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The Business of Innovation



*Field Tests of Geologic Sequestration in
Midwestern Regional Carbon Sequestration
Partnership – Validating Sequestration
Heterogeneity in a Diverse Geologic Setting*

**Presented by – Neeraj Gupta
Battelle, Columbus, Ohio**

Presentation #174

5th Annual Conference on Carbon Capture and Sequestration

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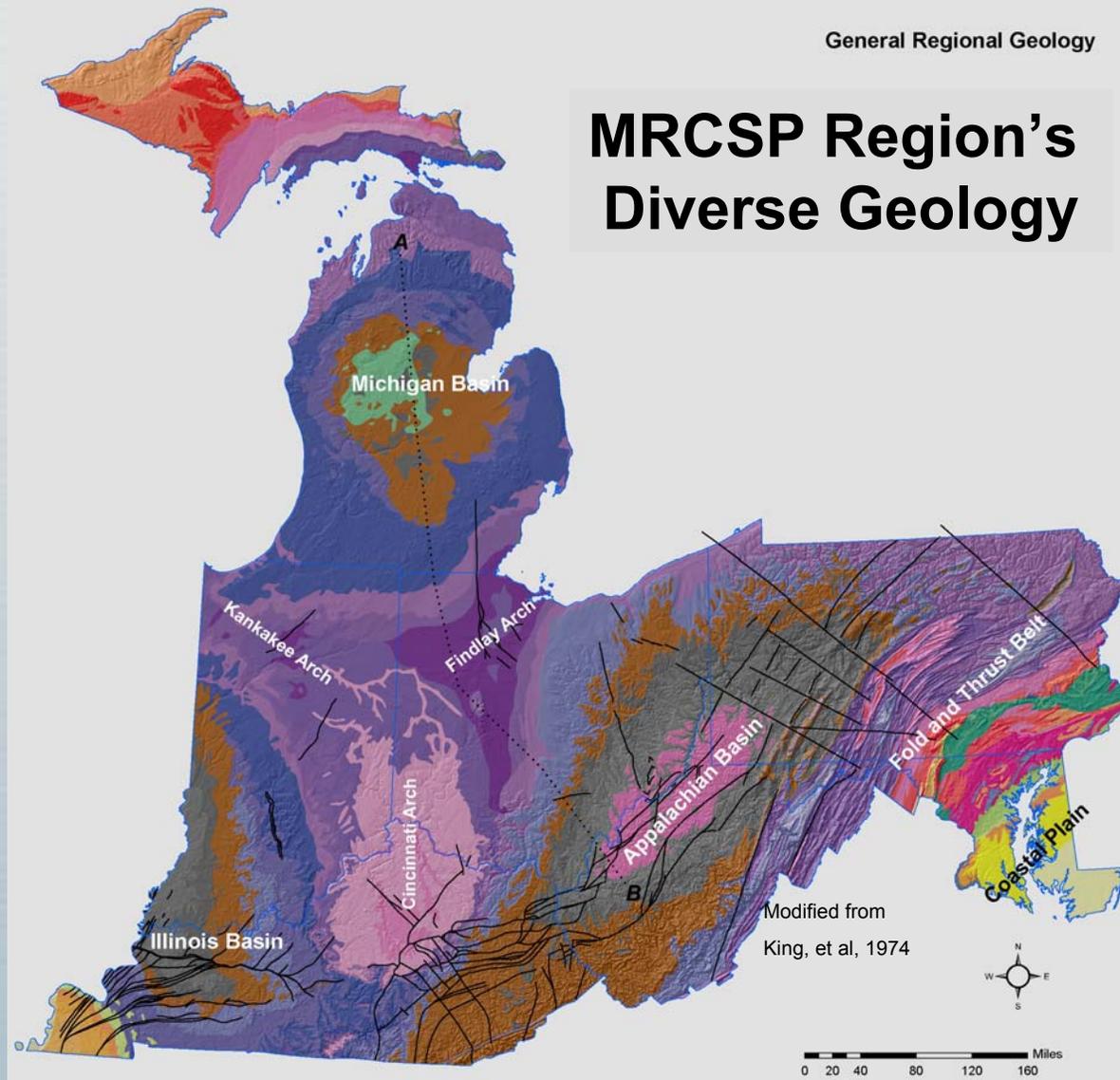
Our partner team is a strategic asset as well as a source of funding



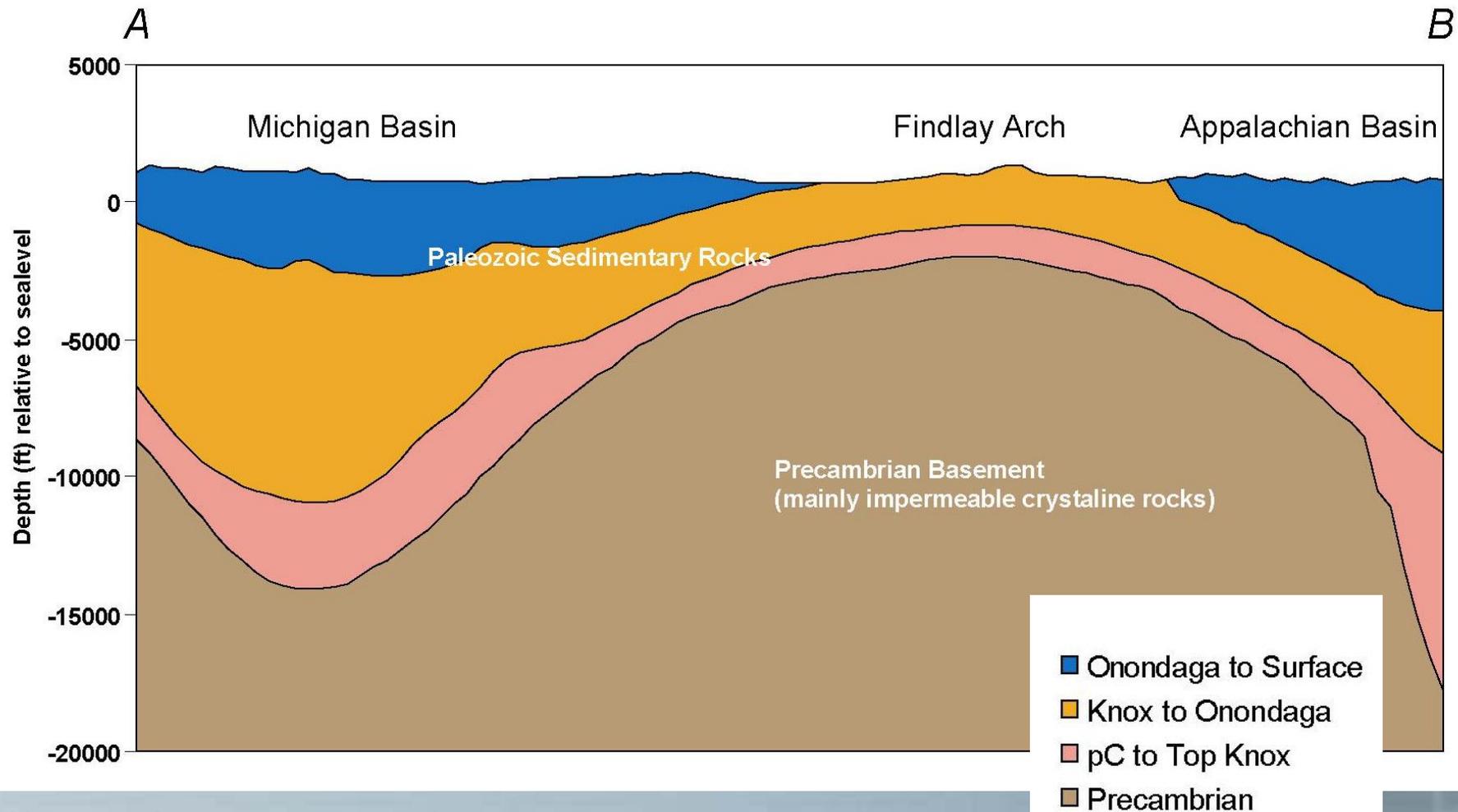
This Presentation is Based on Contributions from a Number of Researchers

- Battelle – David Ball, Phil Jagucki, Joel Sminchak, Bruce Sass, Jim Dooley, Danielle Meggyesy, Bob Janosy, Diana Bacon, Judith Bradbury, Jerry Tompkins, Vic Saylor, and others
- Ohio Geological Survey - Larry Wickstrom, Mark Baranoski, and others
- Indiana Geological Survey - John Rupp, Wilfred-Solano
- Kentucky Geological Survey - Steve Greb, Jim Drahovzal
- Maryland Geological Survey - Jerry Baum
- Pennsylvania Geological Survey - John Harper, Kris Carter
- West Virginia Geological Survey - Lee Avary
- Western Michigan University - Bill Harrison, Dave Barnes
- Project Hosts – FirstEnergy, DTE, Duke Energy
- Other Participants – Schlumberger, Stanford University Geophysics Department, Praxair, AJW Inc., Babcock & Willcox, Consol

Geologic Diversity of MRCSP Region



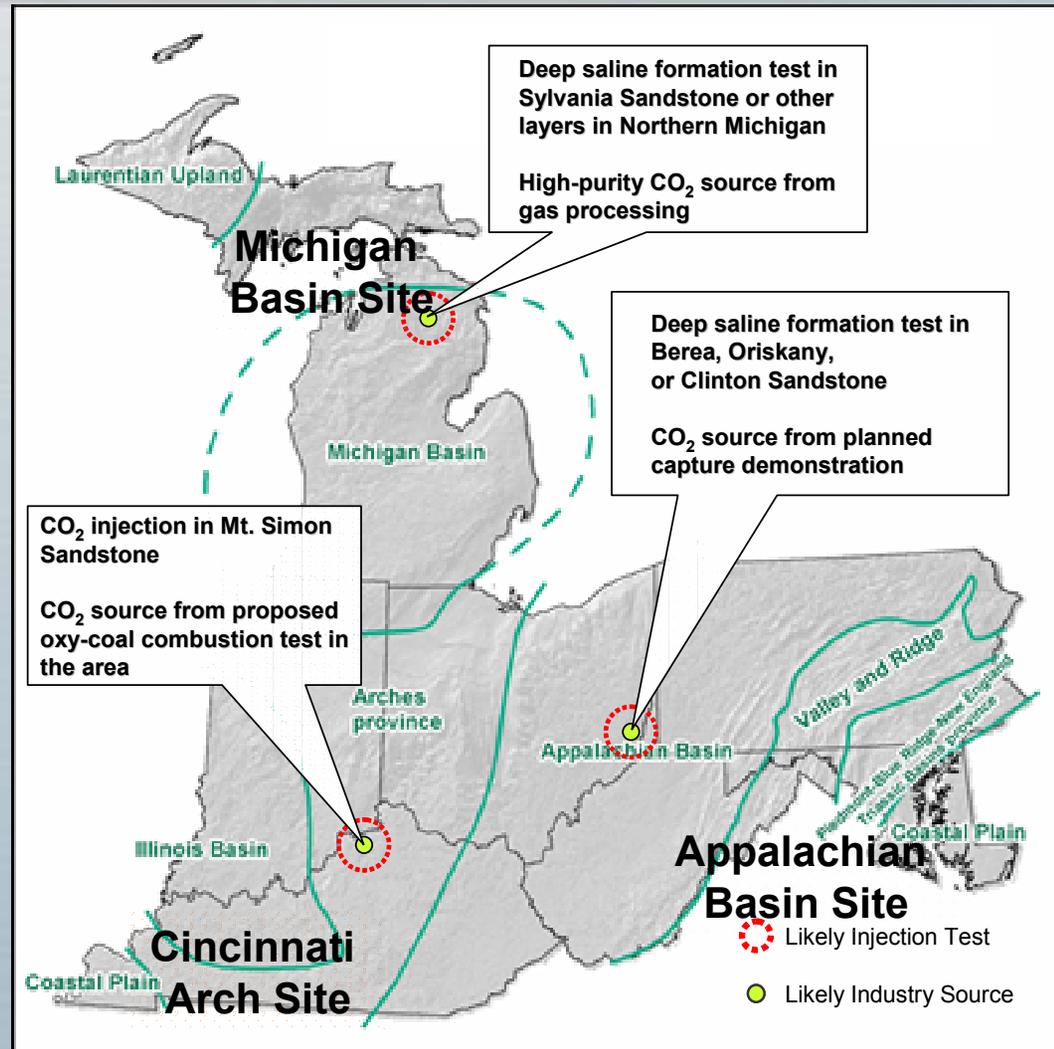
Basins and Arches Region Cross Section



Illustrative cross section

Phase II – Demonstration Site Descriptions

- Three main sites were identified in site selection process.
- Sites were visited during Phase I to ensure physical setting would be suitable for drilling, testing, and other field work.
- Sites are located in major geologic structures in MRCSP region



Site Overview: Appalachian Basin

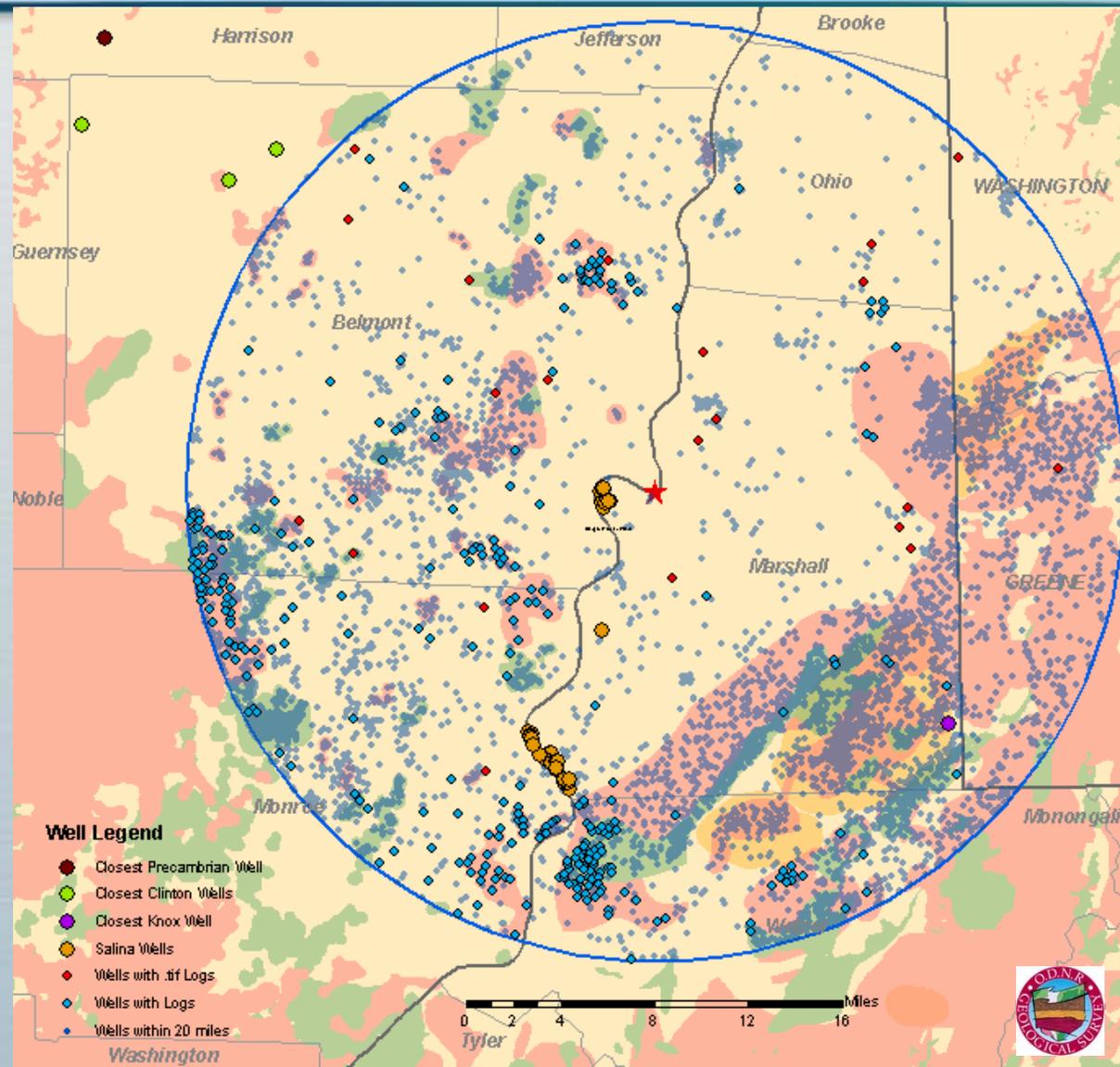
- Injection at or near First Energy's R.E. Burger coal-fired power plant in Eastern Ohio
- CO₂ from planned extension of PowerSpan's process for CO₂ capture, gas processing plants, or commercial sources
- Multiple but probably thin saline formations present in the area. EOR and ECBM are also possible
- Ohio has Primacy for permitting of injection wells.
- Seismic monitoring may be difficult in deeper layers but possible in shallow formations

Site Overview: Appalachian Basin

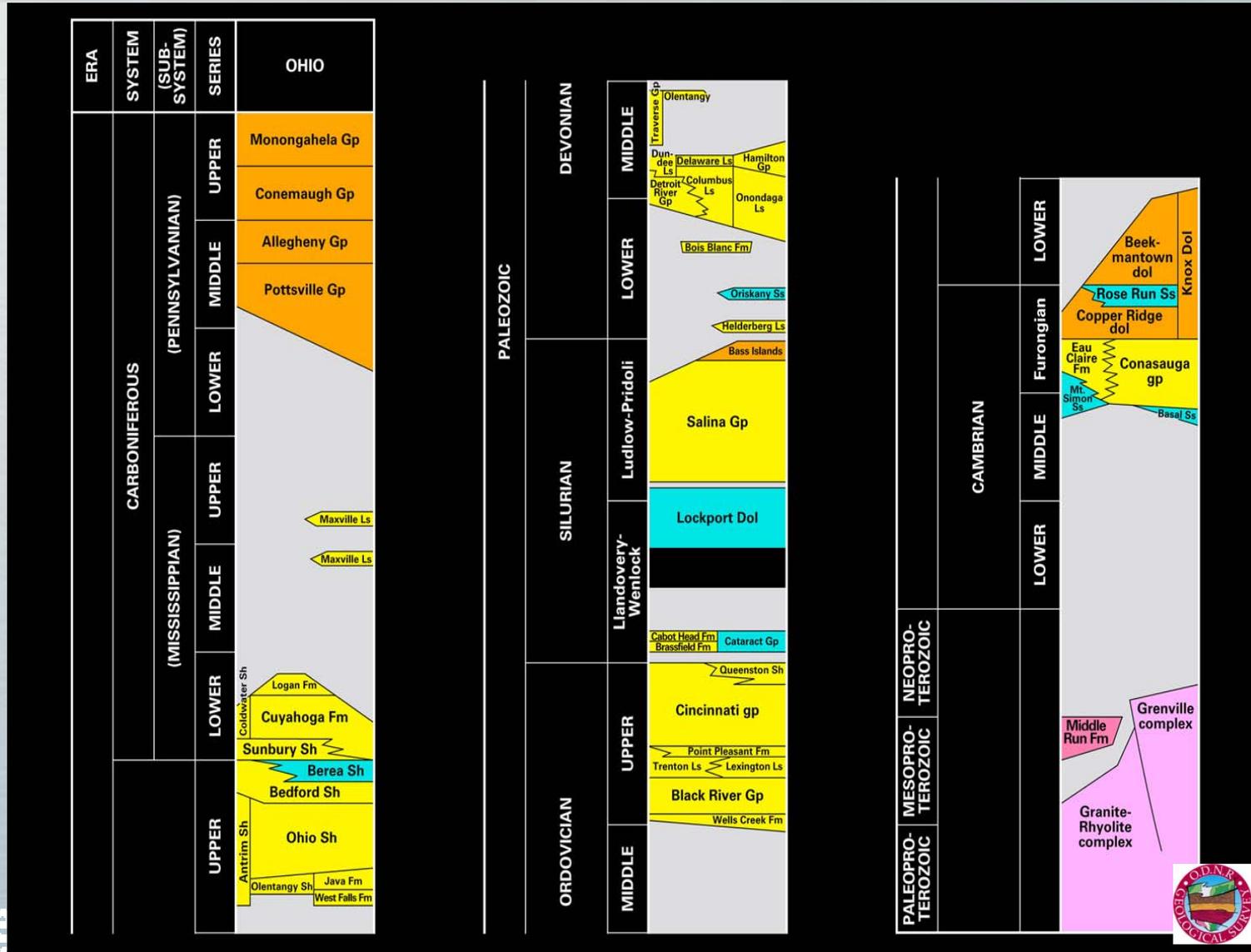
- R.E. Burger Power Plant and PowerSpan's Demonstration Unit



Appalachian Basin Site- Preliminary Geologic Assessment



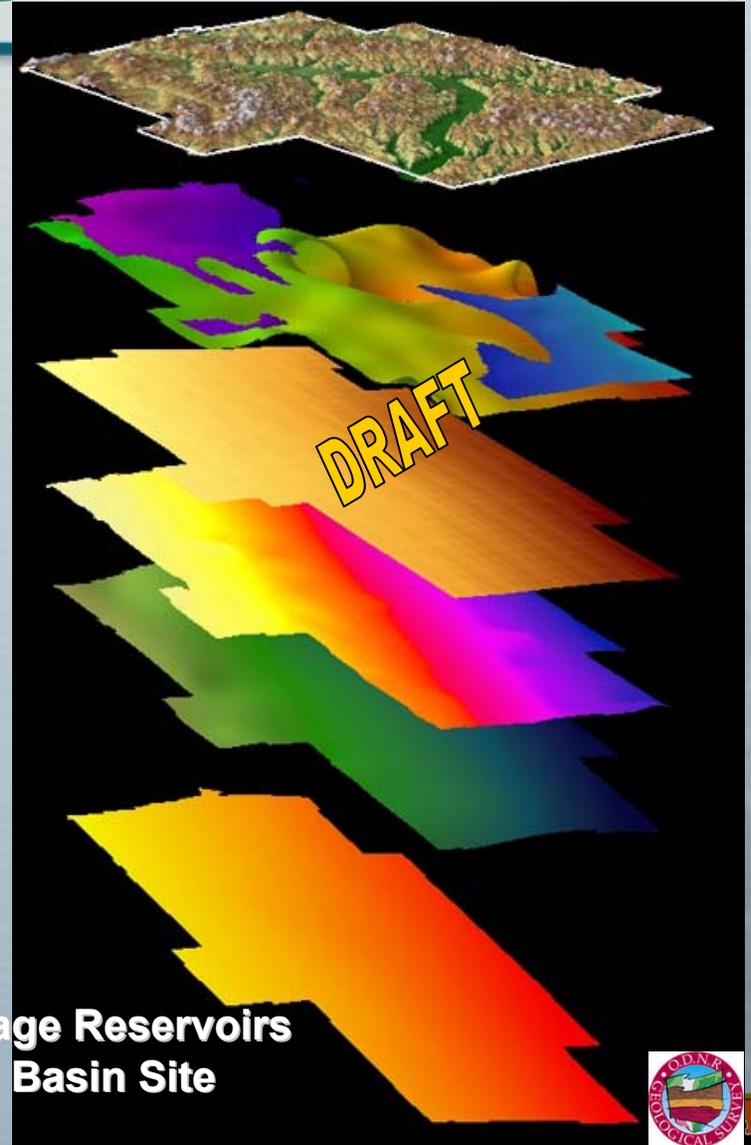
Appalachian Basin Site- Preliminary Geologic Assessment



Appalachian Basin Site- Preliminary Geologic Assessment

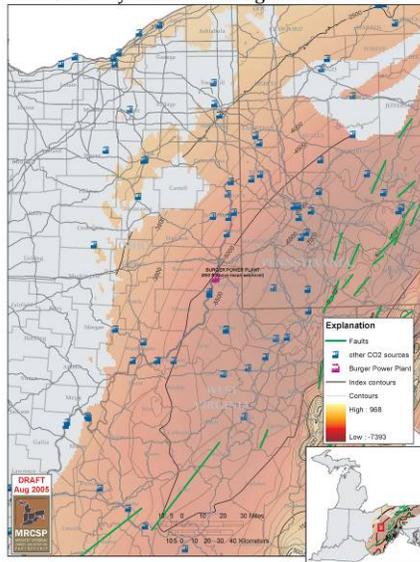
- Detailed Geologic Site Assessment nearing completion for site. Multiple storage targets have been identified.
- Total sedimentary rock thickness in the area exceeds 12,000 ft.
- Well drilling and characterization efforts will likely focus on the upper 8,000 ft where several CO₂ storage targets exist.
- Held a preliminary meeting to brief the Ohio regulatory personnel about the project

Potential CO₂ Storage Reservoirs
at Appalachian Basin Site

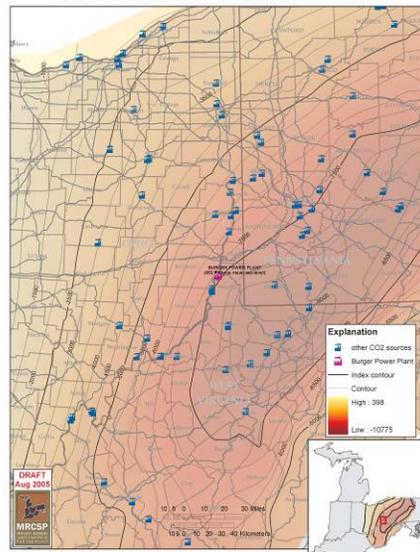


Appalachian Basin Site- Preliminary Geologic Assessment

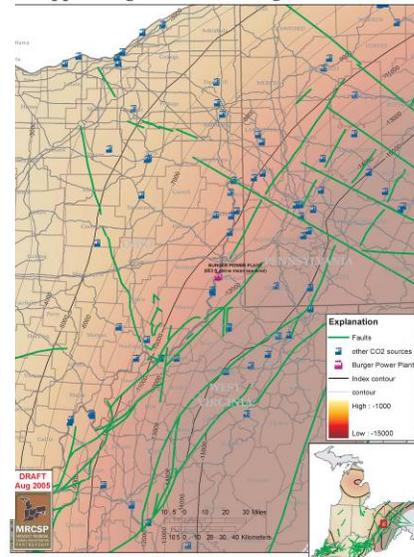
Oriskany Structure - Burger Power Plant



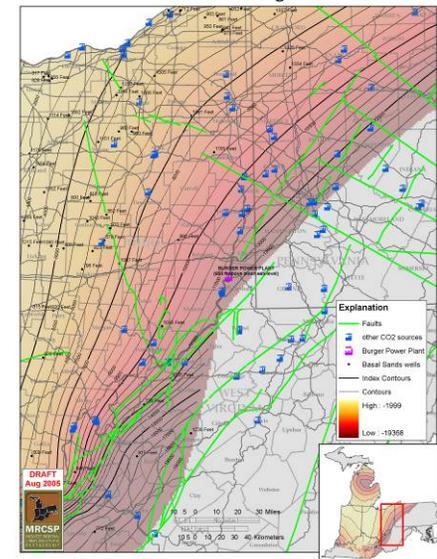
Medina Structure - Burger Power Plant



Copper Ridge Structure - Burger Power Plant



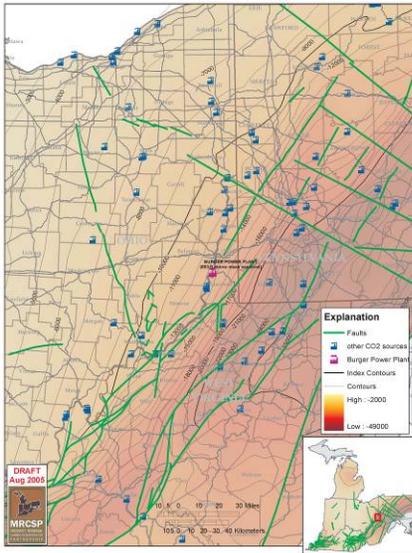
Basal Sands Structure - Burger Power Plant



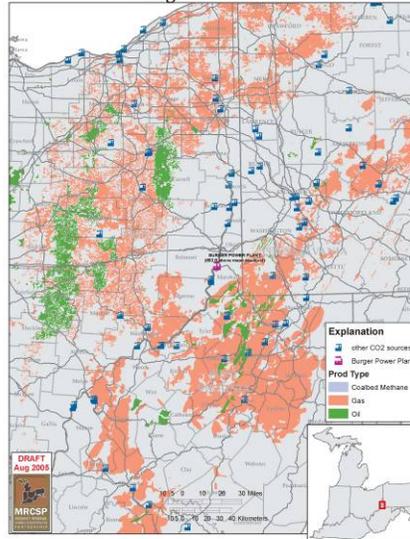
- Use of Phase 1 maps for preliminary site assessment and to guide the site characterization efforts and MMV

Appalachian Basin Site- Preliminary Geologic Assessment

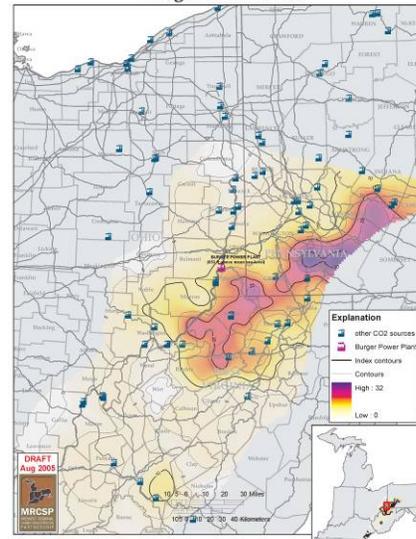
Pre Cambrian Structure - Burger Power Plant



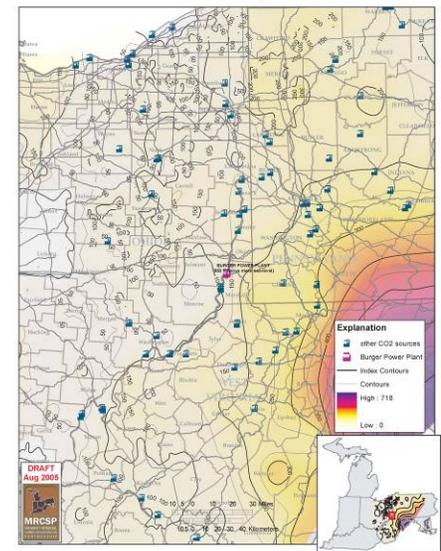
Oil and Gas Fields Greater than 2500 ft Deep
Burger Power Plant



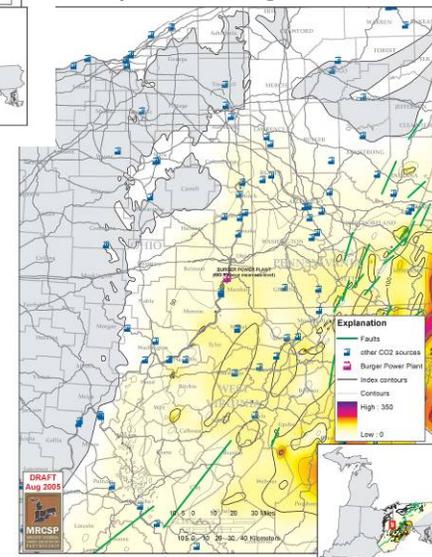
Total Coal Thickness - Greater than 500 ft Deep
Burger Power Plant



Medina Thickness - Burger Power Plant



Jriskyany 1 thickness - burger power plant

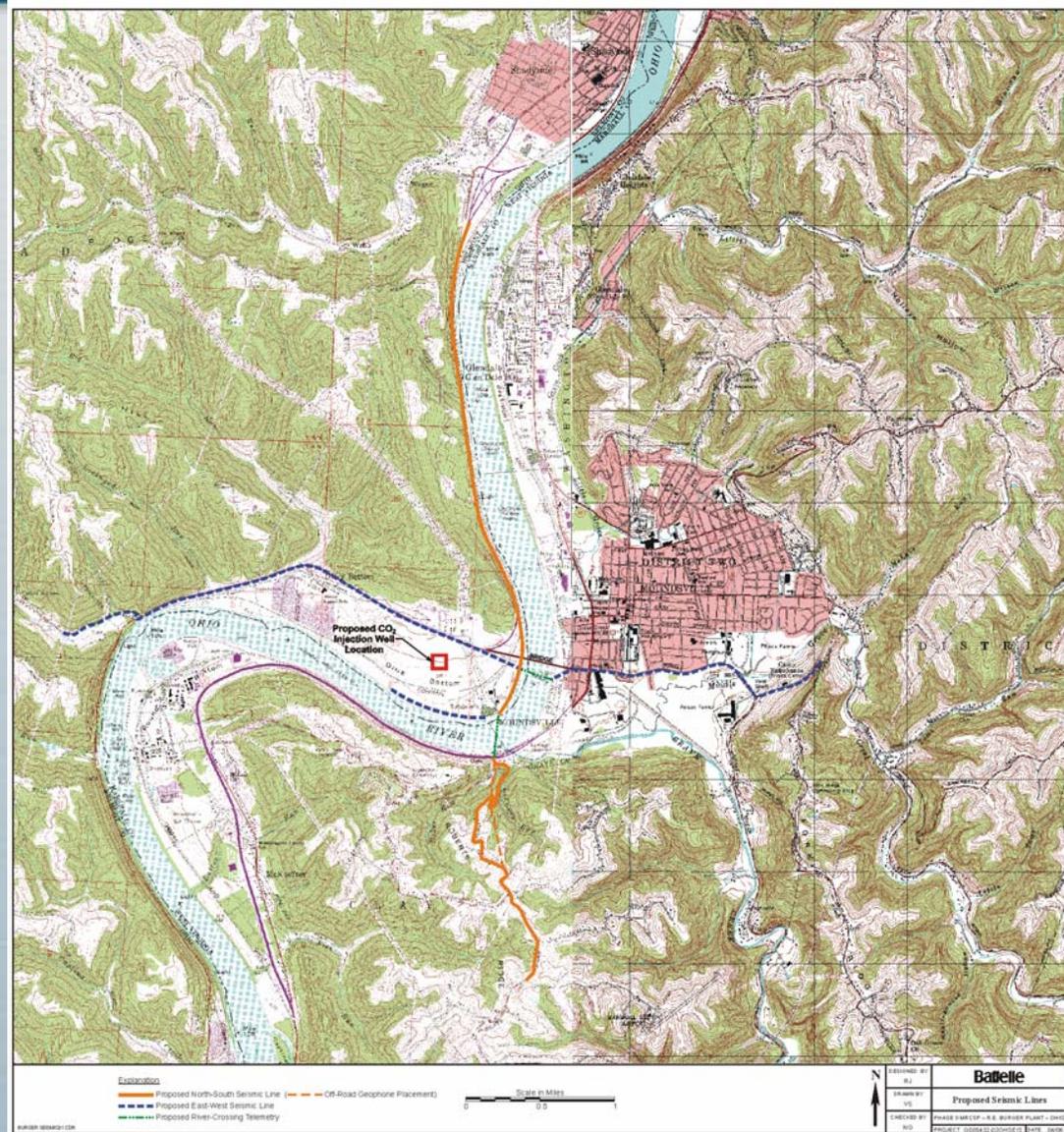


- Geologic structure, isopach maps, oil/gas, and deep coal seams

Appalachian Basin Site- Site Characterization Plans

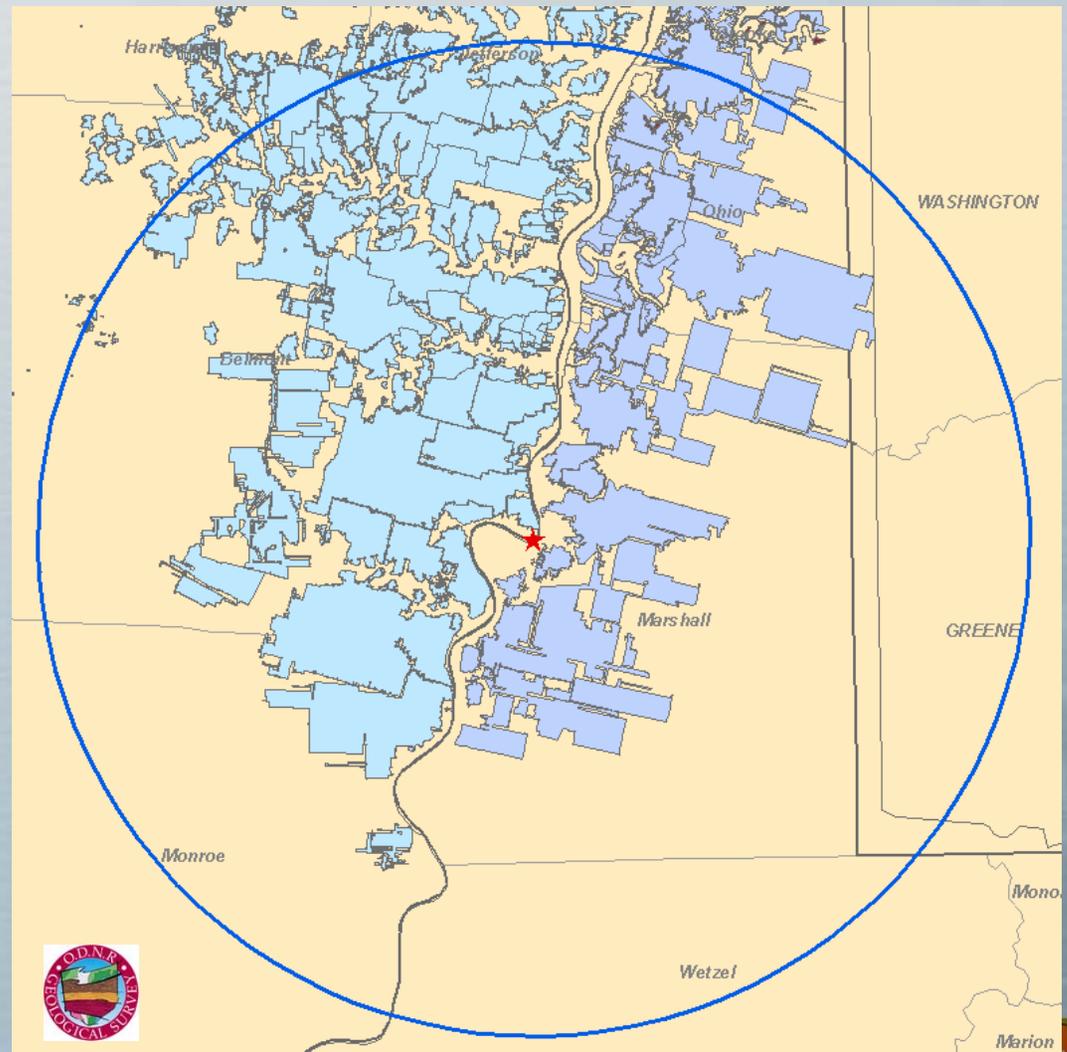
- Proposed Seismic Line Locations have been determined.

A series on “quasi-3D” seismic lines are also planned on site.



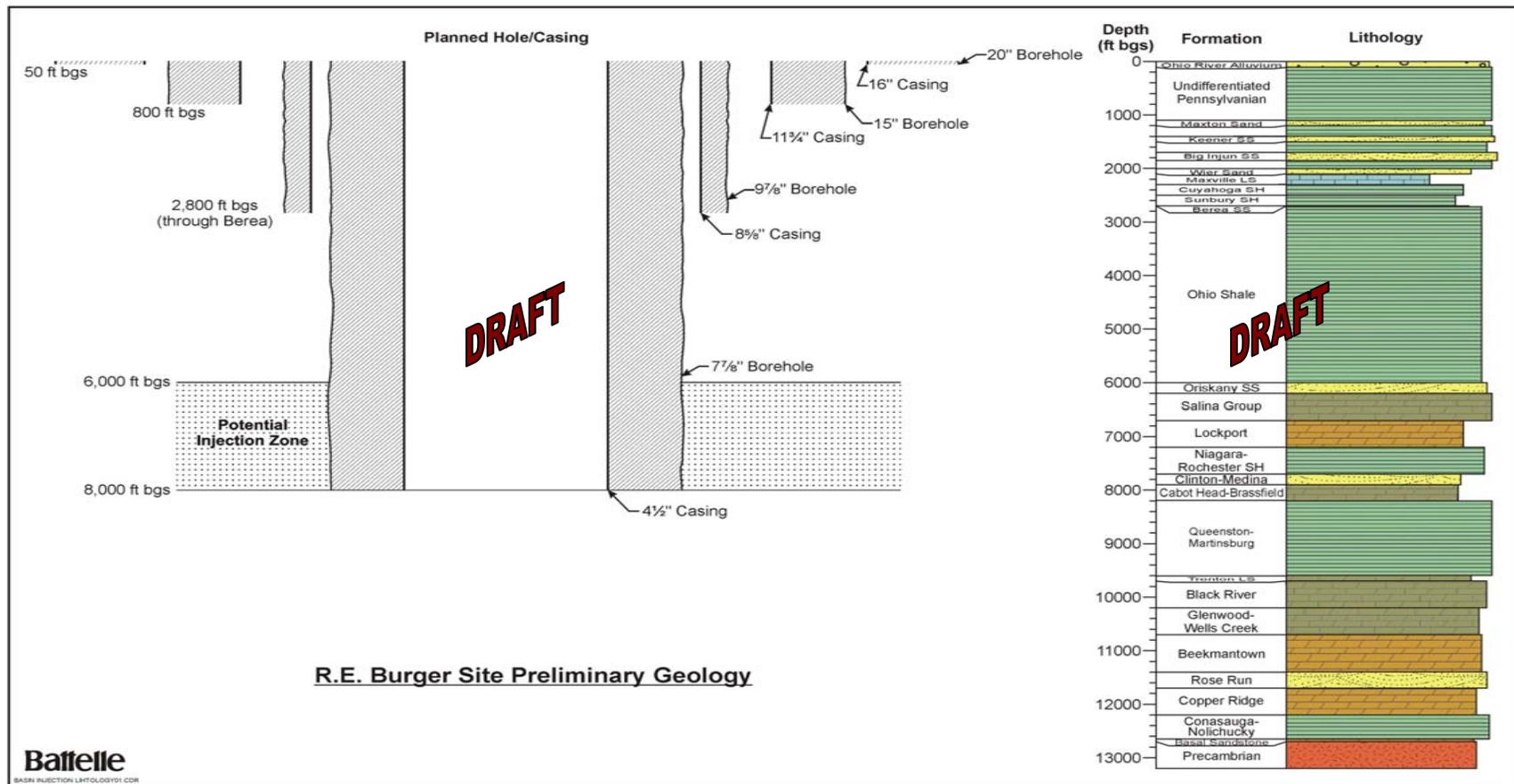
Appalachian Basin Site- Preliminary Geologic Assessment

- Extensive mining in area in both Ohio and West Virginia.
- Mines may present challenges to seismic survey and well drilling.



Appalachian Basin Site- Site Characterization Plans

- Well designs are being compiled that fulfill requirements for site characterization, injection tests, and regulatory permits.



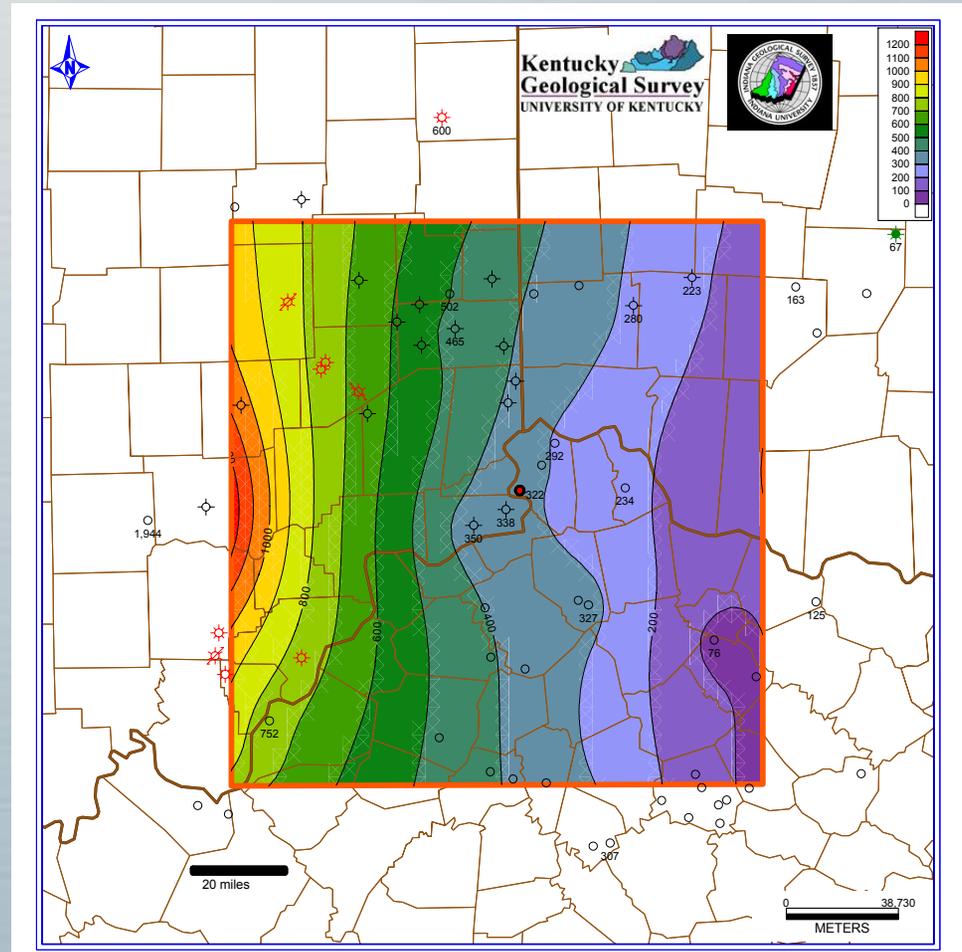
Preliminary Well Design for Appalachian Basin Site

Site Overview: Cincinnati Arch

- Located at or near a Duke Power coal-fired plant between Appalachian and Illinois basins
- CO₂ from a planned oxy-fuel capture test in Cincinnati area or from commercial source
- Mt. Simon sandstone is the primary storage candidate with good thickness and Eau Claire Shale as caprock. Potential for other zones below Mt. Simon
- Permitting by EPA Region 4 in Kentucky, Region 5 in Indiana, and Primacy for Ohio
- Mt. Simon should have high injectivity and be conducive to seismic monitoring

Preliminary Geologic Assessment: Cincinnati Arch Site

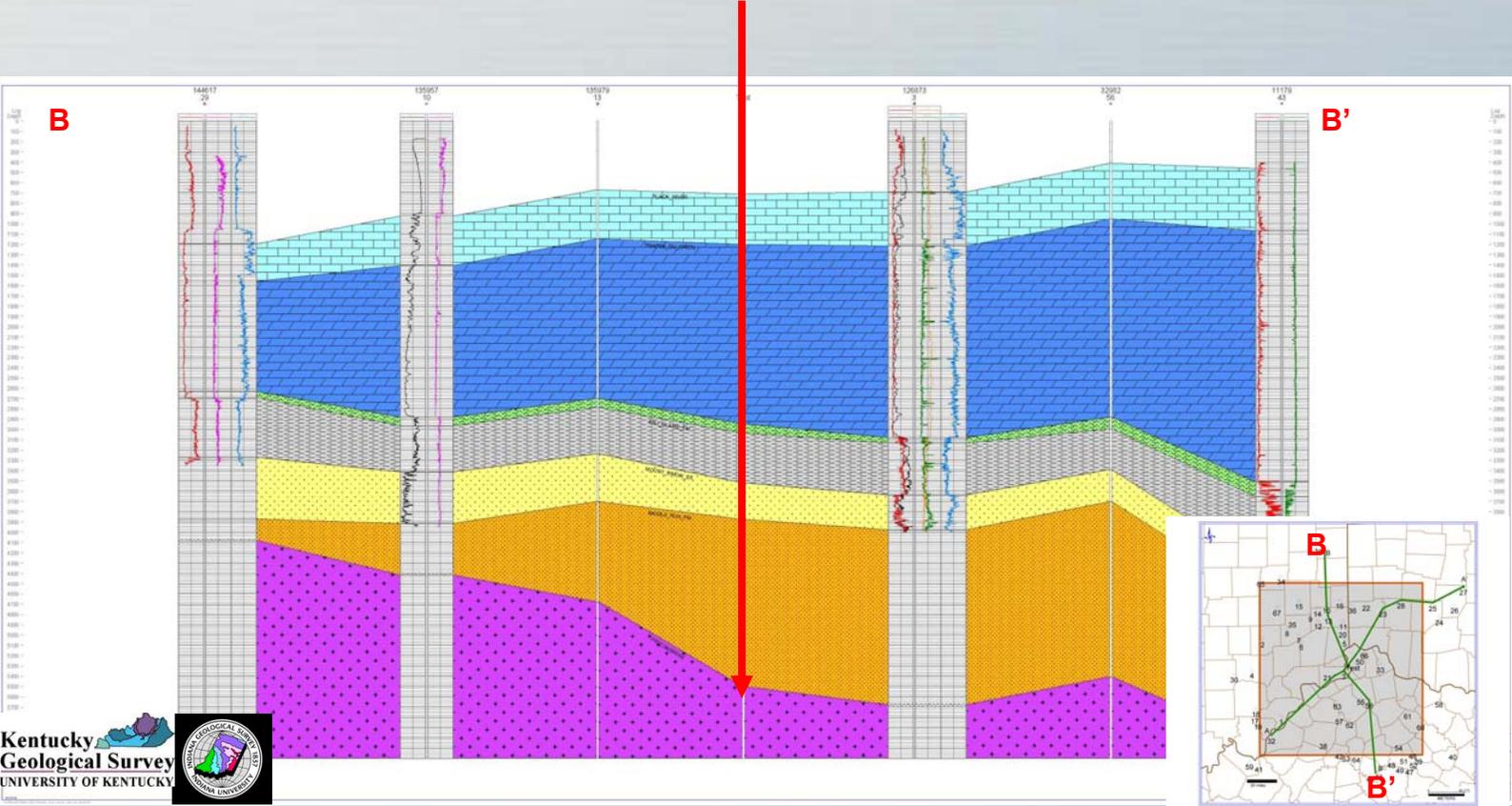
- Preliminary geologic site assessment has been completed for Cincinnati Arch Site.
- Results indicate a thick Mt. Simon /Basal Sandstone formation is the primary storage target at depths of approximately 3200-3500 ft.
- More analysis of site-specific parameters is being performed to support field work and test-well design.
- An initial briefing to regulatory personnel has been completed.



**Thickness Map of Mt. Simon/Basal
Sandstone for Cincinnati Arch Site**

Preliminary Geologic Assessment: Cincinnati Arch Site

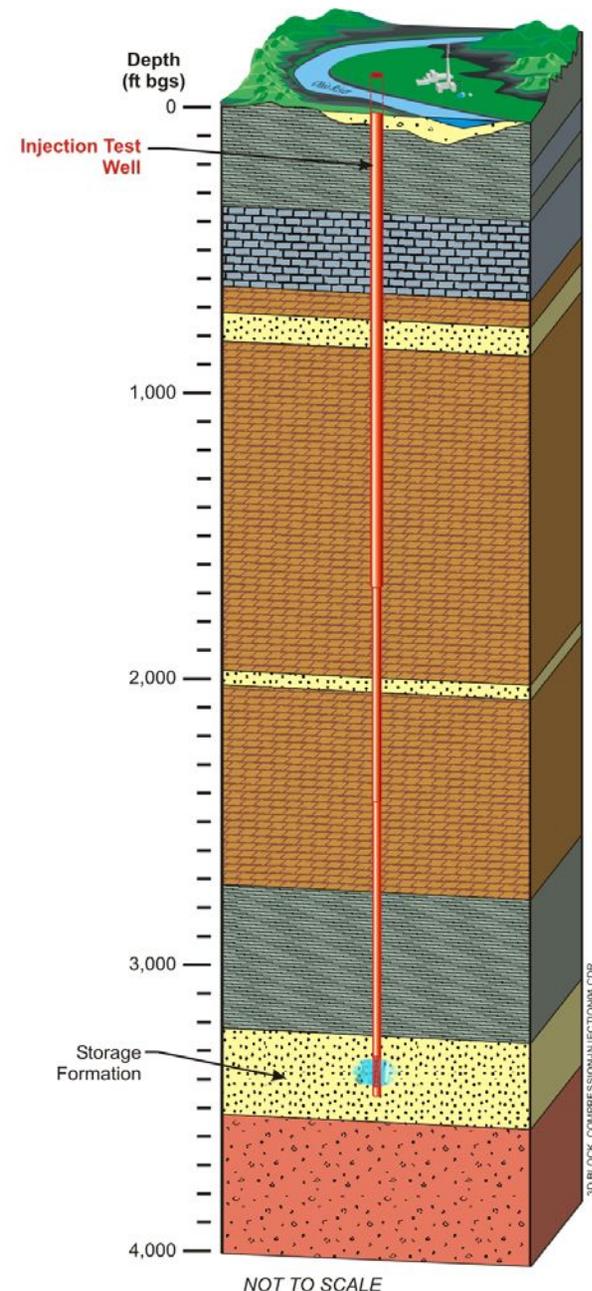
Proposed Well Site



Deep Rock Formations in Cincinnati Arch Area

Site Characterization and System Design: Cincinnati Arch Site

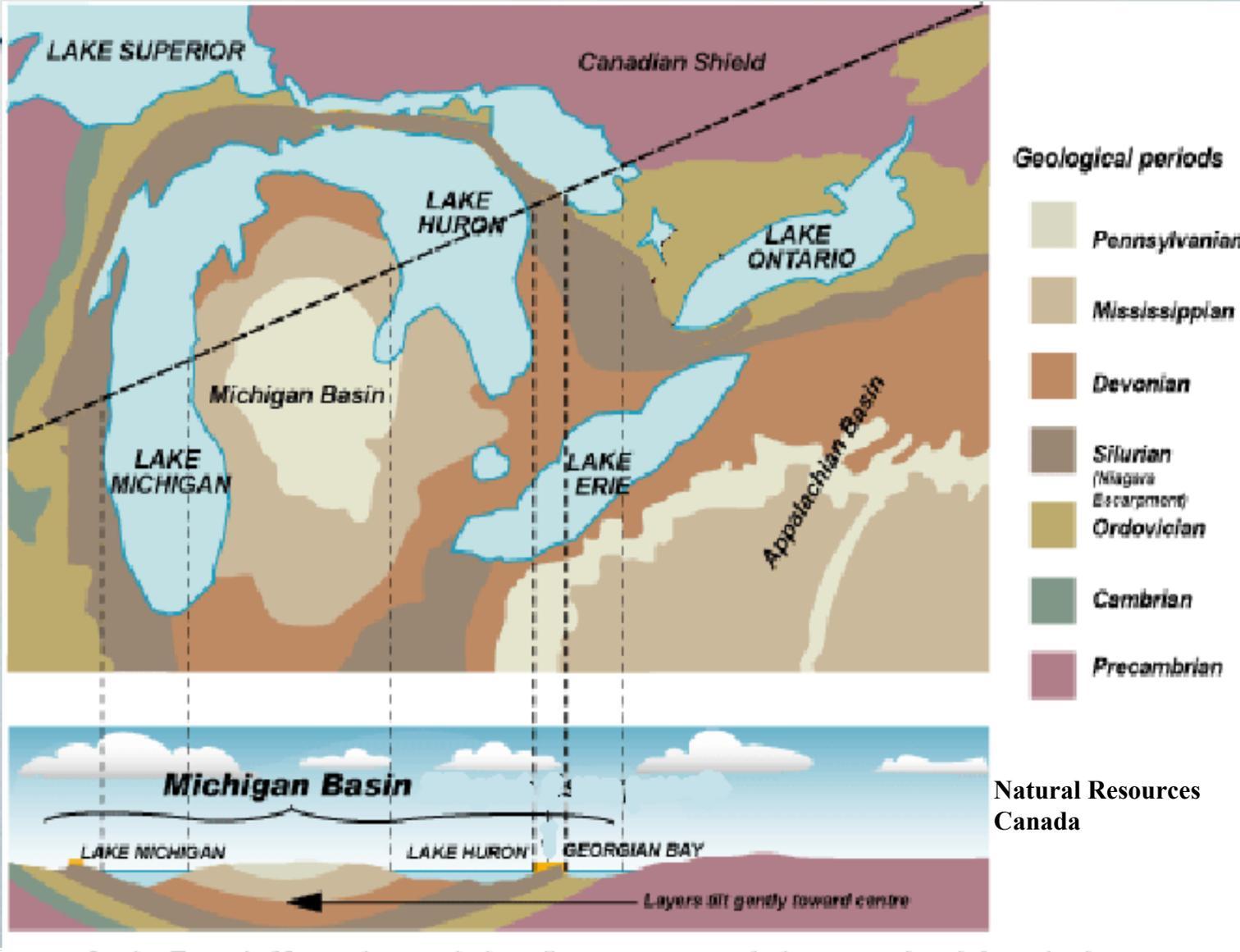
- Seismic survey for site characterization planned for summer, 2006
- Design of injection test system is underway.
- Site characterization results provide information necessary for meaningful testing.



Site Overview: Michigan Basin

- Located at the northern rim of Michigan Basin
- Gas processing plants owned by DTE can provide pure CO₂
- Compression facility and ~8-mile long pipeline for active EOR – possibility of longer-term injection test
- Geology suitable for tests in multiple saline formations (Sylvania Sandstone, Mt. Simon, St. Peter) and/or EOR (Niagaran Reefs) if desired.
- Available geologic data from existing wells
- Potential for 4-D seismic or cross-well monitoring
- EPA Region 5 permitting for all classes of wells in Michigan

Preliminary Geologic Assessment: Michigan Basin Site



Site Selection: Michigan Basin



CO₂ Capture, Compression, Pipeline in the Vicinity of Potential Injection Sites



Site Selection: Michigan Basin

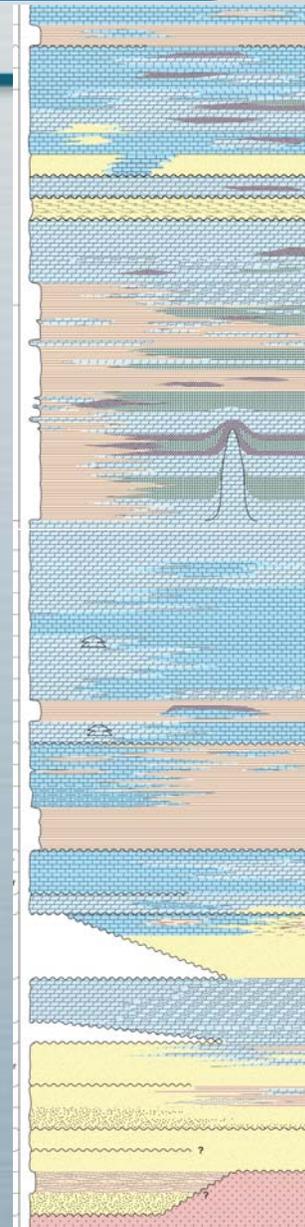


Active CO₂ EOR Flood with several additional wells present



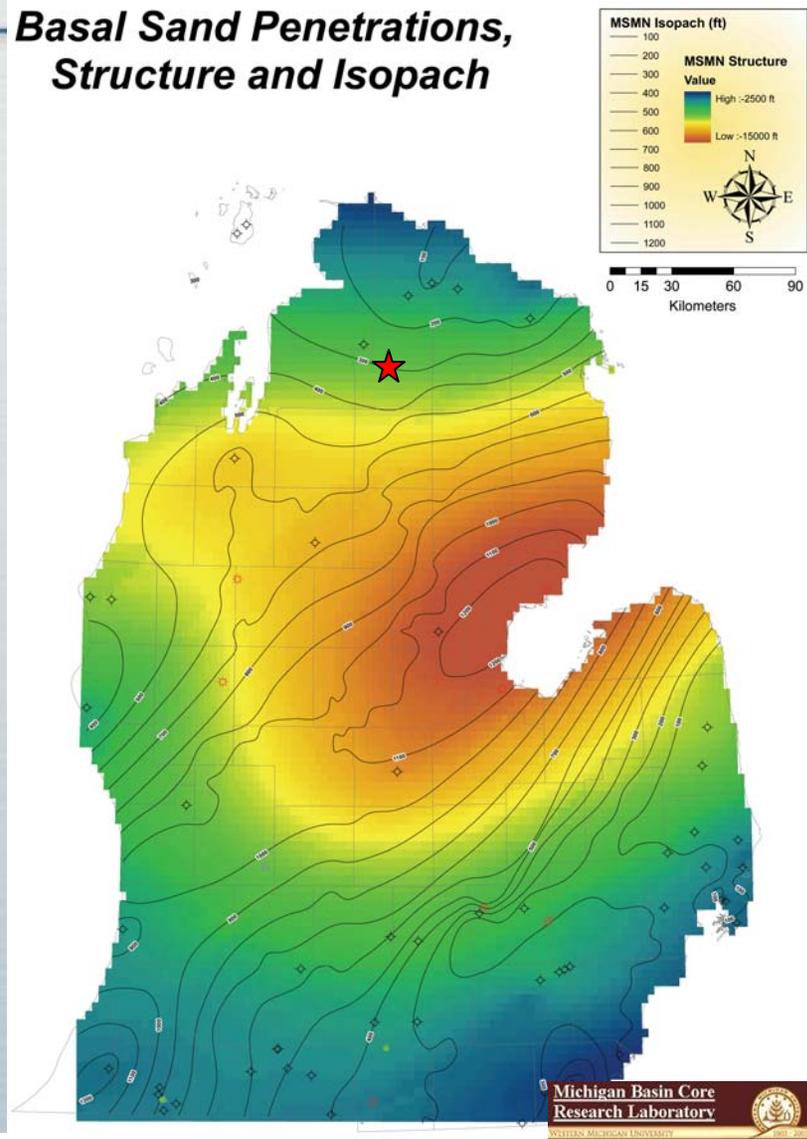
Preliminary Geologic Assessment: Michigan Basin Site

EON	ERA	PERIOD	ROCK UNIT
PHANEROZOIC	CEMO.	QUATERNARY	Glacial drift
		TERTIARY	
	MESO.	CRETACEOUS	
		JURASSIC	"Red beds"
		TRIASSIC	
		PERMIAN	
	CARBONIFEROUS	PENN.	Grand River Formation
			Saginaw Formation
		MISS.	Bayport Ls.
			Michigan Fm.
			Marshall Ss.
			Coldwater Sh.
			Sunbury Sh.
			Berea Ss.
			Bedford Sh.
	DEVONIAN	U	Ellsworth Sh.
			Antrim Sh.
			Traverse Fm.
		M	Traverse Ls.
			Bell Sh.
			Rogers City
Dundae Ls.			
SILURIAN	U	Detroit River Group	
		Lucas dol.	
	M	Amherstburg dol.	
		Sylvania Ss.	
		Bois Blanc Fm.	
ORDOVICIAN	L	Bass Islands Group	
	U	Salina Group	
		Niagara Group	
		Burnt Bluff Gp.	
CAMBRIAN	U	Clinton Fm.	
		Cabot Head Shale	
	M	Manitoulin Dol.	
		"Cincinnatian"	
		Utica Shale	
PRECAMBRIAN	U	Trenton Group	
		Black River Group	
	M	Glenwood Fm.	
		Prairie du Chien Gp.	
		Foster Fm.	
		St. Peter-Bruggers Ss.	
		Trempealeau Fm.	
CAMBRIAN	U	Franconia Fm.	
		Galesville Ss.	
	M	Eau Claire Fm.	
		Mt. Simon Ss.	
		Oronto Gp.	
		Jacobsville Ss.	
		Basement	

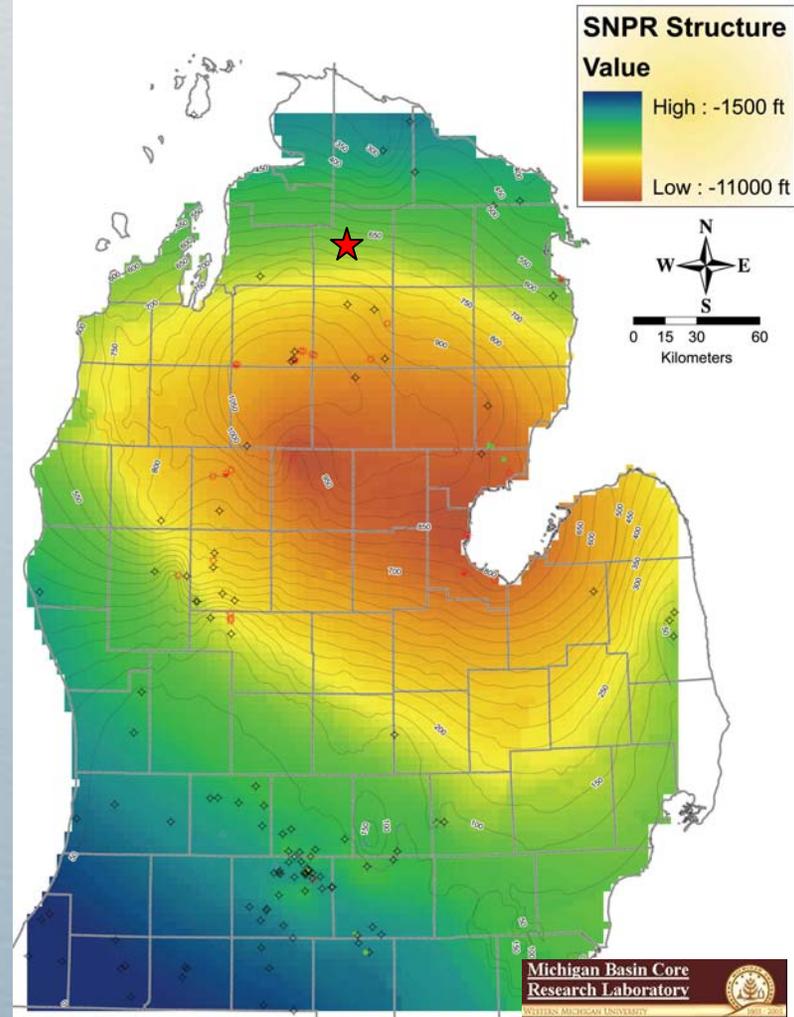


Preliminary Geologic Assessment: Michigan Basin Site

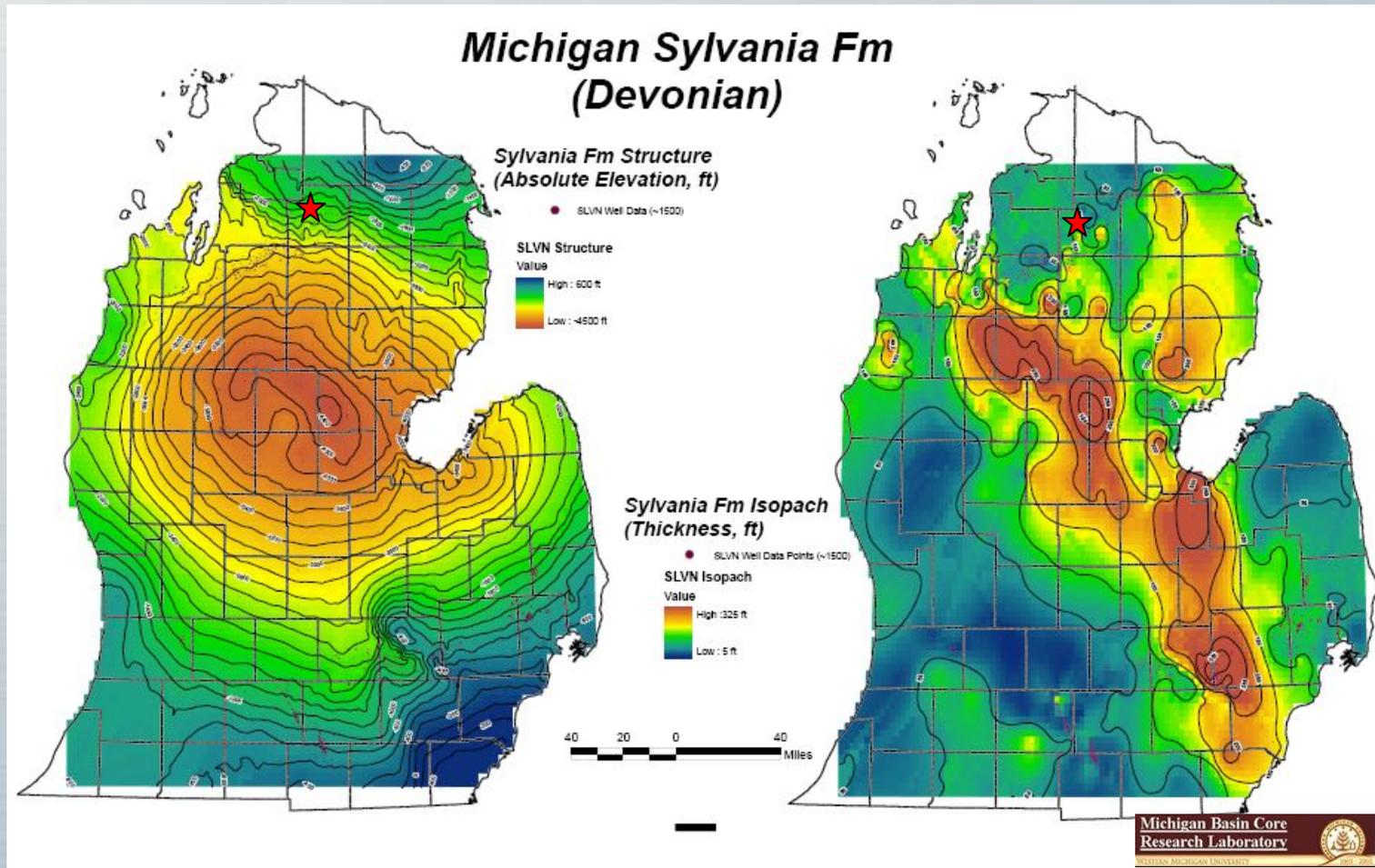
Basal Sand Penetrations, Structure and Isopach



St Peter SST (SNPR) Penetrations Isopach, and Structure (grid)



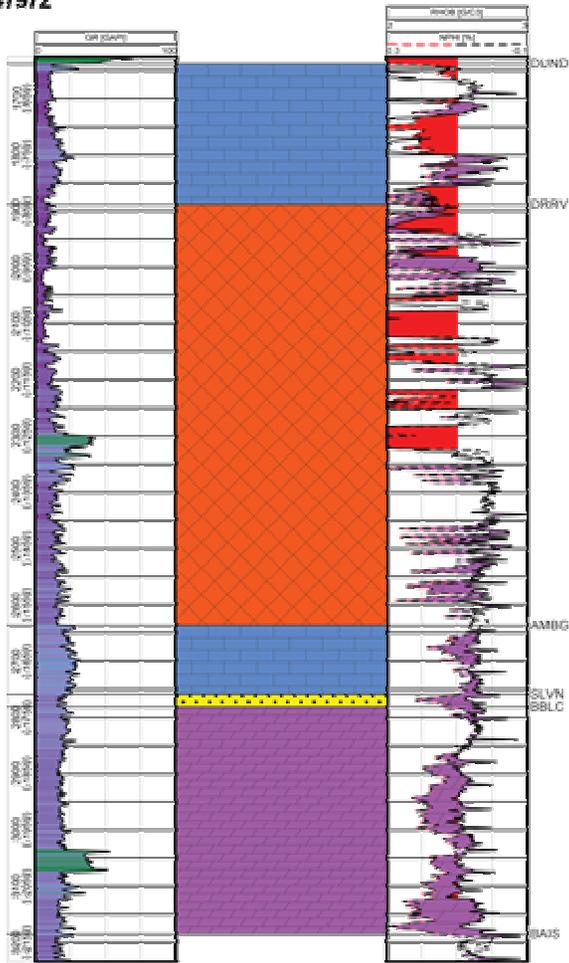
Preliminary Geologic Assessment: Michigan Basin Site



Preliminary Geologic Assessment: Michigan Basin Site

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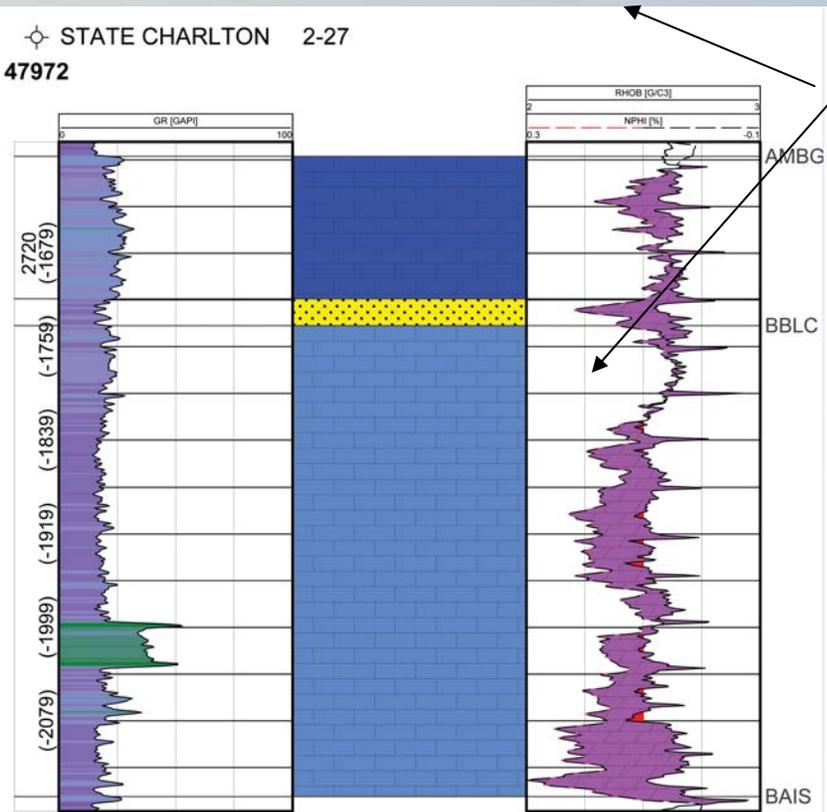


Otsego
T31N R1W S27

•Sylvania Sandstone

STATE CHARLTON 2-27

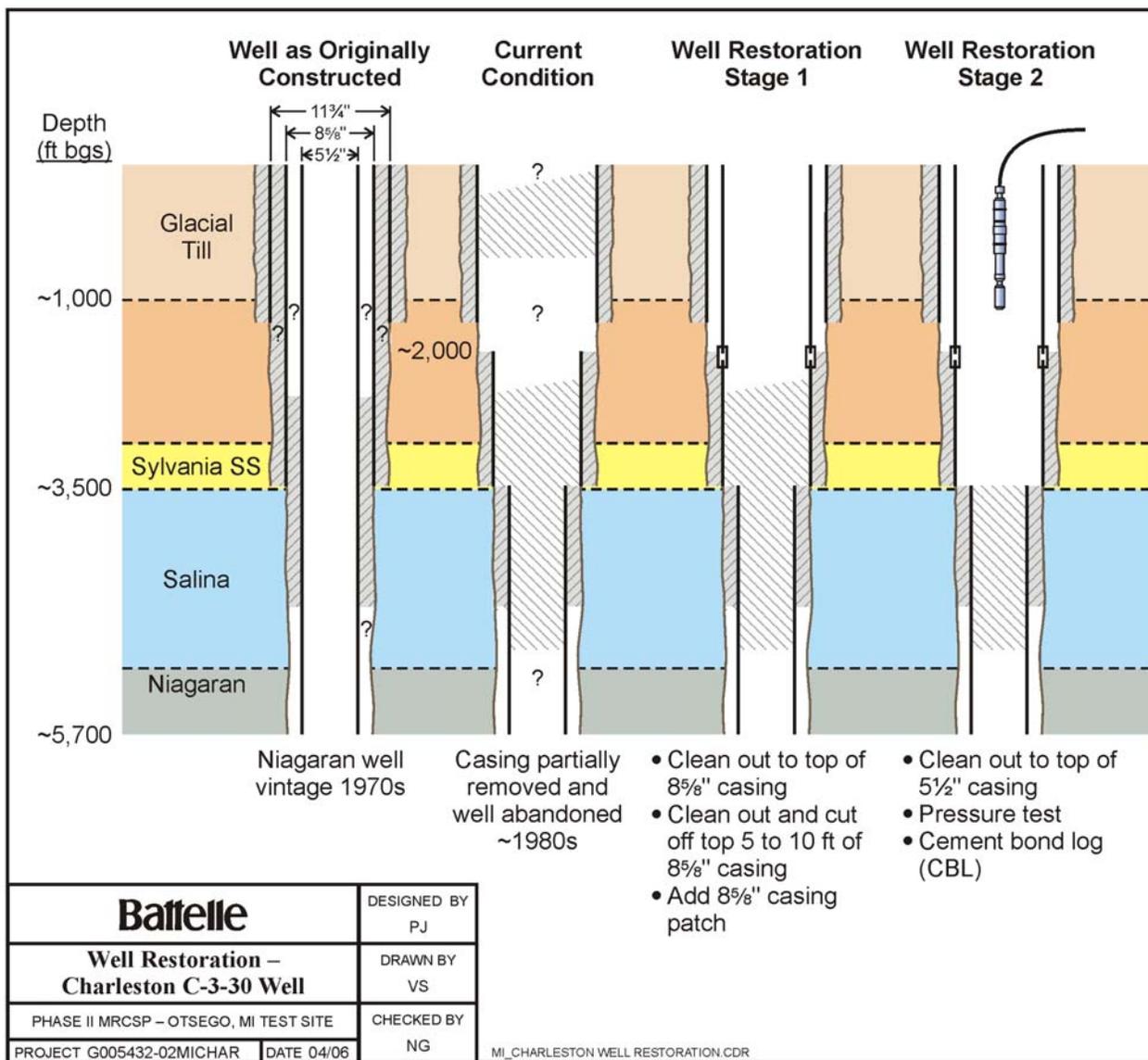
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Michigan Basin Core
Research Laboratory
WESTERN MICHIGAN UNIVERSITY



Site Characterization and Design: Michigan Basin Site



Preliminary Monitoring Possibilities at Project Sites

Category	Method/Description	App. Basin	Cinci. Arch	MI Basin	Weyburn	Frio	Sleipner
Setting	Location	Belmont Co., OH		Otsego Co., MI	Calgary	Texas	N. Sea
	Target Reservoir	Clinton SS	Mt. Simon SS	Sylvania SS	Carbonate	Frio SS	Utsira SS
	Geologic Setting	Appalachian Basin	Cincinnati Arch	Michigan Basin	Williston Basin	Gulf Coast	North Sea Shelf
	Depth (ft)	7,800	3,200	3,400	3,300	5,000	3,000
	Injection Volume (metric ton)	1,000s	1,000s	1,000s	>6,000,000	1,600	>7,000,000
Inj. System	Injection Well Measurements	+++	+++	+++	√	√	√
Fluid-phase	Shallow GW Monitoring	+	---	--		√	
	Surface water sampling	--	---	---		√	
	Reservoir Sampling	+	+++	+++	√	√	
Gas-Phase	Monitoring injectate	+	+	+	√	√	√
	Tracers in injectate	+	--		√	√	
	Shallow soil-gas monitoring	--	-	--	√	√	
	Lower atmospheric mon.	--	--	--		√	
Wireline or Down-well	Traditional Wireline	+	++	+++	√	√	
	RST	+	+	+++		√	
	DSI	-		+		√	
Other Geophysical methods	4-D Seismic	-	++	+++	√		√
	VSP	-	+	+++	√	√	
	Microseismic	+	--	--	√		
	Crosswell Seismic	-	+	+++	√	√	
	ERT/EMT	---	--	-		√	
Remote Sensing	Airborne gas	---	--	+			
	Aeromagnetics/Gravity	---	---	---			√
	Hyperspectral imagery	---	---	--			
	Surface deformation/tilt	---	---	--			√

Preliminary - Do not Cite

Regional Potential and Phase II Pilot Injection Tests

Table 7.—Summary of estimated CO₂ storage capacity by geologic interval or reservoir type (in gigatonnes)

Sequestration Target	Porosity (%)	Density (g/cc)	Gas Content (scf/ton)	Area (mi ²)	Total (GT)	10% of Total
Oil and Gas Fields					25.1	2.51
Waste Gate Formation	10			1,342	43.8	4.38
Net Coal		1.32	100	25,578	2.5	0.25
Antrim and Ohio shales		2.62	42.9	109,043	453	45.3
Needmore Shale		2.62	42.9	850	0.5	0.05
Sylvania Sandstone	10			25,324	151.1	15.11
Oriskany Sandstone	10			57,313	194.3	19.43
Medina/Tuscarora SS	8			72,328	705.3	70.53
St. Peter Sandstone	10			41,796	881.3	88.13
Rose Run sandstone	8			57,493	492.7	49.27
Potsdam Sandstone	2			9,298	17.1	1.71
Conasauga Formation	2			24,973	42.5	4.25
Rome trough sandstone	1			18,452	12.3	1.23
Mt. Simon Formation	8			85,916	2,171.8	217.18
Total					5,193.5	519.35

To fully evaluate the region's potential pilots should be designed to test as many of the best candidate reservoirs as possible, over a broad area of the partnership.

Conclusions/Results

- MRCSP Phase II sites represent a large spatial and geologic extent of the region
- During the last six months substantial progress has made in the geologic assessments, planning of site characterization and field tests.
- Working relationship with host locations has been established
- A foundation for outreach effort and regulatory aspects has been prepared in collaboration with the host sites
- The main tasks in the near future are seismic surveys for the Appalachian Basin site and the Cincinnati Arch site, which are scheduled for this summer.
- Plans are also proceeding with retrofitting a dry well at the Michigan Basin site for monitoring in the next few months.
- We are off to a solid start!