Identification of Residual Oil Zones (ROZs) in the Williston and Powder River Basins

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Presentation Outline

- Benefit to the program
- Project overview
- Methodology
- Expected outcomes
- Organizational chart
- Communication plan
- Task breakdown
- Deliverables–milestones–decision points
- Risk
- Proposed schedule
- Summary

Benefit to the Program

- Second and fourth goals of Carbon Storage Program:
  - Improve reservoir storage efficiency while ensuring containment effectiveness.
  - Develop best practices manuals (BPM).
- Potential ROZs will be identified and evaluated for oil recovery and CO_2 storage potential.
- Repeatable methodology will allow others to perform similar assessments in sedimentary basins.

Project Overview:
Goals and Objectives

Objectives:

- Identify and characterize the presence and extent of potential ROZs in the Williston Basin (WB) and Powder River Basin (PRB).
- Estimate residual oil in place and CO_2 storage potential (Goal 2).
- Determine feasibility of CO_2 enhanced oil recovery (EOR) in identified ROZs (Goal 2).
- Develop repeatable methodology for sedimentary basins to be included in a BPM (Goal 4).

Project Overview:
Goals and Objectives, cont.

Success criteria:

- Validated petroleum system models of the WB and PRB complete.
- Milestone 6 – ROZ fairway mapping complete.
- Milestone 7 – Oil and CO_2 storage resource assessments complete.
- Deliverable 4 – Final report, including BPM, complete.

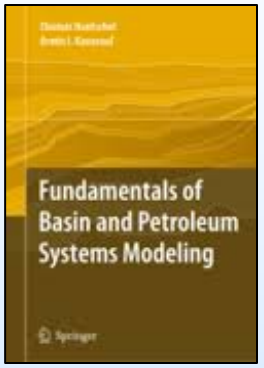
Methodology – Overview

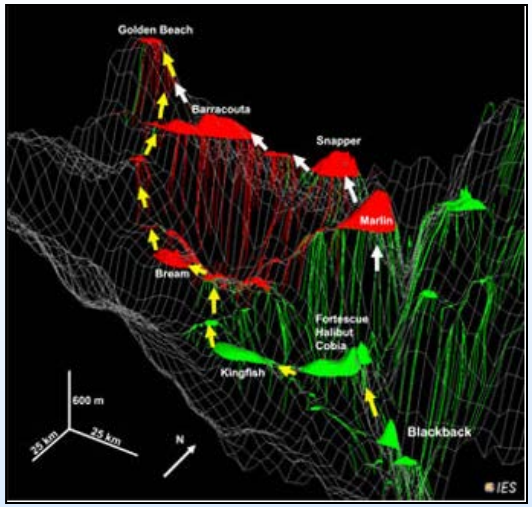
1. Build petroleum system models to integrate all physical aspects (source, trap, seal, reservoir) and time (charge) to identify and quantify hydrocarbon generation, migration, and placement.
2. Use field tools such as pulsed-neutron logs (PNLs) to validate models and presence of ROZs.
3. Build probabilistic fairway maps of each basin.

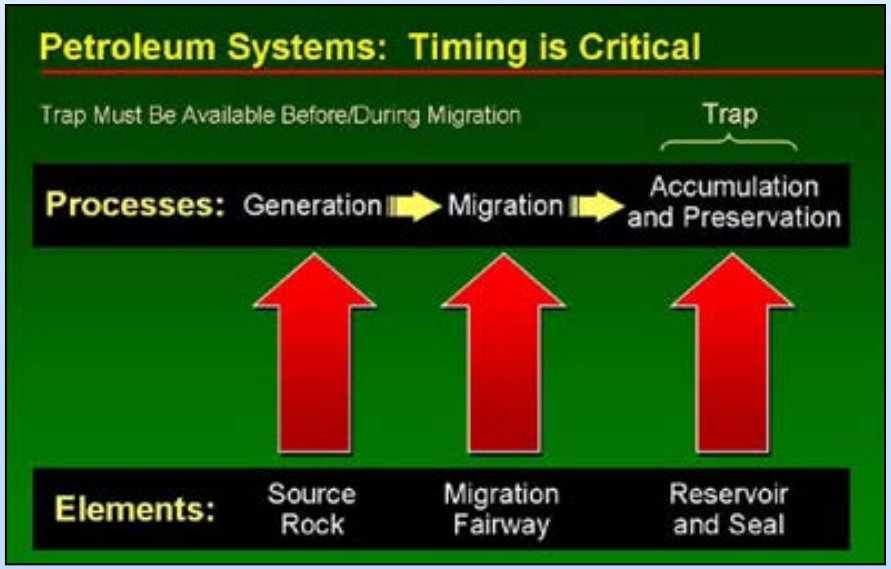
Methodology – Basin Modeling

Provide a complete record of the evolution of a petroleum system, including:

- Deposition and erosion.
- Pressure and compaction.
- Heat flow analysis.
- Petroleum generation.
- Fluid pressure, volume, temperature analysis.
- Reservoir volumetrics.
- Structural evolution.
- Generation, migration, and accumulation.



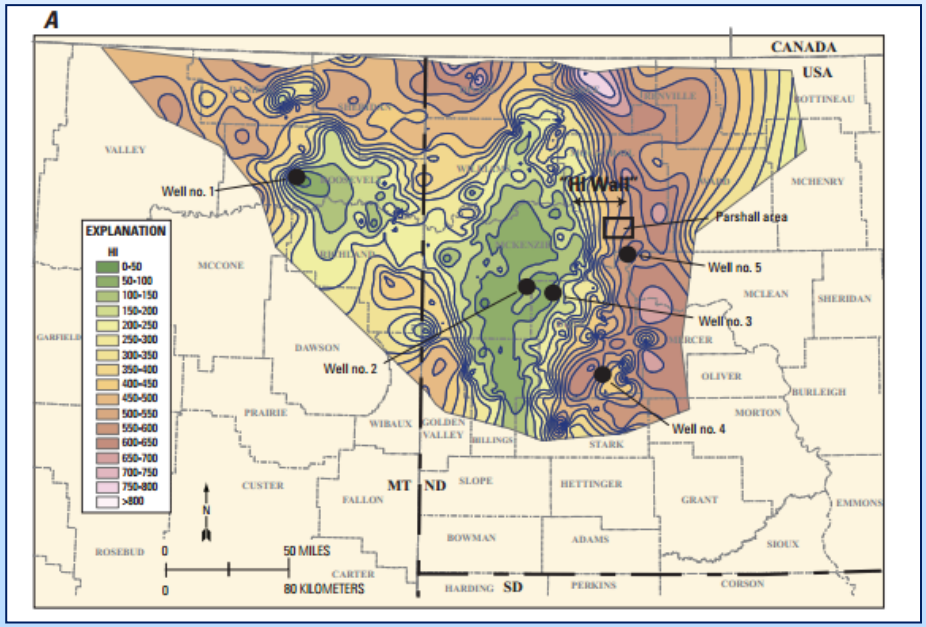


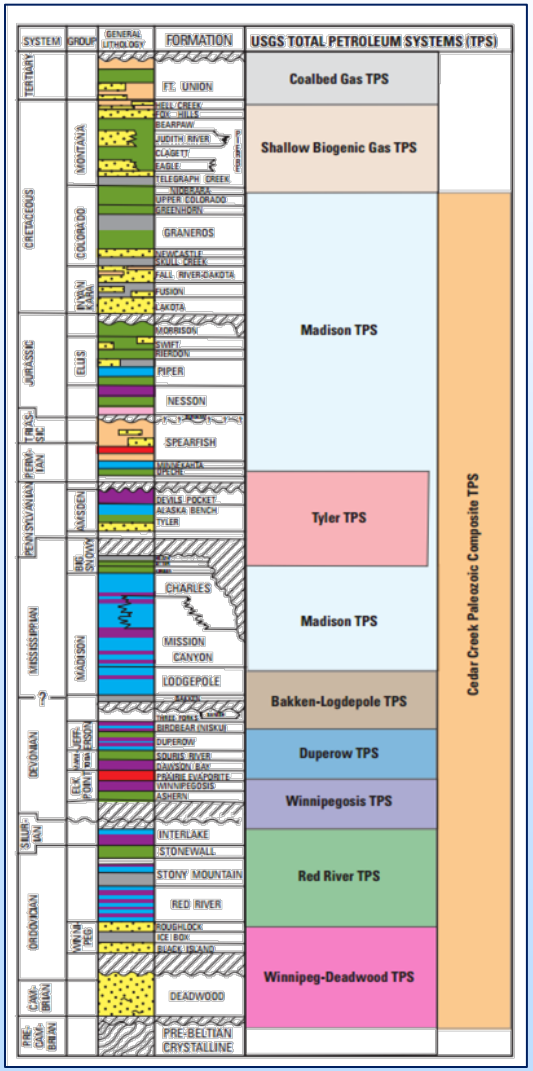


Methodology – Literature Review

Goals:

- Understand ROZs and previous work in basin modeling.
- Translate geologic history of basins as an input for modeling.
- Gather data required for model construction.





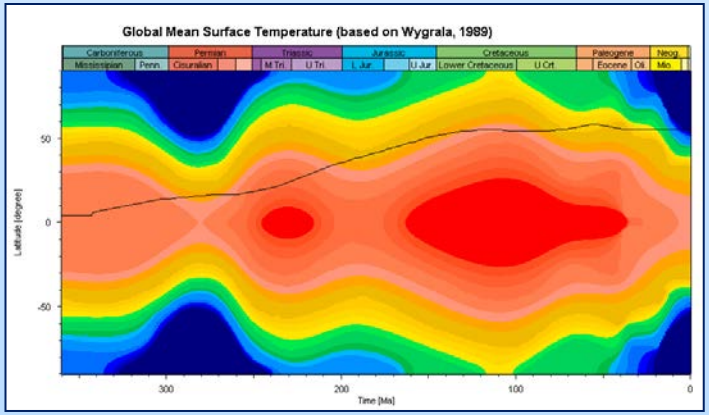
Methodology – 1-D and 2-D Modeling

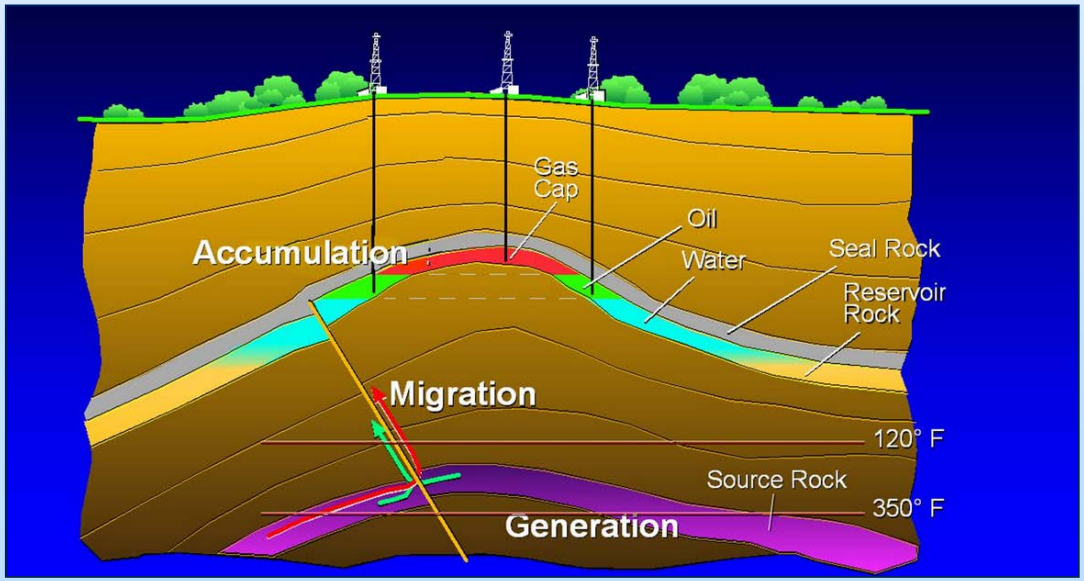
1-D Models:

- Point location examination of:
  - Burial history
  - Temperatures
  - Boundary conditions

2-D Models:

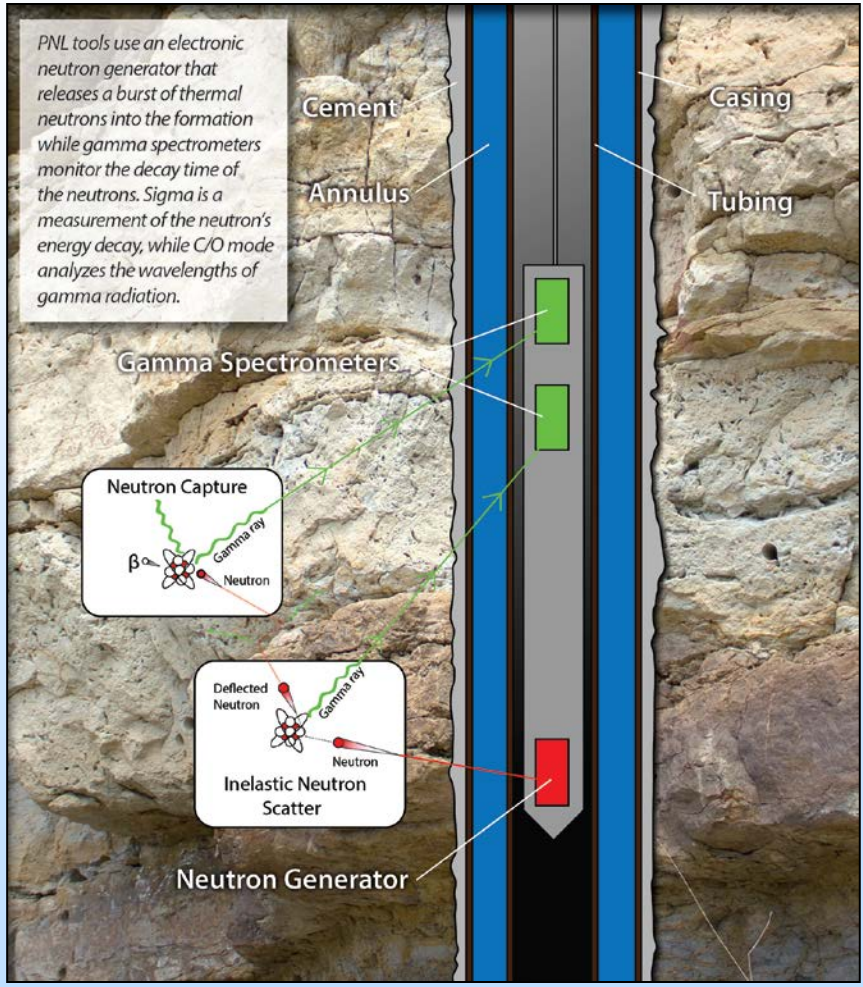
- Rapid cross-sectional analysis to investigate lateral migration





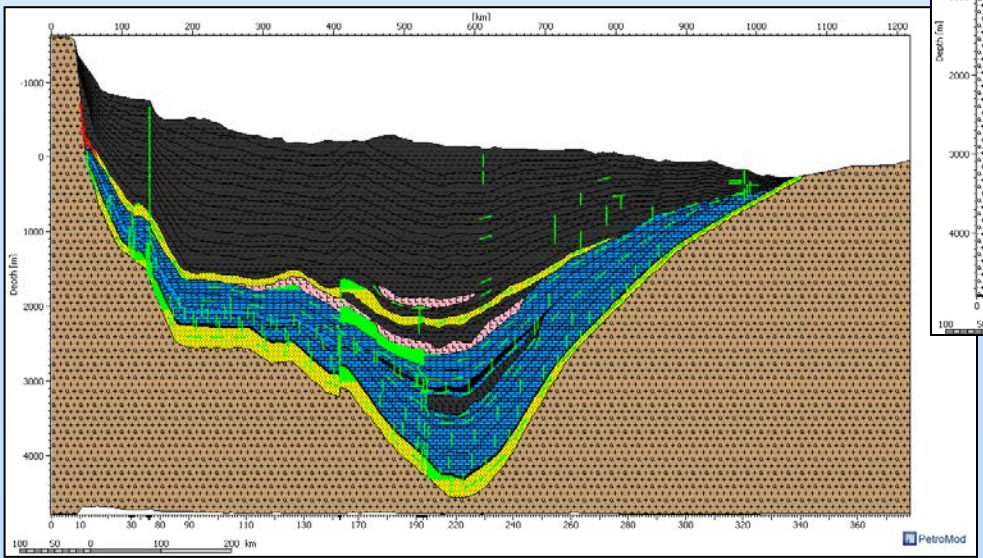
Methodology – Pulsed-Neutron Logging

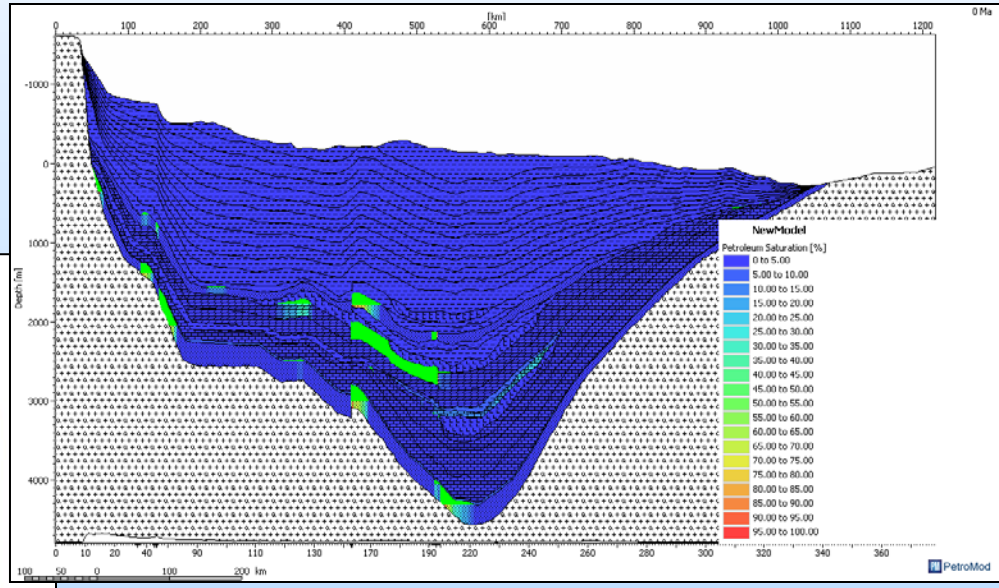
- Up to 20 wells (total for both basins) chosen based on 2-D modeling results.
- Wireline logging measurement:
  - Sigma (rate of capture of thermal neutrons).
- Means of model validation:
  - Provides gas and fluid saturations, pressure and temperature profiles, and formation lithology.



Methodology – Update 2-D Models

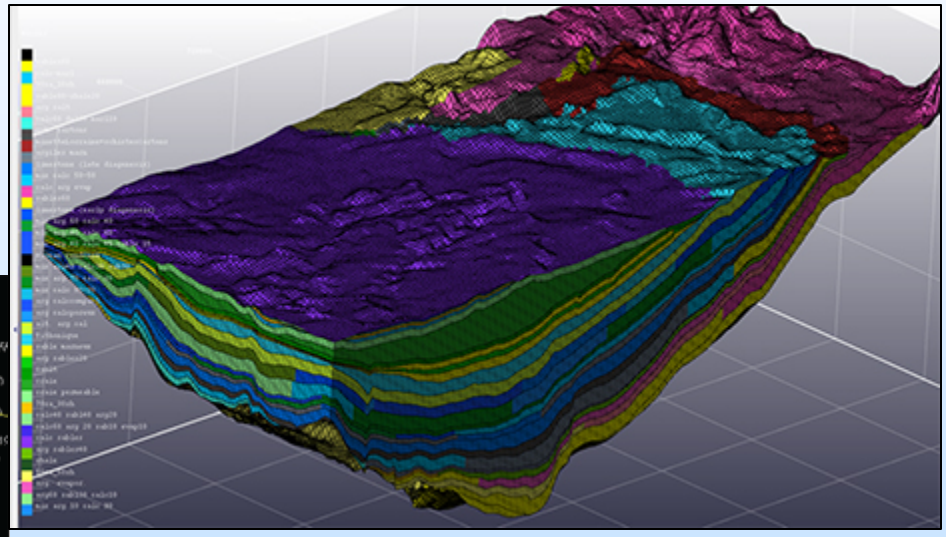
- Using processed PNLs, the 2-D cross-sectional models will be updated to reflect the actual field results.
- Provides model calibration and validation before building more complex 3-D models.



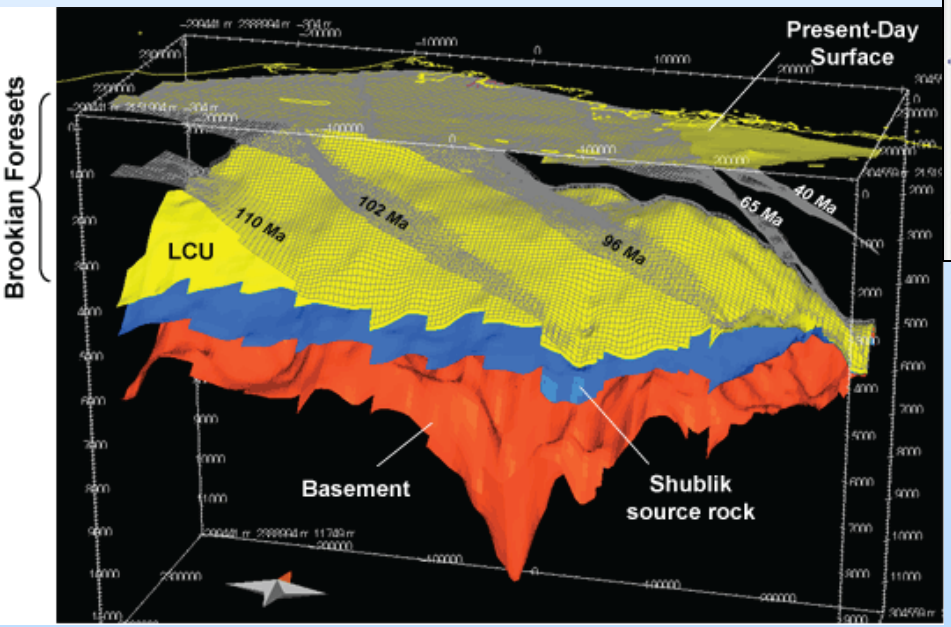


Methodology – 3-D Models

- Robust basin analysis that provides more detail than a simplified 2-D model.



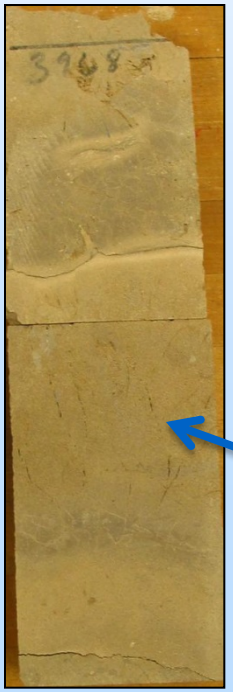
www.brgm.eu



Energy.usgs.gov

Methodology – Select Submodels

- Select regions of interest will be further examined to investigate:
  - Salt movement.
  - Hydrogen sulfide existence.
  - Free sulfide migration.



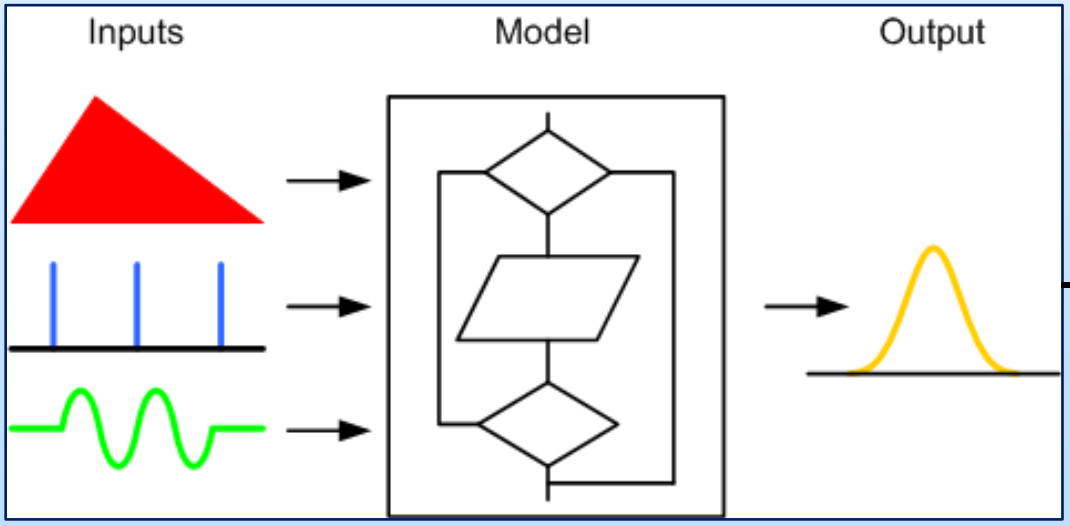
Expulsion Cracks

Free Sulfur

Noncontinuous Oil Staining

Methodology – Risk Analysis

- Uncertainty analysis using Monte Carlo simulations will be performed to better understand the impact of key variables.
- Range of data for each variable will come from literature review database.
- Probabilities, confidence intervals, error bars, correlations, and calibration will be considered to find the best model fit.
- High-, mid-, and low-probability models will be used in fairway mapping.



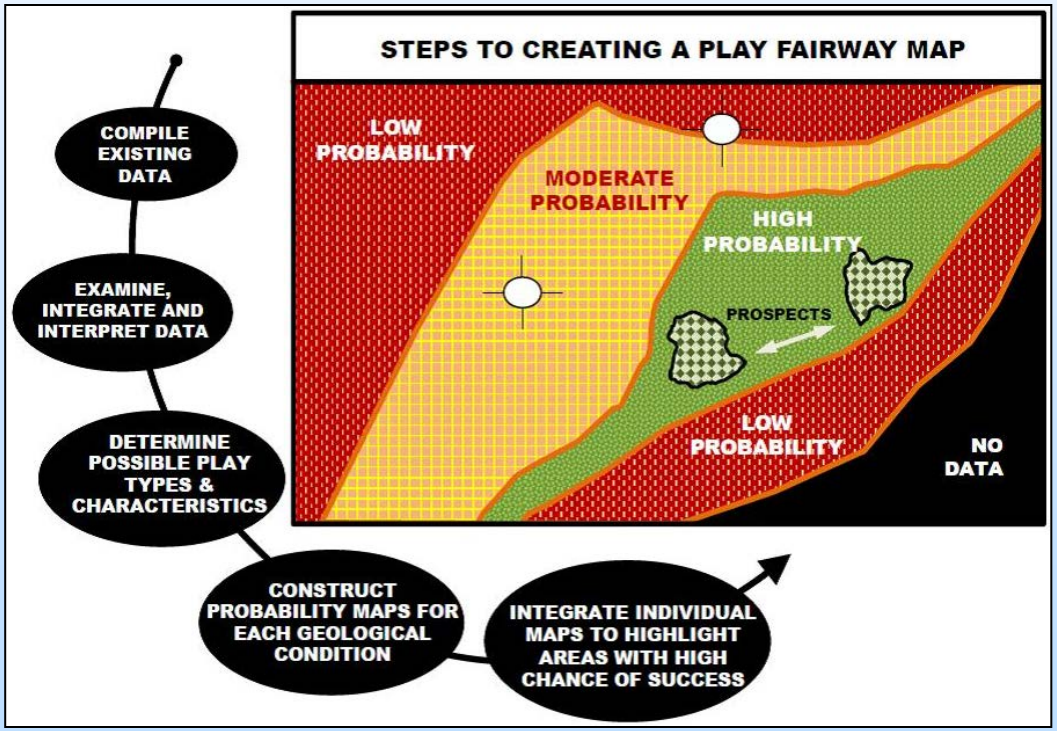
http://www.brighton-webs.co.uk/montecarlo/simulation.aspx

Analyze

- Histograms
- Tornado plots
- Cross plots
- Distributions

Methodology – ROZ Fairway Mapping

- Create play fairway maps showing discovered brownfield and greenfield ROZs.
- Display high, mid, and low probabilities.



Methodology – CO_2 EOR Feasibility Study

- Analyze potential ROZs to determine feasibility for enhanced recovery using CO_2.
- Use published ranges for recovery and utilization factors for conventional CO_2 EOR projects.
- Make high, mid, and low estimates.

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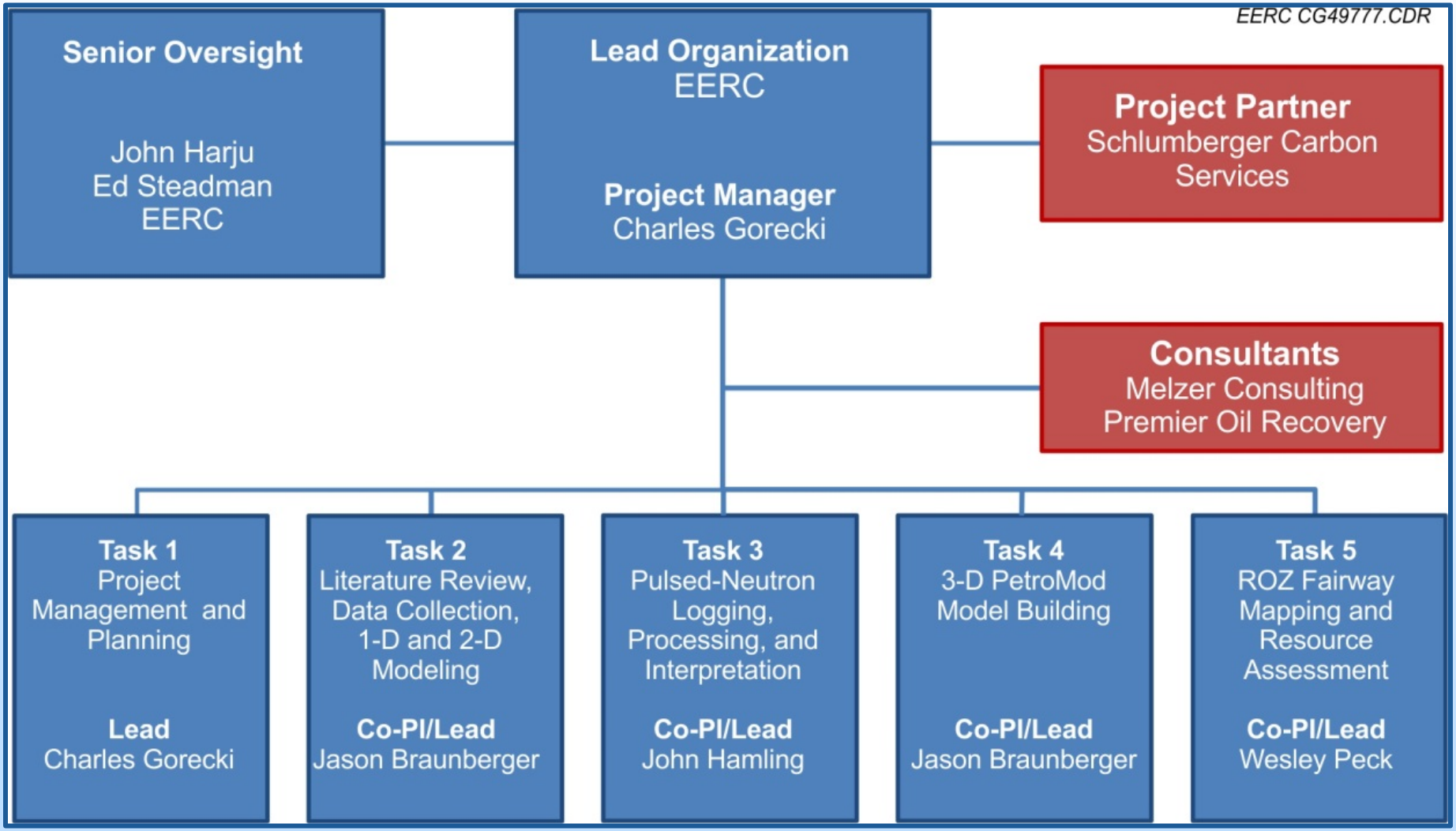
Expected Outcomes

- Petroleum system models for the WB and PRB.
- Oil in place and CO_2 storage recourse estimates for identified potential ROZs.
- ROZ play fairway maps.
- A repeatable methodology that could be applied to other sedimentary basins around the United States presented in BPM.

Organization Chart/ Communication Plan



Communication Plan

- Regular update meetings with project team.
- Communication with partners/consultants via conference call, e-mail, Webinar, and in-person meetings.
- Quarterly reports and annual briefings to DOE.
- Major decisions affecting scope, budget, or time line will be discussed with DOE project manager.

Task 1:
Project Management and Planning

Includes management and reporting on the project, NEPA compliance, and submission of data to the Energy Data Exchange (EDX):

- *Subtask 1.1 – Perform Project Management*
  - Subtask 1.1.1 – Project Management Plan
  - Subtask 1.1.2 – Provide Briefings and Ensure NEPA Compliance

- *Subtask 1.2 – Project Reporting*
  - Subtask 1.2.1 – Project Reporting
  - Subtask 1.2.2 – Data Submission to NETL EDX

Task 2: Literature Review, Data Collection, and Simulation of 1-D and 2-D PetroMod Models

- *Subtask 2.1 – Literature Review and Data Collection*
  - Literature review will be performed to understand existing work on ROZs and to collect various data on the WB and PRB. Wells will be selected for the field work in Task 3.

- *Subtask 2.2 – Build Dynamic1-D PetroMod Models*
  - 1-D models will be constructed and simulated using the data and wells found in Subtask 2.1.

Task 2: Literature Review, Data Collection, and Simulation of 1-D and 2-D PetroMod Models, cont.

- *Subtask 2.3 – Build Dynamic 2-D PetroMod Models*
  - The 1-D models will be used to build 2-D models in order to reconstruct hydrocarbon generation and migration.

- *Subtask 2.4 – Recalibrate, History-Match, and Simulate 2-D PetroMod Models Based on Field Logging Interpretation*
  - Selected 2-D models will be updated based on PNL interpretations. This Subtask will be iterative until field work is complete.

Task 3: Pulsed-Neutron Logging, Processing, and Interpretation

- *Subtask 3.1 – Planning and Preparation*
  - Six to 20 wells will be selected based on Task 2. Operators will contacted for well access.

- *Subtask 3.2 – Pulsed-Neutron and Temperature Logging Operations*
  - PNLs will be collected in wells within potential ROZs identified in Task 2. Processing and interpretation will provide fluid saturations, neutron porosity, and temperature.

Task 4: Build 3-D PetroMod Models

- *Subtask 4.1 – Build, Calibrate, History-Match, and Simulate 3-D PetroMod Models*
  - 3-D models will be built and simulated to better understand oil generation and migration in the WB and PRB.

- *Subtask 4.2 – Select Submodels for Evaluation of Salt Movement, Hydrogen Sulfide Existence, and Free Sulfide Migration*
  - Regions of interest determined from Tasks 2 and 3 will be examined through a comprehensive hydrogeology, structural, and geochemical history to help predict potential ROZ extents and hydrocarbon volumes.

Task 4: Build 3-D PetroMod Models, cont.

- *Subtask 4.3 – Perform Risk Analysis*
  - An uncertainty analysis using Monte Carlo simulations will be performed to examine the influence of each key variable used in the simulation of 3-D PetroMod models. This analysis will enhance the probabilistic ranking of economic ROZs.

Task 5: ROZ Fairway Mapping, Volumetric Resource Estimates, and Preparation of Methodology to Be Used in Other Basins

- *Subtask 5.1 – Build, Calibrate, History-Match, and Simulate 3-D PetroMod Models*
  - Greenfield ROZ fairway extent and saturation maps will be created. Varying levels of confidence and high, mid, and low oil in place values will be incorporated.

- *Subtask 5.2 – CO_2 EOR Feasibility Study*
  - CO_2 EOR feasibility will be assessed for each ROZ based on residual oil saturations and oil properties. CO_2 storage resource potential will also be estimated for the identified ROZs.

Deliverables – Milestones – Decision Points

Task/ Subtask	Milestone Title	Planned Completion Date	Verification Method
1.2	D1 – Updated Project Management Plan (PMP)	12/31/14	PMP file
1.1	M1 – Project Kickoff Meeting Held	1/31/15	Presentation file
1.2	D2 – Project Fact Sheet	2/28/15	Data for project fact sheet
2.2	M2 – First Cross Section of 1-D Model Completed	2/28/15	Reported in subsequent quarterly report
2.3	M3 – Potential ROZ Identified	6/30/15	Reported in subsequent quarterly report
3.2	M4 – First PNL Interpretation Completed	9/30/15	Reported in subsequent quarterly report
1.2	D3 – Data Submission to EDX	4/30/16 10/31/17	Data uploaded to EDX
3.2	M5 – First PNL Collection Completed	4/30/16	Reported in subsequent quarterly report
4.3	M6 – Risk Analysis Completed	1/31/17	Reported in subsequent quarterly report
5.2	M7 – Resource Assessment Completed	6/30/17	Reported in subsequent quarterly report
1.1	M8 – Debriefing Meeting with Operators Held	8/31/17	Reported in subsequent quarterly report
1.2	D4 – Final Report (including a BPM)	10/31/17	Final Report submitted

D = Deliverable
M = Milestone

Deliverables – Milestones – Decision Points, cont.

- Sufficient data to construct 1-D and 2-D models
- 2-D models required for selection of wells for field work
- Go/No-Go Decision Point:
  - Before the collection of PNLs (Task 3), operator's permission to access the field site, NEPA clearance, and written authorization from the DOE project officer will be obtained.
- Sufficient data to construct 3-D models

Risk

Category	Potential Risk	Mitigation
Resource/Site Availability	• Insufficient computing capability	• Multiple existing computer stations. • High-performance computing cluster.
	• Field equipment unavailable	• Contingency plans for backup equipment. • Experienced service provider.
	• Site access not granted	• Staff and consultants with field work experience and relationships in WB and PRB.
	• Lack of personnel	• Cross-training and redundancy in skill sets. • Senior management overseeing personnel and resource availability.
Technical Difficulties	• Insufficient data or loss of data	• Large in-house geological database. Large amount of public data easily available. • Workstations and servers backed up.
	• Inability to model target basins with sufficient detail	• Prior training and experience with required software. • Large in-house geological database. Large amount of public data easily available.
	• Problems collecting field data	• Experienced EERC staff on-site to oversee field work. • Existing relationship with service provider who has demonstrated success in PNLs. • Consultants with decades of experience in oil and gas industry.

Risk, cont.

Category	Potential Risk	Mitigation
Environmental, Health, and Safety (EHS)	• Personal injury	• EERC personnel will complete safety training prior to and on-site for field work. • Personal protective equipment will be used. • Existing regulatory guidelines, safety protocols, and reporting requirements for commercial oil and gas operations.
	• Environmental damage	• NEPA compliance. • Existing regulatory guidelines, safety protocols, and reporting requirements for commercial oil and gas operations.
Management Issues	• Inability to manage large-scale project	• Majority of work conducted at the EERC facility allowing regular interaction and communication with project team members. • Planning meetings held before field work. • Proven working relationship with consultants and project partner. • Existing standardized workflow processes, communication protocols, and contractual procedures. • Working knowledge of managing similar-scale resource assessment and oil and gas-related projects.

	Start Date	End Date
Task 1 – Project Management and Planning	**11/1/2014**	**10/31/2017**
1.1 – Perform Project Management	11/1/2014	10/31/2017
1.2 – Project Reporting	11/1/2014	10/31/2017
Task 2 – Literature Review, Data Collection, Compilation and Simulation of 1-D and 2-D PetroMod Models	**11/1/2014**	**12/31/2016**
2.1 – Literature Review and Data Collection	11/1/2014	4/30/2015
2.2 – Build Dynamic 1-D PetroMod Models	12/1/2014	9/30/2015
2.3 – Build Dynamic 2-D PetroMod Models	3/1/2015	9/30/2015
2.4 – Recalibrate, History Match, and Simulate 2-D PetroMod Models Based on Field Logging Interpretations	10/1/2015	12/31/2016
Task 3 – Pulsed-Neutron Logging, Processing, and Interpretation	**1/1/2015**	**12/31/2016**
3.1 – Planning and Preparation	1/1/2015	10/31/2016
3.2 – Pulsed-Neutron and Temperature Logging	8/1/2015	12/31/2016
Task 4 – Build 3-D PetroMod Models	**5/1/2016**	**1/31/2017**
4.1 – Build, Calibrate, and Simulate 3-D PetroMod Models	5/1/2016	1/31/2017
4.2 – Select Submodels for Evaluation of Salt Movement, Hydrogen Sulfide Existence, and Free Sulfide Migration	7/1/2016	1/31/2017
4.3 – Perform Risk Analysis	12/1/2016	1/31/2017
Task 5 – ROZ Fairway Mapping, Volumetric Resource Estimates, and Preparation of Methodology to Be Used in Other Basins	**2/1/2017**	**8/31/2017**
5.1 – ROZ Fairway Mapping	2/1/2017	4/30/2017
5.2 – CO_2 EOR Feasibility Study	2/1/2017	6/30/2017
5.3 – Propose Methodology for Others to Identify and Assess ROZs in Sedimentary Basins	7/1/2017	8/31/2017

Summary Task
Activity Bar
Milestone (M) ◆
Deliverable (D) ▼
Critical Path

Key for Milestones (M) ◆

M1 – Project Kickoff Meeting Held
M2 – First Cross Section of 1-D Model Completed
M3 – Potential ROZ Indentified
M4 – First PNL Interpretation Completed
M5 – First Round of PNL Collection Completed
M6 – Risk Analysis Completed
M7 – Resource Assessment Completed
M8 – Debriefing Meeting with Operators Held

Key for Deliverables (D) ▼

D1 – Updated PMP
D2 – Project Fact Sheet
D3 – Data Submission to EDX
D4 – Final Report

Summary

- A novel approach combining basin evolution modeling and field work to identify and evaluate the presence and extent of ROZs will result in:
  - Petroleum system models for the WB and PRB.
  - Oil in place and CO_2 storage recourse estimates for identified potential ROZs.
  - ROZ play fairway maps.
  - A repeatable methodology that could be applied to other sedimentary basins around the United States.