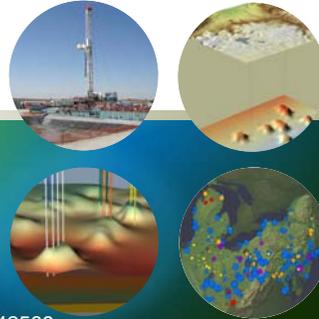


MRCSP - Large-Scale CO₂-Enhanced Oil Recovery and Geologic Storage Test in Midwestern USA

Carbon Sequestration Leadership Forum
Technical Group Meeting
Washington, DC
November 4, 2013



Presented by:
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DOE/NETL Cooperative Agreement # DE-FC26-0NT42589

MRCSP – cornerstone of the Battelle’s program on the CCUS technology development

- AEP Mountaineer Projects**
- Site Characterization, Design
 - Permitting, Construction
 - Operations, workover
 - Post-Injection Monitoring
 - >150,000 hours of safe drilling



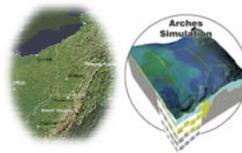
- FutureGen Program**
- 1 MT/yr scale
 - Design/costing
 - Class VI permitting



Wellbore Integrity

Simplified Modeling

Storage Feasibility in Sichuan Basin China



Ohio Valley Characterization, Basin-Scale Modeling

Private Client Studies – Domestic and Global

Emerging Program in Brine Disposal, EOR, Shale Gas

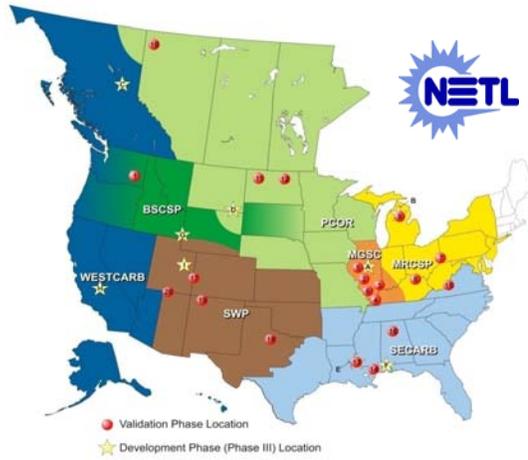
Regional Carbon Partnership



- Regional Mapping
- Policy & Regulation
- Small-Scale Tests
- Large-Scale Test
- EOR and Storage
- Exploration

The MRCSP assesses viability of carbon sequestration

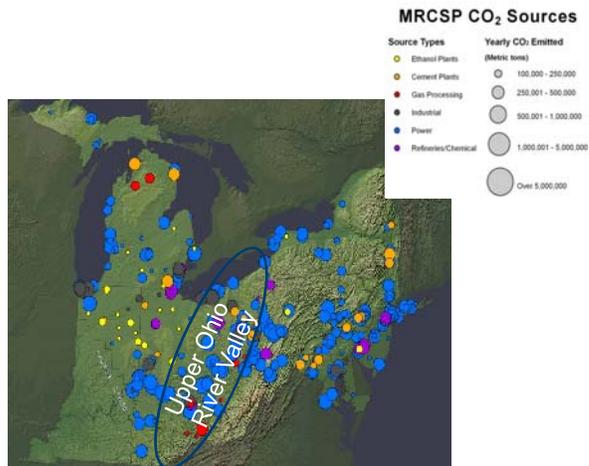
- Established in 2003 by Battelle with DOE-NETL funds – Currently in Phase III
- Led by Battelle, there are 40 organizations from non-profit, government, and commercial entities
- Mission – The premier resource for CO₂ storage and utilization expertise in the region



3

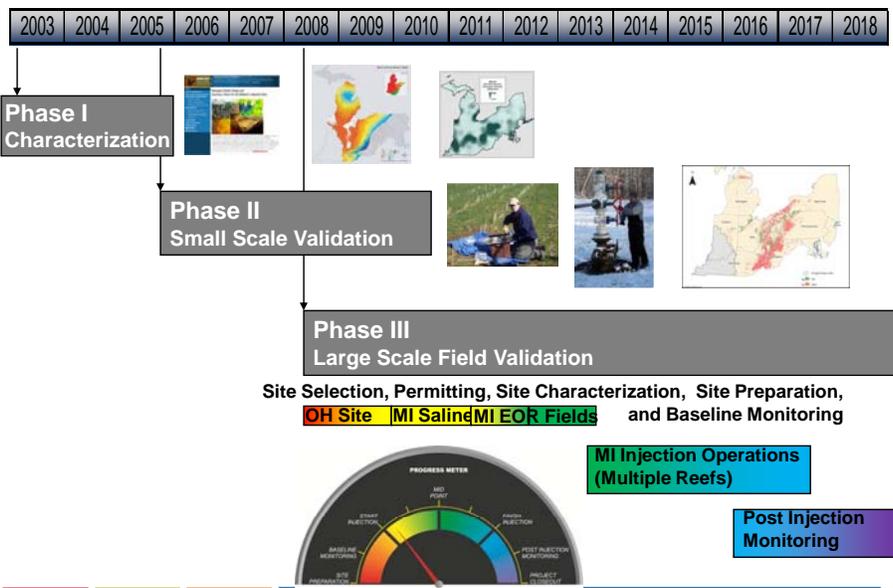
MRCSP region: Many CO₂ emission sources with dependence on coal

- CO₂ storage/utilization technologies key to affordable energy supplies
- Environmental/climate issues and shale gas, are leading to energy supply transition
- Coal continues to be dominant fuel source, but will be impacted due to emission limits



4

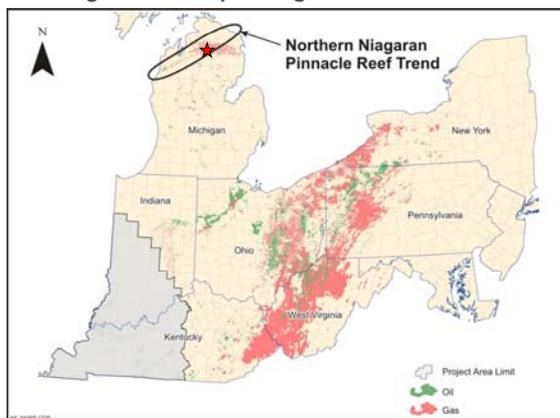
Overall schedule for MRCSP – 10 Years of achievements and more to come!



MRCSP region has many large historic oil and gas producing areas

- ~ 8,500 million metric tons of CO₂ could be stored within depleted O&G fields (~10 years worth of regional emissions)*
- Using CO₂ for EOR could lead to the production of an additional ~1.2 billion barrels* of oil
- However, EOR needs to be proven in the region

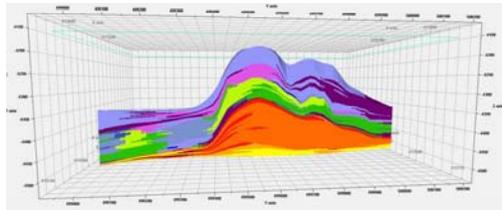
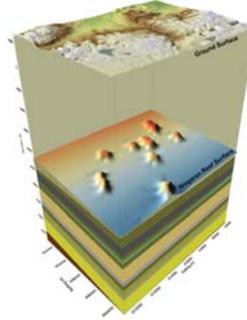
Oil and gas fields map for region*



* Source: Estimates developed by the Geological Surveys within the MRCSP

MRCSP large-scale test site — only CO₂-EOR site in the Midwest

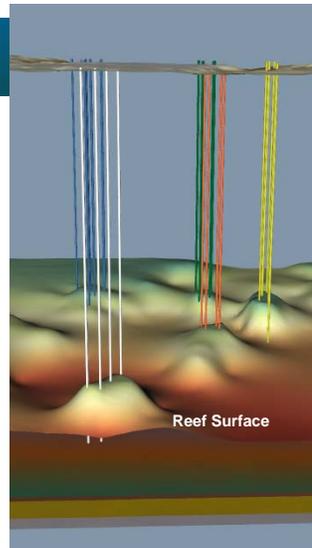
- Location:**
Otsego County, Michigan
- Host Company:**
Core Energy LLC
- Reservoir Type:**
Closely-spaced, highly compartmentalized oil & gas fields located in the Northern Michigan Niagaran Reef Trend
- Source of CO₂:**
Natural Gas Processing Plant
- Injection Goal:**
At least 1 million metric tons of CO₂ over ~four years



MRCSP study fields are in multiple oil production stages

Oil fields are in various production life-cycle stages

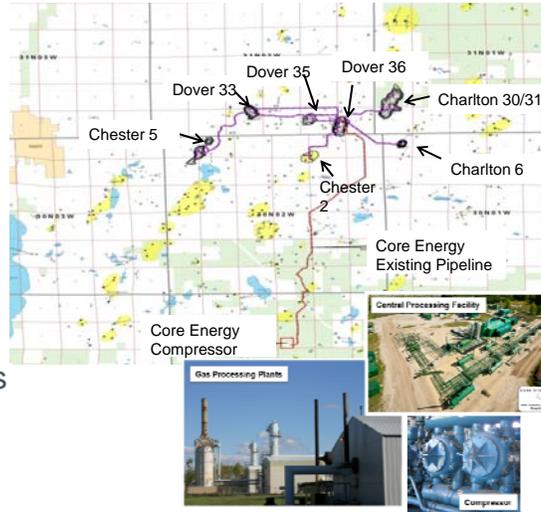
- **Late-Stage EOR Reefs**
Undergone extensive primary and CO₂-EOR – highly depleted
- **Active EOR Reefs**
Completed primary oil recovery and CO₂-EOR is under way
- **Pre-EOR Reefs** – New CO₂ EOR
Undergone primary oil recovery but no CO₂-EOR yet



Existing EOR infrastructure enables cost effective research for MRCSP tests

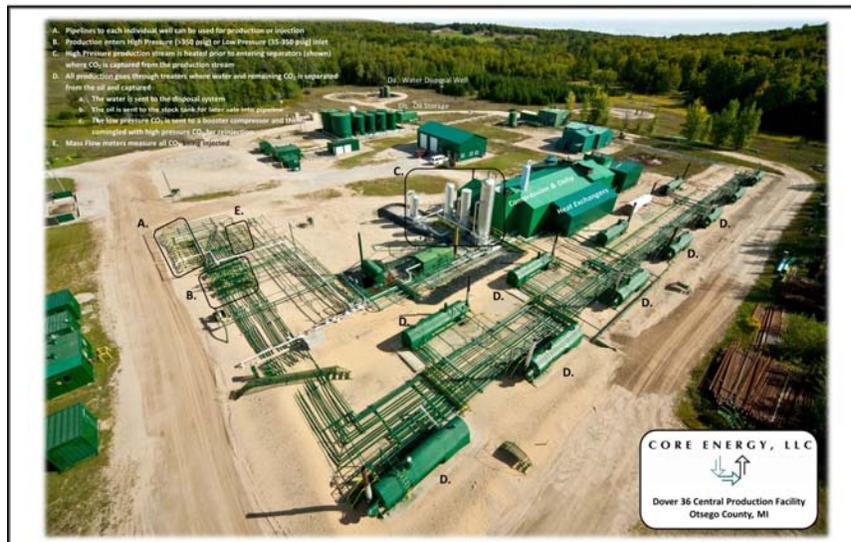
• Infrastructure:

- CO₂ uptake from capture
- Compression and dehydration systems
- Pipelines for transport
- Central processing facility (Dover 36)
- Injection and production-monitoring wells (7 fields)
- Monitoring and measurement systems

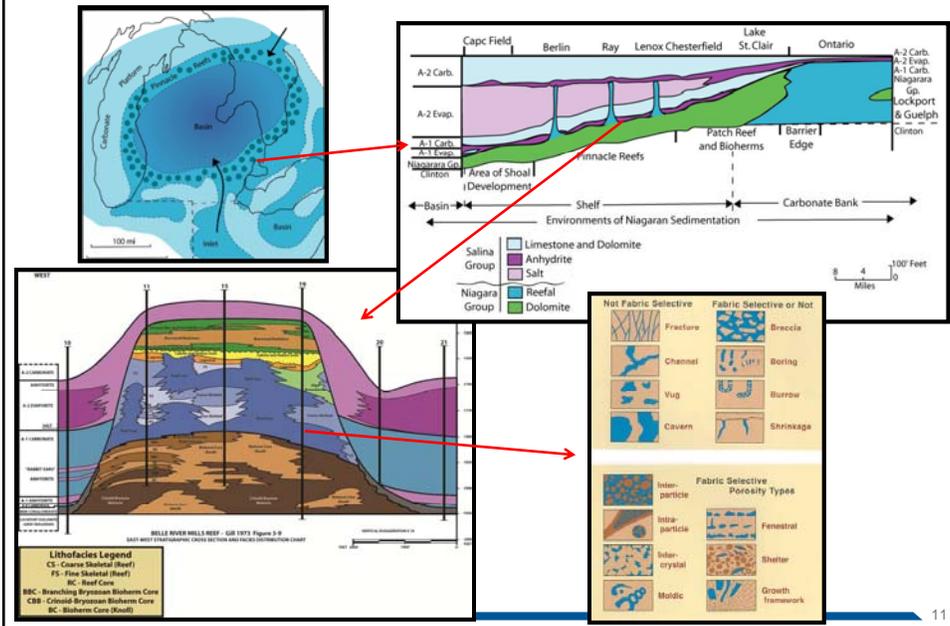


- Total system capacity is >1200 tonnes/day (10-15% of 500MW coal-based plant)

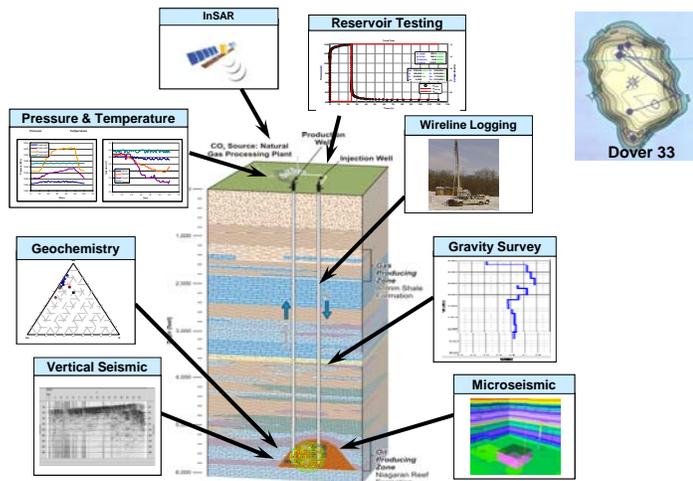
Dover 36 Processing Facility – central hub for fluids and data flow



Geologic Setting – Complex Reef Structures

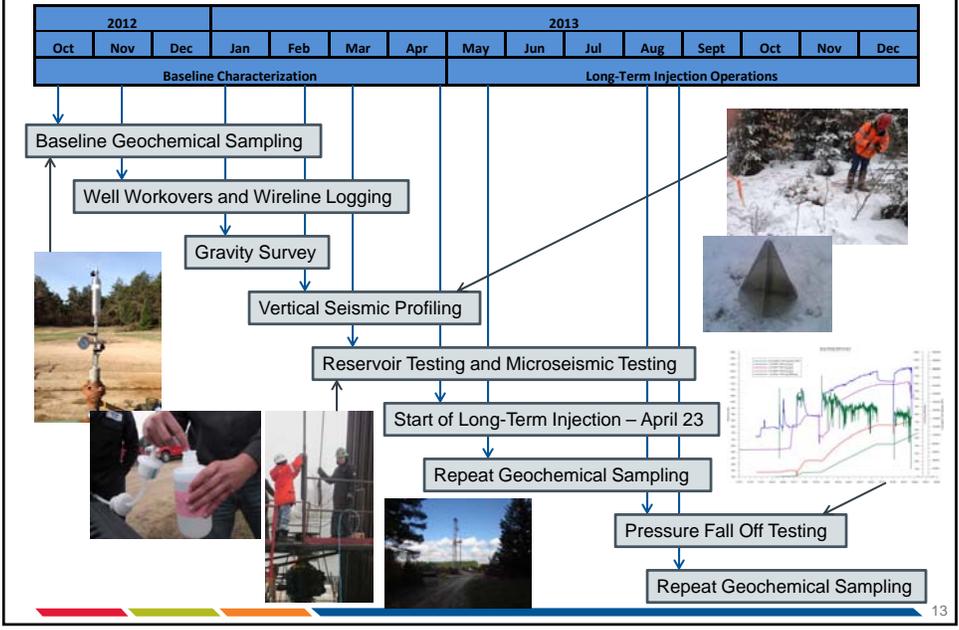


Highly depleted field provides a test bed for advanced monitoring technologies

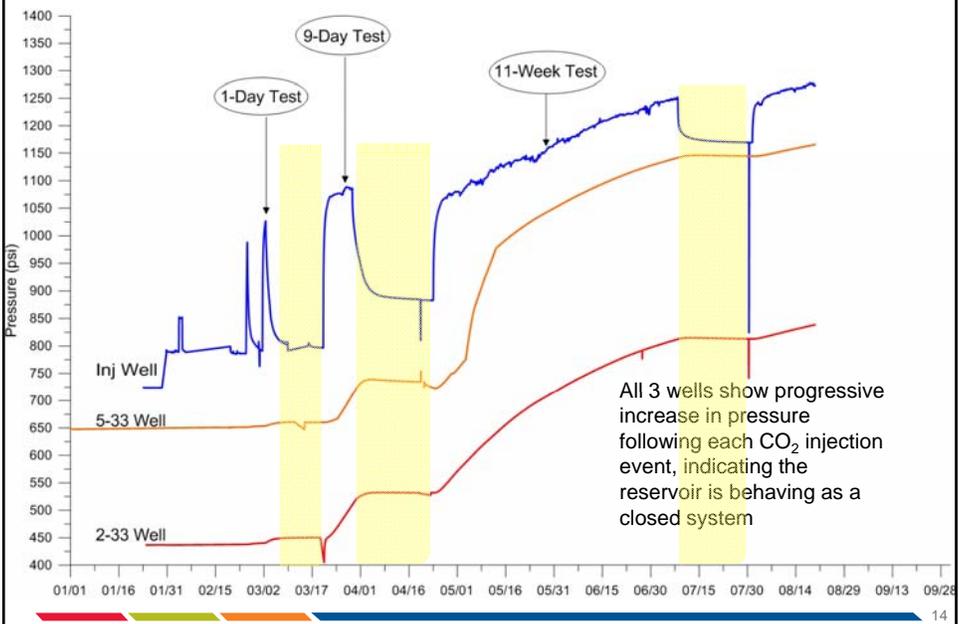


Monitoring options under testing at Dover 33 field

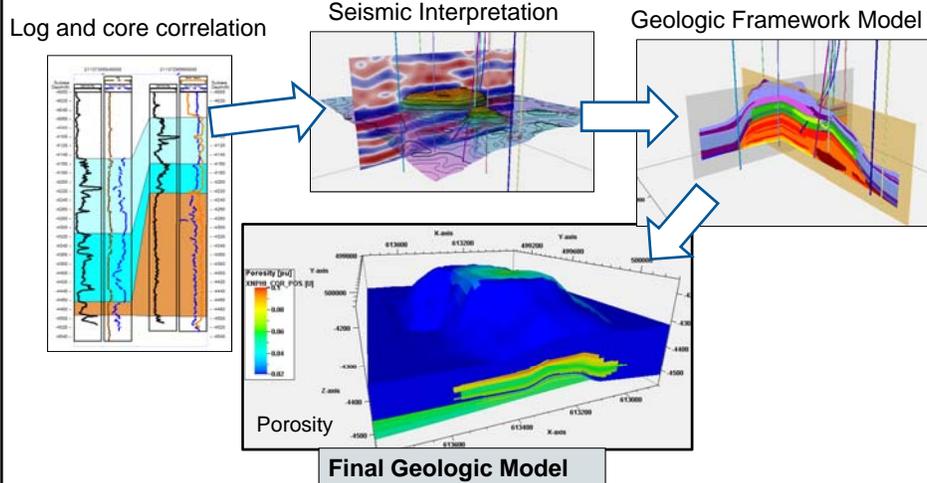
MRCSP Phase III Field Activities – Dover 33



Pressure response in 3 wells in late-stage reef



Developing detailed geologic model work for MRCSP based on seismic and well log data



The modeling integrates seismic and well log data
Provides basis for fluids flow models

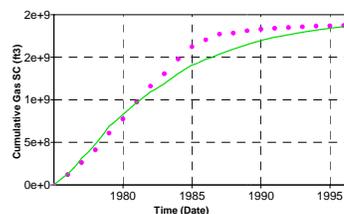
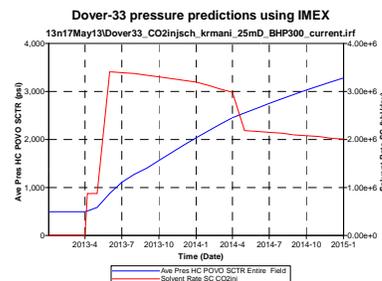
MRCSP Dynamic reservoir simulations

Expected Outcome:

- Full accounting for (1) reservoir geology and (2) compositional phase behavior

Strategy:

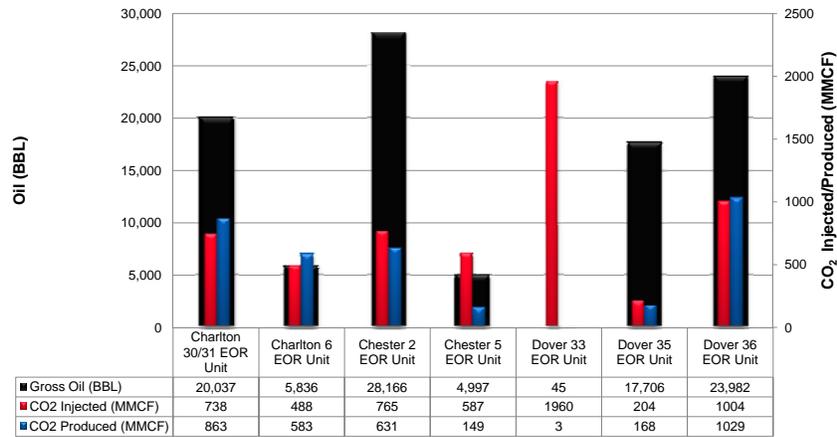
- **CO₂-Prophet** for initial simulations
- **GEM** (Computer Modeling Group) to model multiphase flows for CO₂-EOR
- Requires detailed information about (1) rock / fluid properties and (2) production history
- Can be used for all phases of history matching (primary, CO₂-EOR, depleted), flood design and production forecasting
- Possible partial or full coupling of flow, geochemistry, and geomechanics



MRCSP – Understanding CO₂-EOR System-wide operations

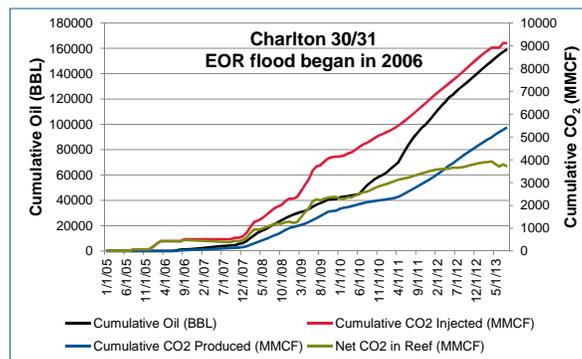
- Data collection and reporting from all fields
- Compilation and review of historic operations data
- Systematic calibration of flow meters

2013 YTD (end August) Production by Reefs



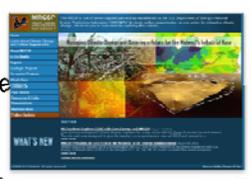
Monitoring in Active EOR Reefs

- Work plan approved by DOE
 - Review historical operations
 - Selected piggyback monitoring
 - Model one reef in detail
 - Evaluate mass balance and retention

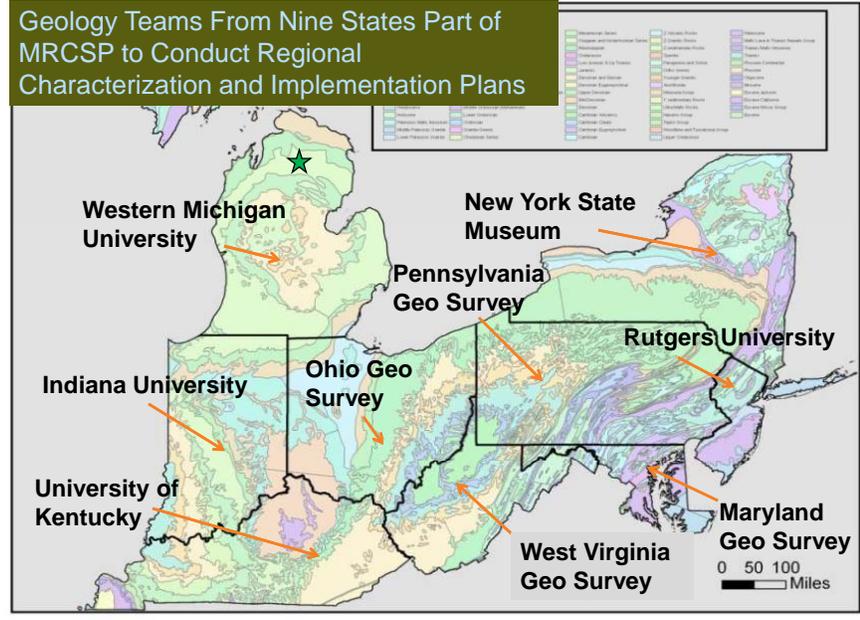


MRCSP Outreach Goals

- ❑ Support the large volume injection test
 - ❑ Updated communication plan for restructured project
- ❑ Maintain reputation of MRCSP as a neutral and credible source of scientific information on CCS
 - ❑ Over 20 Topical Reports available
 - ❑ Over 30 Presentations and Briefings available on MRCSP Website
- ❑ Improve public understanding and acceptance of CCS
 - ❑ Synthesizing project results into key findings and messages for stakeholders.
- ❑ Increase public understanding of EOR, subsurface activities, and their role in the larger energy mix
 - ❑ Speaking at conferences and meeting with trade associations

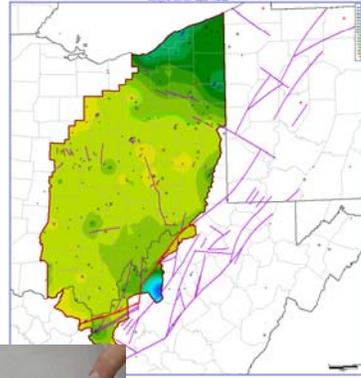
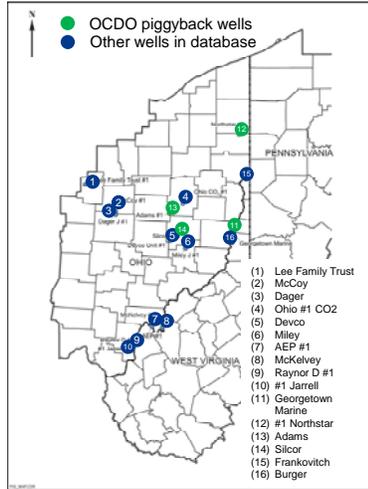


Geology Teams From Nine States Part of MRCSP to Conduct Regional Characterization and Implementation Plans



Finding storage options in Appalachian Basin

- Battelle is working with oil/gas operators to obtain crucial geologic data for mapping storage zones
- Funded by Ohio Coal Development Office as a joint effort with MRCSP



Copper Ridge
vuggy Dolomite
Core 8370'

MRCSP status and plans

- MRCSP Phase III injection began Feb. 2013 –
- ~350K tonnes till Oct. 2013 in Dover 33 and other active reefs
- Up to 500,000 tonnes of CO₂ injection planned in Dover 33 depleted reef
- Additional fields for new CO₂-EOR tests with ~500,000 tonnes planned
- >200,000 tonnes injection monitored in active reefs by Oct. 2013
- A period of monitoring after completion of injection
- Wells to be returned for normal operations by Core Energy at the end



Acknowledgements

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