PRECAMBRIAN MIDDLE RUN SANDSTONE IN WESTERN KENTUCKY: RESULTS FROM THE KENTUCKY GEOLOGICAL SURVEY #1 MARVIN BLAN CO_2 SEQUESTRATION TEST WELL

J. Richard Bowersox[1], John Hickman, Stephen F. Greb, James A. Drahovzal, and David C. Harris
Kentucky Geological Survey, Lexington, Kentucky

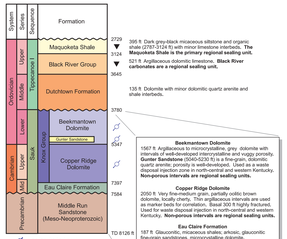
Abstract

Precambrian strata in western Kentucky are poorly known from electric logs from a limited number of penetrations and recovered drill cuttings. Precambrian Middle Run Sandstone was cored in the Kentucky Geological Survey #1 Marvin Blan test well, Hancock County, Kentucky, to evaluate the CO_2 sequestration potential of pre-Mount Simon Sandstone strata. The Middle Run was penetrated at 7584–8126 ft (2312–2477 m) TD, and an oriented core was cut at 8000–8030 ft (2438–2448 m). The Middle Run is a brick-red, fine-grained, lithic arkose, with an illite clay matrix, and hematite cement. About 30% of grains are lithic fragments derived from underlying granite-rhyolite province igneous rocks and sparse grains of metamorphic rocks derived from Grenville basement. Quartz and feldspar grains are angular suggesting a local source, whereas lithic grains are rounded, suggesting a more distant source. Quartz grains show partial dissolution and authigenic overgrowths at their boundaries in thin sections. Structural dip in the Middle Run is 10° north. Several generations of east-dipping, microcrystalline quartz-filled fractures are evident in the cores. The nearest well to penetrate Precambrian strata, the KY Operating Company #1 Braden well located 16 mi (26 km) to the southeast in Breckinridge County, drilled 468 ft (143 m) of rhyolite below the Middle Cambrian unconformity. Interpretation of 2-D reflection seismic data suggests the Middle Run section under the #1 Marvin Blan well is 4500 ft (1372 m) thick and pinches out to the south on the older rhyolite basement. Sedimentary structures evident in the core include tidal laminations, crossbeds, flaser bedding, reactivation surfaces, scours, and mudstone ripup clasts and edgewise conglomerates, suggesting deposition on a sandy tidal flat. Paleotransport analysis of restored crossbed foresets suggests westerly transport across the tidal flat toward the East Continent Rift basin in meandering channels, approximately perpendicular to the Grenville front. Horizontal and vertical porosity and permeability were measured in three core plugs. Porosity averaged 1.35% and permeability averaged 0.00023 md, with horizontal and vertical values being approximately equal for both measurements. Therefore, the Middle Run in this area has no potential as a CO_2 sequestration reservoir.

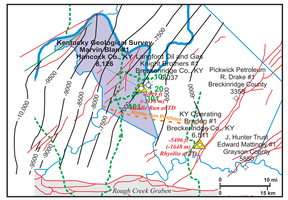
Location of the Marvin Blan #1 and Regional Injection Wells.

Kentucky Geological Survey
UNIVERSITY OF KENTUCKY

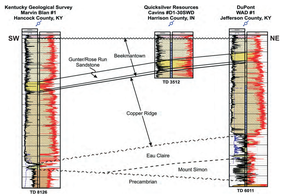
[1]J. Richard Bowersox
Kentucky Geological Survey, 228 Mining and Mineral Resources Building
University of Kentucky, Lexington, KY 40506-0107
j.r.bowersox@uky.edu



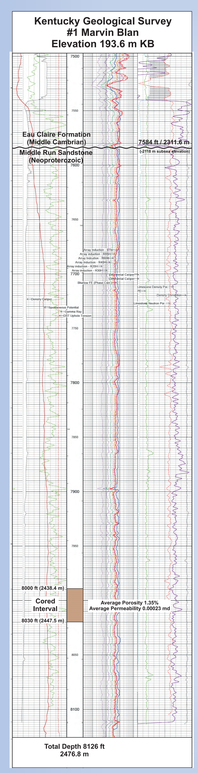
Generalized Lower Paleozoic stratigraphy of western Kentucky. Potential CO_2 storage and sealing intervals are noted. Injection testing in the Marvin Blan #1 focused on porous and permeable intervals within the Knox Group. The Middle Run Sandstone had insufficient reservoir quality to merit injection testing.



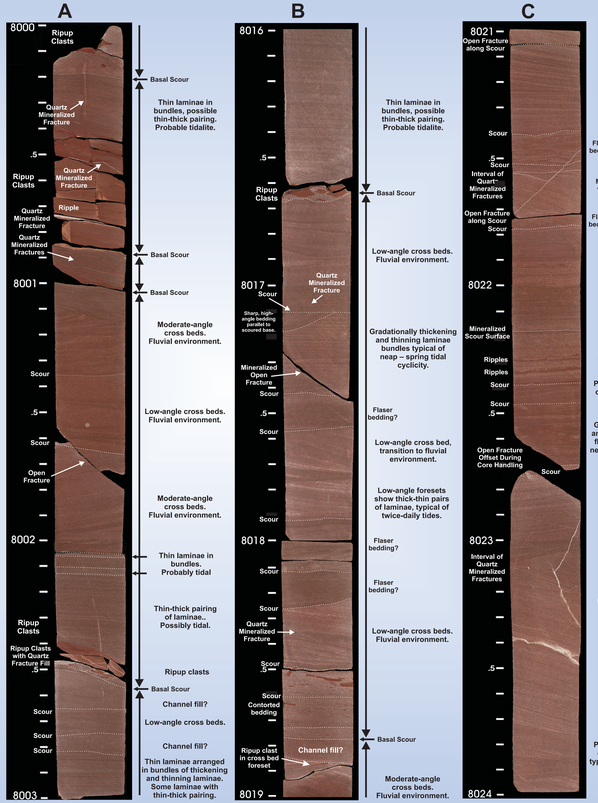
Structure of the Precambrian unconformity surface in the Hancock County region, interpreted from 2-D seismic data (modified from Drahovzal, 2009). Seismic lines are shown with green dashes. Surface faults and faults interpreted from seismic data are shown in red. At the #1 Marvin Blan wellsite, Precambrian Middle Run basement was found at 7584 ft / 2311.6 m (-6949 ft / -2118 m subsea). Pinchout of the Middle Run on the older volcanic complex is noted by the orange dashed line.



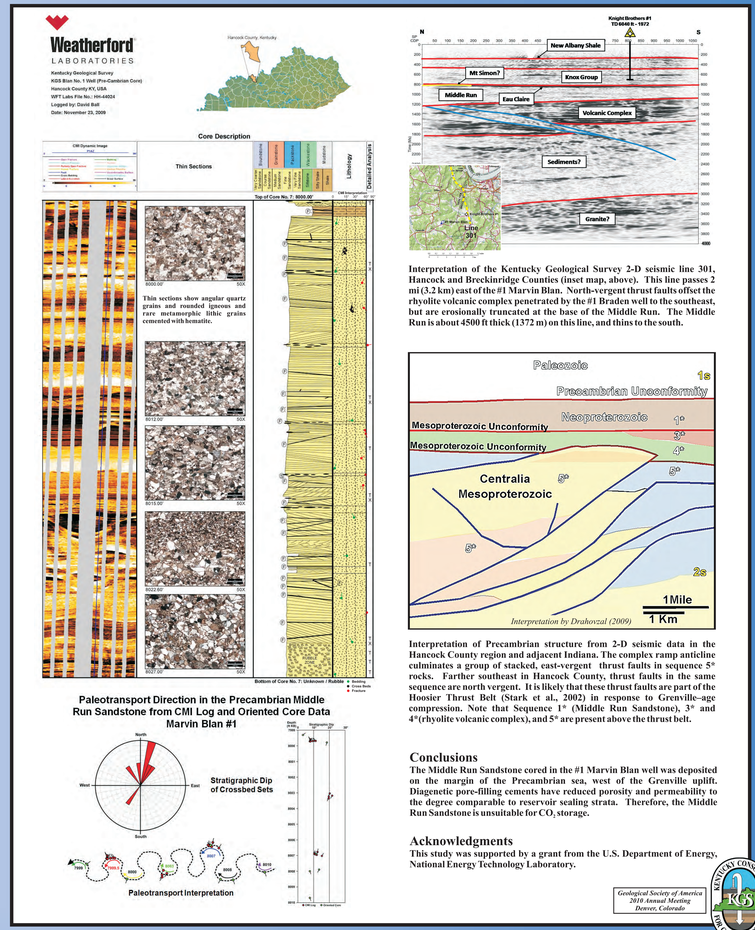
Generalized stratigraphic cross section from the #1 Marvin Blan well to the DuPont WAD #1 well (see index map). Index datum is the Middle Ordovician unconformity on top of the Knox Group.



Geophysical electric log suite recorded in the #1 Marvin Blan. Neoproterozoic Middle Run Sandstone was penetrated at 7584 – 8126 ft total well depth (2311.6 – 2476.8 m) below the drilling rig Kelly Bushing (KB, 15 ft / 4.6 m above ground level). The Middle Run is unconformably overlain by the mixed clastic – carbonate strata of the Middle Cambrian Eau Claire Formation.



Representative cores from the Middle Run Sandstone (depth in feet). A-B. Stacked sets of scour-based beds. Shale rip up clasts are overlain by cross bedded or flat-laminated heterolithic strata. Many laminae sections are difficult to discern because of the homogenous color of the core. Some laminae exhibit thick-thin pairing indicative of twice-daily tides, and some are arranged in a gradationally thickening and thinning bundles of laminae similar to neap-spring tidal deposits. Fluvial cross beds typically cap the beds. These are the first tidiaites recognized in the Middle Run Sandstone. C. Tidal and tidal flat deposits again showing gradationally thickening and thinning bundles of laminae in cross bed foresets similar to neap-spring tidal deposits. Beds transition upwards from tidal cross beds to tidal flat flaser bedding bounded by scour surfaces. The overall sequence in the cores suggests a period of relative sea level fall to a more terrestrially-dominated environment at the margin of a shallow sea.



Interpretation of the Kentucky Geological Survey 2-D seismic line 301, Hancock and Breckinridge Counties (inset map, above). This line passes 2 mi (3.2 km) east of the #1 Marvin Blan. North-vergent thrust faults offset the rhyolite volcanic complex penetrated by the #1 Braden well to the southeast, but are erosionally truncated at the base of the Middle Run. The Middle Run is about 4500 ft thick (1372 m) on this line, and thins to the south.

Interpretation of Precambrian structure from 2-D seismic data in the Hancock County region and adjacent Indiana. The complex ramp anticline culminates a group of stacked, east-vergent thrust faults in sequence 5* rocks. Farther southeast in Hancock County, thrust faults in the same sequence are north vergent. It is likely that these thrust faults are part of the Hoosier Thrust Belt (Stark et al., 2002) in response to Grenville-age compression. Note that Sequence 1* (Middle Run Sandstone), 3* and 4* (rhyolite volcanic complex), and 5* are present above the thrust belt.

Conclusions

The Middle Run Sandstone cored in the #1 Marvin Blan well was deposited on the margin of the Precambrian sea, west of the Grenville uplift. Diagenetic pore-filling cements have reduced porosity and permeability to the degree comparable to reservoir sealing strata. Therefore, the Middle Run Sandstone is unsuitable for CO_2 storage.

Acknowledgments

This study was supported by a grant from the U.S. Department of Energy, National Energy Technology Laboratory.

Geological Society of America 2010 Annual Meeting Denver, Colorado