Alaska North Slope (ANS) Coventional and Unconventional Oil and Gas

(Resource Characterization and Development)

UAF
UNIVERSITY OF ALASKA FAIRBANKS

Shirish Patil, Director

Professor of Petroleum Engineering

John Cheshire and Thomas Polasek

Undergraduate Research Assistants

Petroleum Development Laboratory

PDL

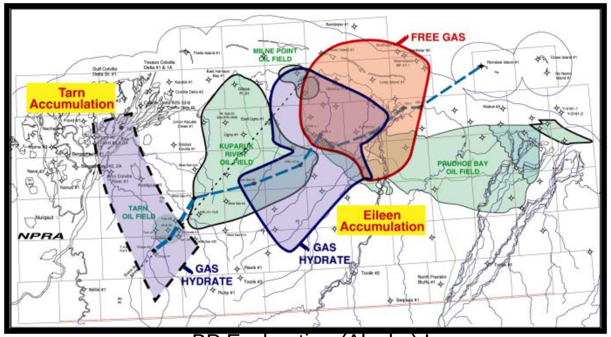
PDL Mission: Resource Development

<u>Mission:</u> **Resource Development**

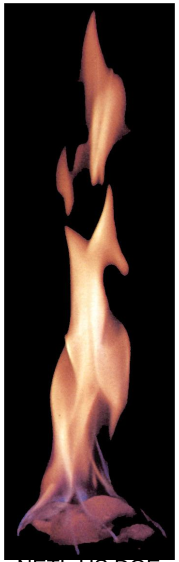
- conventional oil
- viscous/heavy oil
- natural gas
- hydrate/associated free gas
- GTL Transportation, and
- CBM resources

<u>Vision:</u>

Through integrated academic, industry, & government collaborative research to promote safe, low cost, & environmentally responsible production of abundant, strategic resources and secure energy needs of the State of Alaska and the nation.

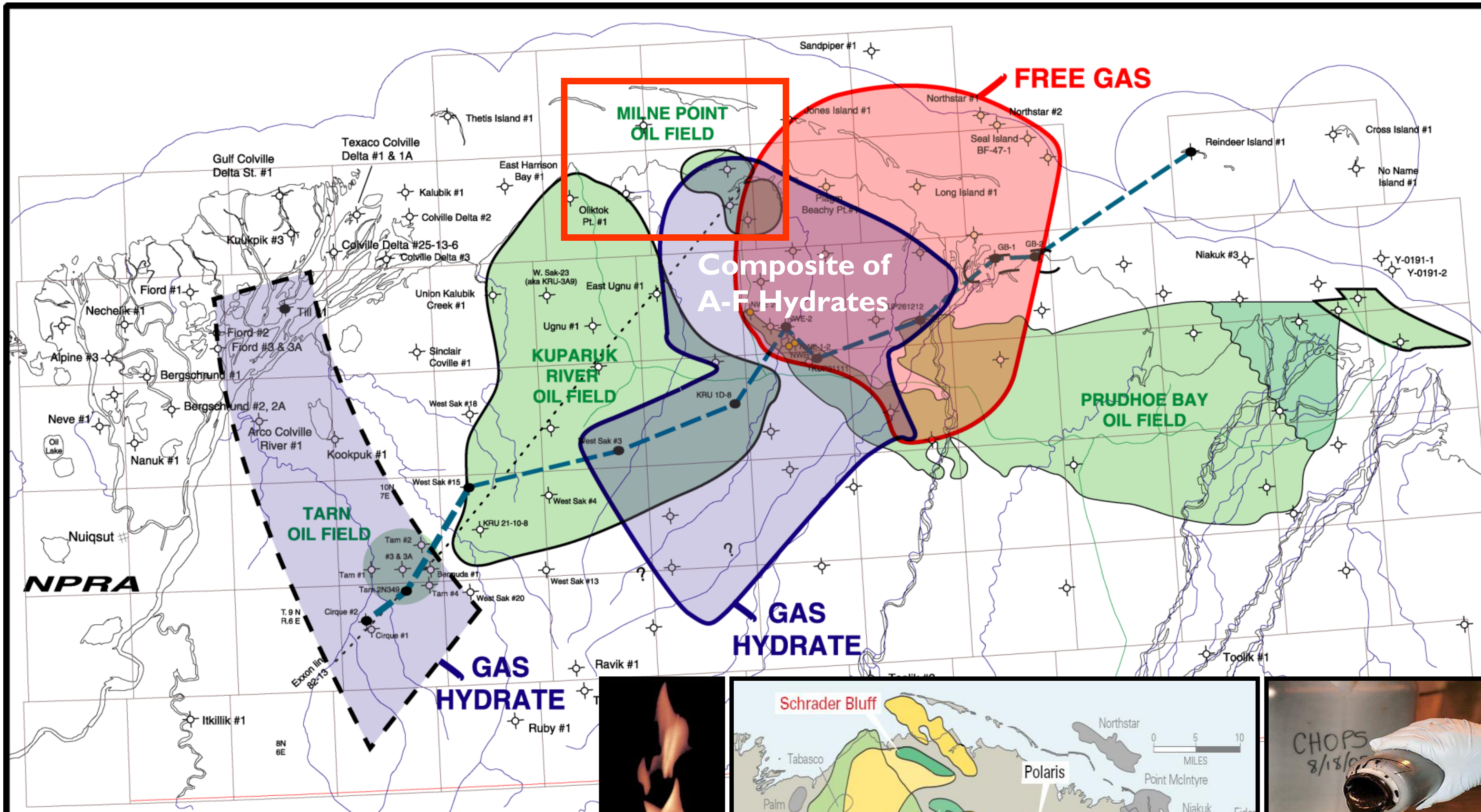


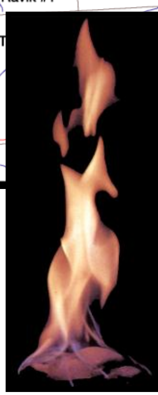
BP Exploration (Alaska) Inc.

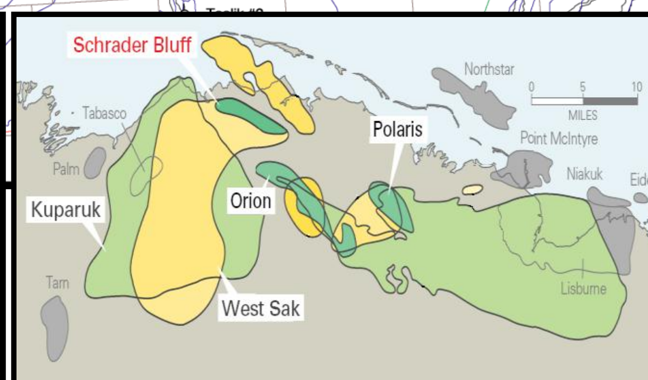


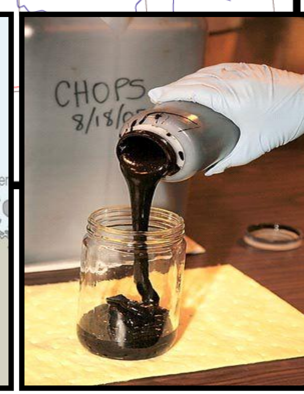
NETL-US DOE

ANS Heavy Oil and Gas Hydrate Resources



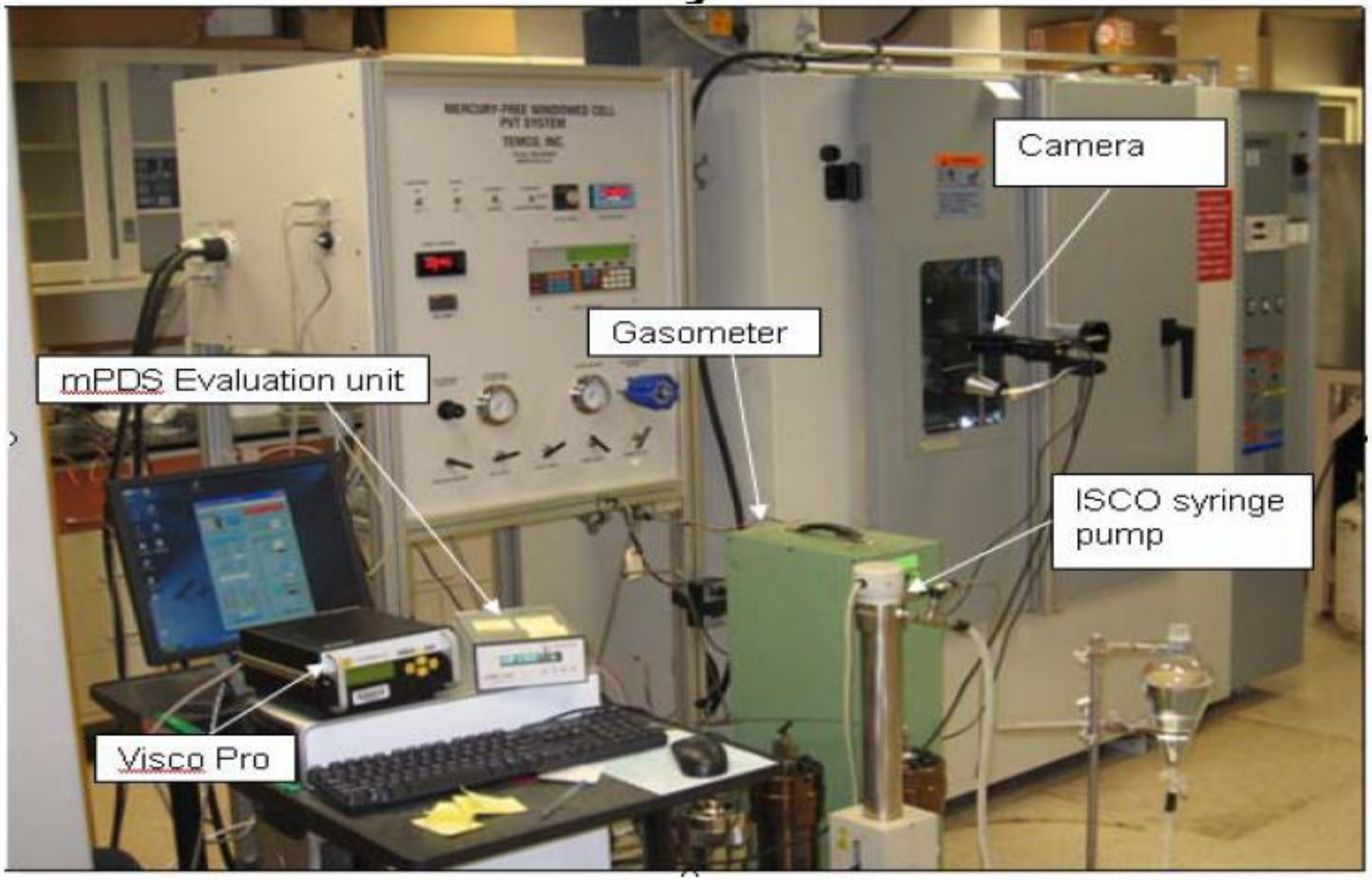






Collett et al., 2004 and BPXA, and NETL-USDOE

Integrated PVT Rig for Fluid Phase Behavior Including Online Density and Viscosity Meter



Operating limits: can handle upto 7500 psia and 350 deg F

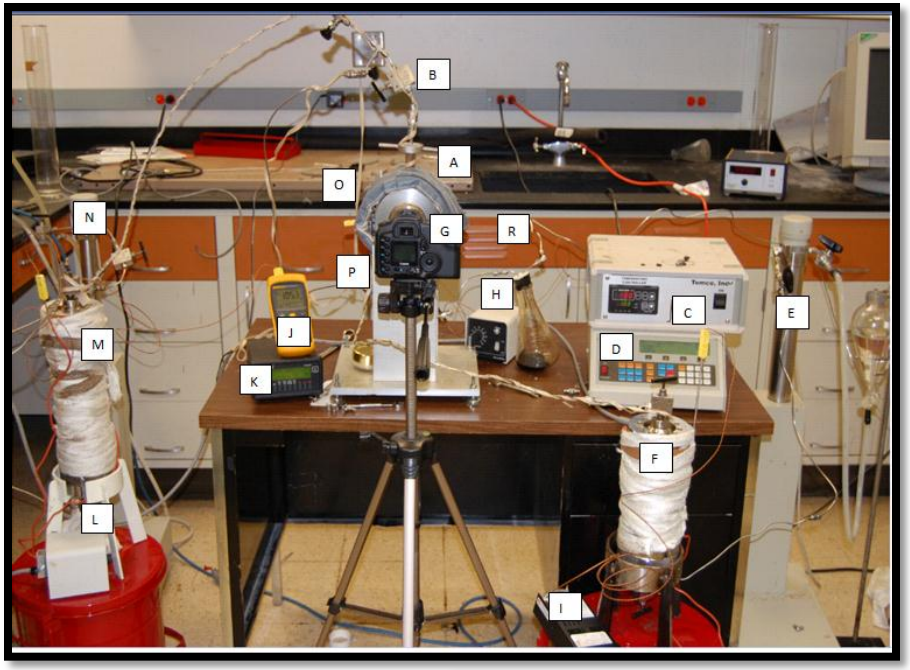
Phase Behavior Rig for Hydrate Studies

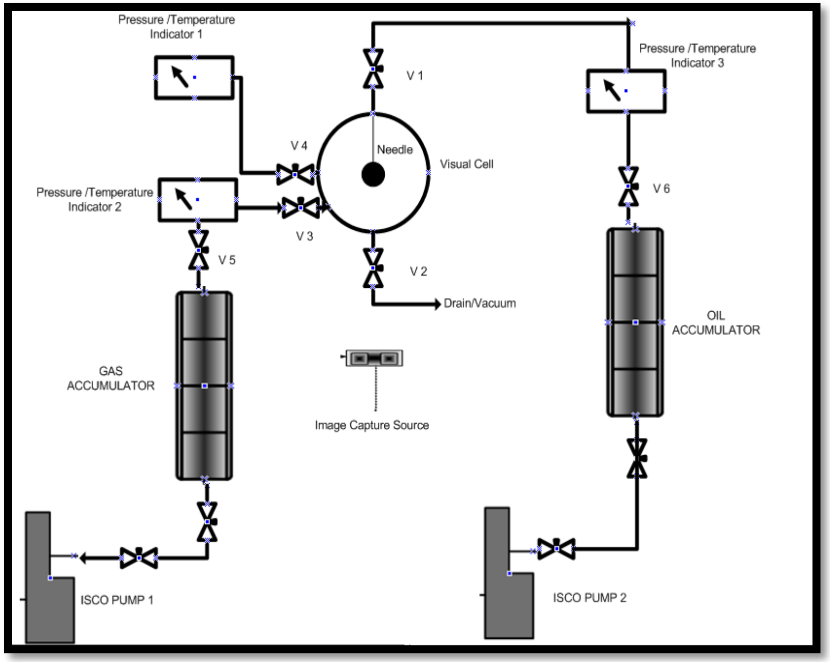
DBR hydrate phase behavior set-up for bulk hydrate

Set-up for hydrate studies in porous media

Operating limits: can handle upto 3000 psia and -94 to 392 deg F

Vanishing IFT and Coreflooding Set-ups





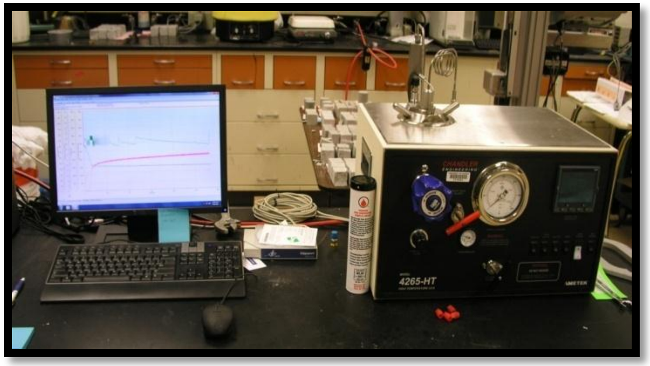
Core Flooding Rig 4 for Formation Damage Studies

Operating limits: can handle upto 5000 psia and 350 deg F

Chandler 1910 HPHT Curing Chamber

Chandler 8340 HPHT Consistometer

Chandler Atmospheric Consistometer



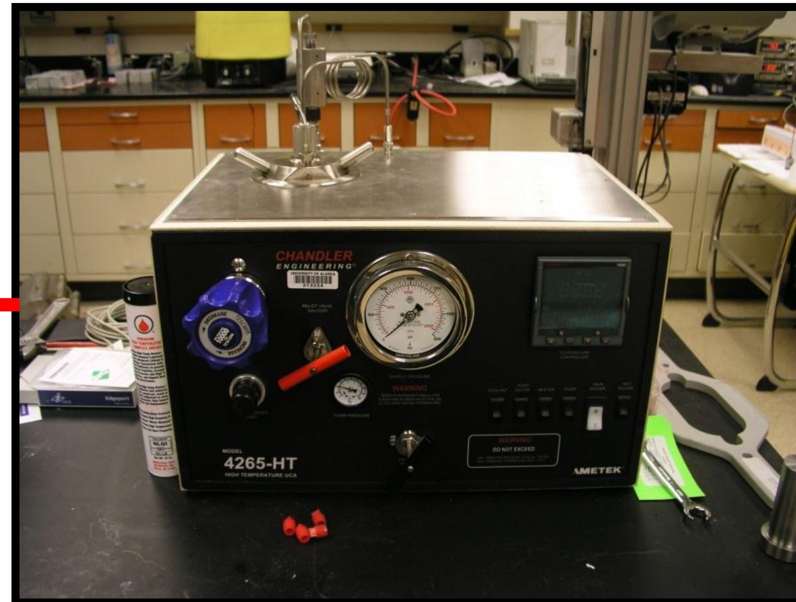
Chandler 4265-HT UCA (Ultrasonic Cement Analyzer)

HPHT Filter Press (fluid loss)

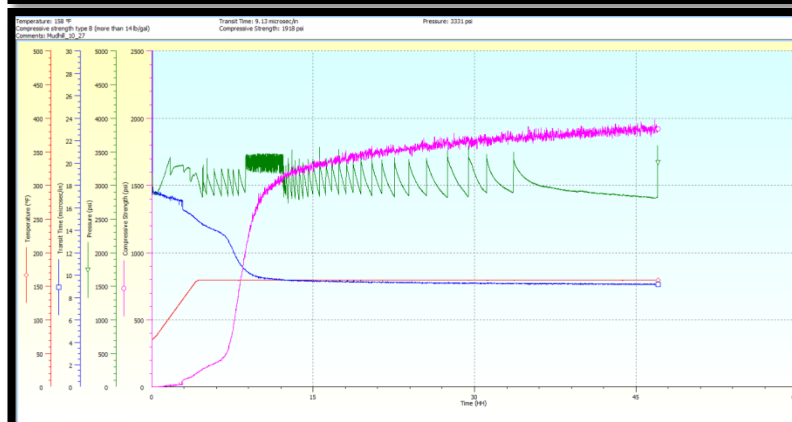
Uniaxial Loading Rock Mechanics Lab

Cement Testing Equipment

The Cement Testing Laboratory is newly equipped to determine properties of cement under range of pressure and temperature conditions.



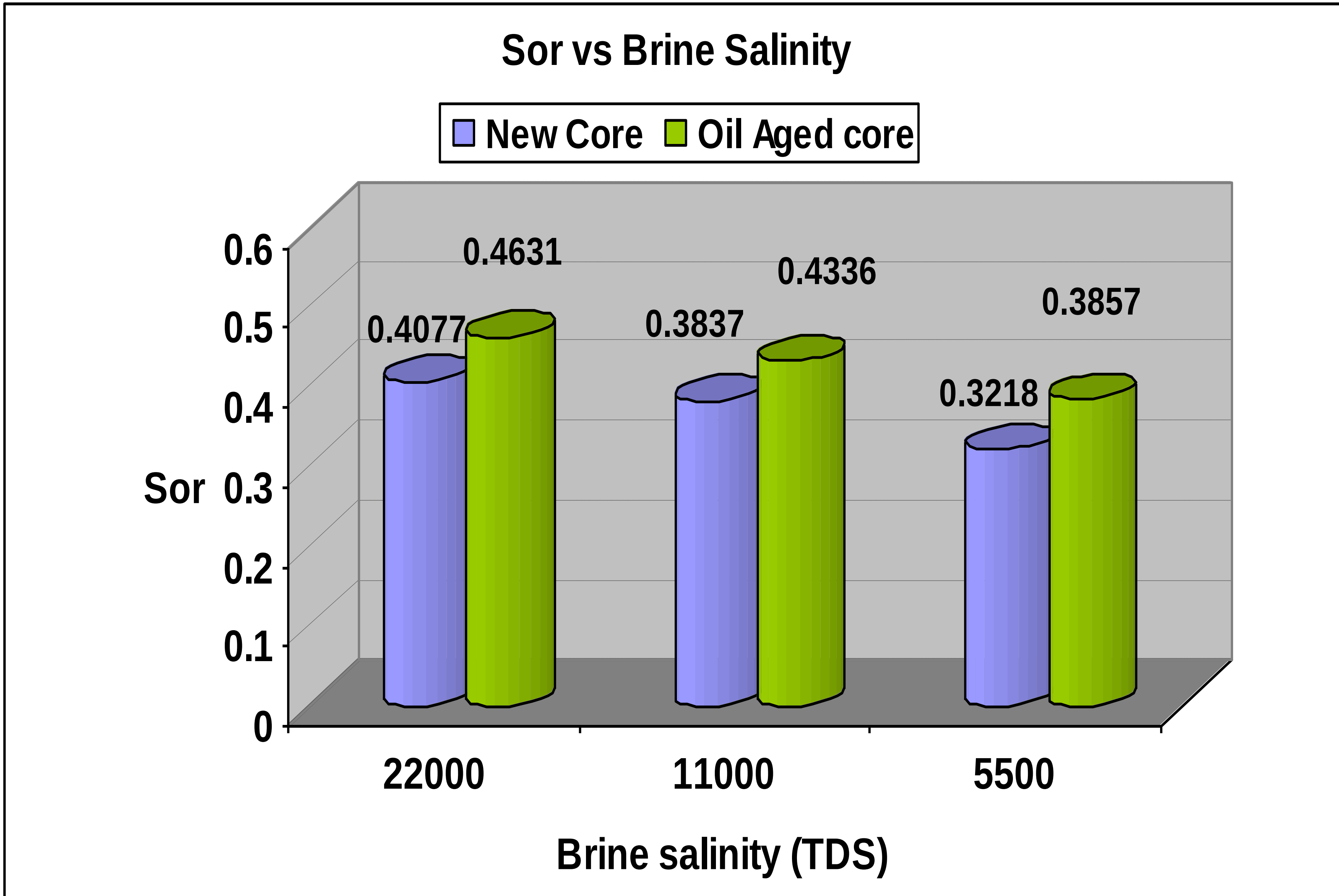
HPHT Consistometer and Curing Chamber used simulate well temperatures and pressures.



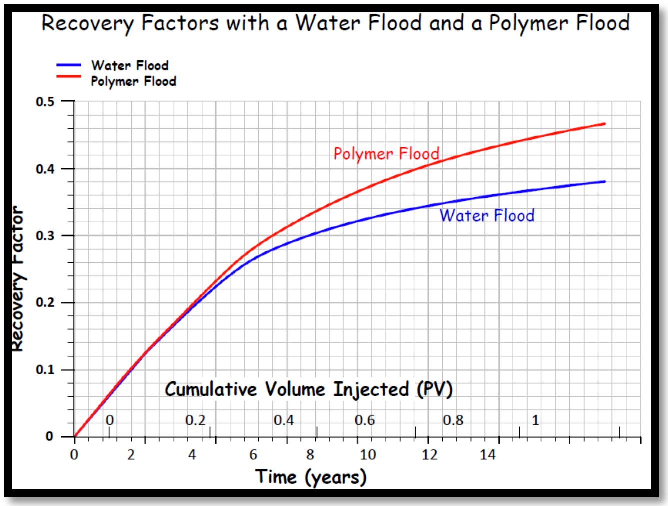
Ultrasonic Cement Analyzer: Provides real time compressive strength data

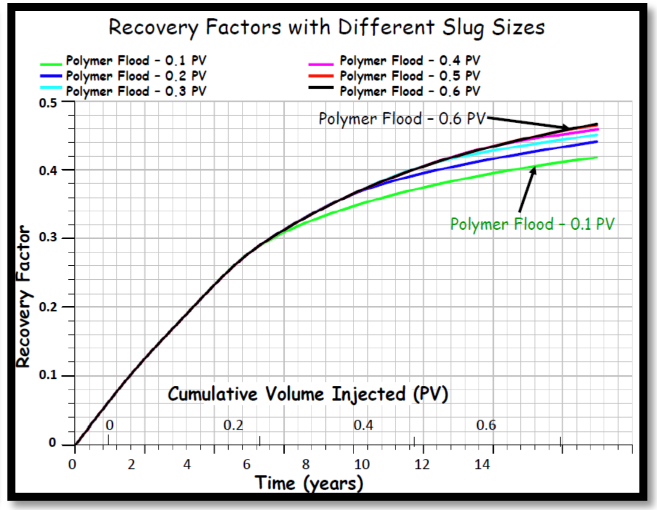
HPHT equipment- test temperature up to 600°F and pressures of 30,000 psi

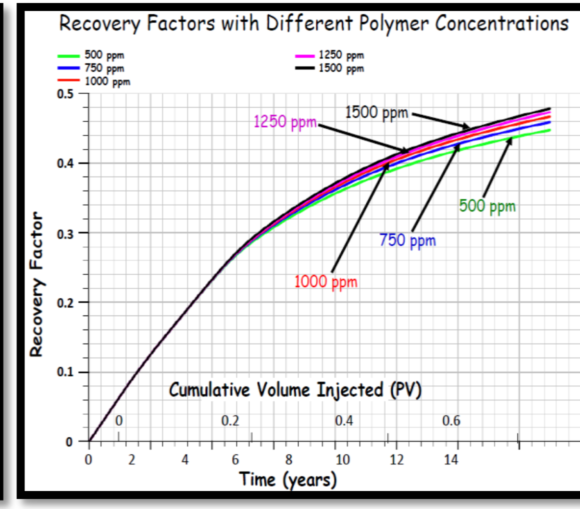
LOW SALINITY WATERFLOODS

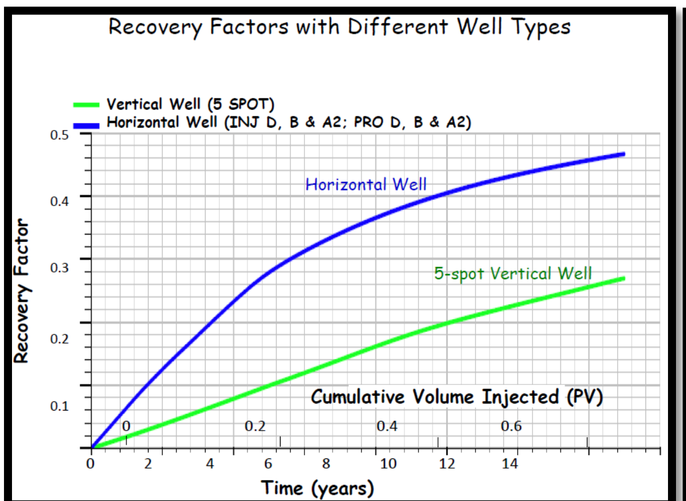


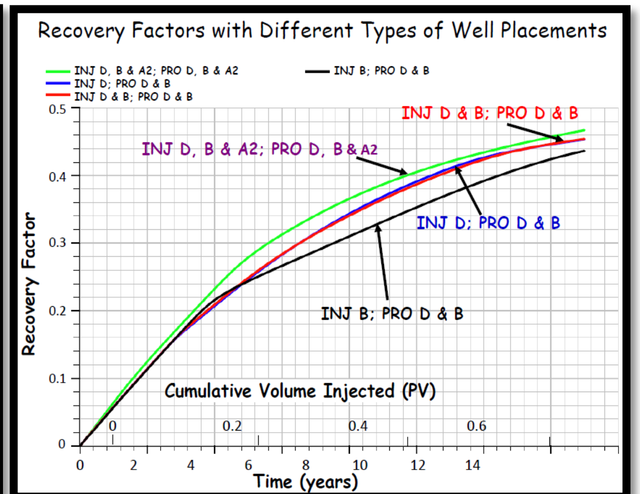
Chemical Flooding

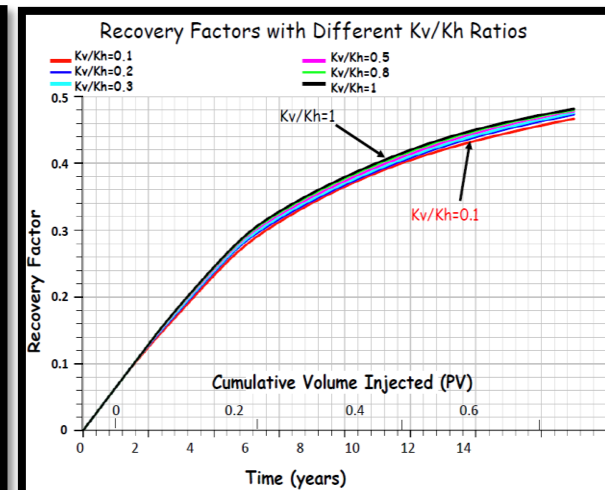




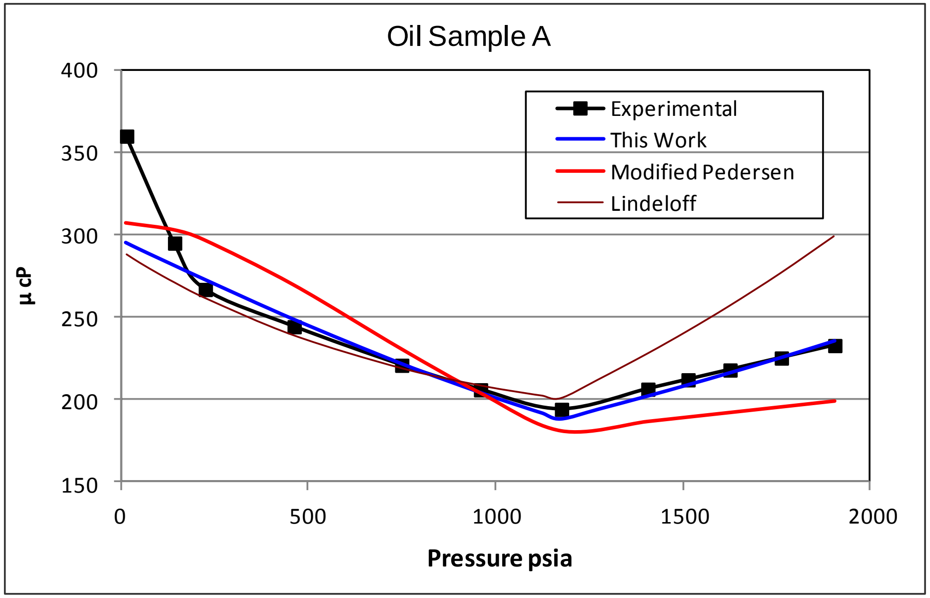


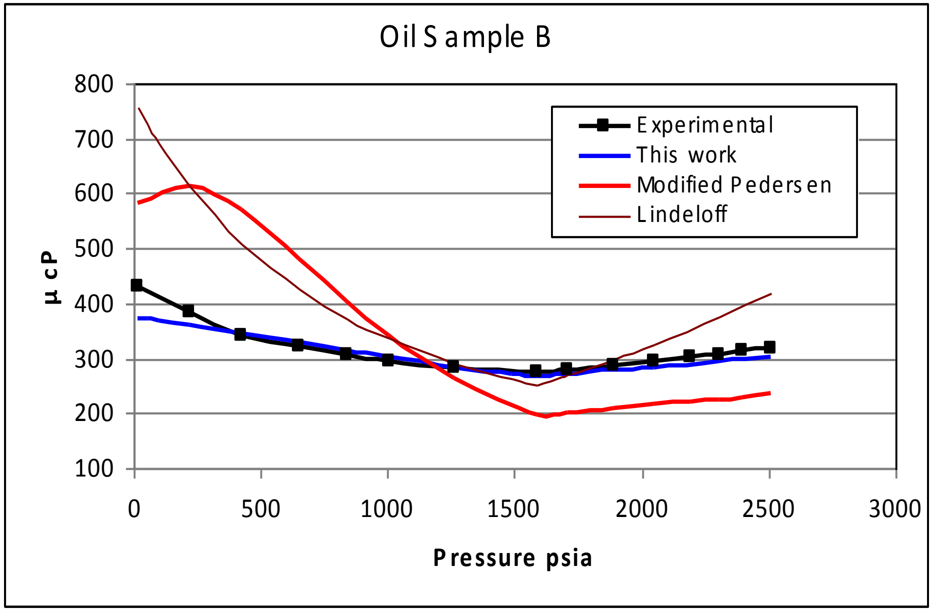






Application of Compositional Viscosity Models



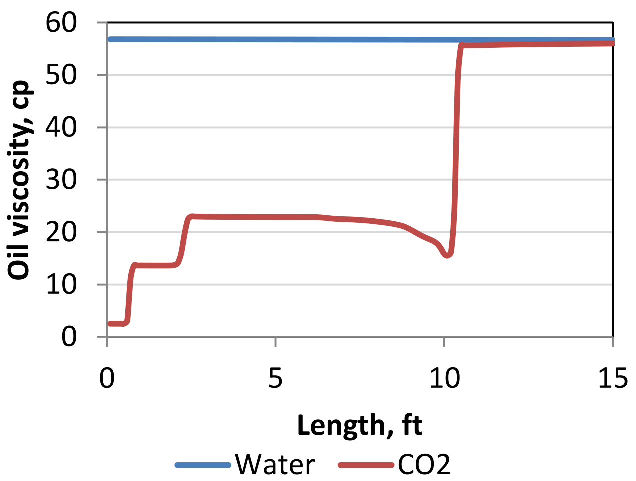


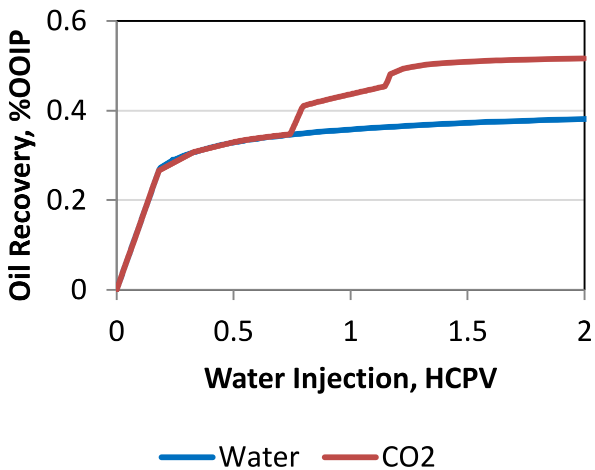
Oil A , Average To=40.15K

Oil B , Average To=42.44 K

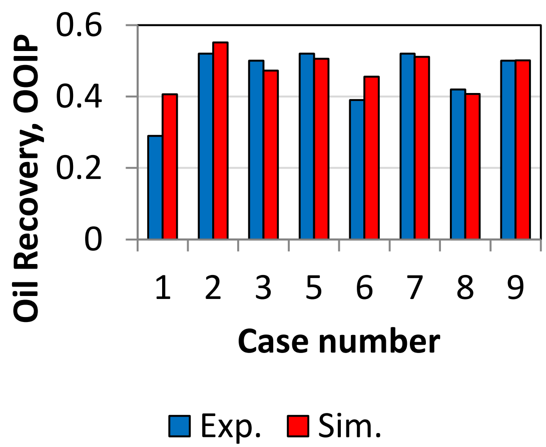
% Average absolute deviation	Modified Pedersen	Lindeloff	This Work
Oil Sample A	10.868	9.196	3.078
Oil Sample B	37.266	44.673	4.292

CO2-EOR Sequestration in Heavy Oil Reservoir





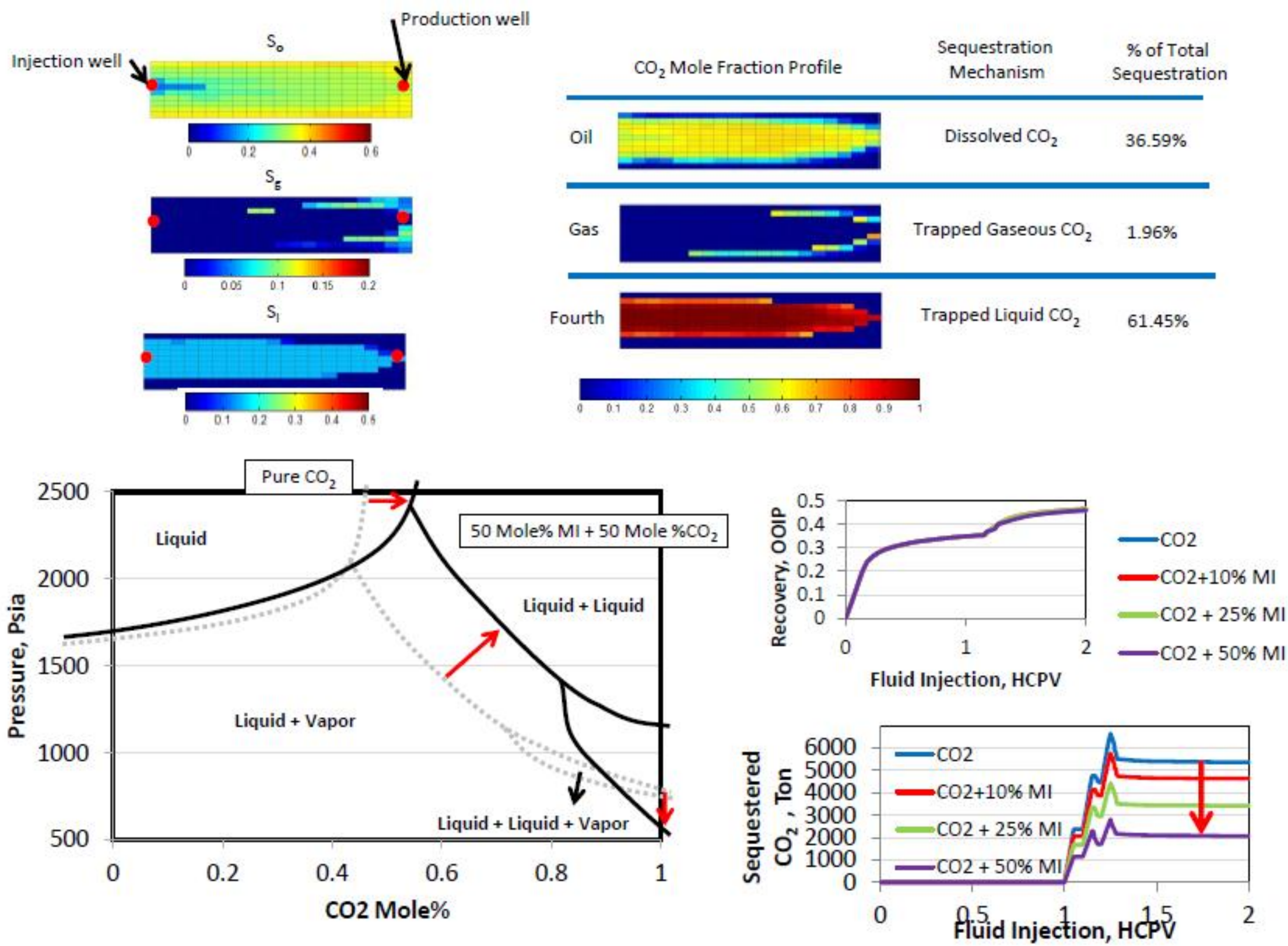
Case Number	K (md)	Porosity (%)	Sw_i (%)	
1	500	20.1	25.0	Waterflooding
2	500	20.3	26.0	1.48 HCPV liquid CO_2
3	500	20.1	25.0	0.72 HCPV liquidCO_2
5	500	20.4	27.2	0.17 HCPV liquid CO_2 (wag)
6	1500	27.6	17.6	Waterflood
7	1500	26.8	19.7	0.09 HCPV liquid CO_2 (wag)
8	1500	27.6	24.5	Waterflood (T=100°F)
9	1500	26.8	20.8	0.08 Gaseous CO_2 + Waterflood (T=100°F)



Objective: Quantify the amount of CO_2 than can be stored in Alaska oil reservoirs

This is a multi-disciplinary research, with focus on how and how much CO_2 can be sequestered and used as an EOR solvent.

Investigating pure CO_2, enriched CO_2 and CO_2-WAG injection for ANS reservoir



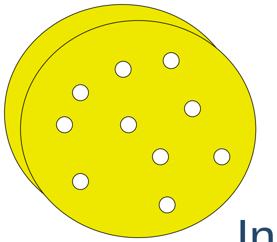
Injection well
Production well
So
0 0.2 0.4 0.6
Sg
0 0.05 0.1 0.15 0.2
Sl
0 0.1 0.2 0.3 0.4 0.5
CO2 Mole Fraction Profile
Sequestration Mechanism
% of Total Sequestration
Oil
Dissolved CO2
36.59%
Gas
Trapped Gaseous CO2
1.96%
Fourth
Trapped Liquid CO2
61.45%
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Pure CO2
50 Mole% MI + 50 Mole %CO2
Liquid
Liquid + Liquid
Liquid + Vapor
Liquid + Liquid + Vapor
Pressure, Psia
2500
2000
1500
1000
500
0 0.2 0.4 0.6 0.8 1
CO2 Mole%
Recovery, OOIP
0.5 0.4 0.3 0.2 0.1 0
0 1 2
Fluid Injection, HCPV
CO2
CO2+10% MI
CO2 + 25% MI
CO2 + 50% MI
Sequestered CO2, Ton
6000 5000 4000 3000 2000 1000 0
CO2
CO2+10% MI
CO2 + 25% MI
CO2 + 50% MI
0 0.5 1 1.5 2
Fluid Injection, HCPV

MEOR

- Objective 1: Isolate and identify indigenous biosurfactant producing bacteria from 6 different ANS heavy oil reservoirs

Liquid enrichment cultures (incubated 1-3 months)

Spread bacteria onto agar plates



Inoculate 96-well plate with colonies

Optical distortion assay (Chen et al., 1997)

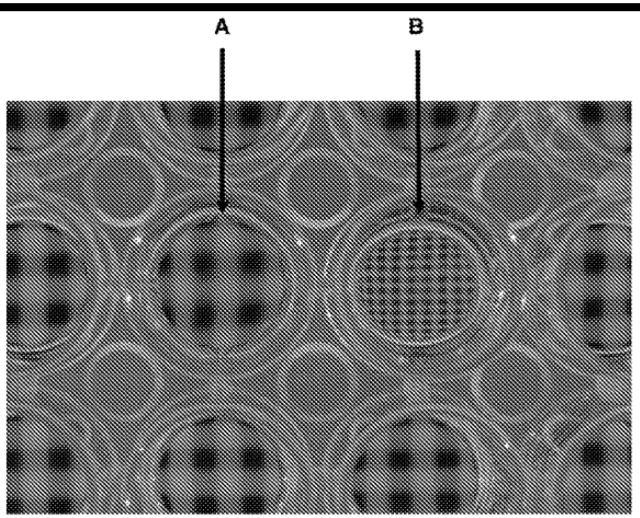


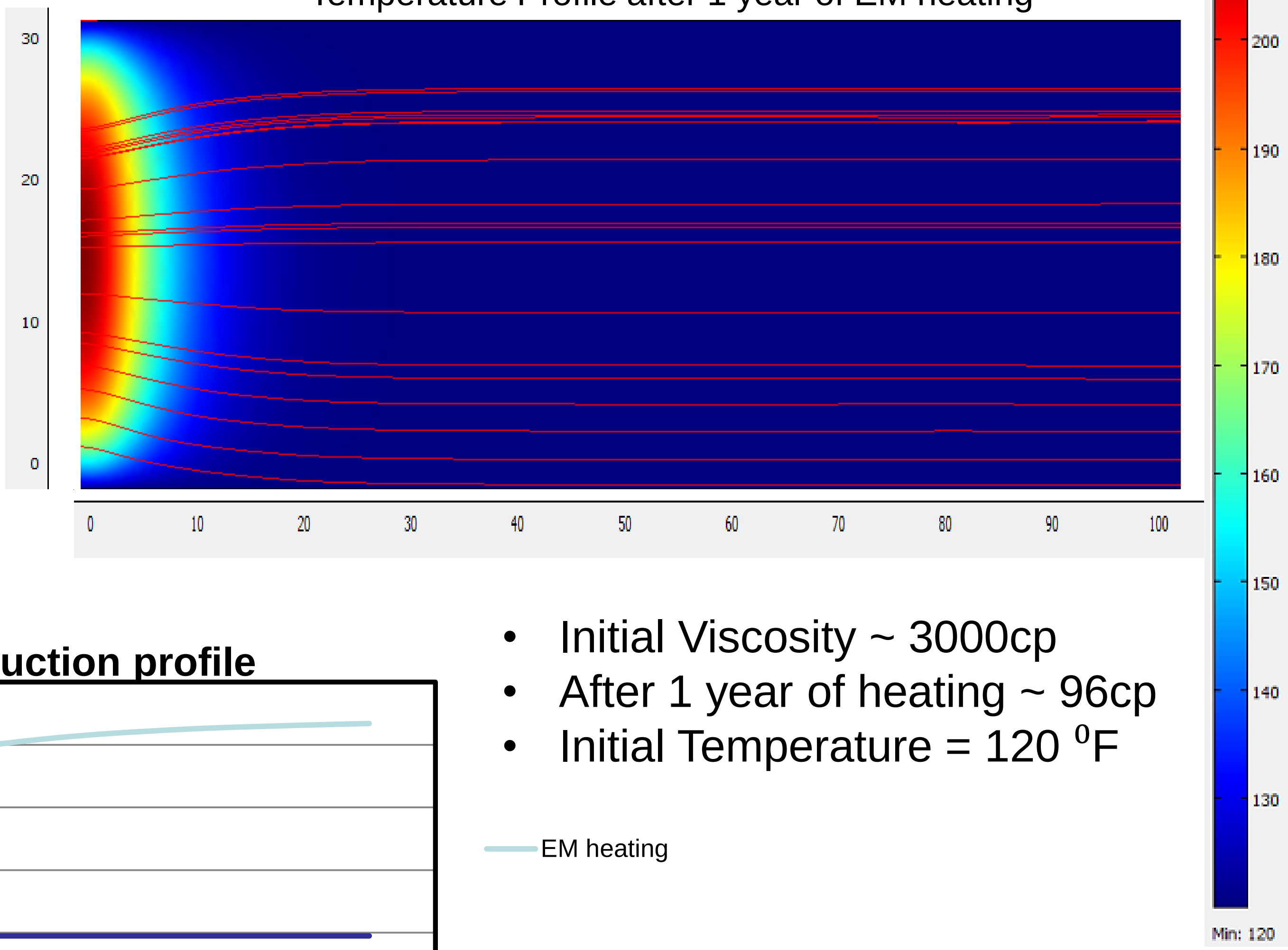
Fig. 3. Qualitative microplate assay of a high quality water control (A) and biosurfactant from strain BBK016 (B).

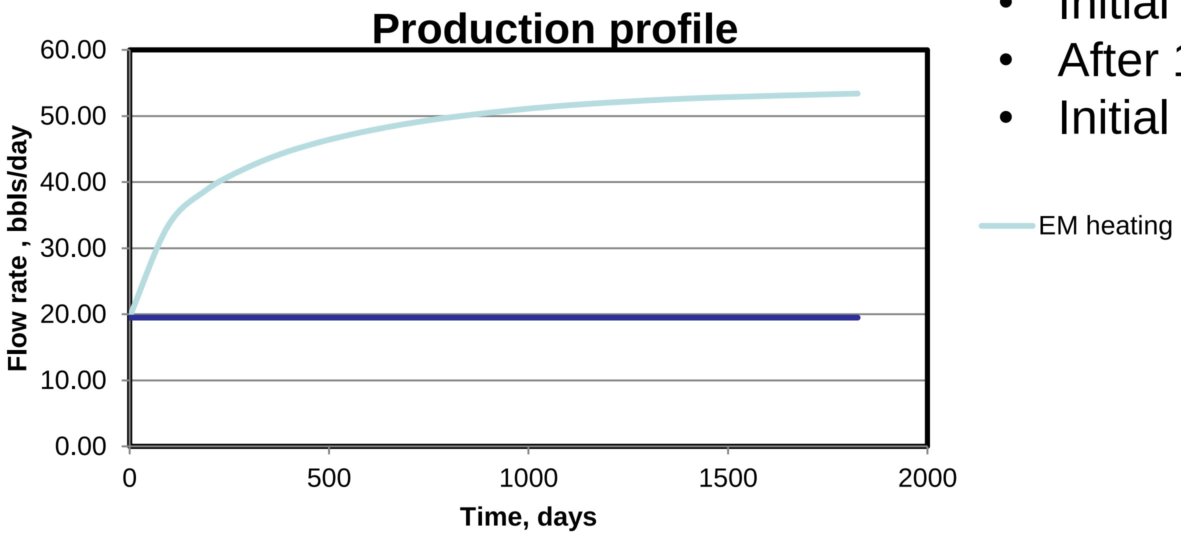
Isolate and identify positive organisms

Electromagnetic heating of Reservoirs: Application to Methane Hydrates and Heavy Oil Recovery

- Good well stimulation technique for heavy oil reservoirs on the ANS.
- Can be applied to dissociate methane hydrates and unlock the gas.

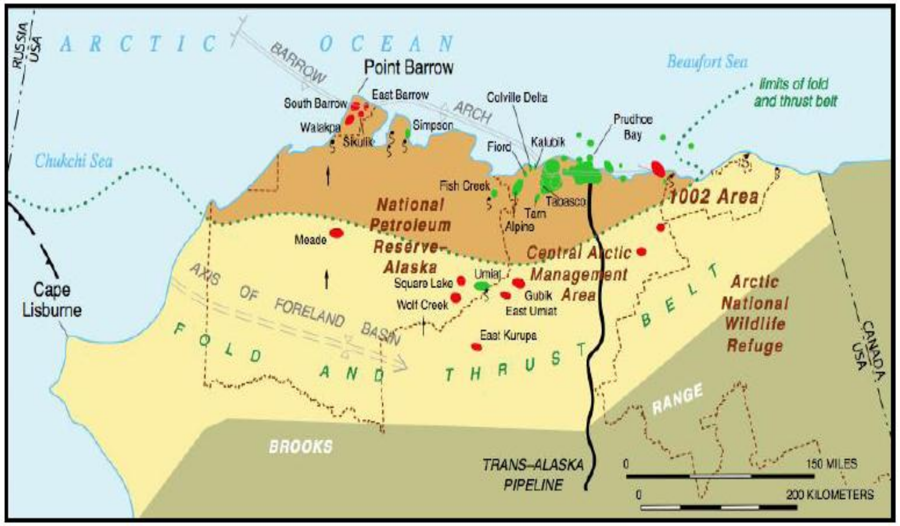
- Temperature Profile after 1 year of EM heating





- Initial Viscosity ~ 3000cp
- After 1 year of heating ~ 96cp
- Initial Temperature = 120 ^{0}F

UMIAT- Challenges and Opportunities



Why Umiat?

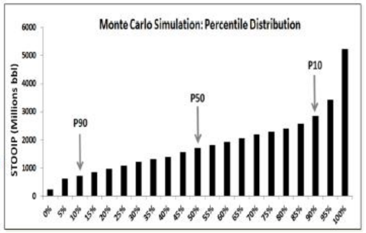
- Large proven shallow oil accumulation (7500 acres) with large OOIP
- Unique circumstance of having a light oil (37 API in sub-freezing (24-36 F) temperature) reservoir at shallow depth – 200 to 1300 ft
- Good pre-existing database – logs and core from 12 wells: relatively small geologic risk
- Reservoir and oil properties conducive to pressure maintenance using cold gas injection
- Proven multilateral well drilling technology for production at commercial rates
- An extremely high oil price is not necessary for commerciality

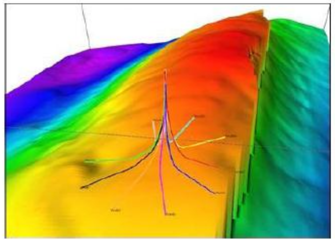
Development Challenges

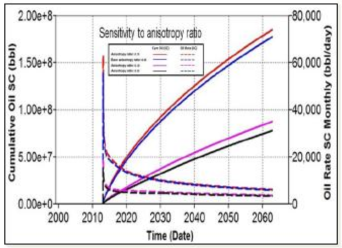
- Understanding fluid flow behavior in the presence of frozen bound water i.e. ice around the sand grains
- Maintaining the stability of the pore system with the injection of gas, air or liquid for pressure maintenance
- Effect of dislodging of ice crystals from the pores under increased pressure during injection on oil recovery
- Reduction in permeability to rock as a result of frozen water
- Attain infrastructure access

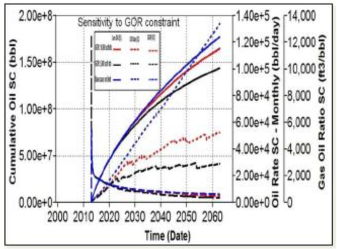
Umiat Field Development Study

OOIP estimate and simulation of gas injection

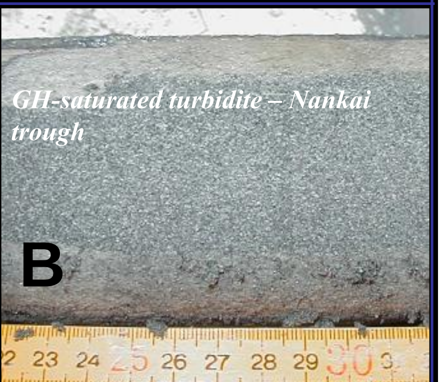


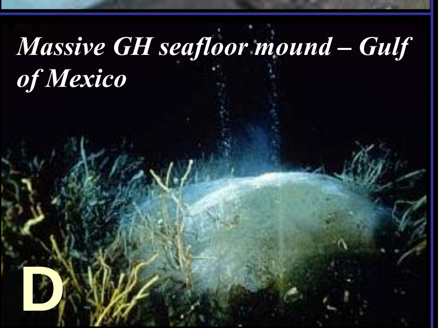


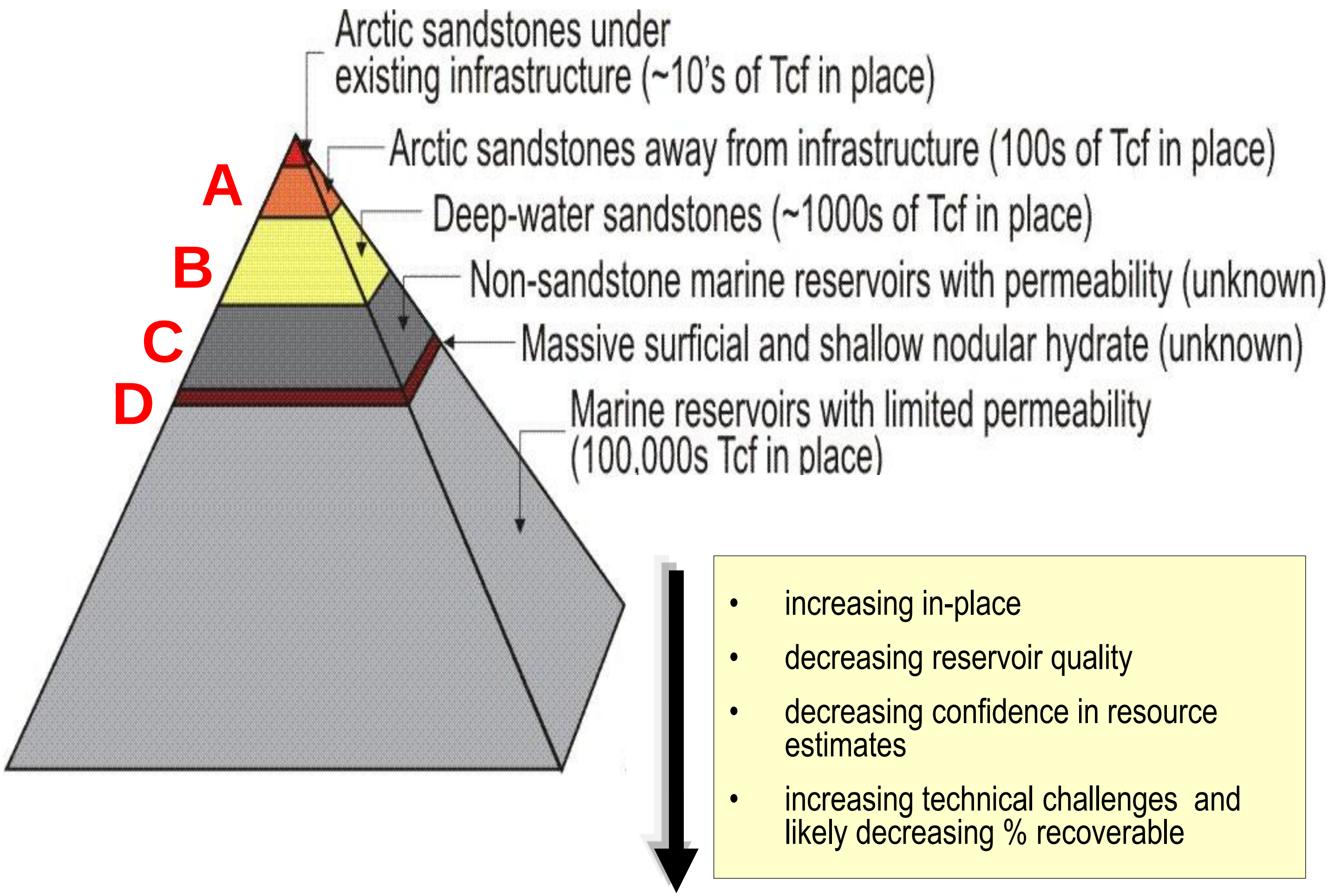




The Gas Hydrate Resource Pyramid



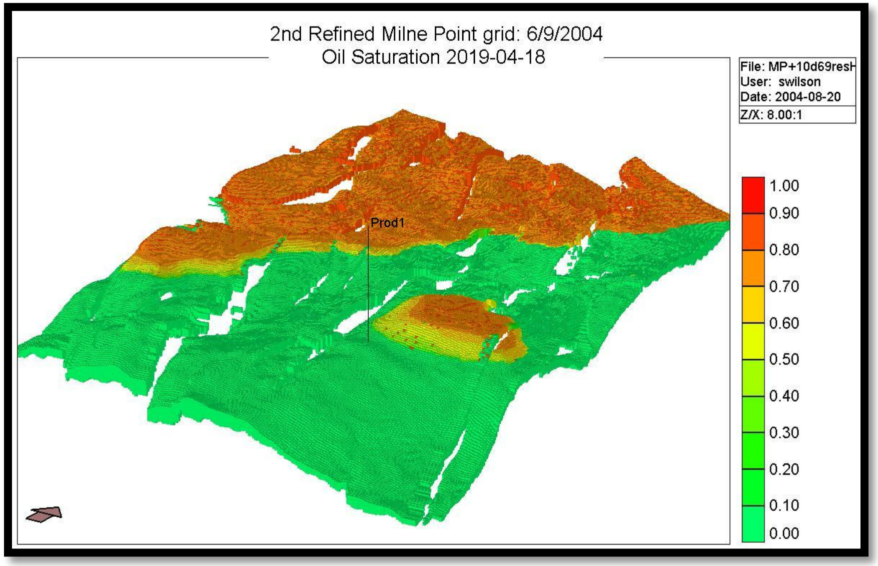


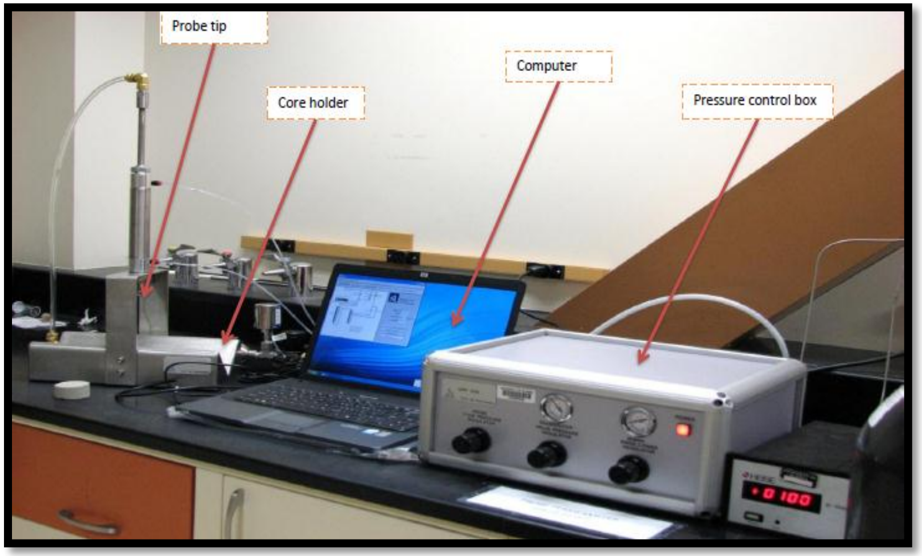


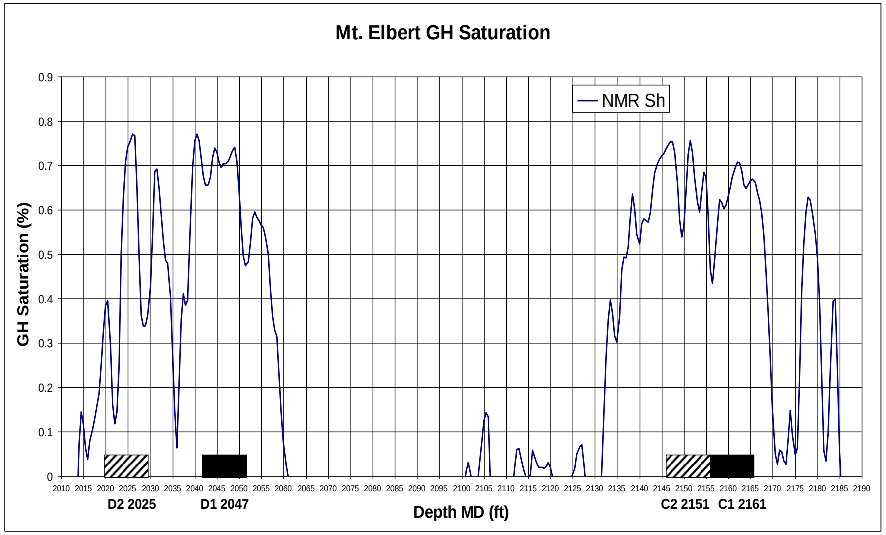
- increasing in-place
- decreasing reservoir quality
- decreasing confidence in resource estimates
- increasing technical challenges and likely decreasing % recoverable

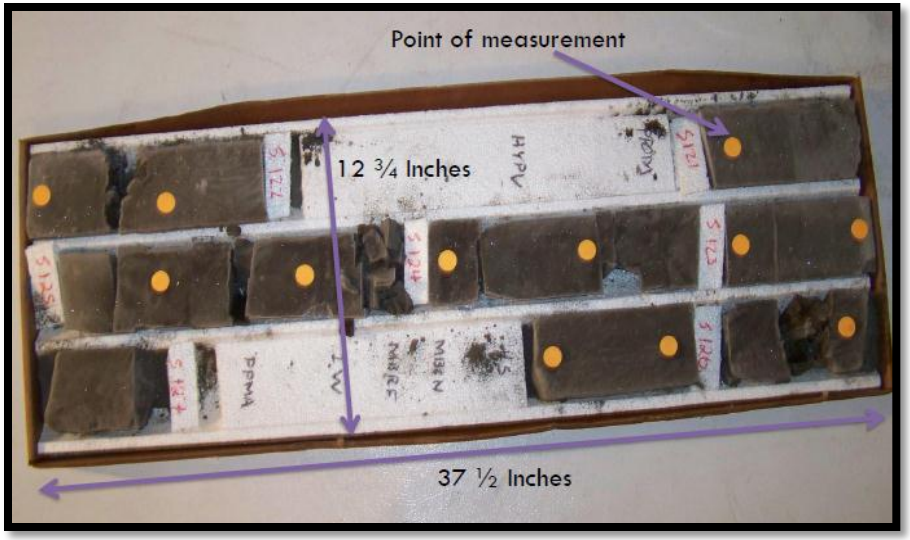
NETL- USDOE

Gas Hydrate Production Modeling

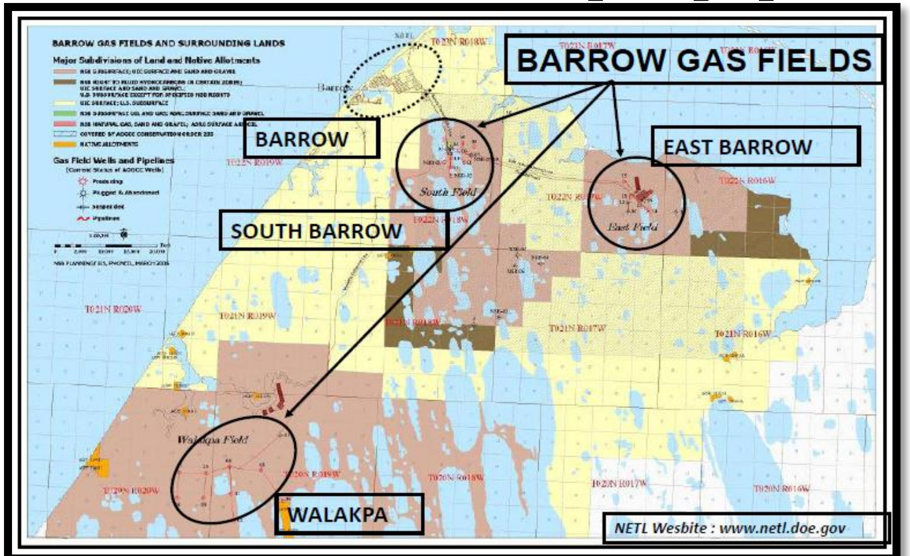


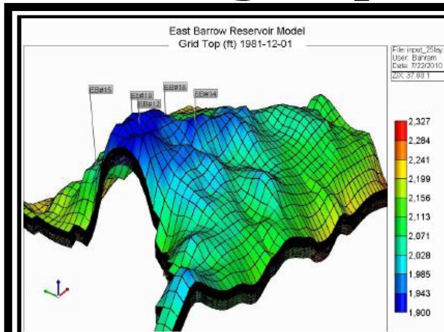






Barrow Gas Hydrates (Opportunity?)



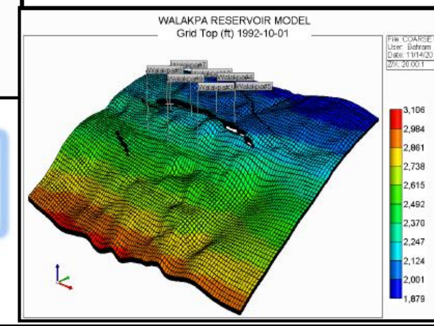


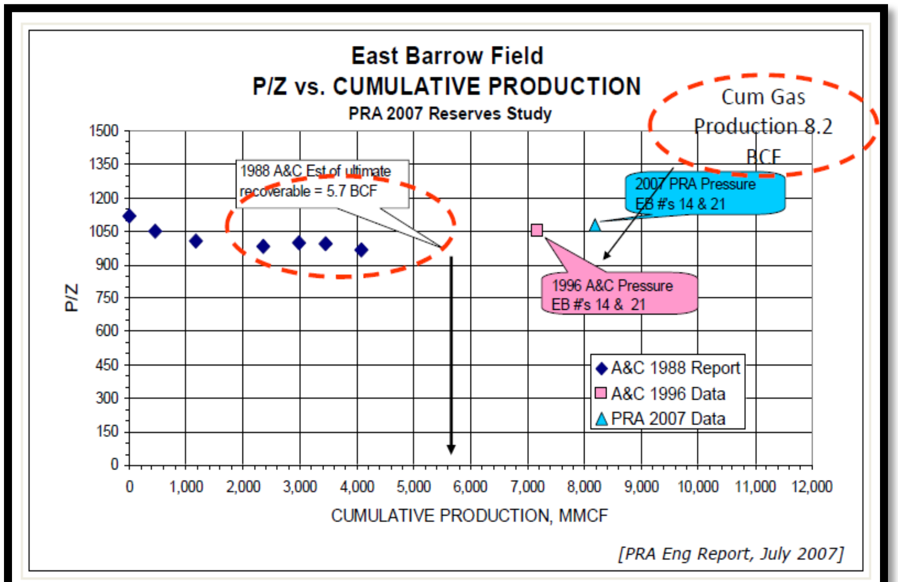
Research objective

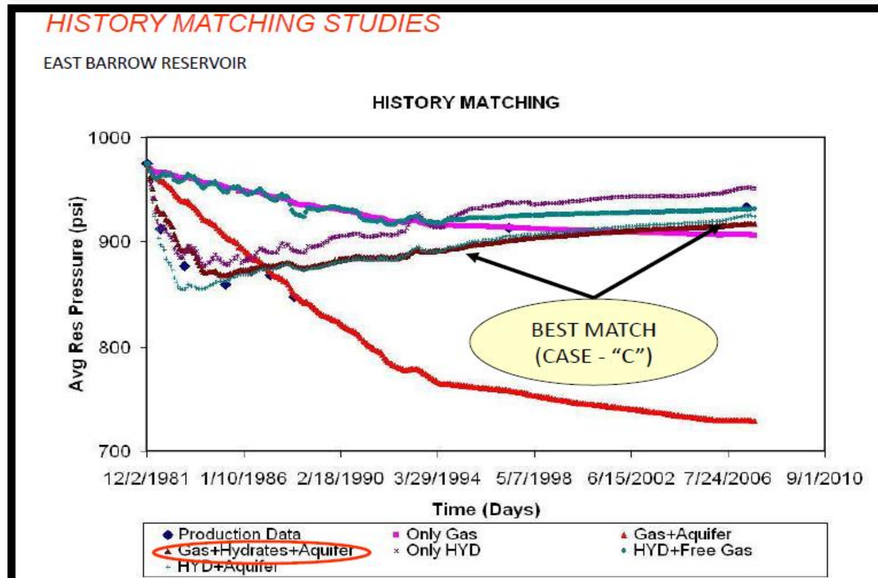
- To simulate natural gas production from gas hydrate reservoir accounting for gas hydrate dissociation phenomena.
- To forecast and optimize natural gas production with precise reservoir management."

Goals

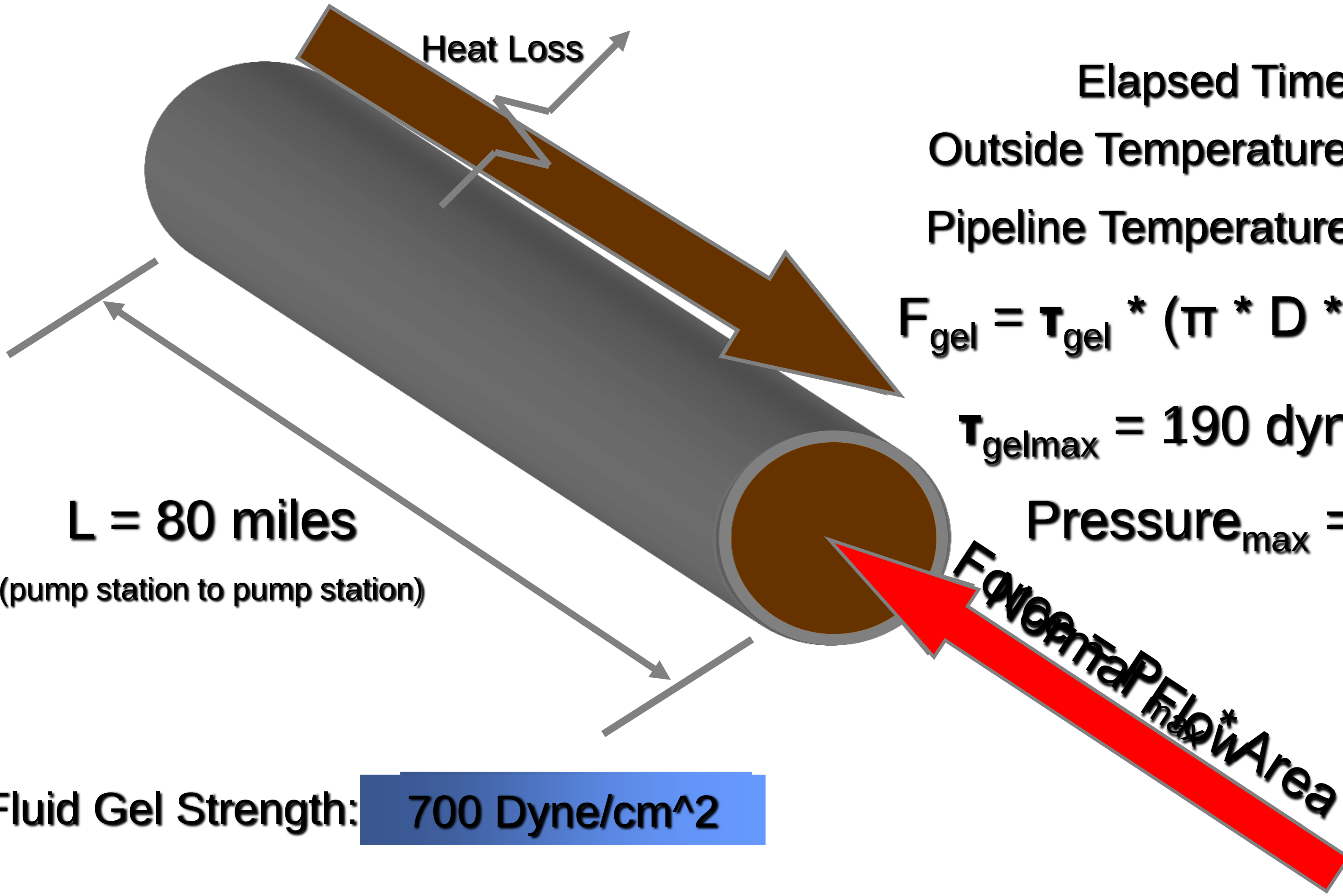
- Perform a study on production variance depending on different wellbore designs.
- Predict production behavior in planned wells.







GTL: The Gel Strength Problem



Elapsed Time: Day 15

Outside Temperature: -40°F

Pipeline Temperature: 0°F

$F_{gel} = \tau_{gel} * (\pi * D * L)$

$\tau_{gelmax} = 190$ dyne/cm^2

$Pressure_{max} = 1200$ psi

Fluid Gel Strength: 700 Dyne/cm^2

Restart Impossible! **No Flow Condition**

Miscible Injectant (MI) and CO_2 for Enhanced Recovery of Heavy Oil

Moving Closer to Producing Alaska's Heavy Oil

John Cheshire

Undergraduate Research Assistant
Permafrost Subsidence Project Lead
Petroleum Development Laboratory
University of Alaska Fairbanks

Alaska's Heavy Oil Resources

What is heavy oil?

- Flows like syrup
- More dense than conventional oil

Where is it found in Alaska?

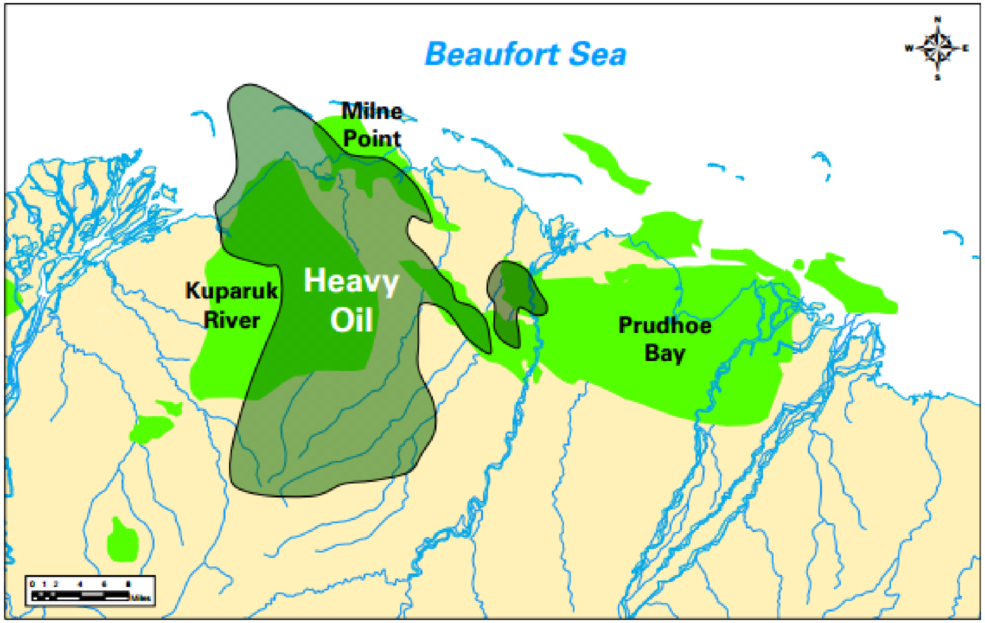
- On North Slope near conventional deposits
- Shallower depth than conventional oil

How much is there?

- 24 – 33 billion barrels

What's the challenge?

- High viscosity makes the oil difficult to produce economically



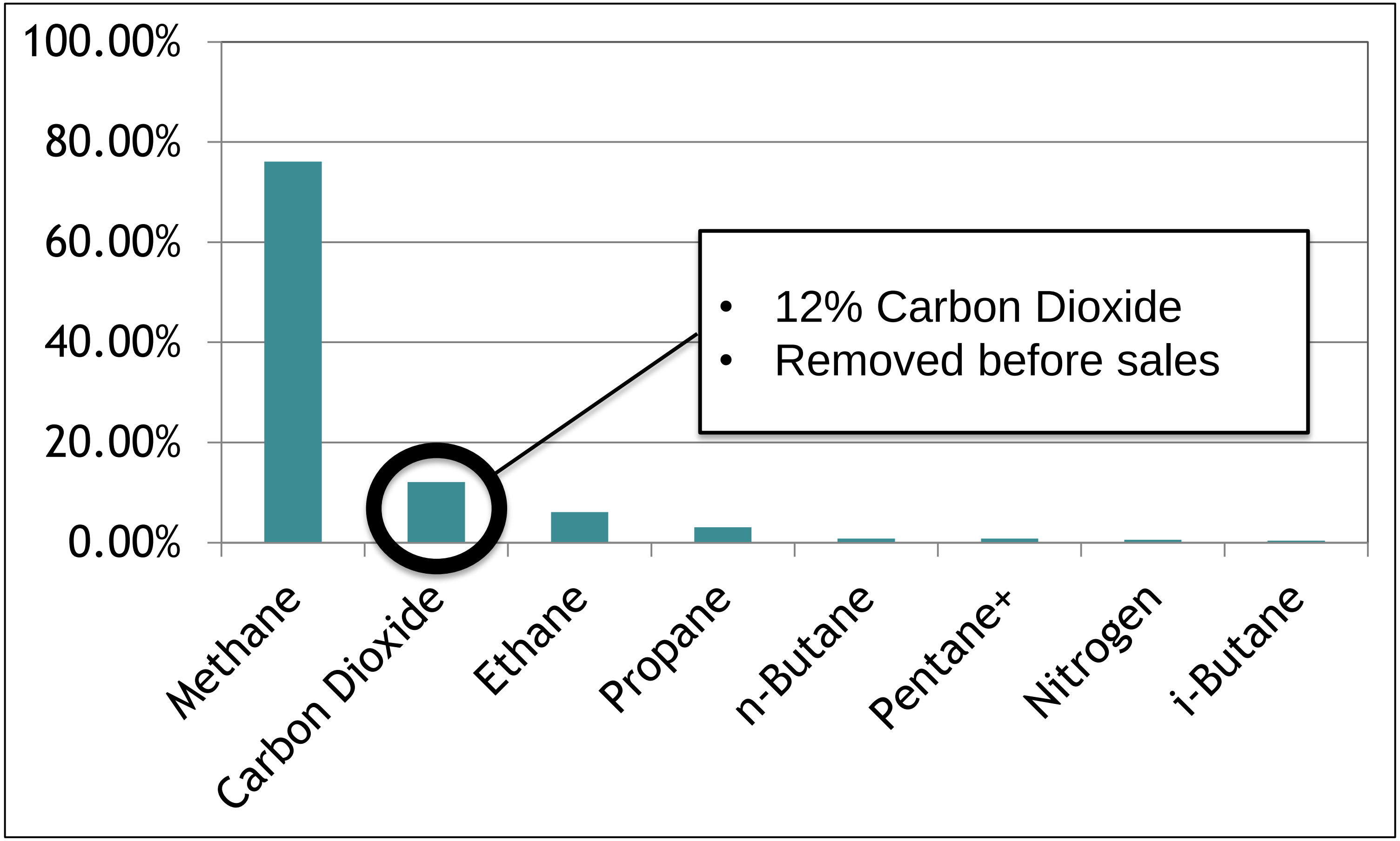
Location of Alaskan Heavy Oil (BP Exploration)

Enhanced Recovery of Heavy Oil

Methods:

- Water Flood
  - Low cost
  - Implemented on the Alaska North Slope (ANS)
  - Poor recovery efficiency
- Thermal
  - Injection of steam heats oil, helping it flow more easily
  - Arctic environment makes steam injection on ANS difficult
- Solvents
  - Mix with oil causing it to flow more easily
  - **Carbon dioxide** and light hydrocarbons are typical solvents
  - Could be available on ANS with gas sales
  - Research ongoing

Carbon Dioxide Content of ANS Gas

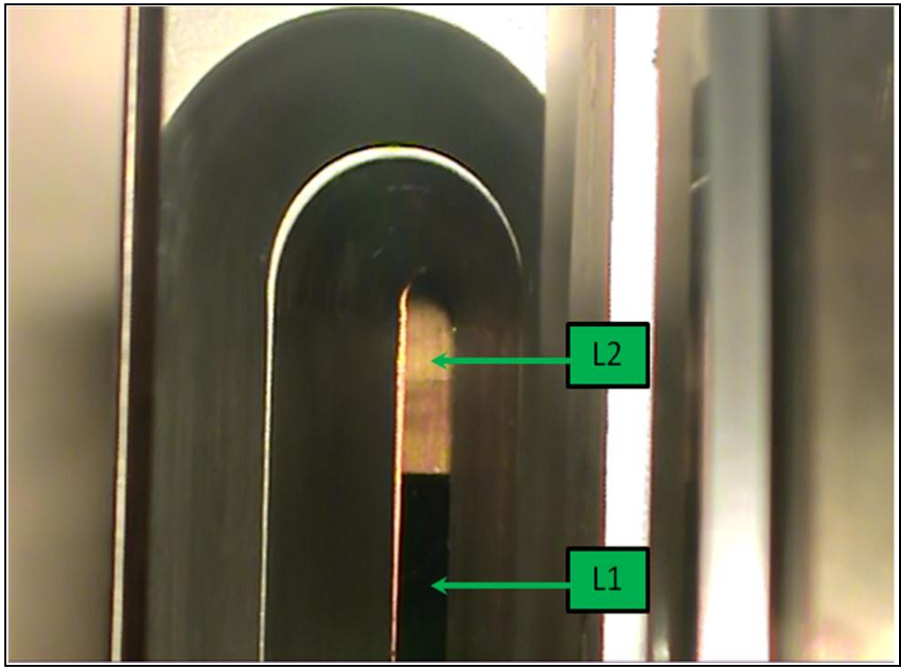


Alaska North Slope Gas Content (Transport of Natural Gas to Tidewater)

Research Background

Background:

- Blend of carbon dioxide and light hydrocarbons have potential to increase heavy oil recovery
- Numerical simulations are used to make development decisions
- Phase behavior of heavy oil when combined with carbon dioxide and light hydrocarbons is not well described numerically so difficult to simulate



Carbon Dioxide and Heavy Oil Forming Two Liquid Phases

Conclusions

- Ongoing research is step toward additional production of heavy oil resources from ANS
- Additional production would be boon to TAPS
- CO_2-MI blend would utilize existing ANS resources to increase heavy oil production
- Sequestration of carbon through injection of CO_2-MI blend

Future Research

- Identify CO_2-MI blend that eliminates formation of second liquid phase
- Measure density and viscosity of heavy oil in contact with optimized CO_2-MI blend
- Conduct slim-tube experiments to determine minimum miscibility pressure of optimized CO_2-MI blend
- Evaluate recovery potential of development scenarios using numerical simulator
- Tune or develop a numerical simulator to match empirical phase and property behavior

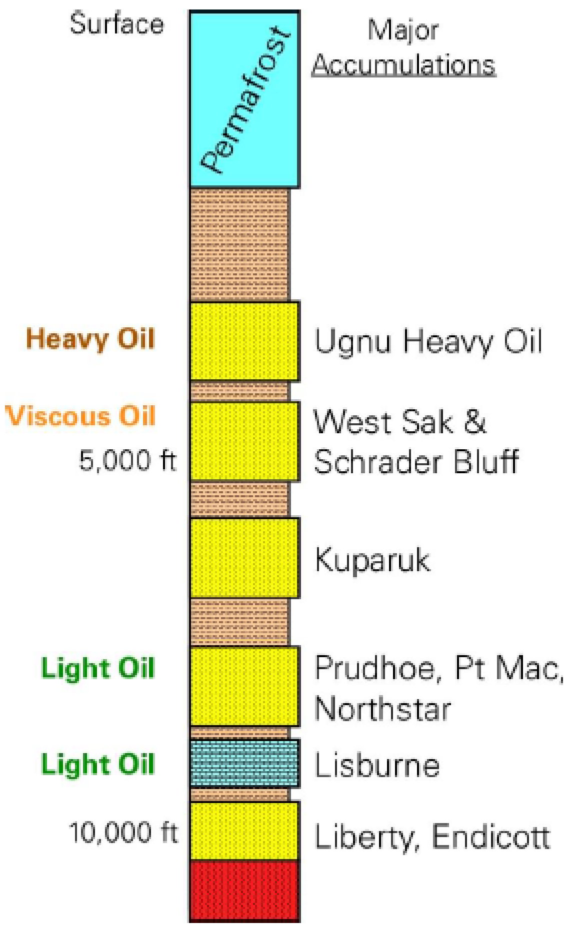
Protecting ANS Wells and Infrastructure from Permafrost Subsidence

Tom Polasek

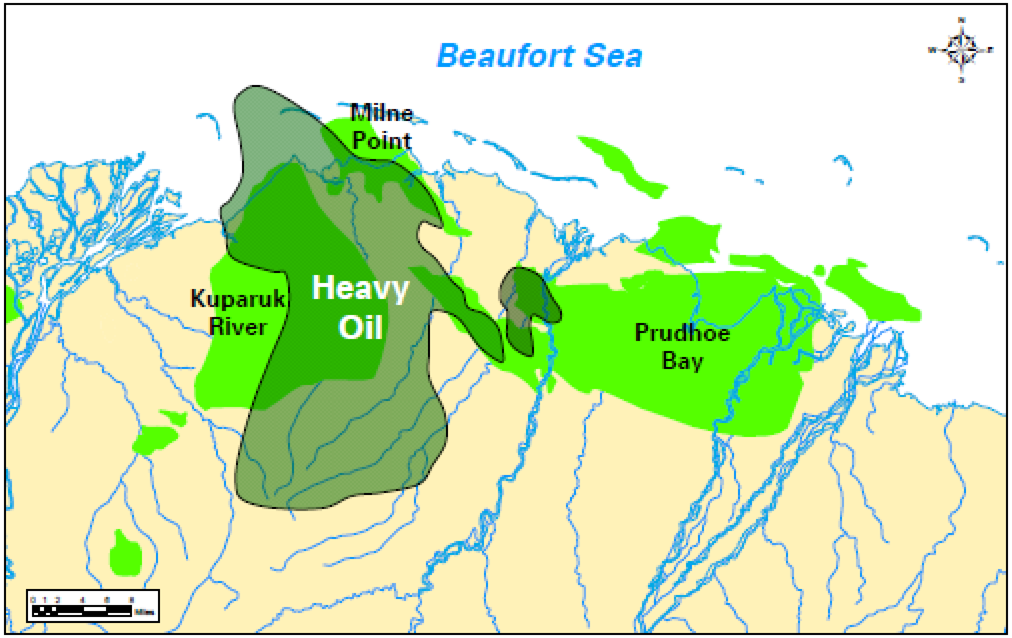
Undergraduate Research Assistant
Permafrost Subsidence Project Lead
Petroleum Development Laboratory
University of Alaska Fairbanks

Alaska Heavy Oil Resource

Alaska Viscous & Heavy Oil Resource

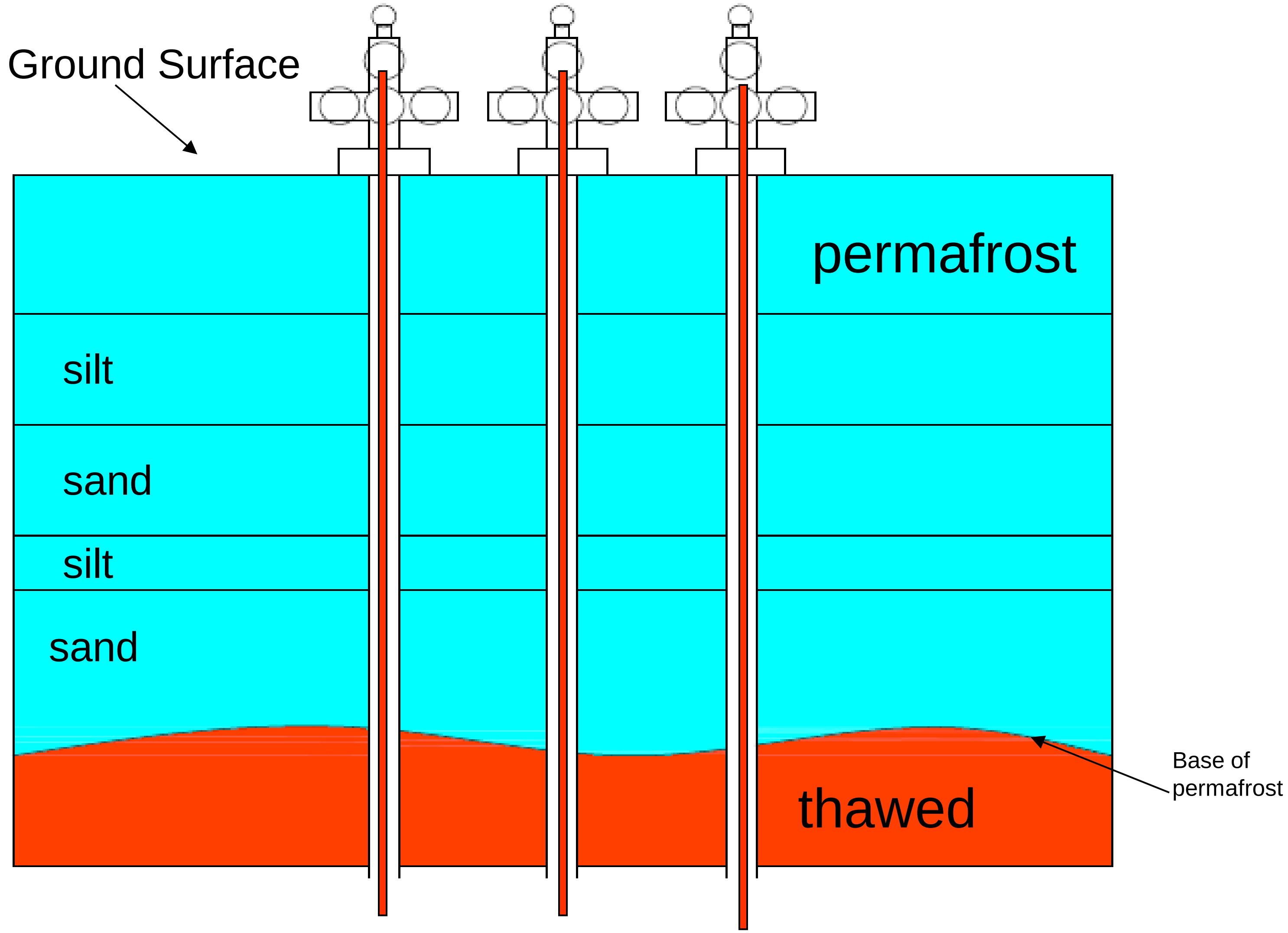


- Heavy oil resource overlies existing fields
- Oil is present in multiple reservoir zones
- **Total: 24 – 33 Bbbls Oil in Place**
  - Schrader Bluff / West Sak – ~12 Bbbls (14-22 API)
  - Ugnu – 12-18 Bbbls (8-14 API)

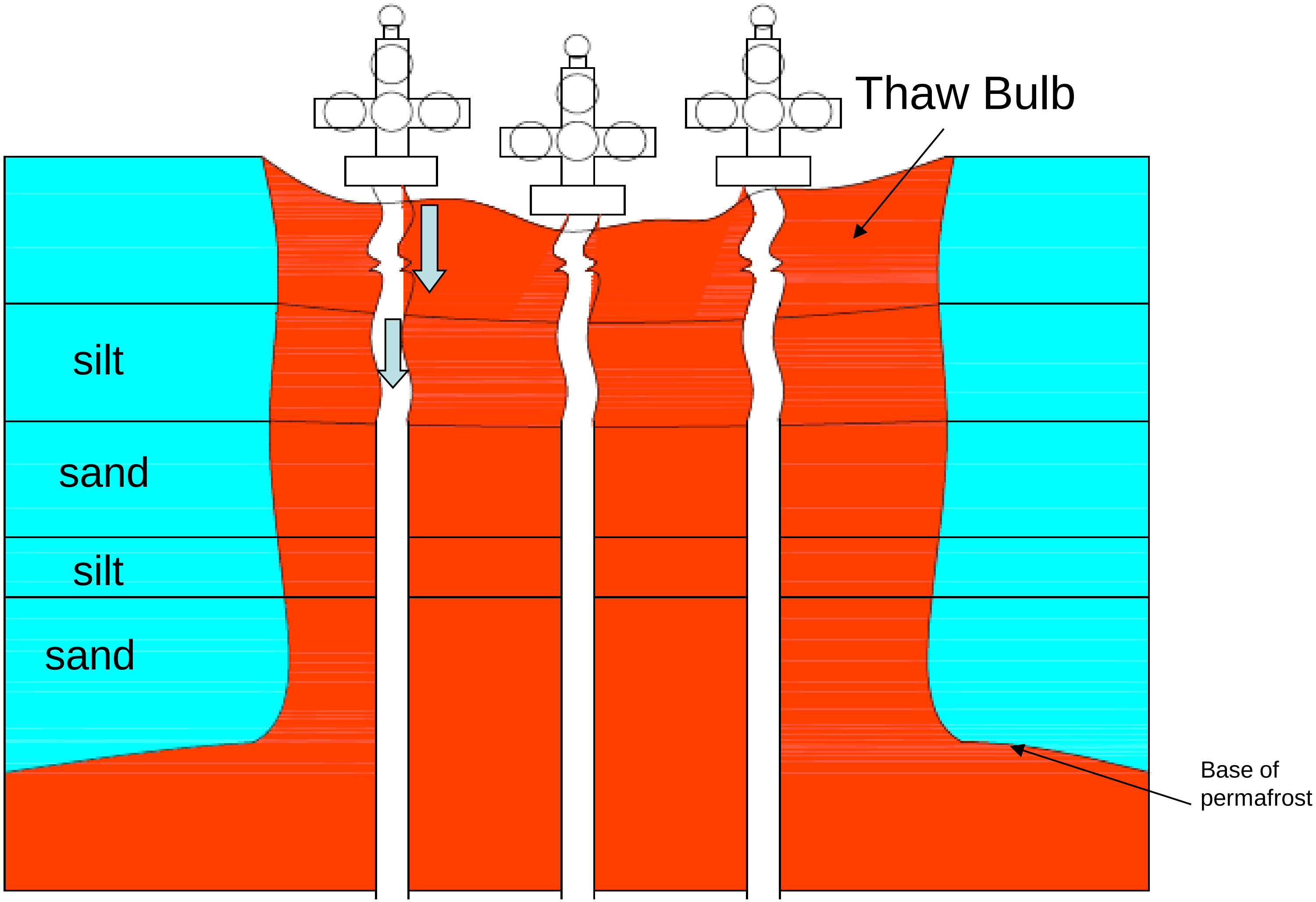


Source: BP Exploration Alaska, 2011. www.aoga.org

Permafrost Thaw and Subsidence

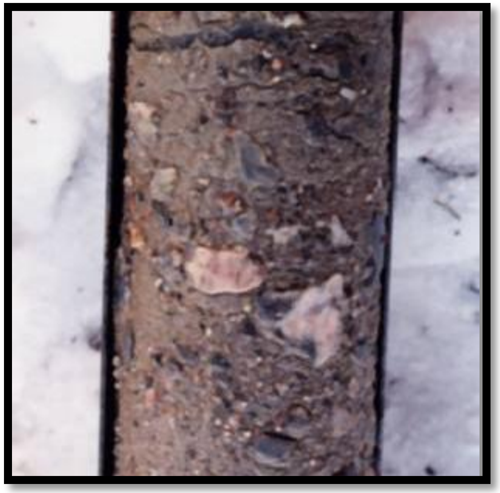


Permafrost Thaw and Subsidence



Ice Content Upper Permafrost Soils

Ice rich frozen silt



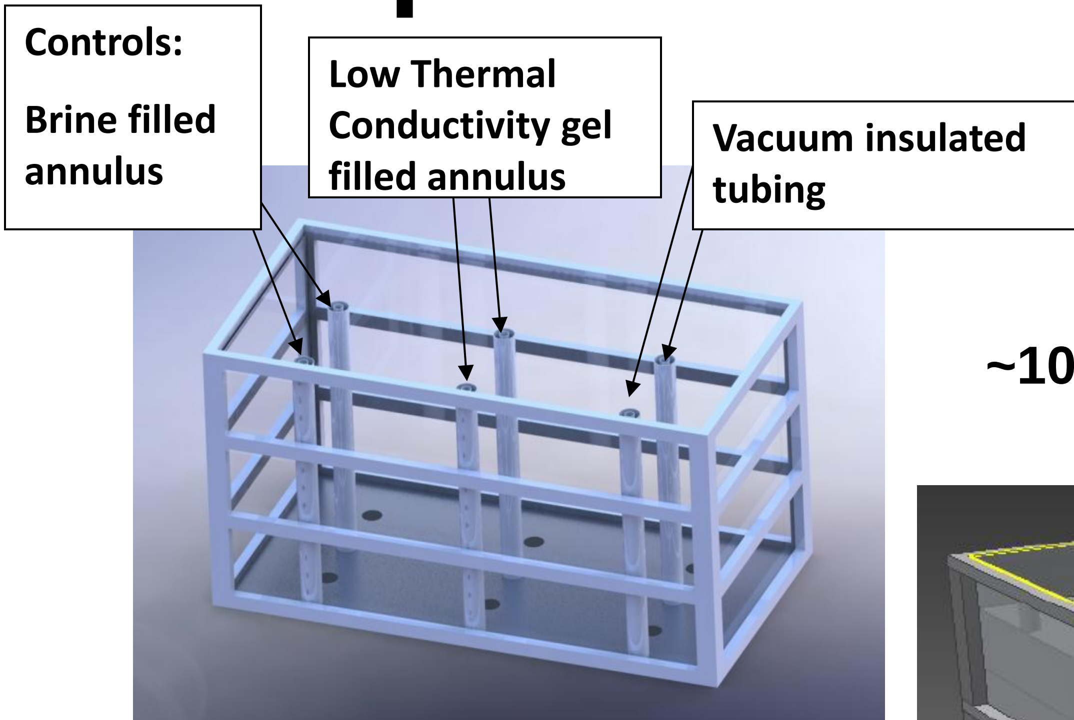
Ice poor frozen till

Frozen gravelly silty sand till

Thawed gravelly silty sand till

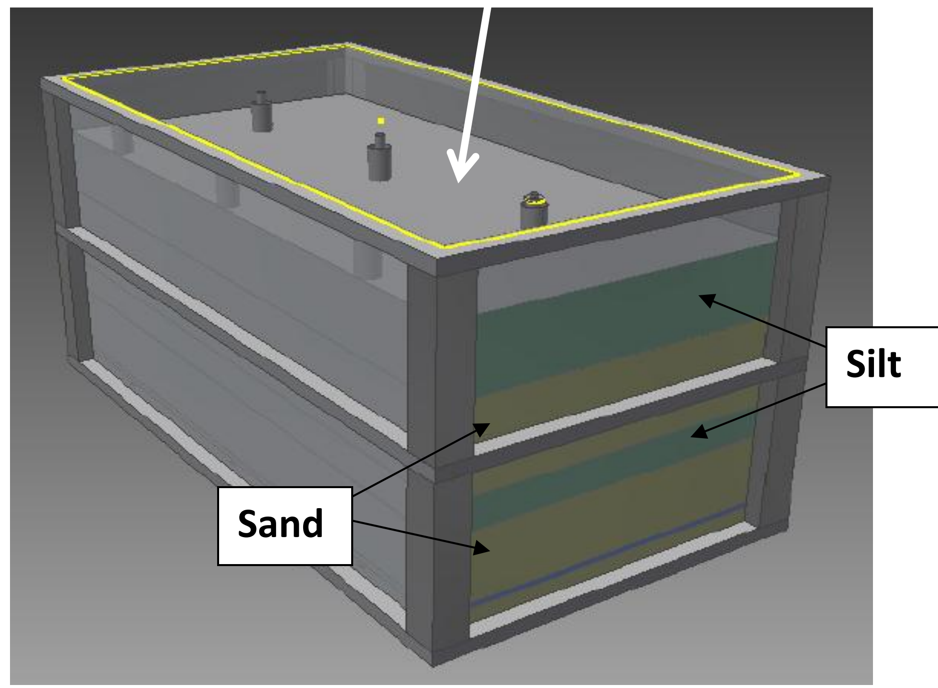
Source: I. Holubec Consulting

Experimental Equipment

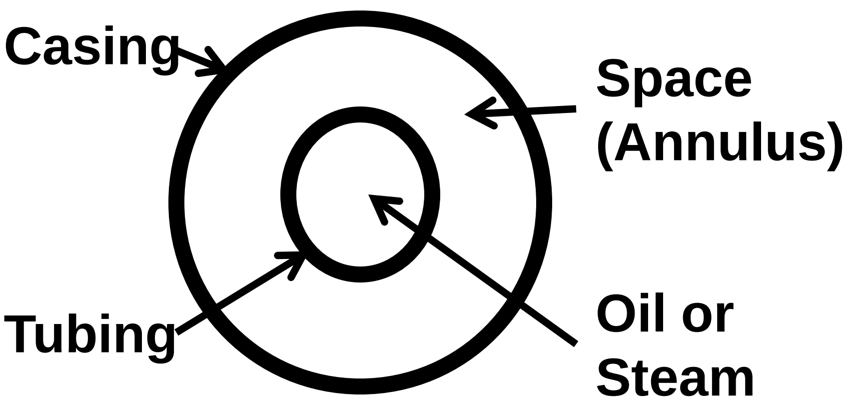


Data Collection

~100 thermistors (heat sensors)
IR thermal image camera



Looking Top-Down

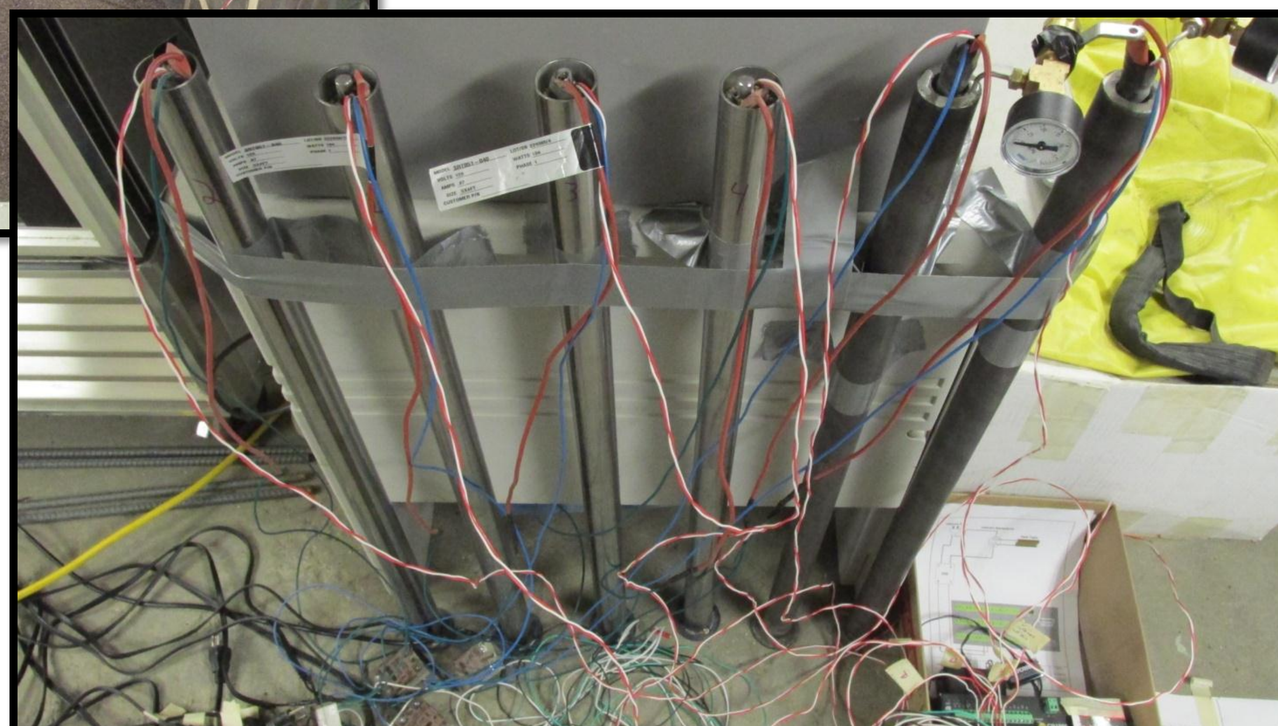


Project Objectives

- Collect data to analyze how best to protect current and future wells
- Acquire empirical data for tuning permafrost thaw computer simulations
- Gain lessons learned for future research using frost cell equipment

Project's Current Progress

Project's Current Progress



Impacts on Future Alaska North Slope Oil Production

1. Estimated 24 – 33 billion barrels of heavy oil, much of it is inaccessible without thermal EOR

2. One step closer to unlocking access to heavy oil on Alaska's North Slope

Future Work

1. More complex/multilayered models. UAF is the first to do this type of physical modeling.

2. Further research into geomechanical forces on scaled down wells

3. Collaboration with Alaska’s energy industry

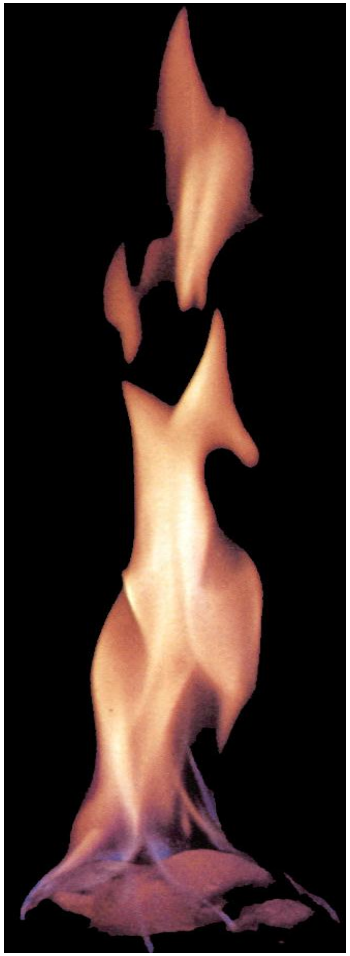
Oil & Gas Related R&D at UAF
Synergies, Partnerships (University, State Govt., Federal Govt., and Industry)

- Phase Behavior, Asphaltene Precipitation- Viscous/ Heavy Oil
- Chemical Flooding and Conventional EOR
- Wettability and Improved Oil Recovery
- Chemical & Microbial Characterization- Viscous Oil
- Methane Hydrates
- CBM- Rural Energy Applications- Ft. Yukon
- Novel Ceramicrete Technology for the Arctic
- Carbon Sequestration
- GTL Transportation

Workforce Development

New Reserves to Declining Production

Economic Development



NETL-US DOE

Student Success

Professional Development- Strong SPE and AADE Sections

KELLY LYONS wants to get the most out of Alaska's oilfields.
The East Coast native didn't take the most direct route to Alaska. For awhile she made sails in Maryland, was a live-in nanny, then drove a flatbed truck. She hit all 48 contiguous states but not Alaska, and since she wanted to go back to school anyway (she has a bachelor of arts degree from St. John's College in Annapolis) she figured she'd check out UAF. "I'm definitely here to stay," she says. "I actually like 50 below." Today she's a senior in petroleum engineering.

"I had no idea I wanted to do engineering, but I thought, well, they have a lot of oil, and I'm good at math and science, so I thought I'd try it." Lyons is president of the UAF chapters of a national engineering honor society and the international Society of Petroleum Engineers, and she's on the advisory and development council for the College of Engineering and Mines.

It's a good thing she's making her home in Alaska, because the state needs her expertise. As an intern with ConocoPhillips, Lyons got hooked by the challenge of enhanced oil recovery. **Now that ConocoPhillips has offered her a job after graduation, she can be added to the list of Alaska's natural resources.**

UAF Petroleum Engineering Student Success

Phillip Tsunemori (B.S.)
1st Place 2004 SPE WRM

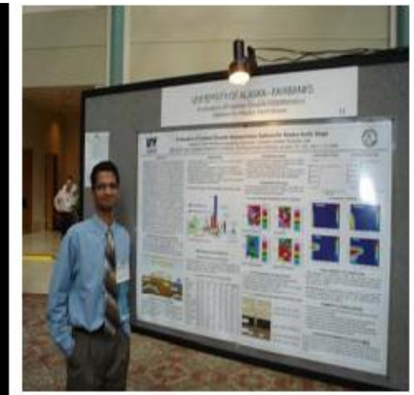
Now with BP Alaska

Namit Jaiswal (M.S.)
3rd Place 2004 SPE WRM

Now with Shell, Houston

Prasad Kerkar (M.S.)
3rd Place 2005 AADE

Now with Shell, Houston



Santosh Patil (M.S.)-
2nd Place 2006 AADE

Now with BP Alaska

Sudiptya Banerjee (M.S.)
1st Place 2005 AADE
3rd Place 2005 SPE WRM

1st Place Sandy Purdy award

Now with Baker Hughes, Houston

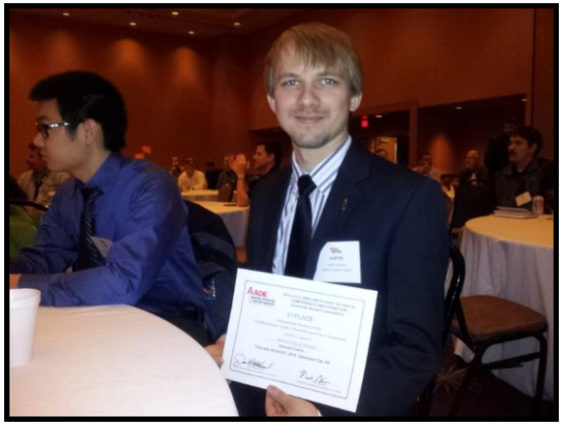
Chinedu Agbalaka (M.S.)-
2nd Place 2006 SPE WRM

Now with Chevron, Houston

Praveen Singh (M.S.) (right), 2nd Place
Aditya Deshpande (M.S.) (left), 3rd Place
2008 SPE WRM

Now with BP Alaska & Occidental, CA

UAF Petroleum Engineering Student Success



Petroleum Engineering Alum featured in USA Today

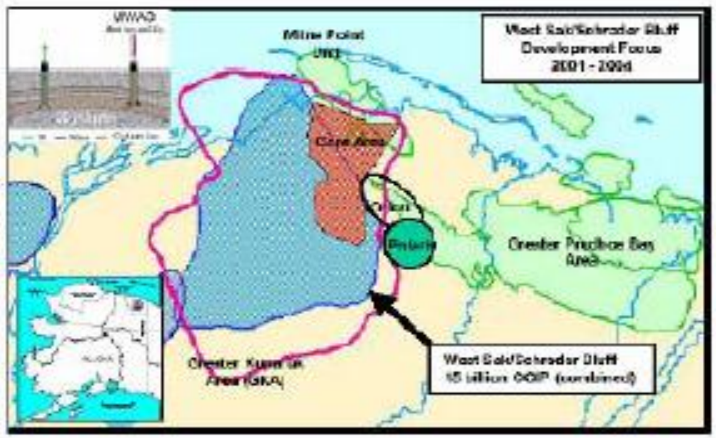
Abhijeet Kulkarni, UAF/CEM Petroleum Engineering alum (MS, class of 2005), now Reservoir Engineer with Shell in Denmark was featured in "USA Today" on February 18, 2013 as New Face of Engineering. Since 2005, Abhijeet has worked numerous assignments for Shell in Netherlands, Middle East and Denmark. He also is the Chairman of the SPE Young Professionals Program, mentoring young petroleum engineers throughout the world. Kulkarni is a reservoir engineer who designs methods to enhance oil and gas production from the North Sea fields. He was nominated by the Society of Petroleum Engineers.

The New Faces of Engineering is a recognition program that focuses on highlighting engineering contributions of young engineers two to five years out of school. These engineers are nominated by Engineers Week sponsoring societies from among their membership.

Partnership for Economic Development

Potential Prize:
25 Billion Barrels
of Viscous Oil

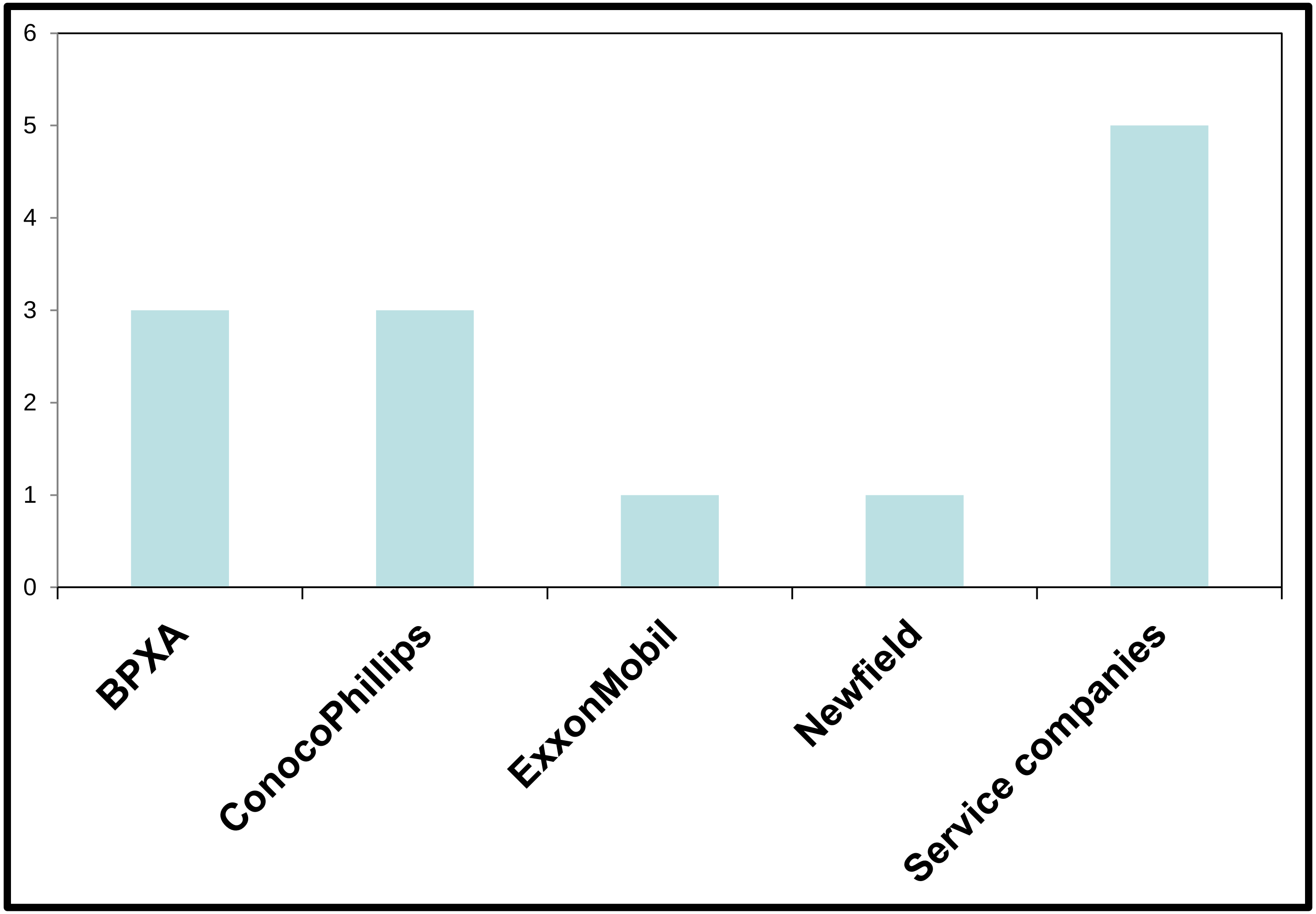
Potential Prize:
100 TCFof NG in
Gas Hydrates



State-of-the-art
Laboratory
Facilities
PDL- UAF

Benefits:
Sustained Resource
Development for
the State of Alaska

2014 Undergraduate Placement Success



Thank you.

www.uaf.edu/ine

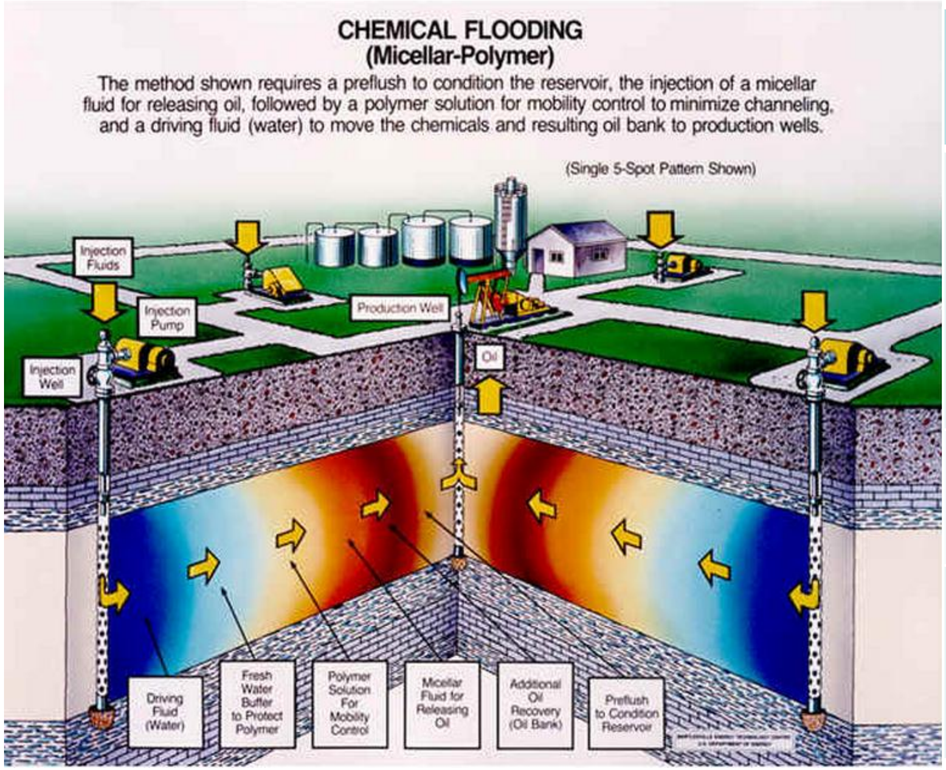


Contact:
Shirish Patil, Director
Petroleum Development Laboratory
Institute of Northern Engineering
College of Engineering and Mines
(907) 474-5127
slpatil@alaska.edu

EXTRA SLIDES

Current Research Projects- PDL

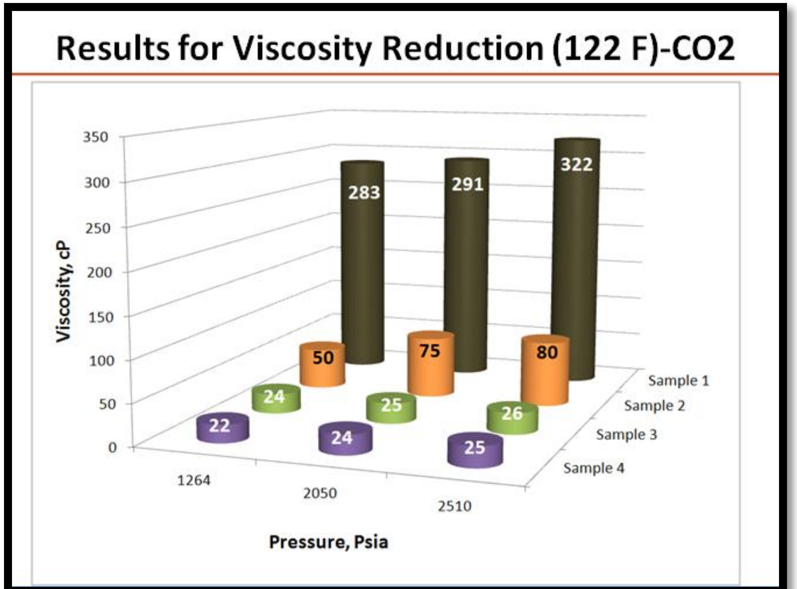
- LowSal™ Water Flooding Studies for ANS Fields
- CO2-MI Phase Behavior Studies
- Reservoir Engineering Studies in Support of Umiat Field Development
- Development of Zeolite Based Cement for HTHP Geothermal Wells
- CO2 Sequestration and CO2 EOR
- Shale Study Project
- Umiat Field Development Study
- EOR For Conventional Oil Recovery

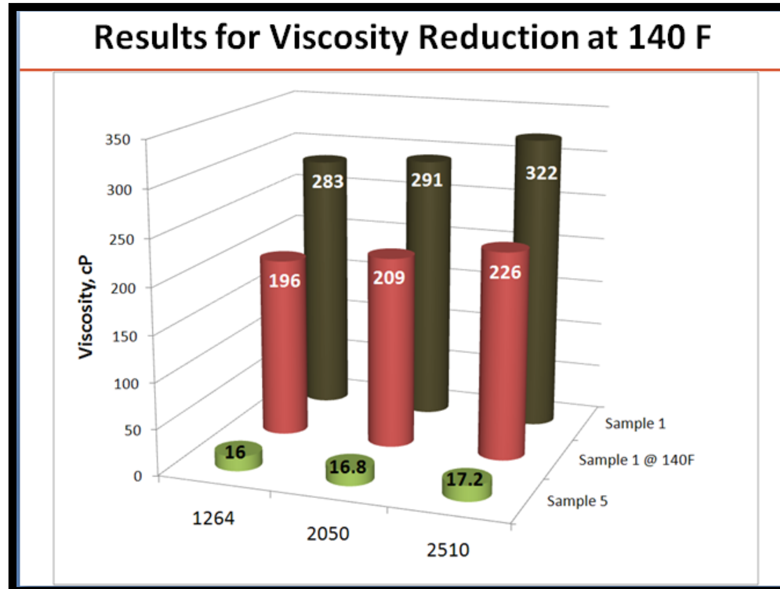


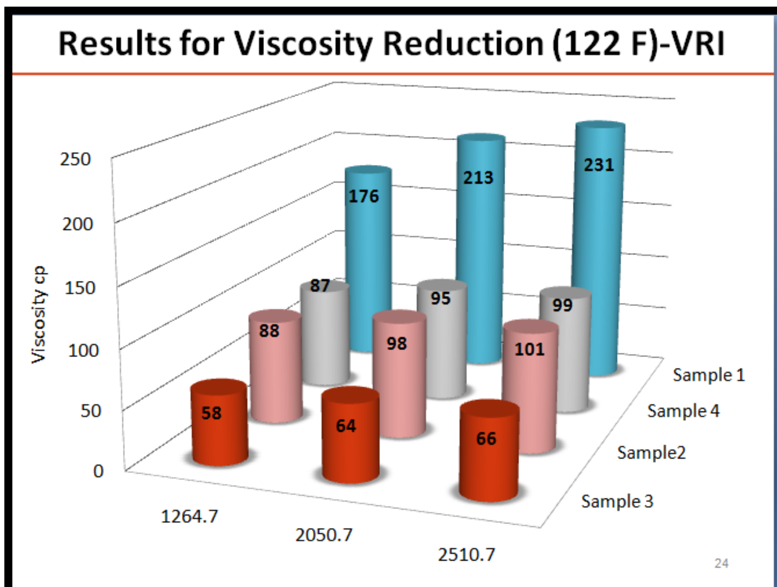
Component	Chemicals	Effect
Alkali	NaOH	Decreases IFT, regulates phase behavior
Surfactant	Anionic/Cationic	Decreases IFT
Polymers	PAM	Controls sweep

- Proven recovery technique worldwide
- Mature fields
- Declining reservoirs
- Permafrost presence doesn’t allow thermal recovery methods
- Heavy oil recovery
- Saved injection gas can be used to generate revenue.
- Increase in recovery factor – Simulation results

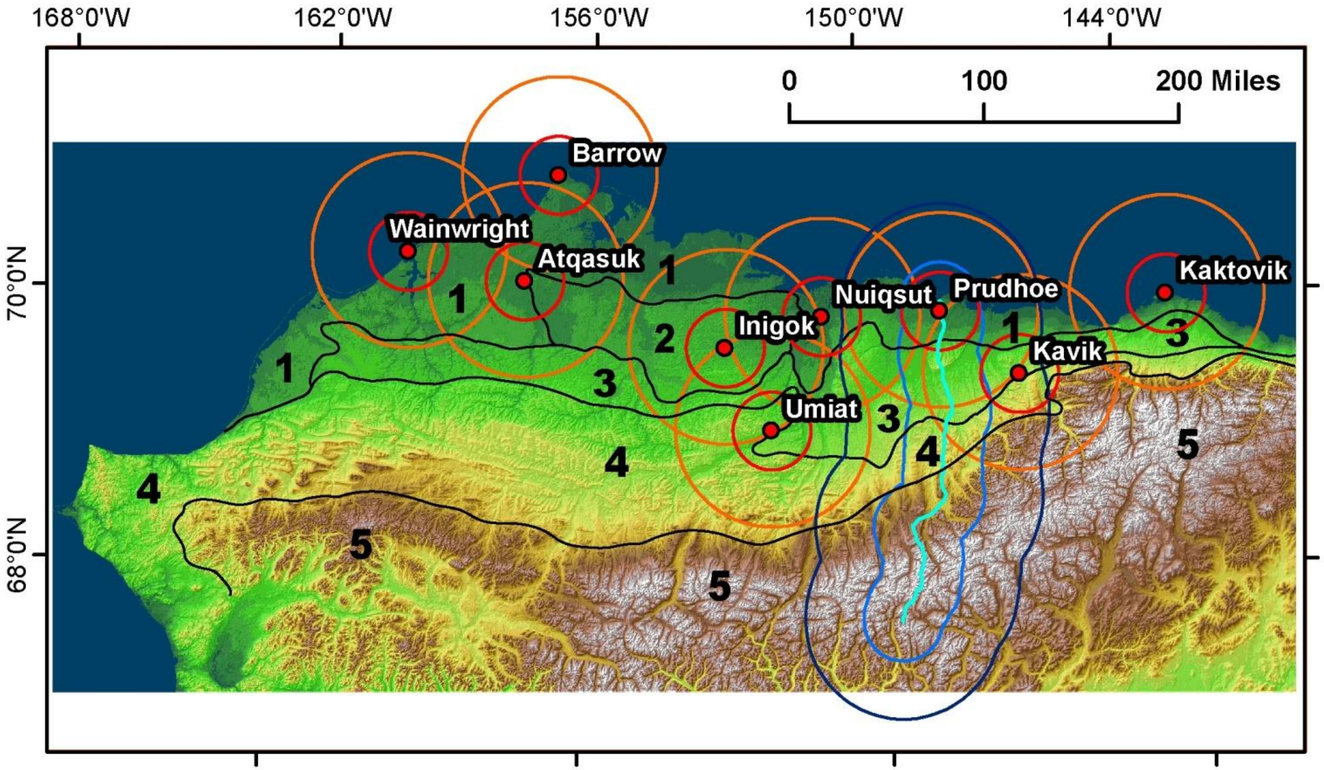
CO2 EOR- Enriched with Nano-Particles







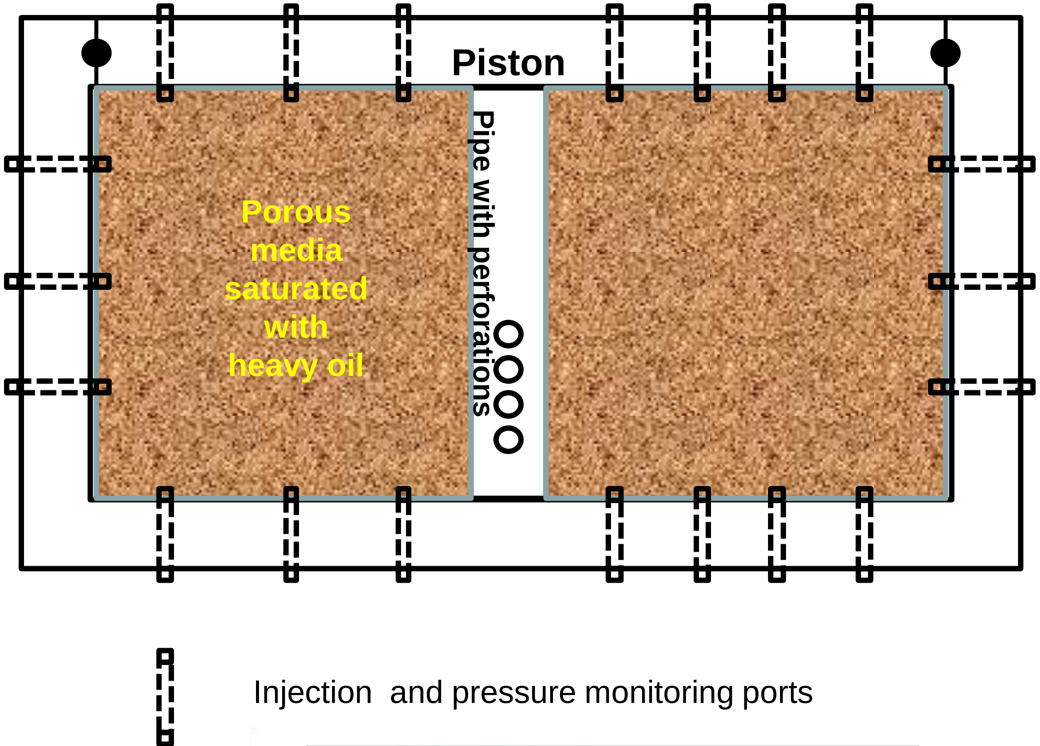
Schematic map of the Northern Alaska permafrost regions



No	Name of the region	Permafrost temperature, °C	Thickness of permafrost, m	Ground ice	Permafrost related hazards
1	Arctic Coastal Plain	–7…–11	200-650	Active ice wedges, pingos	Thermokarst, thermal erosion
2	“Sand Sea”	–5…–8	200-350	Pingos, small active ice wedges	Wind erosion, thermokarst, thermal erosion
3	“Silt belt”	–5…–8	200-550	Huge ice wedges, pingos	Thermal erosion, thermokarst, thaw slumping
4	Arctic Foothills	–5…–7	250-550	Ice wedges	Thermal erosion, slope processes, thermokarst
5	Moderately high mountains	–4…–6	100-300	Buried glacier ice, small ice wedges	Slope processes, thermal erosion

CHOPS Process

- Use an experimental setup to answer the following questions
- What is the effect of reservoir rock and fluid properties on
  - wormhole length,
  - wormhole stability,
  - wormhole pattern?



Injection and pressure monitoring ports

- Is carbonate acidizing a useful analog for the CHOPS process?
- Are concepts like pore volumes to breakthrough useful in this context?

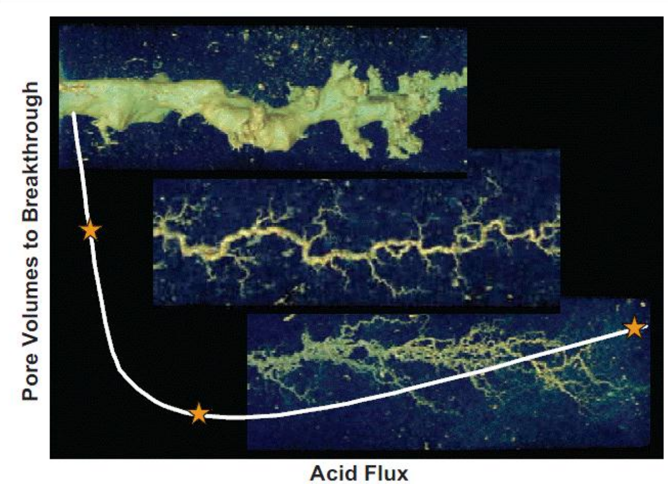


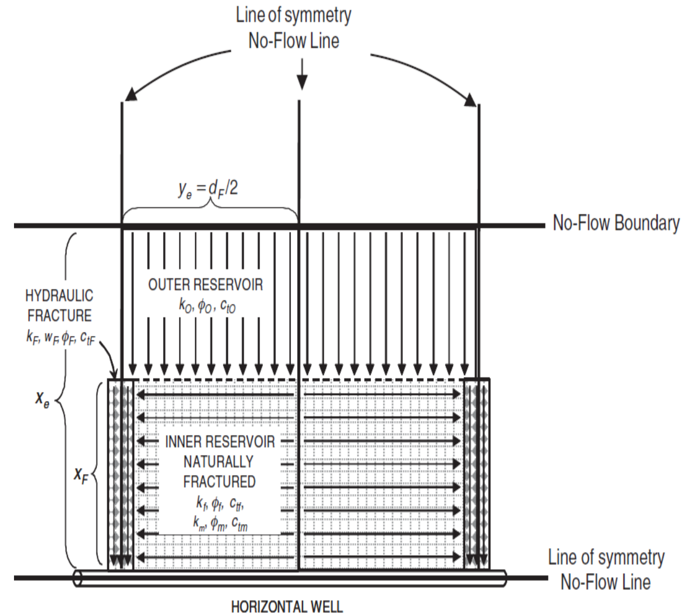
Fig 1—Wormhole-efficiency curve for Indiana limestone with corresponding high-resolution CT images.

Shale Resource Development

In Depth Understanding of Development Challenges in Unconventional Shale Reservoirs

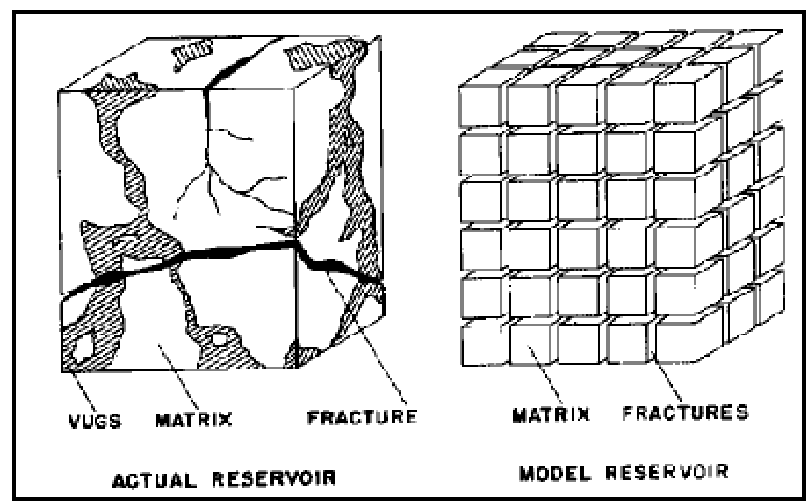
Objective: Identify the challenges associated with development of Alaska shale resources including leasing and fracturing, as well as expected recovery

This project includes simulation study in two different areas: Hydraulic fracturing and Reservoir simulation.



Focus is on enhancing understanding of shale resources dynamic behavior in order to optimize their development. Both analytical and simulation techniques are used to help ADNR to put in place a successful management plan to facilitate development of these resources:

Thin streaks representing natural fractures



Warren and Root, 1962

UAF Petroleum Engineering Graduates

About The Program

The graduate program in petroleum engineering at the University of Alaska Fairbanks (UAF) offers high quality, contemporary education and research in all areas of petroleum engineering at the M.S. level. A special emphasis is placed on arctic oil and gas development.

The petroleum engineering curriculum is accredited by the Accreditation Board for Engineering and Technology (ABET), the national accrediting agency for engineering programs. Petroleum engineers are in high demand worldwide, and graduates of the UAF program are immediately employable for high-paying positions within Alaska, the rest of the nation and beyond.

Though admission into the graduate programs in Petroleum Engineering is highly competitive, the flexibility in accommodating those with industry experience enables working engineers to take advantage of the opportunity.

A World Of Opportunities

As the only petroleum engineering graduate program in Alaska, students have numerous opportunities available to them at America's arctic university:

- State of the art laboratory equipment
- Excellent computing facilities
- Outstanding faculty
- Small student to professor ratio
- Unique oil and gas research projects
- Great career opportunities

"UAF provided me with excellent career guidance. Upon completing my Masters in Petroleum Engineering I started a new job immediately with an energy company with a large regional office in Alaska. I really enjoy my new career field and I'm very grateful to UAF for being in touch with the job market and pointing me in a great direction with excellent career opportunities."—Mike Timmcke, Petroleum Engineer

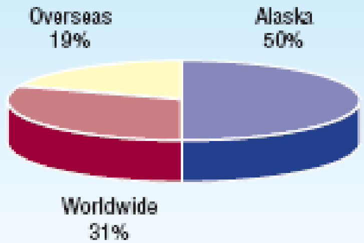
Petroleum Development Laboratory

Established in 1984, Petroleum Development Laboratory (PDL) is a state of the art research laboratory conducting energy related research at the University of Alaska Fairbanks. The primary function of PDL is to explore the various aspects of enhanced oil and gas recovery research. In addition to addressing the unique challenges confronting the petroleum industry, it provides excellent laboratories to supplement petroleum engineering courses. Petroleum engineering students at UAF have access to PDL facilities that match or rival what is being used by industry today. Research conducted at PDL includes basic and advanced studies of oil displacement, reservoir properties of the Alaska fields, thermal recovery, miscible flooding, improved water flooding, gas hydrates, gas-to-liquids (GTL) conversion and transportation, drilling and production. PDL facilities are also supplemented by well equipped reservoir rock and fluid properties, and drilling fluids teaching laboratories. Petroleum engineering graduate students routinely design and develop specialized experimental set-ups for specific research projects.

Career Opportunities

Petroleum engineers earn among the highest starting salaries in the field of engineering. Favorable opportunities are expected for petroleum engineers because the number of job openings is likely to exceed the relatively small number of graduates. Petroleum remains the dominant source of energy, with current world production of oil and gas at record rates. Because oil and gas are an international commodity petroleum engineers have the opportunity to work in the U.S and overseas. UAF graduates are pursued by oil and oilfield service companies in Alaska and worldwide.

UAF Petroleum Program Graduates (BS and MS): Worldwide Employment Distribution



Society of Petroleum Engineers (SPE)

The petroleum engineering department at UAF has a very active SPE student section. The section regularly organizes technical seminars, carries out student mentoring, organizes field trips, and arranges social events. The SPE section also plays an important role in the organization of regional meetings and student paper contests.

American Association of Drilling Engineers (AADE)

The AADE student section is also very active in the professional development of petroleum engineering students. The AADE mission is similar to that of SPE; however, it has a stronger focus on drilling-related issues.

PDL-Established Research Partnerships

NETL

RYDER SCOTT
GEOSCIENTISTS
PETROLEUM ENGINEERS
TECHNICAL ANALYSTS

PRA
Geological, Geophysical, and Reser
Consulting for the Alaska Oil and Ga

bp

ConocoPhillips

BJ

Alyeska pipeline
SERVICE COMPANY

NATCO

SIGILLVM UNIVERSITATIS ARIZONENSIS 1885

CYNARA

BERKELEY LAB

ASRC Energy Services
a subsidiary of Arctic Slope Regional Corporation

USGS

Anadarko
Petroleum Corporation

U. S. Department of the Interior
Bureau of Land Management

Pacific Northwest National Laboratory

Energy Technology Division
Argonne National Laboratory

Department of Natural Resources
Division of Geological and Geophysical Surveys

UAF
UNIVERSITY OF ALASKA FAIRBANKS

Recent NETL-DOE Funded Oil & Gas Related R&D at UAF
Synergies, Partnerships (University-Federal Govt., State Govt., Industry, Non Profits)