

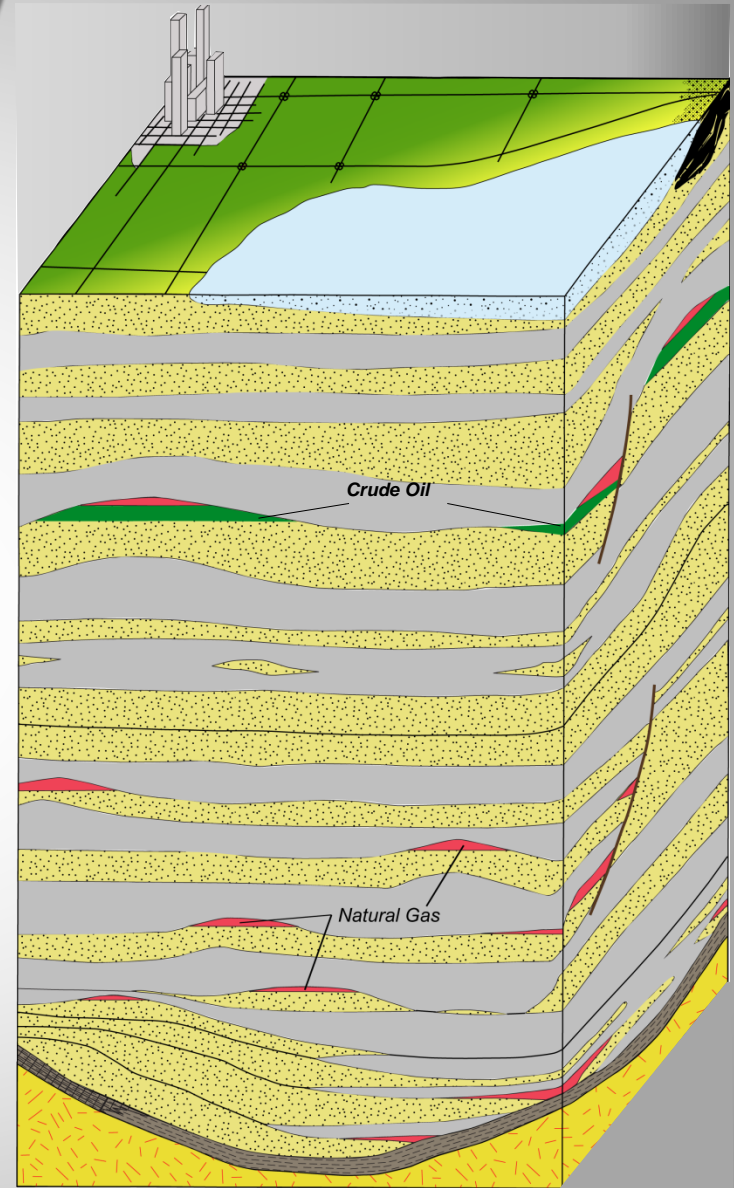
Application of Uniaxial Confining-core Clamp with Hydrous Pyrolysis in Petrophysical and Geochemical Studies of Source Rocks at Various Thermal Maturities

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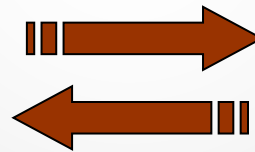
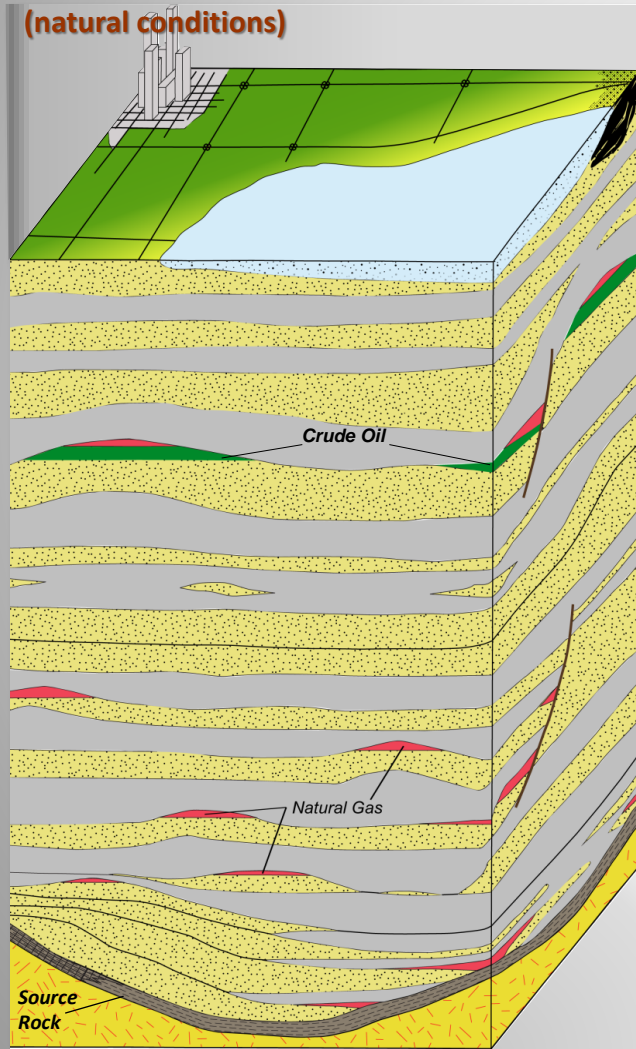
Issues in studying only the natural systems

- **Vastness of Sedimentary Basins Limits Data w/ respect to thermal maturation lithofacies & organic facies**
- **Mobility of Oil and Gas results in their complete or partial migration away from their source.**



Mutual Reliance on Natural and Lab Observations

Field Studies
(natural conditions)



Laboratory Studies
(higher temp/shorter time)



Hydrous Pyrolysis

Heating of source rock in presence of liquid water

Conditions

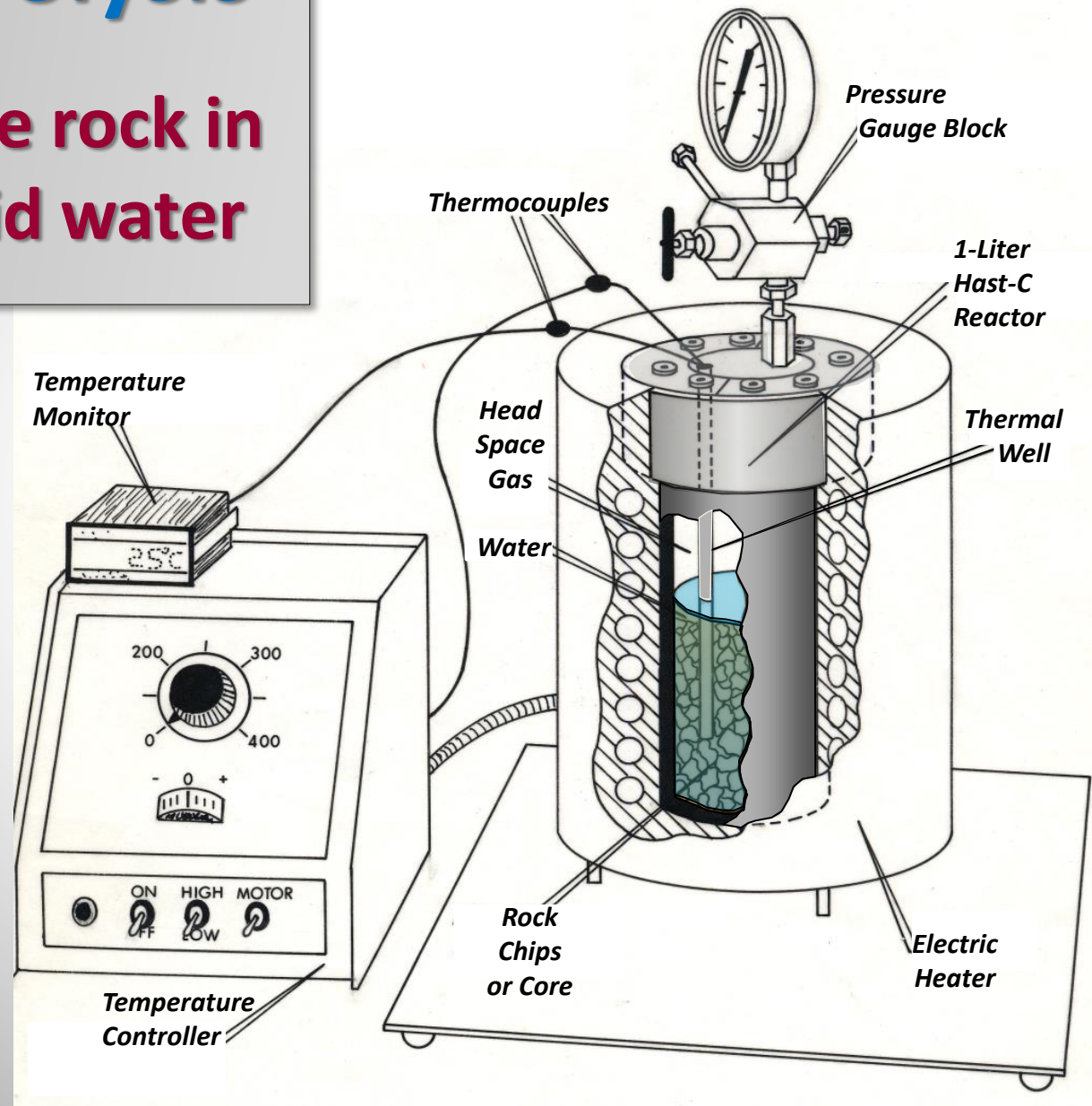
$P = 1,250 - 6,000$ psia

$t = 72$ h (12- 120 h)

$T = 300$ to 365 °C

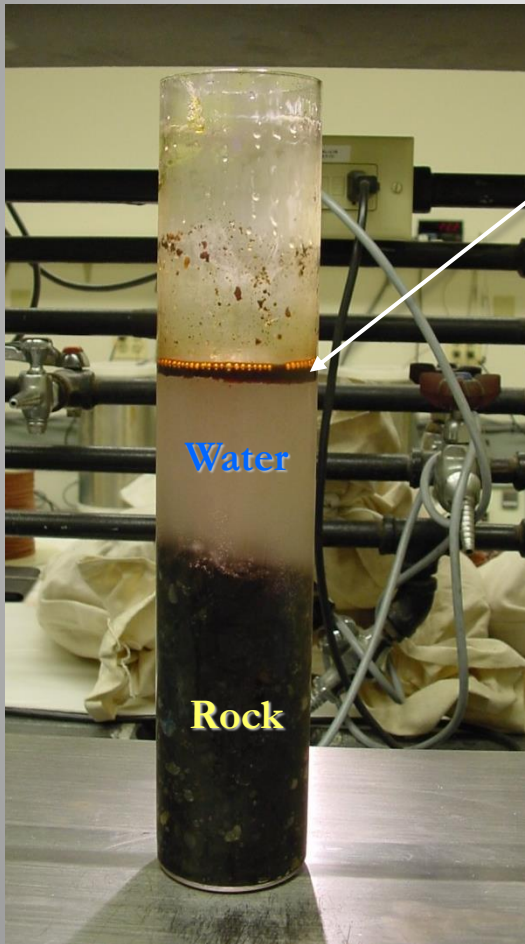
Rock = 200-500 g
0.5 -2 cm chips
or 4.3 cm core

Water = 300-450 g
distilled - brine



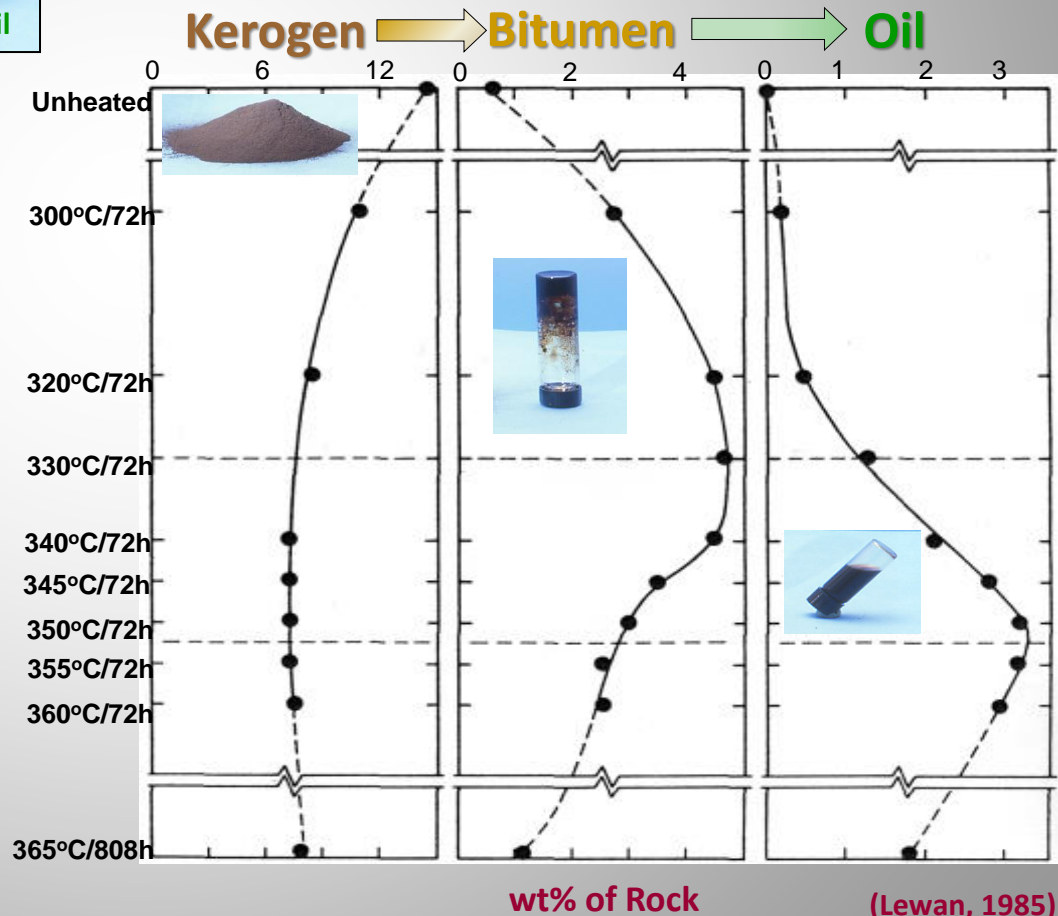
Hydrous Pyrolysis Advantages

Generates an expelled oil that helps define two-step reaction



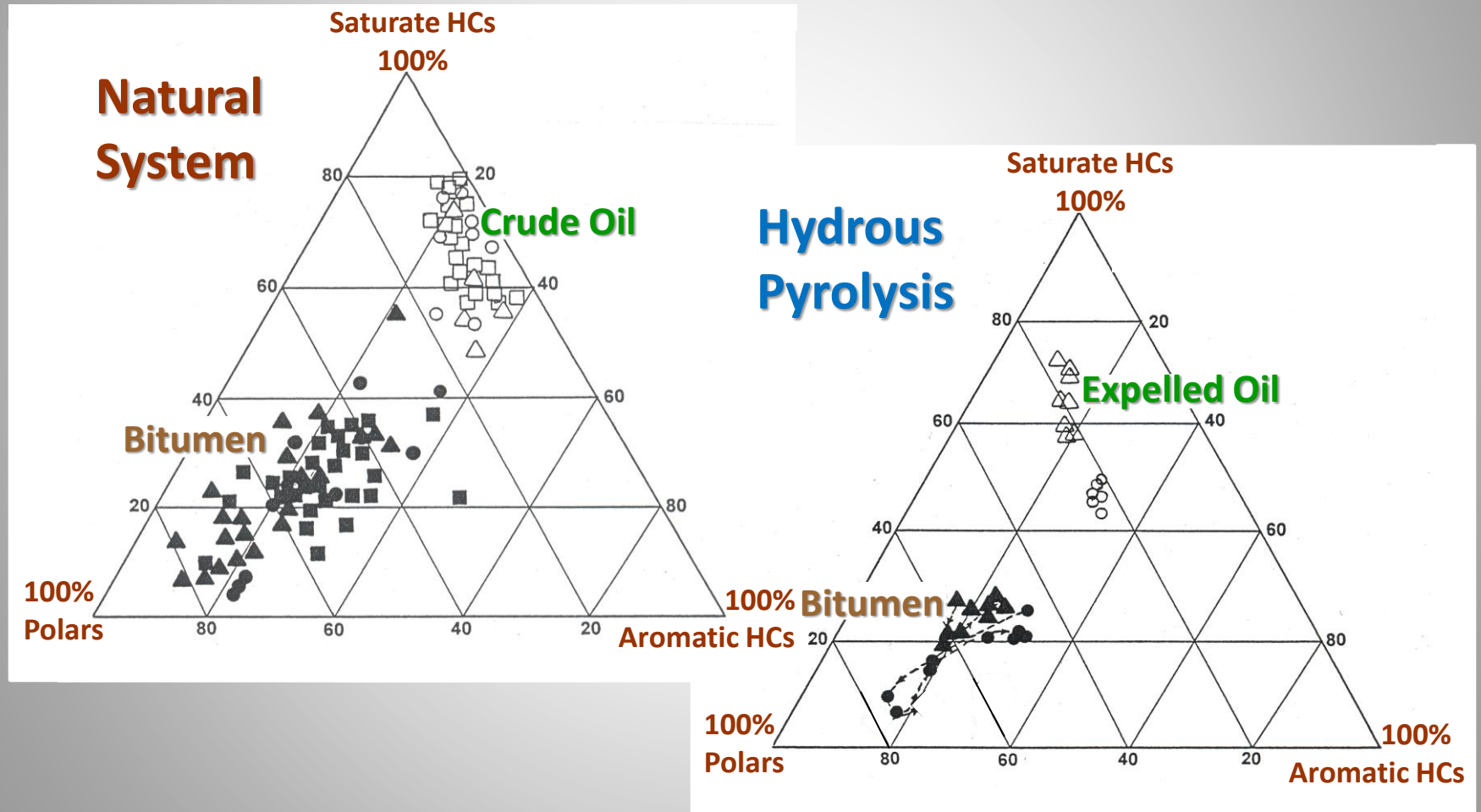
After 330°C/72 h

Hydrous Pyrolysis
Woodford Shale

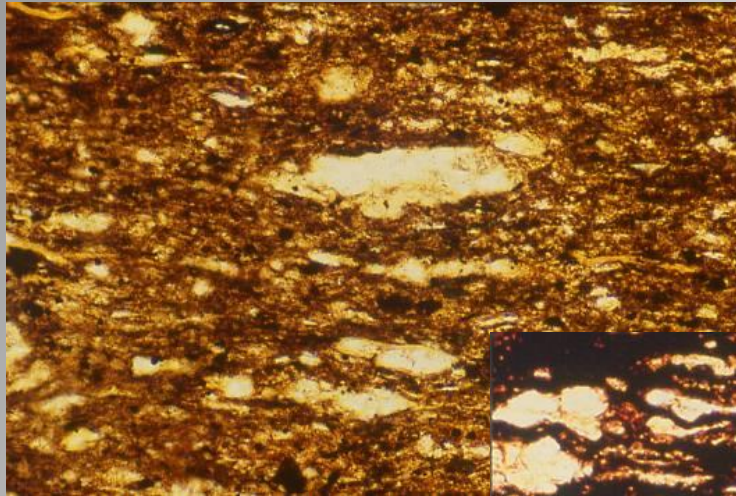


(Lewan, 1985)

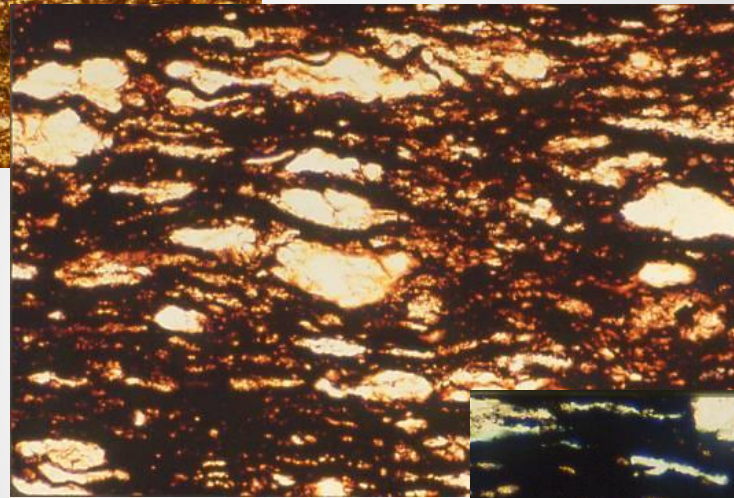
Bitumen vs. Oil Compositions



Oil Expulsion is the Result of Net-Volume Increase

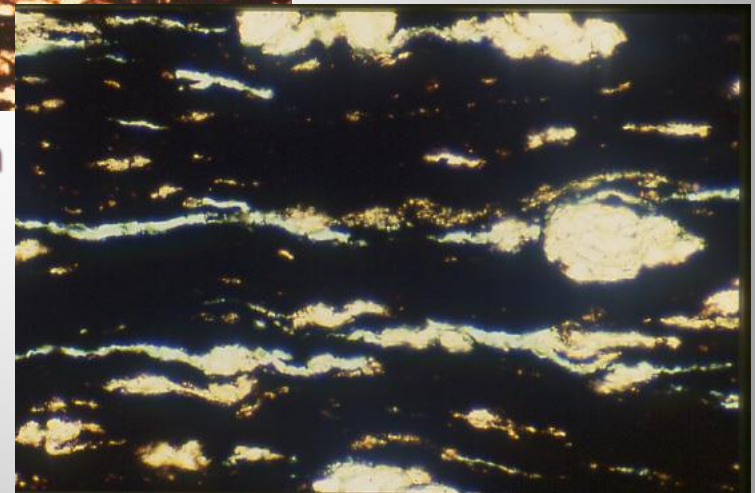


immature unheated



kerogen → bitumen
(300°C/72h)

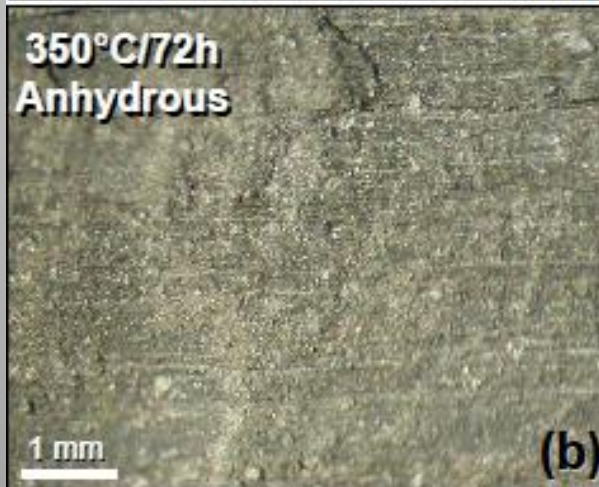
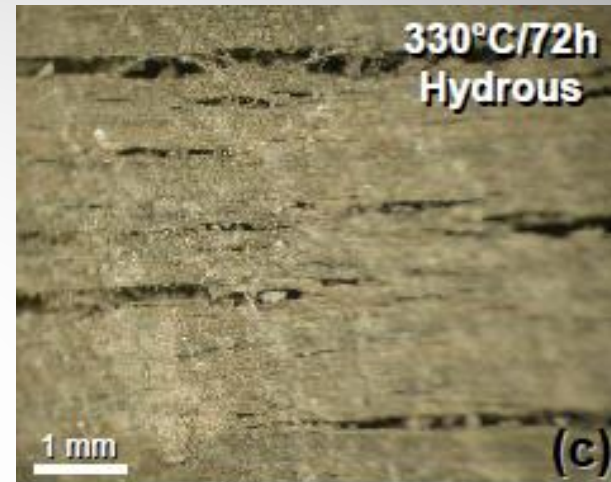
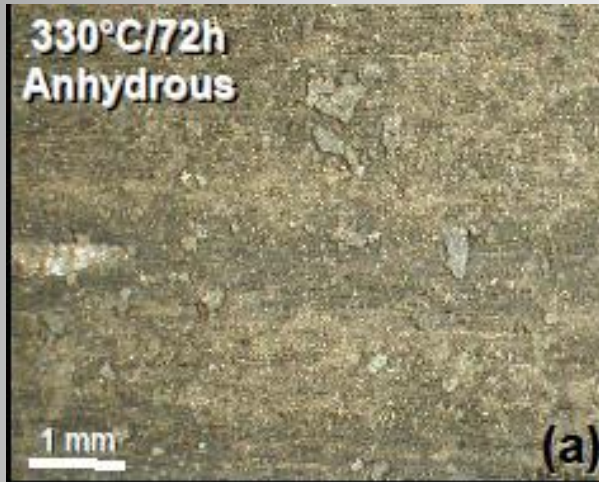
125 mm



bitumen → oil (352°C/72h)

Hydrous Pyrolysis of Woodford Shale Cores

Expansion Partings Parallel to Bedding Fabric (Green River Fm. Mahogany Oil Shale)

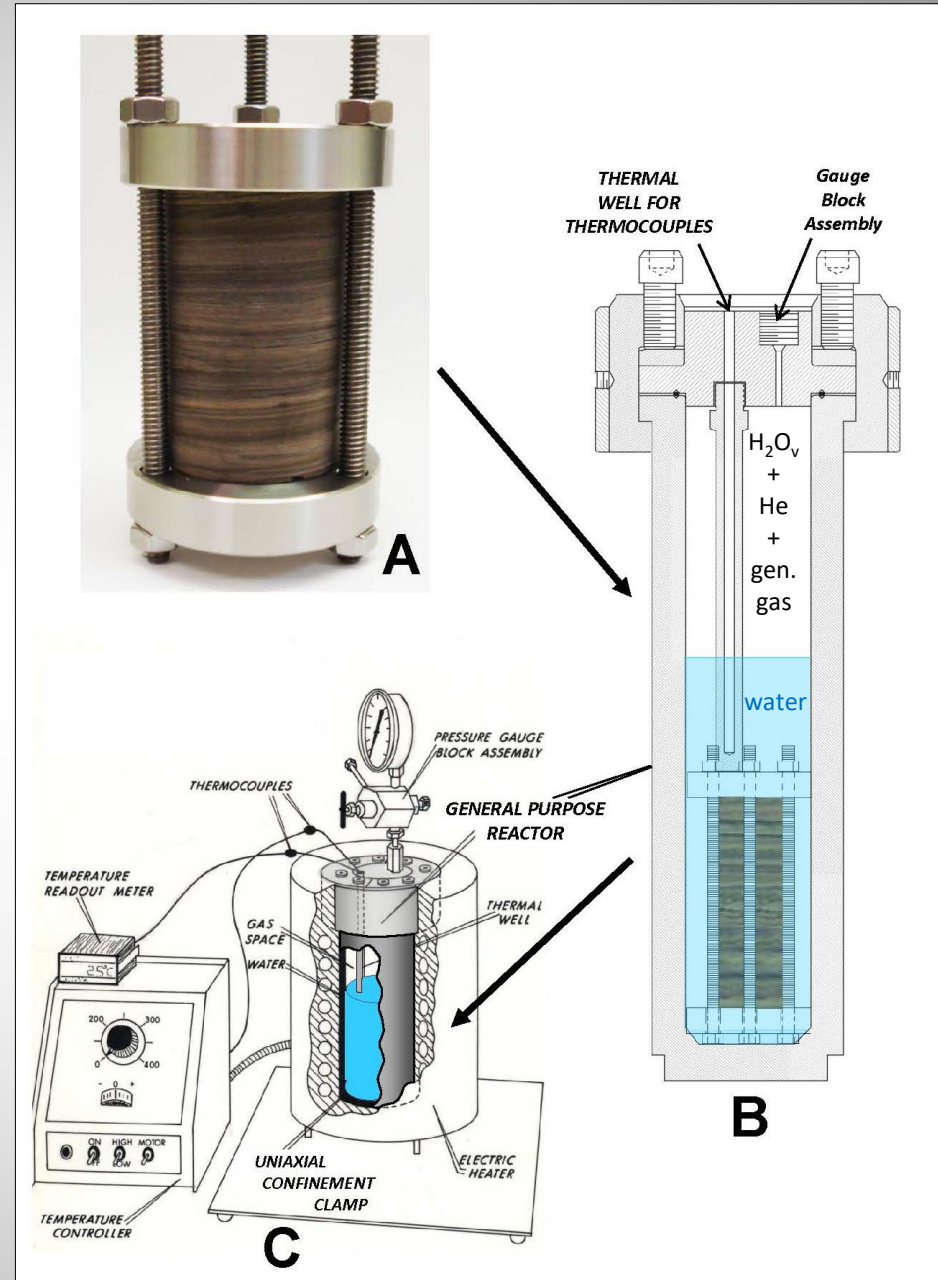


No Water: No Expelled Oil & No Open Partings

Water: Expelled Oil & Open Partings

Uniaxial Confining-Core Clamp

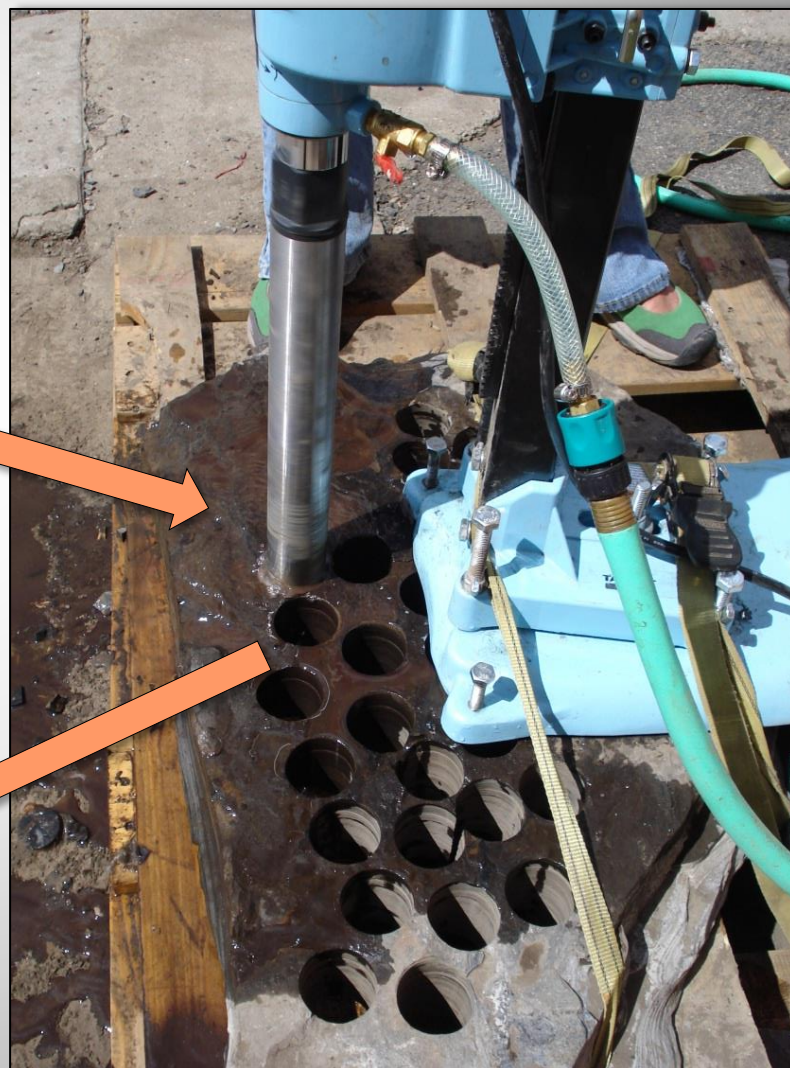
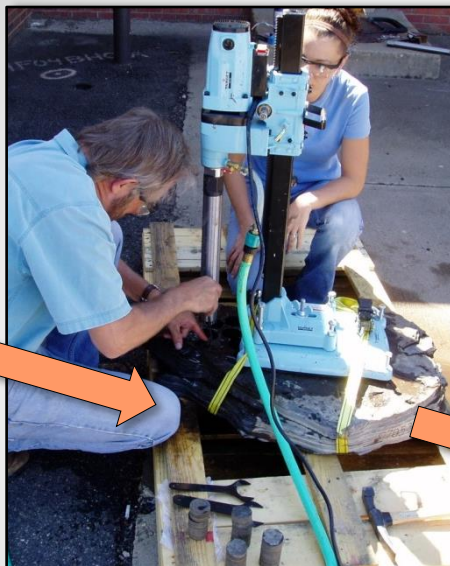
- A. Prevents expansion normal to bedding fabric (Maximum Overburden).
- B. Confining pressure determined by steam or added helium.
- C. Induce various levels of thermal maturation with hydrous pyrolysis.



Induce Various Levels of Thermal Maturation on Cores from the Same Source-Rock Interval/Facies with Hydrous Pyrolysis.



1.7" Diameter cores trimmed to same stratigraphic interval of 2.3 to 2.4".

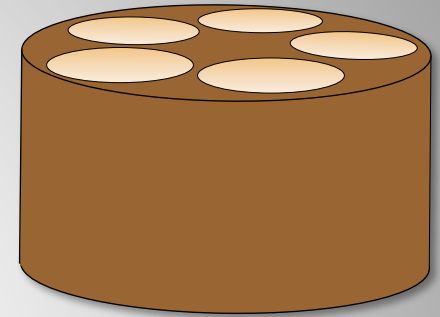


Mahogany Shale 070531-2 Cores

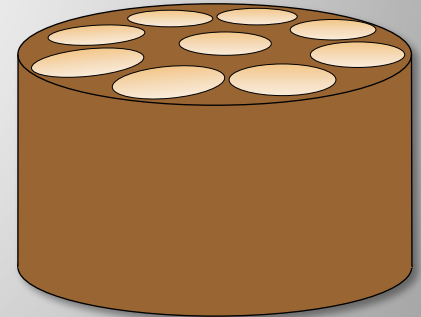
Rock Slabs of immature Source Rock are not always Available



Slab of Mahogany Oil Shale, Green River Fm.



4" Diameter Core yields five 1.5" cores



4" Diameter Core yields nine 1" cores

Mahogany Shale, Green River Fm.

070351-2



Laminated Dolomitic Marlstone

Type-I Kerogen

TOC = 16.2 wt%

HI = 834 mg/g TOC

OI = 17 mg/g TOC

Tmax = 433 °C

PI = 0.04

Bitumen = 155 mg/g TOC

Hydrous Pyrolysis Experiments

Mahogany Shale 070531-2 Cores , Green River Fm.



Original Unheated.....Immature
(no confining pressure)

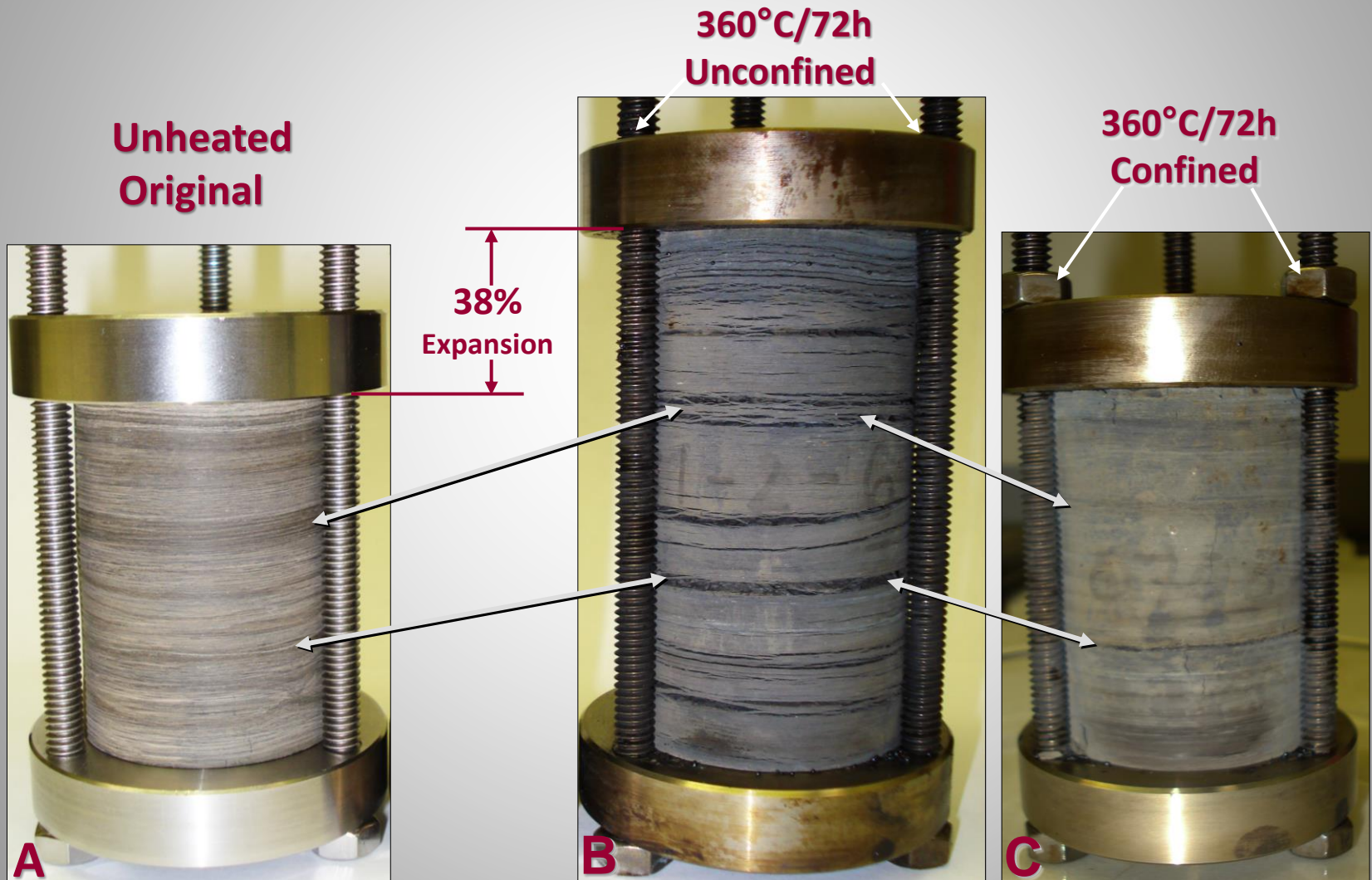
330°C/72 h Confined.....Max. Bitumen
(2100 psig confining pressure)

360°C/72 h Unconfined.....Max. Oil
(3180 psig uniform pressure)

360°C/72 h Confined.....Max. Oil
(3190 psig confining pressure)

Hydrous Pyrolysis Experiments

Mahogany Shale 070531-2 Cores , Green River Fm.



Hydrous Pyrolysis Yields

Mahogany Shale 070531-2 Cores , Green River Fm.



**360°C/72h
Unconfined**

**360°C/72h
Confined**

38

% Expansion

0

9.48

**Expelled Oil
(wt% orig. Rock)**

9.75

6.60

**Generated Gas
(wt% orig. Rock)**

6.76

0.80

**Bitumen
(wt% orig. Rock)**

0.69



Leco TOC and Rock Eval Data on Recovered Rock Mahogany Shale 070531-2 Cores , Green River Fm.



**360°C/72h
Unconfined**

**360°C/72h
Confined**

6.7

Leco TOC
(wt% Recov. Rock)

6.5

127

Hydrogen Index
(mg/g TOC)

120

4.76

S₁
(mg/g rock)

3.89

8.51

S₂
(mg/g rock)

7.78

443

Tmax
(°C)

442



Uniaxial Confinement Clamp-Intact Cores for Petrophysical Properties



**Confined Core
360 °C/72 h**



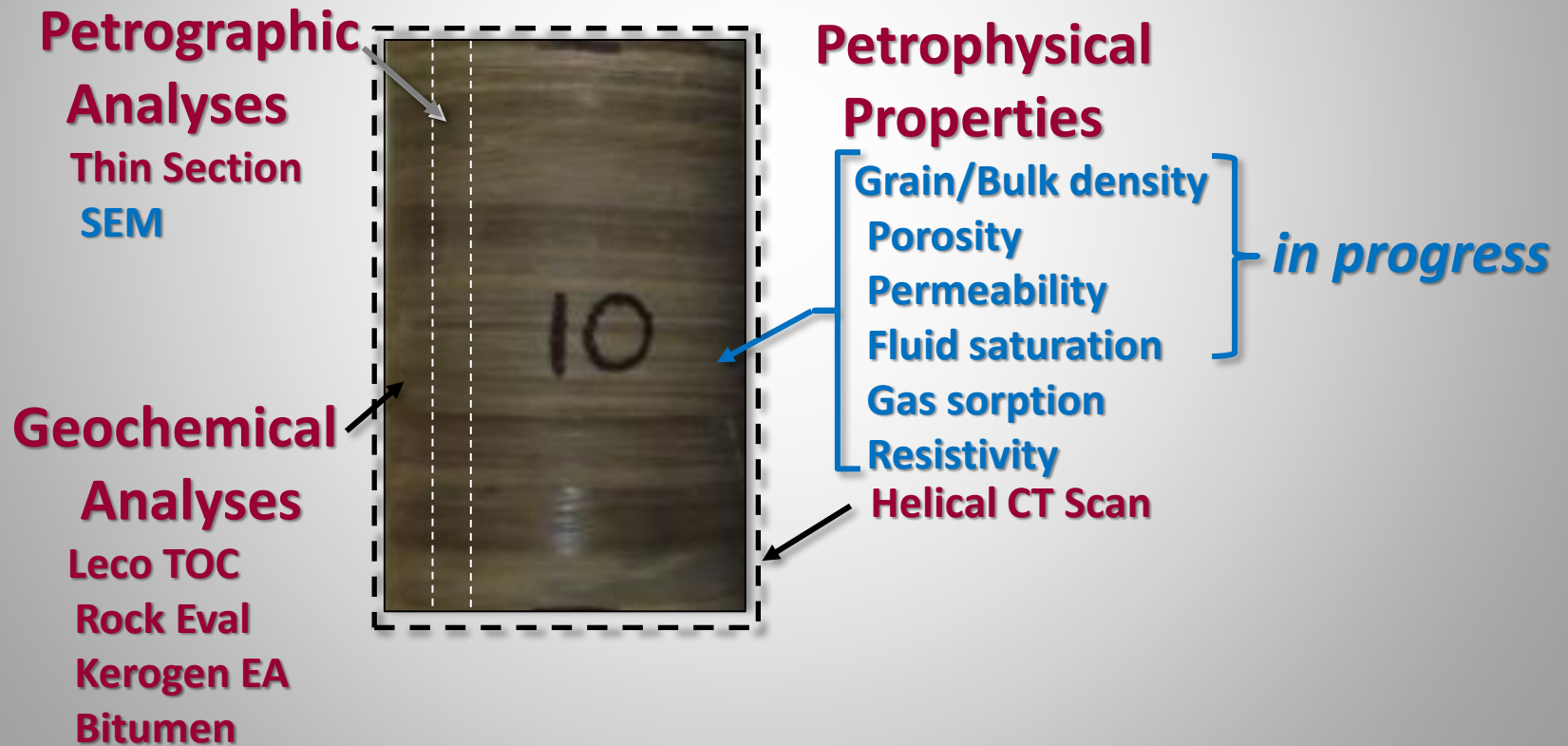
**Original
Core**



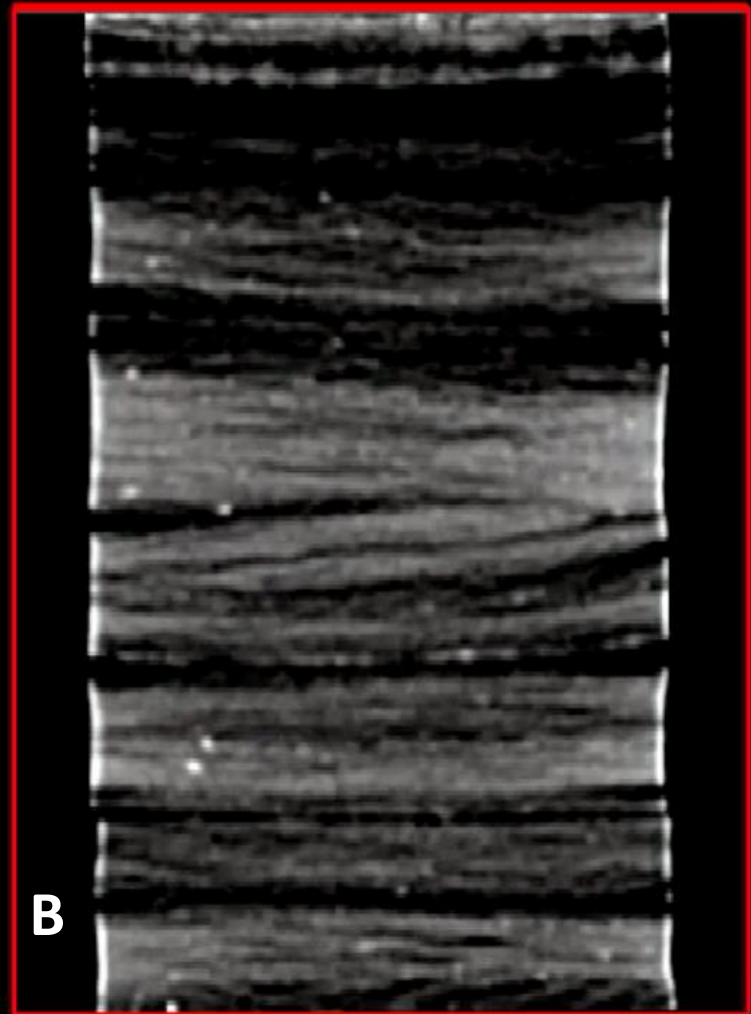
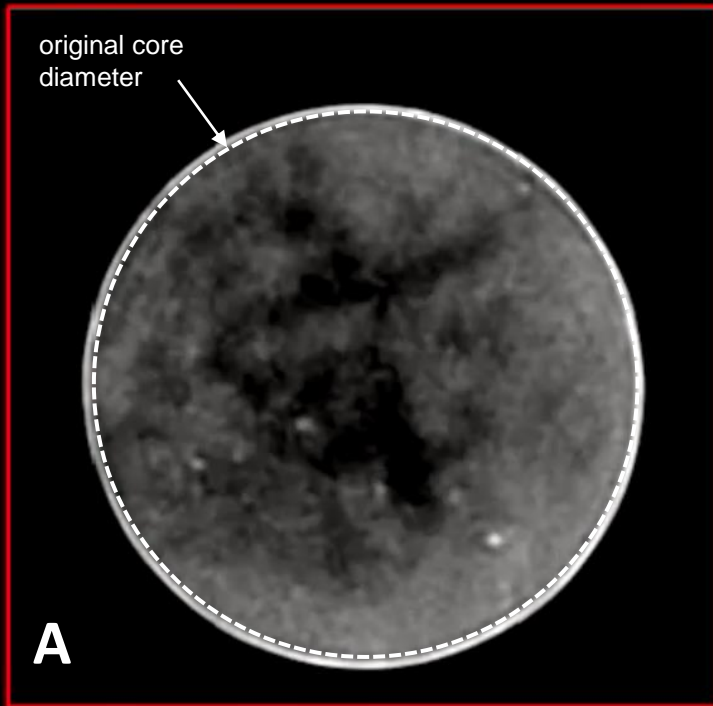
**Confined Core
360 °C/72 h**



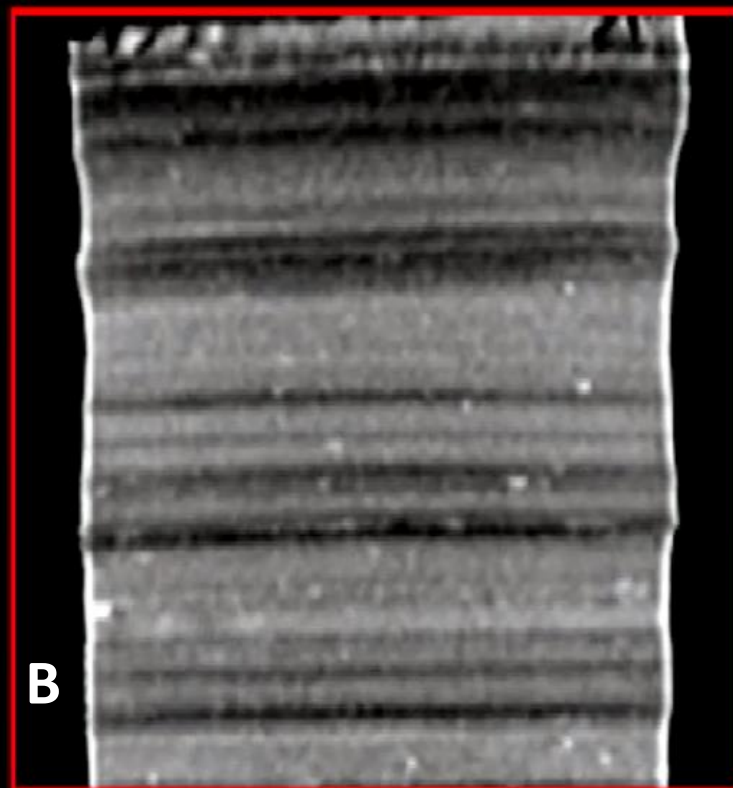
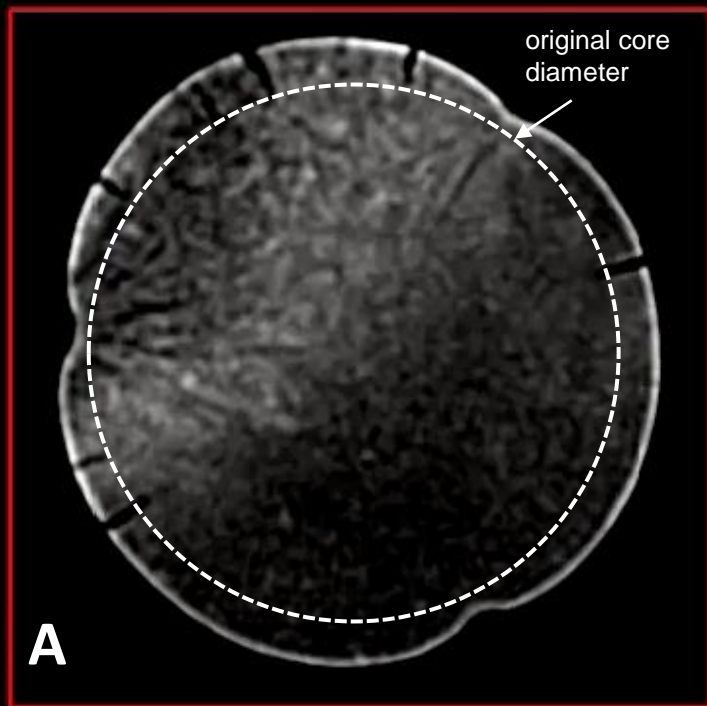
Although uniaxial confinement does not influence petroleum formation in HP experiments, does it influence Petrophysical Properties of a source rock?



Helical CT Scan
HP-3606
360°C/72h Unconfined



Helical CT Scan
HP-3605
360°C/72h Confined



Take-Home Points

Uniaxial Confinement-Core Clamp with Hydrous Pyrolysis provides intact cores at various thermal maturities for determining petrophysical properties.

Uniaxial confinement does NOT effect Geochemical Properties.

Petroleum formation does NOT generate pressures sufficient to induce fractures normal or oblique to bedding fabric of source rocks (*see Justin's talk Wednesday afternoon*).