

APPALACHIAN STORAGE HUB PROJECT

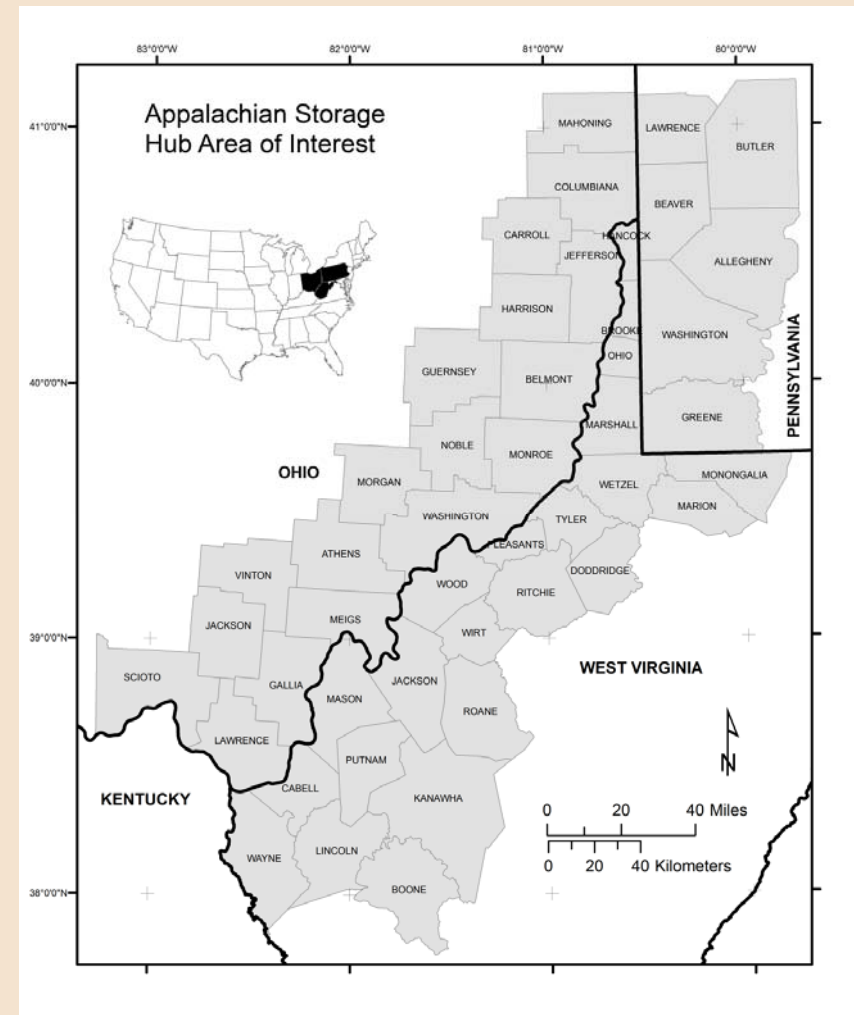
Michael Solis
Mohammad Fakhari

Ohio Department of Natural Resources
Division of Geological Survey



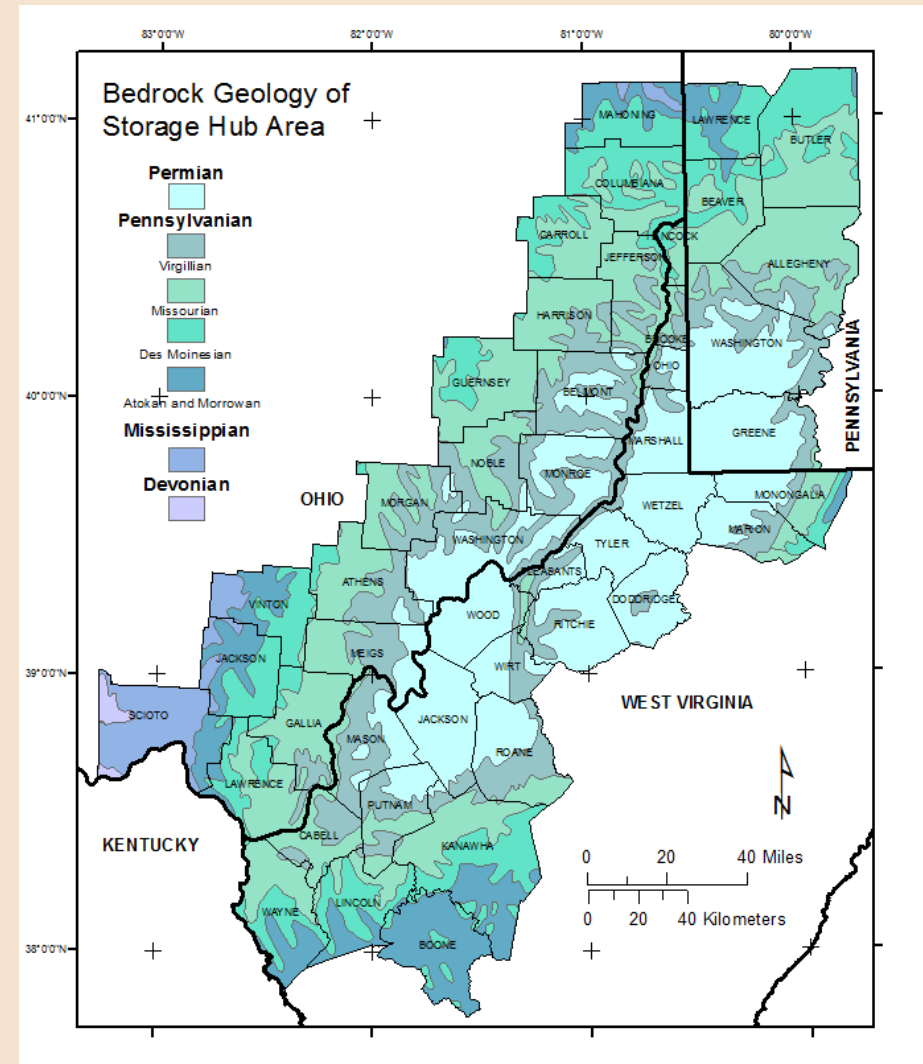
APPALACHIAN STORAGE HUB AREA OF INTEREST

- Focused on Ohio River Valley
- Incorporates W. Virginia, Pennsylvania, and Ohio
- 46 counties in AOI
 - 20,107 mi²



GEOLOGIC MAP OF AREA OF INTEREST

- The AOI is in the Appalachian Basin
- Bedrock map outcrops:
Permian, Mississippian,
Pennsylvanian, Devonian
- Older units, subsurface:
Silurian, Ordovician,
Cambrian

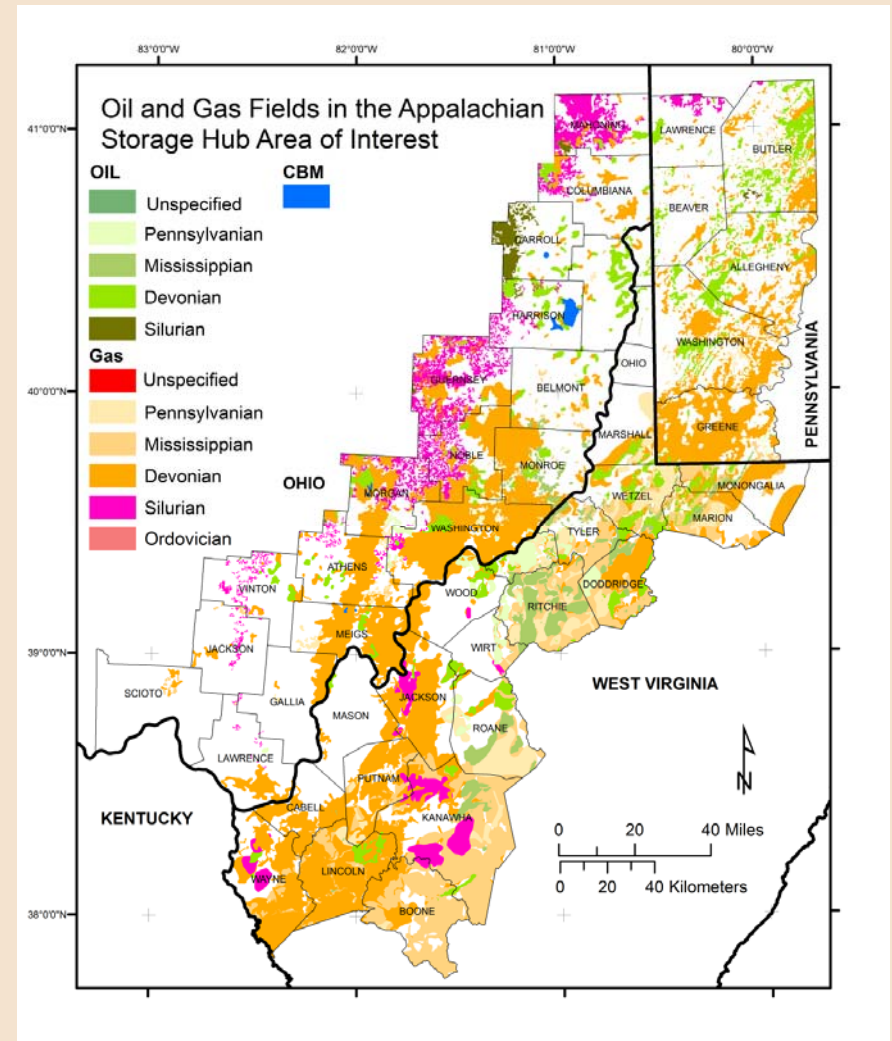


Modified from Wickstrom and others (2005)

OIL AND GAS FIELDS OF THE AOI

(AREA OF INTEREST)

- Active and depleted oil and gas fields



Modified from Wickstrom and others (2005)

POTENTIAL GEOLOGIC FORMATIONS OF OHIO FOR NGL STORAGE

- Oriskany Sandstone
- Salina Group salt
- Clinton /Tuscarora Sandstone
- Rose Run Sandstone

CAMBRIAN ROSE RUN SANDSTONE

- ~100 ft thick sandstone
- Studies:
 - Riley and others, 1993
 - Baranoski and others, 1996
 - Wickstrom and others 2005
 - Wickstrom and others (2011)
 - Others

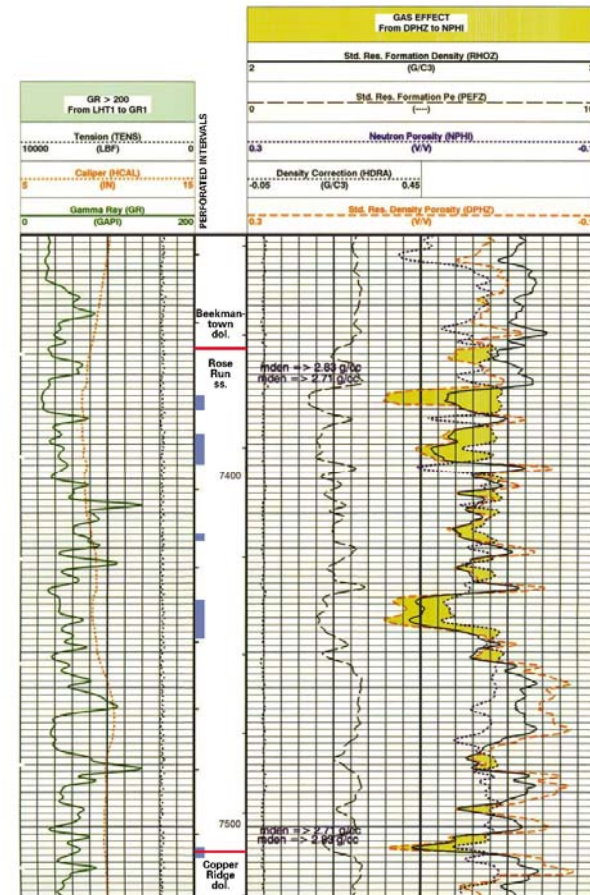
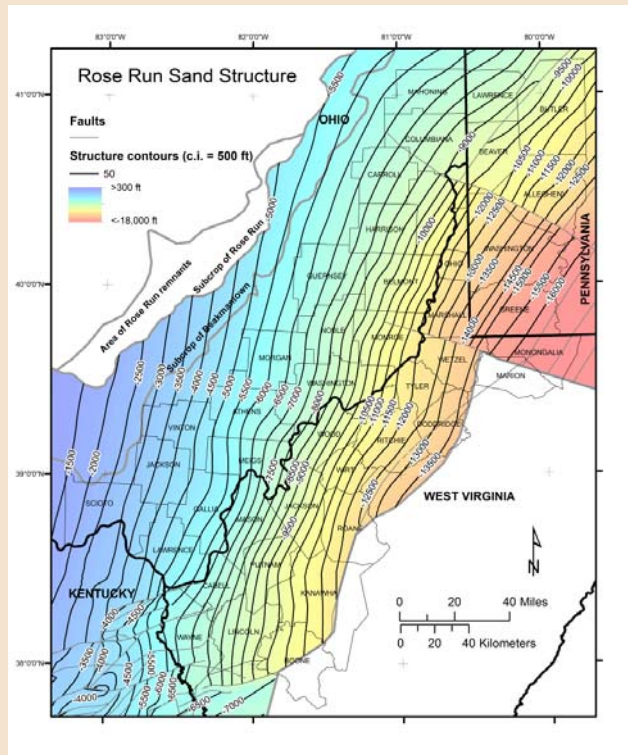


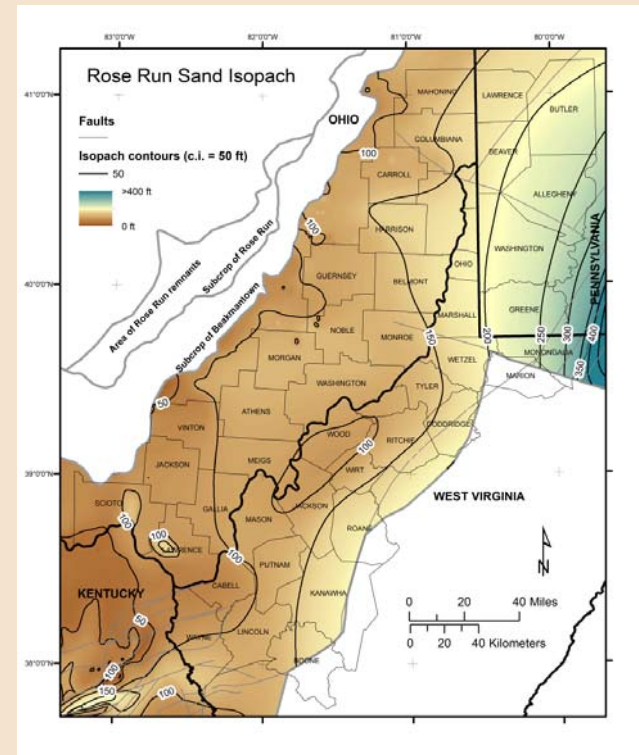
FIGURE 30.—Geophysical log of the Rose Run sandstone interval at the Ohio Geological Survey CO₂ No. 1 well site. Also shown are the perforated intervals used for brine injection zones.

Wickstrom and others (2011)

ROSE RUN SAND STRUCTURE & ISOPACH MAPS



Subsea depth range:
-1,500ft to -16,000ft



Average thickness: 120ft

SILURIAN MEDINA/CATARACT GROUP ("CLINTON") INTERVAL

- 100-300ft of interbedded sandstone and shale
- Studies:
 - McCormac and others, 1996
 - Carter and others, 2010
 - Riley and others, 2010
 - Others

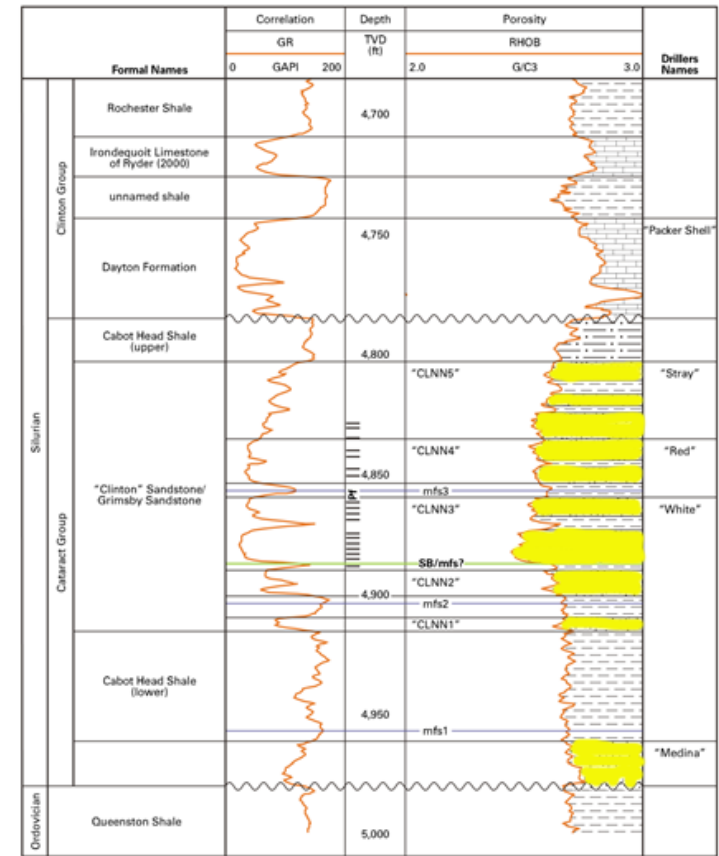
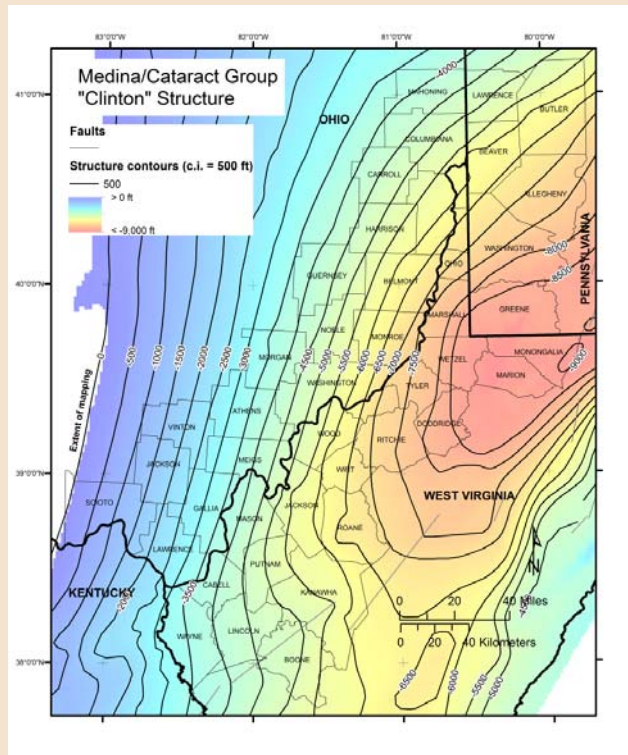


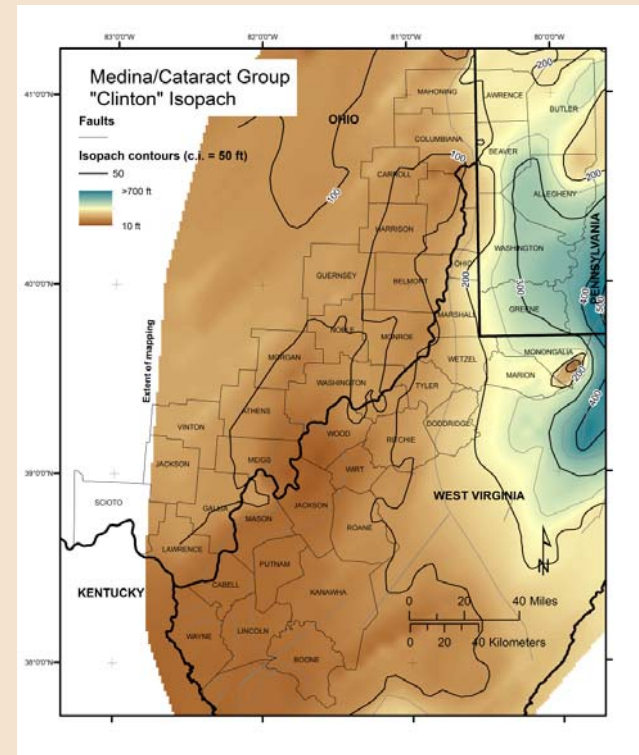
Figure 7.—The Slickafosse-Morris #1 (APNO 3415122018) type log and the mapped units for this study of the East Canton oil field. Also shown are the formal names and corresponding drillers' names. The proposed sequence boundary is uncertain by the authors of this report and may be a maximum flood surface (mfs).

Riley and others (2010)

MEDINA/CATARACT GROUP "CLINTON" INTERVAL



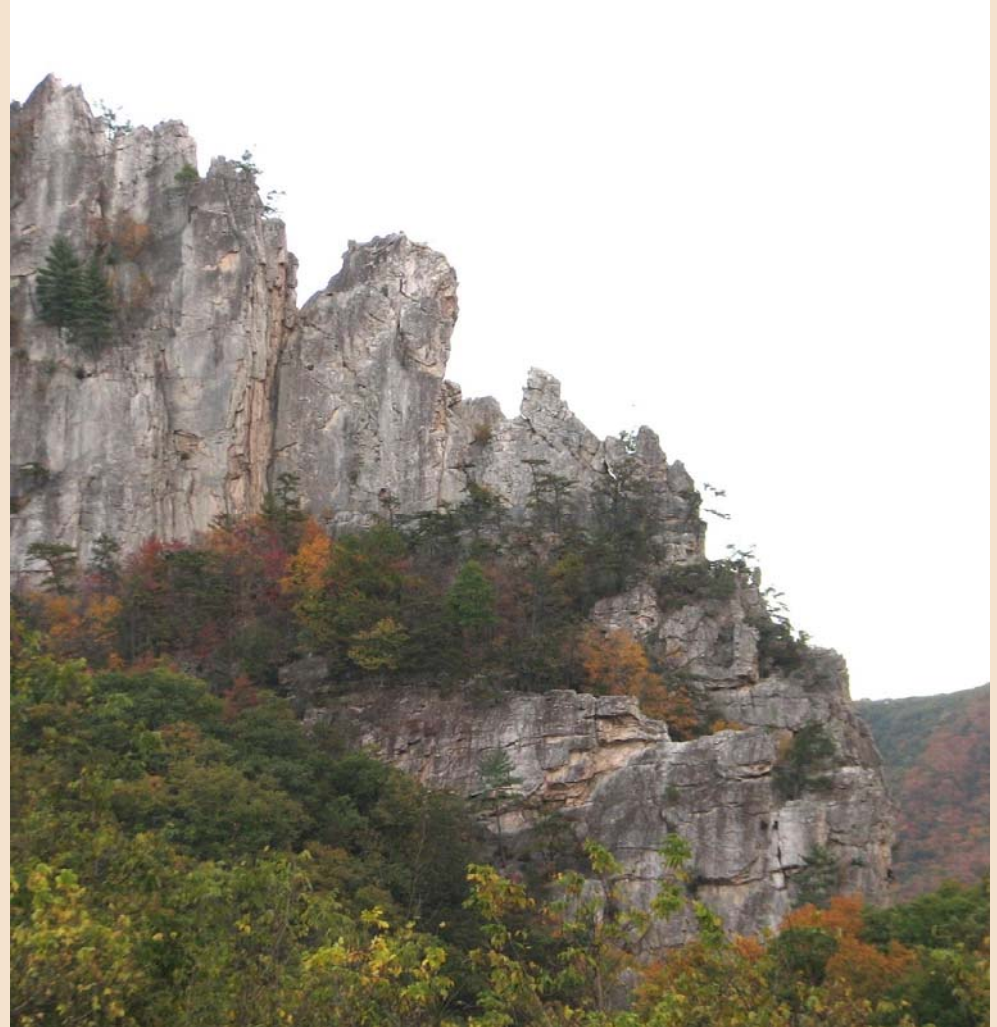
Subsea depth range:
Sea level to - 9,000ft



Average thickness: 300ft

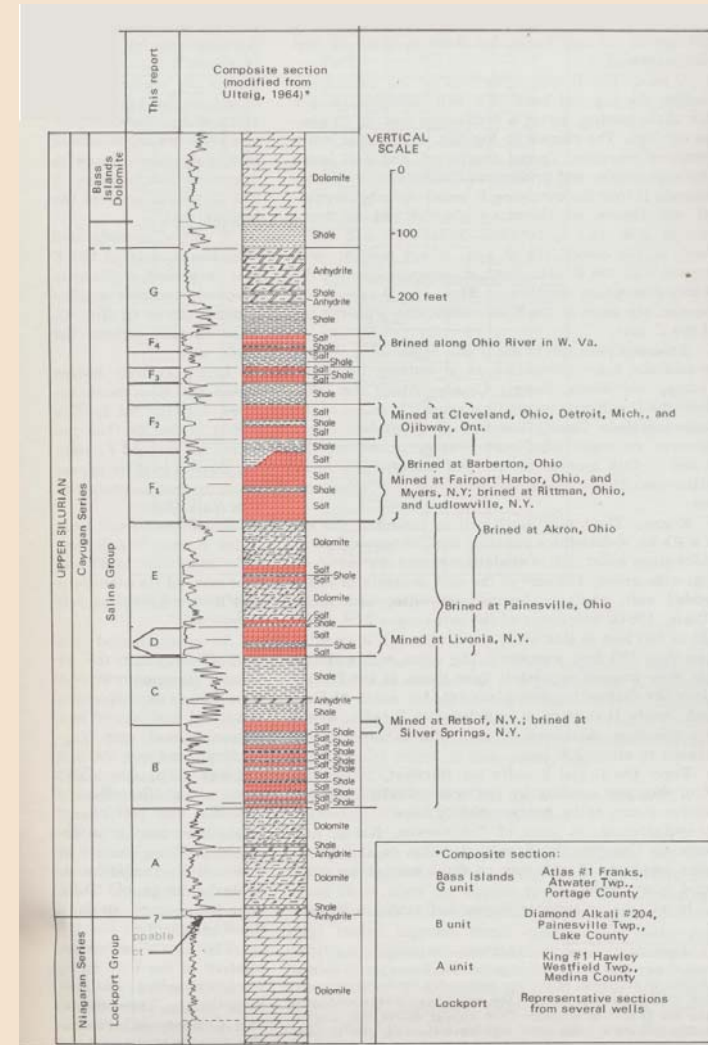
TUSCARORA / CLINTON SANDSTONE OUTCROP

Seneca Rocks, West Virginia



SILURIAN SALINA GROUP, SALT-BEARING UNITS

- Salina salt units in AOI
 - B: numerous thin salt beds < 10ft thick
 - D: ~40ft thick
 - E: 2 beds each ~20ft thick; locally, 1 bed > 100ft thick
 - F₁: 2-3 beds total ~80ft thick; pinchout to the south
 - F₂: 2 beds ~20ft thick; pinchout to the south
 - F₃: 2 beds ~20ft thick; pinchout to the south
 - F₄: 1-3 beds > 100ft thick along the Ohio River Valley
- Studies:
 - Stehli and others 1963
 - Ulteig, 1964
 - Clifford, 1973

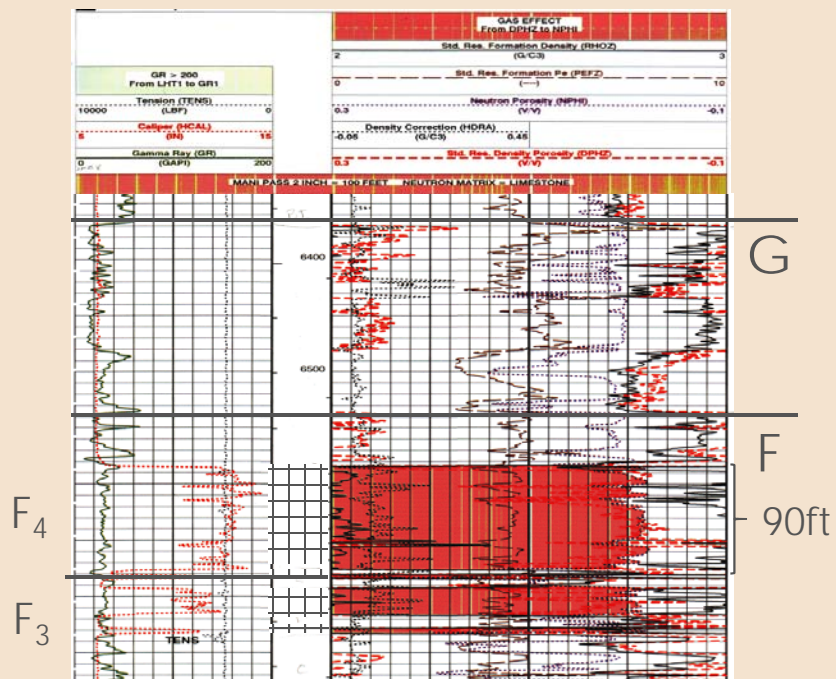


(Clifford, 1973)

SALINA F4 SALT, BELMONT COUNTY

34013205860000

FEGENCO #1



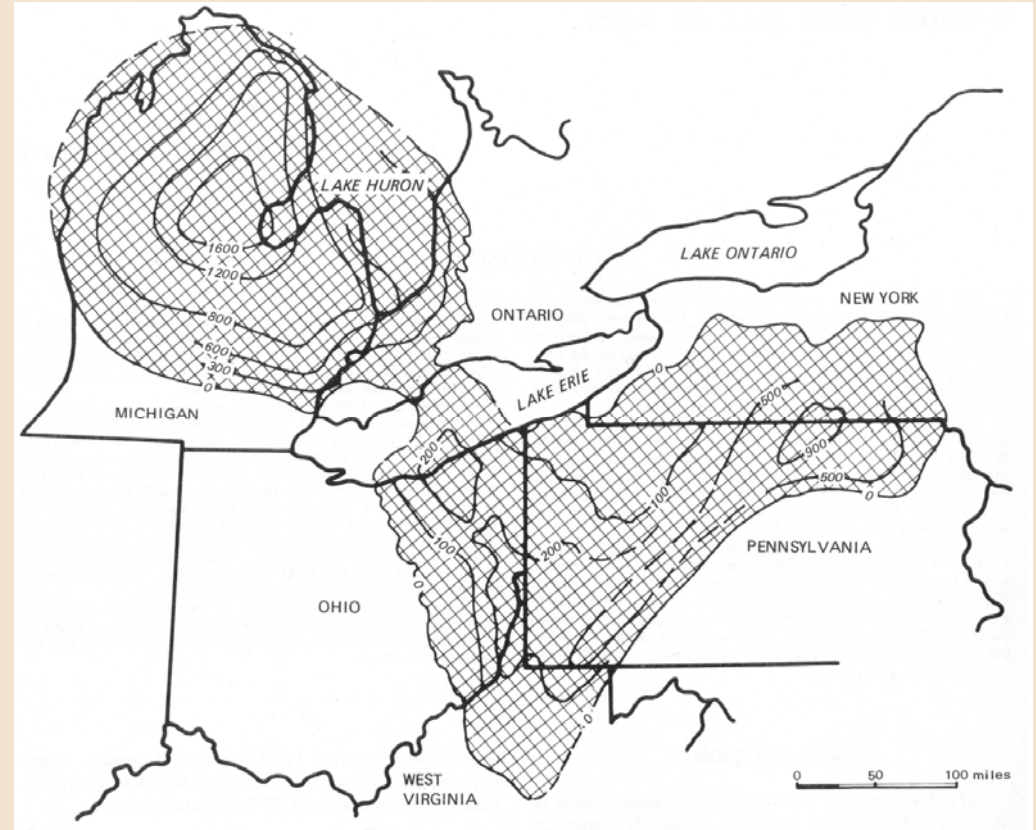
F₄ salt > 100ft
along Ohio River
Valley



(Clifford, 1973)

SILURIAN SALINA GROUP

- Salt deposition in the Michigan and Appalachian Basins
- Salt thickness vary in the AOI; however net salt thickness is > 200ft along the Ohio River Valley



(Clifford, 1973)

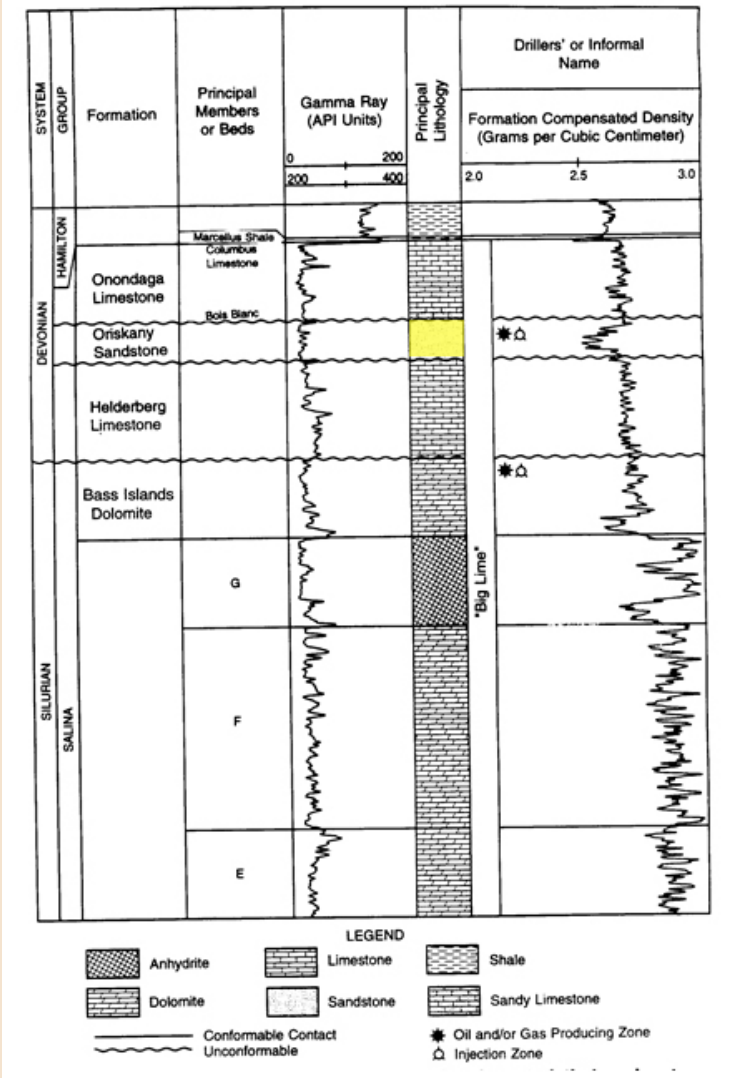
SILURIAN SALINA SALT F1 MEMBER

Cargill Underground
salt mine, Cleveland,
Ohio



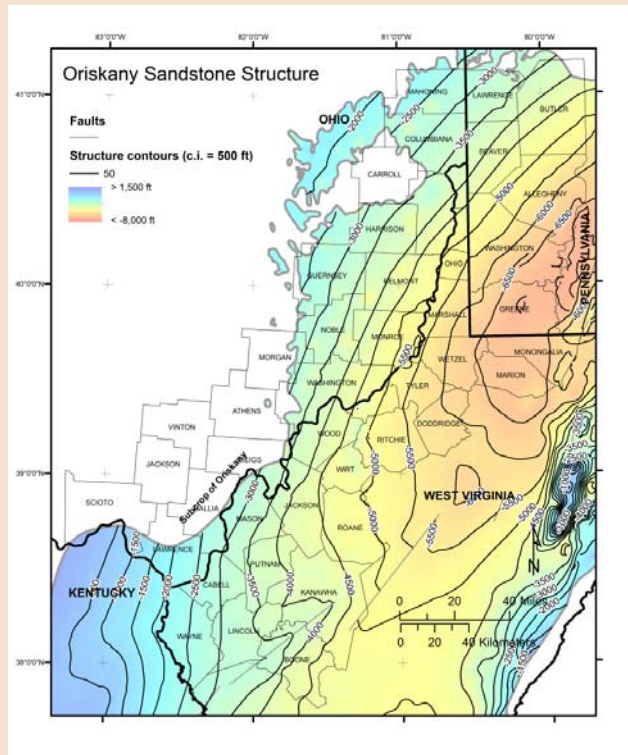
DEVONIAN ORISKANY SANDSTONE

- 0-100ft of sandstone
- Studies:
 - Harper and Patchen, 1996
 - Opritza, 1996
 - Patchen and Harper, 1996
 - Kostelnik and Carter, 2009
 - Carter and others, 2010
 - Others

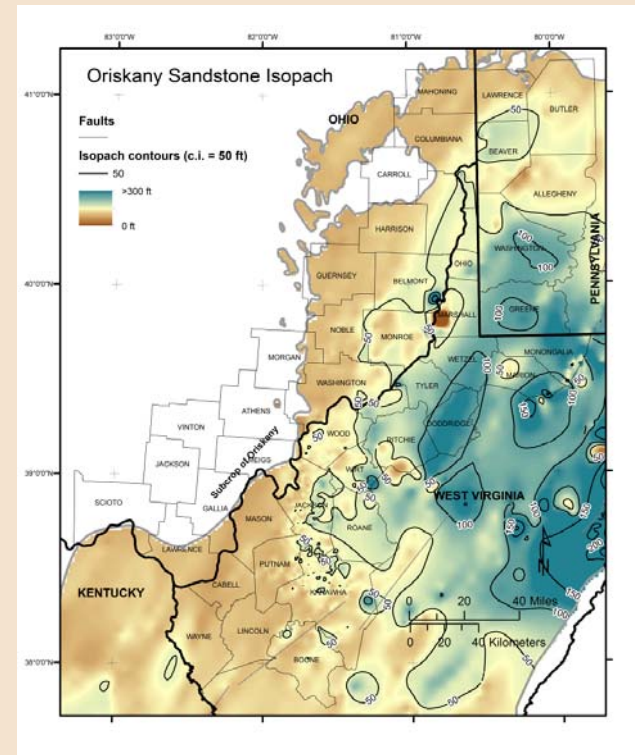


Opritza (1996)

ORISKANY SANDSTONE



Subsea depth range:
-1,000 to - 6,500ft



Thickness range: 0 - 150ft

REFERENCES

- Baranoski, M.T., Riley, R.A., and Wolfe, M.E., 1996, Cambrian-Ordovician Knox Group unconformity play, *in* Roen, J.B., and Walker, B.J., eds., The atlas of major Appalachian basin gas plays: West Virginia Geological and Economic Survey Publication v. 25, p. 145-150.
- Carter, K. M., Kostelnik, J. J., Laughrey, C. D., Harper, J. A., Barnes, D. A., Harrison, W. B., III, Venteris, E. R., McDonald, James, Wells, J. G., Wickstrom, L. H., Perry, C. J., Avary, K. L., Lewis, J. E., Hohn, M. E., Stolorow, A., Slater, B. E., and Greb, S. F., 2010, Characterization of geologic sequestration opportunities in the MRCSP region, Middle Devonian–Middle Silurian formations—MRCSP phase II topical report October 2005–October 2010: Midwest Regional Carbon Sequestration Partnership report submitted to Battelle Memorial Institute and U.S. Department of Energy, Cooperative Agreement No. DE-FC26-05NT42589, 150 p.
- Clifford, M.J., 1973, Silurian rock salt of Ohio: Ohio Division of Geologic Survey, Department of Natural Resources, Columbus Ohio, Report of Investigations No. 90, 42 p., 4 plates.
- Harper, J.A. and Patchen, D.G., 1996, Lower Devonian Oriskany Sandstone structural play, *in* Roen, J.B., and Walker, B.J., eds., The atlas of major Appalachian basin gas plays: West Virginia Geological and Economic Survey Publication v. 25, p. 109-117.
- Kostelnik, J., and Carter, K.M. 2009a. The Oriskany Sandstone updip permeability pinchout: A Recipe for Gas Production in Northwestern Pennsylvania: Pennsylvania Geology, v.39, no.4, p. 19-24.
- Kostelnik, J., and Carter, K.M. 2009b. Unraveling the stratigraphy of the Oriskany Sandstone: A necessity in assessing its site-specific carbon sequestration potential: Environmental Geosciences, v. 16, no.4, p. 187-200.
- Opritz, S.T., 1996, Lower Devonian Oriskany Sandstone updip permeability pinchout, *in* Roen, J.B., and Walker, B.J., eds., The atlas of major Appalachian basin gas plays: West Virginia Geological and Economic Survey Publication v. 25, p. 126-129.
- Patchen, D.G. and Harper, J.A., 1996, The Lower Devonian Oriskany Sandstone combination traps play, *in* Roen, J.B., and Walker, B.J., eds., The atlas of major Appalachian basin gas plays: West Virginia Geological and Economic Survey Publication v. 25, p. 118-125.
- Reasearch Partnership to Secure Energy for America (RPSEA), 2015, Development of subsurface brine disposal framework in the northern Appalachian Basin: Battelle Memorial Institute, Columbus Ohio, 411 p.
- Riley, R. A., Harper, J. A., Baranoski, M. T., Laughrey, C. D., and Carlton, R. W., 1993, Measuring and predicting reservoir heterogeneity in complex deposystems: The Late Cambrian Rose Run sandstone of eastern Ohio and western Pennsylvania. Appalachian Oil and Natural Gas Research Consortium, West Virginia University, Morgantown, WV, U.S. Department of Energy, contract no. DE-AC22-90BC14657, 257 p.
- Riley, R.A., Wicks, J.L., and Perry, C.J., 2010, Silurian “Clinton” sandstone reservoir characterization for evaluation of CO₂-EOR potential in the East Canton Oil Field, Ohio: Ohio Division of Geologic Survey, Department of Natural Resources, Columbus Ohio, Open File Report 2011-2, 31p. 4 plates.
- Stehli, F.G., Namy, J.N., and Aten, M.D., 1963, Evaporite facies in northeastern Ohio, in Symposium on salt, Cleveland: Northern Ohio Geological Society, Cleveland, Ohio, p. 31-46.
- Wickstrom, L.H., Venteris, E.R., Harper, J.A., McDonald, James, Slucher, E.R., Carter, K.M., Greb, S.F., Wells, J.G., Harrison, W.B., III, Nuttall, B.C., Riley, R.A., Drahovzal, J.A., Rupp, J.A., Avary, K.L., Lanham, Sacha, Barnes, D.A., Gupta, Neeraj, Baranoski, M.T., Radhakrishnan, Premkrishnan, Solis, M.P. Baum, G.R., Powers, Donovan, Hohn, M.E., Parris, M.P., McCoy, Karen, Grammer, Michael, Pool, Susan, Luckhardt, Catherine, Kish, Patrick, 2005, Characterization of Geologic Sequestration Opportunities in the MRCSP Region—Phase I task report October 2003—September 2005: Midwest Regional Carbon Sequestration Partnership report submitted to Battelle Memorial Institue and U.S., Department of Energy, Cooperative Agreement No. DE-PS2605NT42255, 152 p.
- Wickstrom, L.H., Riley, R.A., Spane, F.A., McDonald, James, Slucher, E.R., Zody, S.P., Wells, J.G., and Howat, Erica, 2011, Geologic assessment of the Ohio Geological Survey CO₂ No. 1 well in Tuscarawas County and surrounding vicinity: Ohio Division of Geologic Survey, Department of Natural Resources, Columbus Ohio, Open File Report 2011-3, 81 p.
- Ulteig, J.R., 1964, Upper Niagaram and Cayugan stratigraphy of northeastern Ohio and adjacent areas: Ohio Division of Geologic Survey, Department of Natural Resources, Columbus Ohio, Report of Investigations No. 51, 48 p.