CHARACTERIZATION AND ALTERATION OF WETTABILITY STATES OF ALASKAN RESERVOIRS TO IMPROVE OIL RECOVERY EFFICIENCY

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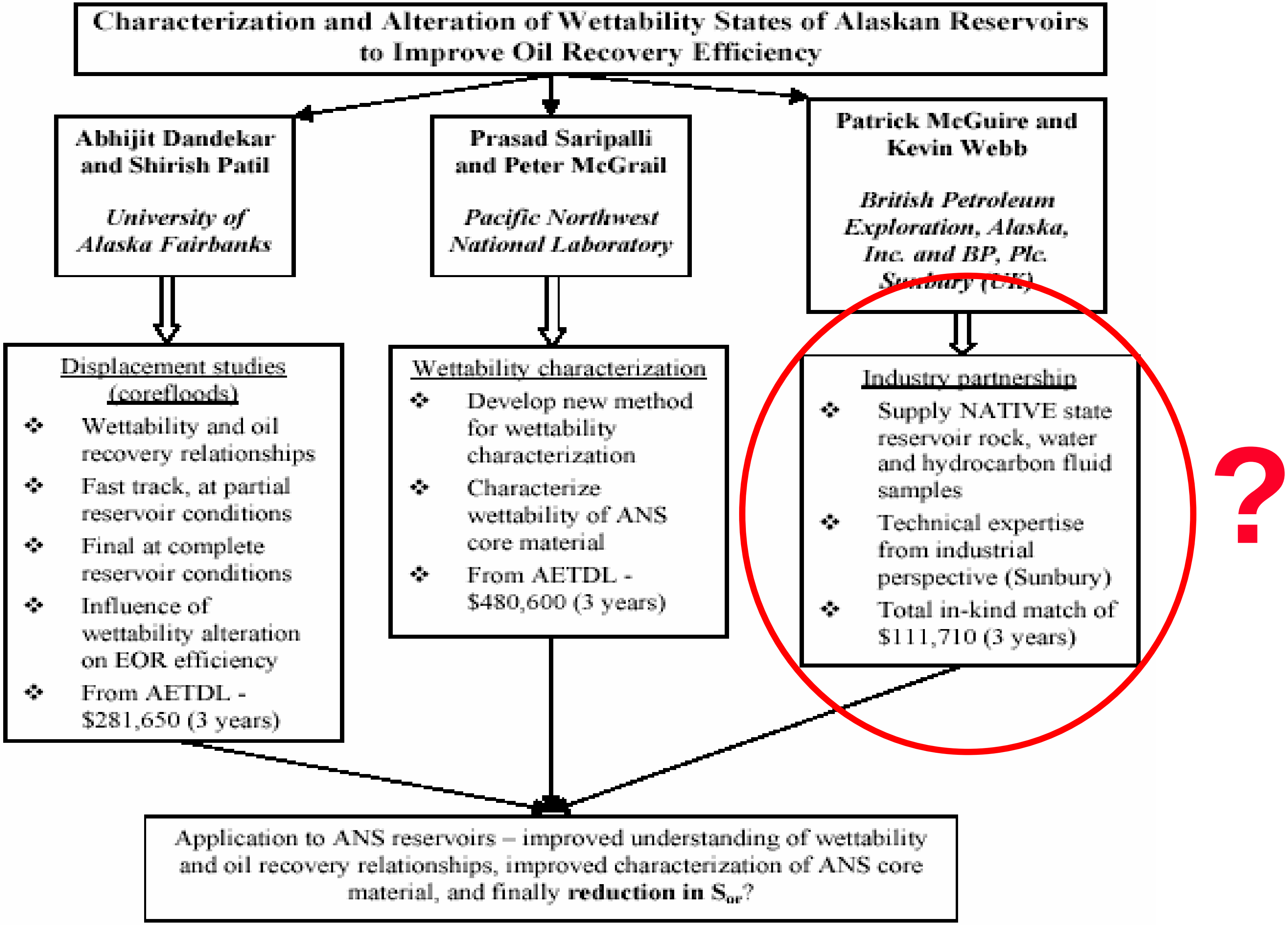
OUTLINE

- ✓ Focus on wettability
- ✓ Project overview
- ✓ Project Test Programme
- ✓ Progress to date
- ✓ Experimental work at PNNL
- ✓ Experimental work at UAF
- ✓ Future work

FOCUS ON WETTABILITY

- Relative distribution of fluids within the pore space of a reservoir rock is controlled by wettability, i.e., influence on S_{or} or oil recovery
- Oil/Brine/Rock system Wettability is a function of numerous variables; prominent ones being fluid chemistry and rock type
- USBM and Amott considered as industry standards; however they characterize average wettability and are inadequate for mixed wettability characterization

PROJECT OVERVIEW



TEST PROGRAMME

Tasks	Year 1 (Nov. 03 to Oct. 04)				Year 2 (Nov. 04 to Oct. 05)				Year 3 (Nov. 05 to Oct. 06)			
Literature review (includes also other wettability determination methods)												
Role of wettability in EOR												
Fast track coreflooding tests to evaluate Low Salinity potential												
Development of new wettability determination technique												
Application of developed wettability characterization method to ANS cores												
Sorting of ANS data in terms of wettability												
Advanced coreflooding tests (reservoir conditions)												
Classification of oil recoveries with respect to OW/WW/MW												
Attempt to alter wettability												
Determine altered wettability												

(SAMPLELESS) PROGRESS TO DATE

- Tasks 1 and 2 are 100% complete. A manuscript has been submitted to the Journal of Petroleum Science and Engineering; currently under review
- Tasks 3 and 4 are ongoing; however, on *other core samples and fluids* due to lack of representative samples from BPXA
- Tasks 5 and 6 are impacted due to non-availability of test materials from BPXA
- Progress has been made as far as Task 7 is concerned. Indigenous design and development of a ‘state of the art’ RESERVOIR CONDITION coreflooding rig. Reservoir condition corefloods not part of the original workplan
- Tasks 8-10 are for the future. However, these will be impacted due to test material non-availability

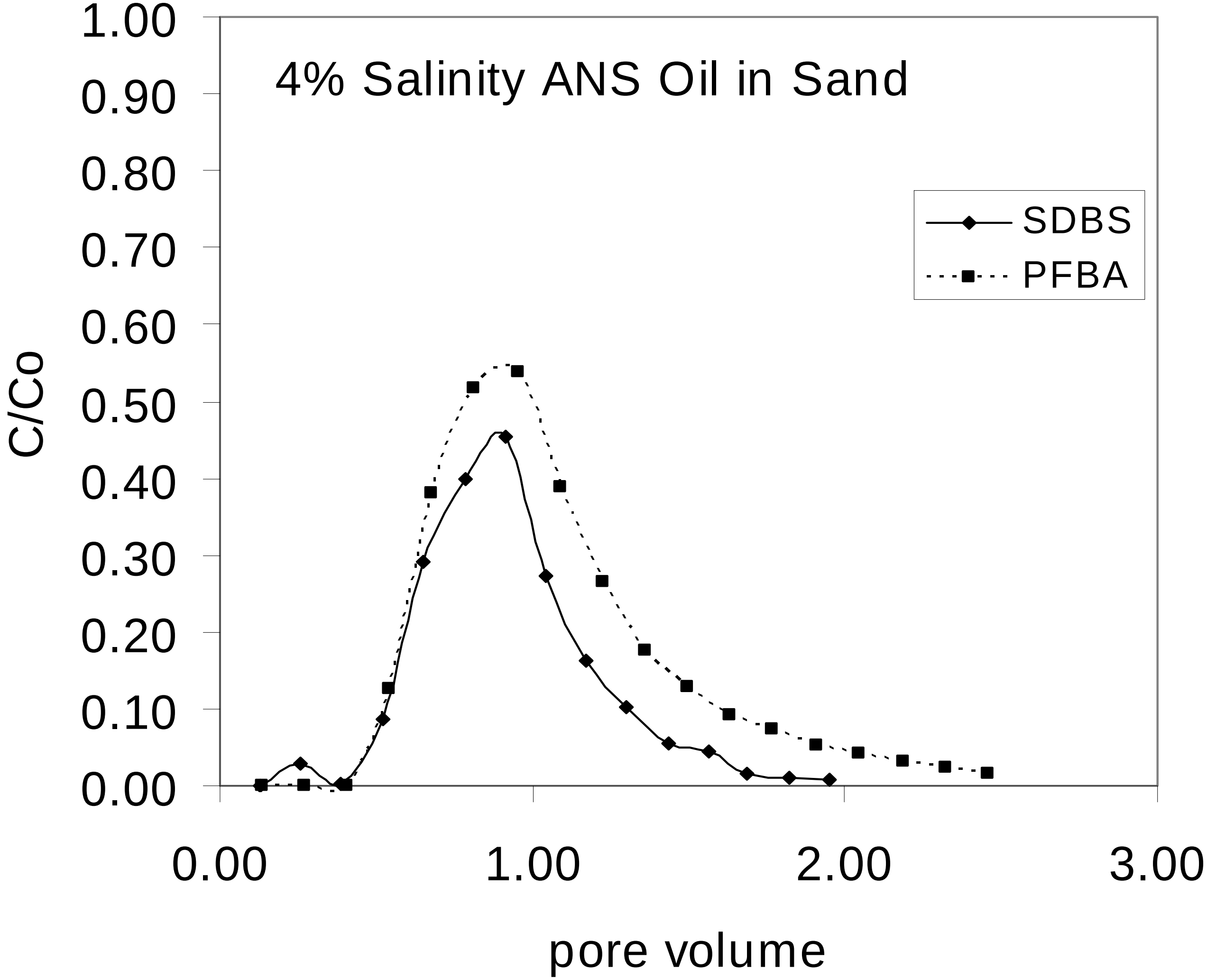
EXPERIMENTAL WORK AT PNNL

Tracer tests using SDBS and Valeric Acid as Interfacial tracers are underway. Tests using PFBA as non-reactive tracer and above interfacial tracers have been completed.

ANS oil and sandstone or porous sand packs were used in these experiments.

Interfacial tracers adsorb only at the oil-water interface as a monolayer. Their lag is a direct measure of (a_{nw}) and hence wettability, including mixed-wet states.

Interfacial Tracer Experiments: 4% Salinity

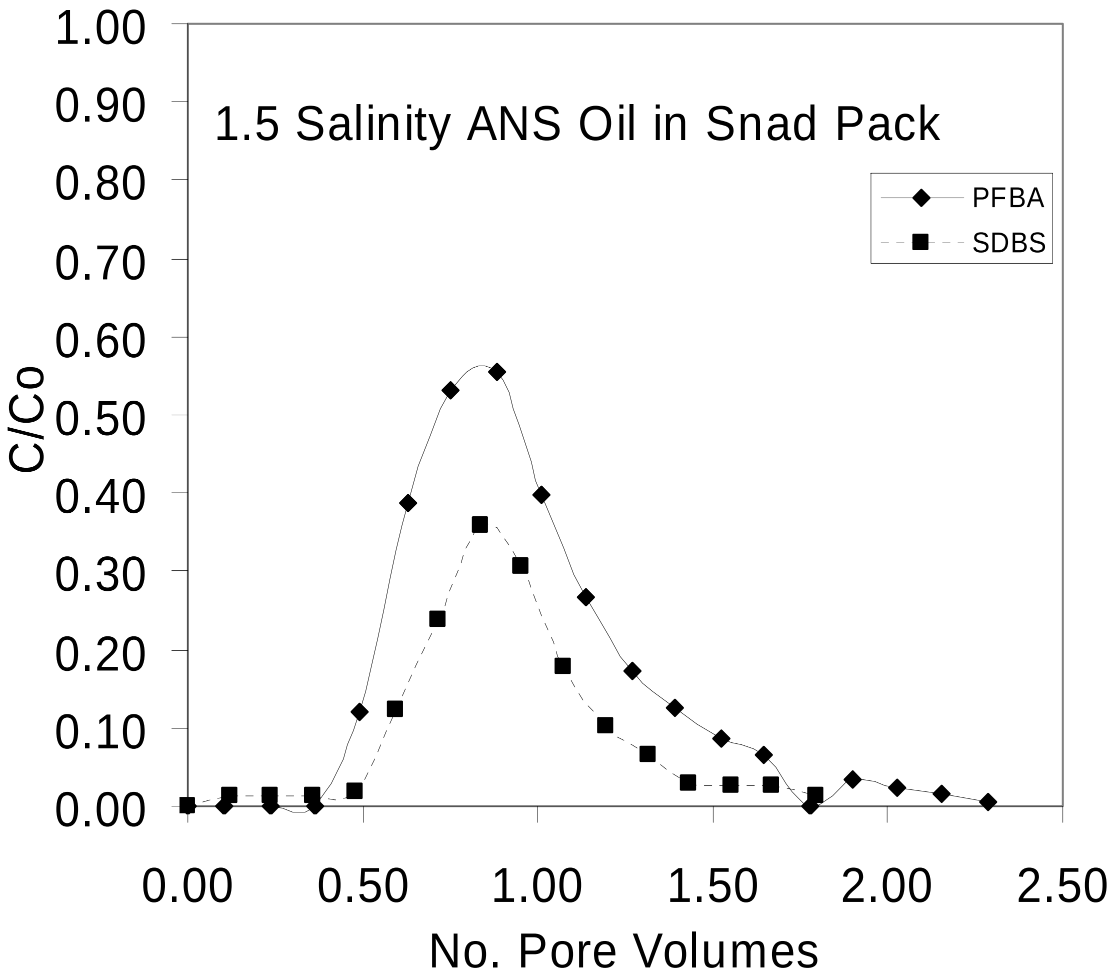


Interfacial Tracer (SDBS) in Water-Wet Sand Column loaded with ANS Oil

S_{or} = 24.5%

Small Retardation (Lag) of SDBS relative to PFBA indicates low a_{ow} and larger oil blobs

Interfacial Tracer Experiments: 1.5% Salinity

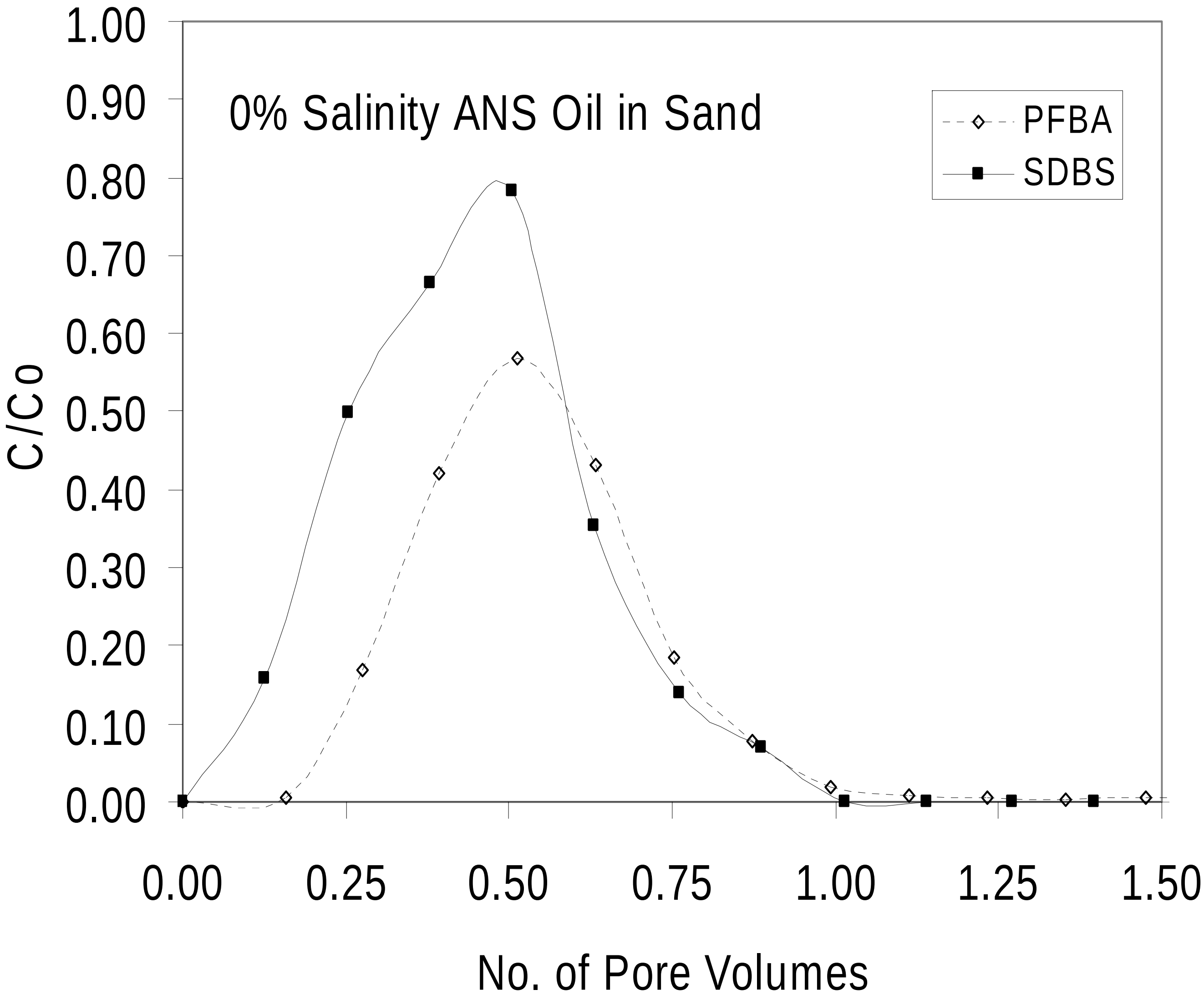


Interfacial Tracer (SDBS)
in
Water-Wet Sand Column
loaded with ANS Oil

S_{or} = 22.6%

Moderate Retardation (Lag) of SDBS relative to PFBA indicates intermediate range a_{ow} and oil blobs

Interfacial Tracer Experiments: 0% Salinity



Interfacial Tracer (SDBS) in Water-Wet Sand Column loaded with ANS Oil

S_{or} = 20.1%*

Large Retardation (Lag) of SDBS relative to PFBA indicates large a_{ow} and smaller oil blobs

*Large uncertainty due to mass balance errors

Results Summary

Salinity (% NaCl)	S_{or}	a_{ow} $(cm^2/cm^3)^+$
4.0	24.5	< 20
1.5	22.6	100 - 150
0.0	20.1*	150 - 300

Results indicate that lowering salinity may lead to increases in oil recovery.

Interfacial Tracer tests show that the interfacial area (a_{ow}) increases with decreasing salinity during flooding, indicating a smaller oil blob morphology, consistent with lower S_{or}.

UV analysis for SDBS in the presence of ANS oil constituents has significant interferences, leading to uncertainty in measurement. An alternative analytical method using HPLC is being developed.

* Large uncertainty due to mass balance errors;
+ Uncertainty due to analytical interference in SDBS analysis using UV

Work in Progress

Additional core flooding experiments using decane to improve precision.

Interfacial Tracer tests using alternative ANS oils.

Advanced analytical methods using HPLC is being developed.

Amott-Harvey characterization of wettability for comparison with new method.

Modeling experimental data for wettability – S_{or} – salinity relationship via interfacial areas.

Spectroscopic/NMR/ESEM analysis of batch experimental matrices to investigate mechanistic explanation for salinity effects.

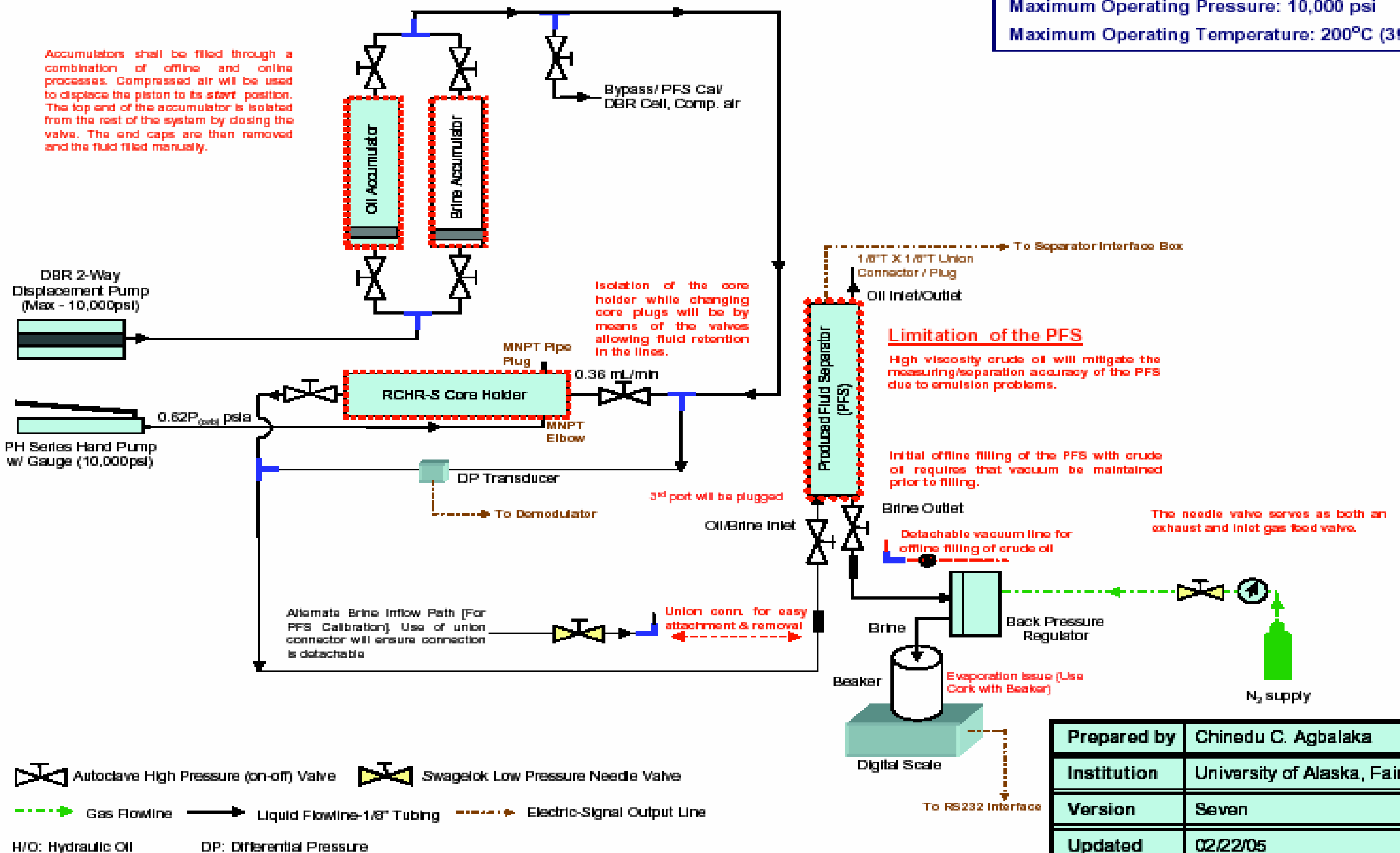
EXPERIMENTAL WORK AT UAF

- UAF's core flooding rig
- Test materials
- Experimental conditions
- Evaluation of the effect of different variables on S_{or} or oil recovery
- Results

RESERVOIR CONDITION COREFLOODING RIG

Maximum Operating Pressure: 10,000 psi

Maximum Operating Temperature: 200°C (392°F)



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Version	Seven
Updated	02/22/05

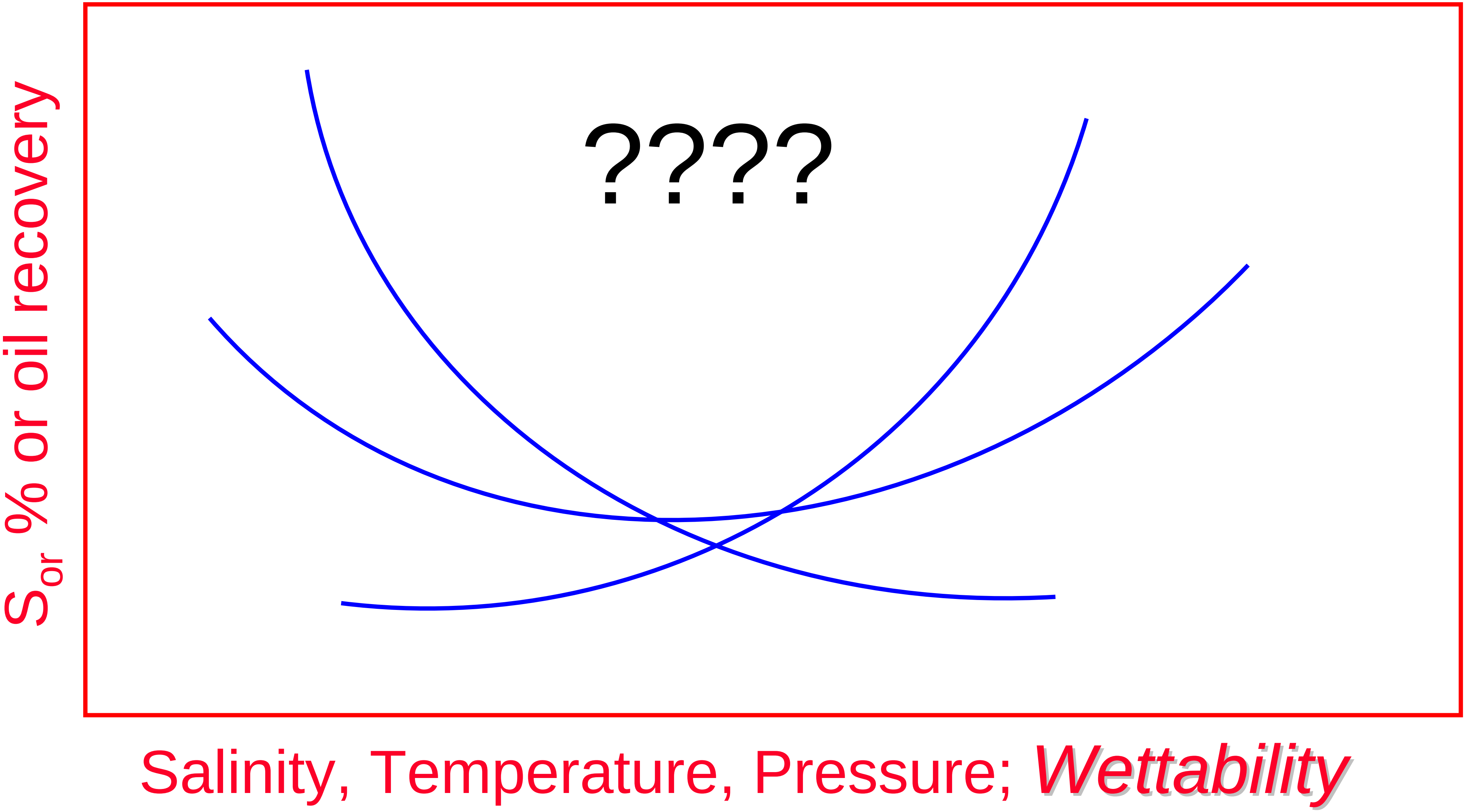
TEST MATERIALS

- 1 and 1.5 inch, variable length, clean Berea sandstone cores
- Brines have been reconstituted using salt and distilled water to obtain different salinities
- Crude oil used is a pipeline blend of various oils from the North Slope, i.e., flashed TAPS oil sample collected at North Pole

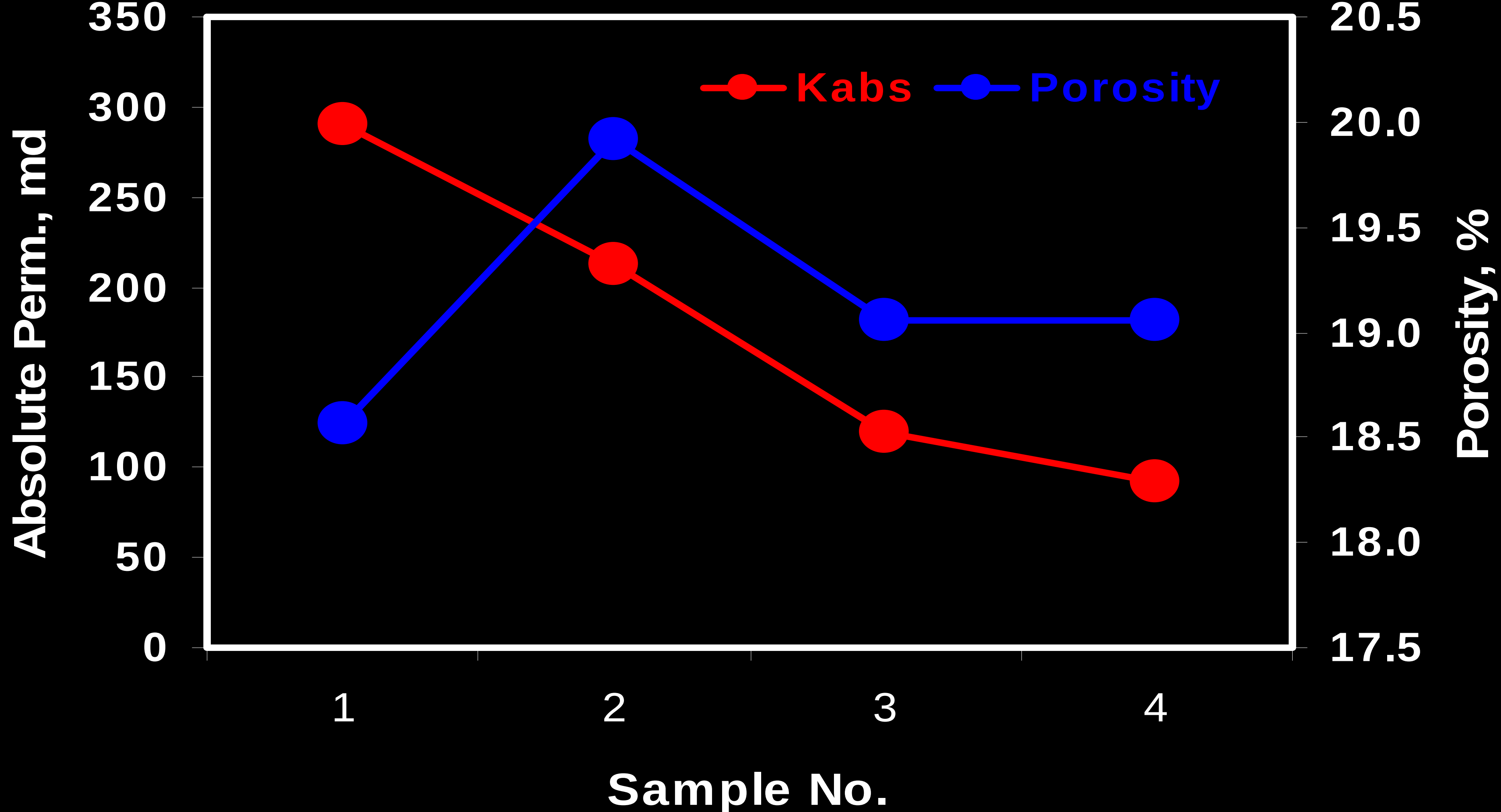
EXPERIMENTAL CONDITIONS

- Flooding rates of 20-60 cc/hr
- Flooding temperature is ambient. Elevated temperature brine is injected to evaluate the effect of temperature on S_{or}
- Pore pressures generated are directly proportional to used flowrates
- A 1500 psi overburden is used in all floods

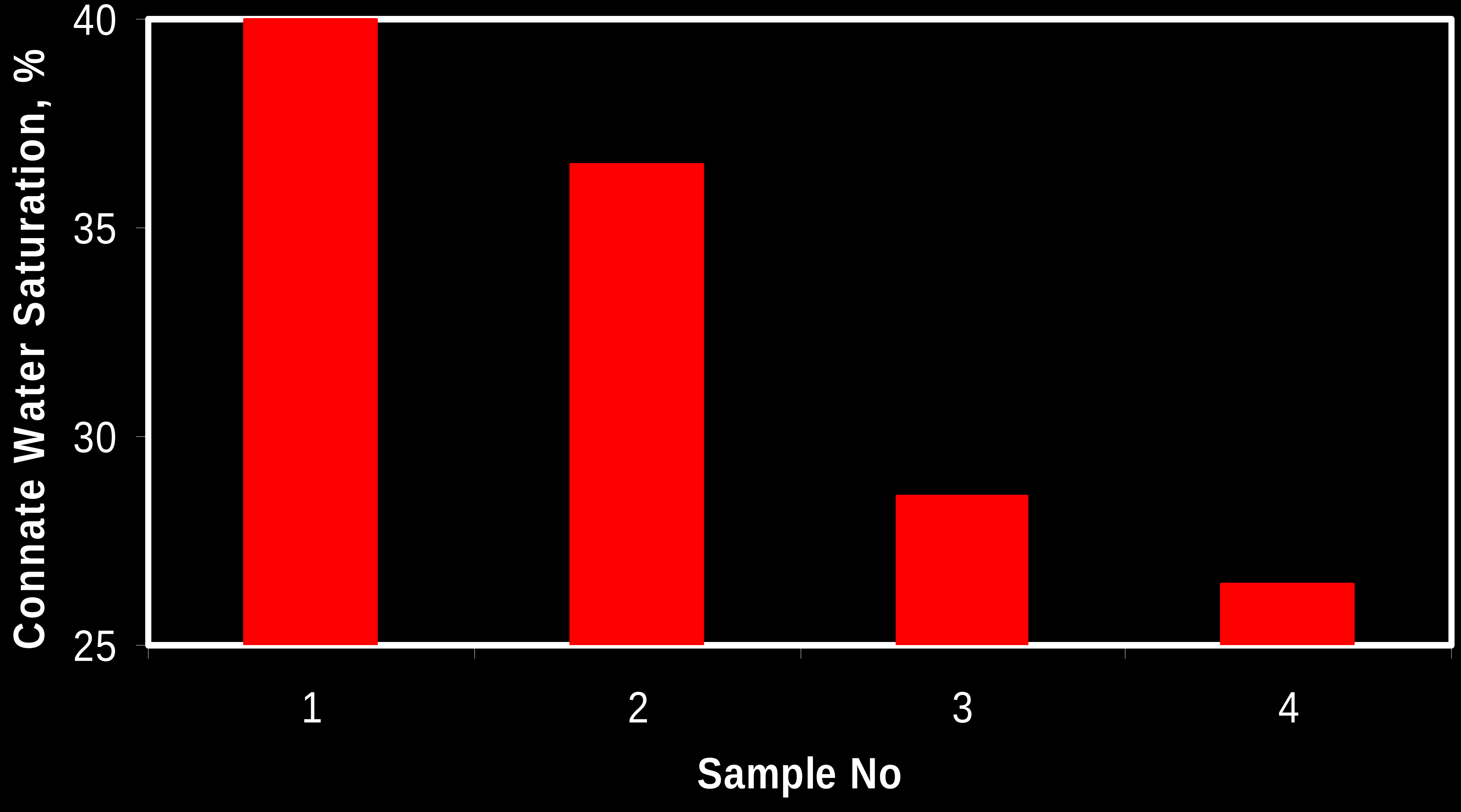
EFFECT OF DIFFERENT VARIABLES ON S_{or}



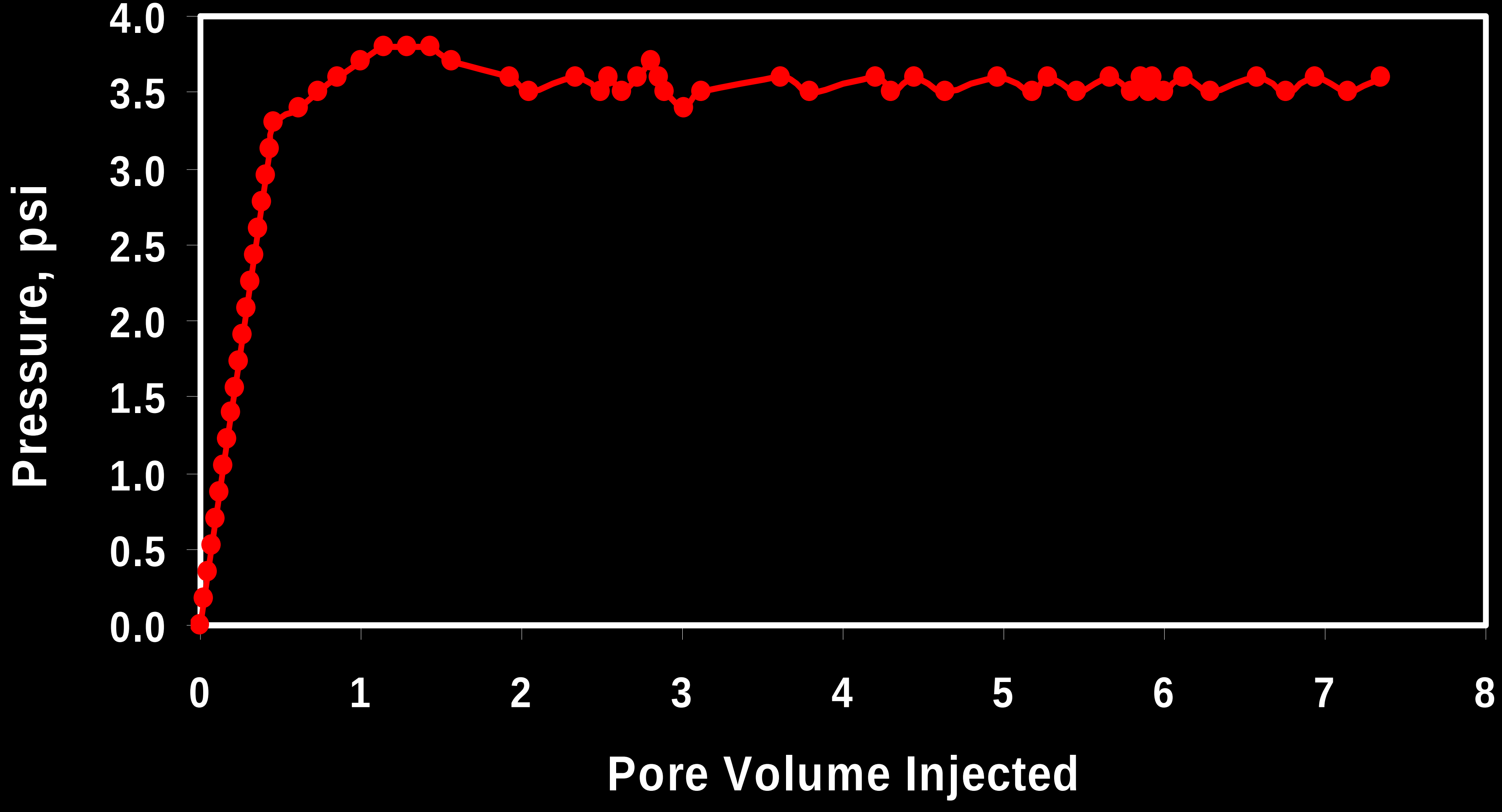
ABSOLUTE PERMEABILITY AND POROSITY VALUES OF THE BEREA SANDSTONE SAMPLES USED



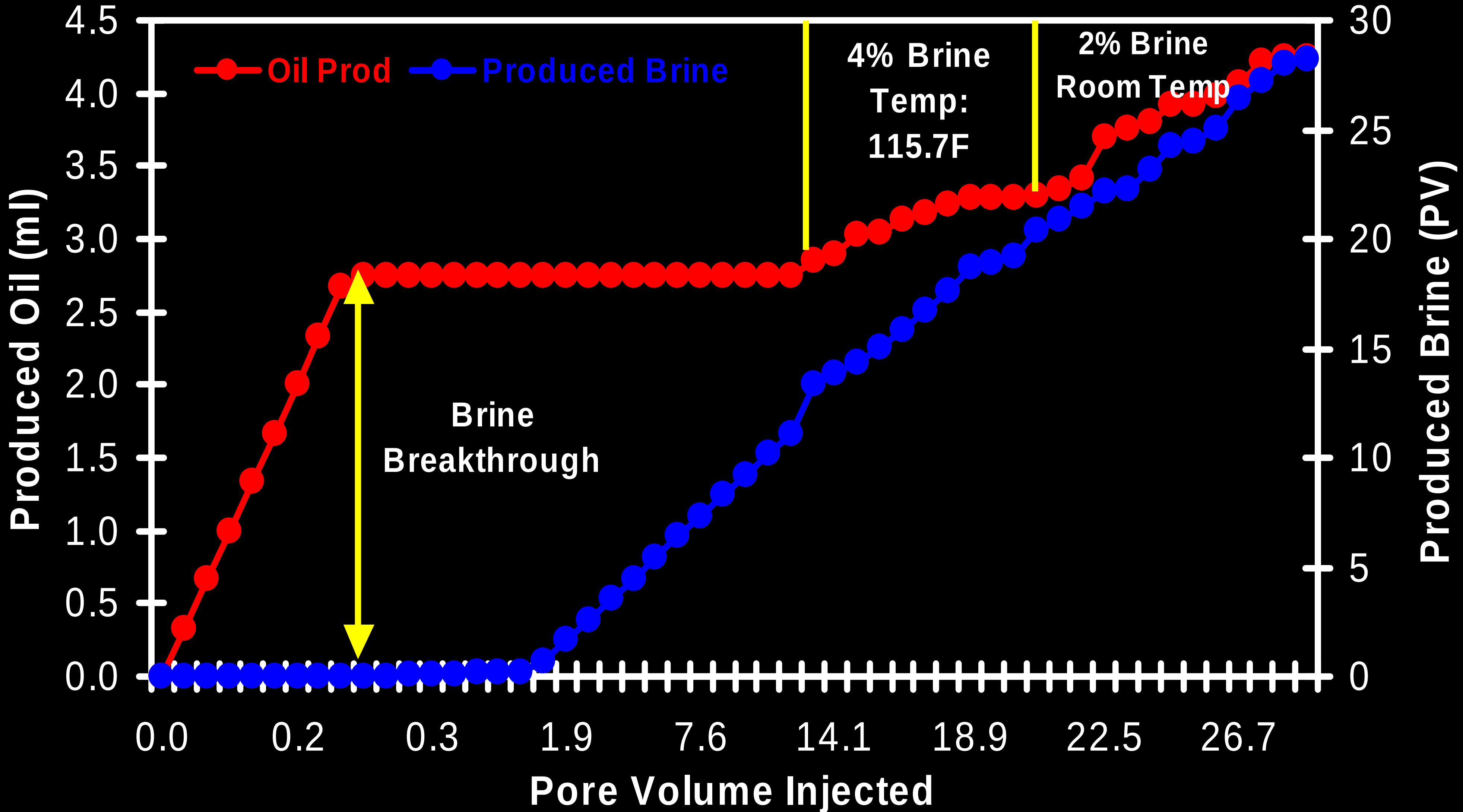
CONNATE WATER SATURATION, S_{WC}, AFTER DRAINAGE



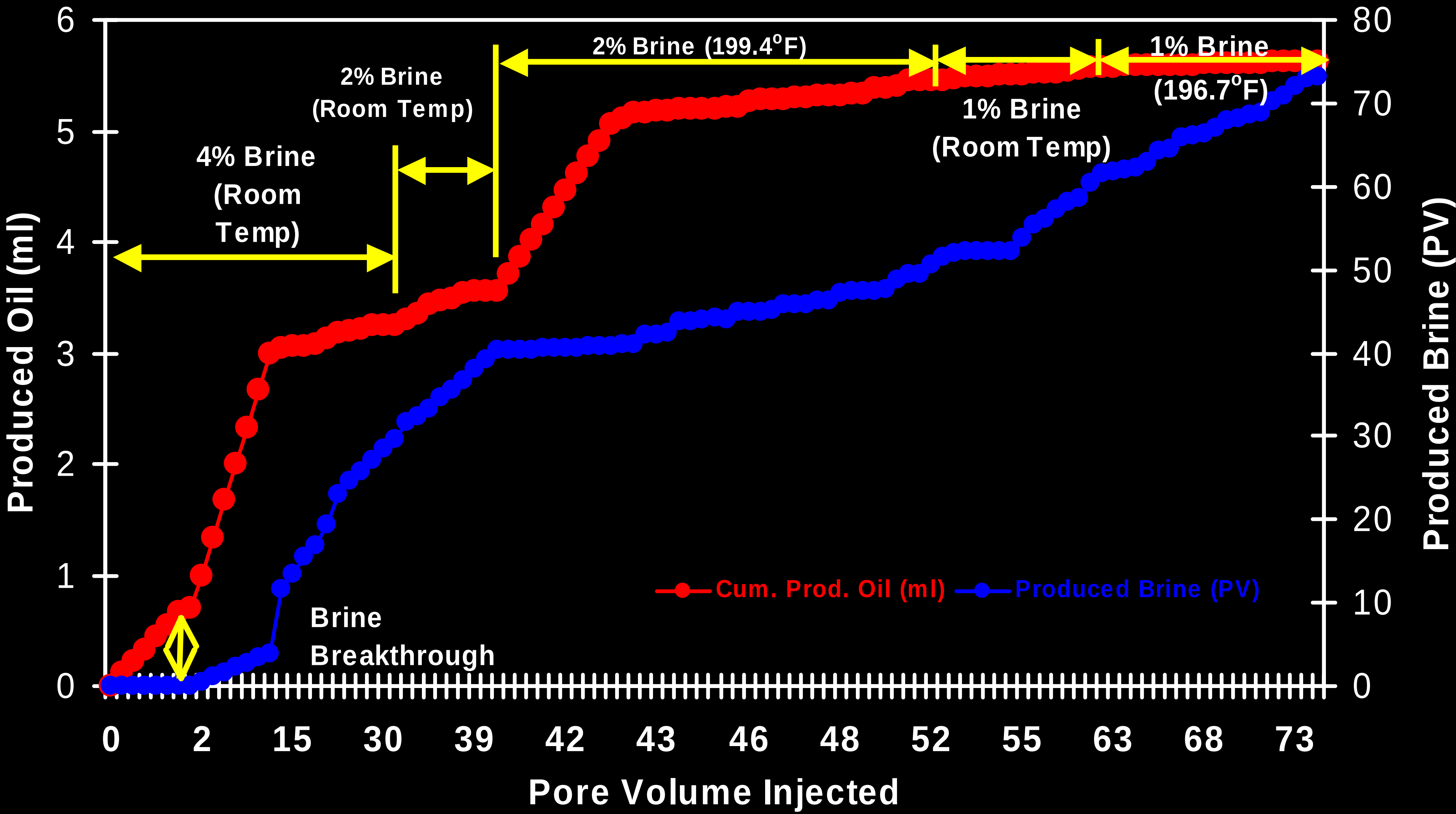
PRESSURE DROP PROFILE FOR ABSOLUTE PERMEABILITY CALCULATION



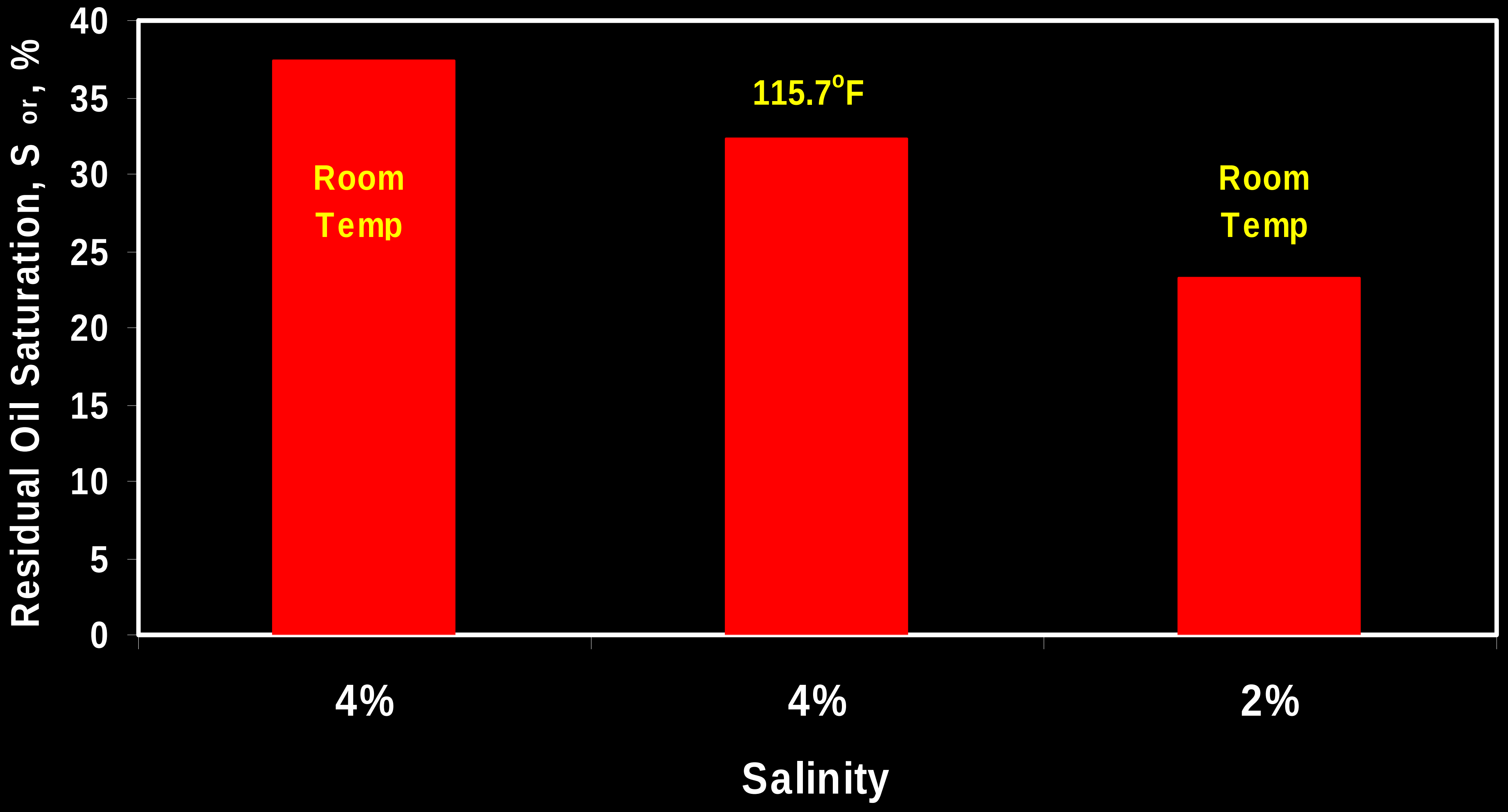
OIL RECOVERY PROFILE – TEMPERATURE AND LOSAL EFFECTS I



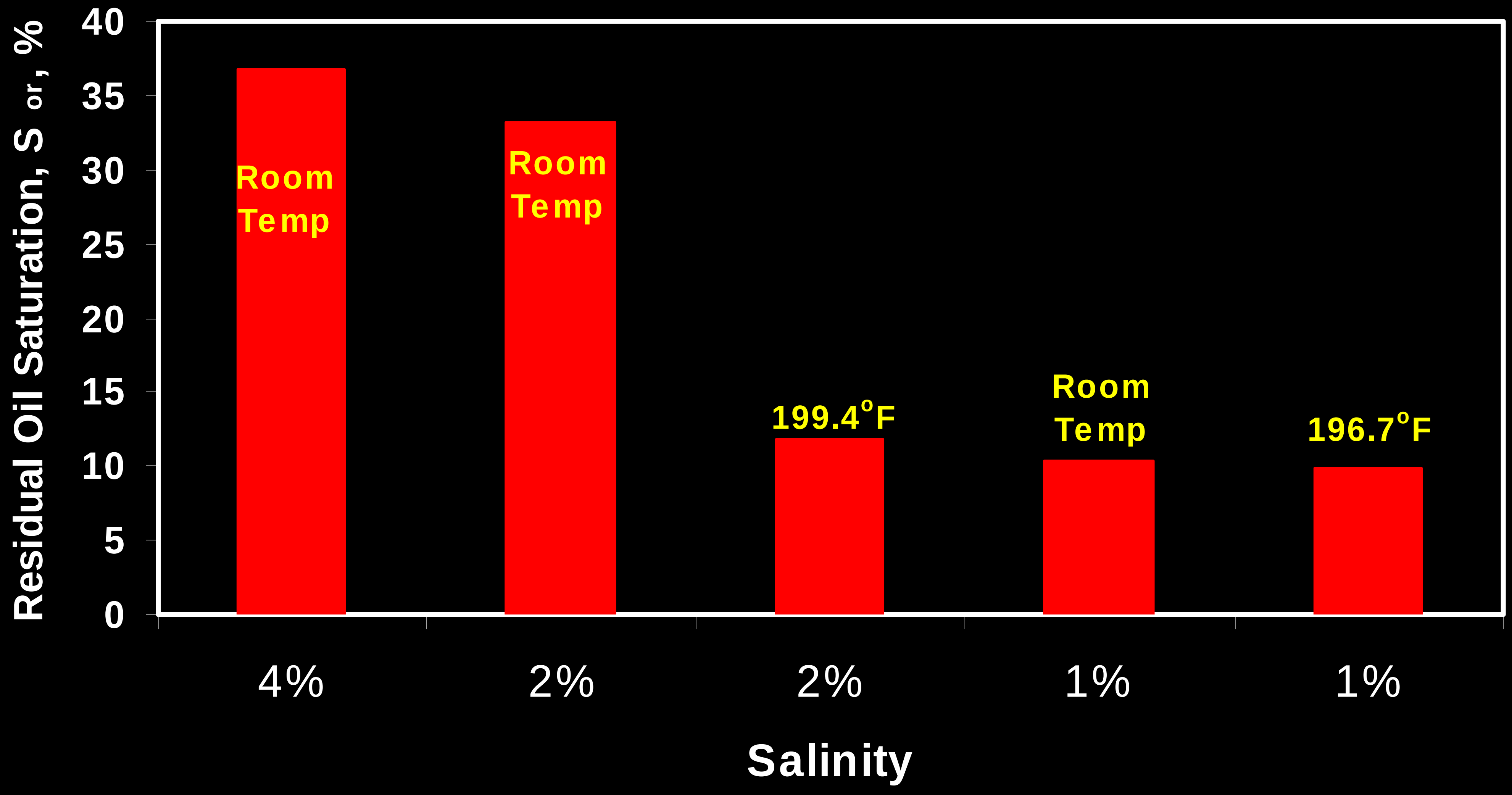
OIL RECOVERY PROFILE – TEMPERATURE AND LOSAL EFFECTS II



RESIDUAL OIL SATURATION – SALINITY AND TEMPERATURE EFFECTS I



RESIDUAL OIL SATURATION – SALINITY AND TEMPERATURE EFFECTS II



FUTURE WORK

- In the absence of representative rock and fluid samples, continue coreflooding and new wettability determination technique experiments using *other rock and fluid samples*
- Determination of Amott-Harvey wettability index (I_{AH}) before and after waterfloods with different salinities to evaluate the change in I_{AH}
- Additionally, pre and post waterflood tracer tests (PNNL wettability characterization method) are also planned to evaluate the wettability changes
- Evaluate the effect of different variables (most important wettability) on S_{or} or oil recovery
- Apply knowledge gained from these test to ANS test materials