

Leveraging a Legacy Sample and Data Collection for Carbon Storage Resource Assessment*

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Abstract

The Delaware Geological Survey's U.S. Atlantic Outer Continental Shelf Sample and Data Repository holds all the remaining core and cuttings samples from the 5 COST and 46 industry wells drilled on the U.S. Atlantic Outer Continental Shelf (OCS) between 1975 and 1984. The collection also includes prepared materials, biostratigraphic slides and thin sections as well as related data including paper and digitized geophysical logs. These invaluable materials are available to government agencies, consultants, industry and academia for studies of OCS geology.

The OCS repository holdings are a key resource for the Mid Atlantic U.S. Offshore Carbon Storage Resource Assessment Project, a multi-institution study of the Atlantic OCS supported by the Department of Energy (Award Number DE-FE0026087). Delaware Geological Survey has compiled a detailed item-by-item inventory of sample holdings and legacy sample data from the 51 OCS wells. The inventory includes around 10,000 unwashed cuttings, 88,000 washed cuttings, 61,900 slides (including 5,600 thin sections), 25,900 vials, 50 core peels, 2,470 linear feet of slabbed core, 200 core slices, 2,000 core chips, and 270 sidewall cores. These samples are being used by project partners for geological characterization of the Baltimore Canyon Trough and Georges Bank Basin, including hydrologic properties of formations of interest, reassessment of biostratigraphic data, and calibration of geophysical logs, among other applications.

A collaborative data mining effort by the project team extracted porosity, permeability and grain density data, among other parameters, from numerous publications and unpublished company reports, mostly from the 1970s and 1980s. The data were analyzed for gaps in coverage and compared to the sample inventory using relational database queries so that samples available in the gaps could be identified for new analysis. Legacy data were also matched to available samples where verification would be beneficial, notably where recorded values are anomalously high or otherwise suspect. Samples that would improve the calibration of well logs to rock properties were also identified. Integration of new analyses with project seismic, well-log, and sequence stratigraphic characterization work, leveraging these legacy samples, will improve understanding of the reservoir properties of units that are potential targets for carbon storage and contribute to increased understanding of the geology of the Atlantic OCS.



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ACE 101: Bridging Fundamentals and Innovation

Aim

Show the value of a legacy sample and data collection for carbon storage resource assessment

Thank you to our project partners...

- Battelle 
- Harvard University 
- Rutgers University 
- Lamont-Doherty Earth Observatory 
- Delaware Geological Survey 
- Pennsylvania Geological Survey 
- Maryland Geological Survey 
- United States Geological Survey 
- Virginia Dept. of Mines, Minerals, and Energy 
- Texas Bureau of Economic Geology 

The Mid Atlantic U.S. Offshore Carbon Storage Resource Assessment project is supported by the Department of Energy under Award Number DE-FE0026087 and led by Battelle Memorial Institute

The Delaware Geological Survey U.S. Atlantic Outer Continental Shelf Sample and Data Repository

- Holds all the remaining samples from the 51 C.O.S.T. and industry wells drilled on the U.S. Atlantic Outer Continental Shelf between 1975 and 1984
 - conventional core, sidewall core, washed and unwashed cuttings



The Delaware Geological Survey U.S. Atlantic Outer Continental Shelf Sample and Data Repository

Holds a substantial collection of prepared materials from legacy studies and returns from recent loans to industry and academia

- biostratigraphic slides, preparations and residues
- thin sections and thin section residues
- geochemical samples and residues
- acetate core peels



Prepared materials (slides, vials)



The Delaware Geological Survey U.S. Atlantic Outer Continental Shelf Sample and Data Repository

Detailed item-by-item inventory completed

- Conventional and sidewall cores:
 - 2,470 linear feet of slabbed core
 - 200 core slices
 - 2000 core chips
 - 270 Sidewall cores
- Washed and unwashed cuttings:
 - 88,000 washed cuttings
 - 10,197 unwashed cuttings
- Prepared materials:
 - 61,900 slides (incl. 5,600 thin sections)
 - 25,900 vials of paleontological and geochemical residues

Other Materials Available

- Geophysical logs: 368 paper logs (35 wells), 1512 raster logs (43 wells), 446 log LAS files (50 wells), 90 misc. logs (28 wells)
- 20 rolls of microfilm containing logs, reports and data from 45 wells
- 1 packet of microfiches containing logs, reports and data from COST B-2
- Paper and PDF format reports, maps, documents, newspaper clippings covering the active leasing and drilling period



The Mid Atlantic U.S. Offshore Carbon Storage Resource Assessment project

US Department of Energy-funded multi-institution project (DE-FE002608)

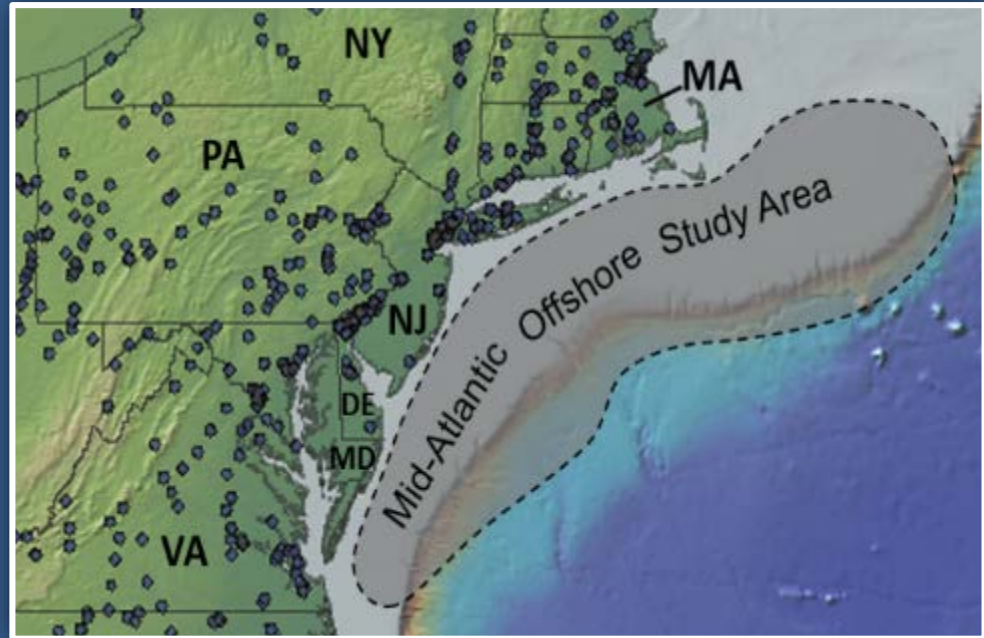
Project Objectives

Define the geologic characteristics of candidate storage sites

Use seismic data to better define continuity of reservoirs and seals

Catalog hydrologic properties of mid-Atlantic offshore storage sites

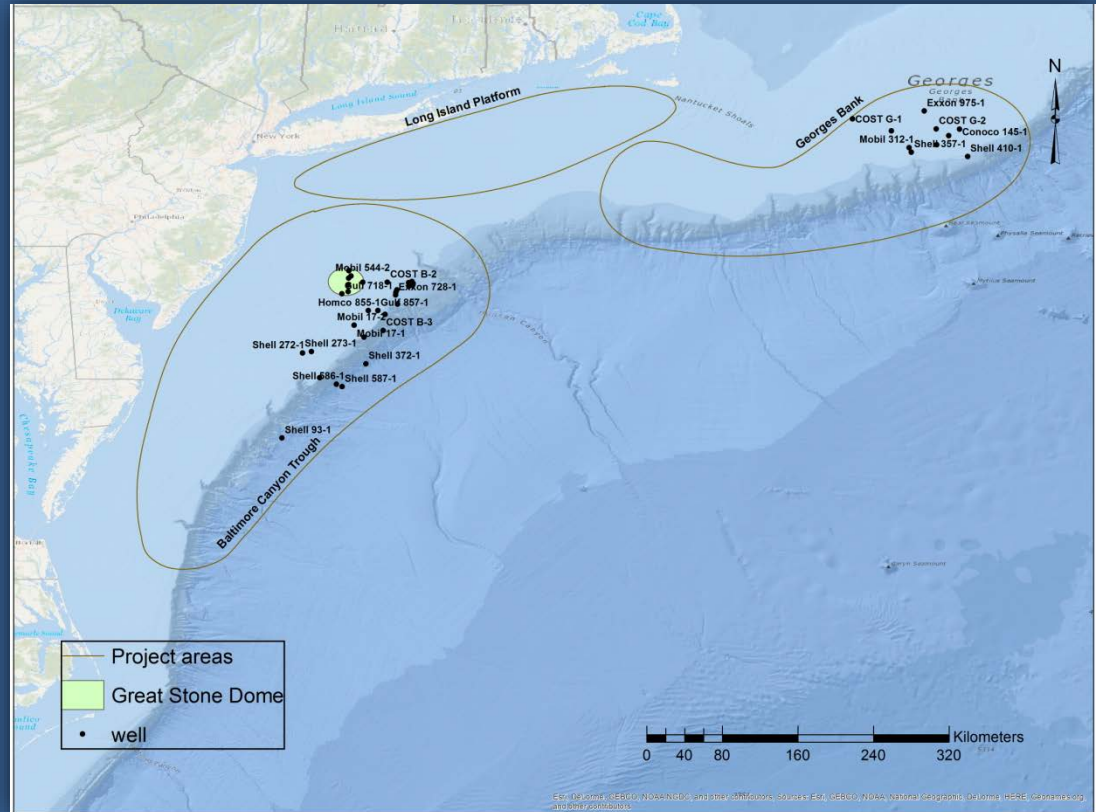
Determine appropriate efficiency parameters specific to offshore lithology



The Mid Atlantic U.S. Offshore Carbon Storage Resource Assessment project

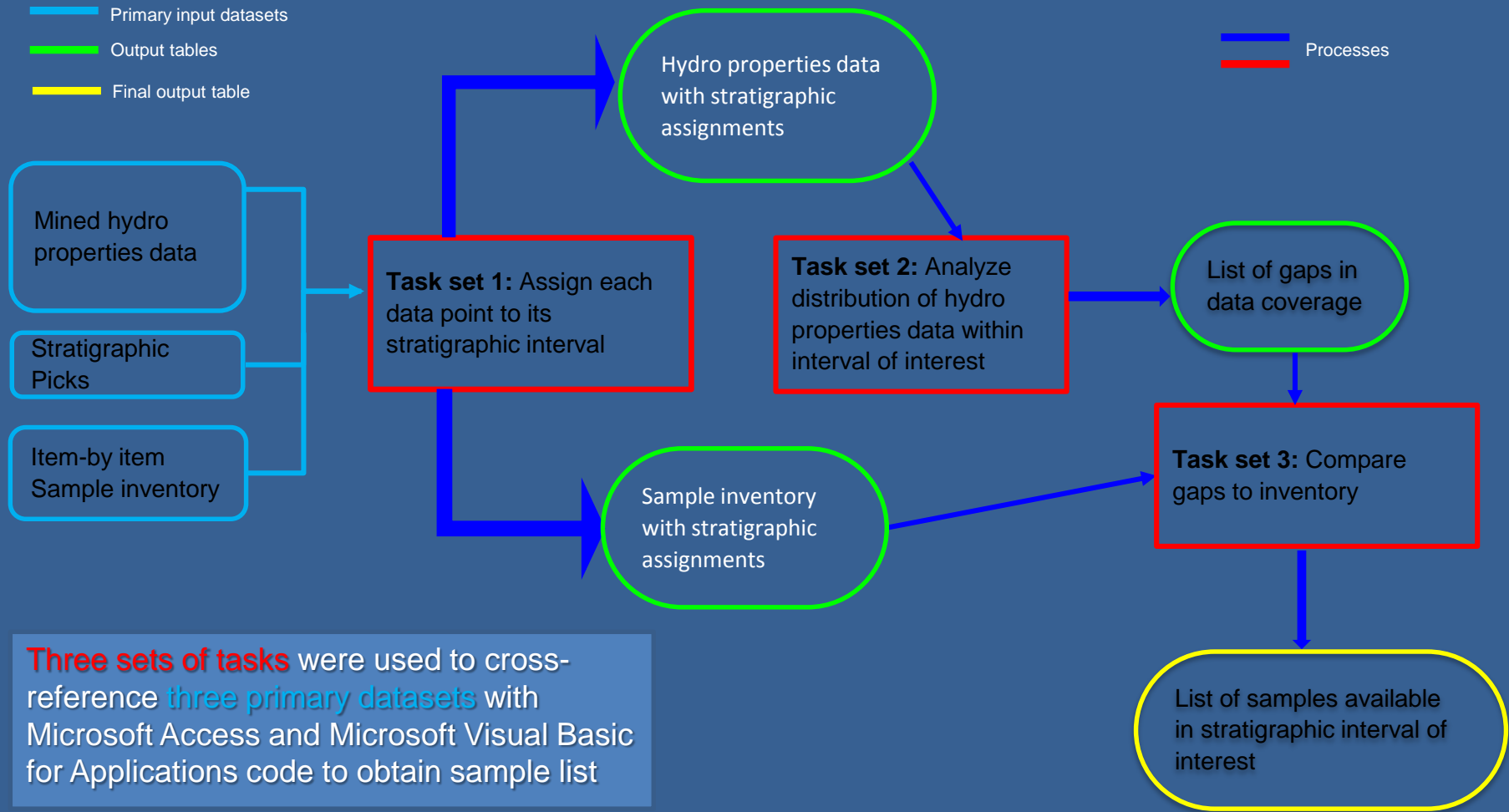
Looking at “Old Data” with “New Eyes”

- 34 wells in the Baltimore Canyon Trough
- 10 wells in the Georges Bank Basin



- Collaborative “Data Mining” effort to extract reservoir property values into Excel spreadsheet and Access Database
 - Porosity, Permeability, Grain Density, sample descriptions
 - Over 9,000 line entries
 - Spreadsheets, database and list of references now part of holdings

- Data were analyzed for gaps in coverage and compared to the sample inventory using relational database queries
 - Allowing samples available in the gaps to be identified for new analysis



Three sets of tasks were used to cross-reference **three primary datasets** with Microsoft Access and Microsoft Visual Basic for Applications code to obtain sample list

Cores and Sidewall Core samples allowed:

1. Targeted selection of available samples for new analysis
 - To fill gaps in reservoir properties data identified from Gap Analysis
 - To verify existing legacy data where recorded values are anomalously high or otherwise flagged
 - To validate existing legacy data to improve log calibration
2. Comparison of core condition to legacy porosity and permeability measurements to assess their validity

Summary of new analyses by well

- Routine core analysis on 40 plugs
- 81 probe permeameter readings
- Petrography, mineralogical and geochemical analysis on numerous samples

Well name	Permeability		Porosity (plug)	Grain density (plug)	Thin section	XRF	XRD	SEM
	(probe)	(plug)						
Conoco 145-1					1	1	1	
COST B-2	17	15	15	15	18	15	17	5
COST B-3	12	6	6	6	13	13	13	4
COST G-1	8	4	4	4	7	5	6	2
COST G-2	3	2	2	2	2	2	2	
Exxon 599-1	2	1	1	1	3	4	3	
Exxon 684-1	10	4	4	4	10	10	8	4
Exxon 684-2	1	1	1	1	1	1		
Mobil 544-1	12	1	1	1	12	11	12	1
Shell 273-1	2				2	2	1	
Shell 372-1	2				2	1	1	
Shell 586-1	2	1	1	1	1	1	1	1
Shell 587-1	1				1	1	1	
Shell 632-1	3	1	1	1	3	3	3	
Shell 93-1	1				1	1	1	
Texaco 598-1	3	3	3	3	3	3	3	1
Texaco 642-1	2	1	1	1	2	2	2	
Totals	81	40	40	40	82	76	75	18

XRF = X-ray fluorescence; XRD = X-ray diffraction; SEM = scanning electron microscopy

Verify Legacy data

- Porosity and grain density values generally close
- Several 1-Darcy level values could not be reproduced

Examples

Well	Sample selection criteria	Depth (ft)	Sample type	Core porosity		Core permeability				Grain density		Notes
				Legacy	New - plug	Legacy	New - probe	New - plugK	New - plugair	Legacy	New-plug	
COST G-1	VE	5473	Slab	32.00	30.29	1120.0	1220.00	286.8886	318.0758	2.67	2.66	
COST B-2	LC	8239.5	Slab	16.20	14.87	13.0	542.00	1.0608	1.5325	2.69	2.72	plug at 8239
		8240.7		26.50		1220.0				2.66		Legacy value of interest
	LC	8241	Slab	18.60	11.37	76.0	202.00	0.3212	0.5098	2.70	2.71	Legacy at 8241.2, plug at 8241.3
	LC	9305.4	Slab	28.10	23.71	983.0	1580.00	60.8881	66.3801	2.67	2.68	Plug at 9305.6
Texaco 598-1	VE, LC	13275-13276	Chip	18.40	17.69	1590.0	151.00	103.4680	190.0954		2.68	New core plug data at 13275

VE = Verify existing data; LC = Legacy data comparison

Validate Legacy data for core-log calibration

- Results essentially the same as legacy data
- Reproducibility of measurements validates the existing data
- Suggests compiled data can be used for log porosity calibration for any matrix

	Well	Sample selection criteria	Depth (ft)	Sample type	Core porosity		Core permeability				Grain density		Notes
					Legacy	New - plug	Legacy	New - probe	New - plugK	New - plugair	Legacy	New-plug	
Examples	Shell 586-1	VE, LC	9058-9058.7	Slab/chip	17.00	17.01	0.5	24.40; 10.00	0.3975	0.5702	2.70	2.71	2 probe at 9058-9058.7, new core at 9058.3, legacy at 9058.0. Limestone
	COST G-2	VE, LC	8756	Slab	18.20	18.05	90.0	56.4; 11.9	17.4784	21.5809	2.67	2.67	Legacy at 8755.95. Sandstone

VE = Verify existing data; LC = Legacy data comparison

Validate legacy data for permeability cut-offs

- New testing where legacy permeability <0.1 mD
- Improvements in detection limits allows more accurate measurement
- Results show the older <0.1 mD values could represent values two or three orders of magnitude smaller

Examples

Well	Sample selection criteria	Depth (ft)	Sample type	Core porosity		Core permeability				Grain density		Notes
				Legacy	New - plug	Legacy	New - probe	New - plugK	New - plugair	Legacy	New-plug	
Exxon 684-1	LC	12137	Chip	N/A	3.58	N/A	1.27	0.0006	0.0035	N/A	2.69	No legacy analysis on shale
Exxon 684-1	LC	12204	Chip	6.60	3.94	<0.1	11.80	0.0710	0.1081	2.66	2.61	Legacy at 12204-12204.5

LC = Legacy data comparison

Filling Data Gaps

- Sidewall cores were the only samples available to fill large gaps
 - COST B-3 (5 samples)
 - Mobil 544-1 (12 samples)
- Available samples only suitable for probe permeability analysis
- Petrography, XRD, XRF and SEM analyses also made
 - Thin section porosity estimates for reservoir properties
 - Mineralogical and geochemical data for additional analyses
- **New data now available where there were none**

Next Steps

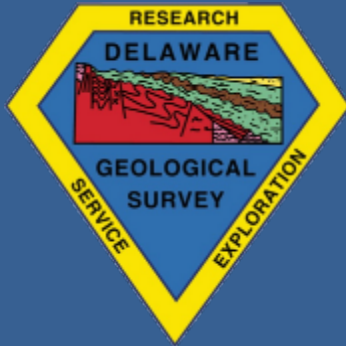
- Compilation of legacy and new hydrologic property data is currently being used to characterize potential storage resources and potential caprock units
- Data will be applied to other tasks as needed, such as stratigraphic analysis, well log calibration and characterization, seismic inversion, and risk assessment
- The results will be integrated to validate and/or update previous and ongoing interpretation of geological carbon storage resources

Conclusions

- Legacy samples and data have been valuable to carbon storage resource assessment efforts by allowing validation of existing data and data enhancement with new analyses
- Integration of new analyses with ongoing seismic, well-log, and sequence stratigraphic characterization work will improve understanding of the reservoir properties of the potential targets
- Results will greatly enhance understanding of the geology of the Atlantic OCS

Thank You

Questions?



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CARBON STORAGE RESOURCE
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