Project Number: DE-FE0031557

SECARB Offshore

Storage Potential of Oil Reservoirs in the Central Gulf of Mexico

Jack C. Pashin, Oklahoma State University

Benjamin Wernette, Southern States Energy Board

This material is based upon work supported by the U.S. Department of Energy National Energy Technology Laboratory. Cost share and research support are provided by the Project Partners and an Advisory Committee.

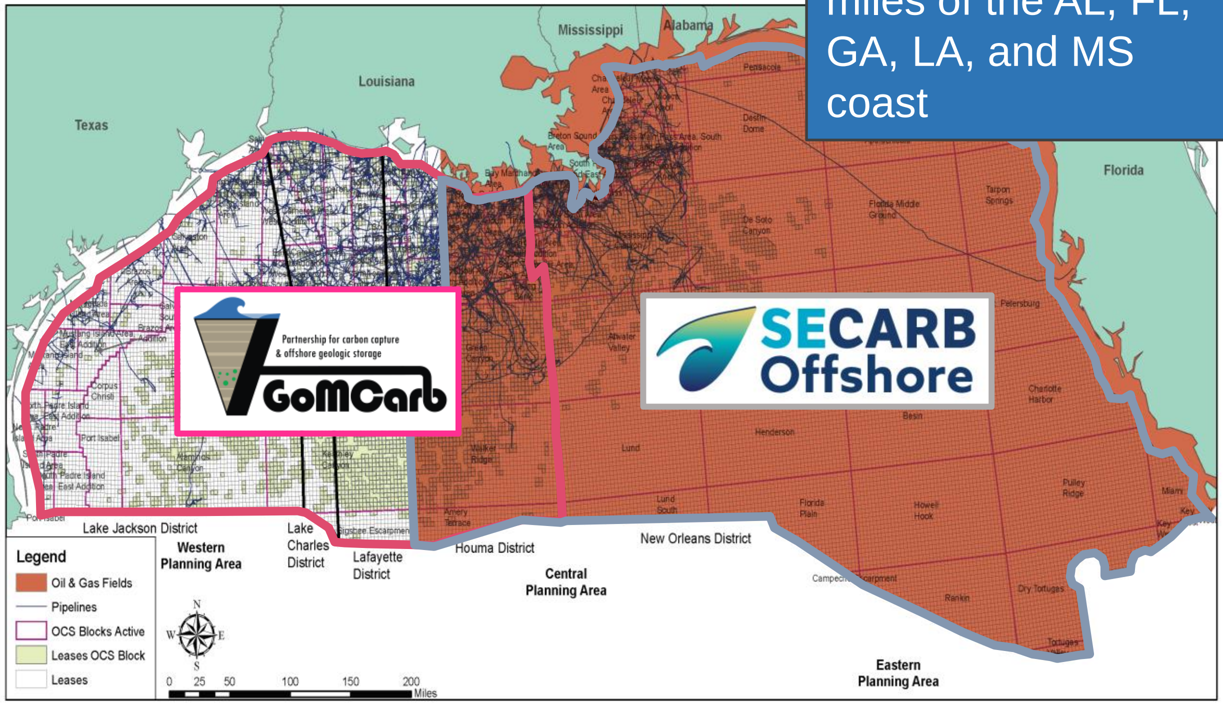
Disclaimer

"This presentation is based upon work supported by the Department of Energy and was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendations, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."

Offshore Partnership-Overview

260 MMT CO_2e per year
From point sources annually within 50 miles of the AL, FL, GA, LA, and MS coast

- Establishing the knowledge base required for secure, long-term, large-scale, subseafloor storage of CO_2 with or without enhanced hydrocarbon recovery



Division of the SECARB Offshore and GoMCarb study areas. Figure courtesy of Advanced Resources International and modified by SSEB.

Offshore Partnership-Overview

Subsurface characterization utilizing existing data – today's focus

Subsurface modeling informed by subsurface characterization

Identification of risks – legacy infrastructure

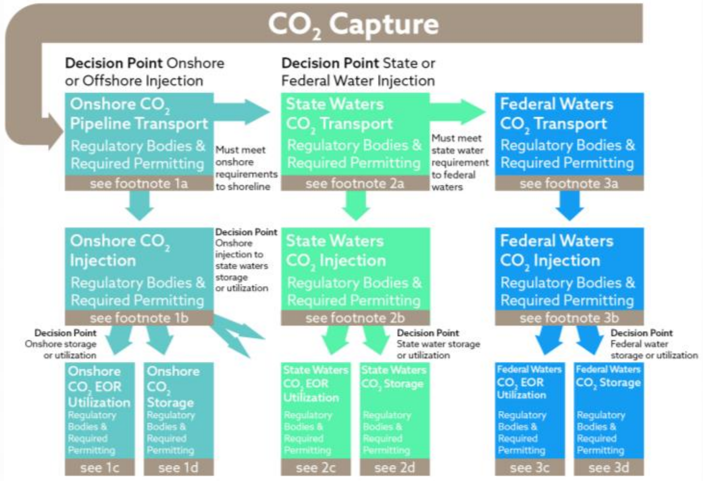
Infrastructure evaluation

Evaluation of legal and regulatory considerations

Outreach

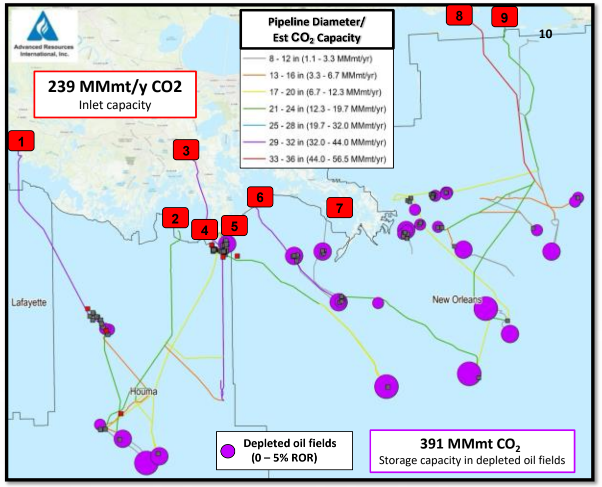
Other Team Activities

1. Legal and Regulatory



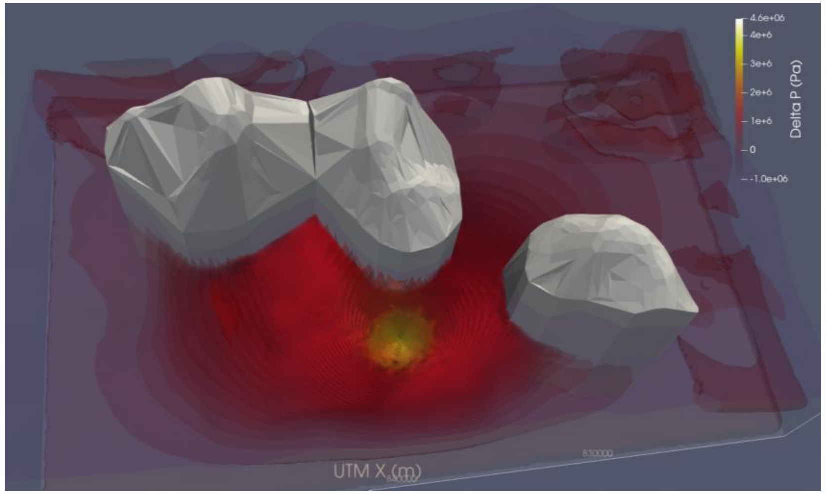
Developing a conceptual flow diagram that includes legal and regulatory considerations for project developers

2. Infrastructure



Developing commercialization scenarios utilizing existing infrastructure focused on depleted oil and gas fields

3. Risk



Developing models to evaluate CO_2 pressure plume interaction with local structural features (e.g., salt diapirs)

Offshore Partnership-Student Participation

LSU

PhD
- Mohamed Abdelaal – storage capacity estimation

OSU

PhD
- Joshua Ademilola – seismic interpretation and reservoir characterization
- Rupom Bhatterjee – data analytics
- Justin Spears (graduated) – mapping and seismic interpretation

MSc
- Kodjo Botchway – data analytics
- Xitong Hu (graduated) – data analytics
- Seyi Sholanke (graduated) – seismic interpretation

Virginia Tech

PhD
- Lars Koehn – reservoir modeling
- Charlie Schlosser – numerical modeling of faults

Undergraduate
- Abdullah Alsawyan

Introduction

- What are key reservoir properties in the Central Gulf of Mexico?
- What are total storage resources in this region?

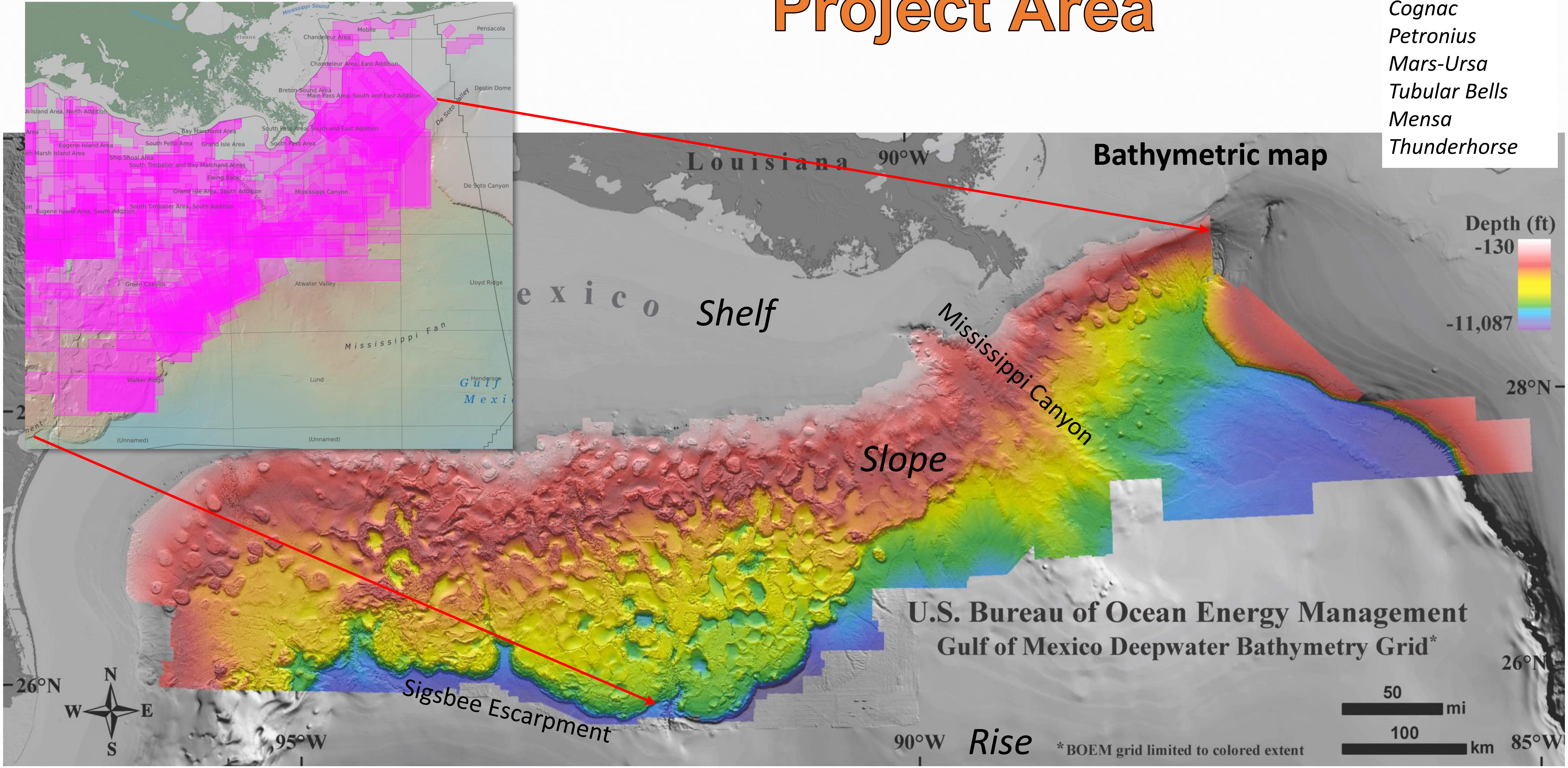
Objectives

- Geological Characterization based on 3D seismic, geophysical well logs, and reservoir data (Stratigraphy, sedimentation, structure, hydrodynamic analysis).
- Analyze reservoir properties, storage volumetrics, potential storage mechanisms, migration pathways, and reservoir integrity to develop geologic screening criteria.
- Understand temperature pressure regime and implications for geologic CO_2 storage and enhanced recovery.
- Determine regional storage resources using NETL static method.

Project Area

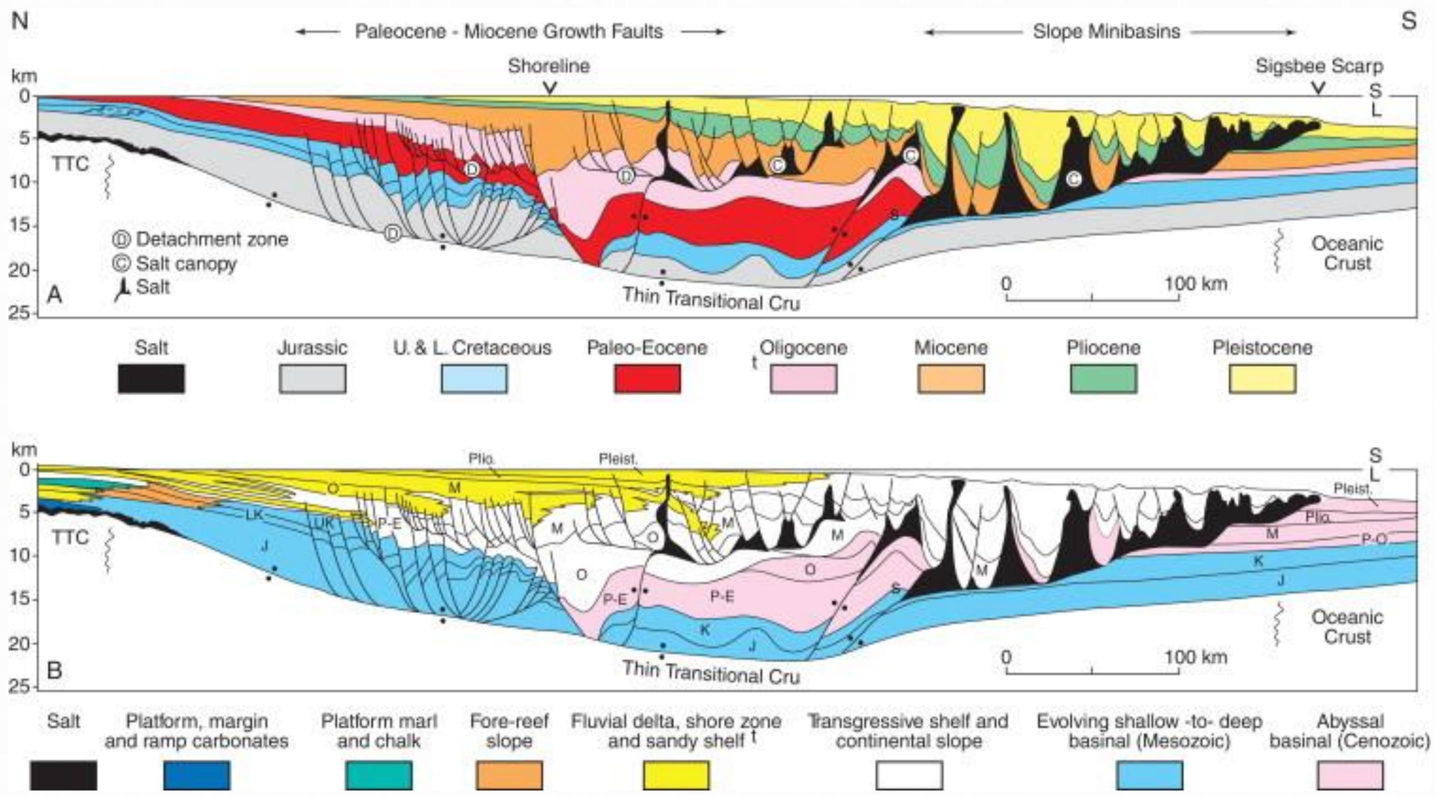
Priority regions:
Cognac
Petronius
Mars-Ursa
Tubular Bells
Mensa
Thunderhorse

Focus area with 3D seismic coverage

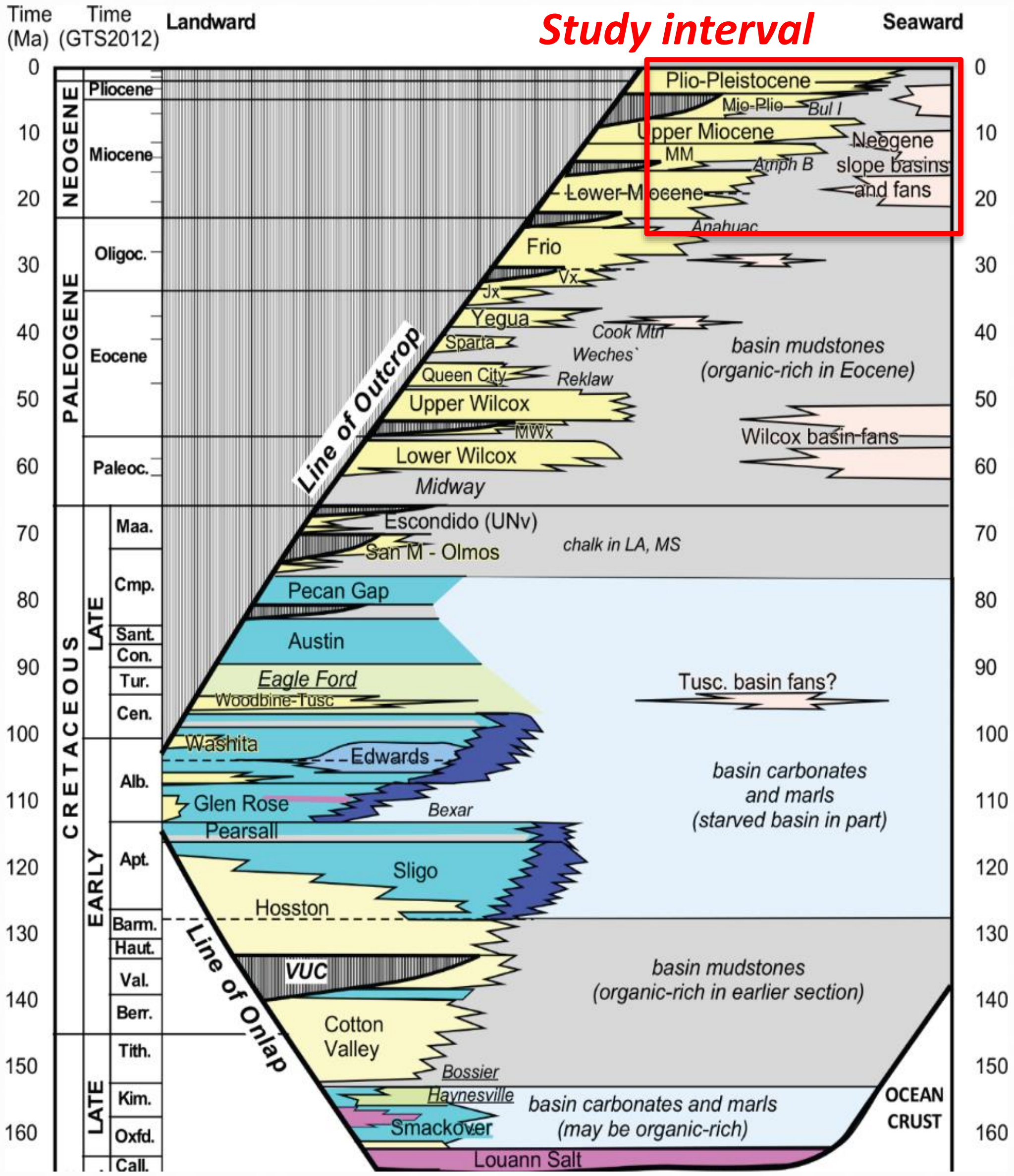


Bathymetric map

Shelf-Slope Transect



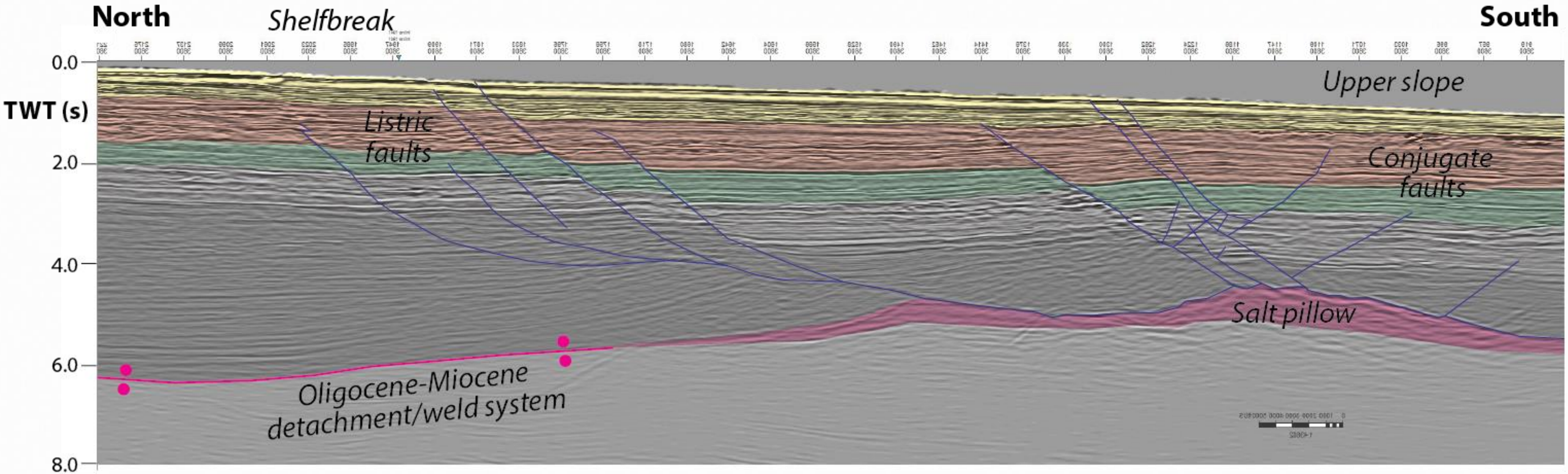
Galloway (2008)



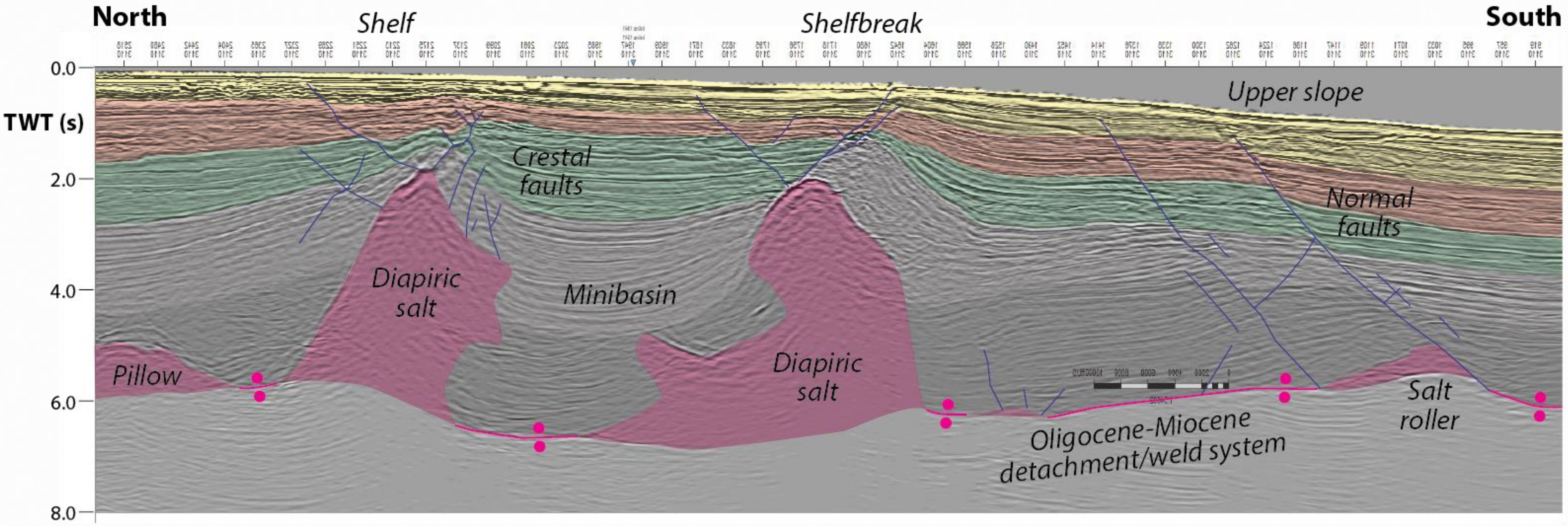
Ewing and Galloway (2019)

SECARB: Offshore

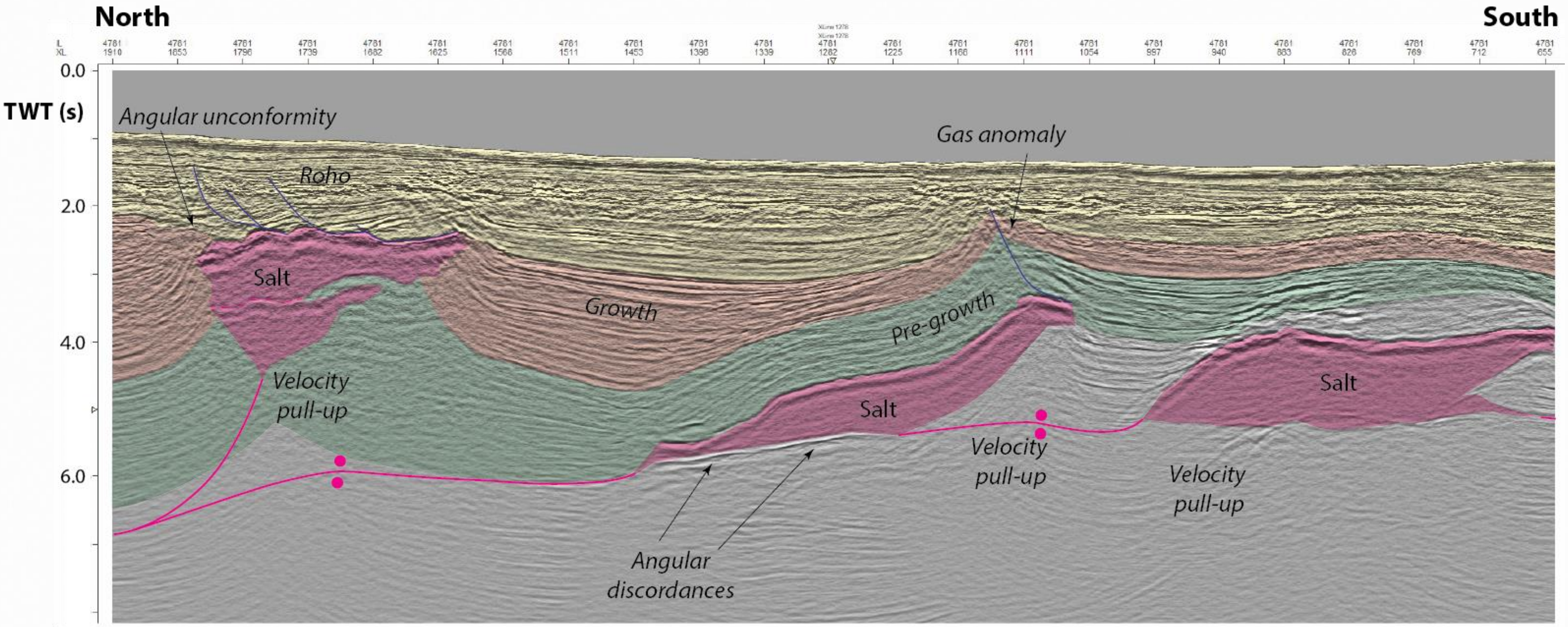
Half Grabens and Salt Pillows, Ewing Bank shelfbreak



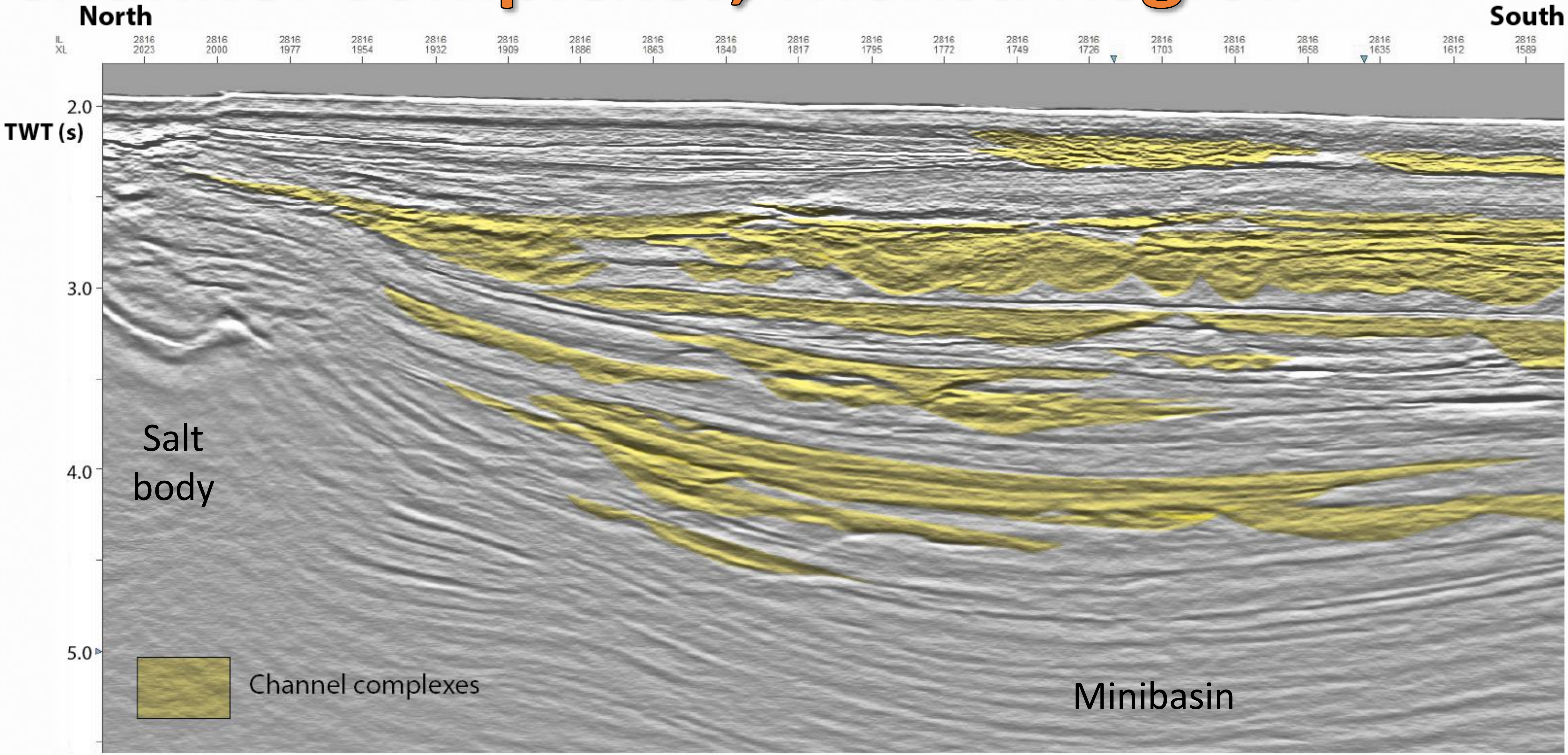
Diapiric Salt Bodies, Ewing Bank Shelfbreak



Mars-Ursa Minibasin Complex



Channel Complexes, Mensa Region



Core Photos

Conglomerate
Thunderhorse Field

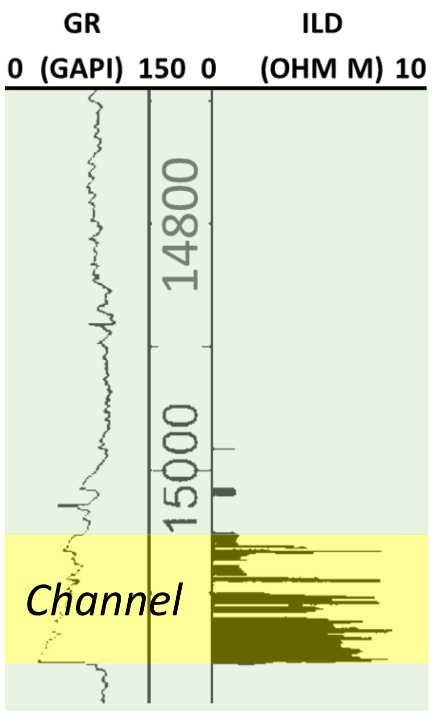
Rippled, Convoluted
Sandstone, GC 18

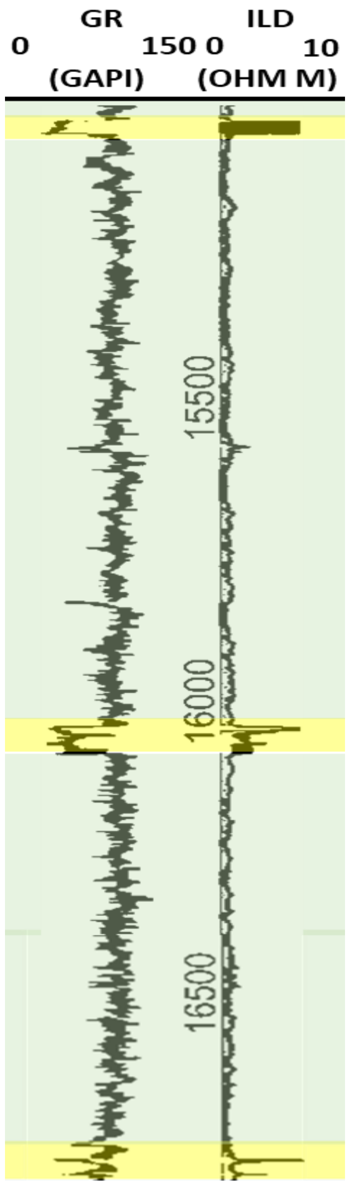
Convolute Mudstone
Thunderhorse Field

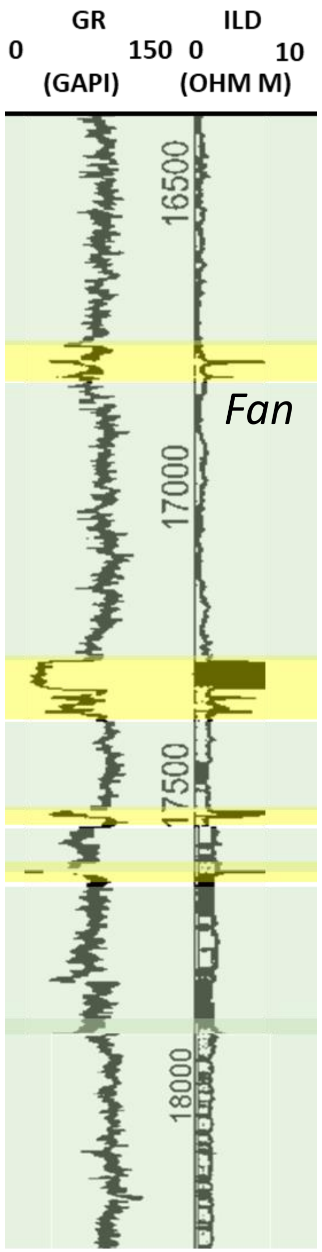
Core diameter = 10 cm
various sources

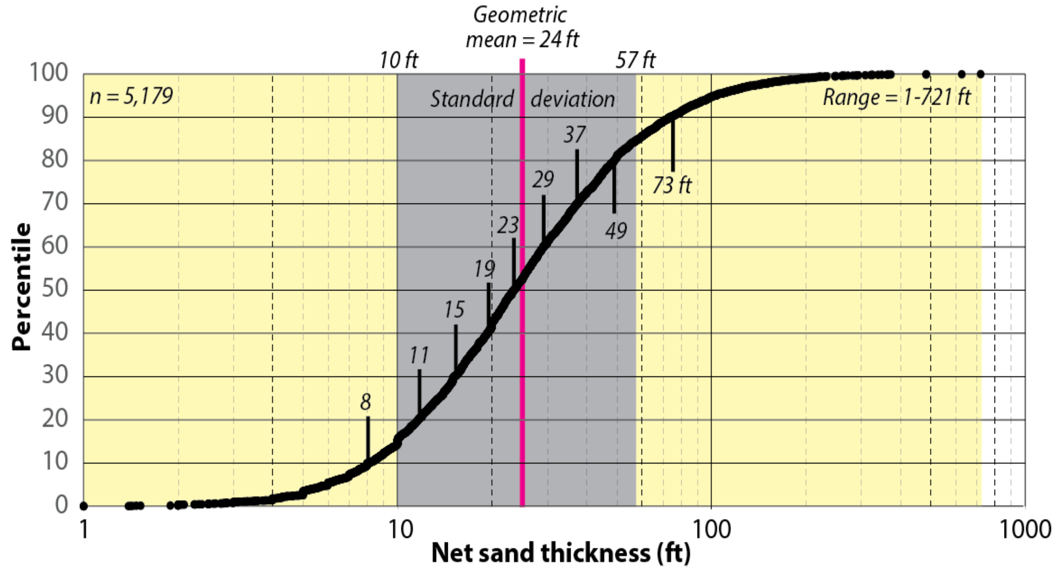
Net Sand Thickness

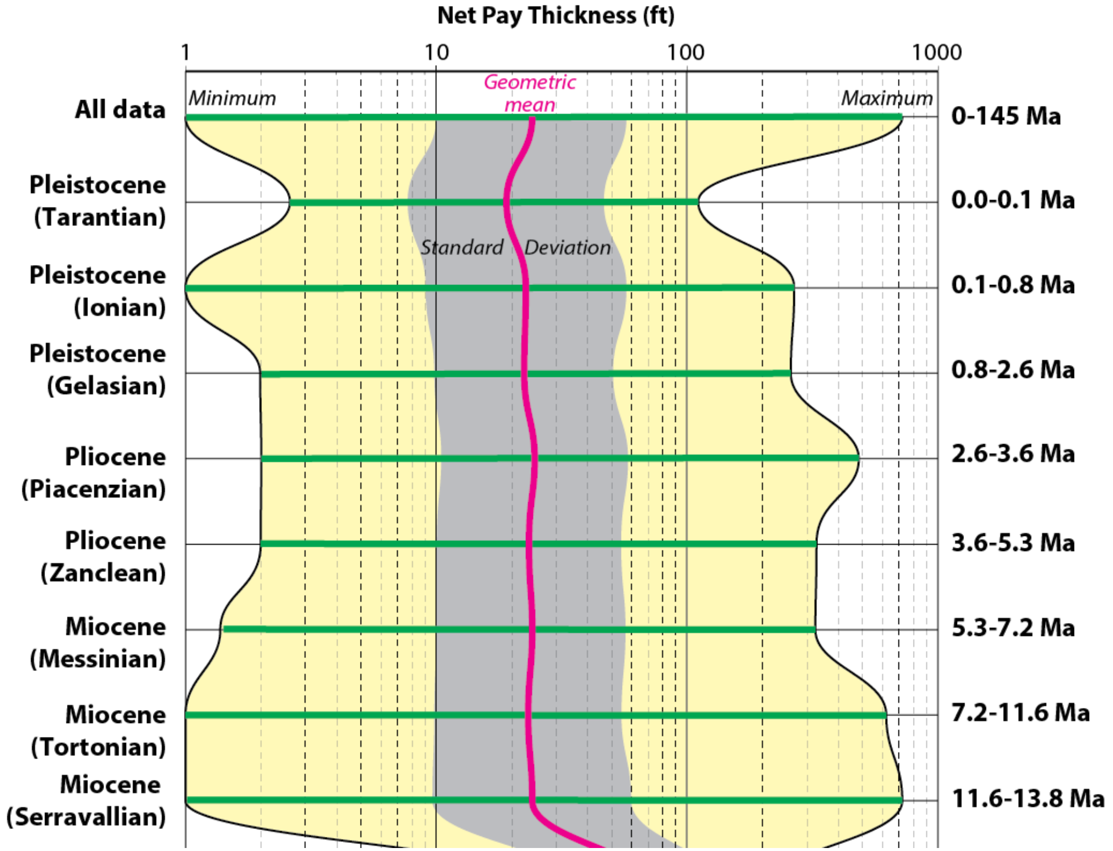
Well logs
Mississippi
Canyon Area



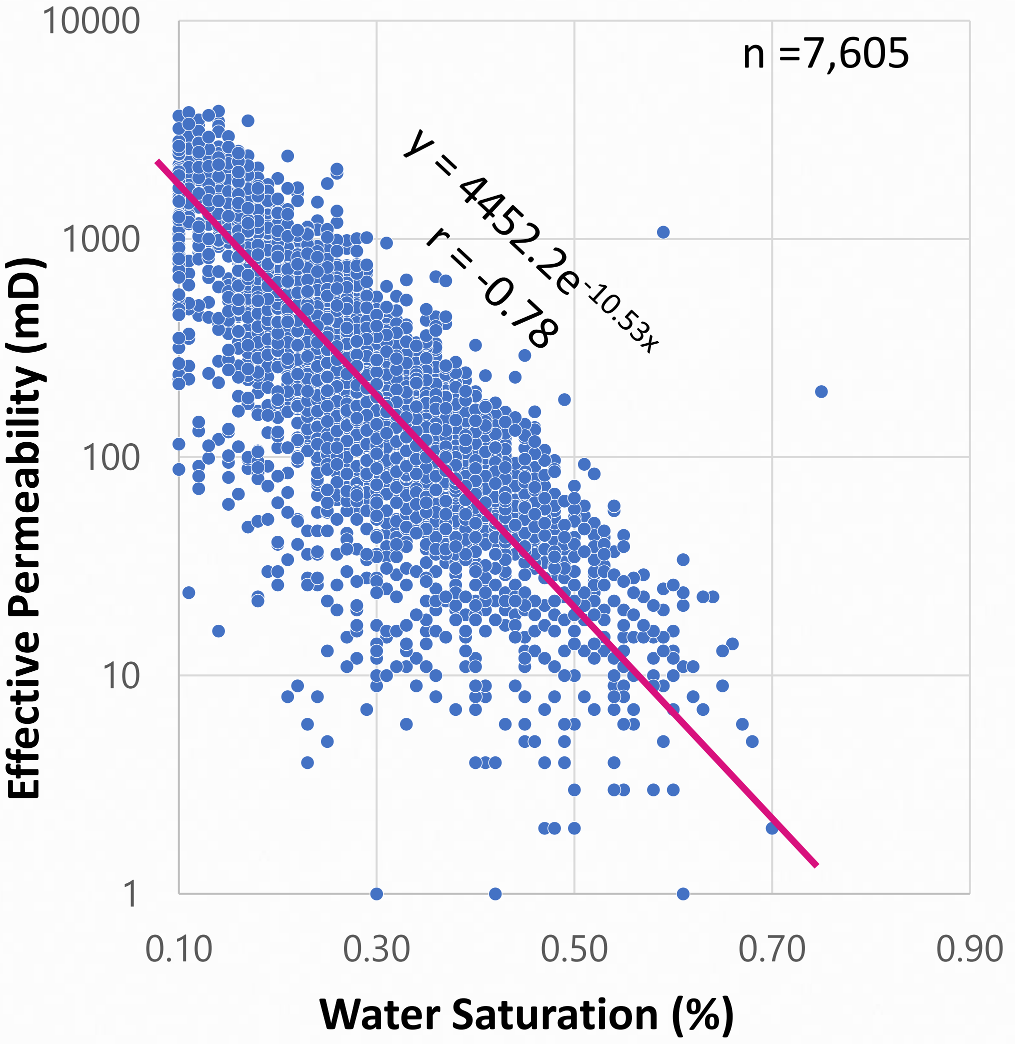


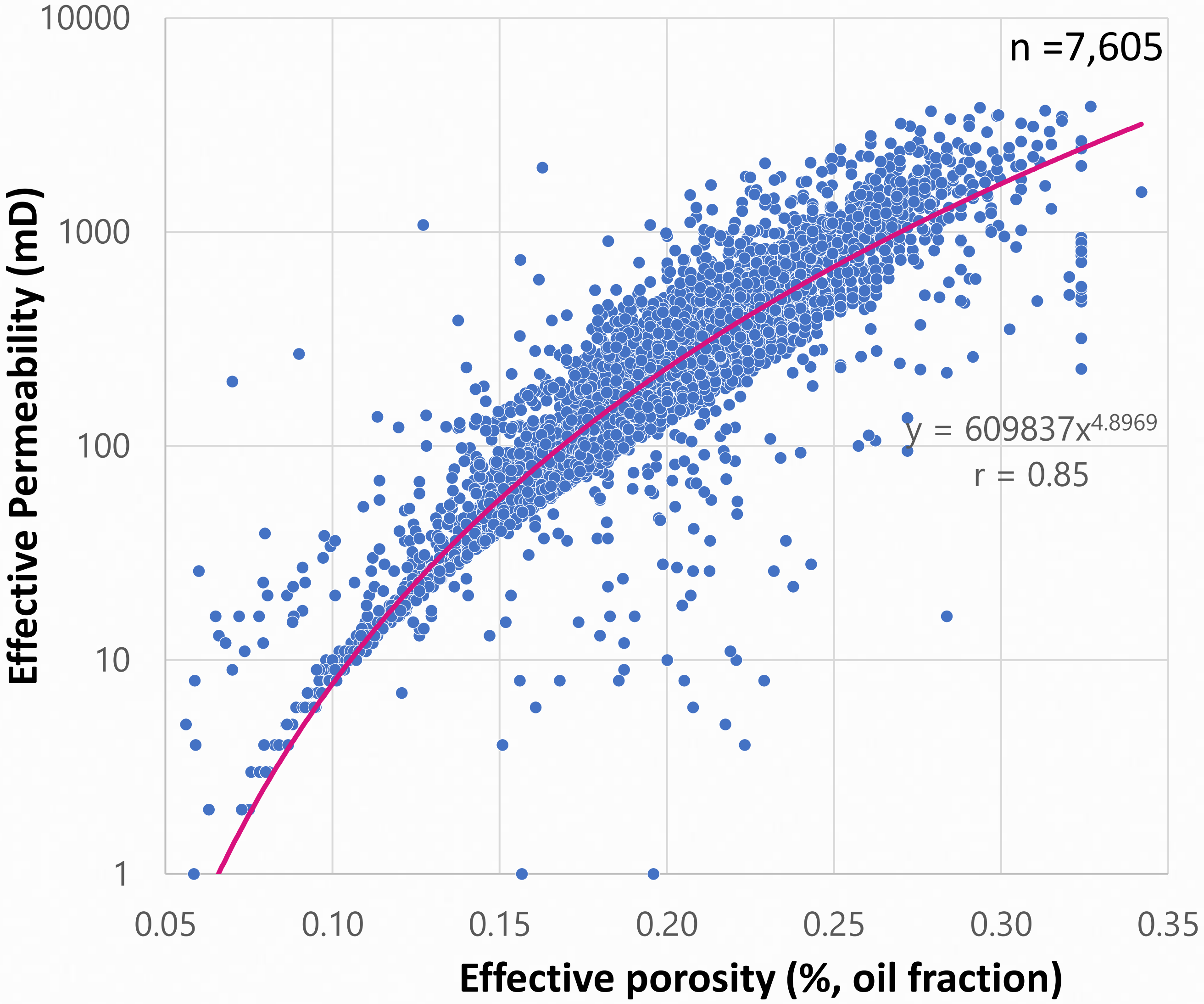






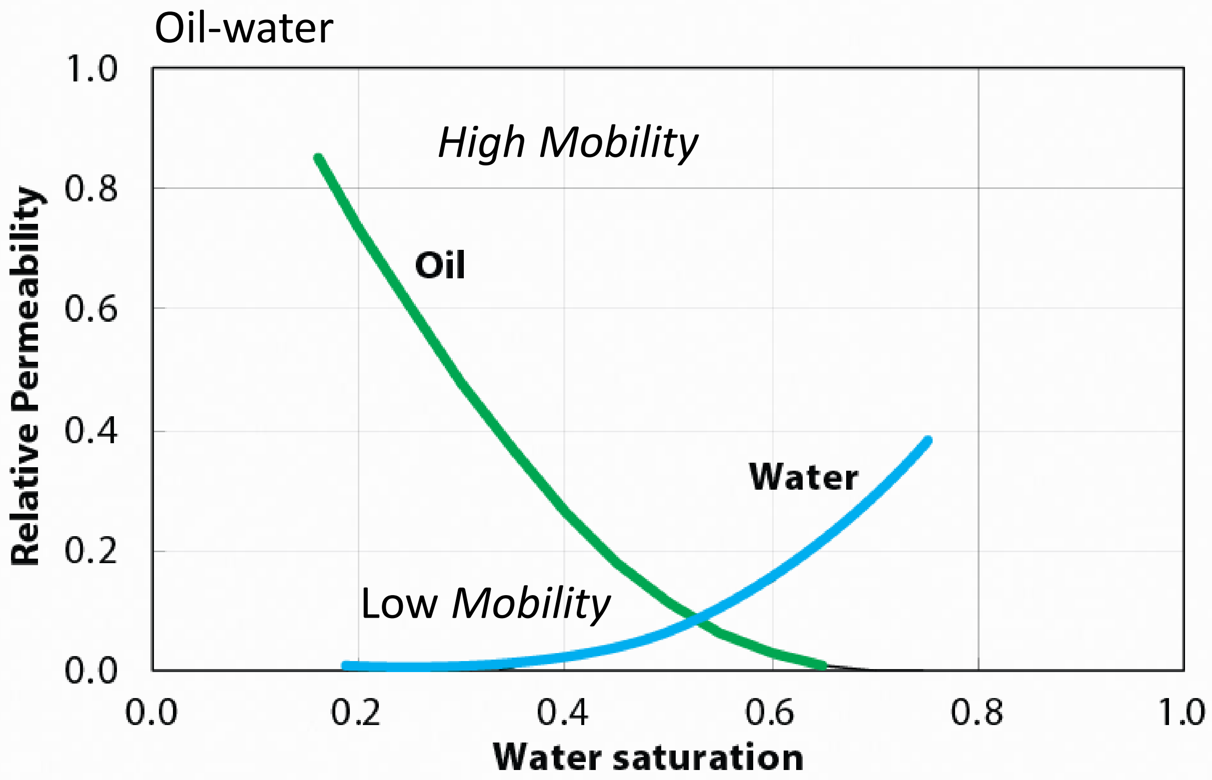
Effective Porosity and Permeability

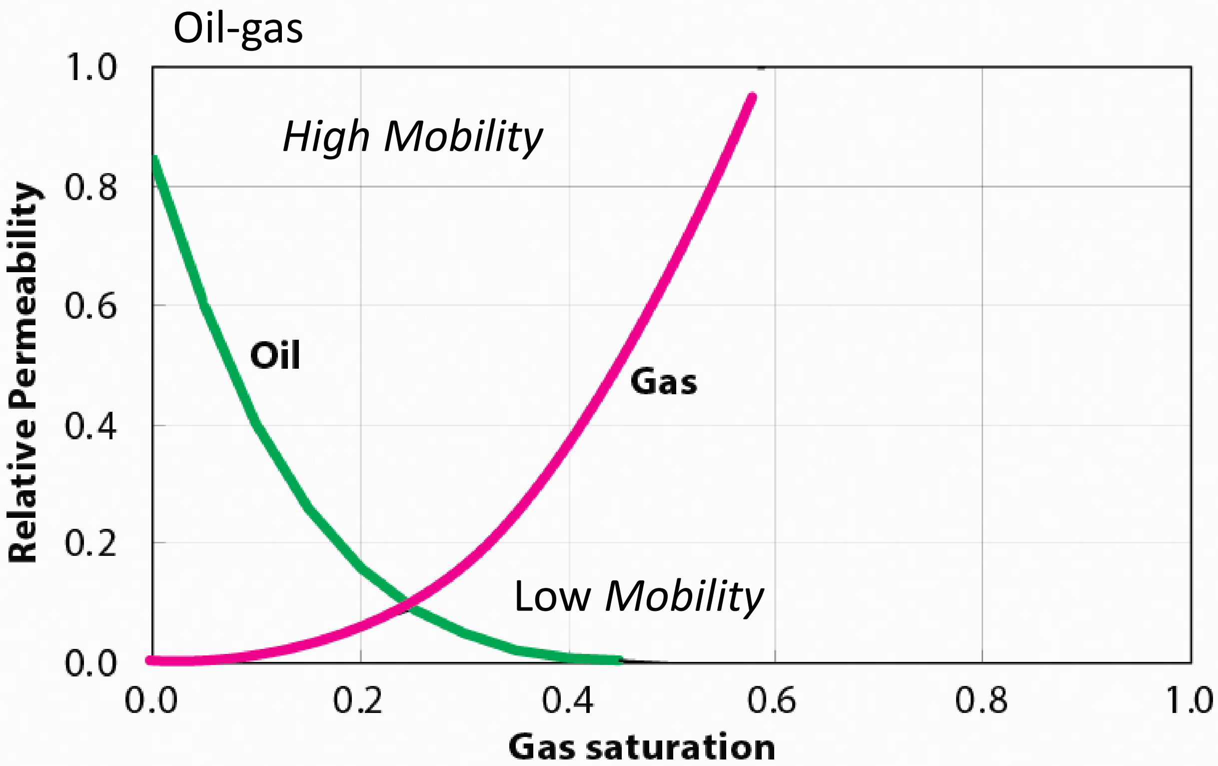




Relative Permeability Curves

Pliocene J1 and J2 reservoirs, Bullwinkle Platform, Green Canyon Block 65

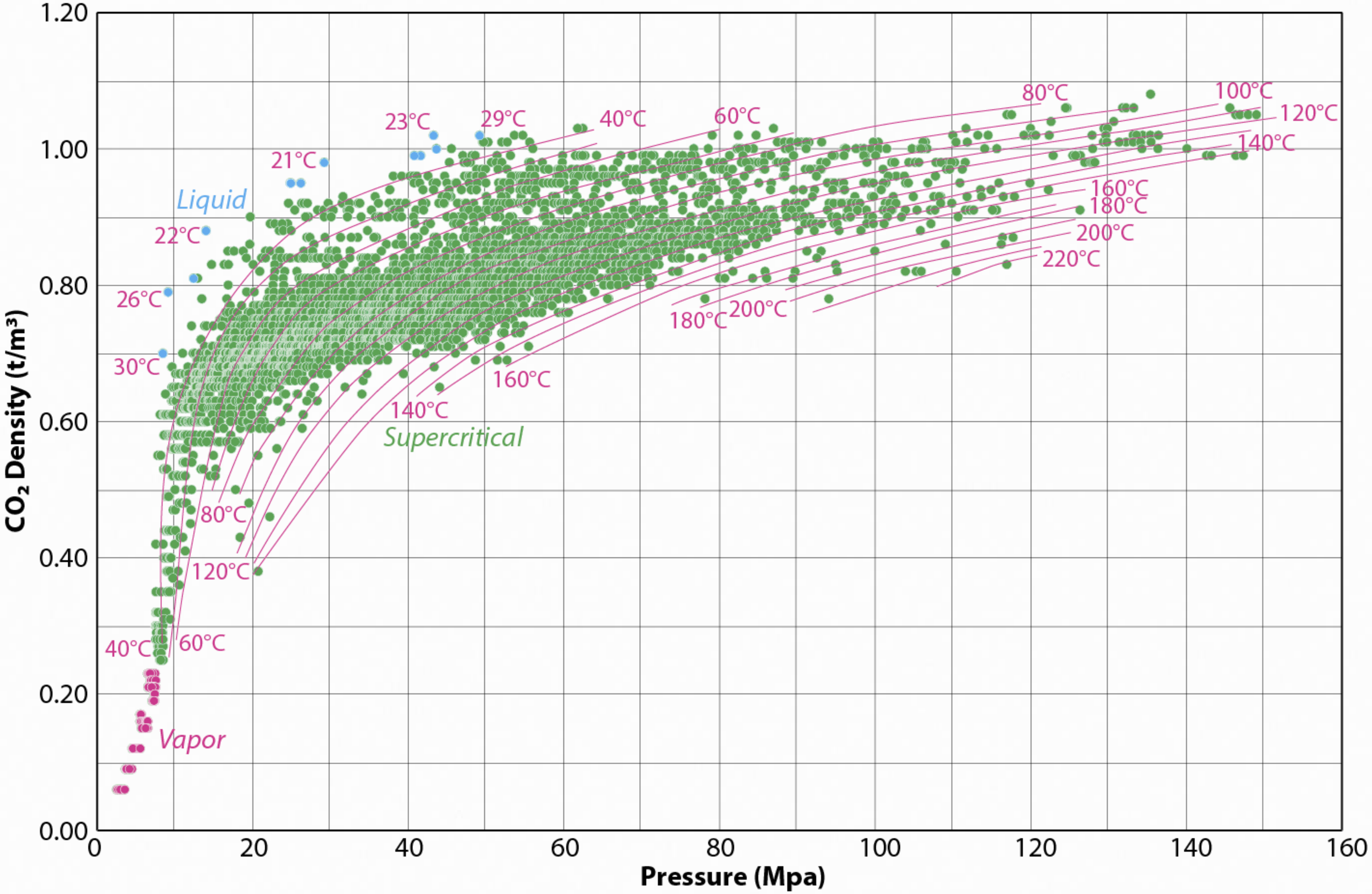




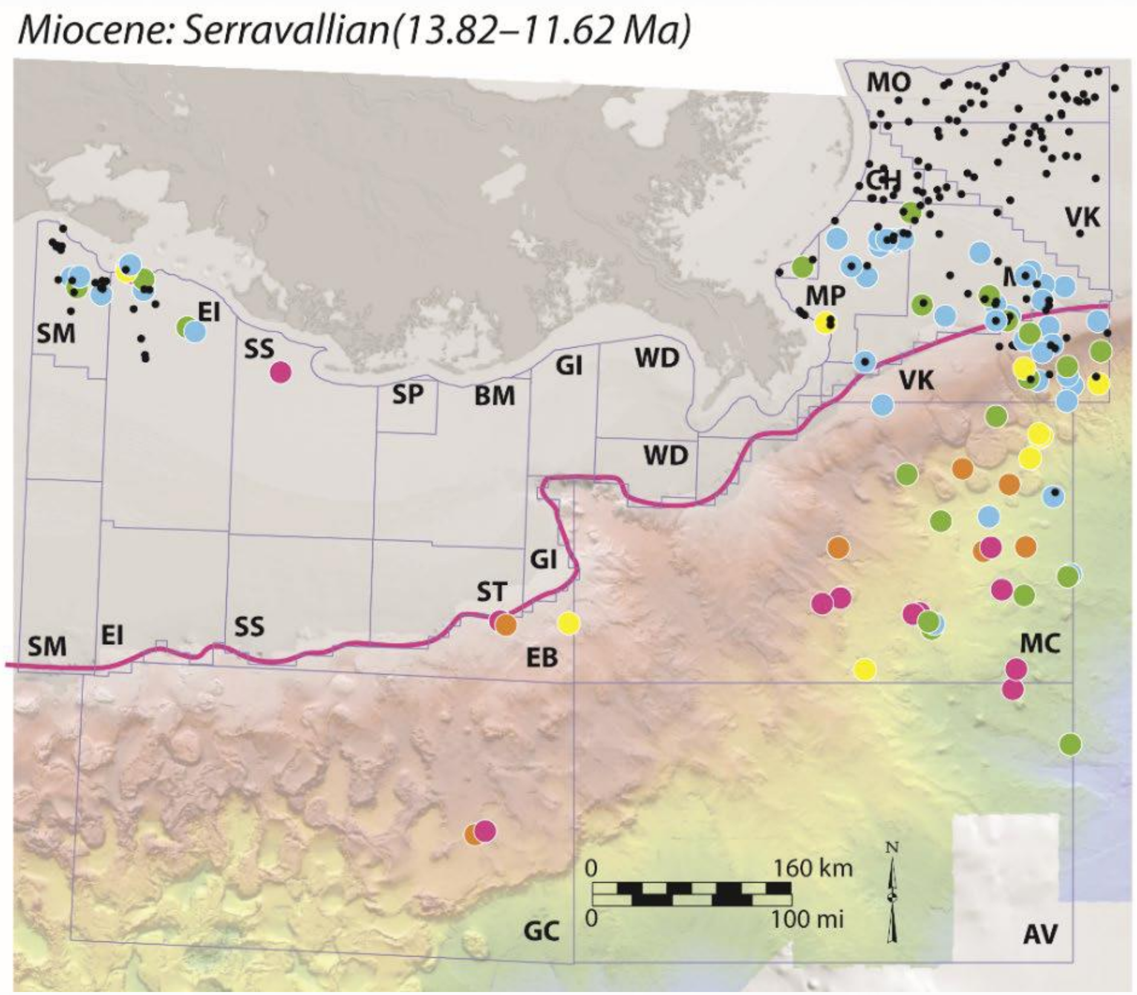
Best (2002)

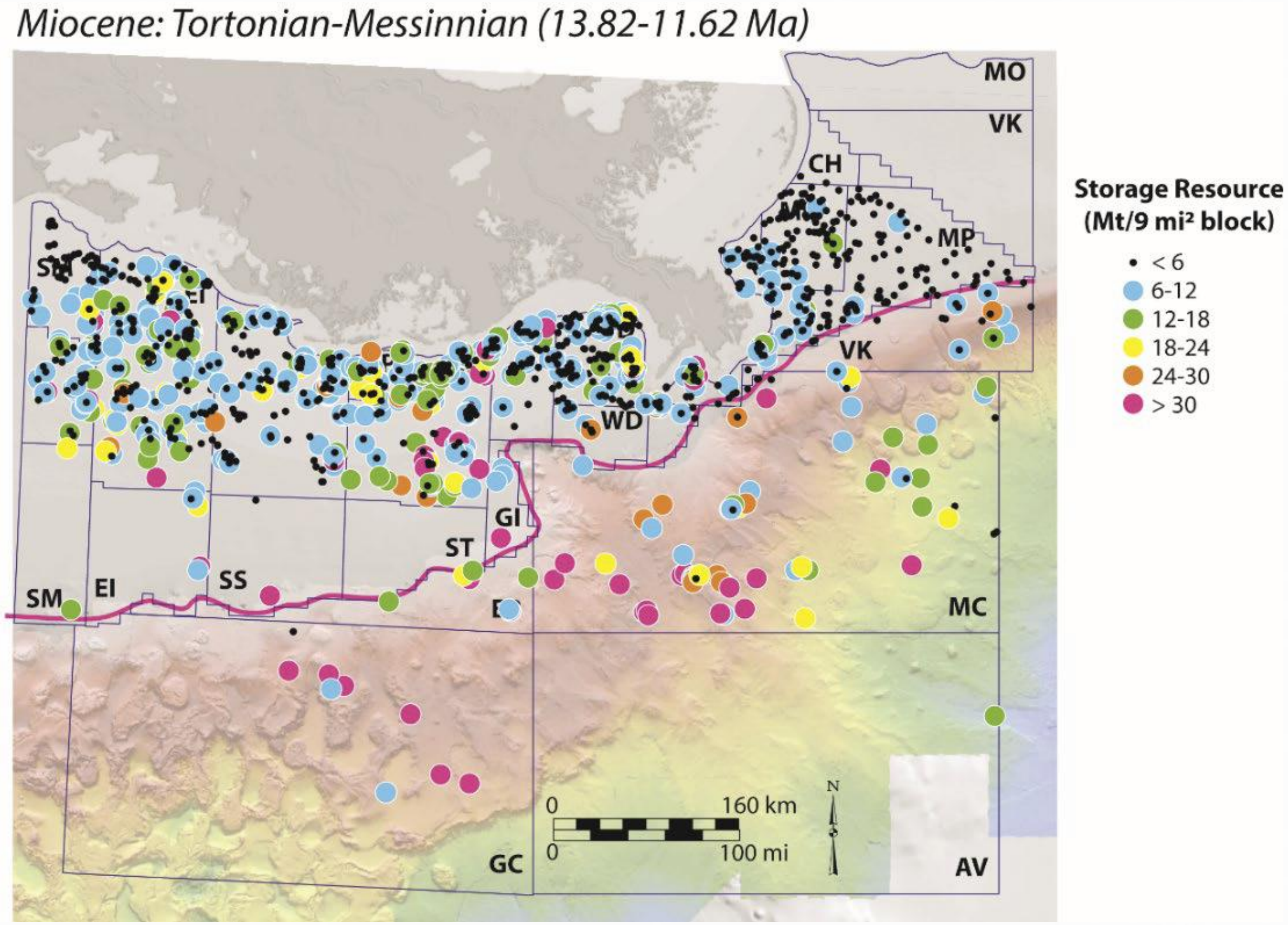
What do relative permeability curves look like in a CO_2 storage system?

CO_2 Density Envelope



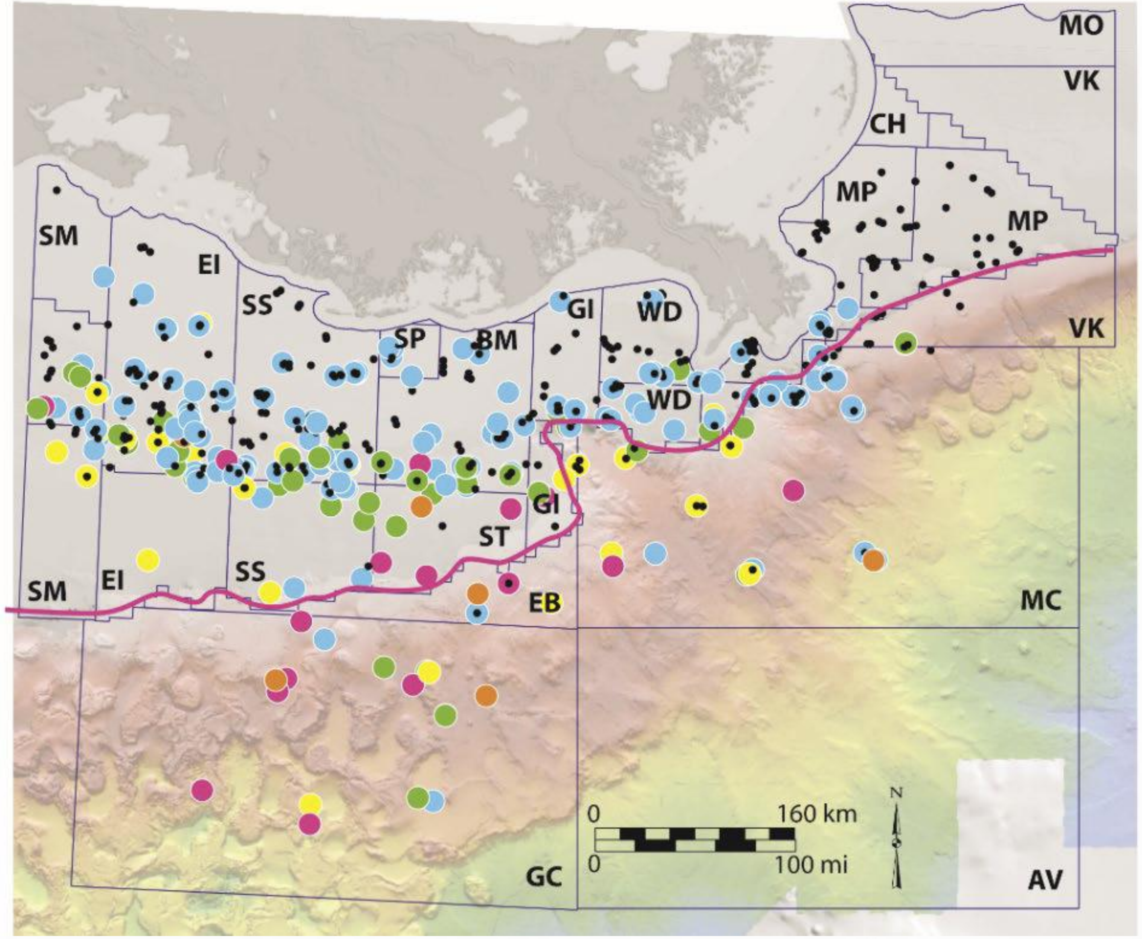
Miocene Hydrocarbon Reservoir Storage Resources



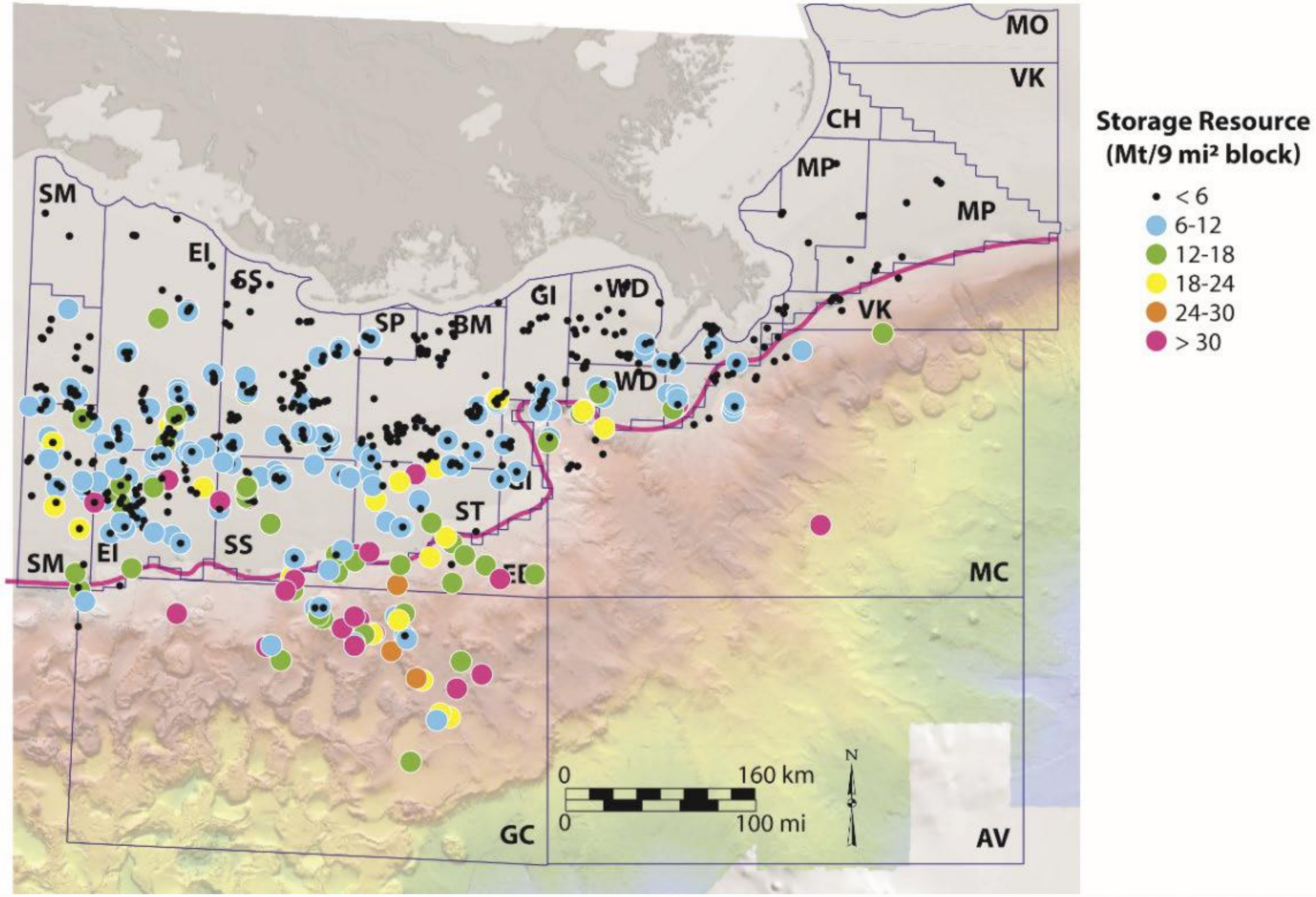


Pliocene Hydrocarbon Reservoir Storage Resources

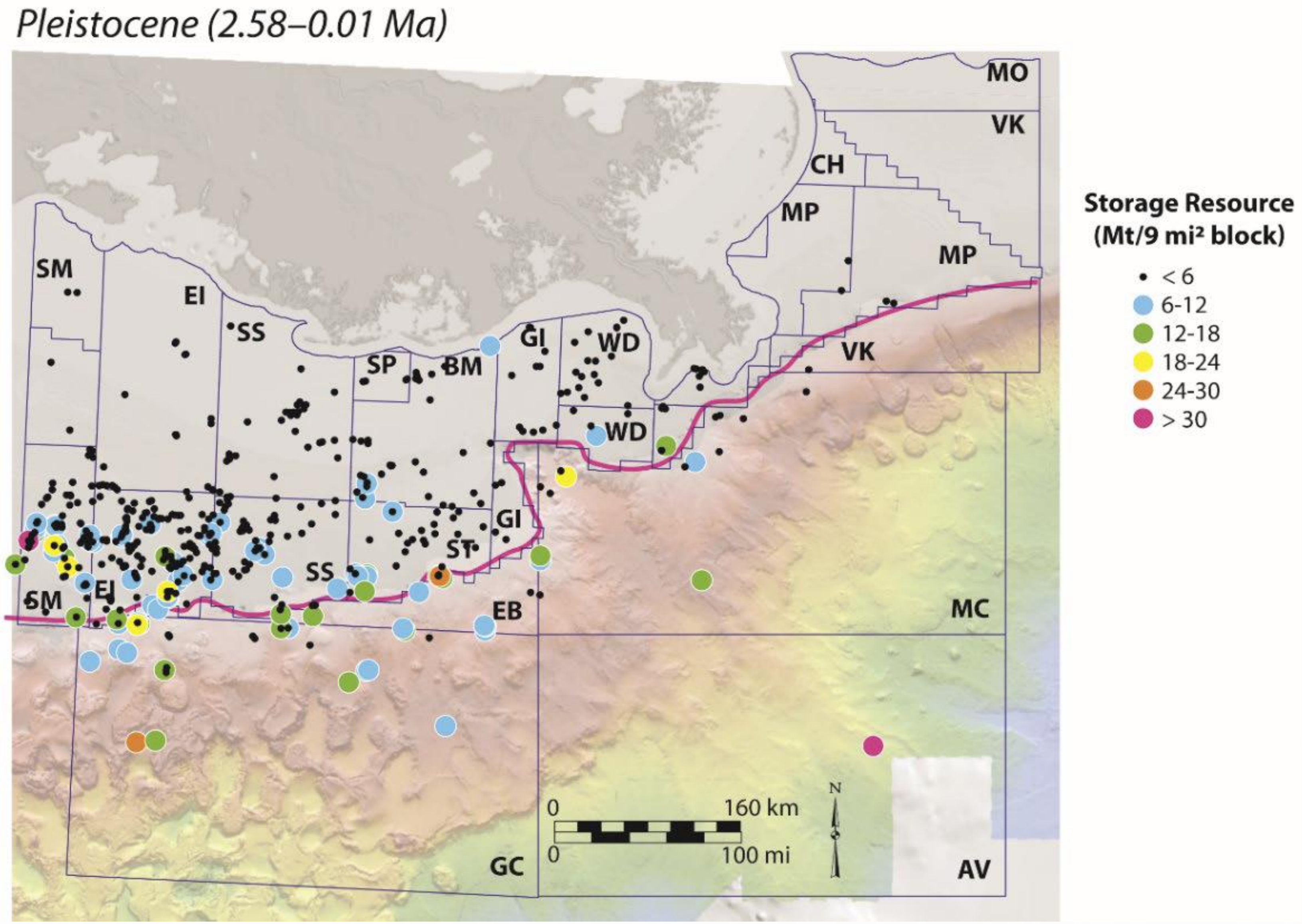
Pliocene: Zanclean (5.53-3.60 Ma)



Pliocene: Piacenzian (3.60-2.58 Ma)



Pleistocene Hydrocarbon Reservoir Storage Resources



Oil Reservoir Storage Resource by Protraction Area

Protraction Area	P_{10}	P_{50}	P_{90}	P_{10}/km^2	P_{50}/km^2	P_{90}/km^2
Bay Marchand	1,550,551,160	2,584,251,934	4,134,803,094	1,546,954	2,578,257	4,125,211
Mississippi Canyon	772,977,200	1,288,295,334	2,061,272,534	2,950,562	4,917,603	7,868,165
Green Canyon	609,044,686	1,015,074,477	1,624,119,163	2,580,931	4,301,552	6,882,484
Eugene Island	442,215,285	737,025,474	1,179,240,759	683,548	1,139,246	1,822,794
Ship Shoal	360,980,194	601,633,656	962,613,849	681,156	1,135,261	1,816,417
South Marsh Island	314,062,852	523,438,087	837,500,939	1,121,755	1,869,591	2,991,346
South Timbalier	281,013,480	468,355,799	749,369,279	741,527	1,235,879	1,977,407
South Pass	233,262,718	388,771,197	622,033,915	960,016	1,600,026	2,560,042
West Delta	221,518,888	369,198,147	590,717,035	590,771	984,618	1,575,388
Grand Isle	210,521,967	350,869,944	561,391,911	997,825	1,663,041	2,660,866
Walker Ridge	156,507,670	260,846,117	417,353,787	7,114,629	11,857,715	18,972,344
Viosca Knoll	154,342,792	257,237,987	411,580,779	3,508,108	5,846,847	9,354,955
Ewing Bank	75,777,570	126,295,949	202,073,519	1,287,939	2,146,565	3,434,504
South Pelto	49,655,485	82,759,142	132,414,627	477,500	795,833	1,273,333
Atwater Valley	11,381,638	18,969,397	30,351,036	1,264,741	2,107,902	3,372,643
De Soto Canyon	4,198,783	163,136,727	261,018,763	1,049,791	1,749,651	2,799,442
Main Pass	770,894	1,284,823	2,055,717	770,964	1,284,940	2,055,903
Breton Sound	616,018	1,026,697	1,642,716	191,250	318,751	510,001
Total	5,449,399,280	9,238,470,889	14,781,553,422			
Eastern Shelf	610,511,311	1,017,518,851	1,628,030,162			
Western Shelf	3,209,000,422	5,348,334,036	8,557,334,458			
Continental Slope	1,629,887,548	2,872,618,001	4,596,188,802			

P_{10} E = 15%
P_{50} E = 25%
P_{90} E = 40%

$P_{10,50,90}/km^2$ values are averages for individual reservoir sands

$$G_{CO2} = Ah\phi(1-S_w)B\rho E$$

Oil Reservoir Storage Resource by Age

Series	Stage	P_{10}	P_{50}	P_{90}	P_{10}/km^2	P_{50}/km^2	P_{90}/km^2
Pleistocene	Gelasian-Tarantian	204,078,297	340,130,494	544,208,791	624,149	1,040,249	1,664,398
Pliocene	Piacenzian	642,473,596	1,070,789,327	1,713,262,922	799,169	1,331,948	2,131,117
Pliocene	Zanclean	641,863,165	1,069,771,942	1,711,635,107	815,656	1,359,427	2,175,083
Miocene	Tortonian-Messinian	1,697,720,705	2,829,534,509	4,527,255,214	1,003,472	1,672,453	2,675,925
Miocene	Serravallian	396,408,492	660,680,819	1,057,089,311	3,848,975	6,414,958	10,263,932
Miocene	Langhian	48,148,914	80,248,190	128,397,104	3,439,519	5,732,532	9,172,052
Miocene	Burdigalian	50,810,357	84,683,929	135,494,287	5,646,106	9,410,177	15,056,283
Cenozoic undiff.		504,304,392	840,507,319	1,344,811,711	9,339,816	15,566,359	24,906,175
Cretaceous	Albian	1,570,657	2,617,761	4,188,418	1,570,799	2,617,998	4,188,797

P_{10} E = 15%
P_{50} E = 25%
P_{90} E = 40%

$P_{10,50,90}/km^2$ values are averages for individual reservoir sands

Observations

- Shelf and slope have numerous storage/enhanced recovery options.
- Abundant high-quality reservoirs and sealing strata.
- Analytical criteria include many aspects of depositional style, structural style, hydrodynamics, geothermics, and routine reservoir properties.
- Fluid saturation and relative permeability important considerations-gas mobility higher in oil than water.
- Broad range of pressure-temperature conditions creates broad CO_2 phase and density envelope.
- Storage resource in oil reservoirs between 5.5 and 14.8 Gt.
- Greatest potential in western shelf and deep water.
- Bulk of storage in Miocene-Pliocene section; different zones prospective in different regions.