# Wettability and Imbibition: Microscopic Distribution of Wetting and its Consequences at Core and Field Scales

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# Research Participants

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  - Jill Buckley and P&SC Group, PRRC
  - Chris Palmer, Chemistry
- University of Wyoming:
  - Norman Morrow, Petroleum & Chemical Eng.
  - Ron Steel, Geology
- Texas Tech University:
  - Purnendu Dasgupta, Chemistry & Biochemistry

# Project Overview

- Oil Composition
  - polar component, especially asphaltenes
  - wide variety of crude oil samples
- Surface Characterization
  - Types I and II contact angles
  - AFM and other surface techniques
- Imbibition in Porous Media
  - Scaling of rates in mixed-wet systems

# Project Objectives

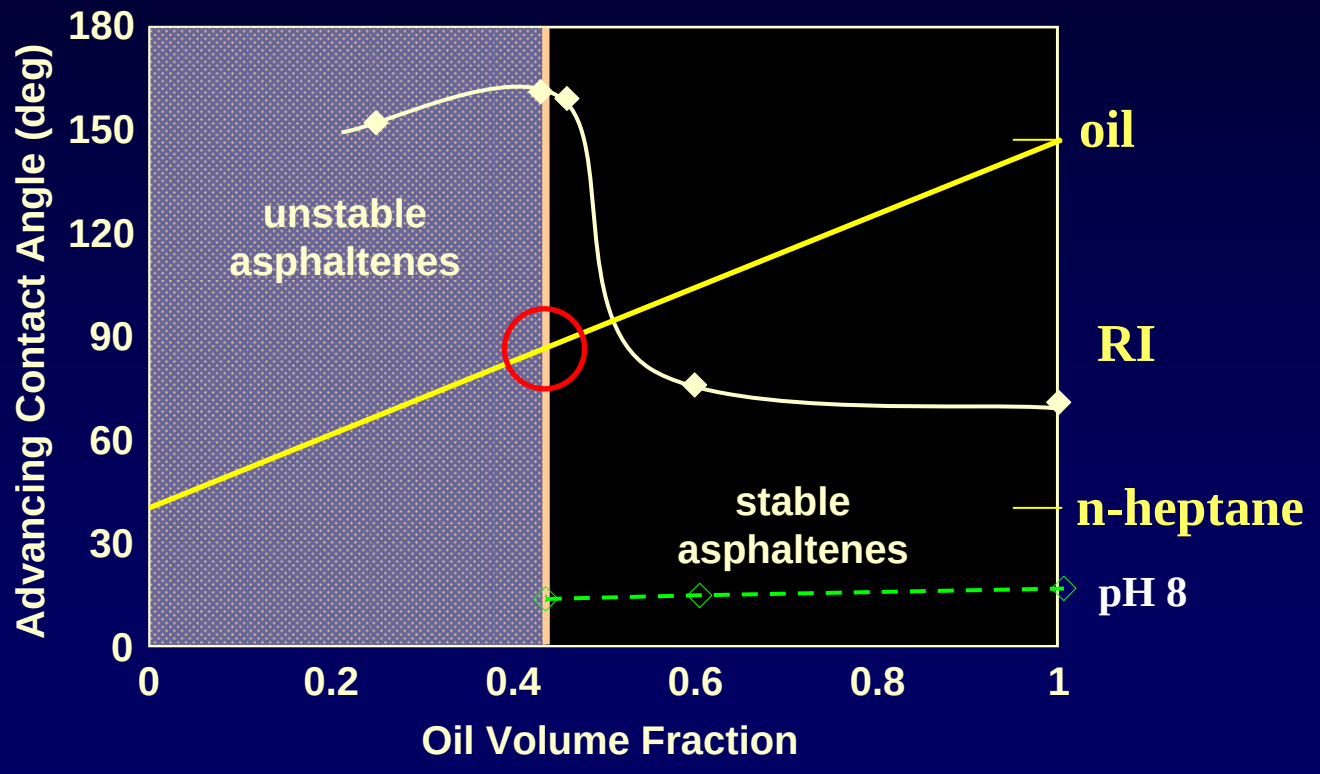
- To quantify the microscopic distribution of altered wetting
- To relate imbibition in mixed-wet porous media to the distribution of wetting.

# What factors influence wetting distribution?

- Equilibrium, reservoir-specific factors
  - rock, oil, brine
  - distribution of initial water saturation
- Changes during production
  - pressure depletion
  - IOR

# Influence of oil composition

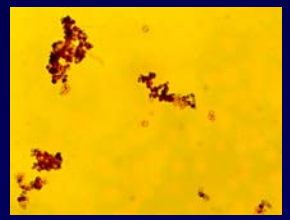
Prudhoe Bay (A-93) plus *n*-heptane with pH4 brine



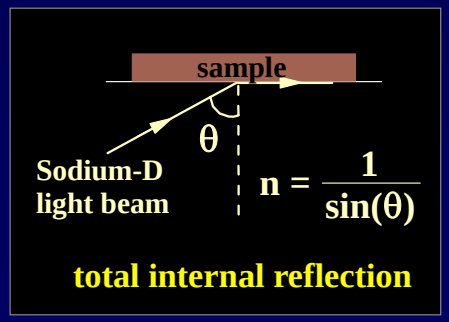
# RI at onset of asphaltene flocculation

1 Mix oil and precipitant (e.g., *n*-heptane) in varying proportions

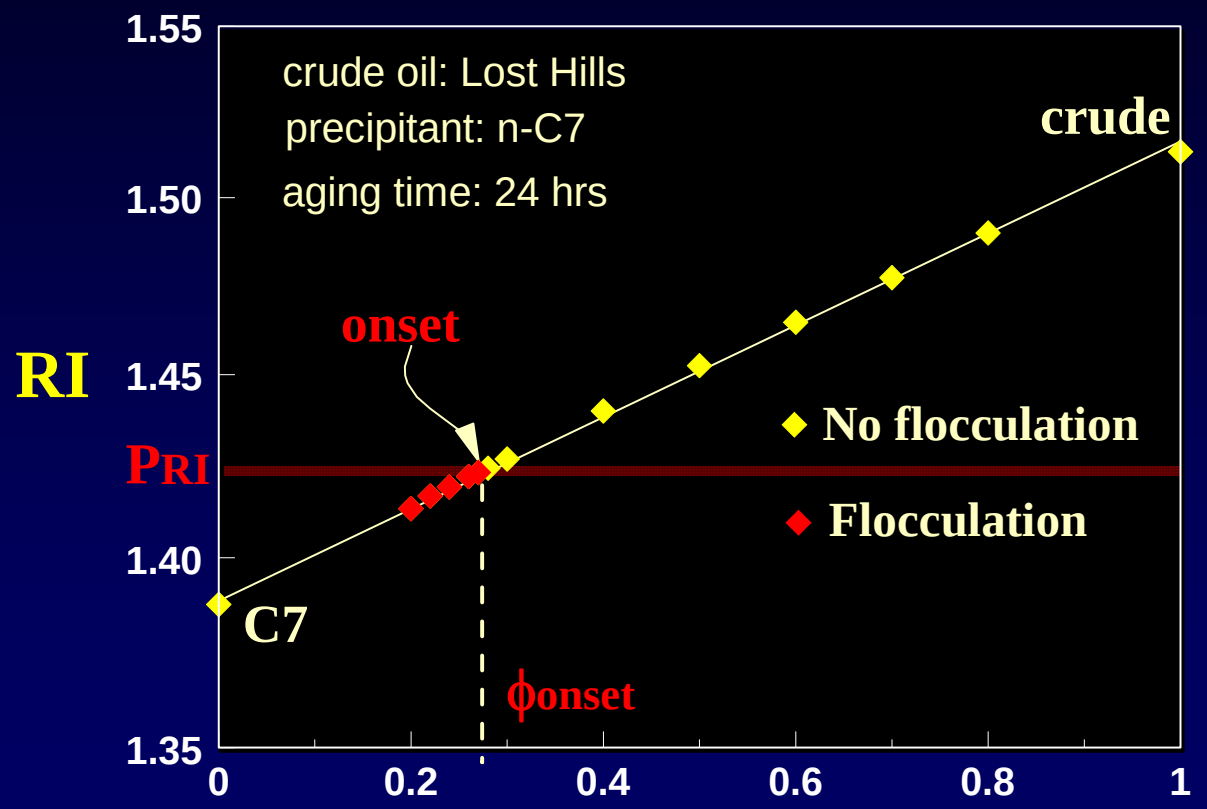
2 After 1 day (or more), observe microscopically



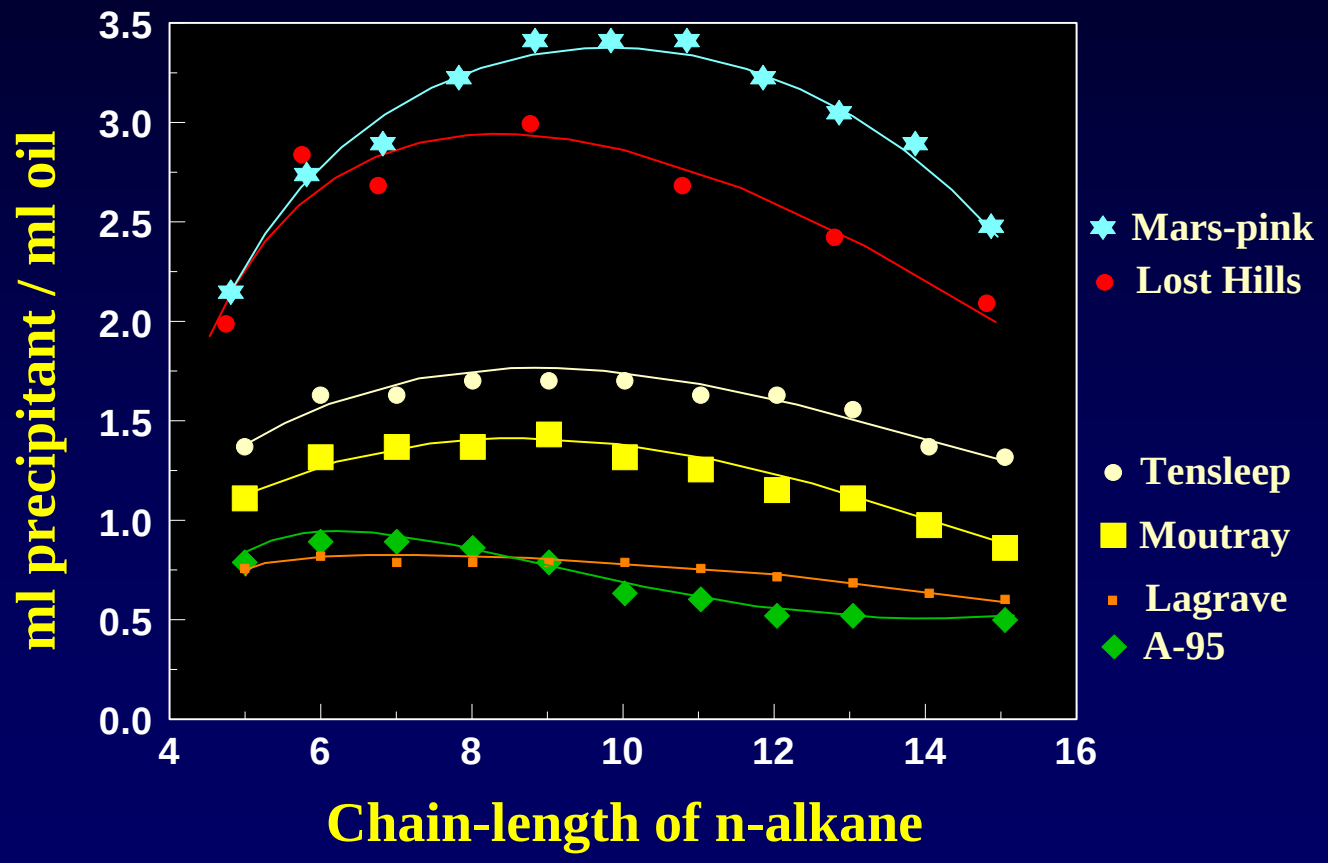
3 Measure RI



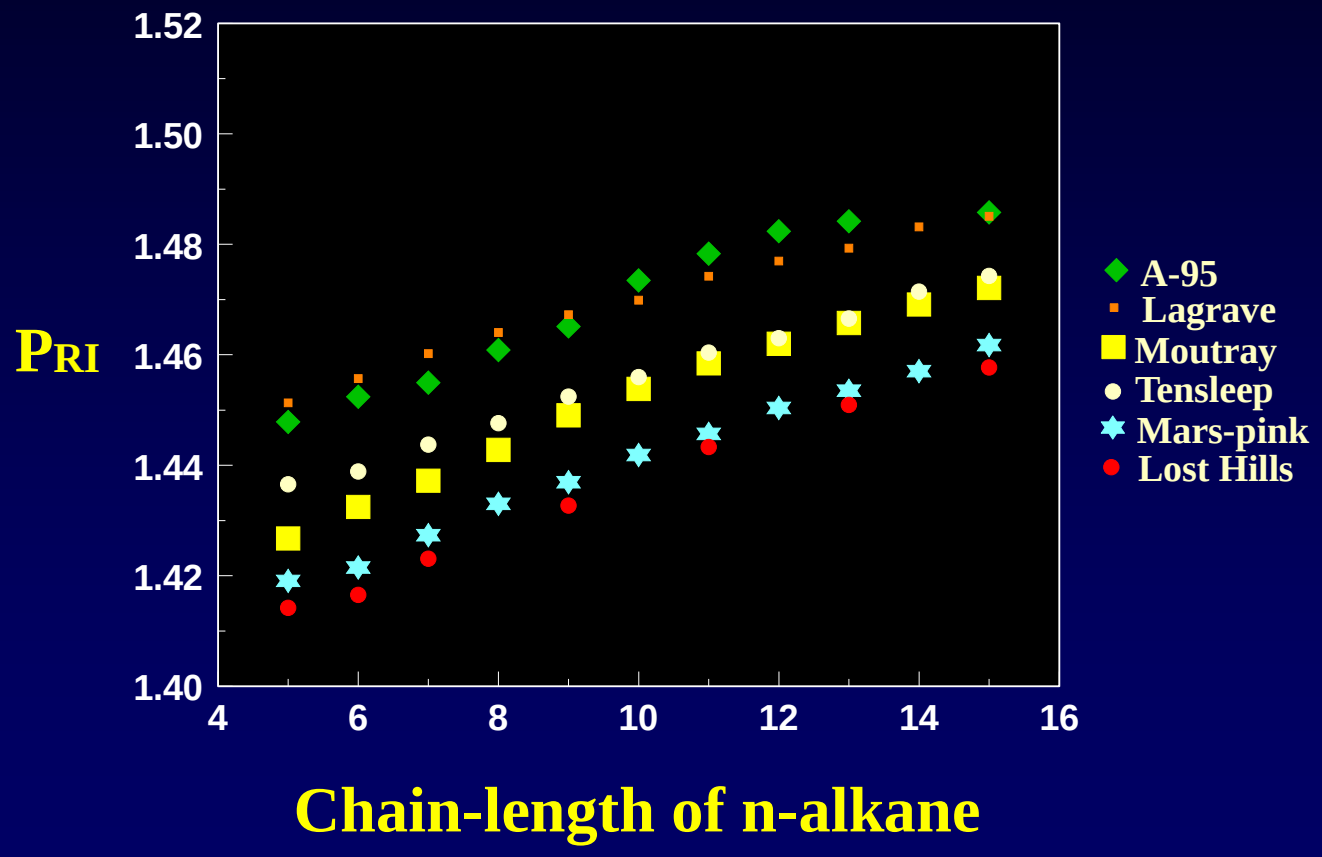
# Step 1: finding the onset



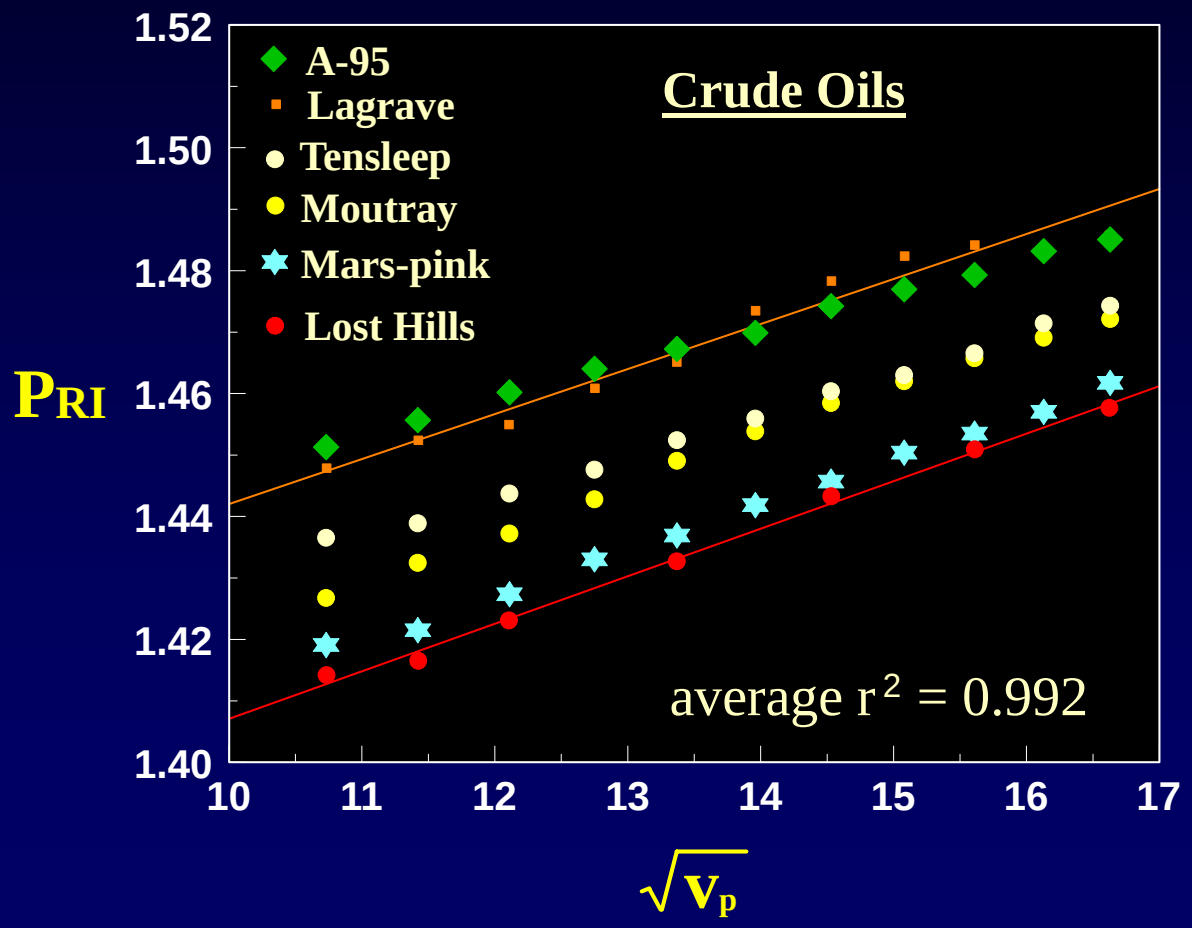
# Volume of precipitant at onset goes through maximum



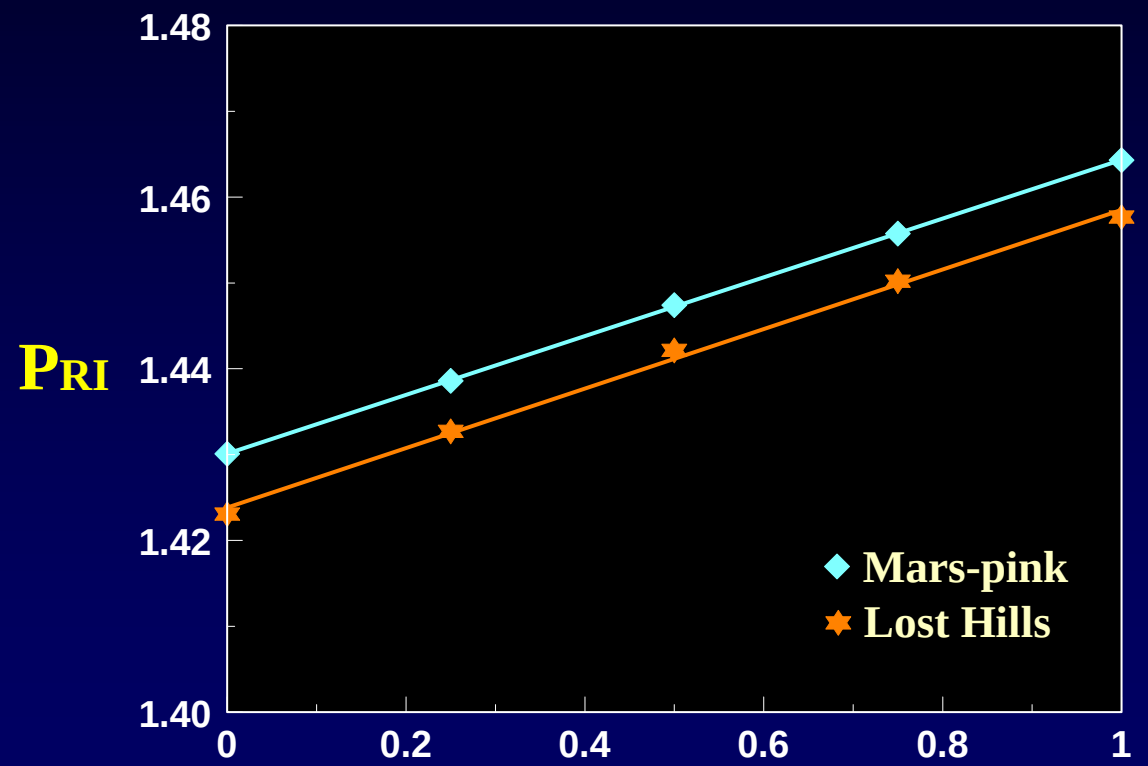
# $P_{RI}$ increases predictably



# Relationship between $P_{RI}$ and $v_p^{1/2}$ is linear



# Mixtures of two precipitants

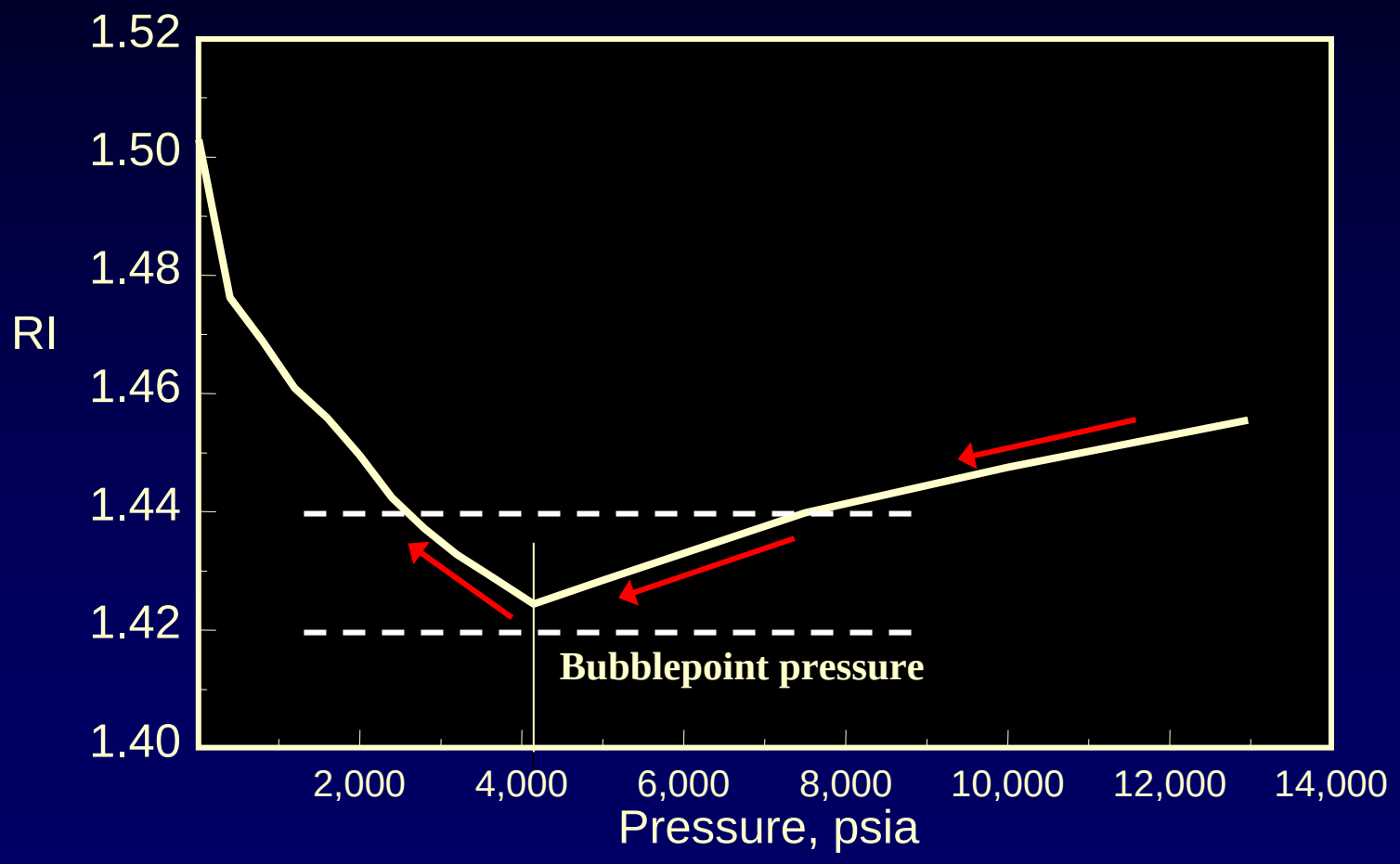



$\phi_{C15}$ **in mixed** $(C_7+C_{15})$

# What causes RI to decrease?

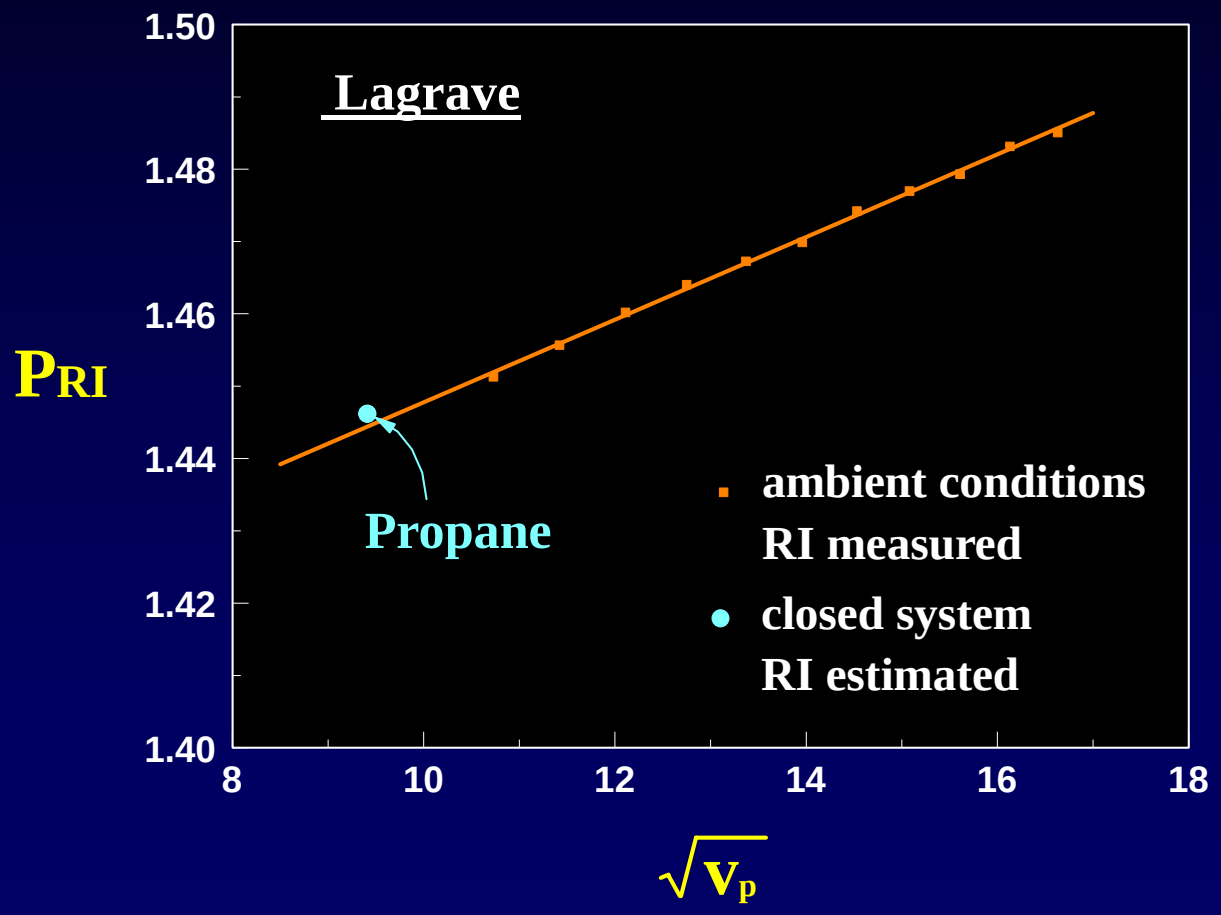
- Decreasing pressure
- Changes in composition
  - mixing with pentane or heptane (laboratory tests)
  - increasing pressure in 2-phase region
  - injecting miscible or partially miscible gas
    - mixtures of $C_1$ - $C_4$
    - $CO_2$

# RI decreases during pressure depletion

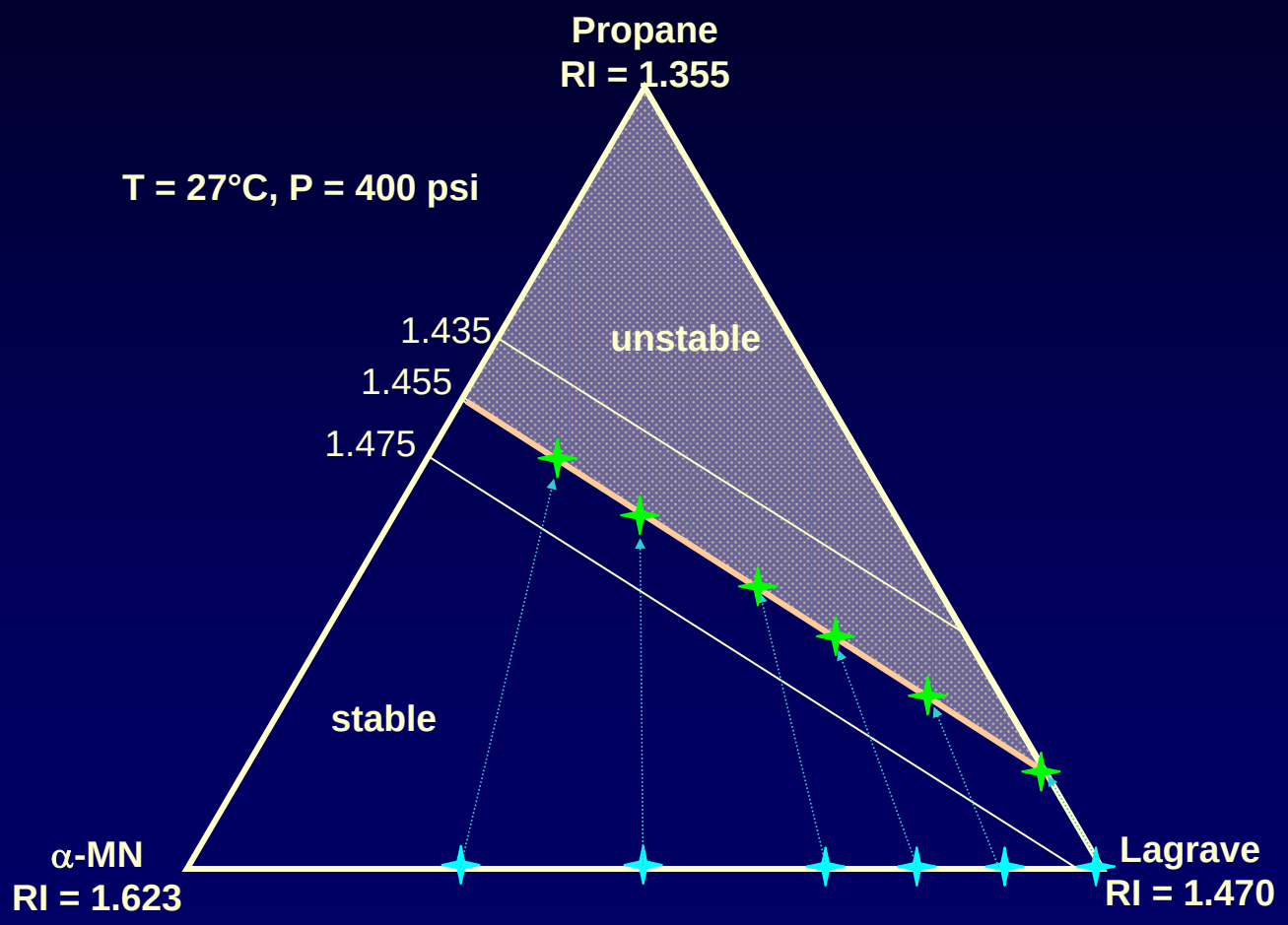



Buckley et al., *Petroleum Sci. and Tech.* (1998) **16**, No. 3&4, 251-285.

# Relationship can be extrapolated to include propane

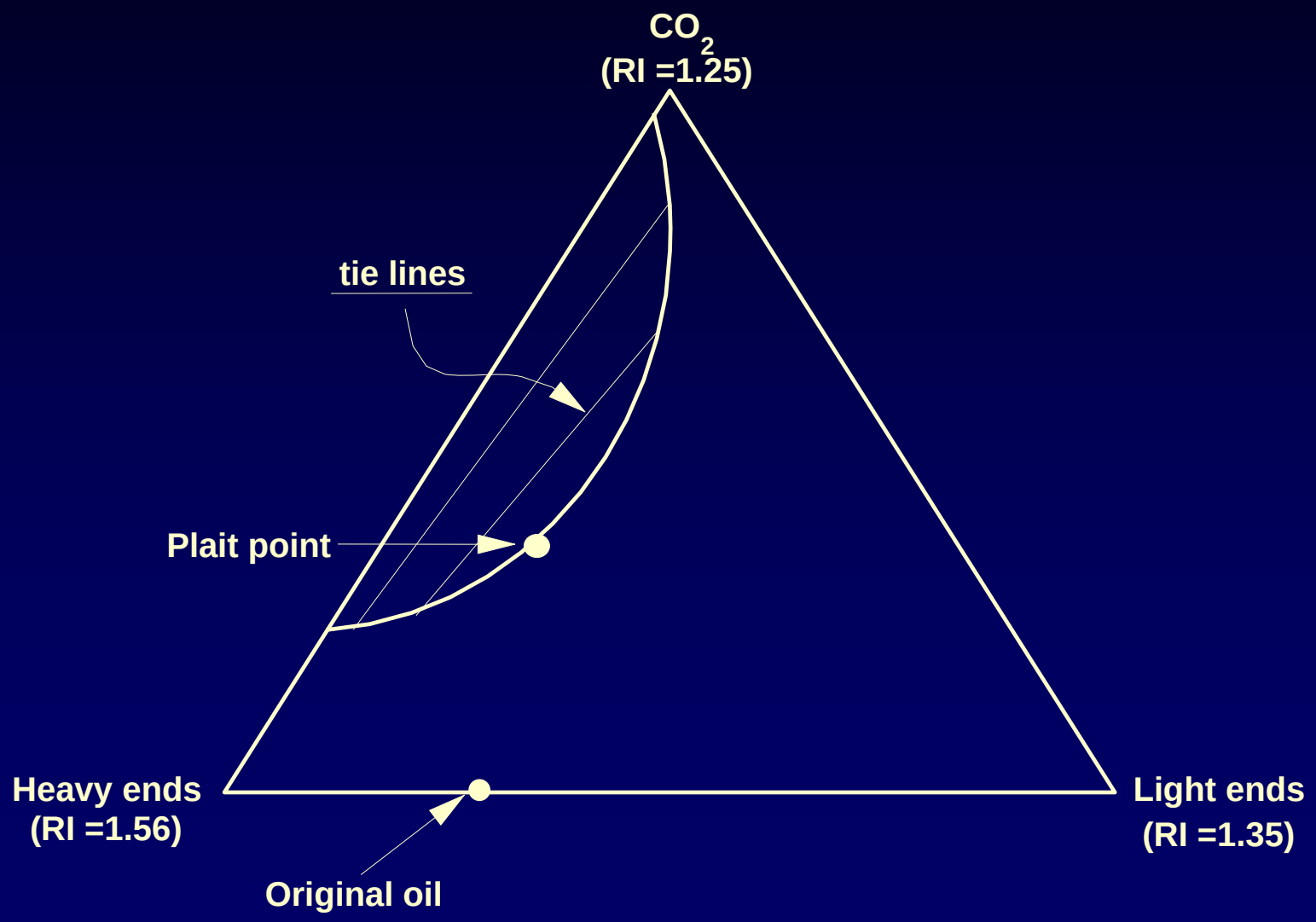


# Asphaltenes precipitated at constant $P_{RI}$

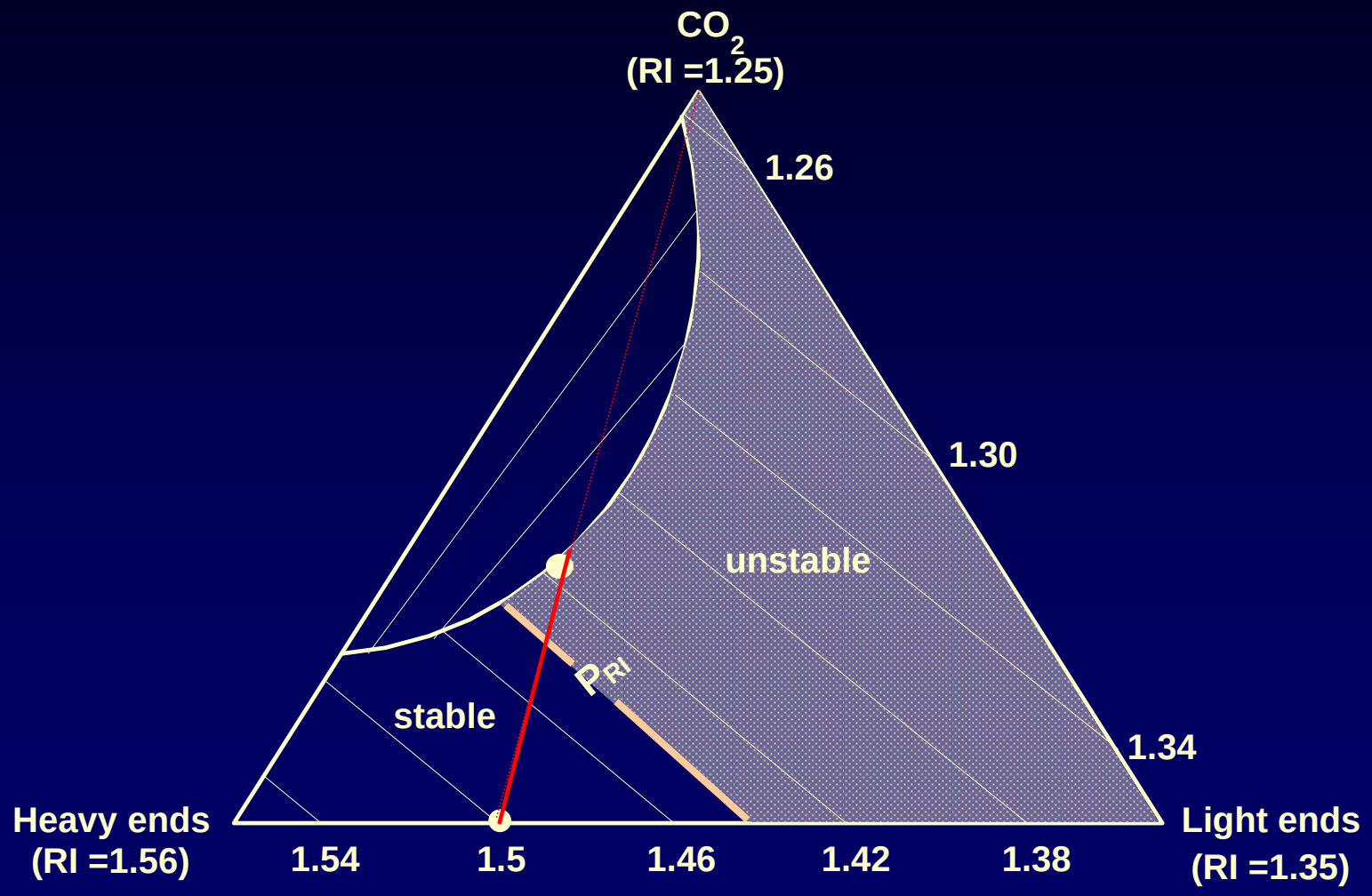



Wang, J.X., Brower, K.R., and Buckley, J.S, SPE 50745, 1999.

# Mixtures of oil and $CO_2$ -1



# Mixtures of oil and $CO_2$ -1



# Conclusions

- On the microscopic scale:
  - Understanding of mechanisms of interaction between oil, brine, and rock surfaces is necessary to predict how much wetting alteration can take place.
  - $S_{wi}$ affects where rock is exposed to oil and thus where and how much wetting alteration occurs.

# Conclusions

- On the macroscopic scale:
  - Equilibrium wetting alteration varies with geology.
  - Wetting may change during production as the initial equilibrium conditions are destabilized.

# Conclusions

- Understanding the aggregation of asphaltenes that can occur in response to changes in temperature, pressure, and composition will help with predictions of the potential for wetting alteration during the life of a reservoir.

# Acknowledgements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