

PS Indexing and Characterization of Mississippian Outcrops in Northwest Arkansas, Southwest Missouri, and Northeastern Oklahoma*

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Search and Discovery Article #30296 (2013)**

Posted November 11, 2013

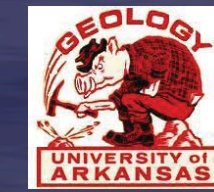
*Adapted from a poster presentation given at AAPG Mid-Continent Section Meeting, Wichita, Kansas, October 12-15, 2013

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Abstract

Over the past 70 years, extensive studies have been conducted on the Mississippian strata of NW Arkansas by faculty and students of the University of Arkansas. The purpose of this project is to index all published outcrops along with newly discovered outcrops in Google Earth in order to form a regional scale model of Mississippian Strata in a 4,000 square mile area. The University of Arkansas is located on the escarpment between the Boston Mountains and the Salem Plateau where a shallow occurrence of Mississippian age rock allows for access to outcrops. These Mississippian strata were deposited on a broad carbonate ramp, designated the Burlington Shelf. Locations of known outcrops have been sourced from previous theses, then located and marked on Google Earth. In order to add to our outcrop inventory, roads in the mapping area are systematically driven in search of other outcrops. Newly discovered outcrops are marked using the iPhone GeoLocation app, photographed, then integrated into Google Earth. Our emphasis is on outcrops in Washington and Benton Counties of Arkansas, an area with many recent road cuts that expose important features of the Mississippian system, including tripolitic chert occurrence, unconformities that form primary information for sequence stratigraphic analysis, and evidence of sediment transport. Stratigraphic correlation is a perennial challenge since most outcrops expose less than 10% of the Miss section. We plan to employ quantitative methods to aid correlation, including bedding characteristics, zone-scale chert concentration, and geophysical measurements.



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1 STUDY AREA

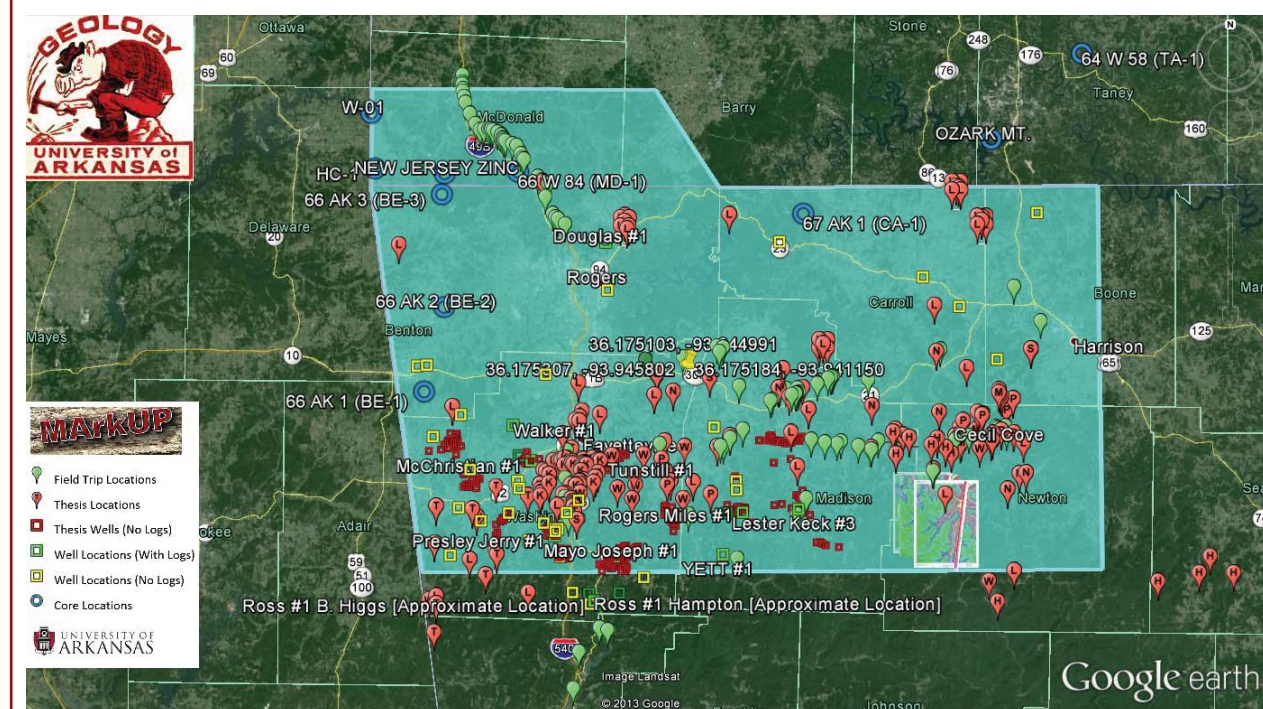


Figure 1: MarkUP study area and collected data points
Online Interactive Map: thomasliners.com/google-earth/

2 STRATIGRAPHIC COLUMN

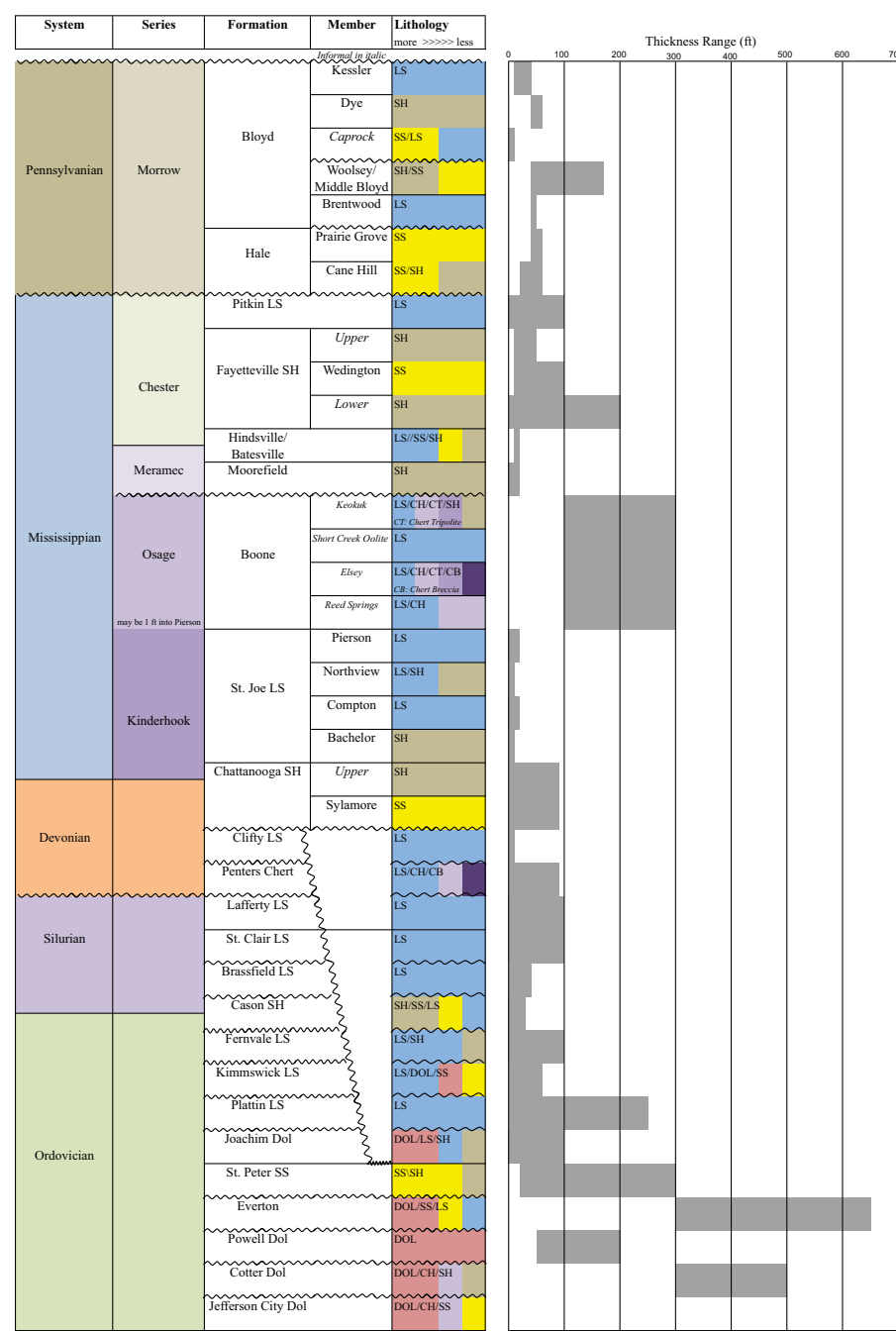


Figure 2: Stratigraphic Column for NW Arkansas (Liner, Zachry, and Manger, 2013)

3 PROGRAMS AND WEB SERVICES

Google Earth is a free virtual globe program that was initially created as "EarthViewer 3D" by Keyhole, Inc. The initial release of Keyhole EarthViewer 1.0 was on June 11, 2001. Google Earth maps the earth's surface through the superimposition of satellite and aerial images. The program also features 3D terrain derived from digital elevation model [DEM] data collected through NASA's Shuttle Radar Topography Mission [SRTM]. Google Earth uses the WGS84 datum as its internal coordinate system. The "General Perspective" projection is used to produce the effect similar to viewing the earth from an elevated platform. This is similar to orthographic projection except the point of perspective is finite not infinite. A resolution of ~15m per pixel is obtained for most of the earth's land areas using 30m Multispectral Landsat Images that have been pansharpened with 15m Landsat Imagery.

Google Earth

The Google Earth API (Application Programming Interface) allows you to embed your own version of Google Earth into web pages as well as draw markers/lines, create image overlays, add 3D models, add place marks and load KML files. These features allow you to take your data set and render it in a free interactive application that has an almost limitless customizability.

Google Maps

Google Maps is a web mapping service created by Google that provides users with street maps, a route planner, and many other map based services. It is the most popular online mapping service and its API is used on more than 800,000 websites. It uses a map projection very similar to the "Mercator Projection". Google Maps uses the Spherical Mercator Formula but coordinates are GPS coordinates based on WGS84. The "My Maps" function allows users to create maps featuring their own data and save these maps for later viewing and distribution. There are four supported map types Roadmap, Satellite, Hybrid, and Terrain.

Google allows access to many Map API keys for free under the agreement that maps created with these tools will only be available on publicly accessible websites. These APIs can be used to customize maps or to create applications built around Google Maps functionality. The Maps API Web Services are a group of HTTP interfaces connecting to the Google services from which mapping applications pull all of their data. A few examples of these are the Directions API, Distance Matrix API, Elevation API, Geocoding API, Time Zone API, and Places API.

Keyhole Markup Language [KML]

The Keyhole Markup Language [KML] is a XML notation developed for Google Earth. It is used to express geographic information in 2D maps and 3D earth browsers. The KML format has been an international standard of the Open Geospatial Consortium since 2008. Images, place marks, 3D models, and polygons are specified within a KML file and each of these are accompanied by latitude and longitude data. More specific data such as tilt, altitude, and heading can also be included in the KML file. KML data is often distributed as a KMZ file which is a zipped KML with a .kmz extension. The KMZ contains the root KML document (doc.kml) along with any images, overlays, or icons referenced in the KML. The 3D geographic coordinates used for KML are longitude, latitude, and altitude. Negative values are used for South, West, and below sea level. Latitude and Longitude data are defined by WGS84 while vertical values are defined by WGS84 and EGM96 Geoid vertical datum.

Typical KML format:

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<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.opengis.net/kml/2.2">
<Document>
  <Placemark>
    <name>"The Pit"</name>
    <description>University of Arkansas</description>
    <Point>
      <coordinates>36.070261, 94.178353</coordinates>
    </Point>
  </Placemark>
</Document>
</kml>
```

SketchUp

"SketchUP" is a 3D modeling program with a wide range of applications. It is owned by Trimble Navigation and a free version known as "Sketchup Make" is available online for download. The program is useful because it is user friendly and allows the placement of its models into Google Earth. The free version can export models in .dae and KMZ formats. Sketchup make can also save "screenshots" [model elevations or renderings] as .bmp, .png, .jpg, and .tiff file formats.

Google Spreadsheet Mapper v3.1

"Spreadsheet Mapper 3" is an online spreadsheet created by Google that can be used to generate a large number of place marks in Google Earth and Google Maps.

- Collaborative editing allows team members to enter data separately and then have it published to the same Google Maps or Google Earth data set.
- Up to 1000 place marks can be created using this tool and more can be added if they are needed. If more than a few thousand place marks are going to be created it is best to use Google Fusion Tables due to the file size of a KML defining that many points.
- Place marks are created using Google App Scripts to generate the KML.
- All edits to the file are continuously updated in Google Earth.

Interactive Data Sets

Version of Google Earth: <http://thomasliners.com/google-earth/>
Version of Google Maps: <http://thomasliners.com/google-maps/>

4 FIELD STUDIES

Increasing the resolution at which the mapping area is seen is one of the key goals of MarkUP. To achieve this goal the surface geology of the area must be studied and the results of these studies must be compiled and compared to other data sources such as well logs and seismic data. Field studies are the backbone of the MarkUP project since new data is crucial to increasing the resolution at which the Mississippian can be viewed. At present ~200 new Mississippian outcrops have been discovered and documented within the mapping area. Before heading into the field new outcrops and points of interest are located Google Earth Street View. Street View is useful for determining the location of possible Mississippian outcrops but the resolution is too poor for further analysis in Google Earth. These new outcrops and points of interest from past excursions are marked using the "My Maps" service. Google Maps for IOS is then used to navigate to these marked places. If the outcrop turns out to be of interest to the project then it is photographed and detailed notes are taken. Collecting data in the field is fun but it inherently leads to an unorganized data set. Google Earth and it's services are helpful when it comes to organizing and presenting field data.

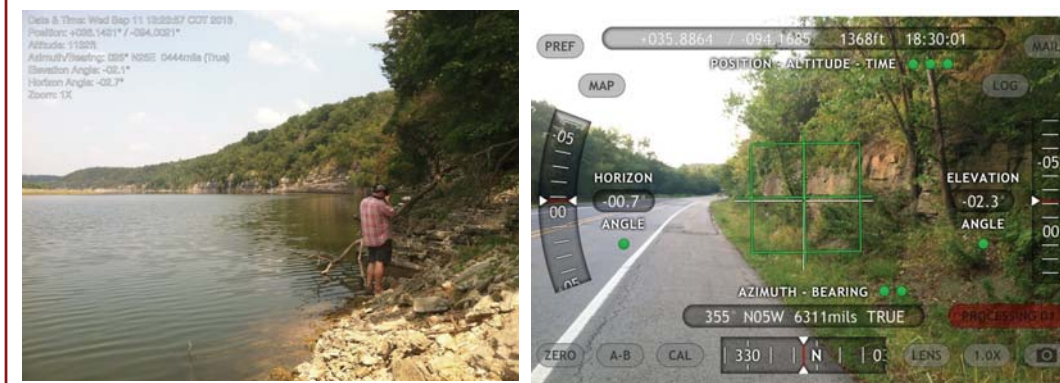


Figure 3: Shows work in the field. The image on the left was taken using the Theodolite App in "Camera" mode and the image on the right was taken using the Theodolite App in "ScreenShot" mode.

The data collected during a day in the field is organized and rendered in Google Earth using the following steps:

- Upload photos to Picasa, Flickr, and Gallery 3.
- Exif (Exchange image file format) data can be pulled from photos using software or by reading the data printed on the photo by Theodolite. The Lat/Lon coordinates of each photo are noted and used in the next step.
- This data is then put into Google's "Spreadsheet Mapper" along with any notes we might have taken. The spreadsheet mapper then creates a KML of my data inputs. This KML renders each data point/outcrop location as a place mark in Google Earth.

5 WORK PLAN

The Mississippian strata are studied using various methods in an effort to provide multi scale data that can be integrated into a 3D model.

Thesis Studies

- Read through the numerous thesis that pertain to the Mississippian.
- Document the measured section locations, strat columns, and described outcrops.
- Locate and mark relevant data in Google Earth and attach a summary of the information.

Outcrop Studies

- Drive around searching for undocumented outcrops.
- Mark notable outcrop locations using the Geo Location App for the iPhone.
- Take photos and detailed notes with the Theodolite App
- Integrate acquired info into Google Earth

Well Log Studies

- Pull relevant logs off of Arkansas Geological Survey website.
- Evaluate the log quality and mark its location in Google Earth
- Import the logs into Petra.
- Correlate the well logs with other existing data.

Well Core Studies

- Find relevant cores locations on the Arkansas Geological Survey website.
- Make phone calls and figure out where the core is being stored.
- Evaluate the cores quality and mark its location in Google Earth.
- Correlate the well core with other well logs and record descriptions of the formation tops.

7 REFERENCES

Liner, C., Zachry, D., and Manger, W., 2013, Mississippian Characterization Research in NW Arkansas, AAPG Mid-Continent Meeting Abstract (accepted)

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Nageotte, A., 1981 Lithostratigraphy And Depositional Environments of the Pitkin Limestone (Chesterian, Mississippian) In Portions of Cherokee, Muskogee, and Sequoyah Counties, Oklahoma.

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6 APPLICATIONS IN GOOGLE EARTH

There are many different ways in which geologic field data can be enhanced. Topographic maps, geologic maps, 2D/3D cross sections, structural map symbols, core data, and even well data can be rendered in Google Earth despite the lack of a subsurface. With a little imagination and a lot of time the subsurface geology can be extrapolated above the surface and a regional scale picture begins to form.

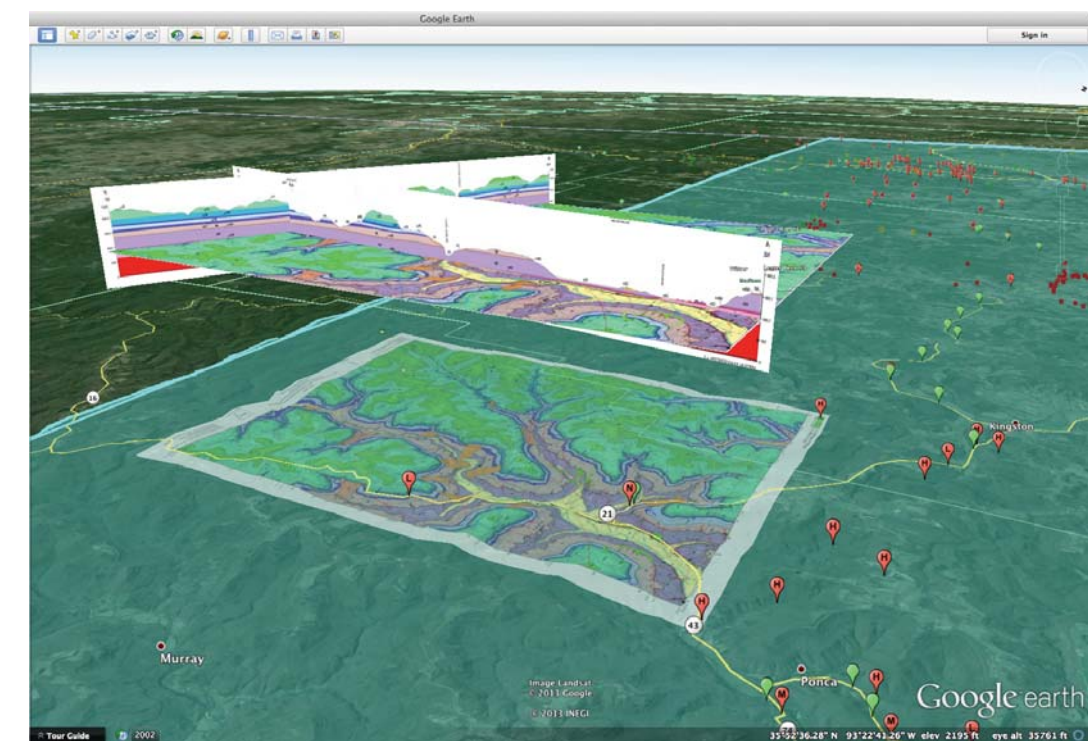


Figure 4: 3D rendering of Boxley geologic quadrangle map and associated cross sections. The figure was created with SketchUp and imported into Google Earth as a KML. The elevated figure is at an altitude of 16161 m above sea level.

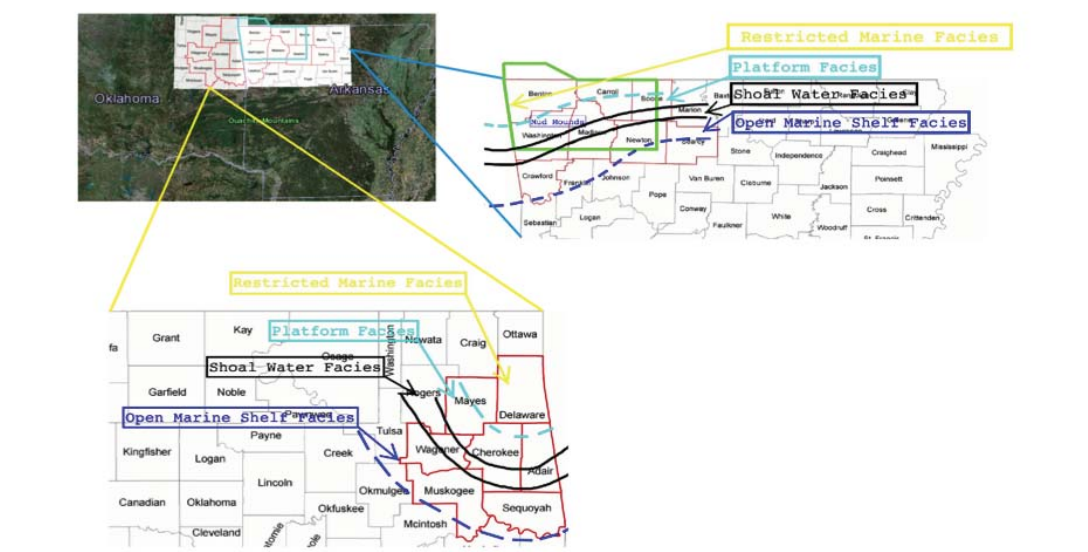


Figure 5: The regional geometry and major facies distribution of the Pitkin Limestone (redrawn from Nageotte, 1981).

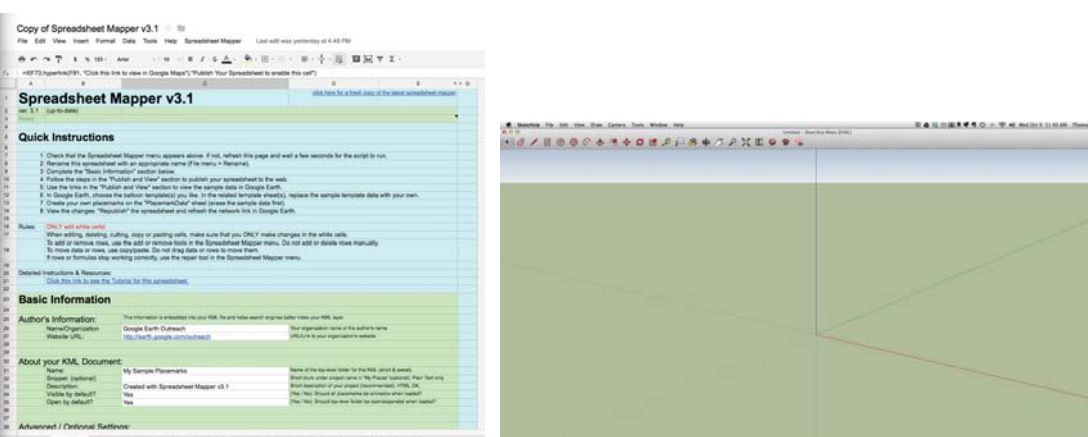


Figure 6: Spreadsheet Mapper Interface

Figure 10: SketchUp Interface