Evaluation of Sequestration Options for Deep Saline Formations and Oil and Gas Fields in Eastern Ohio

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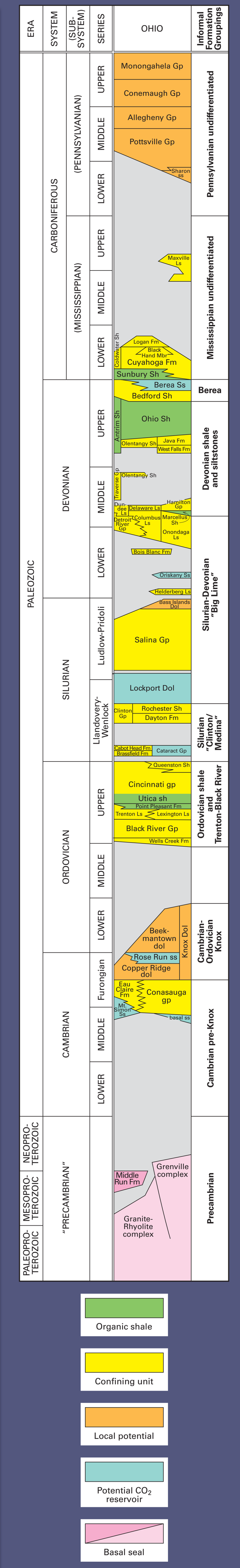
ABSTRACT

A comprehensive characterization of geologic sequestration options in eastern Ohio and the upper Ohio River Valley area is being developed by the Ohio Geological Survey in cooperation with Battelle. This project is partially funded by the Ohio Coal Development Office (OCDO). Eastern Ohio is a crucial area in which carbon sequestration options must be fully explored so that stakeholders may understand the potential options and costs of future carbon capture and storage technologies. The primary task is to compile, assimilate, and interpret the most current geologic data pertinent to CO_2 sequestration for eastern Ohio. This project includes both deep saline formations and oil and gas reservoirs that may have CO_2 enhanced oil recovery (EOR) potential.

Eastern Ohio contains numerous deep saline formations that have limited well penetrations, thus their lateral extents and injectivity properties are not well defined. Yet this region has one of the largest concentrations of large CO_2 point sources in the United States. In Ohio, oil and gas fields hold the potential to store large amounts of CO_2 while simultaneously producing hundreds of millions of barrels of additional oil through EOR.

To evaluate CO_2 sequestration opportunities, updated maps and databases have been generated identifying the locations of all well cuttings, cores, oil and gas geophysical logs, porosity and permeability data, formation and well pressure data, brine geochemistry data, and injection wells. Subsurface horizons with high-data density also have been mapped to ascertain structural trends that are reflected at multiple horizons. These new maps include structure contours on the top of the Silurian Dayton Formation, the Devonian Onondaga Limestone, and the Berea Sandstone. Recent key investigations, such as the deep stratigraphic Precambrian test in Tuscarawas County and the East Canton oil field CO_2-EOR project in Stark County, also have been incorporated into this project.

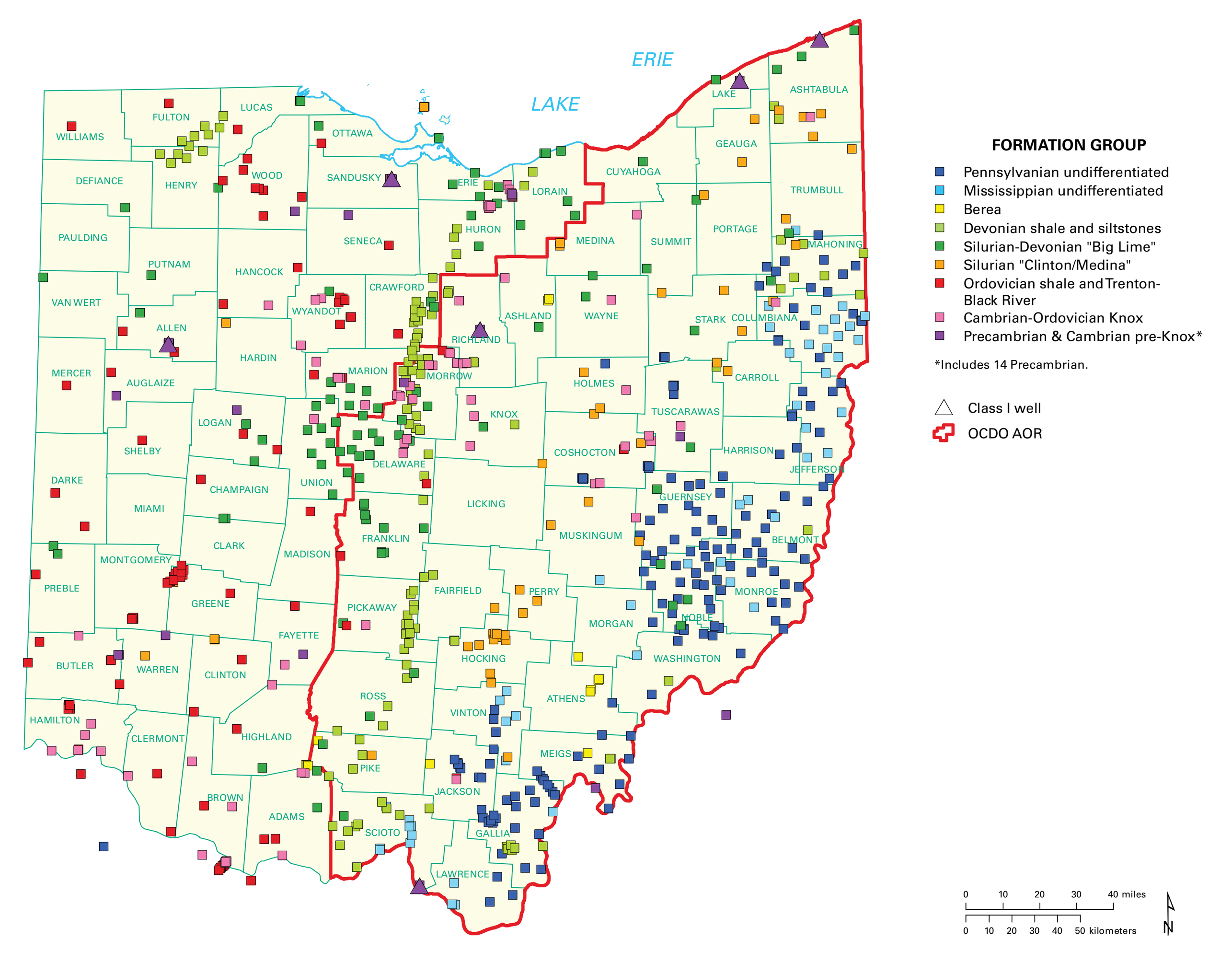


Stratigraphic chart illustrating geologic units found beneath eastern Ohio. Rock units are color coded to illustrate potential injection zones, confining units, organic shales, and basal seals. Modified from Wickstrom and others (2005).

Geologic Formation Names and Corresponding OCDO Formation Groups

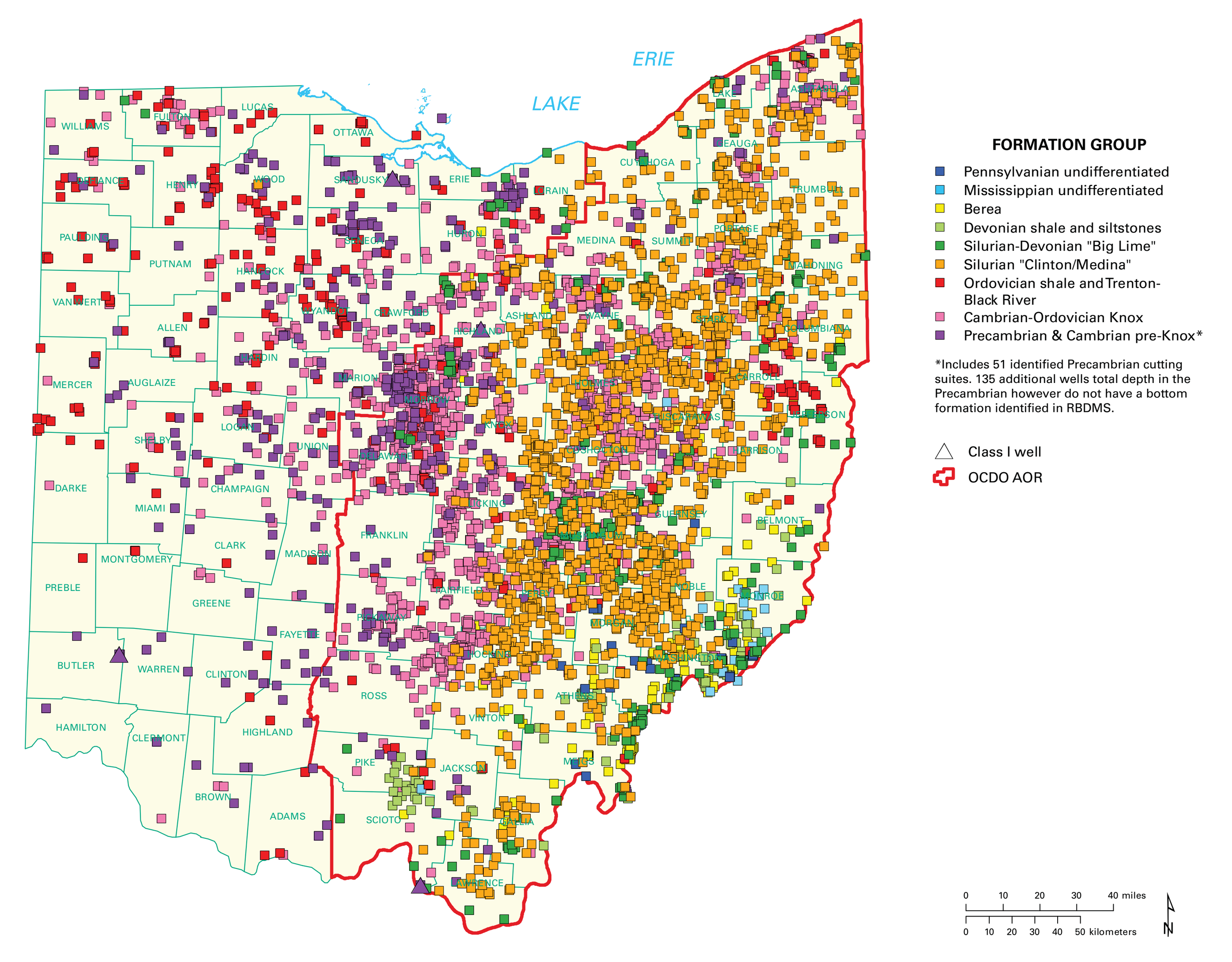
Formation Name	OCDO Formation Group
Pennsylvanian	Pennsylvanian undifferentiated
Pittsburgh coal	Pennsylvanian undifferentiated
Conemaugh Gp	Pennsylvanian undifferentiated
Mitchell sand	Pennsylvanian undifferentiated
Glenshaw	Pennsylvanian undifferentiated
Peeker sand	Pennsylvanian undifferentiated
Cow Run	Pennsylvanian undifferentiated
Buell Run	Pennsylvanian undifferentiated
Macksburg	Pennsylvanian undifferentiated
Macksburg 300	Pennsylvanian undifferentiated
Coal	Pennsylvanian undifferentiated
Allegheny	Pennsylvanian undifferentiated
Cow Run 2	Pennsylvanian undifferentiated
Dorr Run marine zone	Pennsylvanian undifferentiated
Washingtonville marine zone	Pennsylvanian undifferentiated
Macksburg 500	Pennsylvanian undifferentiated
Macksburg 700	Pennsylvanian undifferentiated
Germantown sandstone	Pennsylvanian undifferentiated
Pottsville Group	Pennsylvanian undifferentiated
Pottsville	Pennsylvanian undifferentiated
Quakertown Coal	Pennsylvanian undifferentiated
Number 2 Coal	Pennsylvanian undifferentiated
Brill Sand	Pennsylvanian undifferentiated
Sharon	Pennsylvanian undifferentiated
Maxton	Pennsylvanian undifferentiated
Second Salt sand	Pennsylvanian undifferentiated
Salt sand	Pennsylvanian undifferentiated
Mitchell	Pennsylvanian undifferentiated
Mississippian Undifferentiated	Mississippian undifferentiated
Upper Mississippian undifferentiated	Mississippian undifferentiated
Maxville	Mississippian undifferentiated
Logan	Mississippian undifferentiated
Keener	Mississippian undifferentiated
Big Injun	Mississippian undifferentiated
Squaw	Mississippian undifferentiated
Weir	Mississippian undifferentiated
Hamden	Mississippian undifferentiated
Henley Shale Member	Mississippian undifferentiated
Coffee Shale	Mississippian undifferentiated
Cussewago Sandstone	Mississippian undifferentiated
Sunbury	Berea
Berea	Berea
Berea 2	Berea
Bedford	Berea
Gantz	Berea
Thirty Foot	Berea
Gordon	Berea
Fifth Sand	Berea
Cuyahoga	Devonian shale and siltstones
Devonian	Devonian shale and siltstones
Ohio	Devonian shale and siltstones
Cleveland Shale Member	Devonian shale and siltstones
Little Cinnamon	Devonian shale and siltstones
Chagrin Shale Member	Devonian shale and siltstones
Warren 1st	Devonian shale and siltstones
Speechley Sand	Devonian shale and siltstones
Balltown Sand	Devonian shale and siltstones
Huron	Devonian shale and siltstones
Big Cinnamon	Devonian shale and siltstones
Lower Huron	Devonian shale and siltstones
Antrim	Devonian shale and siltstones
Olentangy	Devonian shale and siltstones
Rhinestreet Shale Member	Devonian shale and siltstones
Sonyea Formation	Devonian shale and siltstones
Marcellus	Devonian shale and siltstones
Gordon Stray	Silurian - Devonian "Big Lime"
Traverse	Silurian - Devonian "Big Lime"
Delaware	Silurian - Devonian "Big Lime"
Onondaga	Silurian - Devonian "Big Lime"
Columbus	Silurian - Devonian "Big Lime"
Big Lime	Silurian - Devonian "Big Lime"
Detroit Group	Silurian - Devonian "Big Lime"
Sylvania	Silurian - Devonian "Big Lime"
Bois Blanc	Silurian - Devonian "Big Lime"
Oriskany	Silurian - Devonian "Big Lime"
Helderberg Group	Silurian - Devonian "Big Lime"
Helderburg	Silurian - Devonian "Big Lime"
Silurian	Silurian - Devonian "Big Lime"
Bass Island	Silurian - Devonian "Big Lime"
Bass Island Group	Silurian - Devonian "Big Lime"
Salina	Silurian - Devonian "Big Lime"
Salina G	Silurian - Devonian "Big Lime"
Salina F	Silurian - Devonian "Big Lime"
Salina E	Silurian - Devonian "Big Lime"
Salina B	Silurian - Devonian "Big Lime"
Salina A	Silurian - Devonian "Big Lime"
Salina undifferentiated	Silurian - Devonian "Big Lime"
Undifferentiated Salina Dolomite	Silurian - Devonian "Big Lime"
Tymochtee	Silurian - Devonian "Big Lime"
Greenfield	Silurian - Devonian "Big Lime"
Salina Dolomite	Silurian - Devonian "Big Lime"
Williamsport Sandstone	Silurian - Devonian "Big Lime"
Lockport	Silurian - Devonian "Big Lime"
Newburg	Silurian - Devonian "Big Lime"
First Water	Silurian - Devonian "Big Lime"
Lockport Group	Silurian - Devonian "Big Lime"
Guelph Dolomite	Silurian - Devonian "Big Lime"
Gasport	Silurian - Devonian "Big Lime"
Rochester Formation	Silurian - Devonian "Big Lime"
Niagaran	Silurian - Devonian "Big Lime"
Neahga Shale	Silurian - Devonian "Big Lime"
Laurel	Silurian - Devonian "Big Lime"
Dayton Formation	Silurian "Clinton/Medina"
Dayton Limestone Member	Silurian "Clinton/Medina"
Packer Shell	Silurian "Clinton/Medina"
Little Shell	Silurian "Clinton/Medina"
Cabot Head	Silurian "Clinton/Medina"
Clinton	Silurian "Clinton/Medina"
Stray Clinton	Silurian "Clinton/Medina"
Red Clinton	Silurian "Clinton/Medina"
White Clinton	Silurian "Clinton/Medina"
Manitoulin Dolomite	Silurian "Clinton/Medina"
Medina	Silurian "Clinton/Medina"
Brassfield	Silurian "Clinton/Medina"
Brassfield	Silurian "Clinton/Medina"
Queenston	Silurian "Clinton/Medina"
Red Medina	Silurian "Clinton/Medina"
Ordovician undifferentiated	Ordovician shale and Trenton-Black River
Ordovician undivided	Ordovician shale and Trenton-Black River
Upper Ordovician undifferentiated	Ordovician shale and Trenton-Black River
Cincinnatian	Ordovician shale and Trenton-Black River
Drakes	Ordovician shale and Trenton-Black River
Waynesville Formation and Arnheim Formations	Ordovician shale and Trenton-Black River
Richmond Group	Ordovician shale and Trenton-Black River
Miamitown Shale	Ordovician shale and Trenton-Black River
Fairview	Ordovician shale and Trenton-Black River
Kope	Ordovician shale and Trenton-Black River
Eden Formation	Ordovician shale and Trenton-Black River
Utica	Ordovician shale and Trenton-Black River
Point Pleasant	Ordovician shale and Trenton-Black River
Trenton	Ordovician shale and Trenton-Black River
Lexington	Ordovician shale and Trenton-Black River
Logana	Ordovician shale and Trenton-Black River
Black River	Ordovician shale and Trenton-Black River
Upper Chazy	Ordovician shale and Trenton-Black River
Gull River	Ordovician shale and Trenton-Black River
Middle Chazy	Ordovician shale and Trenton-Black River
Lower Chazy	Ordovician shale and Trenton-Black River
Lower Argillaceous Unit of Wells Creek	Ordovician shale and Trenton-Black River
Wells Creek	Ordovician shale and Trenton-Black River
Glenwood	Ordovician shale and Trenton-Black River
St Peter	Ordovician shale and Trenton-Black River
Knox Unconformity Surface	Cambro-Ordovician Knox
Beekmantown	Cambro-Ordovician Knox
Rose Run	Cambro-Ordovician Knox
Prairie Du Chien Group	Cambro-Ordovician Knox
Knox	Cambro-Ordovician Knox
Lower Knox	Cambro-Ordovician Knox
Copper Ridge	Cambro-Ordovician Knox
Trempealeau	Cambro-Ordovician Knox
Knox B	Cambro-Ordovician Knox
Cambrian undifferentiated	Precambrian - Cambrian Pre-Knox
Krysik Sand	Precambrian - Cambrian Pre-Knox
Kerbel	Precambrian - Cambrian Pre-Knox
Maynardville	Precambrian - Cambrian Pre-Knox
Franconian	Precambrian - Cambrian Pre-Knox
Conasauga	Precambrian - Cambrian Pre-Knox
Rome	Precambrian - Cambrian Pre-Knox
Eau Claire	Precambrian - Cambrian Pre-Knox
Shady Formation	Precambrian - Cambrian Pre-Knox
Middle Cambrian undifferentiated	Precambrian - Cambrian Pre-Knox
Mount Simon	Precambrian - Cambrian Pre-Knox
basal sand	Precambrian - Cambrian Pre-Knox
Precambrian	Precambrian - Cambrian Pre-Knox
Precambrian crystalline basement	Precambrian - Cambrian Pre-Knox
Middle Run	Precambrian - Cambrian Pre-Knox
Granite	Precambrian - Cambrian Pre-Knox
Granite Wash	Precambrian - Cambrian Pre-Knox
Grenville Orogenic Belt	Precambrian - Cambrian Pre-Knox

AVAILABLE ROCK CORE SAMPLE SETS



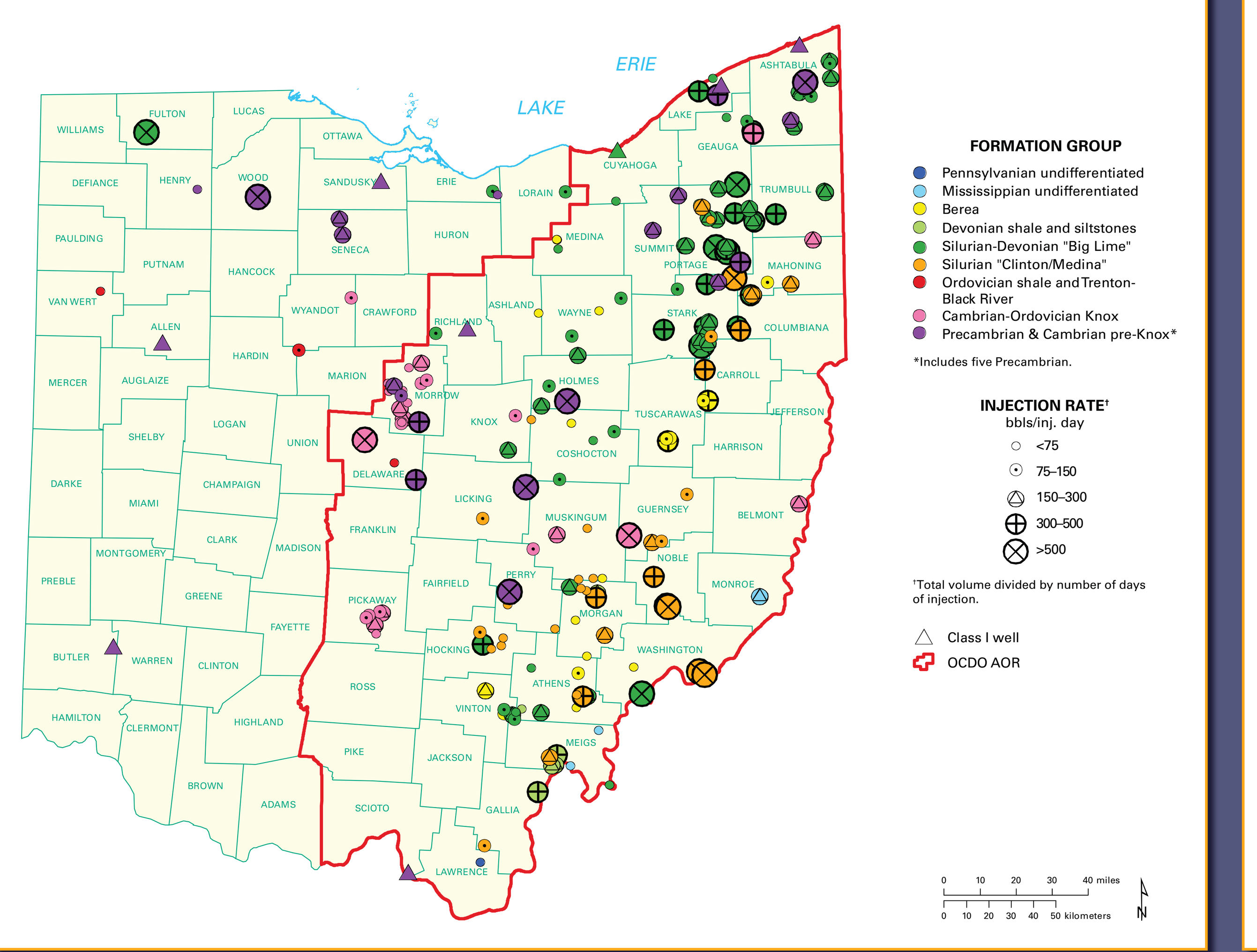
Map showing available rock core, composite. See table at left for a listing of the formation(s) for each OCDO group. The Survey's core collection consists of 955 individual cores from Ohio, Kentucky, and West Virginia. All core is available for observation and some may be sampled.

AVAILABLE ROCK CUTTINGS SAMPLE SETS



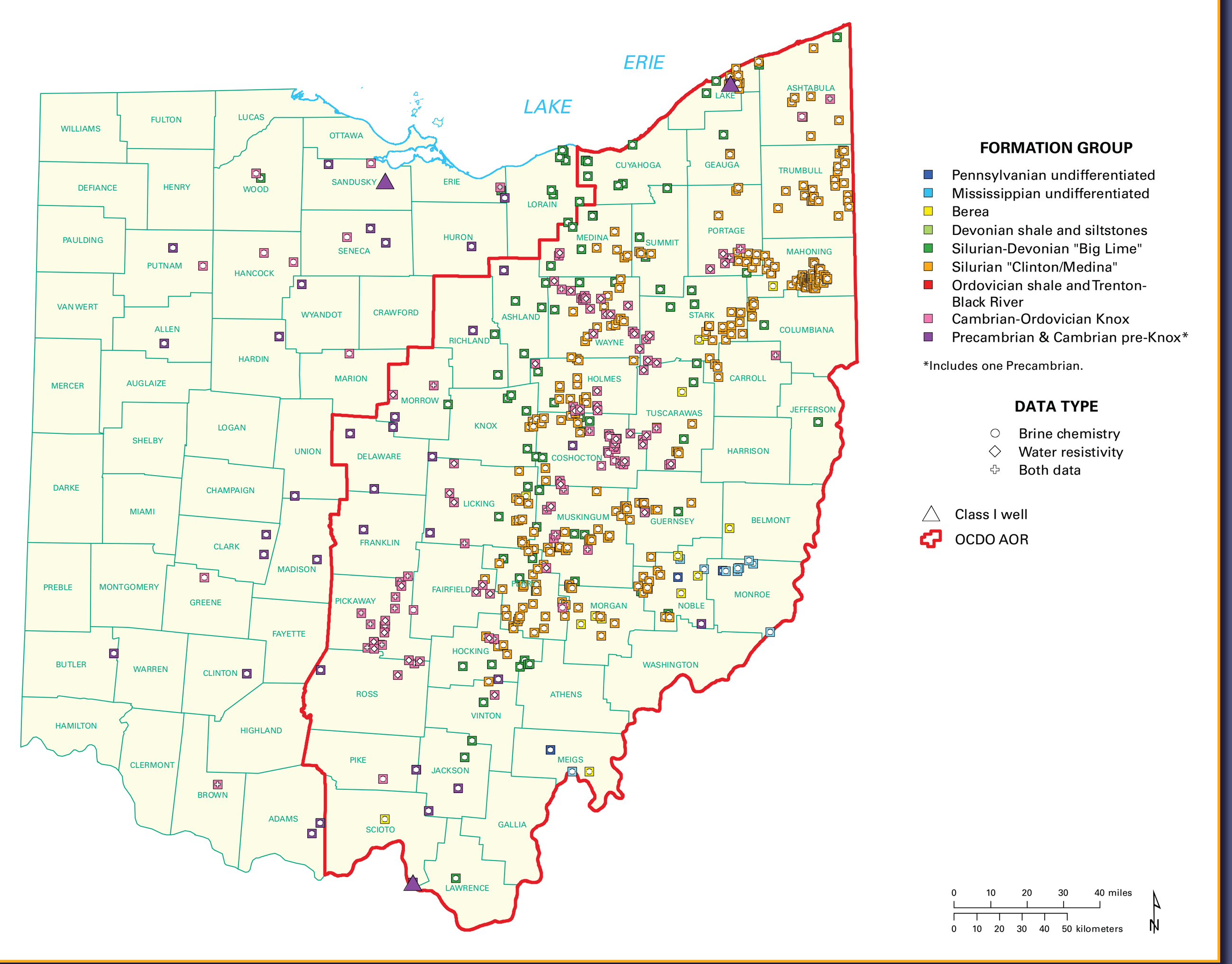
Map showing available rock cuttings sample sets, composite. See table at left for a listing of the formation(s) for each OCDO group. The Survey's well cuttings collection consists of samples obtained from the drilling of 5,066 wells. Also, duplicate sets of cuttings from over 1,200 wells provide additional material for examination, sampling, and geochemical analysis.

BRINE DISPOSAL WELL INJECTION RATES



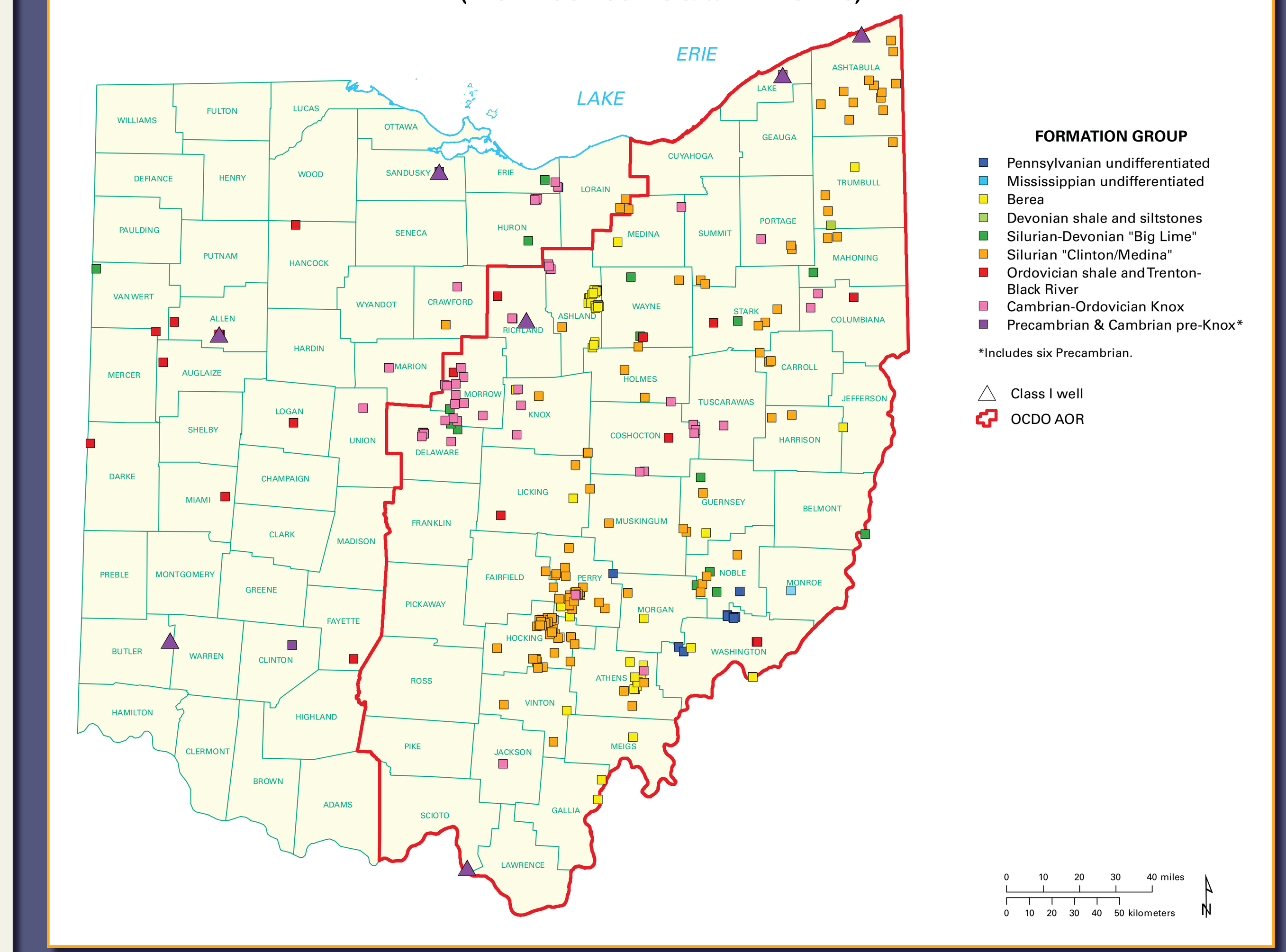
Map showing brine disposal rates, composite. See table at left for a listing of the formation(s) for each OCDO group. Injection rates were calculated based on recorded total volume in barrels of injected brine divided by the total number of injection days. Injection data gathered and managed in RBDMS database.

BRINE CHEMICAL COMPOSITION DATA



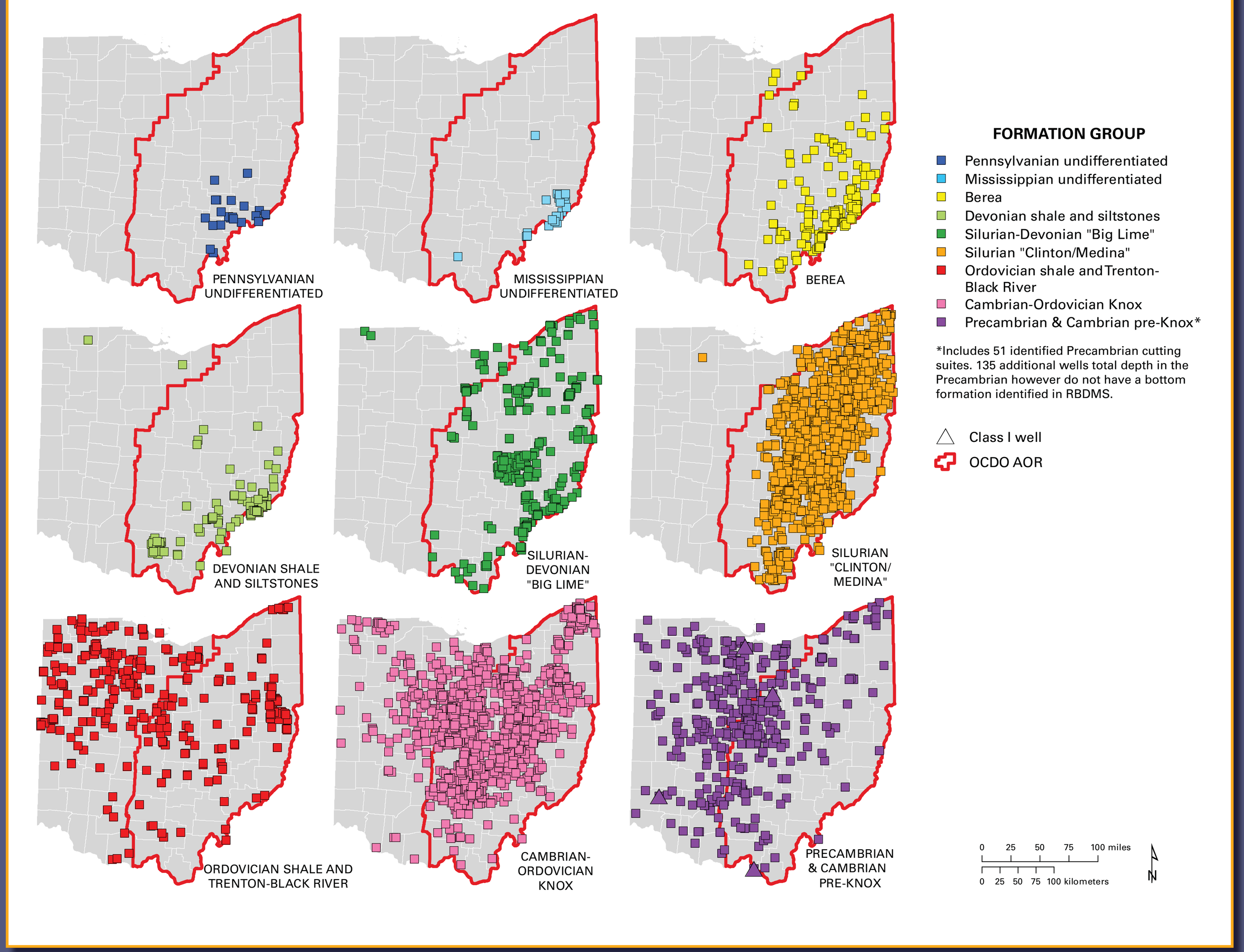
Map showing available brine chemical composition data, composite. See table at left for a listing of the formation(s) for each OCDO group. This data comes from the Ohio Brine database, which consists of 569 formation water analyses.

POROSITY & PERMEABILITY TEST DATA
(FROM ROCK CORES & WELL TESTING)



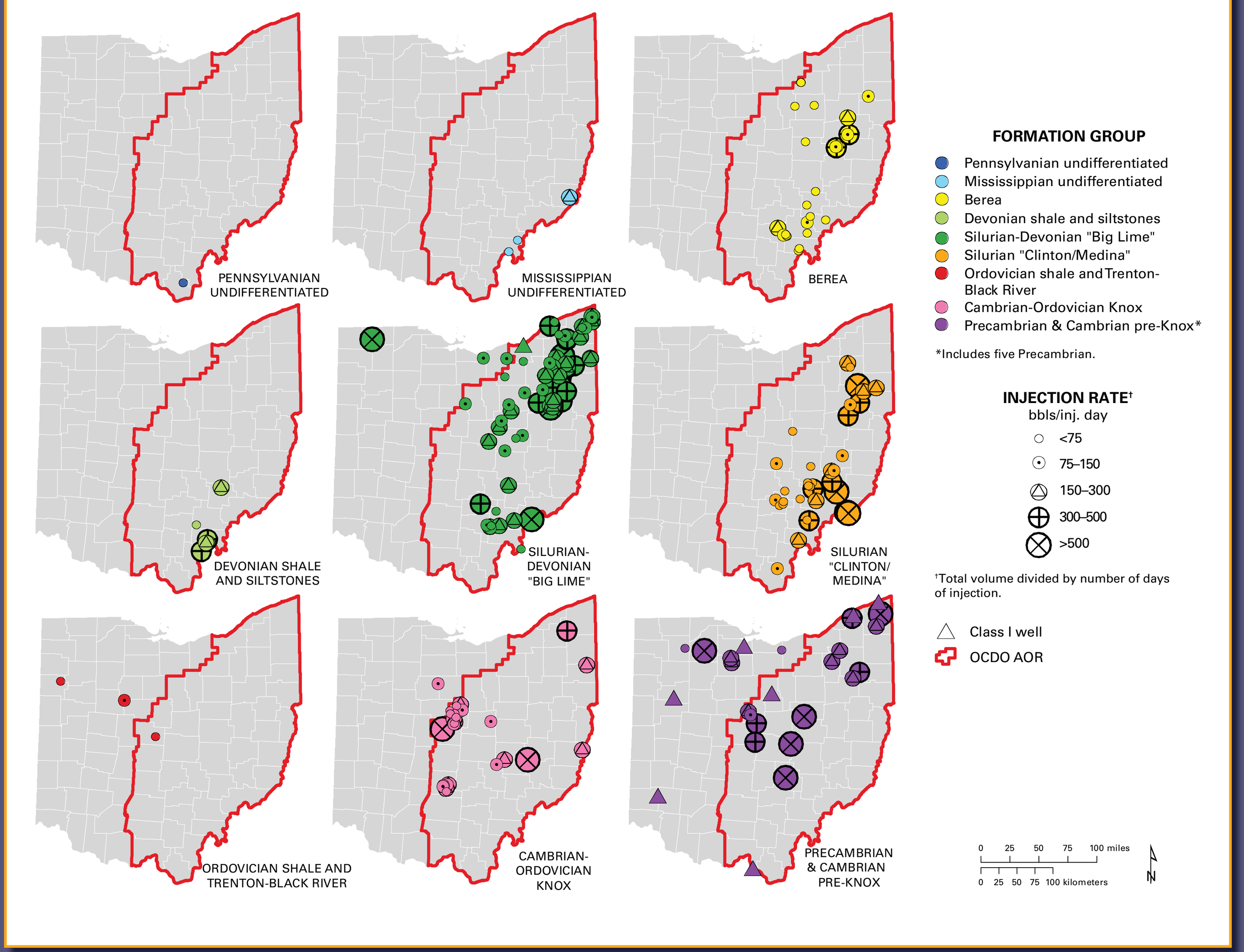
Map showing available porosity and permeability data from rock core and well testing, composite. See table at left for a listing of the formation(s) for each group. Data were compiled by querying the RBDMS database combined with individual well files. The limited data coverage illustrates the need for additional data to be collected.

AVAILABLE ROCK CUTTINGS SAMPLE SETS, PER FORMATION GROUP



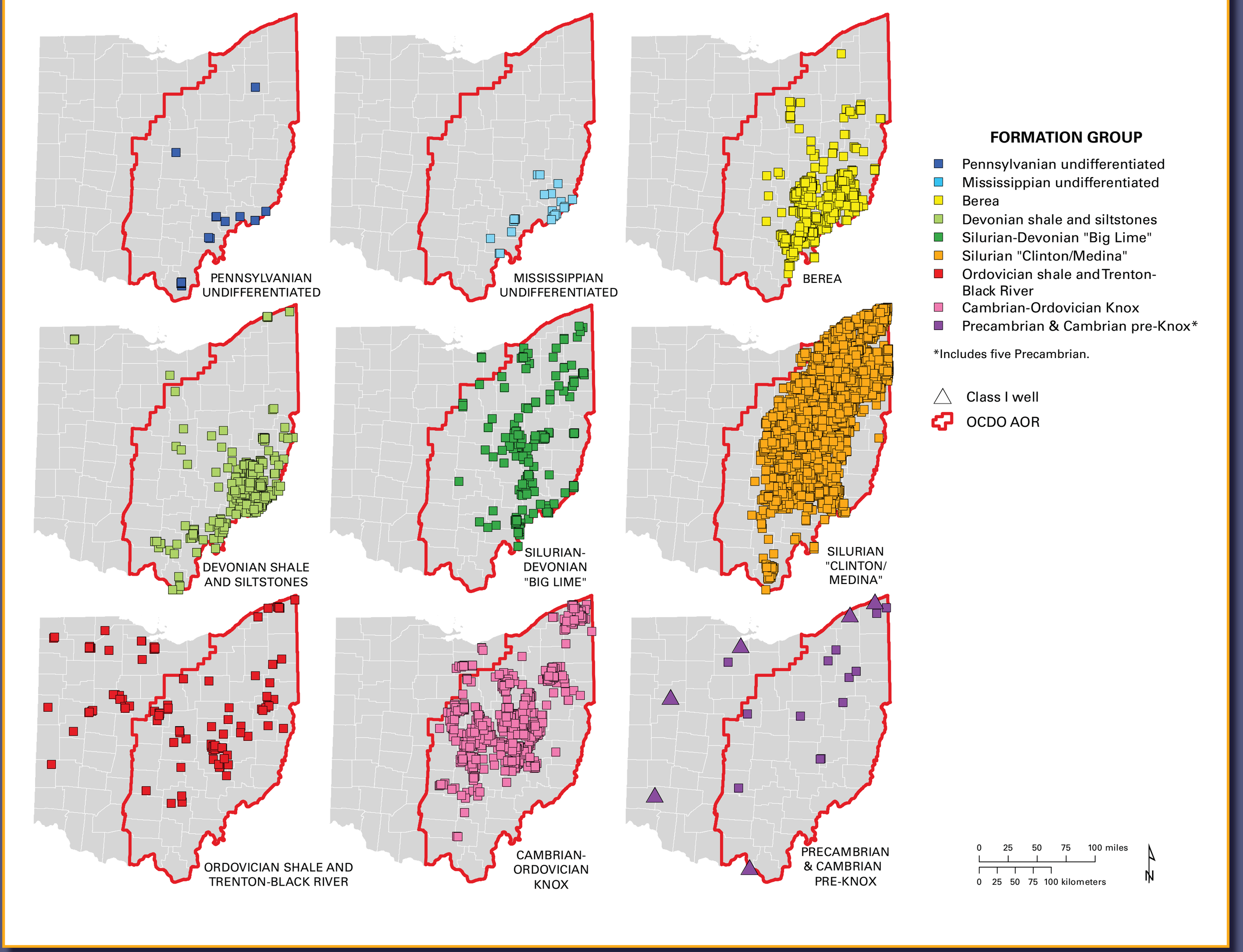
Map showing available rock cuttings sample sets, per formation group. See table at left for a listing of the formation(s) for each OCDO group. The Survey's well cuttings collection consists of samples obtained from the drilling of 5,066 wells. Also, duplicate sets of cuttings from over 1,200 wells provide additional material for examination, sampling, and geochemical analysis.

BRINE DISPOSAL WELL INJECTION RATES, PER FORMATION GROUP



Map showing brine disposal rates, per formation group. See table at left for a listing of the formation(s) for each OCDO group. Injection rates were calculated based on recorded total volume in barrels of injected brine divided by the total number of injection days. Injection data gathered and managed in RBDMS database.

FORMATION PRESSURE DATA



Map showing available formation pressure data, per formation group. See table at left for a listing of the formation(s) for each OCDO group. The pressure database is obtained from well completion reports and is managed by ODNR Division of Oil & Gas Resources Management in the RBDMS database. The dataset includes minimum, maximum, and average pressures of the following data types: bottom hole pressure (BHP), breakdown pressure, treating pressure, instantaneous shut-in pressure (ISIP), and five-minute ISIP.

Reference Cited

Wickstrom, L.H., and 28 others, 2005, Characterization of geologic sequestration opportunities in the MRCSP region: Ohio Department of Natural Resources, Division of Geological Survey report prepared for DOE cooperative agreement No. DE-PS26-05NT42255, 152 p., 1 appendix.