VIRTUAL OUTCROP MODEL OF THE BLAKELEY DAM OUTCROP, BEAR, ARKANSAS: ASSESSMENT AND APPLICATIONS FOR GEOEDUCATION

Rosenbalm, Madeline [1]; Fleming, Zachariah[2];
Department of Earth Sciences and Geologic Resources, Stephen F. Austin State University, Nacogdoches, Texas

Abstract

This study presents a field-based lab learning module for introductory geology students using a rendered 2.5-dimensional photogrammetric virtual outcrop mode (VOM) from the Blakely Sandstone Formation in the area of Lake Ouachita State Park, Bear, Arkansas. The outcrop is a highly-deformed quartz arenite body located at the top of the Blakely Dam, approximately 40 miles northwest of Hot Springs, Arkansas. The structure of the outcrop is the result of the Ouachita Orogeny. The folds present in the outcrop generally trend to the northwest and range from primarily tight and isoclinal folds to less frequent open folds. Fracture sets are also common within the outcrop with a notable conjugate set that correlates to a maximum stress in the now sub-horizontal direction, consistent with the nearly upright to moderately tilted folding expressed in the rocks. Field work was conducted with a DJI Mini 2 to collect 267 aerial images from different viewpoints within the outcrop vicinity. These images were optimized and modeled in Agisoft Metashape Standard. The accuracy of the 3D model was measured in CloudCompare against field data that was taken on visible joints and fractures in the outcrop using a Brunton compass. Using the Blakely Dam VOM an interactive class activity was created which focused on basic structural geology. This activity is aimed at introductory students and has them analyze geometries within the outcrop and allows students to visualize geologic concepts without requiring in-person field work. The lesson involves finding individual folds in the outcrop, labeling the components, and measuring their orientations. This workflow and ability to navigate a realistic outcrop model allows for student development in recognizing fold components and using those components to identify fold types in outcrops. Our hope is that the process of working with and analyzing a realistic VOM will allow students to gain better spatial awareness and, potentially, an increased competency in the field.

Study Area

The study area is located in Lake Ouachita State Park in Bear, Arkansas, about 40 miles northeast of Hot Springs, Arkansas at the top of Blakeley Dam Scenic Overlook (Figure 1). This outcrop is located in the deformation belt of the Ouachita Orogeny, a mountain building event that was at the convergent boundary along the southern border of Laurentia during the formation of the super-continent Pangea (Hatcher et al, 1989). The mountain ranges resulting from this orogeny are characterized by their east-west trend and doubly vergent fold belt. The outcrop is ~80 meters of highly folded chert, sandstone, limestone, and shales in the Blakeley Sandstone Formation.

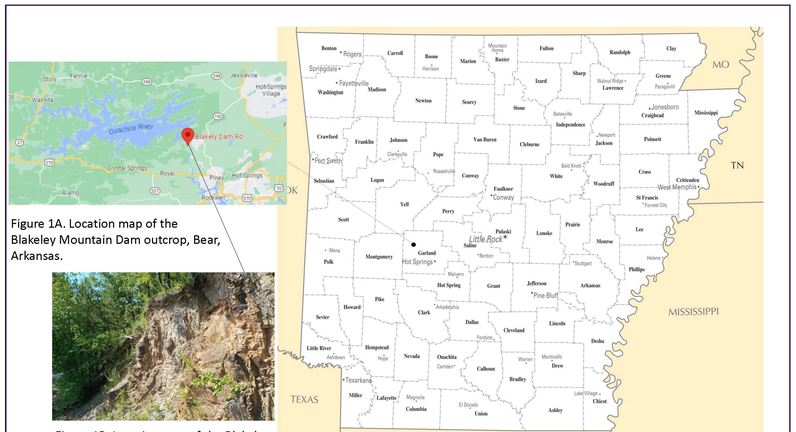


Figure 1A. Location map of the Blakeley Mountain Dam outcrop, Bear, Arkansas.

Figure 1B. Location map of the Blakeley Mountain Dam outcrop, Bear, Arkansas.

Figure 1. Location map of the Blakeley Mountain Dam outcrop, Bear, Arkansas.

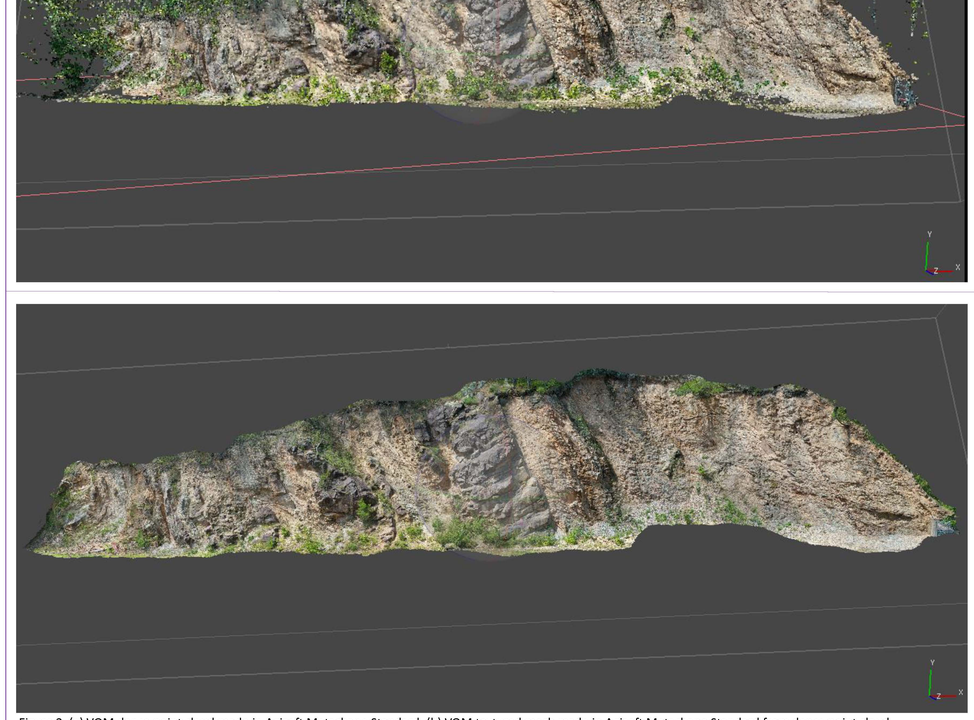
Methods

A DJI Mini 2 was used to collect 267 photos of the outcrop. Before collection, five predetermined planes on the outcrop were marked and numbered with pink duct tape and a strike and dip was taken on each one. These photos were then optimized and modeled in Agisoft Metashape Standard to form a dense point cloud (Figure 2a). Further optimization of the point cloud and generation of the final mesh was then done in Agisoft Metashape Standard (Figure 2b). This model was taken from Metashape to CloudCompare, where measured VOM values were then converted to north, east, down (NED) components. These field and virtual outcrop measurements were then paired in Matlab and run through a script to output three transformation matrices. One was chosen, for now, based on initial measurement confidence, and used to rotate the model in CloudCompare (Eq. 1).

Eq. 1
$$\begin{bmatrix} 0.9989 & -0.0019 & -0.0467 \\ -0.0382 & 0.5417 & -0.8397 \\ 0.0269 & 0.8406 & 0.5410 \end{bmatrix}$$

The ground control point (GCPs) measurements on the VOM were then compared on a stereonet to show the shift in orientation from the transformation matrix (Figure 3).

A lesson plan was written to engage students in the geology of the model and apply classroom learning about deformation in orogenies to the area with specific geologic context. The lesson is intended to be given with each student having their own device to access the model and work through the module using the model as though they were viewing it in the field.



GCPs
GCPs with applied transformation matrix

Figure 3. Stereonet comparison of ground control points before and after transformation matrix

Figure 2. (a) VOM dense point cloud made in Agisoft Metashape Standard. (b) VOM textured mesh made in Agisoft Metashape Standard from dense point cloud.

Conclusions

The use of photogrammetry and virtual models in the classroom allows for students to analyze deformation in outcrop and apply it to greater geologic context without the need for physical field work. This removes the typical barriers to active learning in the geosciences. When following through the accompanying class exercise, students obtain a better spatial awareness and increased field competency.

Future Work

- Further analysis and comparison with detailed mapping of the area
- Creating other models in different software
- Addressing reference and space issues within the model
- Analyzing accuracy of transformation matrices
- Writing more in-depth teaching tactics for higher level education targeting geology majors

Acknowledgements

The most thanks is given to the SURE program for funding and allowing for this project, Dr. Zachariah Fleming for his guidance both in the field and the lab, Luke Whitenburg for the advice, and all of the Earth Resource associates who gave me many helping hands.

Contact

Madeline Rosenbalm
Stephen F. Austin State University
Rosenbalmh@jacks.sfasu.edu

References

Zachariah Fleming, Terry Pavlis, An orientation based correction method for SfM-MVS point clouds—Implications for field geology, Journal of Structural Geology, Volume 113, 2018, Pages 76-89, ISSN 0191-8141, https://doi.org/10.1016/j.jsg.2018.05.014.

Robert D. Hatcher, Jr., William A. Thomas, George W. Viele, The Appalachian-Ouachita Orogen in the United States, ISBN-10 0813752094, ISBN (electronic) 9780813754529, Geological Society of America, 1989 https://doi.org/10.1130/DNAG-GNA-F2