Mid-Atlantic U.S. Offshore Carbon Storage Resource Assessment International Workshop on Offshore Geologic CO₂ Storage, 2016

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PROJECT SCOPE

Goals and Objectives

Define geologic characteristics of candidate storage **DOE Program Goals** sites • Use seismic data to better define continuity of Support Industry's ability to predict reservoirs Catalog hydrologic properties of mid-Atlantic offshore CO_2 storage capacity storage sites Determine appropriate efficiency parameters specific to offshore lithologies • Examine risk factors Develop Best • Engage stakeholders to guide future projects Practices

Study area

The study area consists of three major sub regions:

- Georges Bank Basin
- The Baltimore Canyon Trough
- 3. The Long Island Platform

Potential storage within the mid- and north-Atlantic Planning Areas could provide options for heavily populated states along the east coast.

MID-ATLANTIC OFFSHORE STUDY AREA



A map showing the regional study area, and its proximity to point sources of CO₂

Project organization

Sponsor **Project Lead** William O'Dowd DOE/NETL Project Manager Battelle U.S. Department of Energy/NETL The Business of Innovation **Project Management (Task1)** Project Manager: Lydia Cumming Principal Investigator: Neeraj Gupta <u> Task 2</u> Task 3 Seismic Evaluation <u> Task 4</u> <u> Task 5</u> Offshore Geologica Carbon Resource Hydrologic Properties Characterization Calculations Characterizatior Greg Mountain Ken Miller Peter McLaughlin Isis Fukai (Rutgers) (Delaware Geo. Survey) (Rutgers)

Chart illustrating the project leadership by task

Schedule

	BP1					BP2							
Task Name		FY2016				FY2017			FY2018				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	I Future deliverable
Task 1: Project Management & Planning	ł											1	
Update Project Mgmt. Plan	•												Itemized invento
Task 2: Offshore Geologic Characterization	ł					P							
Complete Initial Characterization						•							🔹 Regional stratig
Task 3: Seismic Evaluation									9				Identification of
Acquire data & complete processing									•				
Task 4: Hydrologic Props. Characterization			ſ						٩				houndarios
Summarize hydrologic conditions									•				Dunuanes
Task 5: Carbon Storage Resource Calcs							9			ł			Storage Resource
Calculate Resource Estimates										•			Otorage Resour
Task 6: Risk Factors for MAC Areas								ſ			ſ		 Offshore risk far
Compile Risk Factor Analysis											•		
Task 7: Stakeholder Education & Engagmnt							•				P		I • Roadmap for fu
Task 8: Reporting and Tech Transfer	•											٩	







LAMONT-DOHERTY EARTH OBSERVATORY

Mid-Atlantic U.S. Project Objectives



- es include: ory of existing data raphic framework report regional hydrologic
- rce Assessments ctor analysis ture CCS projects







METHODOLOGY

1. Assess the geologic characteristics within the study area

- Compilation and review of all existing data
- Construction of a digital database
- Interpretation of the porosity and mineralogy via well log and core analysis

2. Utilize seismic data to define reservoir continuity

- Strategic selection of seismic lines for reprocessing: Bureau of Ocean Energy Management (BOEM) newly
- released multichannel seismic data from 1970's-1980's
- USGS, academic, and other seismic surveys

3. Catalog hydrologic properties

- Lithologic, porosity, and permeability data generated from core and well logs will be used to determine the amount of pore space available for storage
- Data will be obtained from original reports, public databases, and new analysis of core material located at the Delaware Geological Survey

Geochronology			Palynostratigraphy	Lithostratigraphy											
			Hochuli et al. Doyle & Robbins (2006) (1975)	Maryland	New J	ersey	C	Long Island							
05.14			A 6 A 8		Fort Mott Medford	Formations	B-2		B-3	Sand units					
-1 -1	-71.3-	Maastrichtian		Monmouth & Matawan Gps. (undifferentiated)	Red Bank/Navesink	Red Bank/Navesink	Age Depth 71.5 5015			Dawson Canyon	Monmouth				
	-	Campanian		?	Mt. Laurel/ Wenonah Marshalltown	Mt. Laurel/ Wenonah Marshailtown	10			Ganda	& Matawan Groups				
	-83.5-	Santonian	Zone VII	Magothy Fm.	Merchantville Cheesequake	Merchantville Cheesequake	.84?	6009							
Late	LateConiacian				0.000	85.9	76382	85.9 7370 897 7505	Middle Sandstone	Magothy					
Tur	Turonian	Zone V		Magothy	Magothy										
-98.9 -112 Early -121	-93.0-	Cenomanian	Zone IV	Raritan Fm.	Bass River/Raritan	Bass River/Raritan	96	8220	95.5 8200	Logan Canyon Lower Logan Canyon Missisauga	Raritan				
	-		C Zone III	Patapsco Fm.	364 786	Potomac Fm. Unit 3 Potomac Fm. Unit 2	99	8600							
	-112.2	Albian	upper	Arundel and Patuxent	600 983	Potomac Pint Dint 2		8840 9344 10230 12 711448 13	8642 8790 9113 121 9873 127 ?11629						
	-121.2-	Aptian	lower Zone I	Gp. Fms. (undifferentiated)	and the second second	Potomac Fm. Unit 1	120?-								
	-127- -132- -137-	Barremian Hauterivian Valanginian	? Pre-Zone I	Waste Gate Fm.		?Waste Gate Fm ?-	127								
144.2	Juras	Berriasian		Unnamed Jurassic (?) Kocks		_2_									

Stratigraphic column illustrating the stratigraphy and targeted sand intervals (yellow) within the study area (modified from Seker, 2012)

4. Calculate Prospective CO₂ Storage Resources

- Development of first approximations of offshore CO₂ storage efficiency
- Examination of differences in storage efficiency between onshore and offshor environments
- Calculation of prospective storage resource assessments following the DOE methodology (US-DOE-NETL, 20

5. Examine risk factors that may impact storage resource estimates



Geological and other risk factors impacting operations will be considered. The map to the left displays known behavior of faults, fractures, and dipping strata (source: USGS). The map to the right illustrates environmental risks such as marine protected areas, hazardous waste dumping areas, and shipping anes (source: BOEM).





Core from the COST G-2 well currently being inventoried and assessed for additional analysis

$\mathbf{G}_{\mathbf{CO2}} = \mathbf{A}_{t} \mathbf{h}_{a} \phi_{tot} \rho_{\mathbf{CO2}} \mathbf{E}_{\mathbf{saline}}$

			9					
	Parameter	Dimension *	Description					
	G _{CO2}	М	Mass CO ₂ storage resource of reservoir					
	A _t	L ²	Total area of reservoir					
re	h _g	L	Gross thickness of reservoir within the area defined by ${\rm A}_{\rm t}$					
	ϕ_{tot}	L ³ /L ³	Total pore/void space in the volume of rock defined by $A_t h_q$					
12)	ρ _{co2}	M/L ³	Density of CO ₂ at anticipated pressure and temperature conditions of storage					
	E	L ³ /L ³	Storage efficiency factor that represents the fraction of the total volume of the reservoir accessible for CO_2 storage					

*M is mass; L is length



6. Engage stakeholders to guide future projects

• Several workshops will be held with the objective to seek input for road mapping

storage resources, and identifying key formations that exist offshore of the Mid-Atlantic U.S. with the greatest potential for effective, permanent storage of CO₂. The anticipated outcomes are high level storage resource assessments of areas of the mid-Atlantic not previously characterized and improved storage resource estimates. The Project Team will also review and update guidance on efficiency factors for offshore resource assessment and best practices for site selection criteria.



This material is based upon work supported by the Department of Energy under Award Number DE-FE0026087. The Project Team is led by Battelle and includes the state geological surveys of Delaware, Maryland, and Pennsylvania; United States Geological Survey; Lamont-Doherty Earth Observatory at Columbia University; and Rutgers University. In addition, Harvard University, Texas Bureau of Economic Geology, and Virginia Department of Mines, Minerals, & Energy serve as technical advisors.

REFERENCES

BOEM, MMS Mapping & Boundary Branch, Jan 27, 2004 303 275-7186 /wind2/use.map Seker, Z., 2012, Cretaceous well-log and sequence stratigraphic correlation of the outer continental shelf and upper slope off of New Jersey [M.S. thesis]: Rutgers University, 155 p. US-DOE-NETL, 2012, Carbon Utilization and Storage Atlas. U.S. Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory.



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DISCUSSION

Attention towards offshore prospects for CCS in the U.S. is required to address numerous large-point sources located along the U.S. Atlantic Coast. Research is underway to develop a reliable method for screening candidate offshore storage formations, producing data-driven, probabilistic estimates of the prospective CO₂



The first batch of seismic data selected for reprocessing consists of over 1000 km of seismic lines; ultimately, a total of 4000 km lines will be selected (source: Lamont-Doherty)

Cross section constructed using data from wells located within the Great Stone Dome in the Baltimore Canyon Trough, North (left) to South (right) (source: Rutgers University)

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