# Bed-scale stratigraphic study of the structurally complex Upper Atoka Formation exposed at the Paris Reservoir, Paris, AR

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## Introduction

Pennsylvanian-age Arkoma basin is a region for oil and gas exploration that spans from central west Arkansas to central east Oklahoma. The Arkoma Basin was constructed as a foreland basin in response to the Ouachita Orogeny, a result of the formation of Pangea.

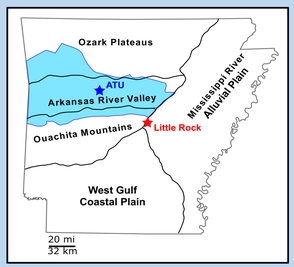
The basin consists of a significantly thick sedimentary rock formation, the Atoka Formation (Fm.), comprised of sandstone, and to a greater extent, shale strata. Most of the oil and gas exploration in the Atoka Fm. focuses on the sandstone reservoirs. Much effort has been spent utilizing gamma-ray signatures from well-logs to correlate target zones for oil and gas in the basin, of which the thick sandstone units are the easiest to distinguish and name.

Interpretation of Atoka Fm. outcroppings in the Arkoma Basin is difficult if the sandstone rich unit is partially exposed, or if the prominent shale strata are the only evident layers. Some geologic maps of the region leave the potential thousands of vertical feet of strata that Atoka Fm. consists of to be undivided due to a lack of information on what portion of the Atoka Formation is exposed at ground surface.

The following research uses a new method, targeting thin sandstone bodies and shale of the upper portion of the Atoka Fm. along a reservoir spillway, and could be used on other man-made exposures of either sandstone or shale.

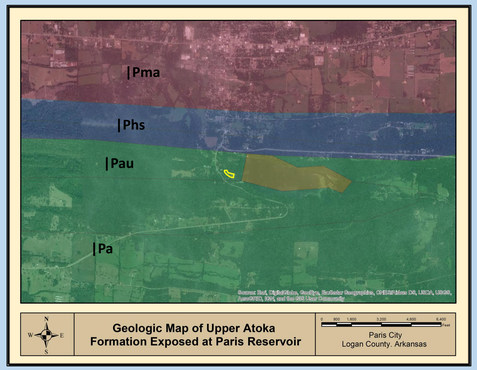
## Purpose

The purpose of this research is to utilize magnetic susceptibility (MS) of Atoka formation rock exposed at the Paris Reservoir Spillway in Paris, Arkansas. This can help determine the bulk mineralogy of that outcrop, small changes in deposition and better knowledge of the stratigraphy, as well as correlation with other intervals in the Arkoma basin.

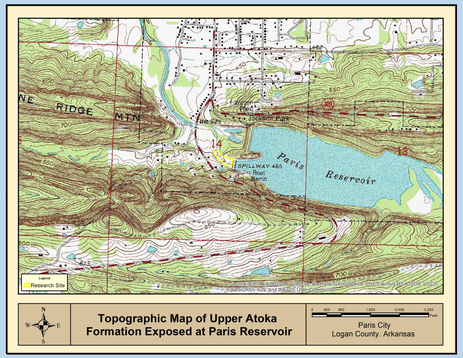



Simplified geologic map of Arkansas. Shaded region represents the Atoka Formation exposed in the Arkoma Basin.

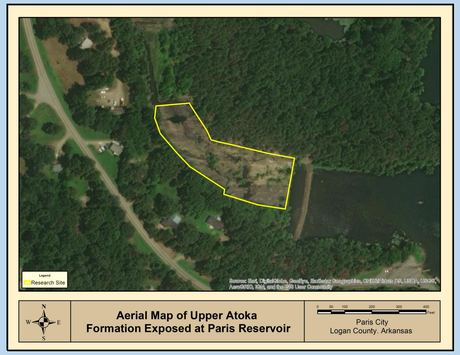
**Pennsylvanian Period formations:**
|Pau = Upper Atoka, |Pa = Atoka undivided, |Phs = Hartshorne, |Pm = McAlester




Geologic map of the Paris Reservoir and immediate area. Colors represent different formations exposed in the area. The striping formations indicate significant tilt to the rock layers, and faults are present in the area. This is why we consider rocks at the spillway to be structurally complex.
Map by K. DeAtley.




Topographic map of the Paris Reservoir Spillway area. The close contour lines represent significant change in elevation in the area due to faulting and preferential weathering of shale over sandstone.
Map by K. DeAtley.




Satellite image of the Paris Reservoir Spillway. The outlined area represents where bare rock is present to sample. Stratigraphic up is from north to south.

## Methods

Magnetic susceptibility (MS) is a geophysical rock property. The value of MS is the measurement of a sample's acquired magnetic field compared to an applied magnetic field, as well as its mass.

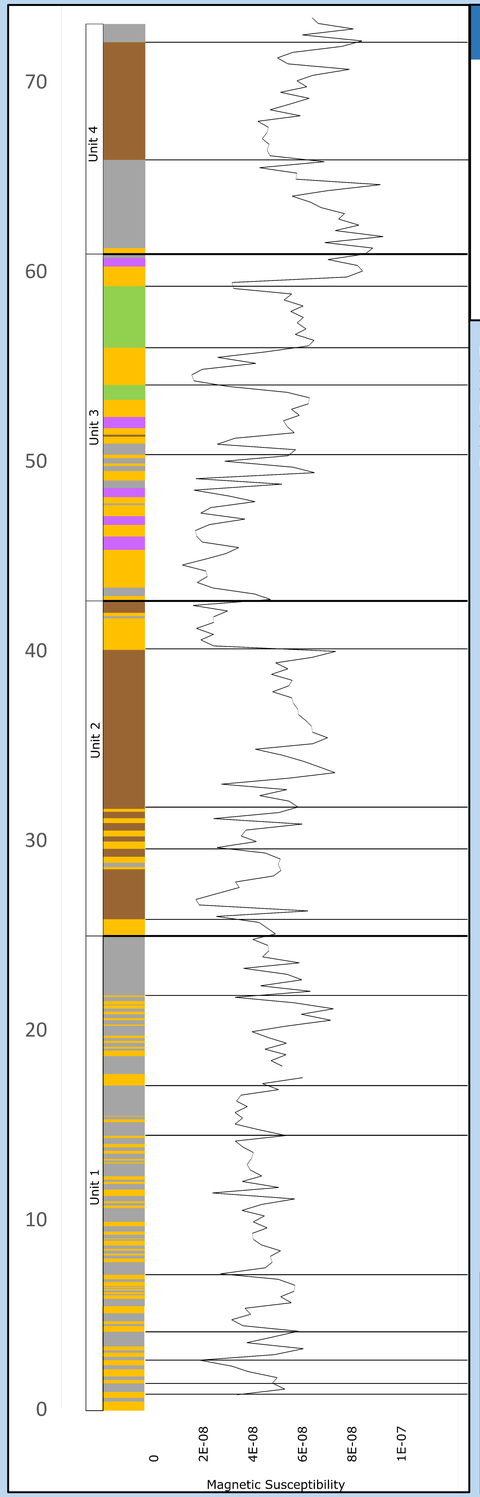
In an applied magnetic field, samples may behave paramagnetically (align with applied field; result: + MS) or diamagnetically (oppose applied field; result: - MS) due to the bulk mineral composition.

Among the present minerals in the Atoka Fm., paramagnetic materials such as clays derive greater positive values than diamagnetic materials such as quartz, and the resulting MS value is weakly positive.

William's Magnetic Susceptibility Bridge at Louisiana State University.
Photo by B. Ellwood.

Field collection at a prominent contact on the highly dipping bedrock composing floor of the spillway.
Photo by J. Grosskopf.

Over a hundred samples, each around 30 grams and spaced 30 cm apart, were taken. These samples were then taken to the Advanced Geology Lab at ATU to be processed (pelletized). 8-10 g of material (to the hundredths place) was kept for measurement. Samples were then sent to LSU-BR to determine MS values so that our team could correlate data to exposed strata and potentially gamma-ray data reported in well-logs/subsurface materials.




## Results and Interpretation

**Type 1:** Well-indurated sandstone of discernable thickness. Cross-beds are typical. May have wavy bottom contact.

**Type 2:** Friable to indurated shale.

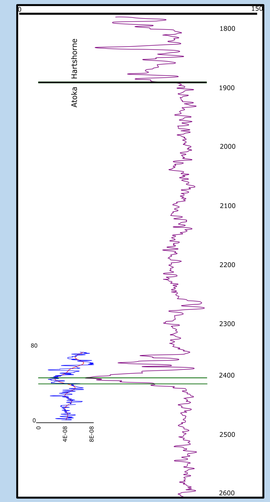
**Type 3:** Thinly bedded sandstone with shale interbeds, normally of same thickness. Beds pinch and swell laterally, some can coalesce into one layer. Ripple-scale cross-beds are prevalent.

**Type 4:** Very friable shale. Bedding is chaotic. Potentially representative of soft sediment deformation.

**Type 5:** Shale interbedded with coarse erosionally resilient laterally discontinuous lenses.

Magnetic susceptibility data curve correlated to rocks exposed at the spillway. Column is true thickness, corrected for dip and reported in meters. Low MS values match with sandstone, high values with shale, which is expected. Units were divided based on packages of rock, and horizontal lines represent good correlation between rocks and MS data.

Possible correlation of MS data from Paris, AR, and gamma-ray data from Walton #1-8 oil and gas well in Oklahoma. The smoothed MS data and gamma-ray data from rocks buried deep in the subsurface show a good correlation (indicated by green lines). The gamma-ray data are reported in API (0-150), and depth is in feet below the ground surface. Basin-wide this correlation from surface exposures to the subsurface will increase our understanding of the Arkoma Basin stratigraphy.




## Conclusions & Future Work

- There is good correspondence between magnetic susceptibility (MS) values and composition of shale and sandstone strata exposed at the Paris Reservoir Spillway.

- The strata exposed to weathering after the reservoir spillway was built has not produced aberrant MS values, they fall in the range of marine rocks. A minimal amount of surface cleaning was needed to produce clean samples.

- The Upper Atoka Formation exposed at the spillway is structurally-complex, there are faults in the spillway and a number of formation contacts in the area. A series of sampling transects were made in the spillway to avoid faults. A significant portion of a sand-rich unit in the Upper Atoka was able to be sampled due to the amount exposed.

- Atoka–Hartshorne formation contact could be traced to the subsurface, and a sand-rich portion of the Upper Atoka could be correlated to; outcrop to subsurface correlation is rare in studying the Arkoma Basin.

- MS is a useful tool for linking strata in outcrop to the subsurface, and can be utilized for hydrocarbon exploration in the Arkoma Basin.

## Acknowledgements

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## References

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