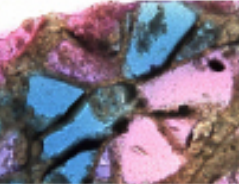
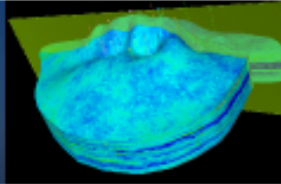


# Thermodynamic Characterization of Reservoir Fluids and Process Analysis

2008/2009 Project

*Hertanto Adidharma*  
*Department of Chemical and Petroleum Engineering*  
*University of Wyoming*

EORI/Soft Materials Laboratory  
January 2009

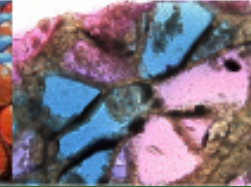
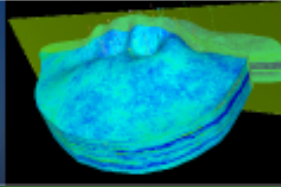


## Thermodynamic Characterization of Reservoir Fluids and Process Analysis

*A continuous program revealing important factors that are still unknown or not well understood but affecting the efficiency of oil recovery*

*Current focuses - three important issues in CO<sub>2</sub> flooding Enhanced Oil Recovery (EOR)*

1. The determination of Minimum Miscibility Pressure (MMP)
2. The study of unexplored yet important factors affecting Water Alternating Gas (WAG) injection performance
3. The understanding of interfacial phenomena in CO<sub>2</sub> Enhanced Oil Recovery



# CO<sub>2</sub> Enhanced Oil Recovery

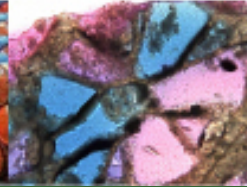
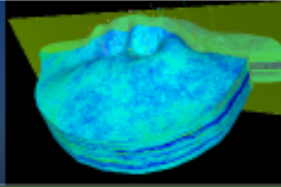
*Its performance depends on:*

1. Microscopic displacement efficiency

Reasons for low efficiency: Low pressure, low concentration of CO<sub>2</sub>

2. Macroscopic displacement efficiency

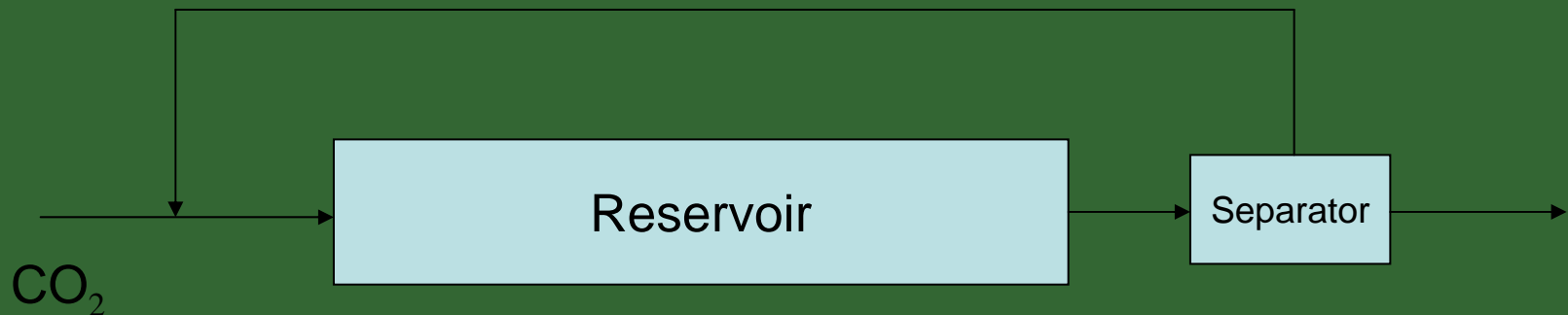
Reasons for low efficiency: High gas relative permeability, low gas density, gas channeling

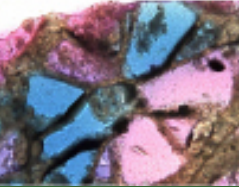
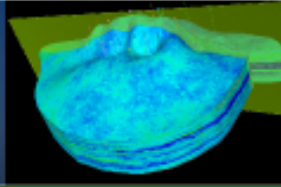


# Minimum Miscibility Pressure

*Develop a computational technology for estimating MMP*

An old technology addressing an old issue?



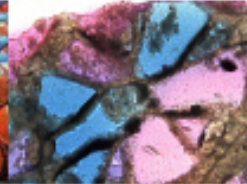
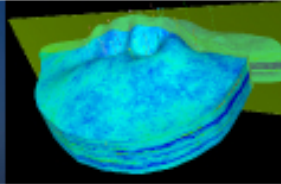


# Minimum Miscibility Pressure

*Develop a computational technology for estimating MMP*

*Consists of 5 steps:*

1. Built a slim tube apparatus
2. Established a Multiple-Mixing-Cell based model  
(Multiple-Mixing-Cell coupled with Key-Tie-Line)
3. Extended our theoretical equation of state (SAFT) to charged systems
4. Combine the results of steps 2 and 3, calculate the MMPs of model oils using this model, and verify the calculated MMPs with experimental data
5. Use the model to calculate the MMPs of real oils and verify the calculated data with experimental data

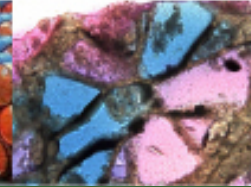
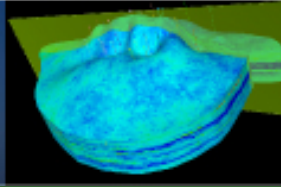


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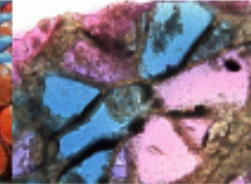
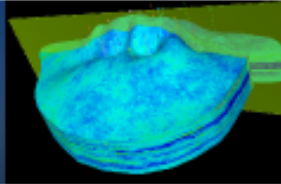
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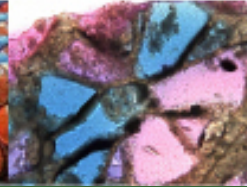
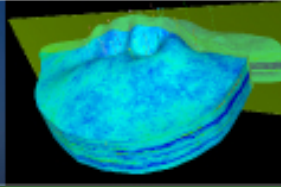


# Water Alternating Gas

*Combines two traditional technologies:*

1. Water flooding
2. Gas injection

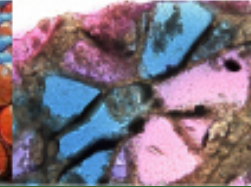
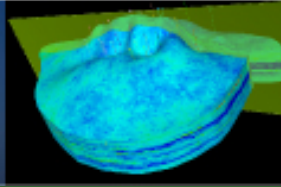
Expected to improve the oil recovery due to the expected increase in *macroscopic displacement efficiency*



# Water Alternating Gas

*Important factors affecting WAG performance:*

1. Reservoir heterogeneity
2. Rock wettability
3. Fluid properties
4. Miscibility condition
5. WAG parameters: WAG ratio, half-cycle slug size
6. Timing of cyclic injection



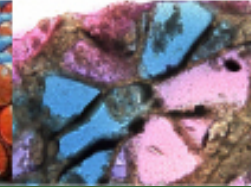
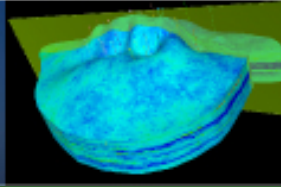
# Water Alternating Gas

*Experimental study of unexplored yet important factors affecting WAG injection performance:*

1. Fluid properties (brine and gas compositions)
2. Miscibility condition (near-miscible and miscible)
3. CO<sub>2</sub> and water half-cycle slug size
4. Timing of cyclic injection

*WAG performance is measured using several parameters:*

1. Percent oil recovery
2. Tertiary recovery factor
3. CO<sub>2</sub>/gas utilization factor

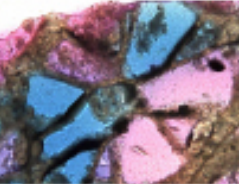
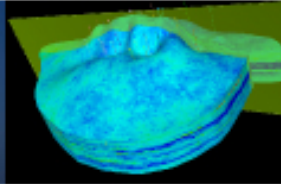


# Water Alternating Gas

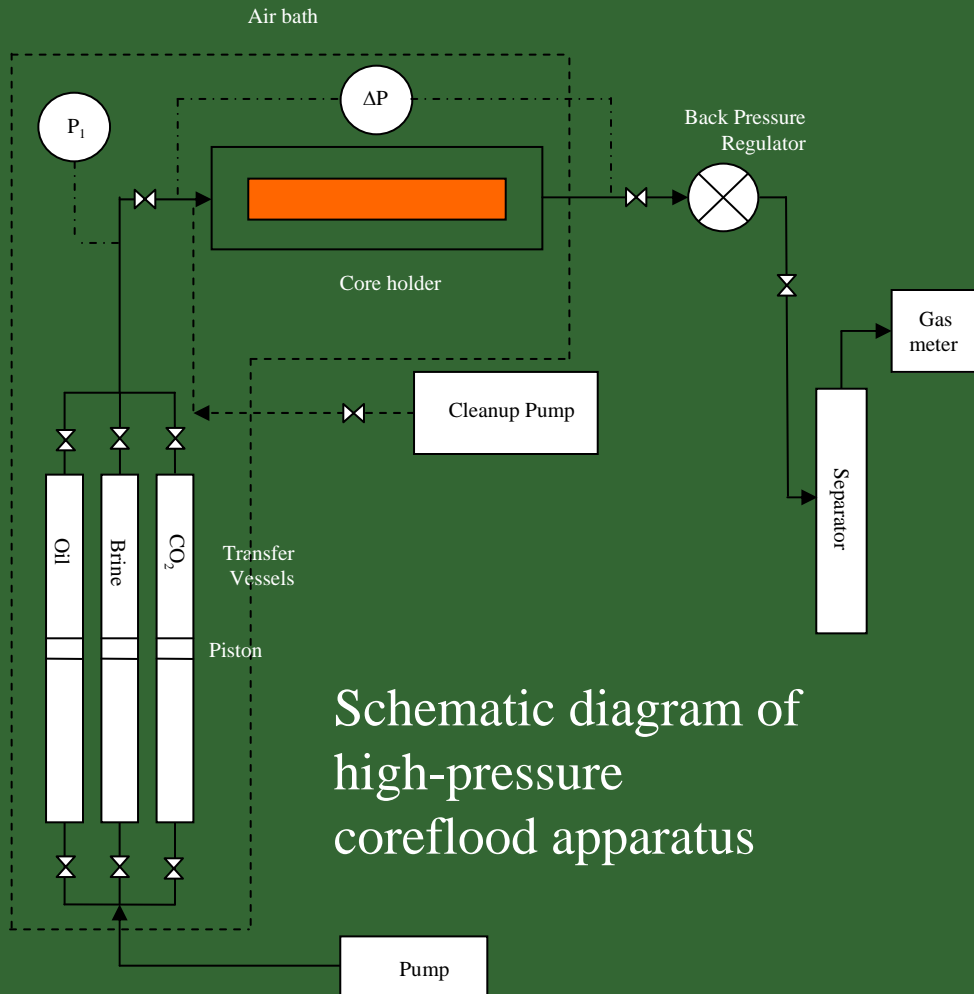
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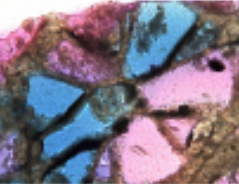
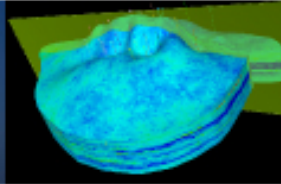
*Consists of 3 steps:*

1. Built a WAG apparatus (high-pressure core flooding apparatus)
2. Test the WAG apparatus and make it operational
3. Perform experimental study



# Water Alternating Gas





*Funding sources:*

UW Enhanced Oil Recovery Institute  
Petroleum Research Fund