The Source and Fate of Oils in the Lawton Oilfield, Southwestern Oklahoma*

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Abstract

The Lawton oilfield is located in the east of the Wichita Mountain Uplift in the Anadarko Basin, Southwestern Oklahoma. Eighteen oil samples were collected and characterized by a variety of geochemical techniques, including bulk composition, biomarkers and stable isotopes. Despite the fate that all of these oils were recovered from reservoirs between 200 and 900ft, none of them appeared to be biodegraded as manifested by the abundance of the complete range of n-alkanes. The presence of the 25-norhopanes in all 18 samples suggests that these oils are in all probability mixtures of degraded and non-degraded oils.

A cross-plot of dibenzothiophene/phenanthrene (DBT/PHEN) and pristane/phytane (Pr/Ph) shows the source rock for the Lawton oils is marine shale. Furthermore, the cross-plot of $\delta^{13}C$ values for the saturate and aromatic fractions shows that the source rock is probably Woodford Shale. The different 25-norhopane/C_{30} hopane ratio and dimethylnaphthalene/C_{28}20S triaromatic steroid ratio suggests differing levels of biodegradation across the field and differing mixes of degraded and non-degraded oils. The isoheptane and heptane ratio cross plot, C_{29}sterane 20S/ (20S+20R) and C_{29}sterane ßß/ (ßß+αα) predicts the thermal maturity of Lawton oil is 1.0-1.3% Ro. This is clearly incorrect and suggests that these commonly used maturity parameters cannot be used for mixtures of degraded and nondegraded oils to predicted maturity level at which the oil was generated.

Finally, a hydrocarbon accumulation model has been proposed for this field: there were two reservoir-charging periods in Lawton oilfield. At first, the crude oil charged the reservoir and was biodegraded. The second charging period was after the uplift of Wichita Mountains and the subsidence of the southern part of the Anadarko Basin leading to deeper burial of the

source rock and production of higher maturity oil. The second charge of light and nondegraded oil is then mixed with the in-situ biodegraded oils. Whilst the Lawton oil field is an old field with a long production history, this study provides the opportunity to further our understanding on reservoir charging history when the oils have undergone secondary alteration.

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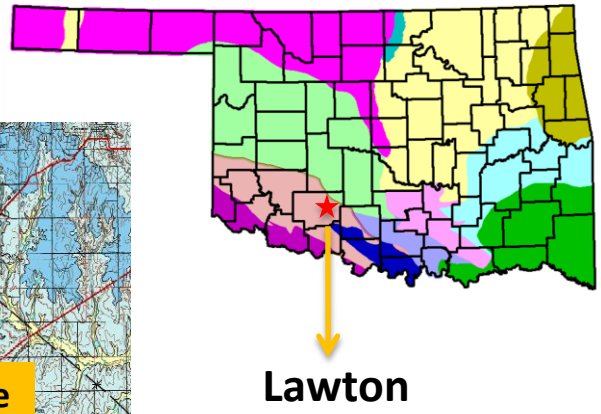
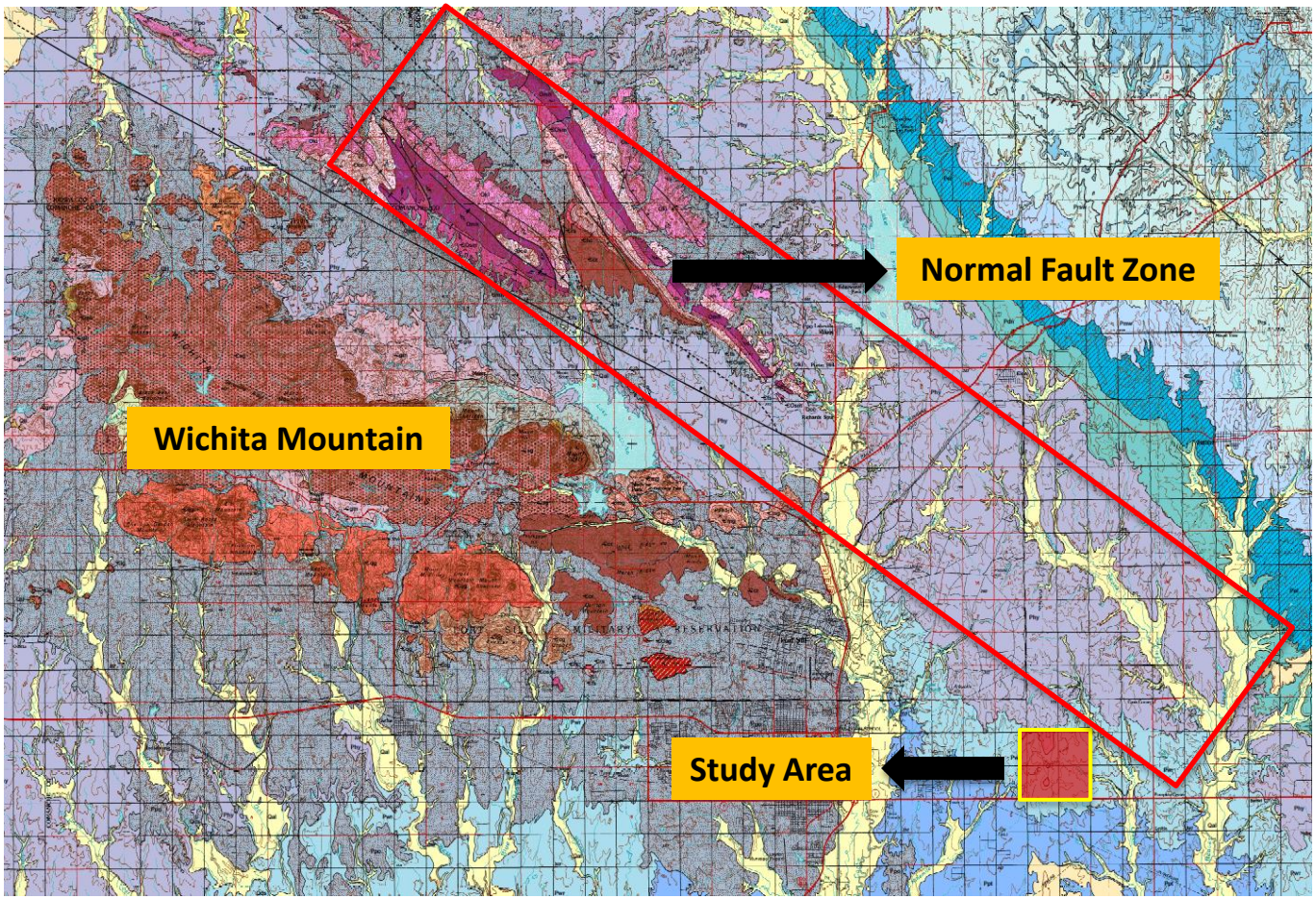
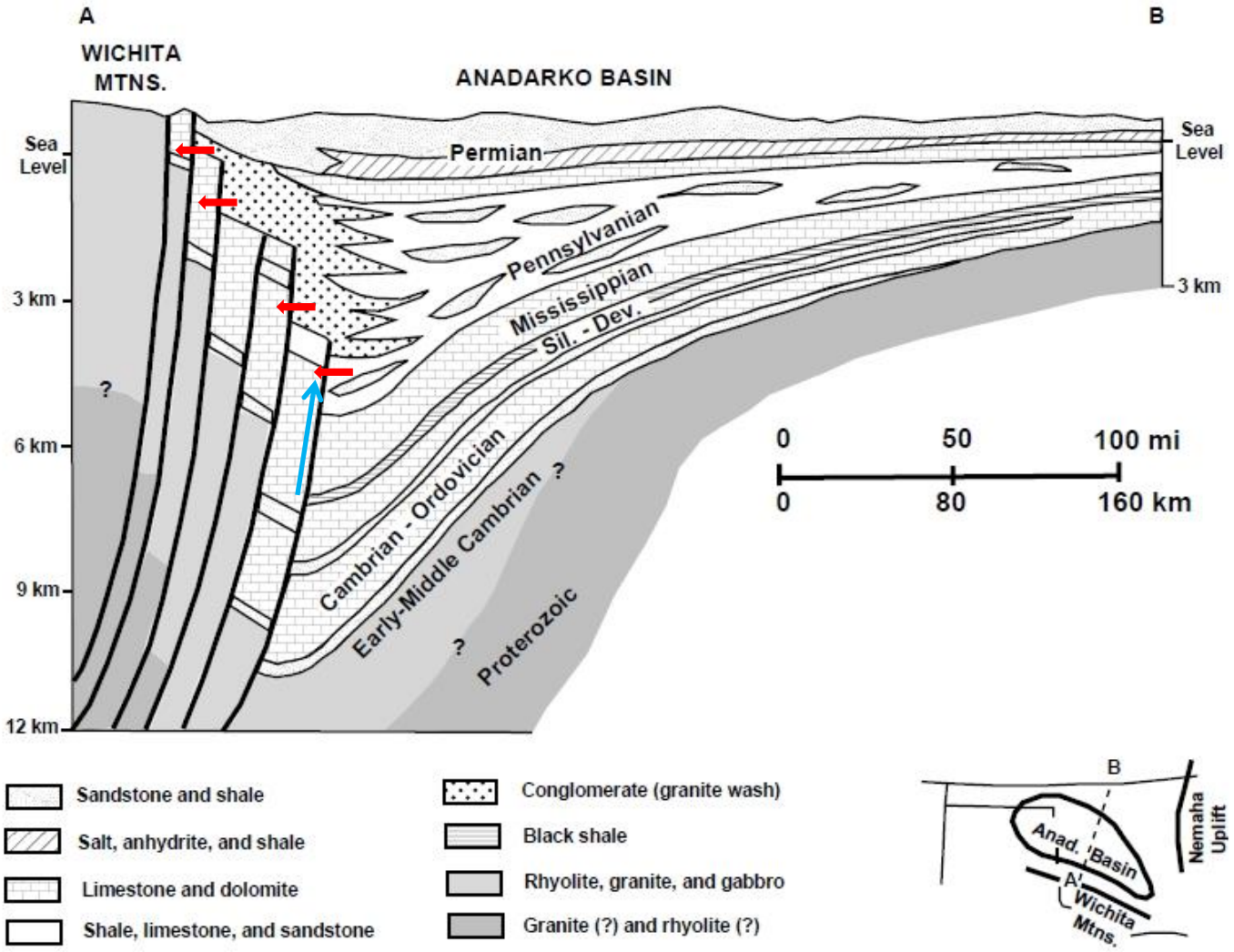
Objectives

1. The strata in this region cannot be the potential source rock. What is the source of these oils?





Objectives



Simplified cross section of the Anadarko basin (Johnson, 1989)

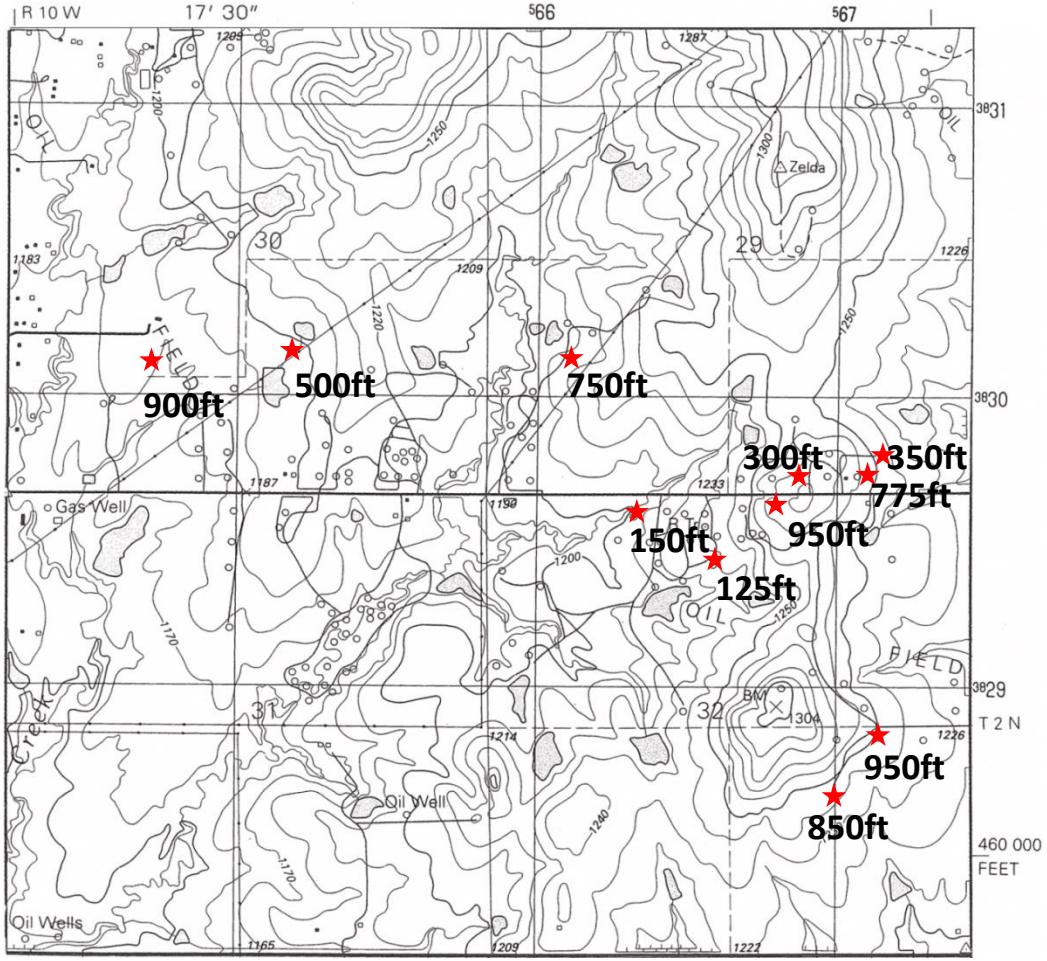
Objectives

1. The strata in this region cannot be the potential source rock. What is the source of these oils?

2. All the oil samples in very shallow reservoirs shows no sign of biodegradation. Why?

Fort Sill Seep

6 miles away



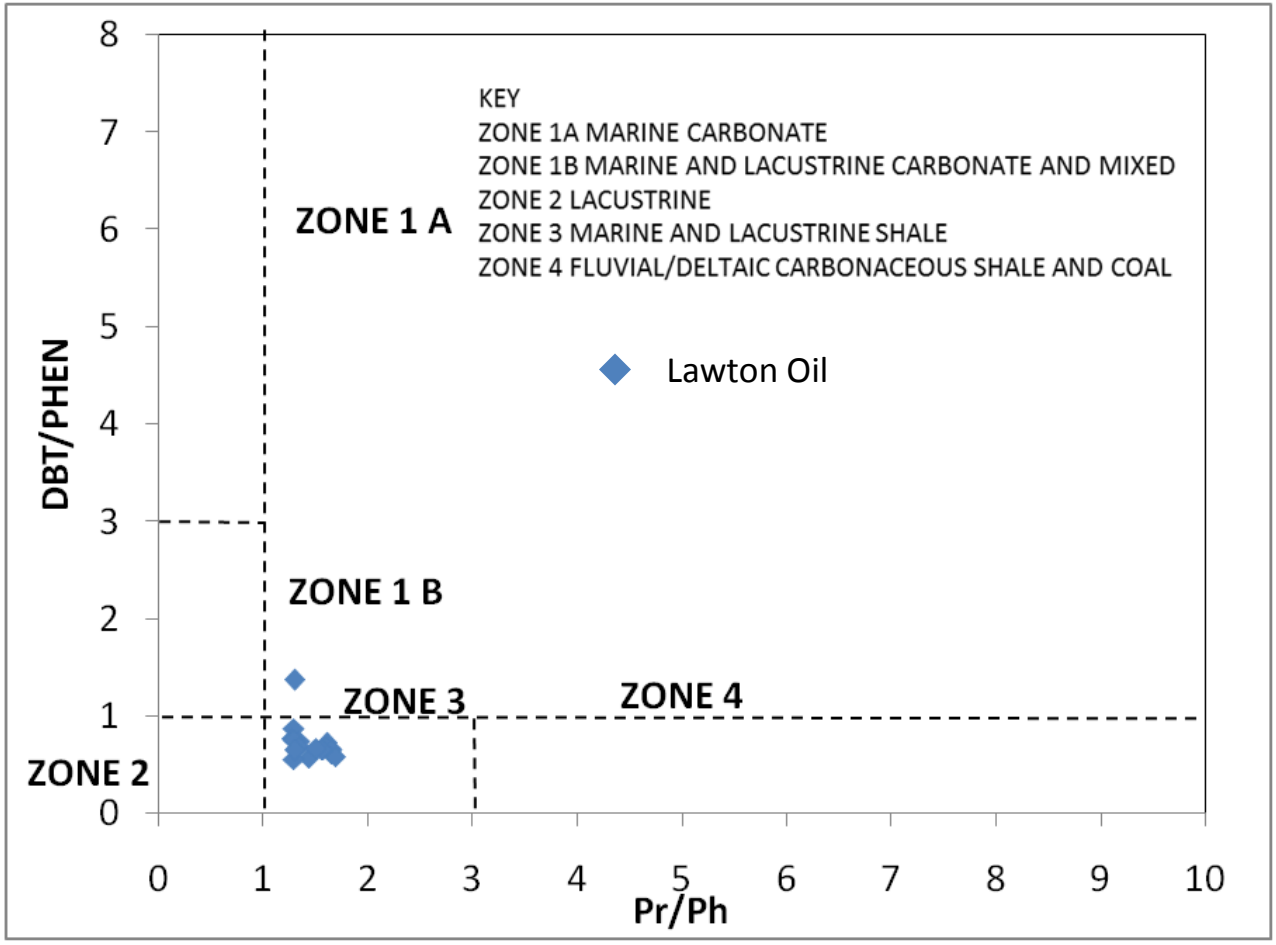
Scale : 0.5 mile

(Offered by Oklahoma Geological Survey)

3. What is the hydrocarbon accumulation and secondary alteration history?

Source of Lawton Oils

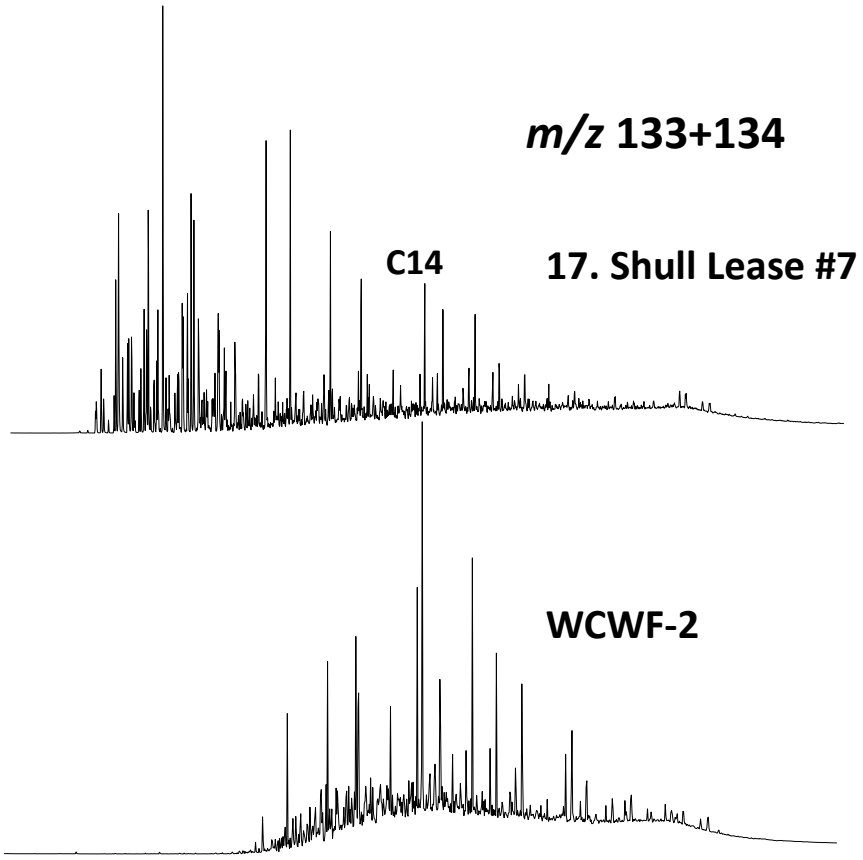
Dibenzothiophene (DBT)/Phenanthrene (PHEN) *vs* Pristane (Pr)/Phytane (Ph)



Modified after Hughes et al. (1995)

The source rock of Lawton oils should be marine or lacustrine shale

Source of Lawton Oils



Aryl isoprenoids

Indicate

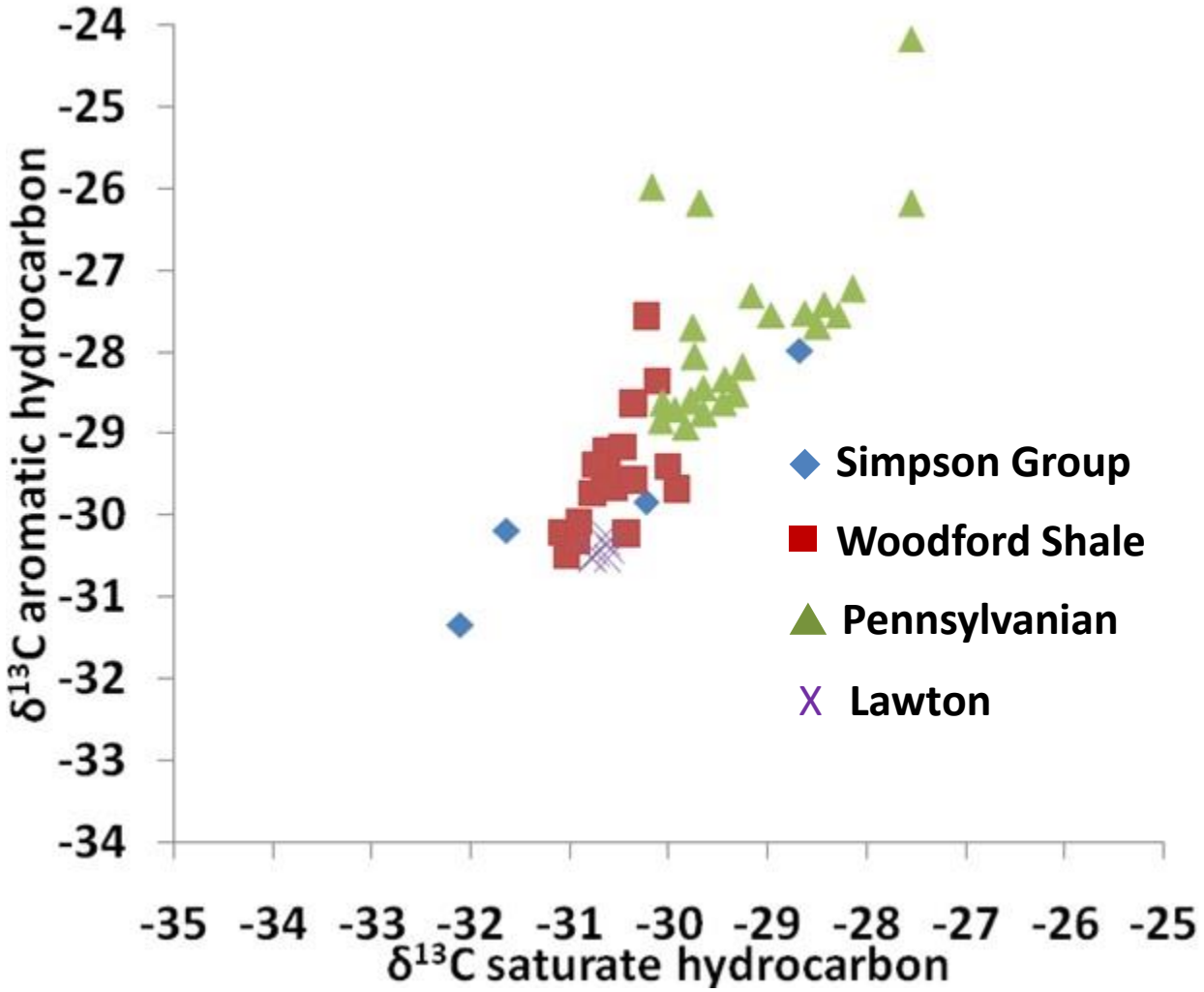
Photic zone anoxia (PZA)

C14: 2,3,6-trimethyl-substituted aryl isoprenoid

WCWF-2 data from Miceli and Philp (2012)

The source rock is deposited in the anoxic photic zone

Source of Lawton Oils

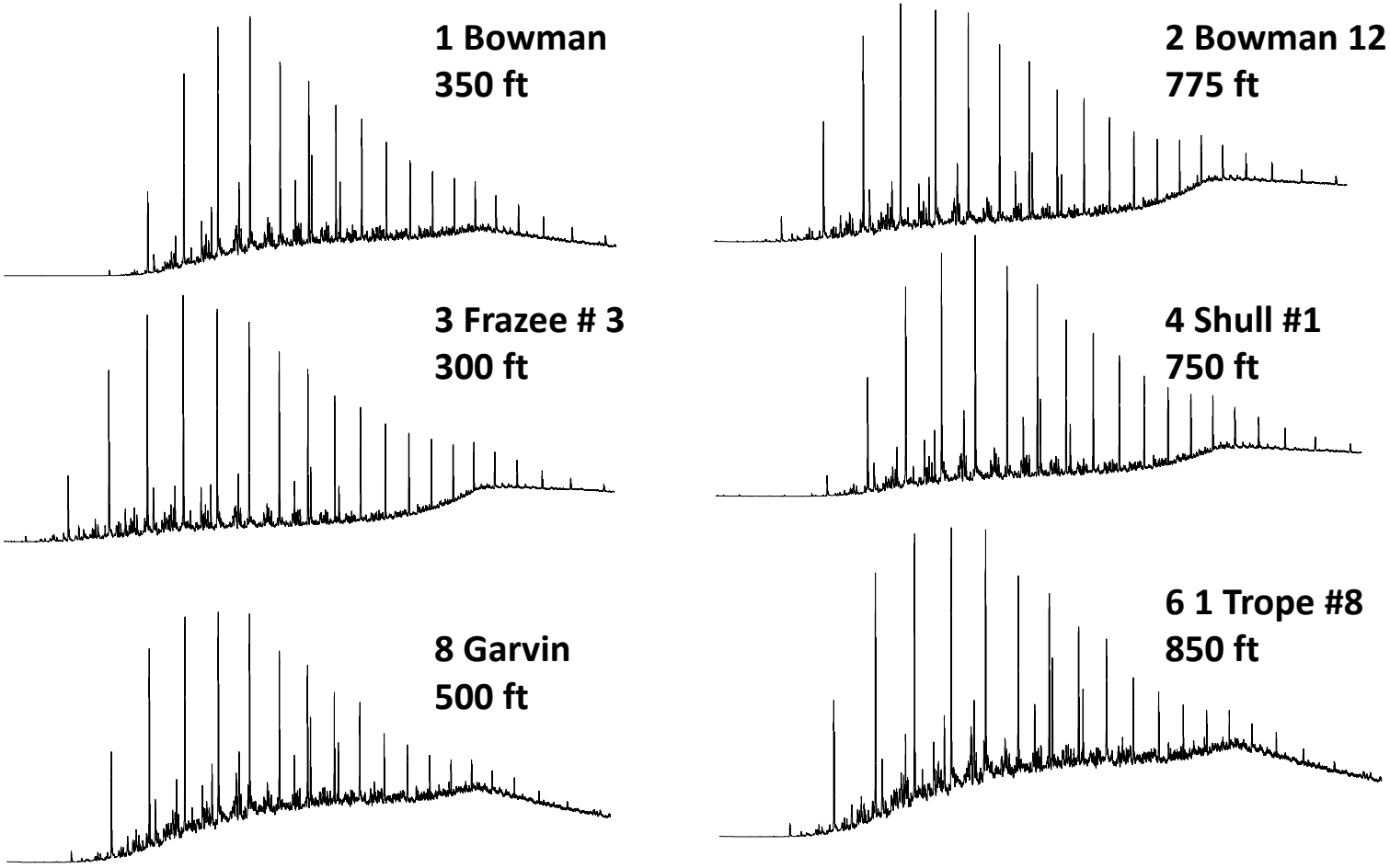


The Simpson, Woodford and Pennsylvanian data come from Burruss and Haych, 1989

The source rock of Lawton oils is probably Woodford Shale

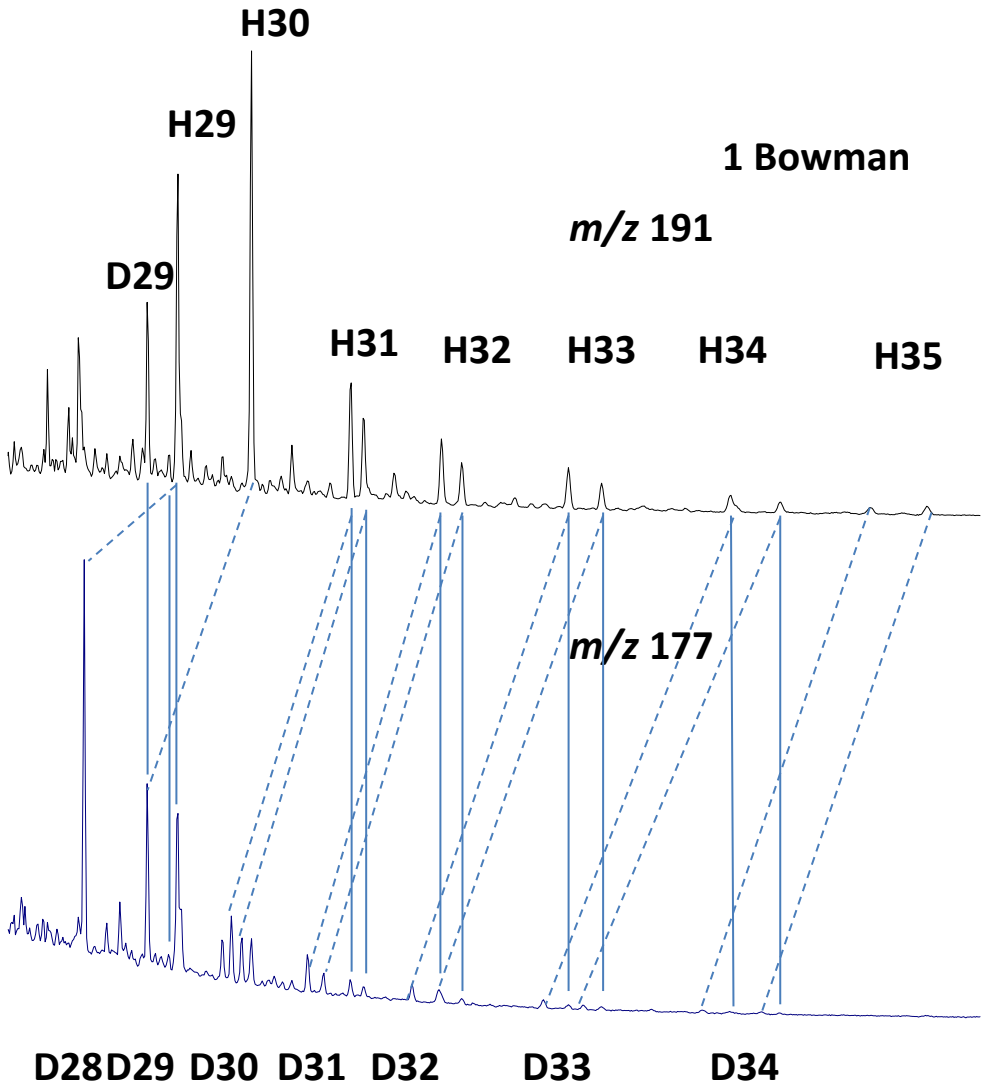
Biodegradation of Lawton Oils

Chromatograms of saturate fraction

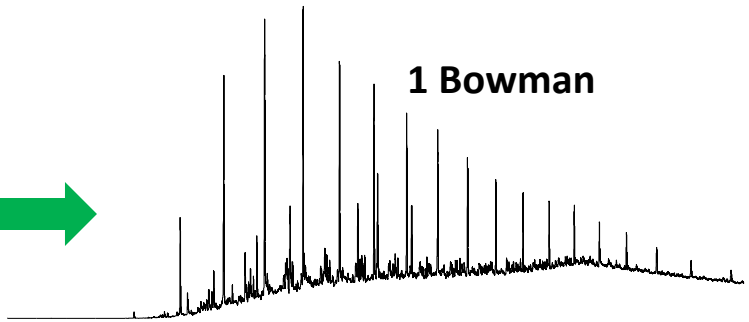


The appearance of *n*-alkanes in shallow reservoir indicates paleopasteurization

Biodegradation of Lawton Oils



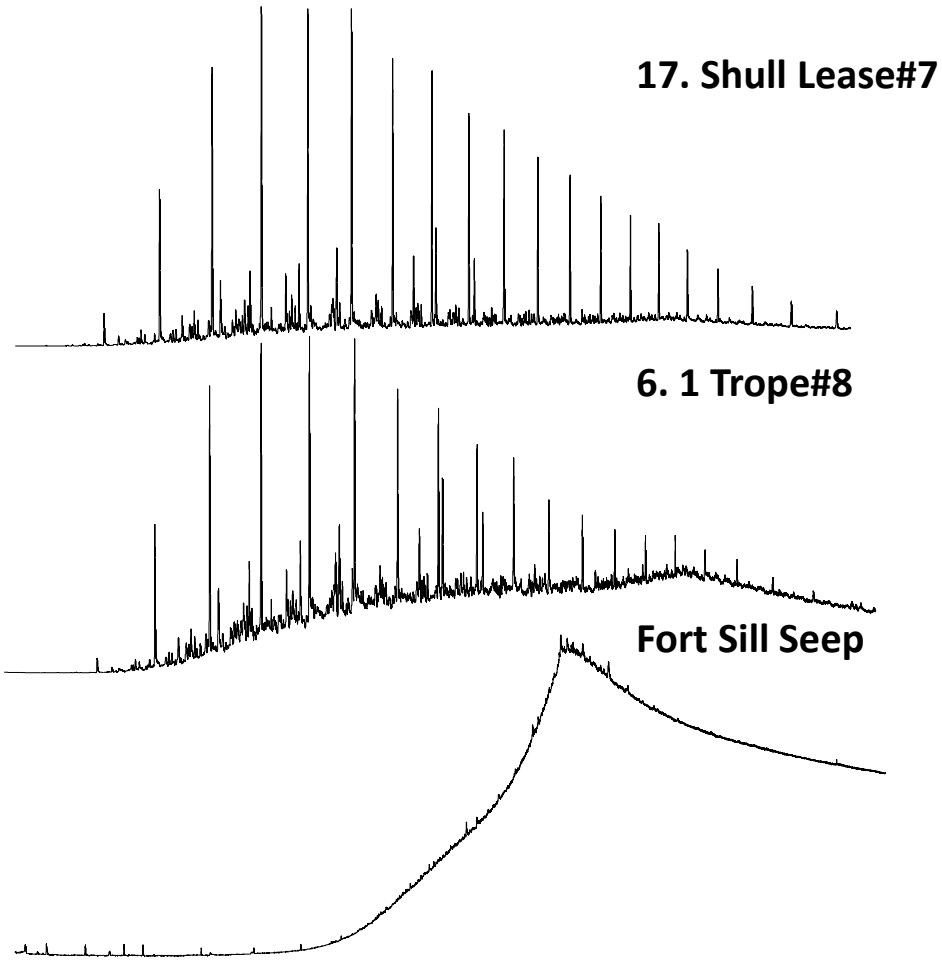
Chromatograms of saturate fraction



All oils are mixture of biodegraded and non-biodegraded oils

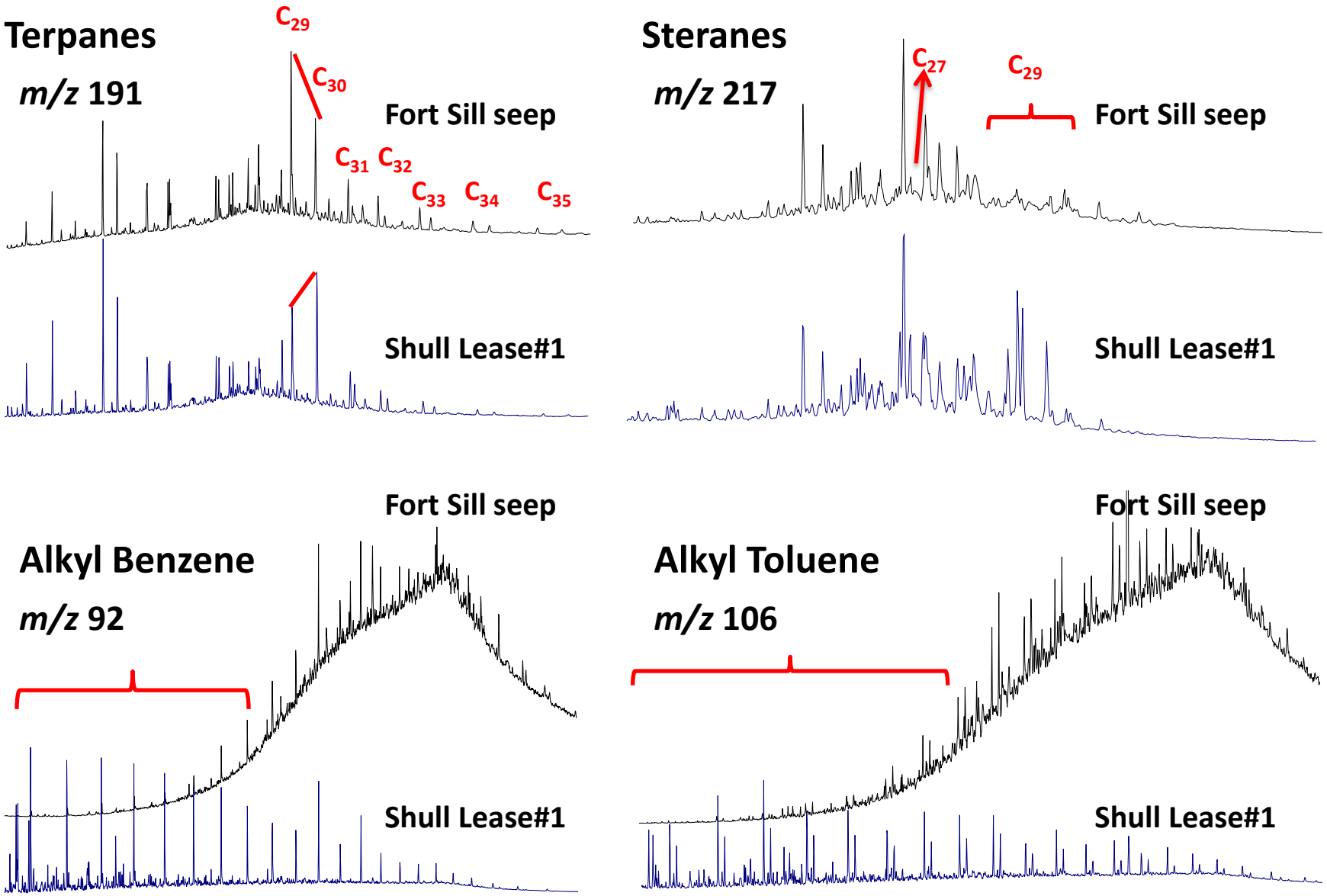
Biodegradation mechanism

Chromatograms of saturate hydrocarbon

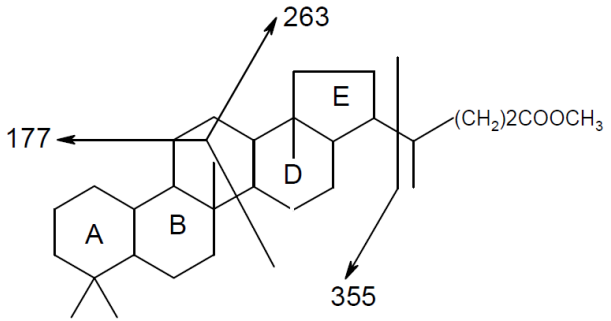


The Fort Sill seep is degraded aerobically

Biodegradation of Fort Sill seep



Aerobic Biodegradation

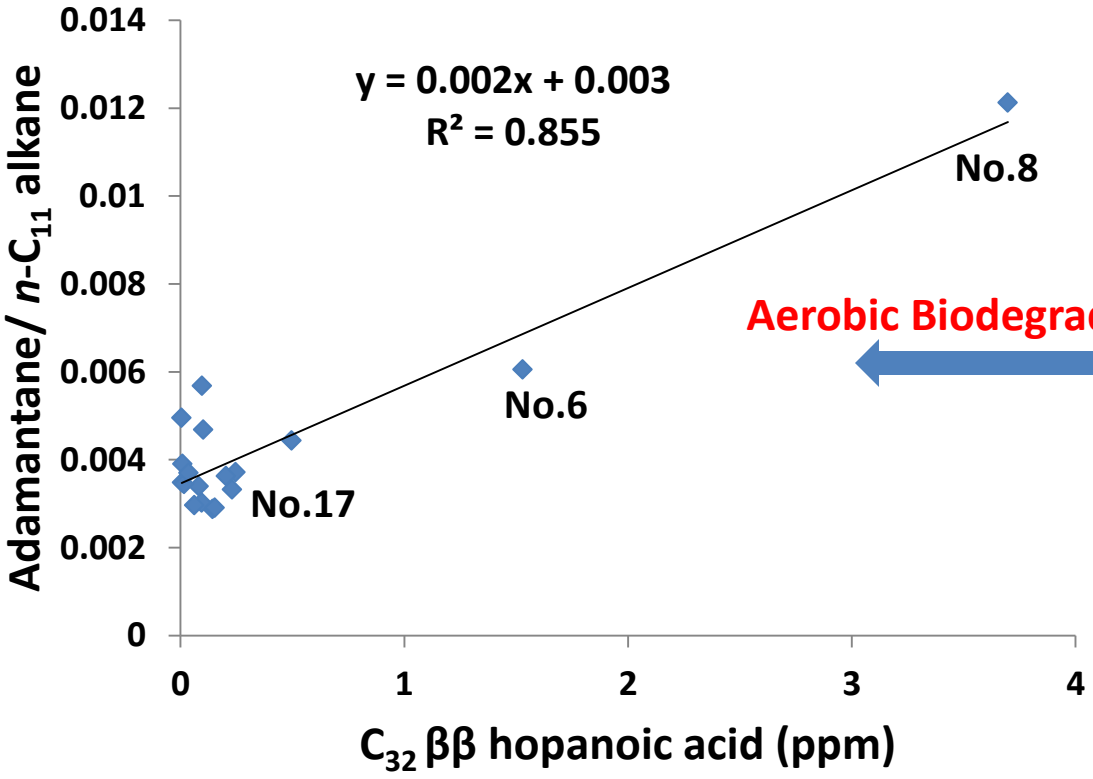


C_{31} 25-norhopanoic acid

Code	Compounds
1	C_{31} αβS HA + C_{31} αβS NHA
2	C_{31} αβR HA + C_{31} αβR NHA
3	C_{31} βαR HA + C_{31} βαR NHA
4	C_{32} αβS HA
5	C_{32} αβR HA
6	C_{32} βαS HA
7	C_{32} βαR HA
8	C_{32} ββR HA

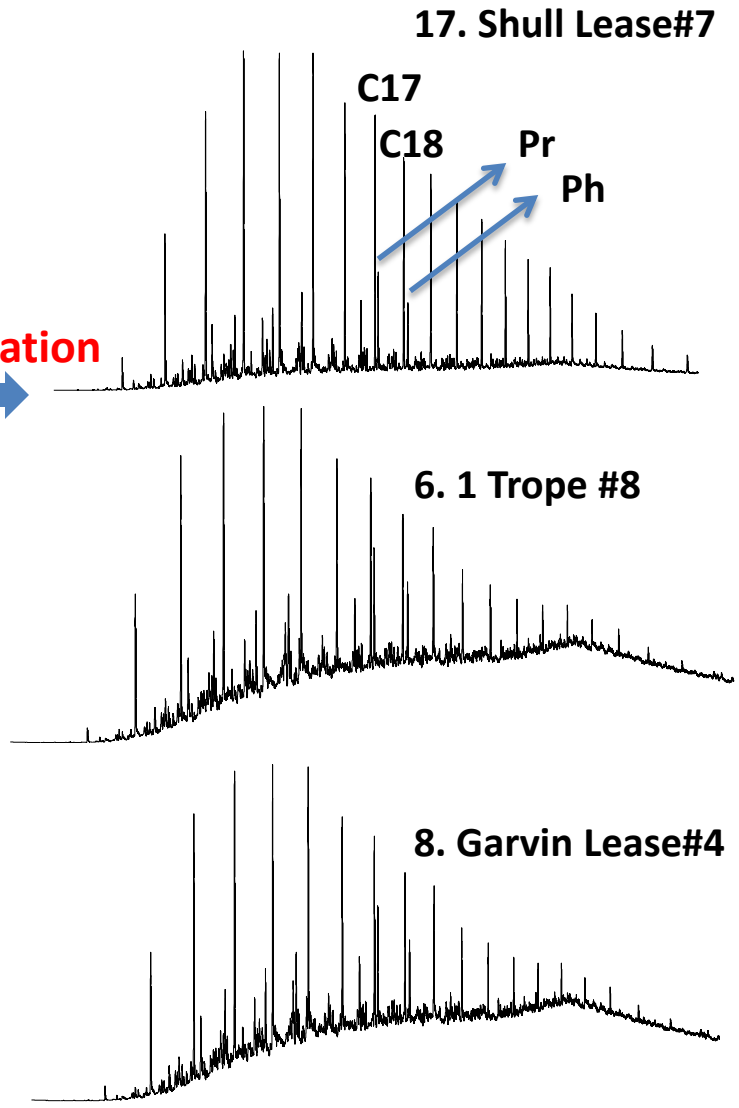
NHA: 25-norhopanoic acid
HA: hopanoic acid

Aerobic Biodegradation

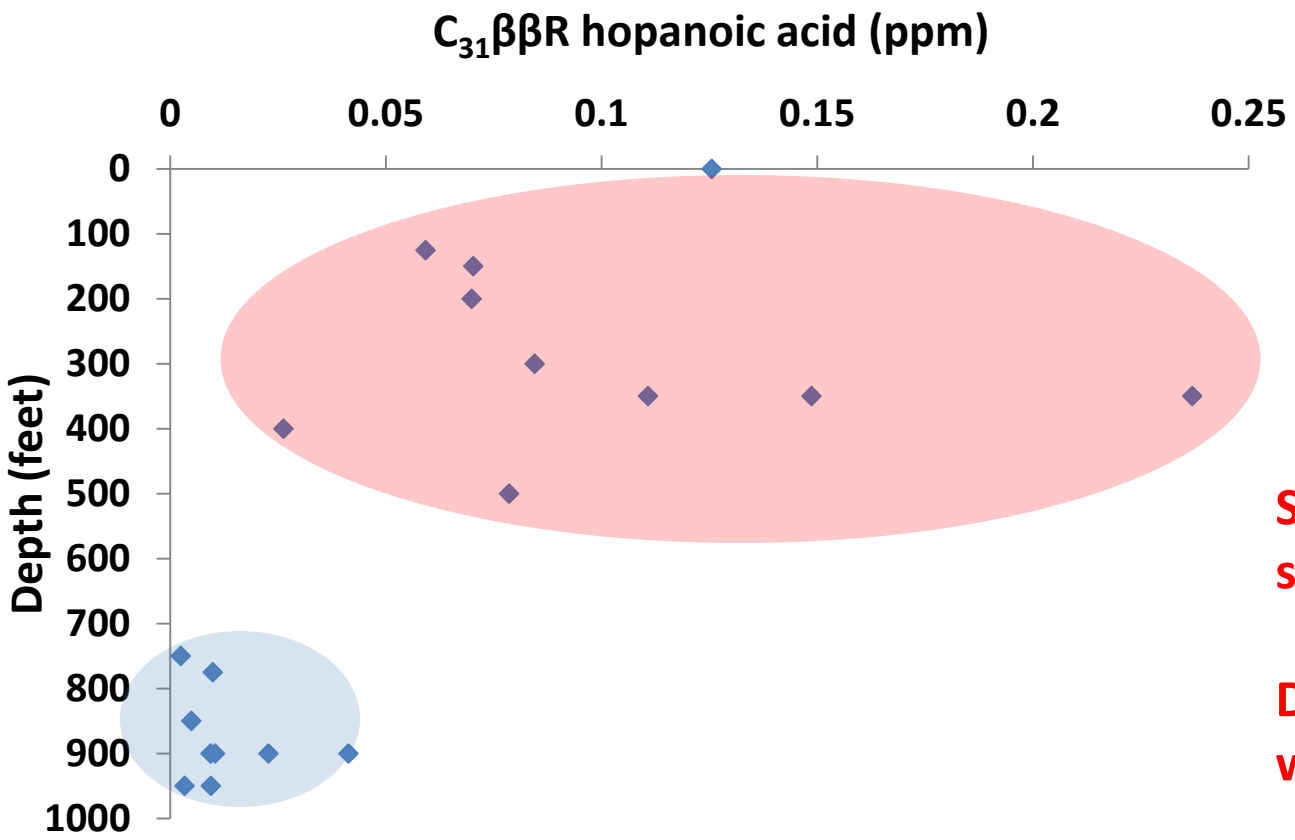


Aerobic Biodegradation

Saturate hydrocarbons



Aerobic Biodegradation

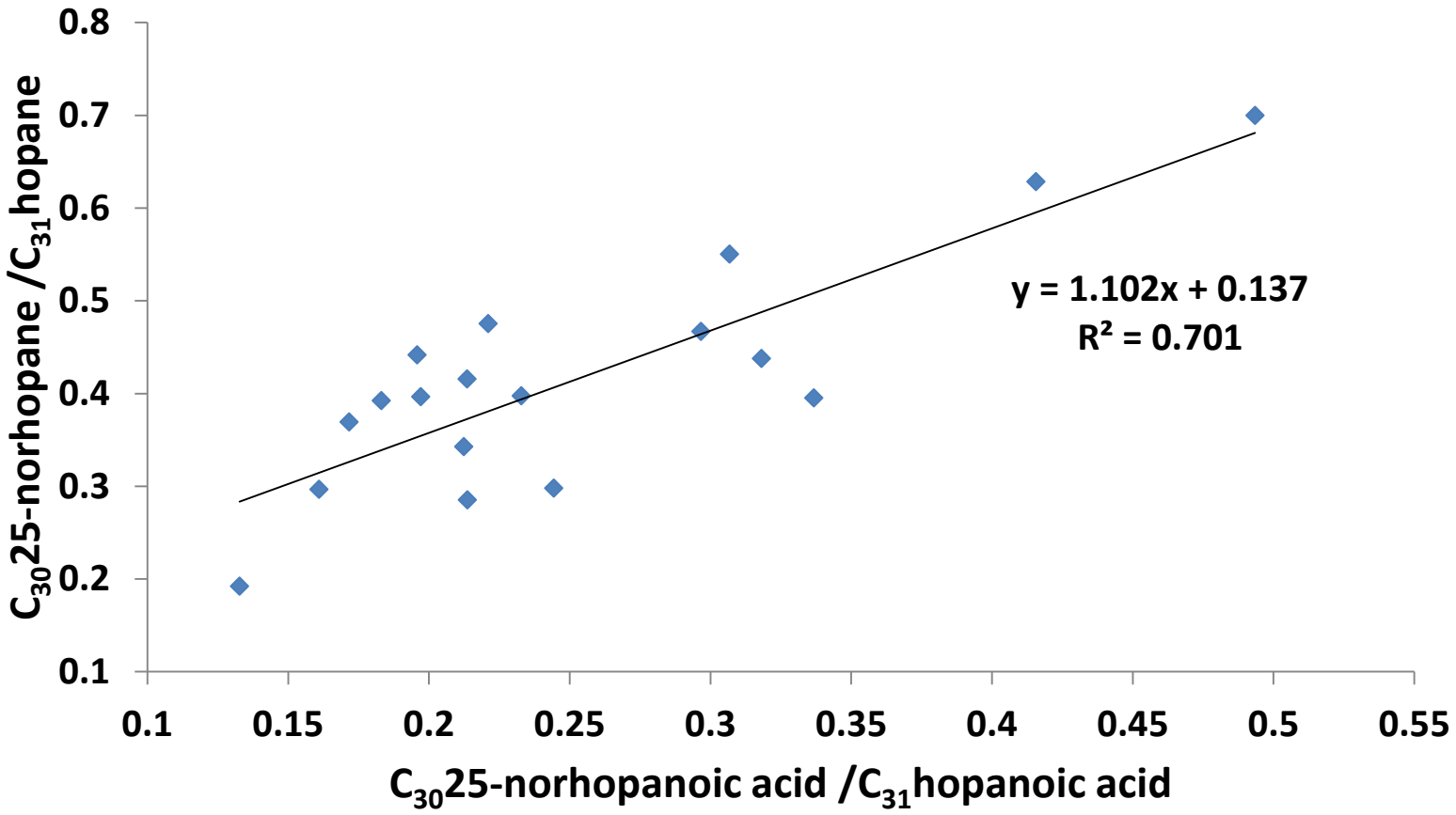


Shallow reservoir: strong bacteria activity

Deep reservoir: weak bacteria activity

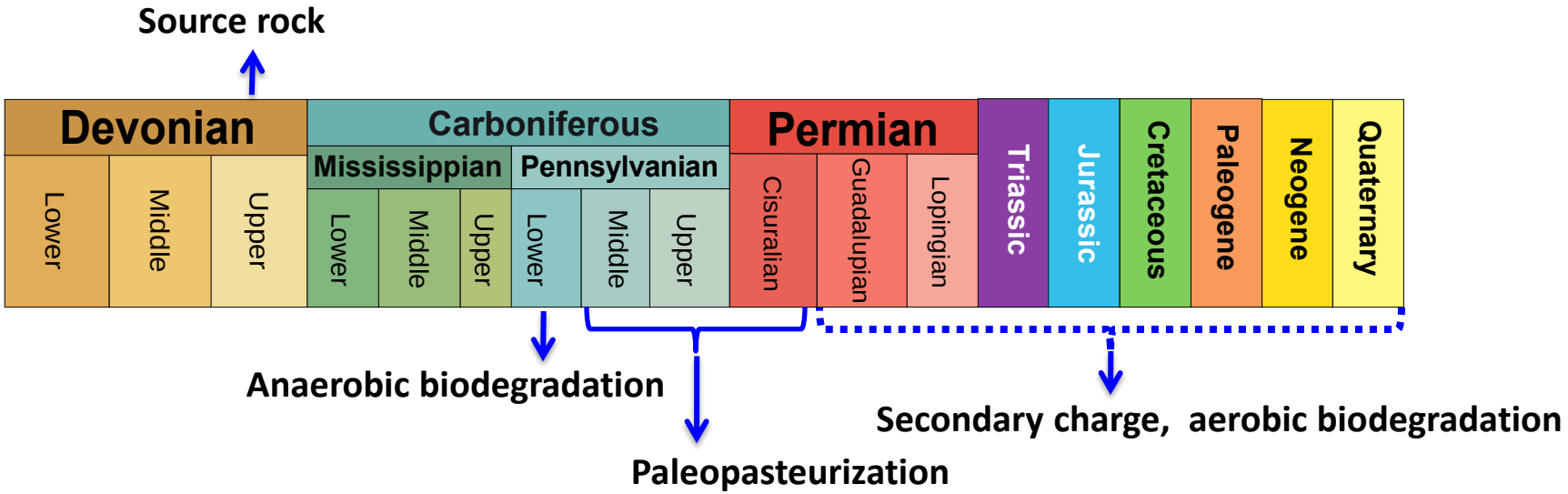
Oilfield water salinity: 18g/L
Sea water salinity: 35g/L

Anaerobic Biodegradation



Parallel demethylation in the hopanoic acids and hopanes

Conclusions



1. The source rock of oil in Lawton oilfield is probably Woodford shale.
2. The first petroleum charge was biodegraded with the formation of 25-norhopane and 25-norhopanoic acid.
3. The reservoir undertook the paleopasteurization and high reservoir temperature sterilized the reservoir.
4. The second high maturity fresh oil charged into the reservoir and probably due to the bacteria and oxygen in the groundwater, the oil was biodegraded aerobically to different extents.
5. This research on Lawton oilfield multi-stage accumulation and complex secondary alteration helps us better understand petroleum filling and alteration history.

THANK YOU!

QUESTIONS?

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