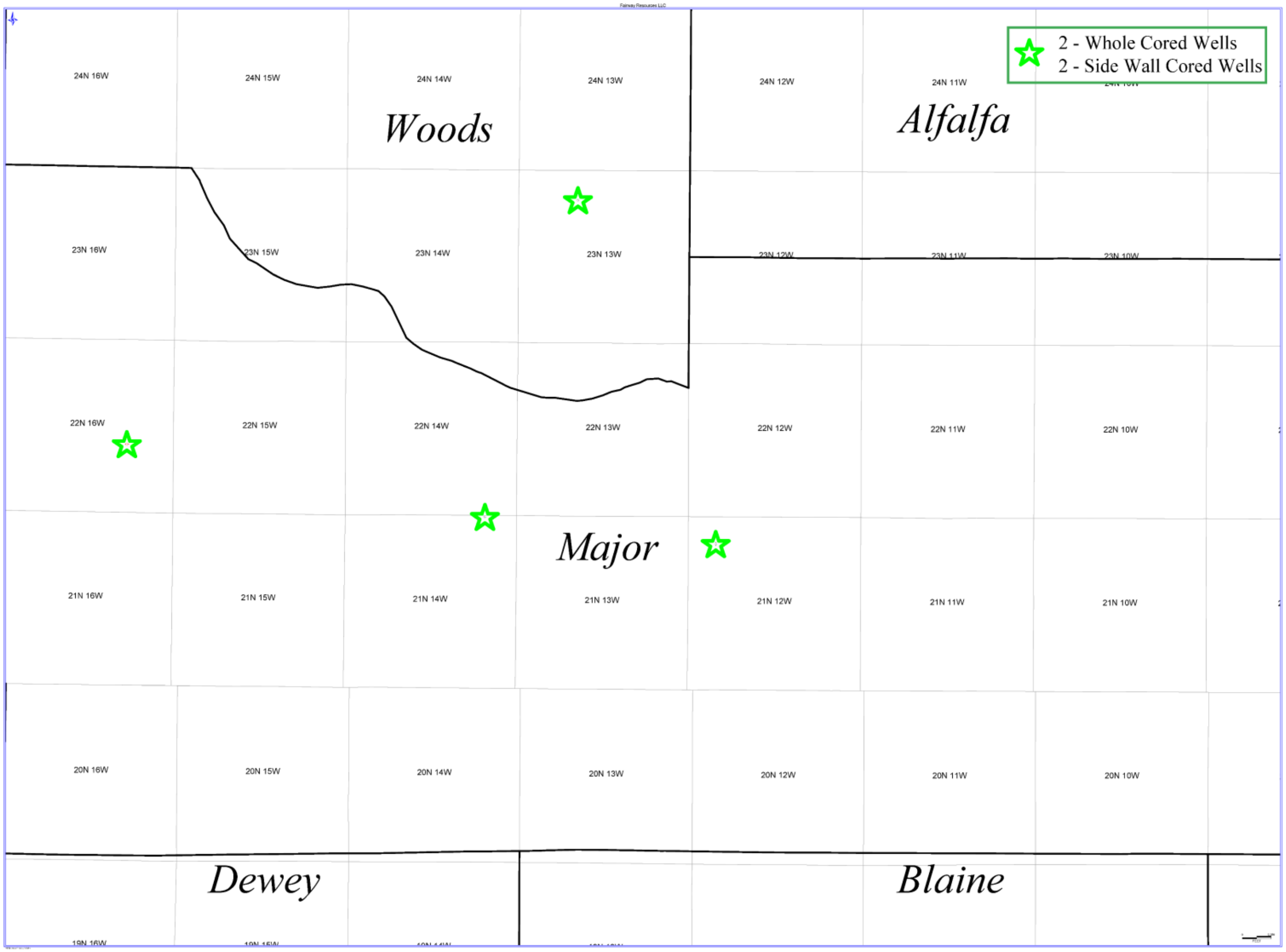
Rock Volatiles Stratigraphy of Meramec, Upper Osage, and Lower Osage carbonates in Fairway Resource's NW STACK wells: logging horizontal STACK wells from PDC cuttings' volatile chemistry

Michael Smith* (Advanced Hydrocarbon Stratigraphy), Geoff Ice (Fairway Resources), Greg Anderson (Fairway Resources), Sarah Rittenhouse (Advanced Hydrocarbon Stratigraphy), David Eby (Eby Petrography & Consulting, Inc.)

NW STACK – Cored Wells



Type Log & Generalized Depositional Model

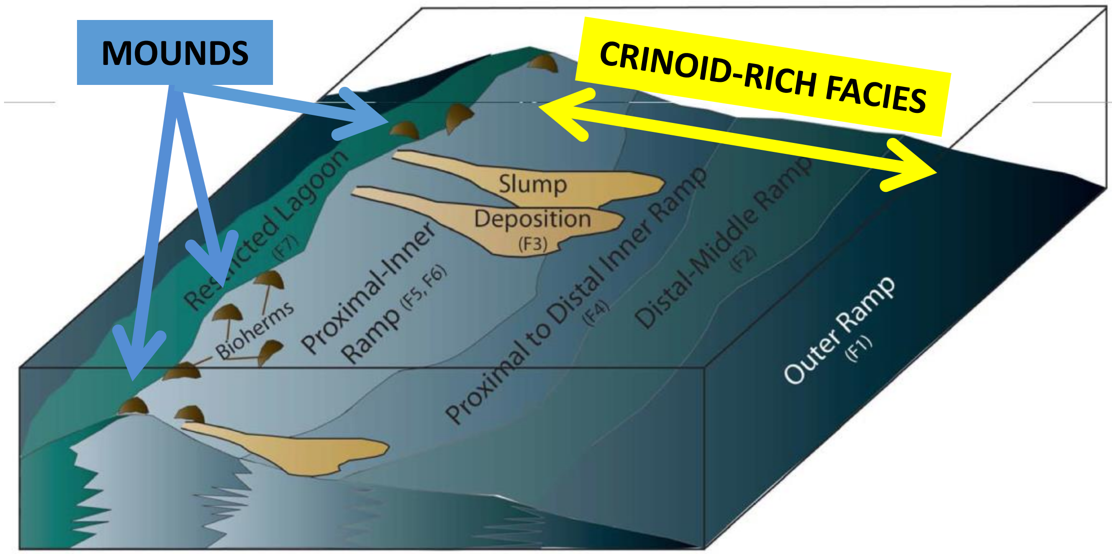
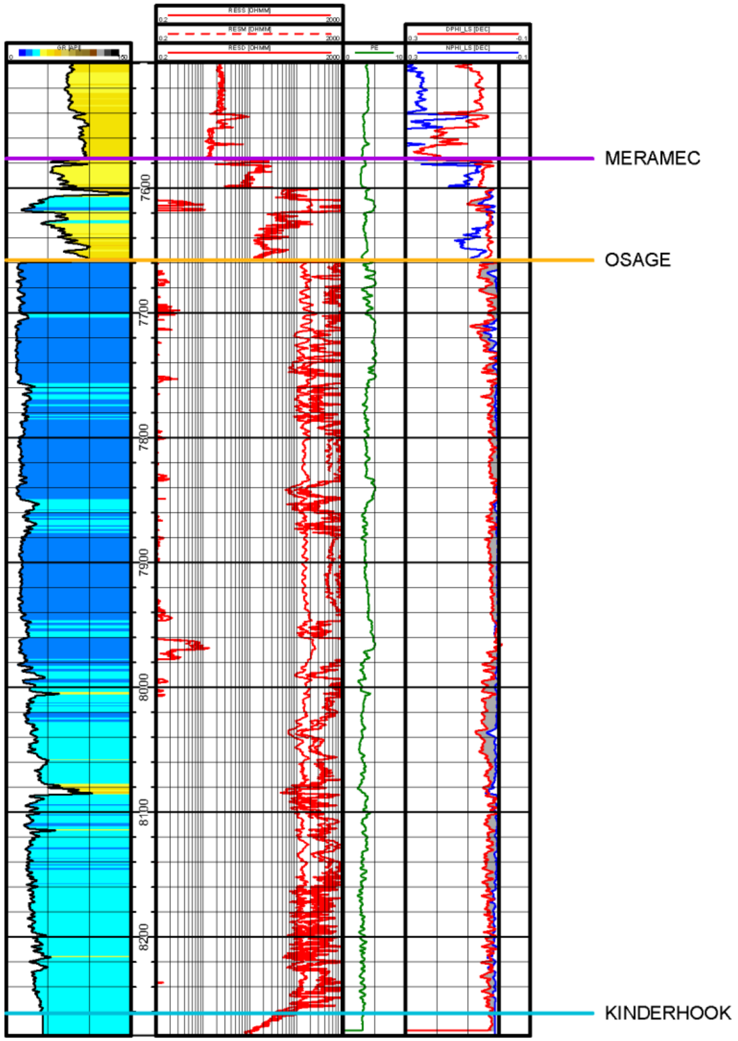


Figure 5. Block diagram showing generalized relationship of depositional environments and proposed lateral relationships assuming a carbonate ramp system with sub-basin topography.

(modified from Vanden Berg & Grammer, 2016, AAPG Mem. 112)



THREE LIMESTONE RESERVOIR TYPES

I. Mound (Bioherm) Facies (Diverse Skeletal Grainstone)

- Large, open pores (and some bitumen)
- Best Oil Production

II. Clean Crinoidal Grainstone Facies

- Dissolution & mostly microporosity
- Background (fair to good) Oil Production

III. Mixed Crinoid/Siliceous or Silty Facies

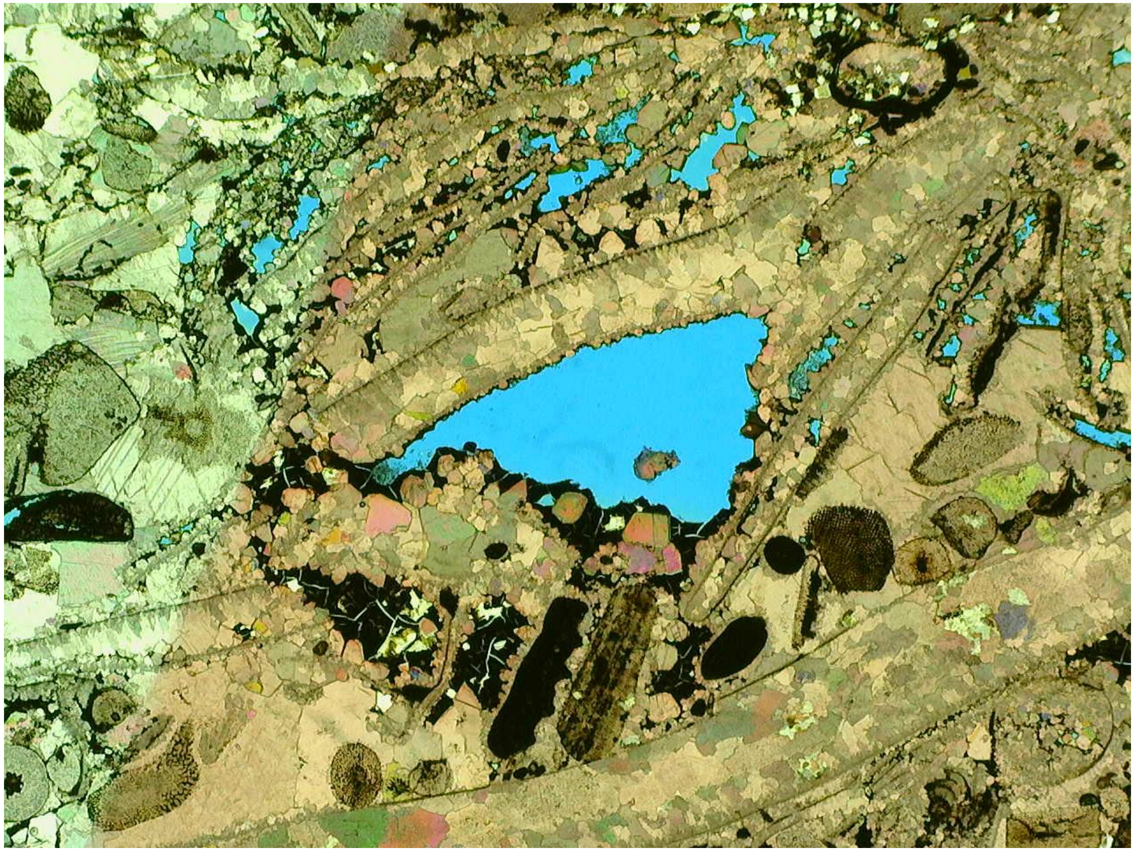
- Mostly nanoporosity (& high Gas/Oil ratios)
- Fair to Poor Oil Production w/ high gas content

RESERVOIR TYPE I

I. Mound (Bioherm) Facies (Diverse Skeletal Grainstone)

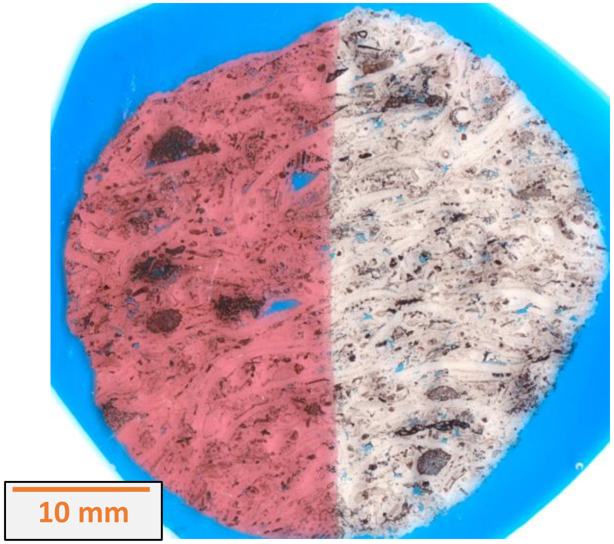
- Large, open pores (and some bitumen)
- Best Oil Production

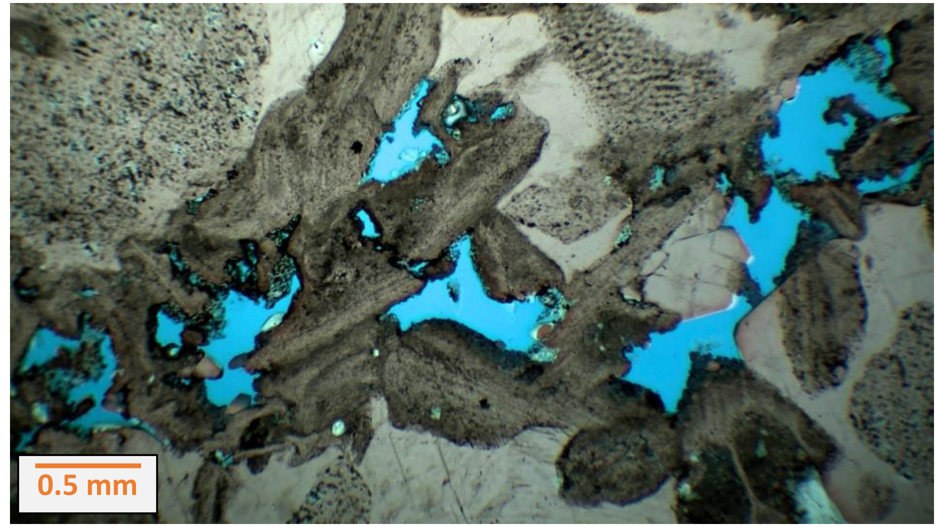
Pl. Light

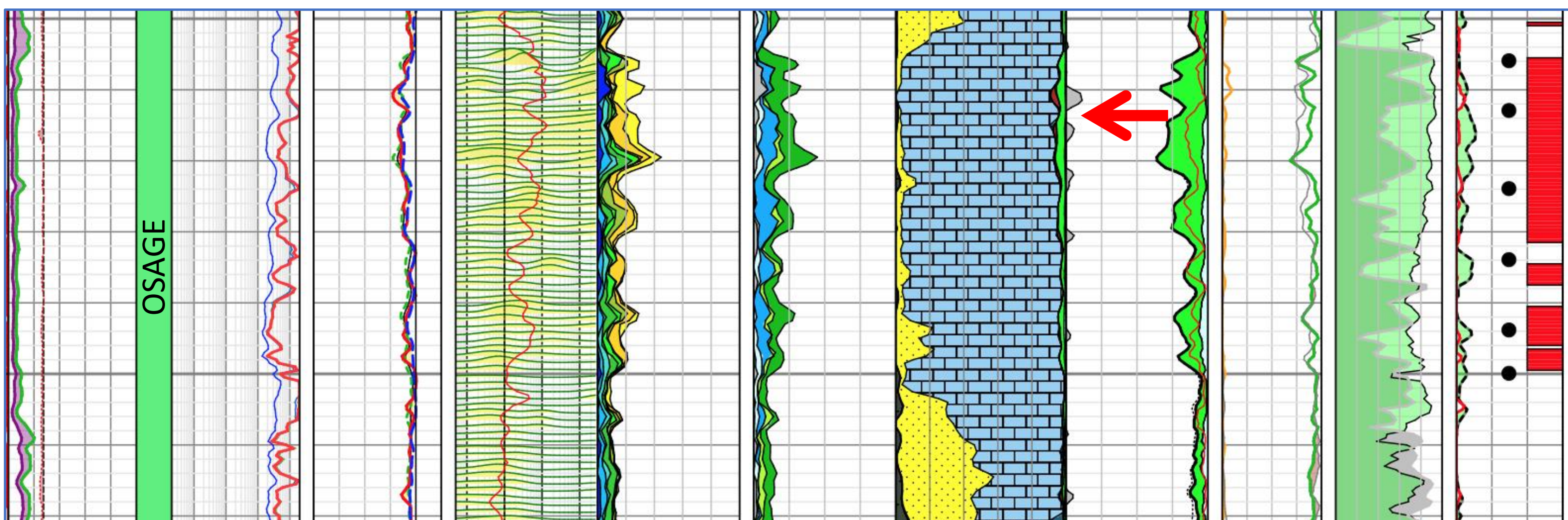


0.5 mm

RESERVOIR TYPE I – Mound Facies





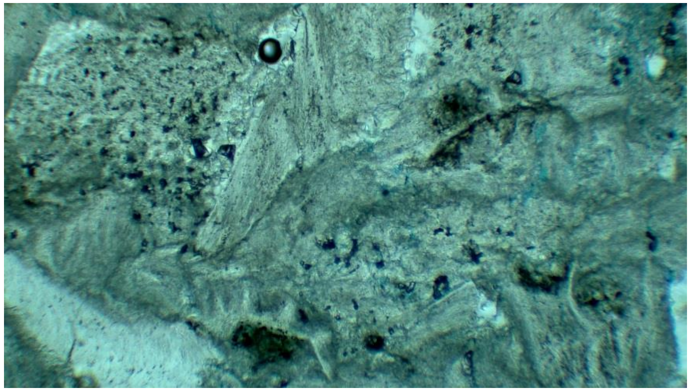


RESERVOIR TYPE II

II. Clean Crinoidal Grainstone Facies

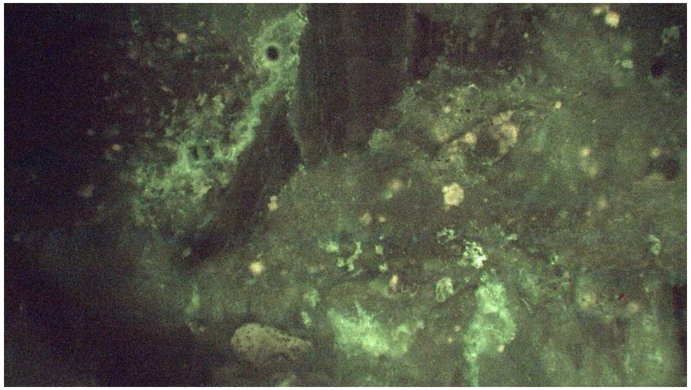
- Dissolution & mostly microporosity
- Background (fair to good) Oil Production

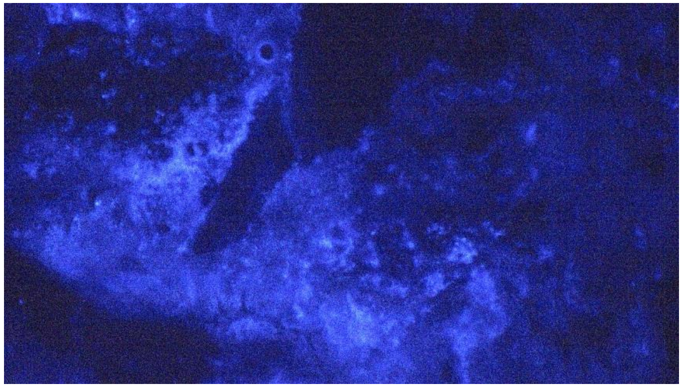
Pl. Light



1.0 mm

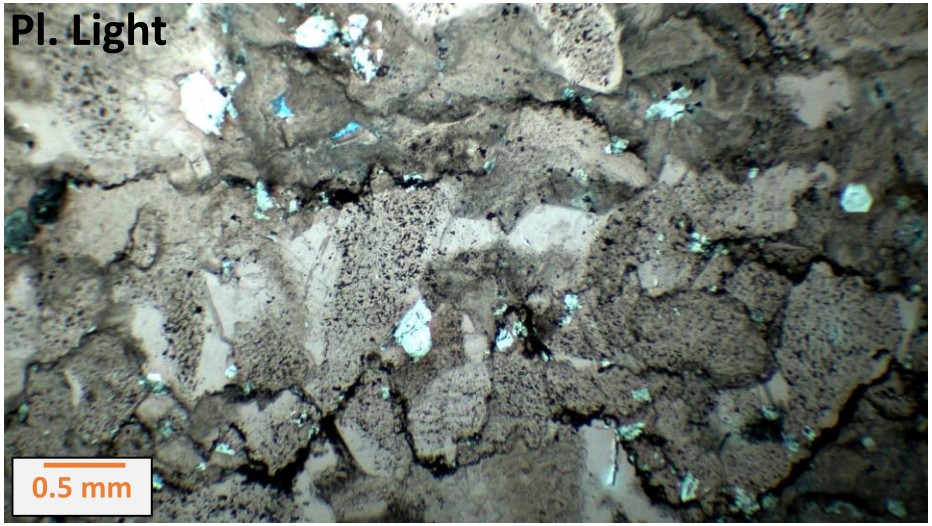
EF
(Blue Light)

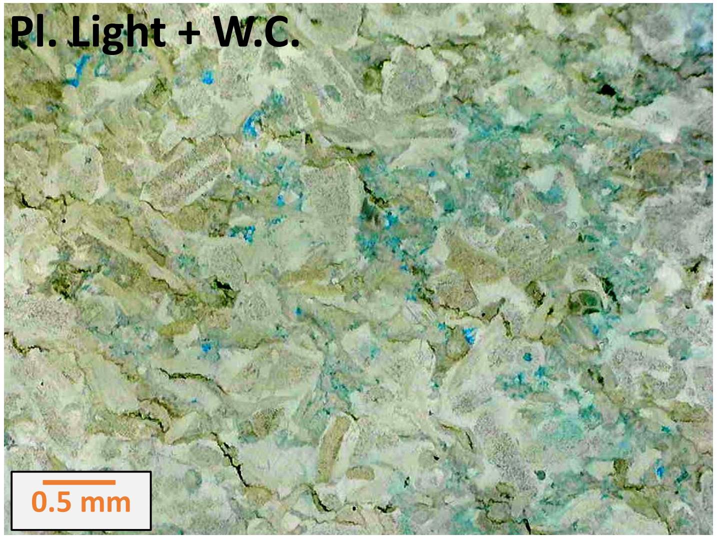


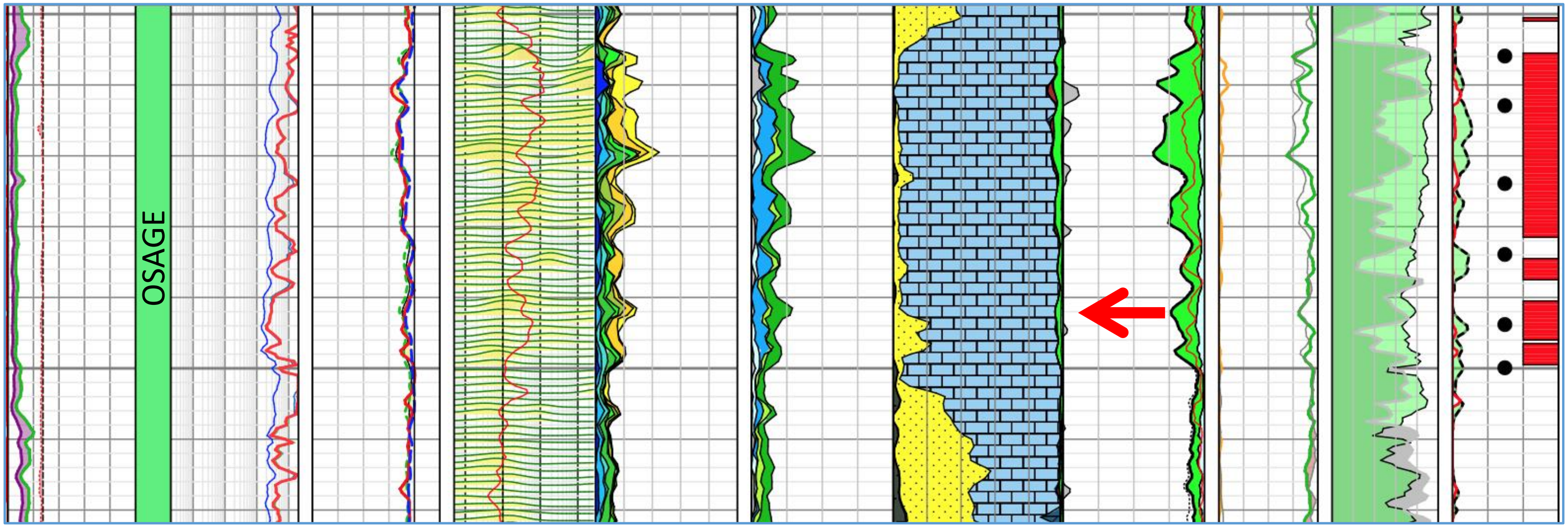


UV

RESERVOIR TYPE II – Clean Crinoidal Facies





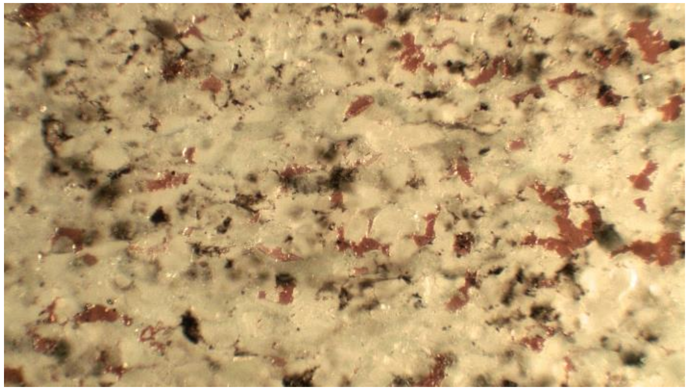


RESERVOIR TYPE III

III. Mixed Crinoid/Siliceous or Silty Facies

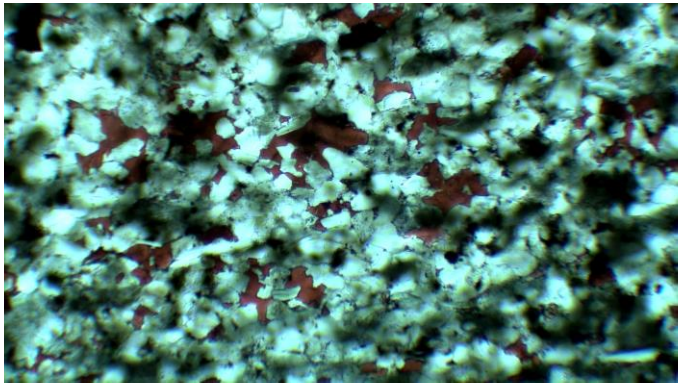
- Mostly nanoporosity (higher Gas/Oil ratios)
- Fair to poor oil production with higher gas content

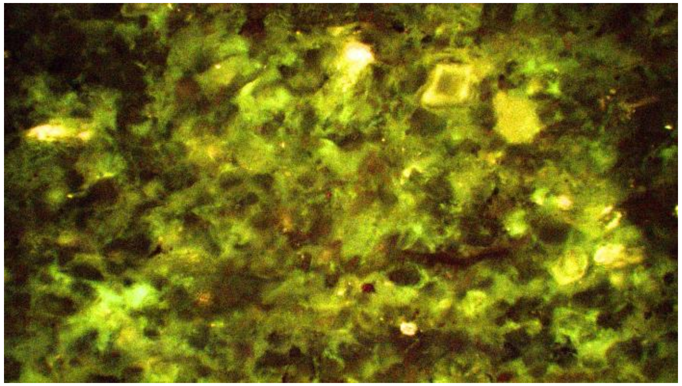
Pl. Light



1.0 mm

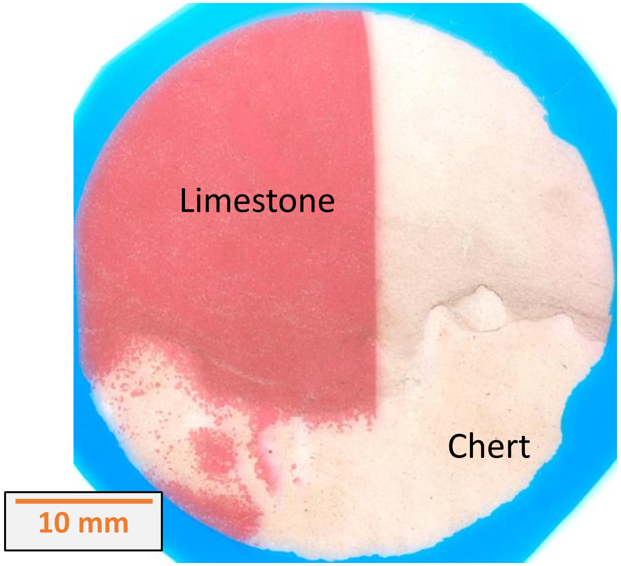
XN Light

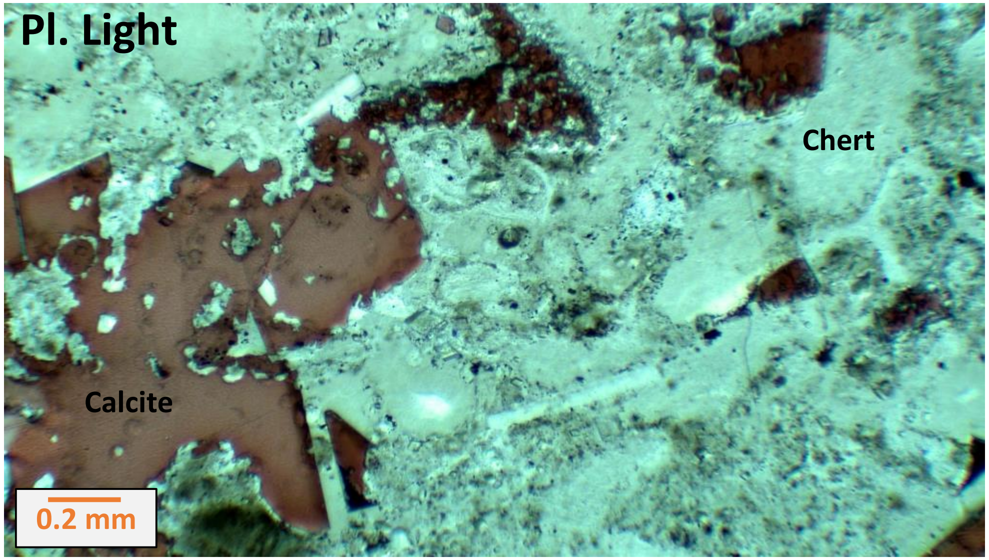


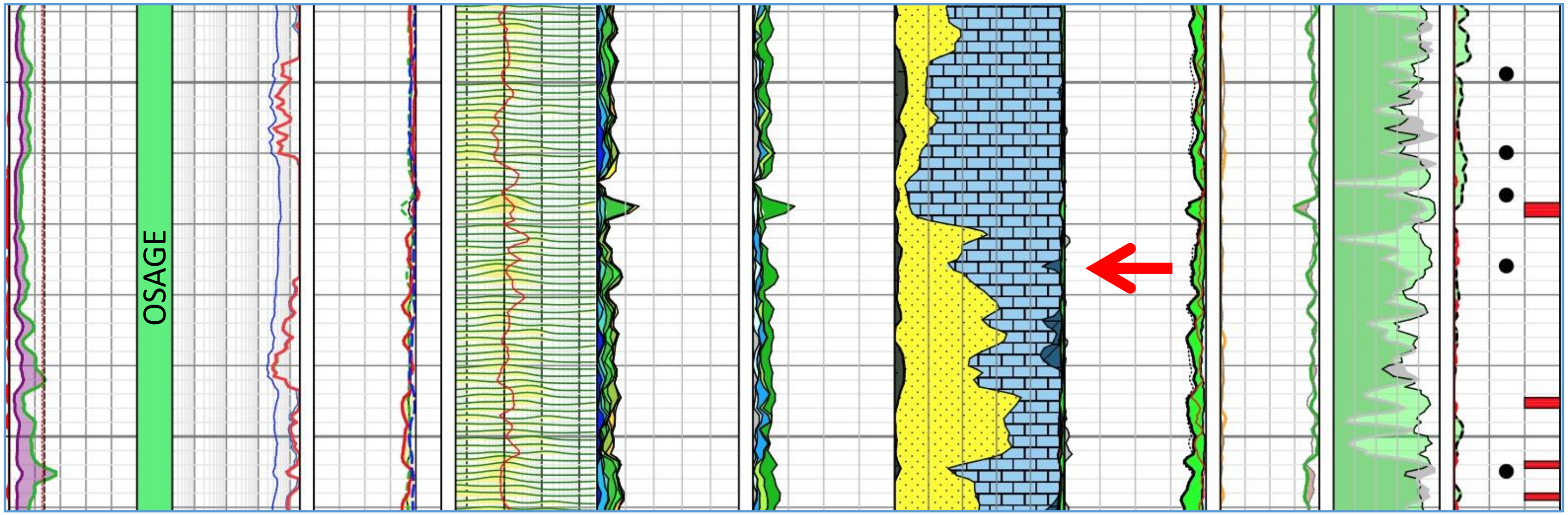


EF (Blue Light)

RESERVOIR TYPE III – Mixed Crinoid/Siliceous Facies







Starting Material: PDC Cuttings

ADVANCED
HYDROCARBON
STRATIGRAPHY

PDC Cuttings

Sub-Millimeter in size

Gently Caught

Washed and Dried then Loaded

Or

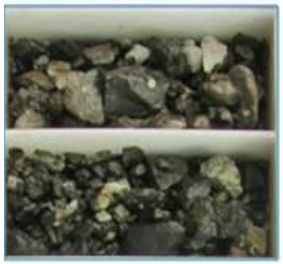
Sealed at Well Immediately after Gently Caught, and Washed. Usually sealed less than a minute after the cuttings are caught.

WBM or OBM
New Wells and Old Wells
Rock Bit Cuttings and Core Also.

AHS's Unique CT/MS Technology

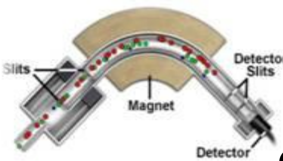
ADVANCED
HYDROCARBON
STRATIGRAPHY

Well Cuttings

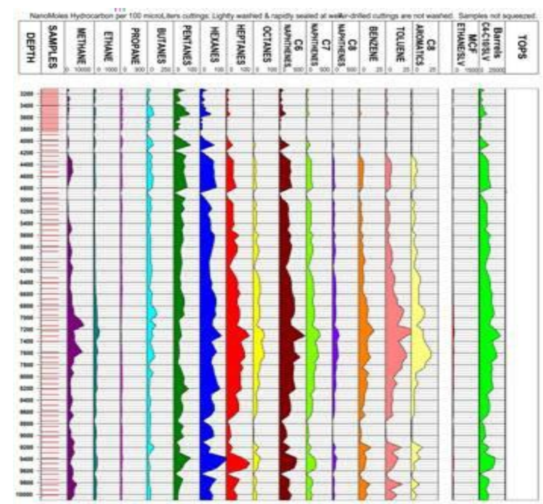


Sample Volatiles Analyzed Using Mass Spectrometry

LN2 Cryo Trap Separation



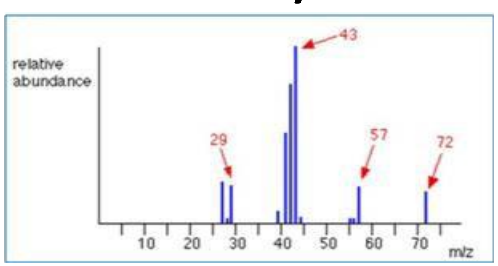
Quantitative Reservoir Contents



The 4th Log

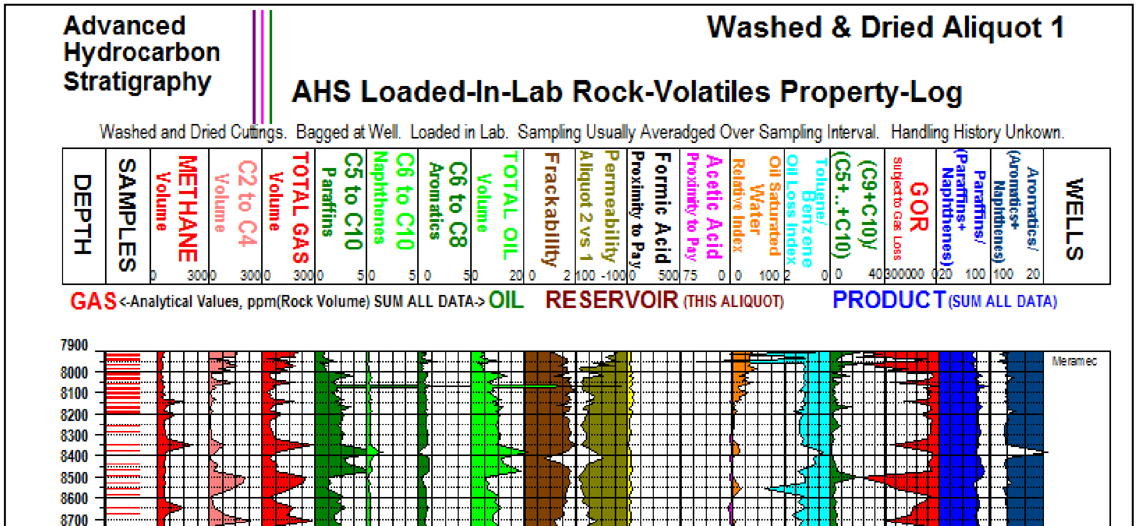
1. Cuttings (or Mud) Samples Sealed or Bagged at Well Site
2. Older well cuttings washed or unwashed
3. Oil based mud and PDC bits have limited impact

MS Analysis



AHS Products and Interpretation

ADVANCED
HYDROCARBON
STRATIGRAPHY



Category	Sample depth	C1-C10, Total Gas/Oil	Frac & Perm	Prospect Evaluation	HC Analysis	Well Tops
Interpretation		HC Detection, ID: faults, fractures, rock types, etc.	AHS exclusive analysis	Proximity to Pay, Organic Acids, Oil Migration	Pay Zone Mapping, product quality	From Client

Fault May Feed Oil Into Reservoir

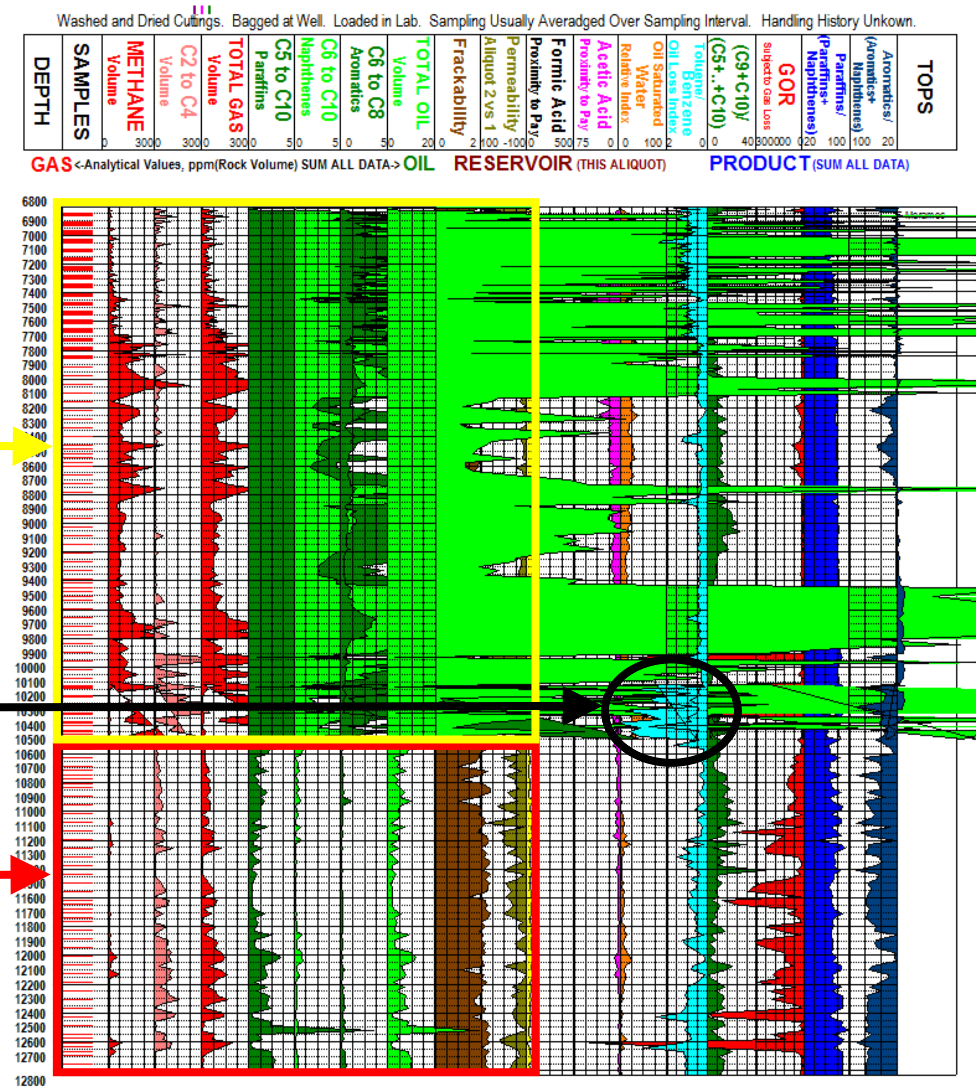
A H S

Tighter Rocks Maintain Oil and Gas from Cuttings through Drilling and Transport to the Surface

High Toluene/Benzene ratio at fault = Zone of Active Oil Migration

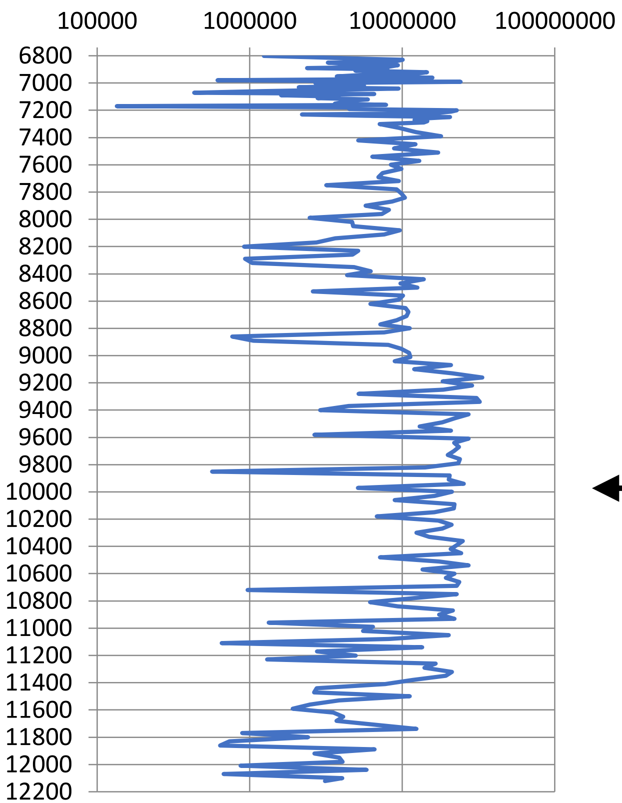
AHS Predicted Preferred Reservoir Zones

High Porosity High Permeability Rocks Can Lose Oil During Drilling , Transport, and Sample Prep



Potential Rock Type 1 CO_2 Response

A
H
S



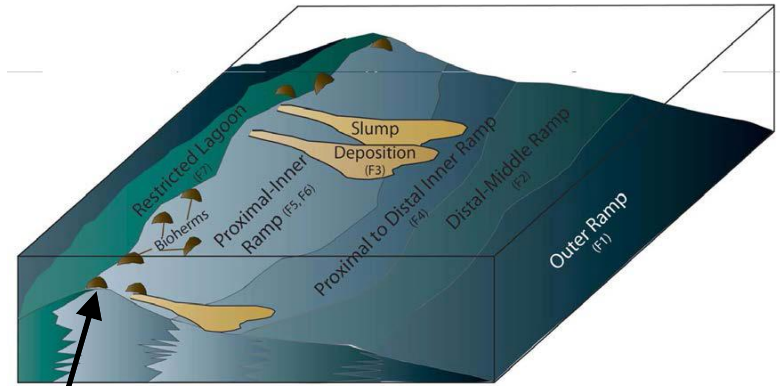
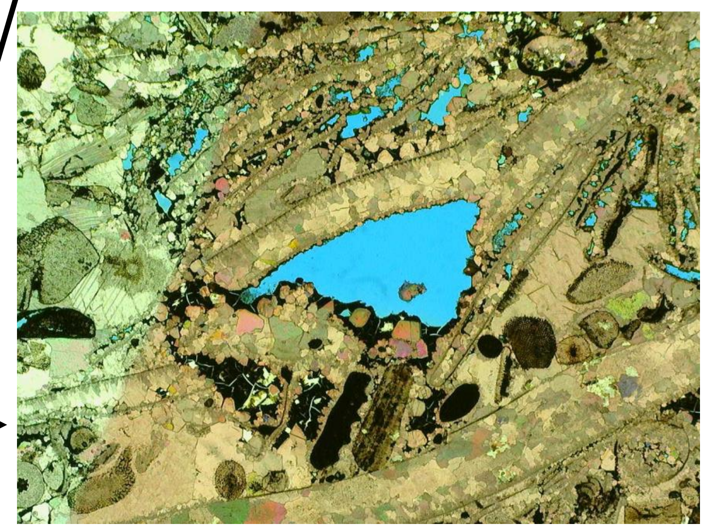


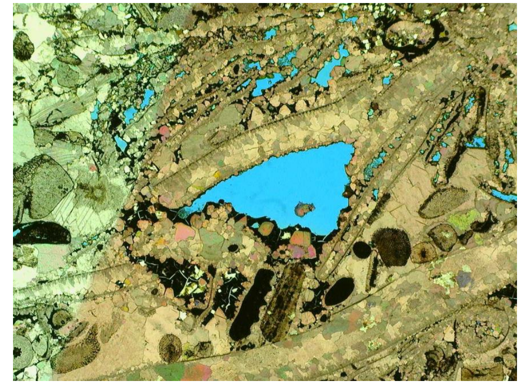
Figure 5. Block diagram showing generalized relationship of depositional environments and proposed lateral relationships assuming a carbonate ramp system with sub-basin topography.

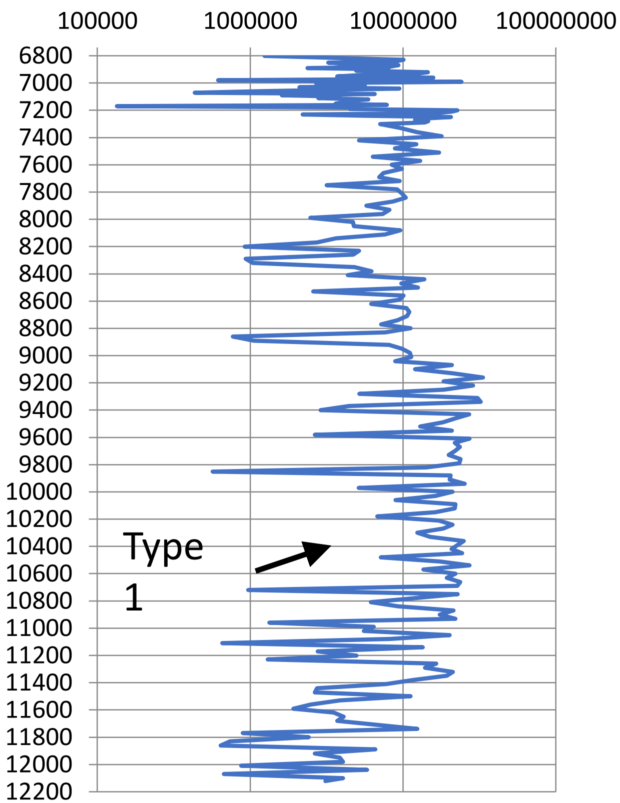
Potential
ROCK Type 1
CO_2
Response

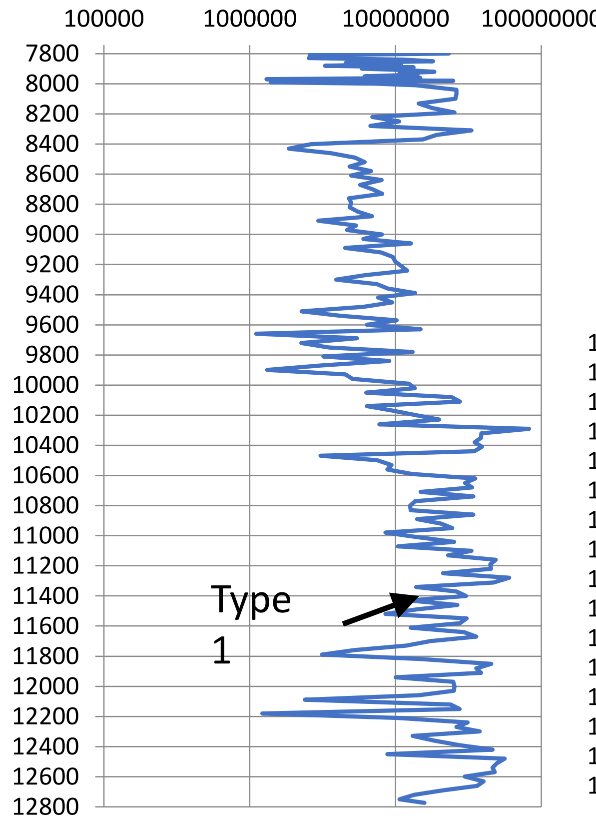
Possibly
Bioherms
Largest Grains
Largest Fluid Inclusions
Highest CO_2 Release

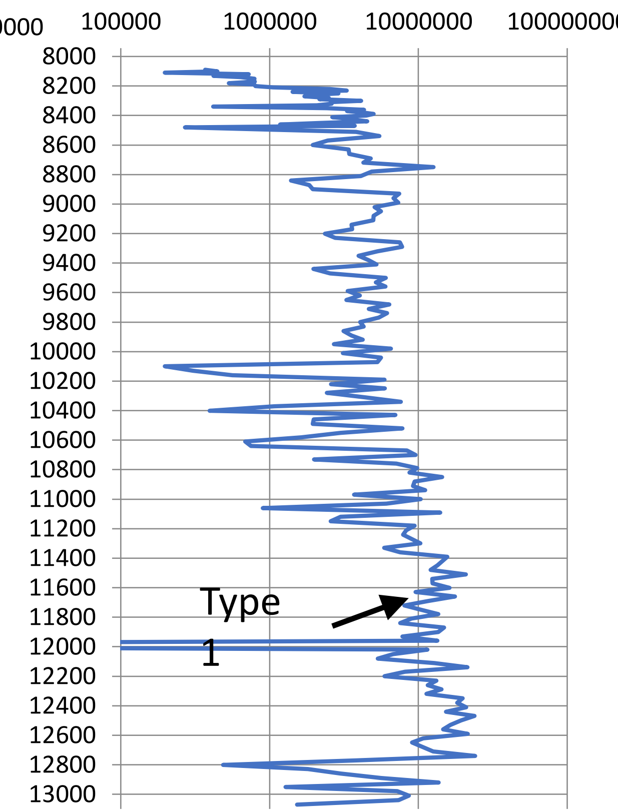


Potential Rock Type 1 CO_2 Response



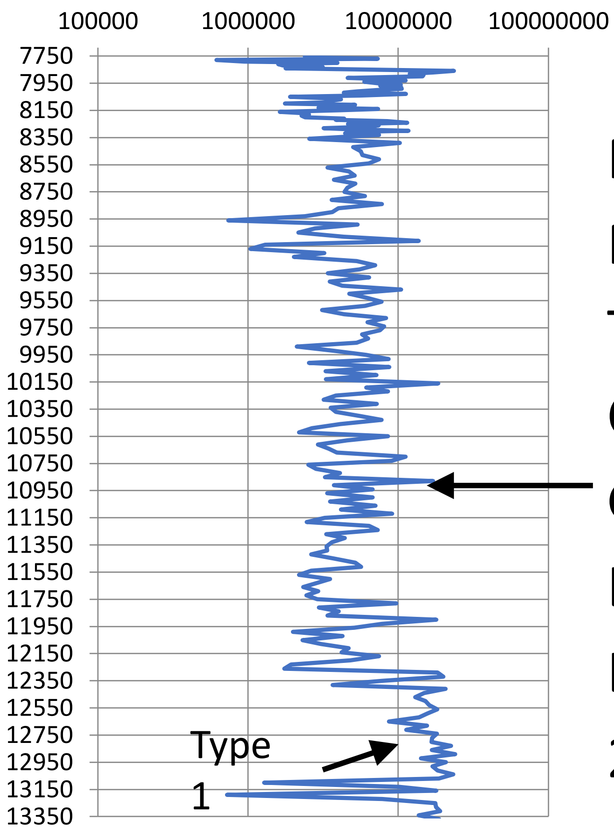






Potential Rock Type 2 CO_2 Response

A
H
S



Potential

ROCK

Type 2

Crinoidal

Grainstones

Large Grains

Large Fluid Inclusions

2nd Highest CO_2 Release

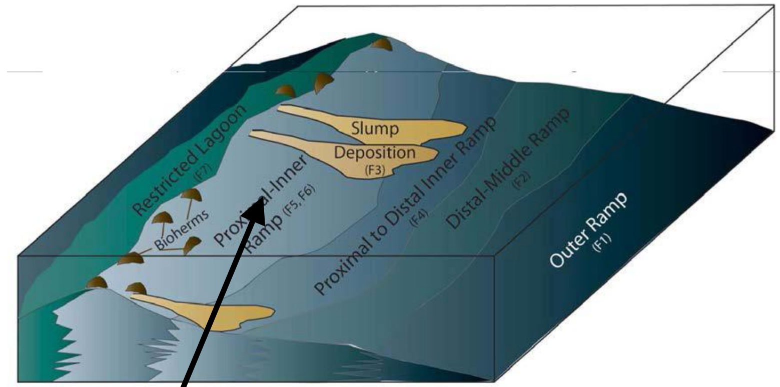
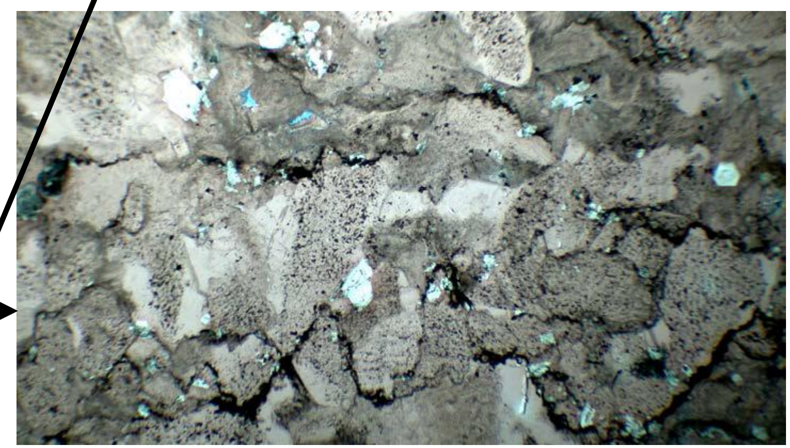
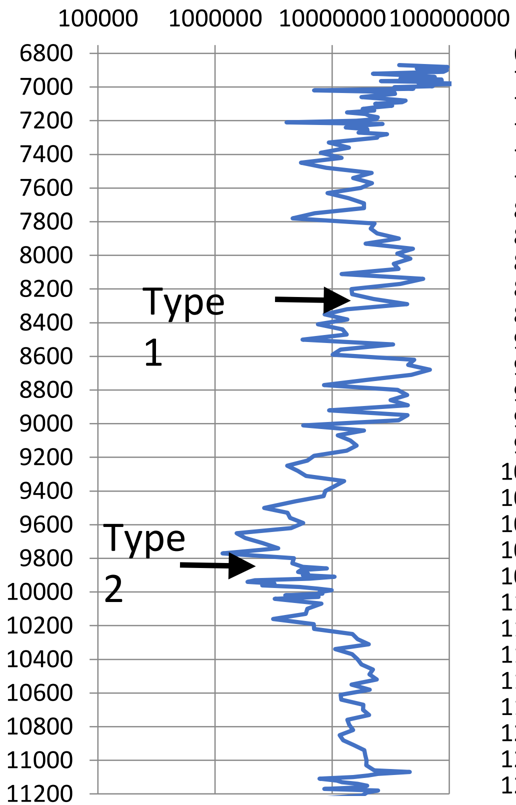


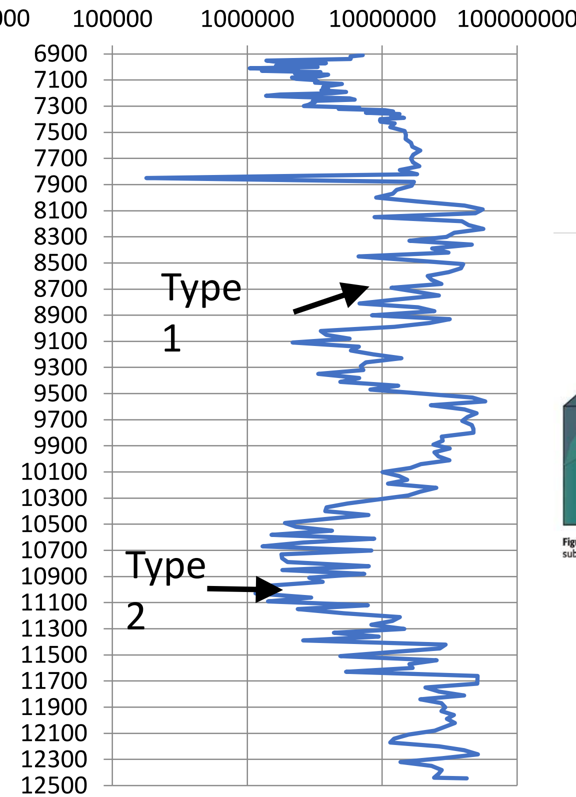
Figure 5. Block diagram showing generalized relationship of depositional environments and proposed lateral relationships assuming a carbonate ramp system with sub-basin topography.



Potential Rock Types 1 and 2

Potential ROCK Types 1 and 2 CO_2 Responses: Bioherms and Shelf Grainstones





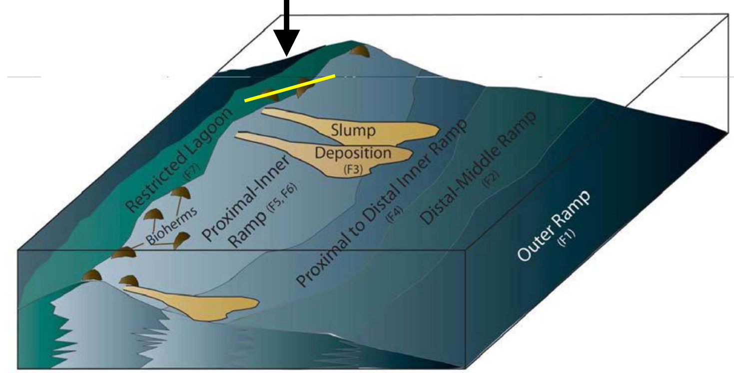


Figure 5. Block diagram showing generalized relationship of depositional environments and proposed lateral relationships assuming a carbonate ramp system with sub-basin topography.

Reservoirs May Show Low Cuttings Oil Response

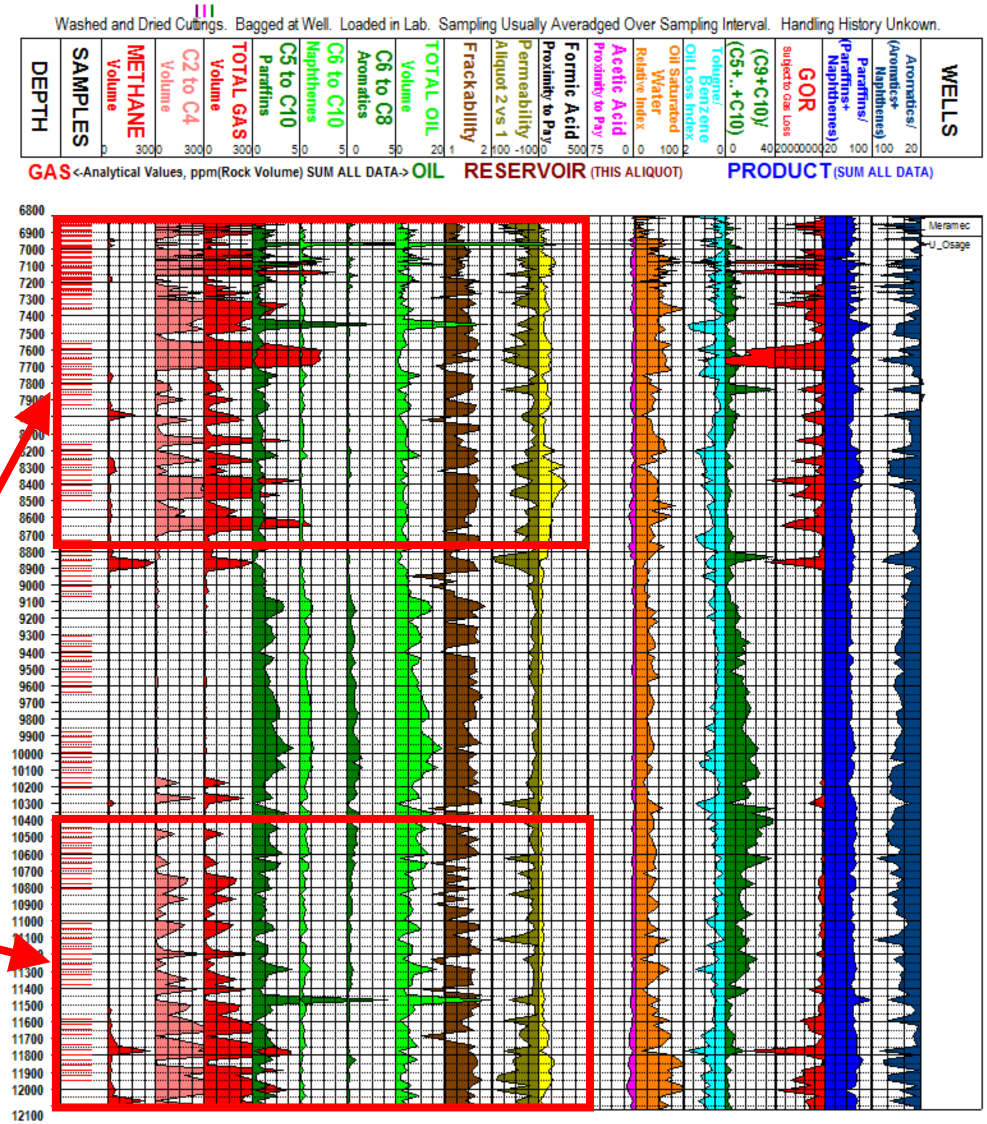
AHS

High Performing Well

Low Cuttings Oil Responses

High Porosity High Permeability Rocks Can Lose Oil During Drilling , Transport, and Sample Prep

AHS Predicted Preferred Reservoir Zones



Reservoirs May Be Filled by Nearby Fault

AHS

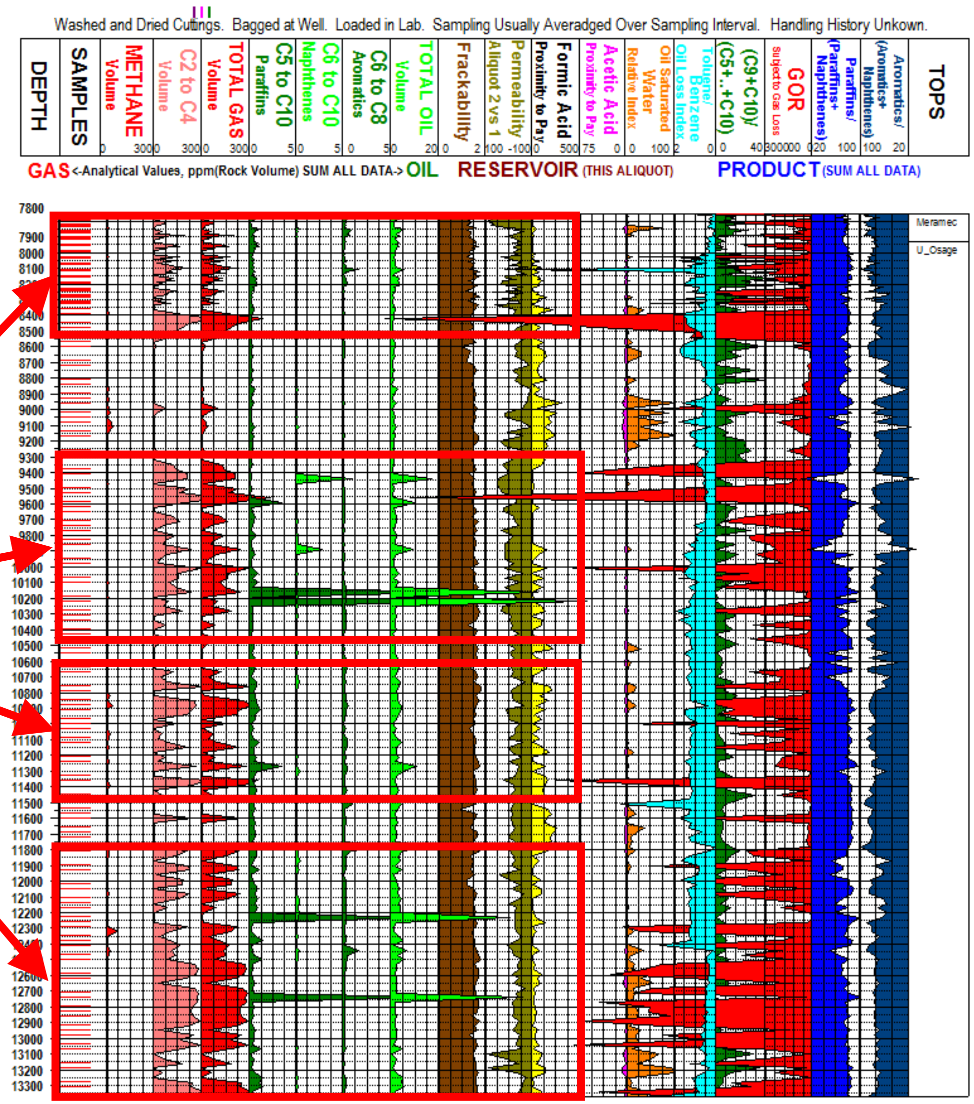
High Performing Well

Lateral Drilled Along N-S Fault

AHS Predicted
Preferred Reservoir Zones

Nearby Parallel Fault
May be Filling Reservoirs the Entire Length of Lateral

High Porosity High Permeability Rocks Can Lose Oil During Drilling, Transport, and Sample Prep



Fault May Feed Oil Into Reservoir

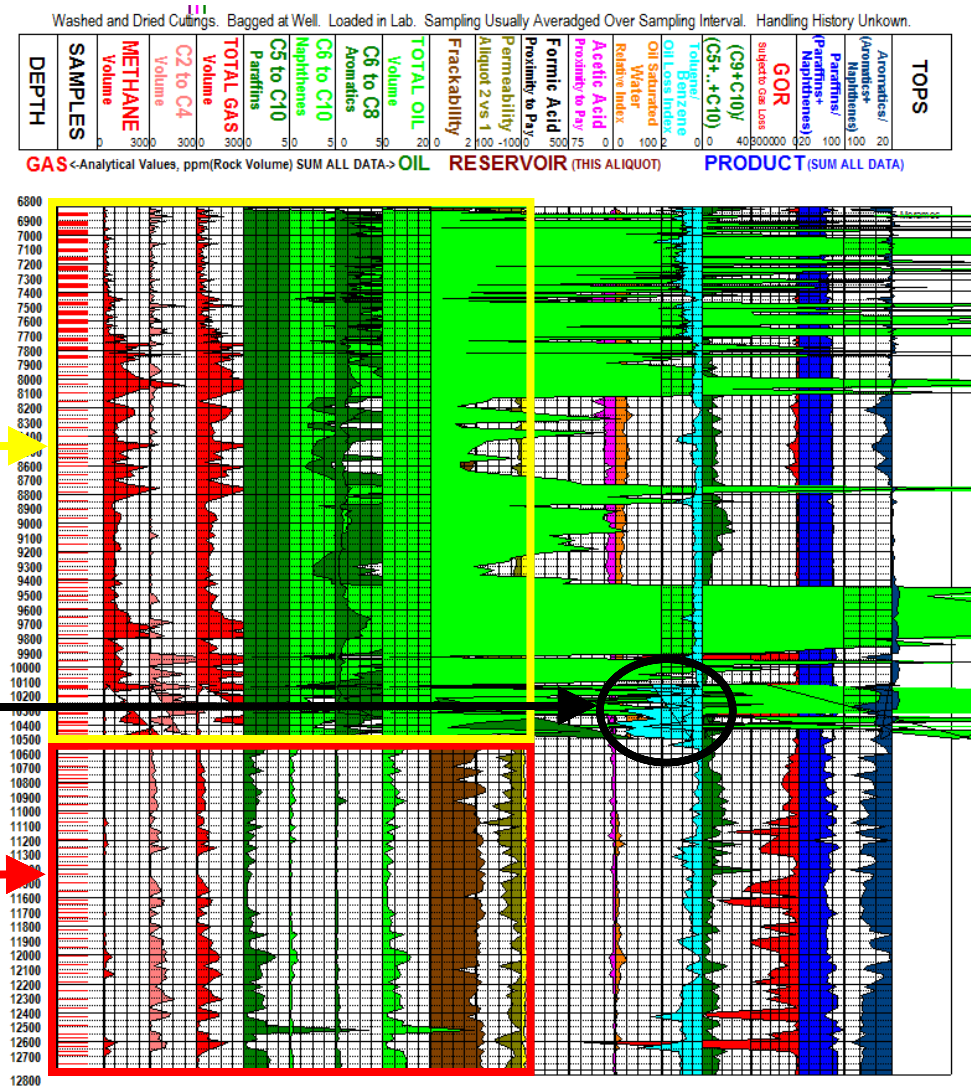
AHS

Tighter Rocks Maintain Oil and Gas from Cuttings through Drilling and Transport to the Surface

High Toluene/Benzene ratio at fault = Zone of Active Oil Migration

AHS Predicted Preferred Reservoir Zones

High Porosity High Permeability Rocks Can Lose Oil During Drilling , Transport, and Sample Prep



Faults Might Feed Reservoirs and Create Porosity

AHS

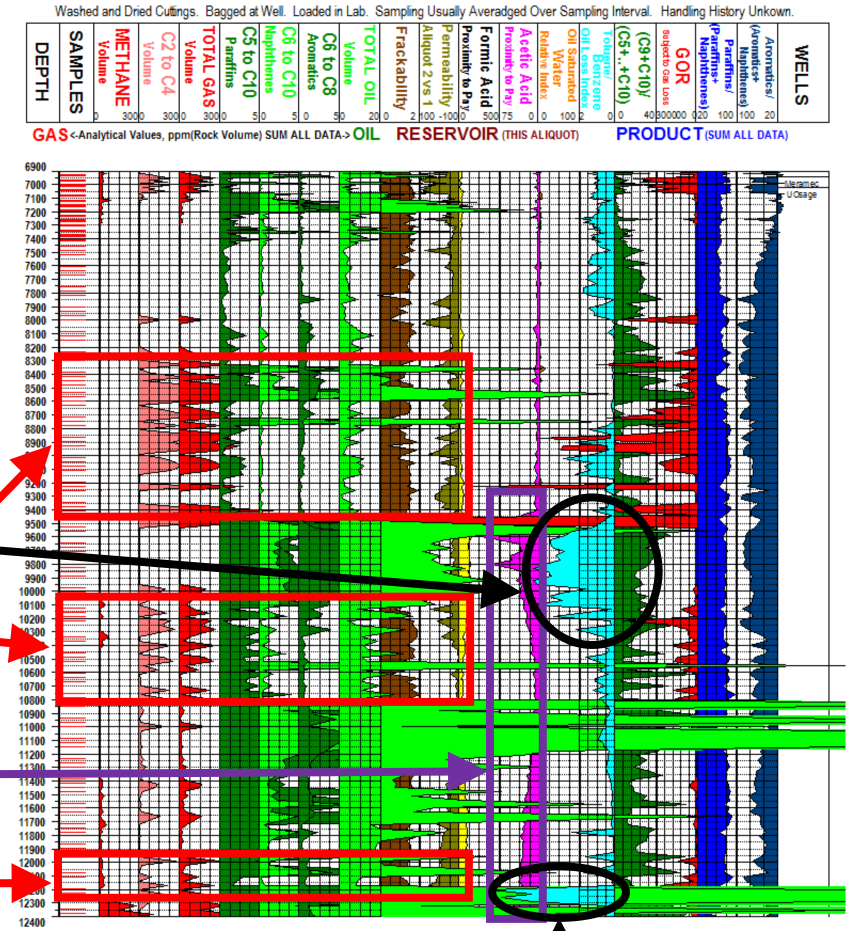
Lateral Drilled through a Fault

High Toluene/Benzene =
Oil Migration along Fault

AHS Predicted Preferred Reservoir Zones Surrounding Fault

High Acetic Acid Toe Side of Fault

Small Fault Feeding Small Reservoir

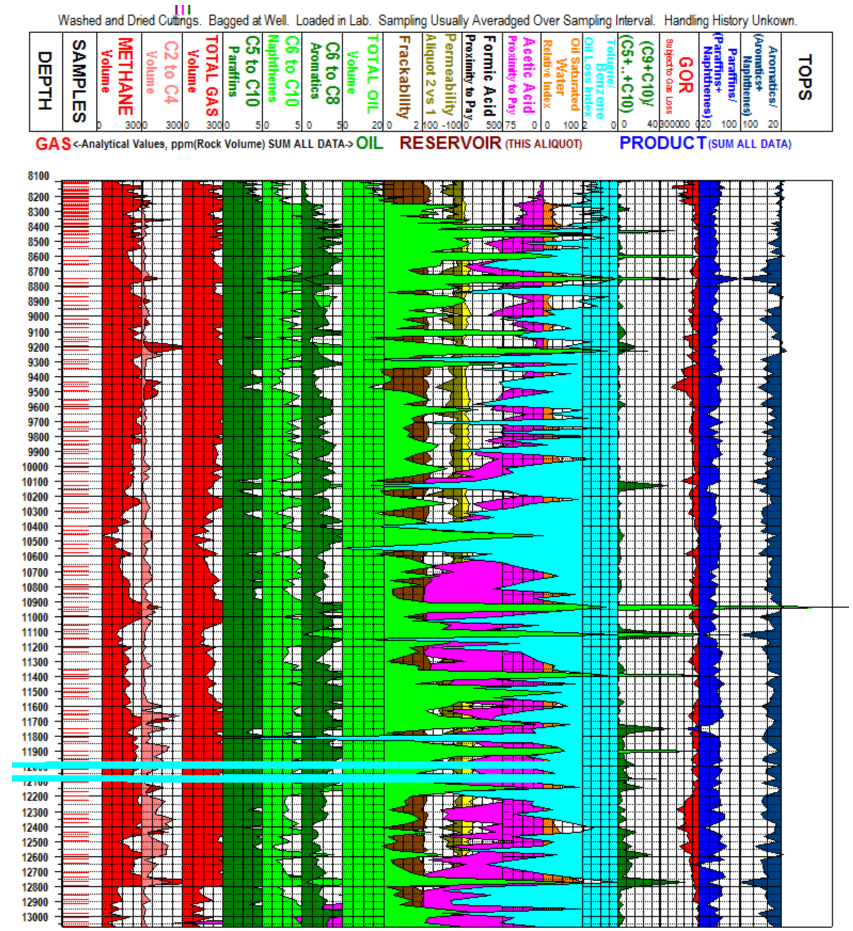


Faults Migrating Oil and Acetic Acid

A
H
S

Lateral Drilled through 2 NE-SW Faults

- Very High Acetic Acid and Toluene/Benzene
- Oil and Acid Rich Oil Field Brines Migrating on NE-SW Faults

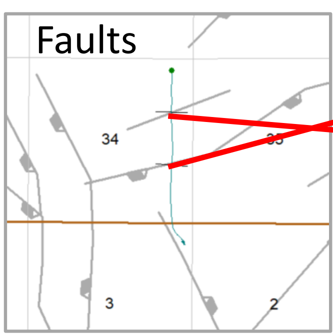


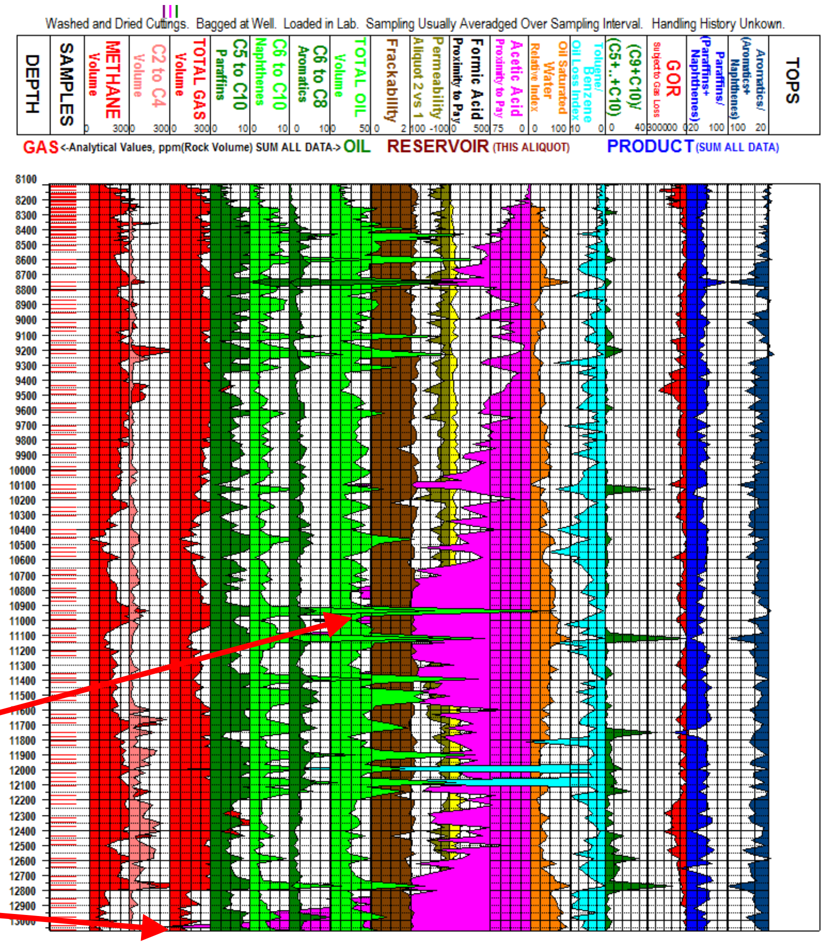
Faults Migrating Oil and Acetic Acid

A
H
S

Lateral Drilled through 2 NE-SW Faults

- Very High Acetic Acid and Toluene/Benzene
- Oil and Acid Rich Oil Field Brines Migrating on NE-SW Faults
- High Response Scaling





Conclusions

- Fairway Resources is successful in producing liquids in the NW STACK by applying a variety of innovative technologies
  - Rock typing identifies potentially producible facies

- AHS RVStrat attempts to map reservoir quality, oil and gas migration and pay zones
  - Combined with rock type facies for more predictive mapping and results

- Faults can be chemically identified
  - Porosity creation may increase rock facies reserves
  - Oil migration pathways provide clarity for well placement and potentially producible zones