Applied Energy Mapping at the Ohio Geological Survey

Michael P. Solis
michael.solis@dnr.state.oh.us

Matthew S. Erenpreiss
matt.erenpreiss@dnr.state.oh.us

Timothy E. Leftwich
tim.leftwich@dnr.state.oh.us

Ohio Department of Natural Resources, Division of Geological Survey
2045 Morse Rd., Bldg. C-1, Columbus, OH 43229-6693

ABSTRACT

The Ohio Geological Survey is currently engaged in a number of projects to appraise Ohio's geologic resources as they apply to developing shale oil and gas, storing CO_2, and geothermal potential. This research is being conducted with funding, in part, provided to address specific project objectives for the Ohio Coal Development Office (OCDO); the Midwest Regional Carbon Sequestration Partnership (MRCSP), funded by the U.S. Department of Energy; and the National Geothermal Data System (NGDS), a project funded by the U.S. Department of Energy.

New regional and statewide isopach maps were developed for the Middle Devonian Marcellus Shale for use in assessing Ohio's shale gas potential (see Panel 1). Existing stratigraphic analyses of Devonian shales in Ohio were used as the starting dataset. The dataset was expanded with additional geophysical logs that span the Marcellus Shale in each county and township, where available, which allowed for an even distribution of control points. The Hamilton Group, Marcellus Shale, and Onondaga Limestone tops were picked using USGS cross sections for reference. With this new information and observing the Marcellus Shale's upper and lower units, net organic thickness was calculated and contoured. Data was also collected from the State Geological Surveys of New York, Pennsylvania, and West Virginia to create a new regional Marcellus organic thickness map.

The initial goal for the OCDO project is to evaluate geologic conditions favorable for CO_2 storage in eastern Ohio (see Panel 2). This includes detailed mapping of potential CO_2 sinks by creating a robust well dataset for analysis. Middle Devonian through Middle Silurian drillers' elevations are quickly assessed by comparing them to existing formation tops interpreted by staff geologists for previous mapping projects. The drillers' picks are co-kriged with existing formation tops to create new maps with much denser well control. These new statewide maps are then merged with existing MRCSP data to update the regional-level maps. New structure contour maps have been generated for top of Onondaga Limestone, Oriskany Sandstone, Bass Islands Dolomite, and Keefer Sandstone. As part of the continual refinement of MRCSP maps, the Precambrian surface map also was updated using more detailed contours provided by Kentucky and Ohio.

CO_2 storage potential is temperature dependent and, globally, geothermal resources are being developed with the aid of new technologies that produce electricity and space heat from relatively lower-temperature (≈ 100°C) rocks, such as those penetrated by some deep Appalachian Basin oil and gas wells. Electricity production has been possible in conjunction with producing oil and gas wells and from coproduction associated with secondary and enhanced oil-and-gas recovery. New techniques allow for space heating and electrical coproduction using injection fluids, such as brine or CO_2, that are usually considered waste products in the energy production cycle. The Ohio Geological Survey began research into the state's geothermal resources in July 2010—as part of a 47-state coalition to develop a new NGDS—and is evaluating its very large dataset of bottom-hole temperatures (BHT) and the AAPG-corrected BHT dataset (see Panel 3). Specifically, selected bottom-hole temperature data was corrected and used with the AAPG dataset to construct BHT and gradient 3-D plots and maps in order to help evaluate the regional, subsurface geothermal environment.

Panel 1: Mapping the Regional Organic Thickness of the "Marcellus Shale," Hamilton Group

Existing Ohio well data from the Ohio Division of Geological Survey (1988) was used as the starting dataset. To expand on that dataset, we selected additional geophysical logs that penetrated and logged the Marcellus in each county and township where available, allowing for an even distribution of control points. Hamilton, Marcellus, and Onondaga tops were picked based on USGS cross sections by Roen and Kepferle (1993). With this new information and observing the Marcellus upper and lower units illustrated by Lash and Engelder (2011), we calculated net-organic thickness and then contoured based on that thickness.

Originally we used only Pennsylvania's Marcellus map of net-organic thickness (Pennsylvania Geological Survey, [2010]). However, the eastern portion of the state did not match up to the recent data points we were given for the Pennsylvania and New York contour maps. The data points did match up to contours on the MRCSP Marcellus thickness map (Carter, K., unpub. data, 2008) as well as New York's contour map (James Leone, written commun., 2011). There were still some issues, such as crossing contours, concerning the western portion of Carter's map, so we merged the western part of the Pennsylvania Geological Survey ([2010]) map to the eastern portion of the Carter (unpub. data, 2008) map, creating a cleaner, data-honoring map. The break between these two maps follows the continuous 250-foot-thickness contour ranging from Pennsylvania into New York. All other contour placement changes in Pennsylvania were made in order to honor the recent data points we were given.

Marcellus thickness maps for New York and West Virginia came from their respective state geological surveys (James Leone, written commun., 2011; West Virginia Geological Survey, 2010, respectively) and were modified based only on data points and the merging process into adjacent states. Again, all state boundary contours were merged in order to preserve the existing maps; contour placement changes were only made where necessary and where data control points provided sufficient evidence that a change could be made with confidence.

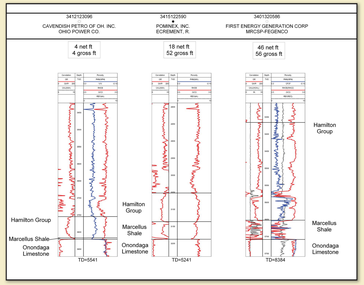


FIGURE 1-1.—Three Marcellus type logs from across Ohio. Some areas of the state only have a single unit just above the Onondaga Limestone, while others have multiple Marcellus units, some bifurcated and others continuous.

FIGURE 1-2.—Map of Ohio showing geographically the two sections A–A' and B–B', shown in figure 1-3.

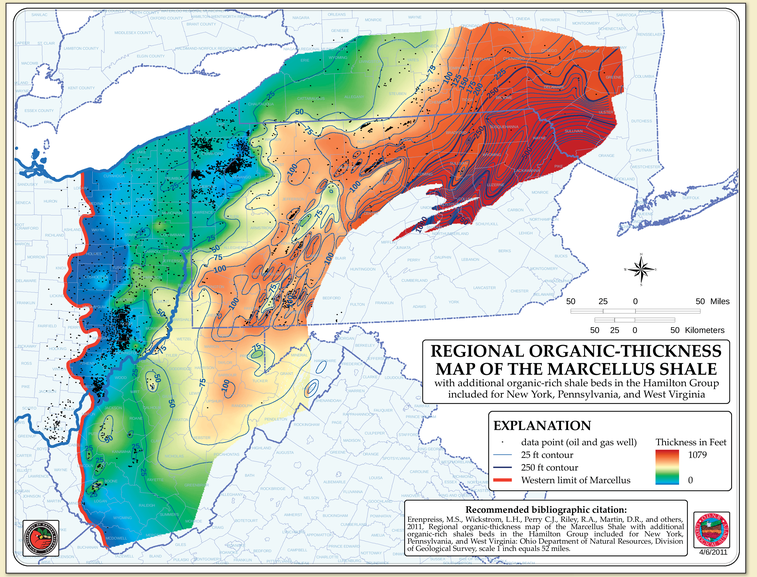
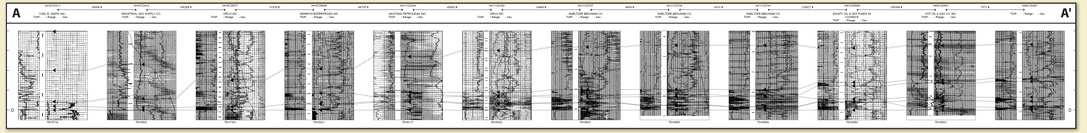


FIGURE 1-3. (below)—Line A–A' shows how the Marcellus Shale thickens as you travel north along the Ohio River and how the Marcellus can have bifurcated units in some areas.



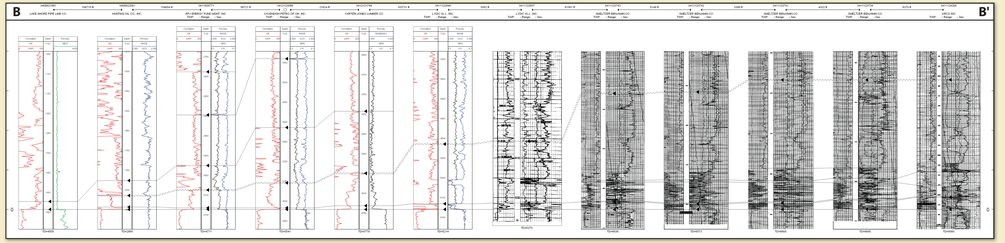


FIGURE 1-4.—Line B–B' shows how the Marcellus thickens as you travel southeast from Licking County to the Ohio River in Monroe County.

REFERENCES

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Roen, J.B., and Kepferle, R.C., 1993, Petroleum geology of the Devonian and Mississippian black shale of eastern North America: U.S. Geological Survey Bulletin 1909.

West Virginia Geological Survey, 2010, Thickness/isopach map (lines)—Marcellus Shale, West Virginia: Morgantown, West Virginia Geological and Economic Survey, vector digital data, last accessed September 21, 2011, at <http://www.wvgs.wvnet.edu/www/datastat/devshales.htm#DownloadMarcellus>.

Panel 2: Updating the Middle Devonian through Middle Silurian Structure Maps for Potential CO_2 Storage Targets in Ohio (OCDO and MRCSP)

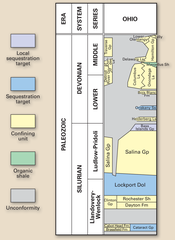

FIGURE 2-1.—A stratigraphic column after Carter and others (2010) shows the potential CO_2 storage targets and seals in blue and yellow, respectively. Currently mapped surfaces include the Onondaga Limestone, the Oriskany Sandstone, the Bass Islands Dolomite, and the Lockport Dolomite. Structural horizons in process include the Bois Blanc Formation, the Helderberg Limestone, and the Rochester Shale. A map for the Salina Group also will be created.

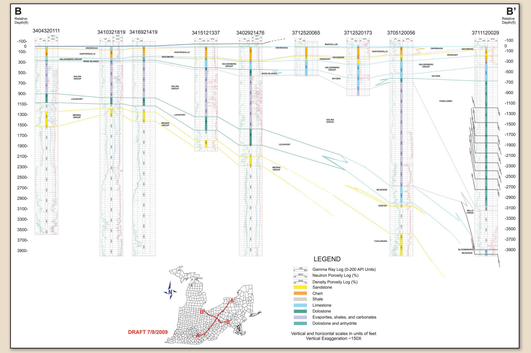

FIGURE 2-2.—Regional stratigraphic cross section of Middle Devonian through Middle Silurian strata, hung on the top of the Onondaga Limestone. From Carter and others (2010).

Formation	CoKrigging Type	Data Source	ni	nf	Trans-formation Type	Decluster	Trend Removal	Kernel Function	Model Type	Anisotropy	RMS
Onondaga Limestone	Universal	Driller	56109	40311	Normal Score	TRUE	Contant	Gausian	Stable	TRUE	15
		Geologist	616	N/A	None	N/A	None	N/A			
Oriskany Sandstone	Ordinary	Driller	9868	6880	None	N/A	None	N/A	Stable	TRUE	22
		Geologist	242	N/A	None	N/A	None	N/A			
Bass Islands Dolomite	Simple	Driller	1789	514	None	N/A	None	N/A	Stable	TRUE	22
		Geologist	616	N/A	None	N/A	None	N/A			
Lockport Dolomite	Ordinary	Driller	12803	7086	None	N/A	None	N/A	Stable	TRUE	21
		Geologist	619	N/A	None	N/A	None	N/A			

FIGURE 2-3.—Parameters and results used in ESRI's Geostatistical Analyst.