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.
ABSTRACT

The seismic survey had a 1-foot spacing between each of 48 total single-component geophones. Our survey design had 4 shots off each end and to achieve continuous offset coverage between 150 - 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 reflector velocities. Note this area has very little soil cover, so we expect the first arrival to be direct arrivals through the Boone/Chattanooga and the Reftown, from farther than the present. 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 all the data. We chose a 2-foot 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.

METHODS AND PROCEDURE

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

The University of Arkansas MAAUP 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 Boyd and Hail Formations as well as the Mississippian Pekin, Fayetteville, Hindsville/Batesville, Boone, St. Joe, and the Deovonian 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 reflection events associated with known Mississippian and Pennsylvanian units to estimate P-wave velocity and depth. Velocity also has possible application for discriminating buried Ll shootout facies in the Boone Formation that are known from outcrops and likely occur at petroleum exploration depths in NE Oklahoma.

STUDY AREA

The Pedro Survey site is located within Benton County, Arkansas on AR highway 412 near the Illinois River and Pedro, AR (Fig. 2). 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 Boone Limestone with a possible transition to St. Joe Limestone near the base.

The University of Arkansas MAAUP Team goes about each experiment. The last step before starting the survey is to plan and mark the geophone locations with yellow power cable clamps. We then start the survey. 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 reflector velocities. Note this area has very little soil cover, so we expect the first arrival to be direct arrivals through the Boone/Chattanooga and the Reftown, from farther than the present. 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 all the data. We chose a 2-foot 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.

Seismographs are then connected to the computer for acquisition. After they are connected we connect the source trigger cable to lead seismograph. We then start the Seismodoc 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.