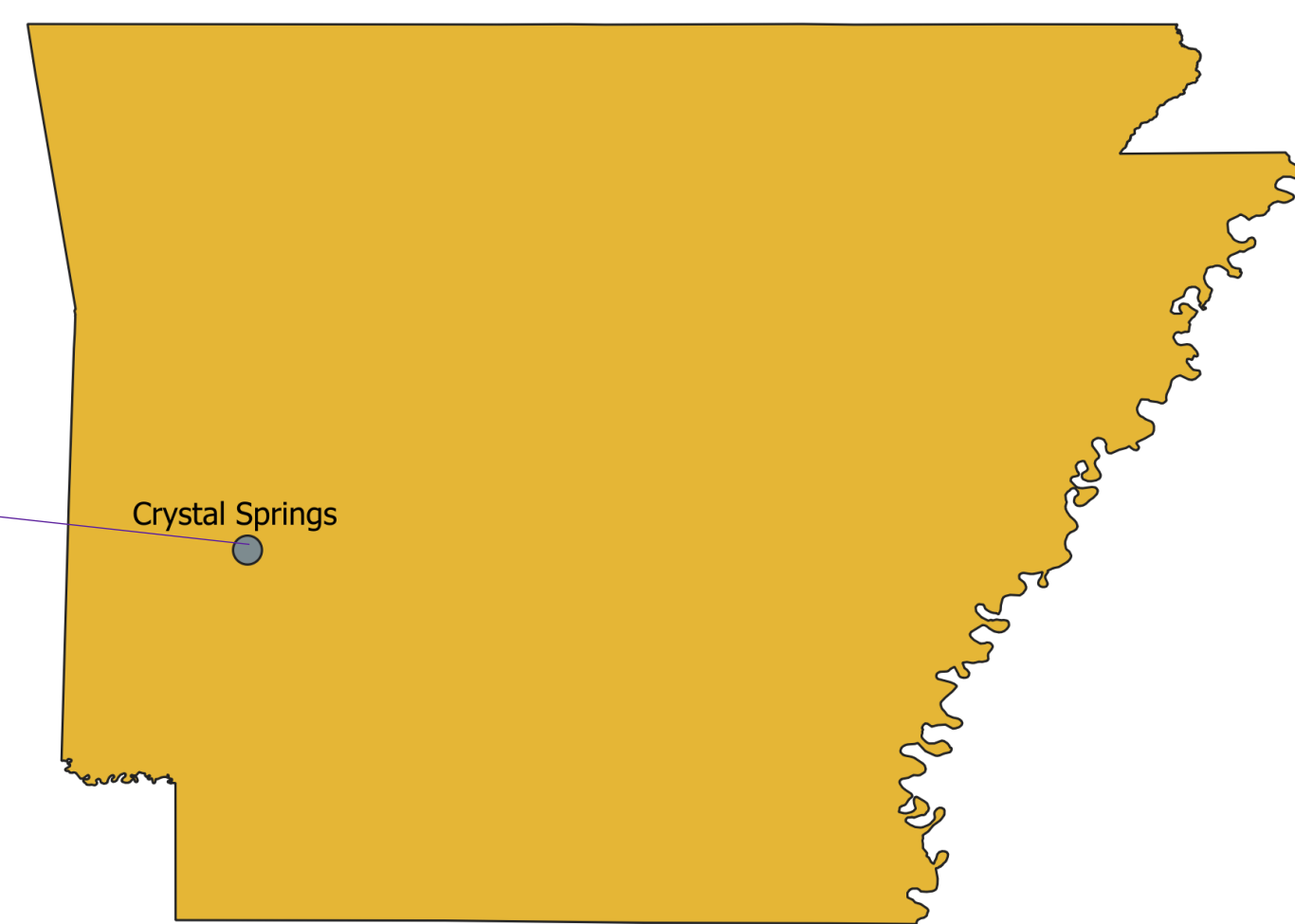
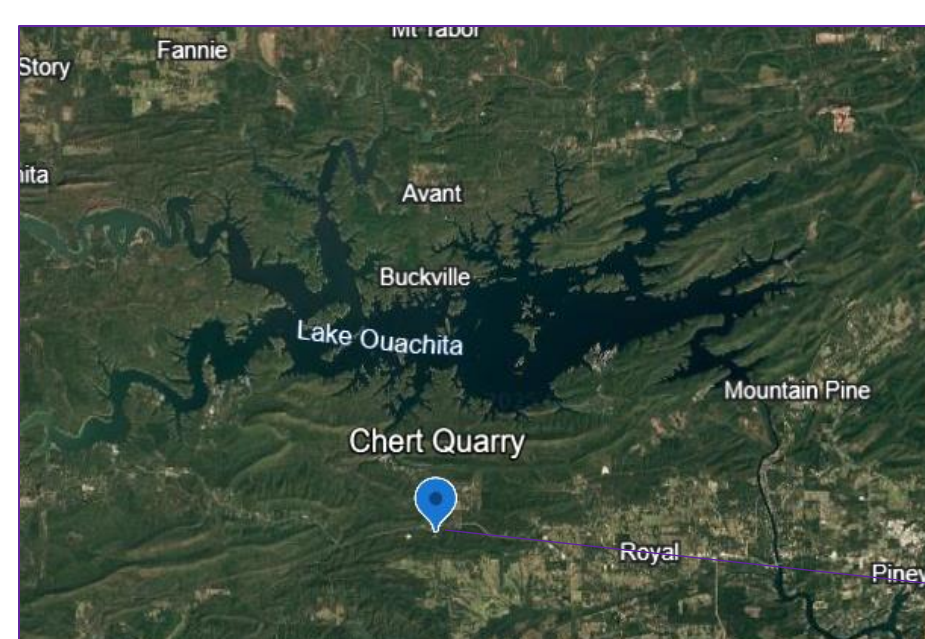
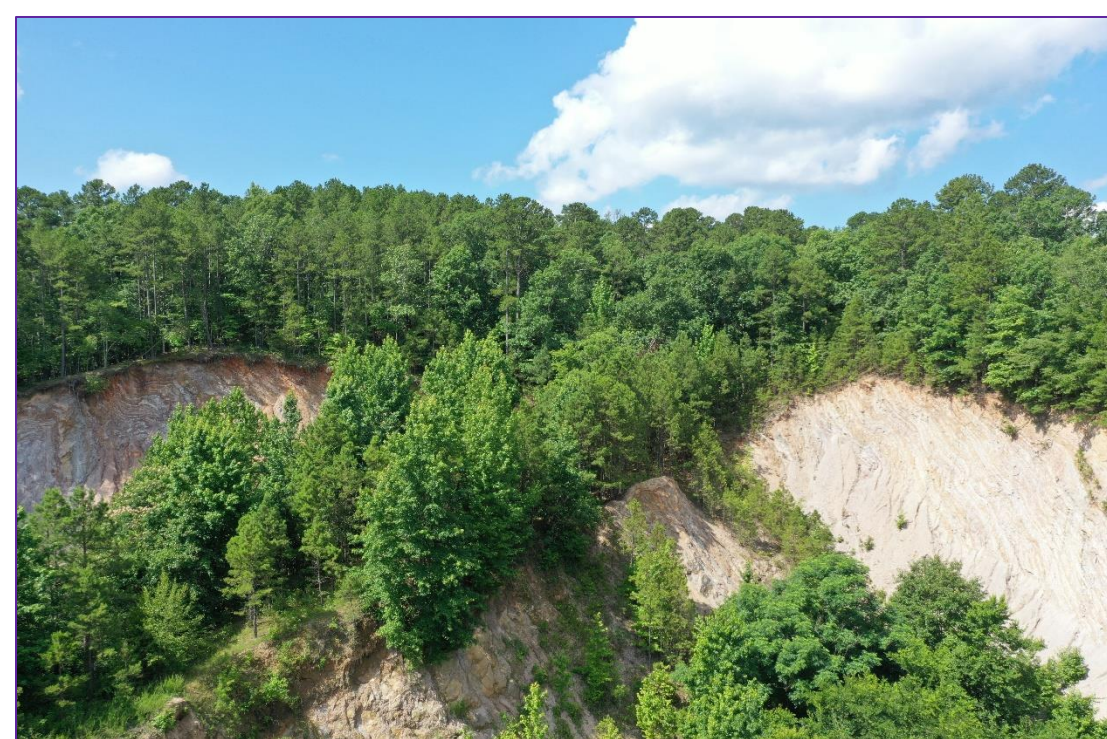


Figure 1. Location of Chert Quarry approx. 0.3 miles South of Crystal Springs, AR. Outcropped are folded beds of the Bigfork Chert Formation.



Methods and Materials

The methods include both field work and digital tools. The digital component relies on structure from motion photogrammetry. Images were taken from the DJI MAVIC 2 with an estimated 60% overlap, then uploaded into *Agisoft Metashape*. The images were generated into tie points and a point cloud. Points were removed due to vegetation noise or due to low confidence. The model was then georeferenced in *CloudCompare*.

In the field, a point was dubbed (0,0,0) near the base of an accessible slope. 5 measurements were taken along the outcrop to establish georeferenced points using distance and angles from (0,0,0). The x,y,z values of the reference points were used to register the model which results in the ability for digital measurements to be taken on exposed beds.

$$\sin(plunge) = \frac{z}{d}, \tan(plunge) = \frac{z}{l}, \cos(trend) = \frac{x}{l}, \sin(trend) = \frac{y}{l}$$

Where d represents distance, l for shared length of plane.

The resulting transformation matrix is as shown:

$$\begin{bmatrix} 2.650 & 0.548 & 8.080 & -232.057 \\ 7.933 & -1.887 & -2.474 & 8.185 \\ 1.630 & 8.291 & -1.097 & 77.004 \end{bmatrix}$$

Field observations on the left wall of the outcrop, features a prominent plunging anticline with a 'M' fold at the fold's apex. A similar fold structure occurs in the central section of the outcrop, suggesting continuity between the two.

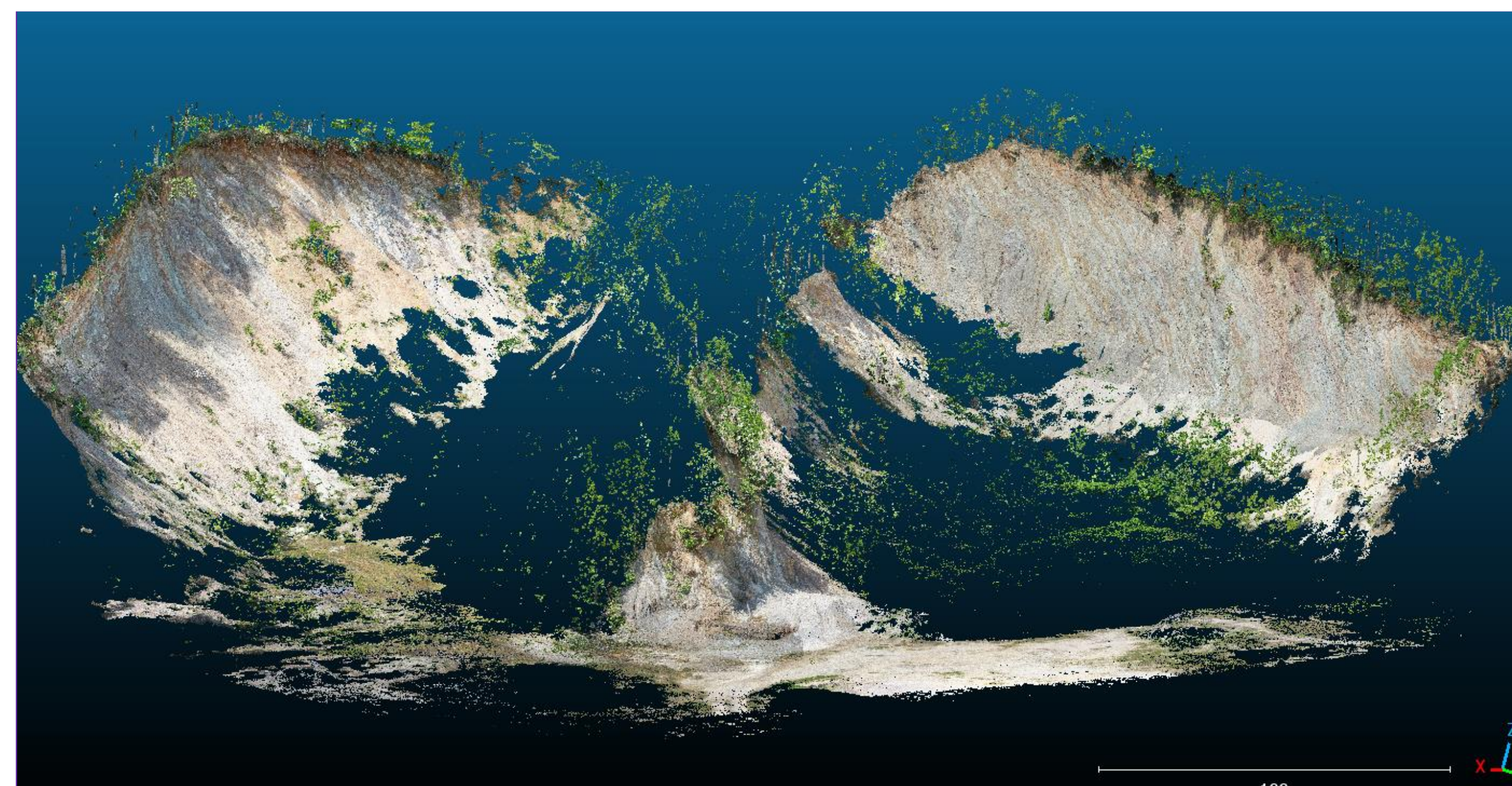
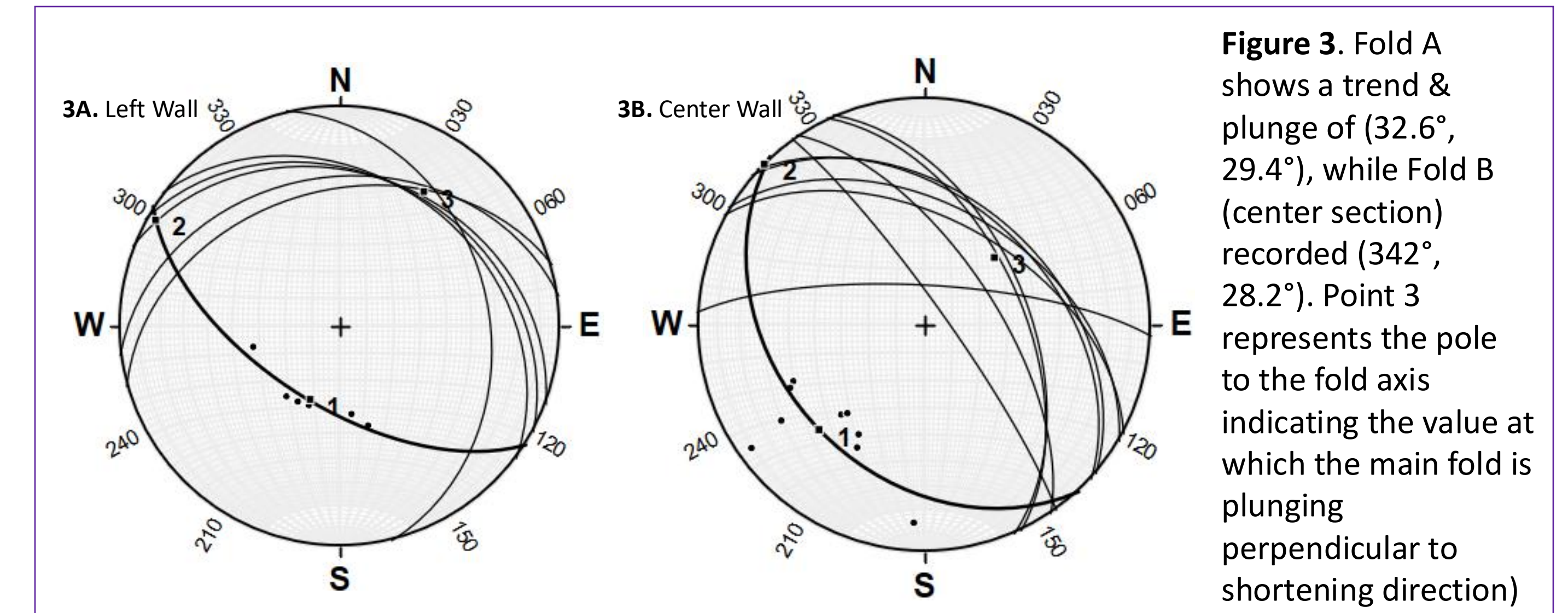


Figure 2: Point Cloud of the study area displaying outcrops pertaining many folds in *CloudCompare*. Several series of Anticlines and Synclines vary in frequency and wavelength reflecting the deformational history



Results

Measurements along bed surfaces were taken in *CloudCompare* and plotted on stereonets (Fig. 3). Varying plunge directions suggests a shift in the fold axis orientation. The 3D model in *MOVE* was used to project bedding layers based on the interpreted plunge directions to visualize the fold geometry.

The outcrop was shortened towards the southeast and northwest. Which is consistent to the varying overall trend of the Ouachita's series of thrust faults (B. R. Haley et. Al, 1993).



Figure 4: MOVE software allowed for a focused isolated fold geometry to visualize how the folded layers are plunging. Adding onto the understanding of the deformation of this study area.

Future Work

Building from this project, further analysis will occur. More measurements will be taken to observe the changes in plunge direction with smaller folds across the area. Future field work includes investigating structures like foliations and cleavages. Further analysis will be compared and added upon by ongoing work done around the Lake Ouachita area. A more advanced *MOVE* model will be generated from this data.

Acknowledgments

To the SURE program for providing funding along with facilitating the project. Dr. Zachariah Fleming for his mentorship and assistance. Emmanuel Darko for his aid in field measurements and camaraderie.

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