[PS]Near Surface Seismic Investigations of Mississippian and Pennsylvanian Outcrops*

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Abstract

The University of Arkansas MArkUP research group has indexed a collection of 185 geologic outcrops of Pennsylvanian and Mississippian age. Our purpose is to apply shallow seismic methods to extend outcrop knowledge. The Pennsylvanian outcrops selected for investigation are the Bloyd and Hale formations as well as the Mississippian Pitkin, Fayetteville, Hindsville/Batesville, Boone, St. Joe, and the Devonian Chattanooga. These formations are predominantly sandstone, limestone, chert and shale. Key outcrop locations were chosen where near surface seismic could extend geologic knowledge of the area and the formations. Tests were conducted using a hammer source and Geonics Geode 48 channel seismograph with single-component geophones. The main interest in this study was to analyze refraction events associated with known Mississippian and Pennsylvanian units to estimate P-wave velocity and depth. Velocity also has possible application for discriminating buried LS/chert facies in the Boone Formation that are known from outcrops and likely occur at petroleum exploration depths in northeastern Oklahoma.

Reference Cited

Liner, C., D. Zachry, and W. Manager, 2013, Mississippian Research in Northwest Arkansas: Search and Discovery Article #41245.

Near Surface Seismic Investigations of Mississippian and Pennsylvanian Outcrops

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ABSTRACT

The University of Arkansas MArkUP research group has indexed a collection of 185 geologic outcrops of Pennsylvanian and Mississippian age. Our purpose is to apply shallow seismic methods to extend outcrop knowledge. The Pennsylvanian outcrops selected for investigation are the Bloyd and Hale formations as well as the Mississippian Pitkin, Fayetteville, Hindsville/ Batesville, Boone, St. Joe, and the Devonian Chattanooga. These formations are predominantly sandstone, limestone, chert and shale. Key outcrop locations were chosen where near surface seismic could extend geologic knowledge of the area and the formations. Tests were conducted using a hammer source and Geonics Geode 48 channel seismograph with single-component geophones. The main interest in this study was to analyze refraction events associated with known Mississippian and Pennsylvanian units to estimate P-wave velocity and depth. Velocity also has possible application for discriminating buried LS/chert facies in the Boone Formation that are known from outcrops and likely occur at petroleum exploration depths in NE Oklahoma.

1 INTRODUCTION

The main purpose of our study is to use near surface tools and observation techniques to analyze Pennsylvanian and Mississippian units in Northwest Arkansas. The field area for this paper is centered around a road cut on Arkansas Highway 412 near the Illinois River and Pedro, AR (Fig. 1). The road cut is Lower Mississippian Boone Limestone with a possible transition to St. Joe Limestone near the base. The seismic refraction survey reported here was shot parallel to the road cut. Through the use of near surface seismic we are hoping to find the top of the Ordovician Everton Formation (dolomite) to aid in correlating well log data. Specifically, the goal is to use seismic data to estimate the depth to base of Mississippian St. Joe limestone at this out crop. We use a hammer source and 24 Channel Geonics Geode Seismographs and 48 single component geophones for our near surface seismic experiment.

2 STUDY AREA

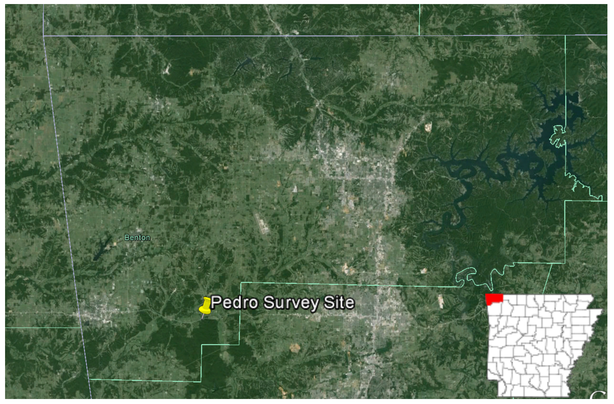

Figure 1: *The Pedro Survey site is located within Benton County, Arkansas on AR highway 412.*

3 GEOLOGIC FRAMEWORK

The Pedro survey site falls within the Springfield plateau of the Western Ozarks. The surface consists of mostly undulating topography. The uppermost formation of this part of the Springfield plateau is the Miss. Boone Formation underlain by the St. Joe Limestone Member. The survey road cut is known to be Boone limestone and possibly St. Joe Limestone near the base. Below the St. Joe is the Devonian Chattanooga Shale exposed in several areas along the nearby Illinois River. Notable about the Pedro road cut are mound-type features of uncertain origin (Fig. 2).

The survey reported here is aimed at estimating the depth to base of St. Joe to constrain the stratigraphic position of the mounds.

Figure 2: *A member of the MArkUP team standing next to one of the Pedro mounds displayed in the road cut. The outcrop is Lower Mississippian in age specifically Boone formation and St. Joe Limestone member.*

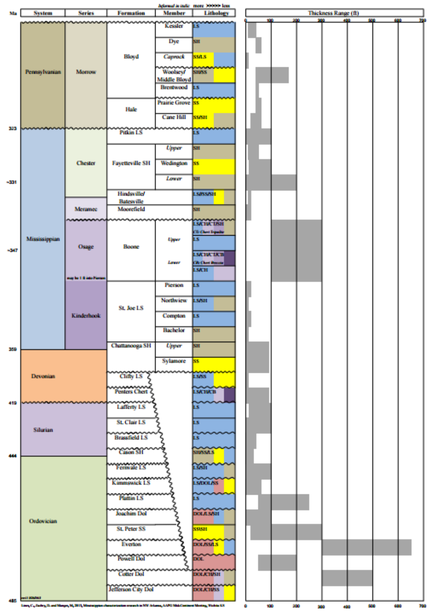

Figure 3: *Stratigraphic Column including the Pennsylvanian and Mississippian formations of interest and their member thicknesses (Liner, Zachry, and Manger, 2013).*

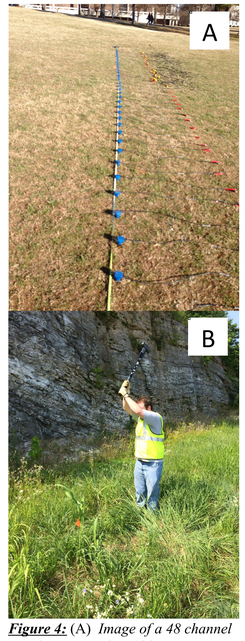

Figure 4: (A) *Image of a 48 channel geophone spread at Old Main test site. (B) Sledgehammer source in action at Pedro survey site.*

4 SURVEY DESIGN

The seismic survey had 1 foot spacing between each of 48 total single-component geophones (Fig. 5). Our survey design had 4 shots off each end to achieve continuous offset coverage between 1-192 ft. The survey was laid parallel to Highway 412 in front of the road cut 20 feet off the edge of the pavement.

The choice to use 1 foot geophone interval allows for measurement of detailed first break slopes for accurate estimation of soil and refractor velocities. Note this area has very little soil cover, so we expect the first arrivals to be direct arrivals through the Boone/St. Joe and refraction from the deeper Everton. This small geophone interval is also beneficial since we are using a low-power 8 lb sledge hammer as the seismic source.

At each shot location we take 5 strikes with the sledgehammer onto a steel plate and vertically stack the results. We chose a 5-fold vertical stack by trial and error as optimum for improving the signal to noise ratio without delaying total acquisition time. The main source of noise in this survey is traffic on highway 412.

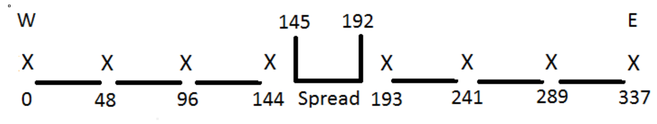

Figure 5: *Pedro out crop seismic survey design. The X locations and numbers represent the shot location and their specific distances from the design starting point. In the center of the model the geophone spread is represented by the range 145 – 192.*

5 MATERIALS AND EQUIPMENT

The materials necessary for the actual survey are provided by Dr. Liner and the University of Arkansas Geosciences Department. The equipment used for each of these are listed as following:

- 2 Geonics Geode 24 channel seismographs
- 48 single component geophones
- 2 Black spread cables for geophone connection
- Battery with yellow power cable clamps
- Sledge hammer with trigger attached and metal plate
- Laptop with seismic control software for acquisition
- Flags, measuring tape, GPS, compass, and field notebook

Figure 6: *(A) Geonics Geode Seismograph paired with a computer for acquisition. (B) Photo of our seismic survey set up at the Pedro Survey area. The two yellow boxes are the connected seismographs hooked to battery power sources. In the background the flags mark where the single channel geophones have been placed. The MArkUP team member in the upper left is sitting at the table with our laptop for acquisition.*

6 METHODS AND PROCEDURE

The University of Arkansas MArkUP Team goes about each survey by planning ahead and taking the steps necessary to acquire the best possible results. A typical survey starts days beforehand with the design of the survey and acquisition of the equipment. The next step is to scout the survey site for potential spots to shoot seismic data. Once planning and preparation are complete, we choose the best date and time to execute the survey.

The first step is to clear any high grass or debris that could be in our shot line. The next step is to measure out all of the locations for shots and geophones and mark with flags. It is important while measuring to double check each location measurement. Once all measurements are complete, set up can begin. The geophones are placed at their locations first and planted firmly into the ground. In some cases it may be necessary to use a pick axe to make planting the geophones possible. After completion we check the measurements again because this is the most crucial piece in acquisition. After the geophones are connected we then hook them to the connection cables. Once the geophones are hooked up to the cables we can connect the cables to the Geonics Geode Seismographs. Two Geode Seismographs are connected together in order to run a 48 channel survey. These seismographs are then connected to the computer for acquisition. After they are connected we connect the source trigger cable to the lead seismograph. We then start the Seismodule for Acquisition software, connect the batteries to the seismographs, and set our parameters in the program.

The last step before starting the survey involves testing the equipment. The order of the geophones must be checked to see if they are in the correct order relative to our survey design. Lastly, a test shot and stack are completed to make sure the program is recording and depositing the SEG-Y file into the correct folder. After tests have concluded we begin a new survey and shoot with the desired stack for each location.

7 FUTURE RESEARCH

The focus of our survey is to use the collected data and associated refraction data to find the top of the Ordovician Everton. Our refraction seismic results will be analyzed by various methods to estimate the depth to top of Ordovician Everton. After we have located the Everton we should be able to move back up section to find depth to the base of Mississippian (since Devonian Woodford shale thickness is known from nearby well control). Our experiment will also yield velocity information for these important formations.

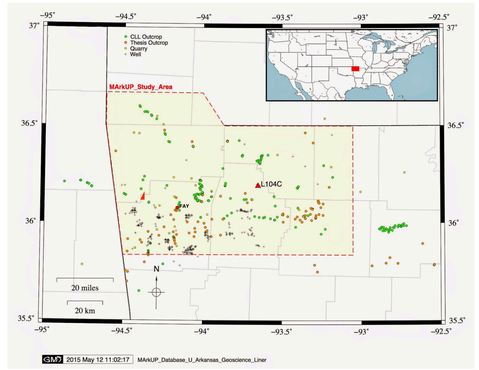

Figure 7: *Map of locations for outcrops, quarries, and wells within the MArkUP research area of NW Arkansas and SE Missouri. The green points represent inventoried outcrops, the orange points represent outcrops being used for thesis research projects, the yellow points represent quarries, and the black crosses represent wells where data can be represented. The Pedro site is MArkUP location L15 shown with thick red circle.*

8 ACKNOWLEDGEMENTS

All pictures and figures represented were provided by the University of Arkansas MArkUP Team Members. The maps and models were created through the use of Google Earth, Microsoft Paint, and Generic Mapping Tools (GMT). The GMT map was created by Dr. Christopher Liner.

9 References

Liner, C. L., Zachry, D. L., and Manger, W., 2013, Mississippian characterization research in NW Arkansas, AAPG Midcontinent Section Meeting, Wichita, KS, Datapages #41245.