

Variability of Paleogene Source Facies of Circum- and Drifted Sundaland Basins, Western Indonesia: Constraints from Oil Biomarkers and Carbon-13 Isotopes*

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Abstract

The Tertiary basins encircling/circum-Sundaland of Western Indonesia (North Sumatra, Central Sumatra, South Sumatra, Sunda-Asri, West Java, East Java, Barito, Kutei, West Natuna, and East Natuna Basins) and its drifted parts (South Makassar Strait, West & South Sulawesi, and Bone Basins) were initially formed in the Mid- to Late Eocene mostly related to trans-tensional rifting induced by regional post-collision escape tectonics of India-Eurasia collision and/or roll-back movement resulting in back-arc opening due to slower rate of coeval subduction. Thick intervals of Paleogene sediments were deposited in infra-rift, main rift, late stage-rift, and early stage post-rift/sag phases of the basins, covering the depositional environments range from nonmarine, lacustrine, fluvio-deltaic, paralic, and marginal- to fully marine facies.

The syn-rift, late stage-rift and early stage post-rift/sag sediments are the most important hydrocarbon source rocks in the region. These rifts and their overlying early stage post-rift/sag formed active kitchens in the basins. These kitchens are almost always devoid of exploration wells causing precise interpretation of the source facies is impossible due to the absence of samples for biostratigraphic analyses. However, characteristics of the depositional environments and nature of the source rocks deposited within the kitchens can be assessed from a detailed examination of biomarkers and carbon isotopes of oils generated. On this basis, interpretation of variation of the Paleogene source facies of circum- and drifted Sundaland basins is presented.

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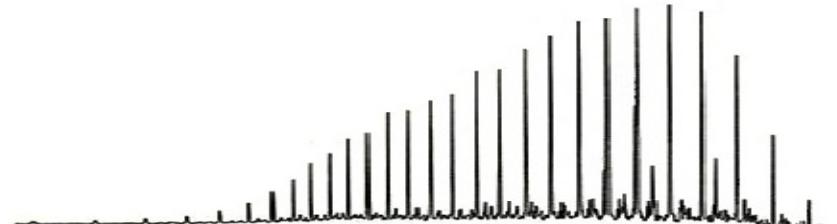


Variability of Paleogene Source Facies of Circum- and Drifted Sundaland Basins, Western Indonesia: Constraints from Oil Biomarkers and Carbon-13 Isotopes



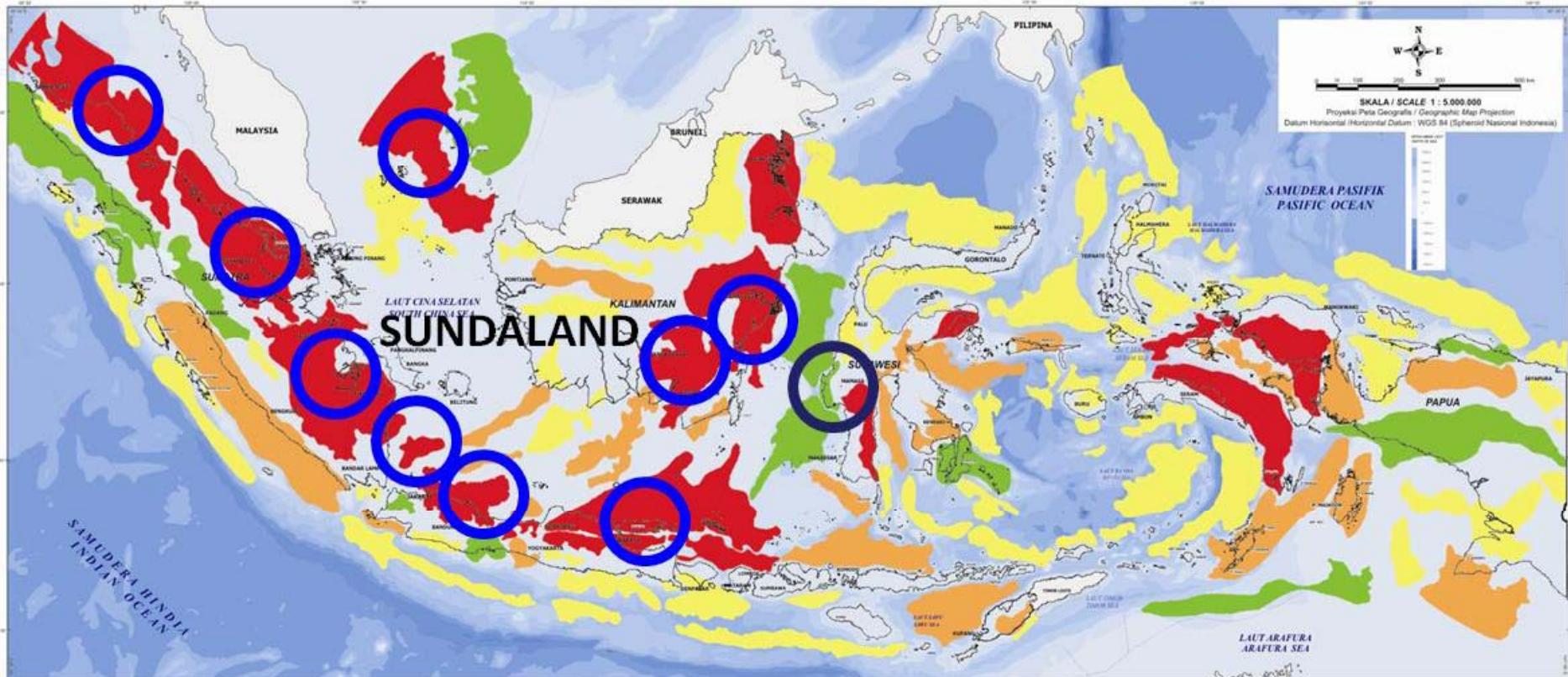
Awang H. Satyana (BPMIGAS)

Margaretha E.M. Purwaningsih (ConocoPhillips Indonesia)



SEDIMENTARY BASIN MAP OF INDONESIA BASED ON GRAVITY AND GEOLOGICAL DATA

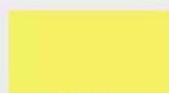
Diterbitkan oleh / Published by :
**BADAN GEologi
GEOLOGICAL AGENCY**
2010



 PRODUCING BASIN

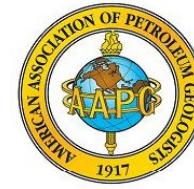
 DRILLED BASIN, DISCOVERY

 DRILLED BASIN, NO DISCOVERY

 UNDRILLED BASIN

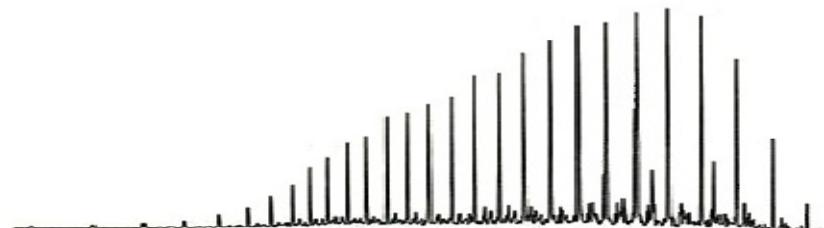
 basin discussed, circum-Sundaland

 basin discussed, drifted from Sundaland



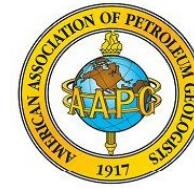
Contents

1. Introduction
2. Regional Tectonics and Stratigraphy
3. Major Source Types of Indonesia's Oils
4. Biomarkers and Carbon-13 Isotopes of Circum- and Drifted Sundaland Basins
5. Conclusions



Reasoning of the Methods

- **Biomarkers** (biological markers): (Peters & Moldowan, 1993)
 - are complex “molecular fossils” derived from once living organisms.
 - measured in both oils and source rock bitumens, therefore the two can be correlated.
 - provide information on: source- lithology, age, depositional environment, maturity, etc.
 - Provide information on: oil maturity, migration, grouping, biodegradation, etc.
- **Carbon-13 isotopes:** (Sofer, 1991)
 - showing genetic relationships between source rocks and oils and among oils.
 - to distinguish between oils derived from marine and nonmarine organic matter.



Contents

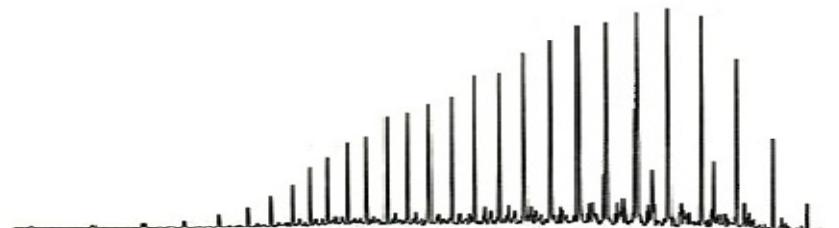
1. Introduction

2. Regional Tectonics and Stratigraphy

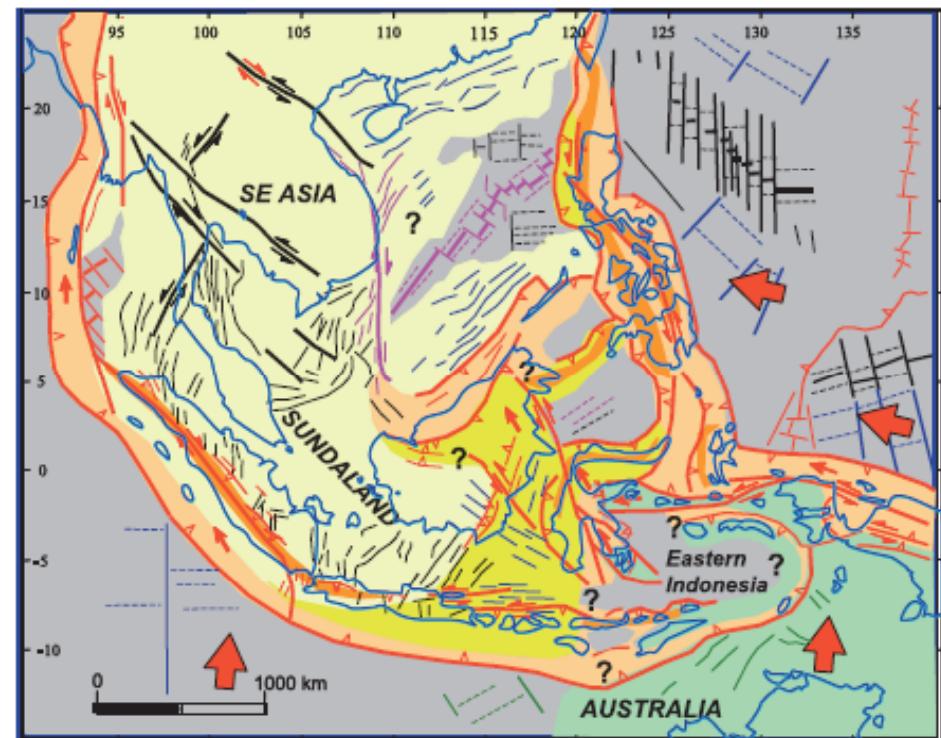
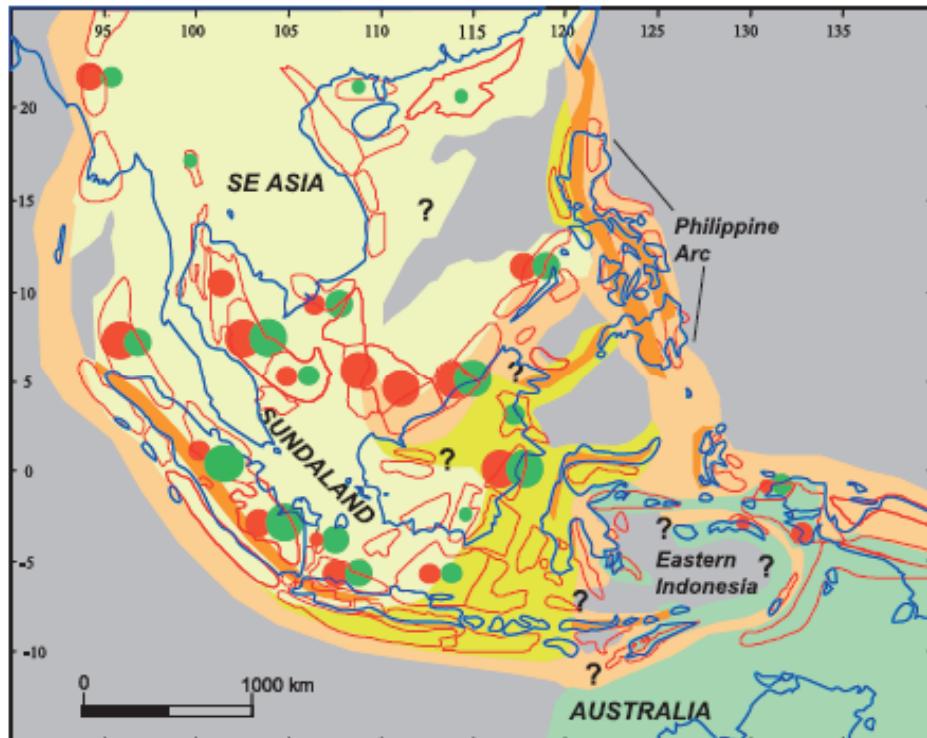
3. Major Source Types of Indonesia's Oils

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Circum- and Drifted Sundaland Basins

5. Conclusions



Major Hydrocarbon Occurrences, Tertiary Basins, Crust Types & Major Tectonic Features of Southeast Asia



Basin UR

- $> 2 \times 10^8$ BBL
- $1 - 2 \times 10^8$ BBL
- $.2 - 1 \times 10^8$ BBL
- $< .2 \times 10^8$ BBL
- $> 10 \times 10^{12}$ SCF
- $5 - 10 \times 10^{12}$ SCF
- $1 - 5 \times 10^{12}$ SCF
- $< 10^{12}$ SCF

Tertiary basins

Crust Types

- Australian
- Pre-Late K continental
- Late K accretionary
- Cenozoic accretionary
- Active volcanic arc
- Oceanic

Structures

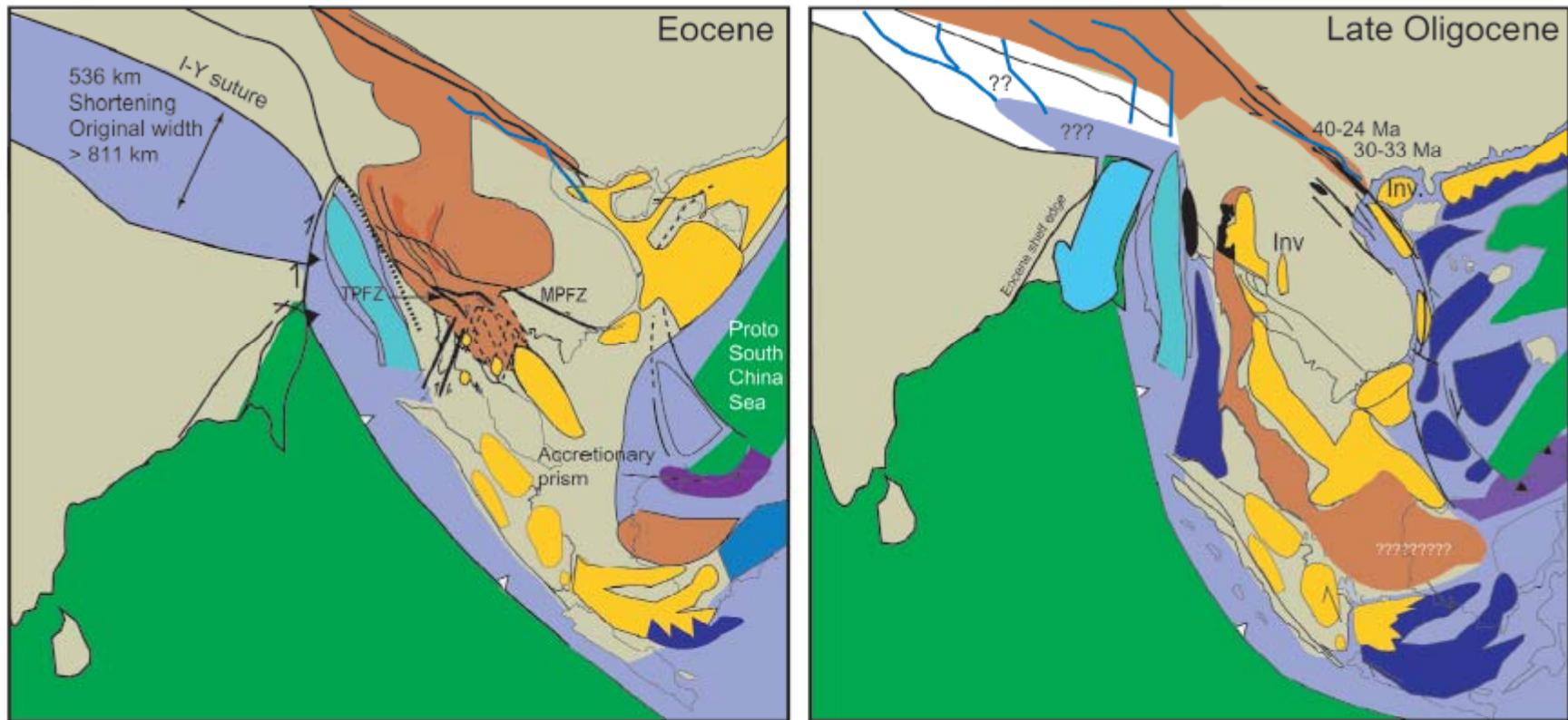
- ↗ Subduction, Thrust
- ↖ Major shear zone
- ↔ Spreading centre
- Magnetic anomalies
- Extensional faults

Major plate motions

Age of structures

- Middle Miocene to Recent
- Early Miocene
- Late Eocene to Oligocene
- Late K to Eocene
- Jurassic to Early K

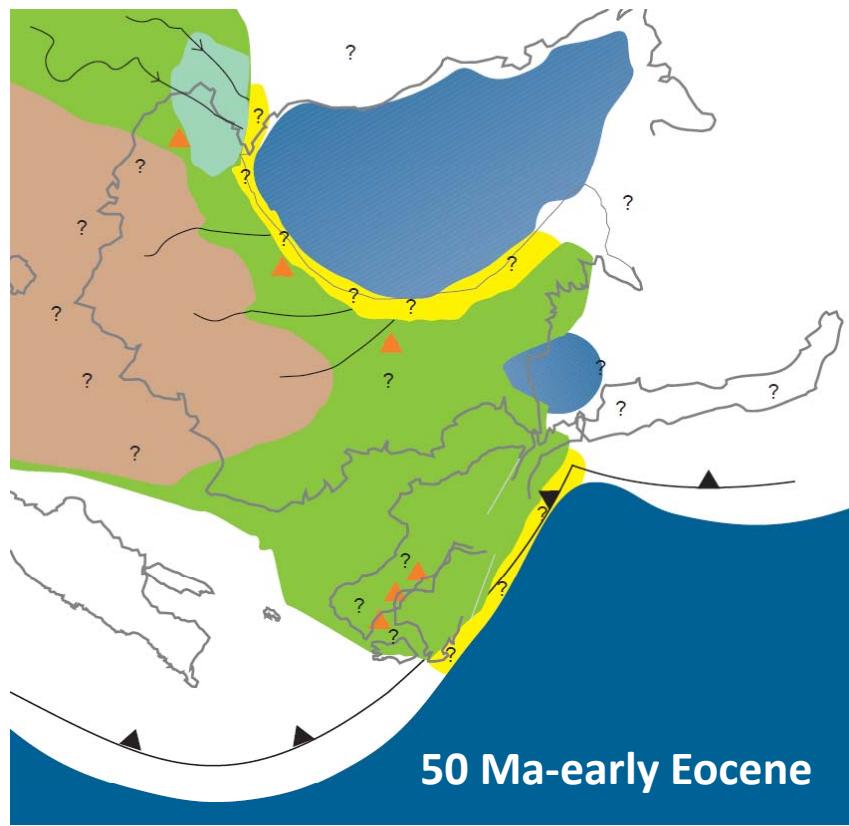
Doust & Summer (2007)



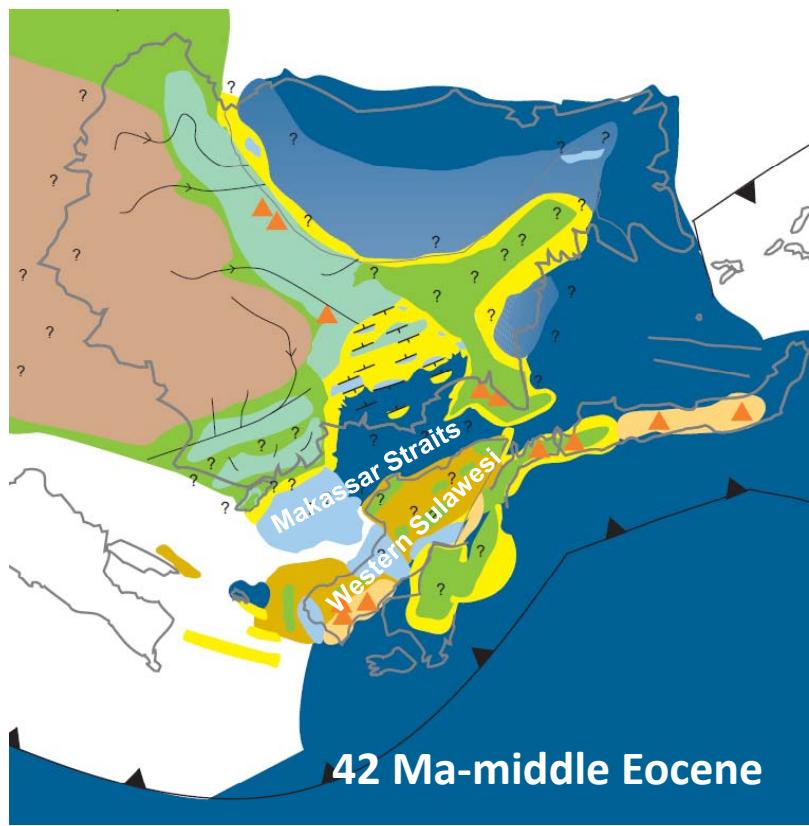
- [Orange square] Area of active uplift
- [Light blue square] Flexural basins accumulating predominantly thrust belt erosional debris
- [Yellow square] Post-rift basin with predominantly continental fill
- [Dark blue square] Post-rift basin with predominantly marine fill
- [Medium blue square] Continental rift with predominantly marine fill
- [Purple square] Shallow marine seas over mostly continental crust
- [Light green square] Emergent continental area (approximate)
- [Dark green square] Oceanic crust
- [Black oval] Metamorphic core complex
- [Blue line] One or more episodes of inversion during time period
- [Blue line with arrow] Inv
- [Blue line with diagonal line] Possible main drainage routes

Reconstruction of SE Asia and Facies of Basin Fills

Hall & Morley (2004)

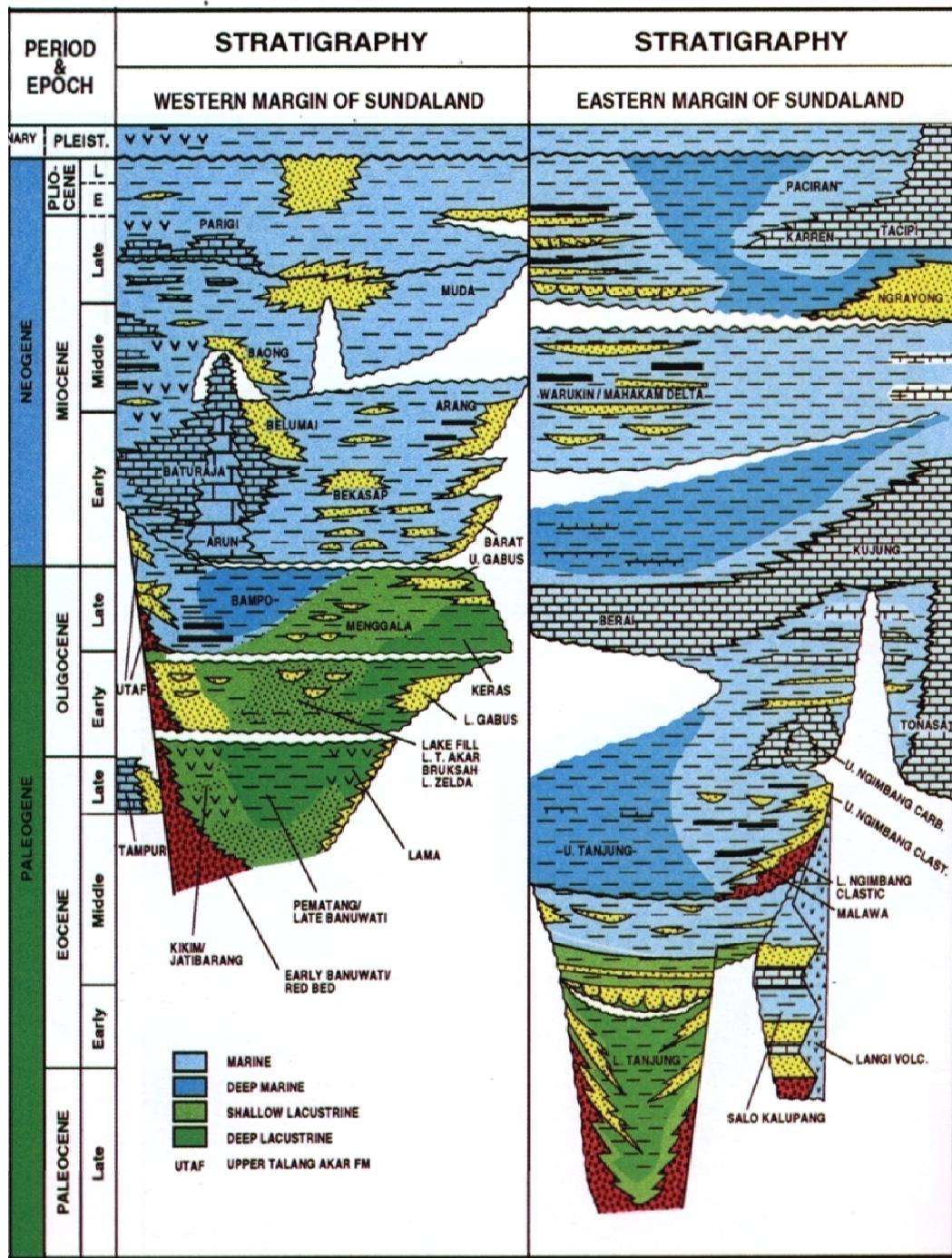


- [Brown] Emergent mountainous (left) and low-lying (right) land areas
- [Light green] Fluvial & lacustrine facies showing inferred rivers and palaeoflow direction
- [Orange/Yellow] Subaerially emergent (left) and submarine (right) volcanic & volcaniclastic lithologies
- [Light blue] Shallow-marine carbonate shelf
- [Yellow] Shallow-marine clastic shelf
- [Light orange] Marginal marine clastics (includes delta & tidal deposits) with coals (black)
- [Gold] Major deltas
- [Dark blue] Bathyal shales/marls interbedded with proximal (top) to distal (bottom) siliciclastic or carbonate redeposited lithologies
- [Dark blue] Bathyal shales and marls



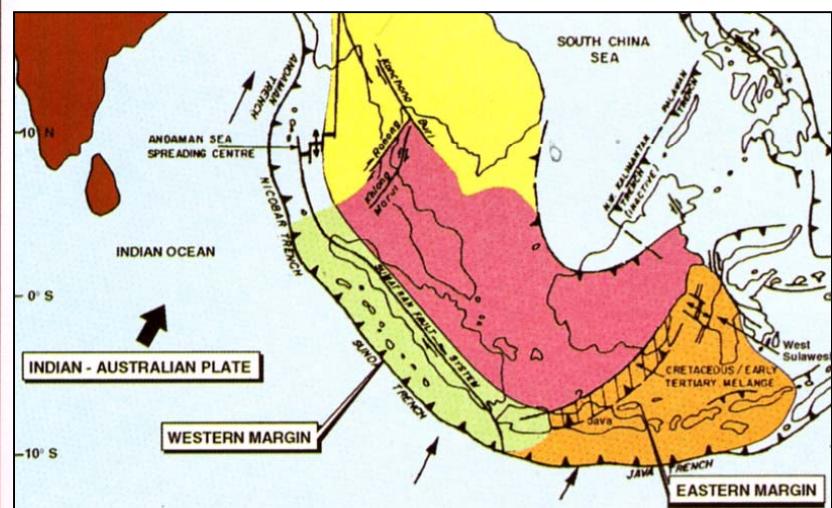
Moss and Wilson (1998)

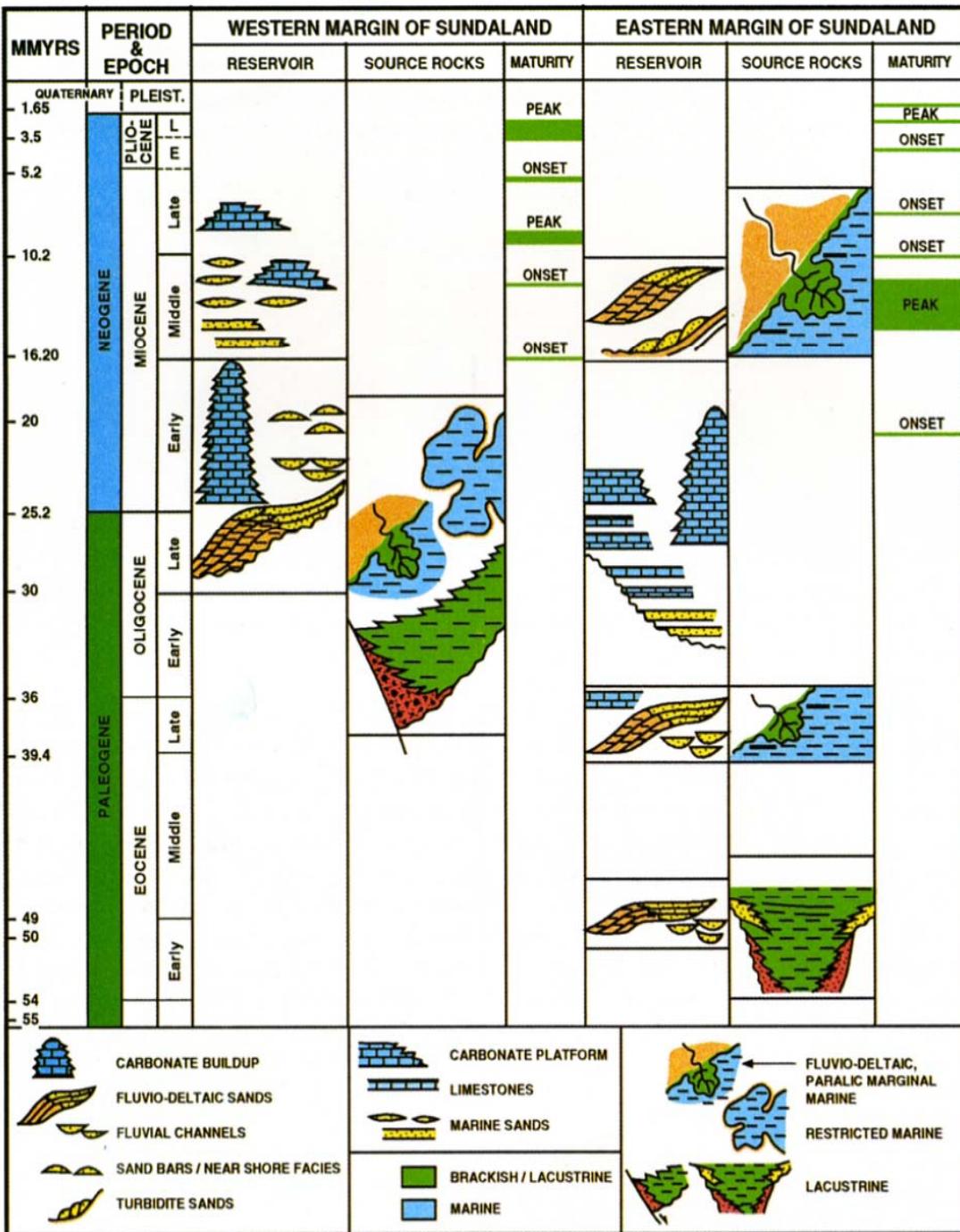
Drifted Sundaland Basins: Makassar Straits and Western Sulawesi



Comparative Stratigraphy of Western and Eastern Margins of Sundaland

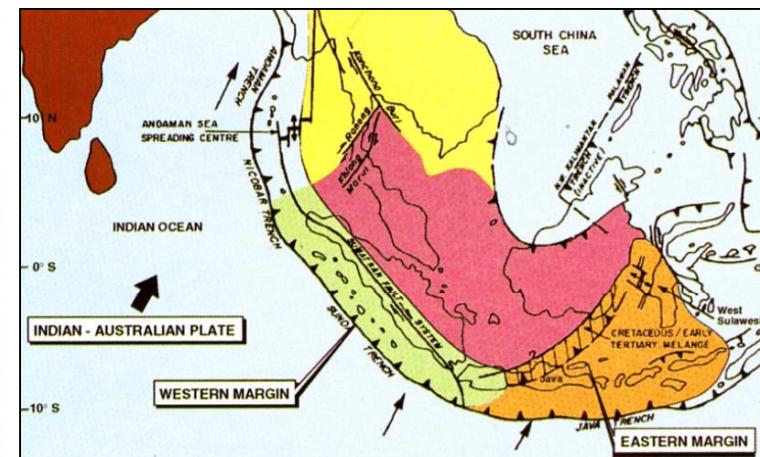
Sudarmono et al. (1997)

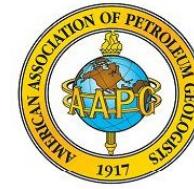




Major Petroleum Stratigraphy of the Western and Eastern Margin of Sundaland

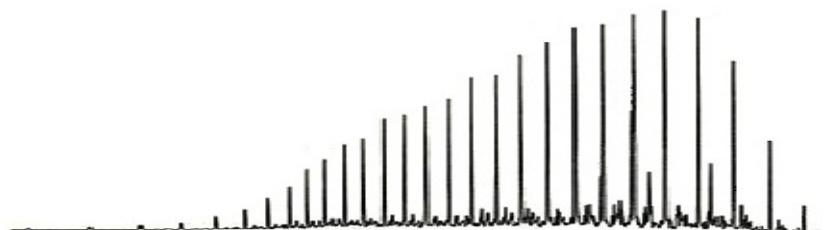
Sudarmono et al. (1997)



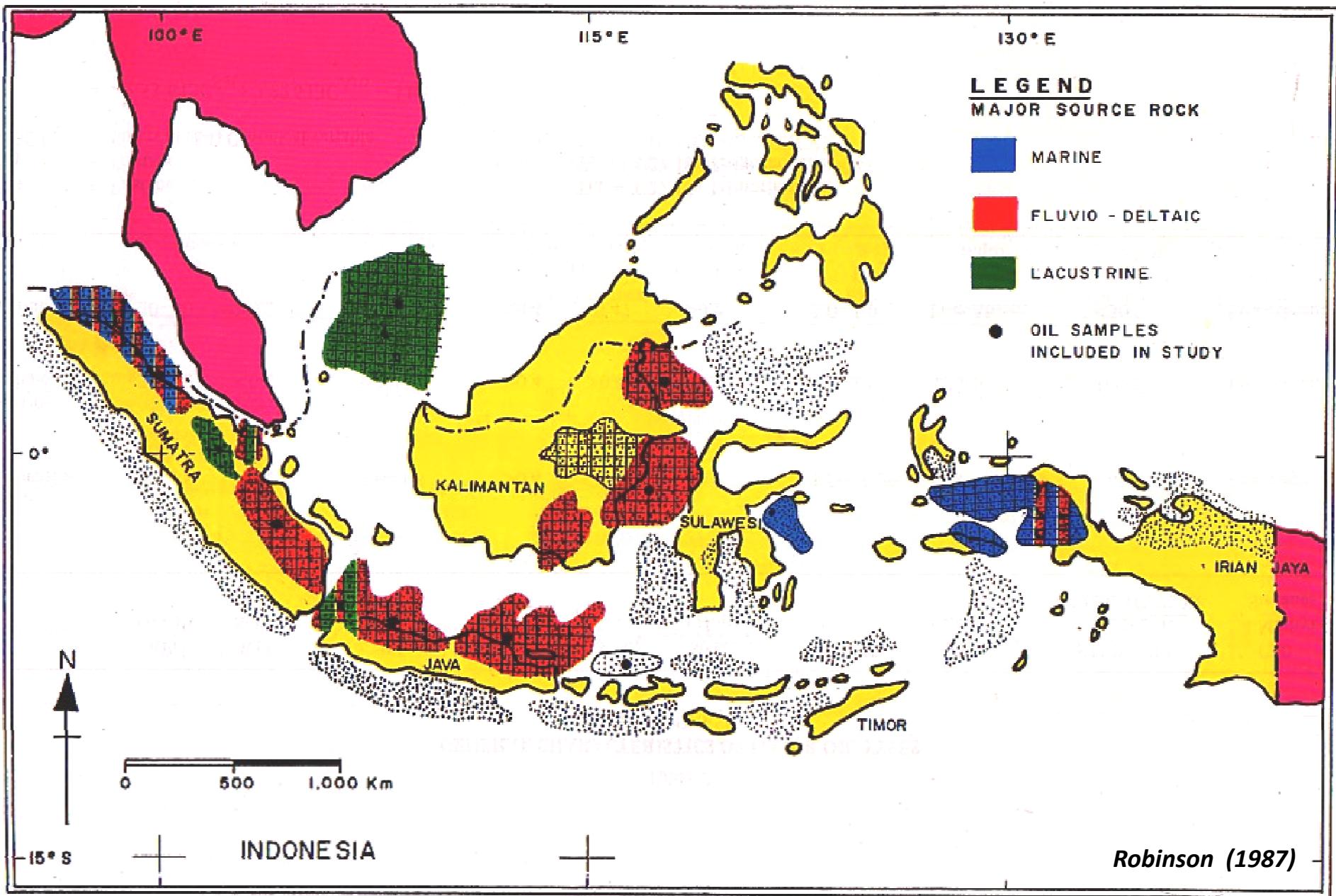


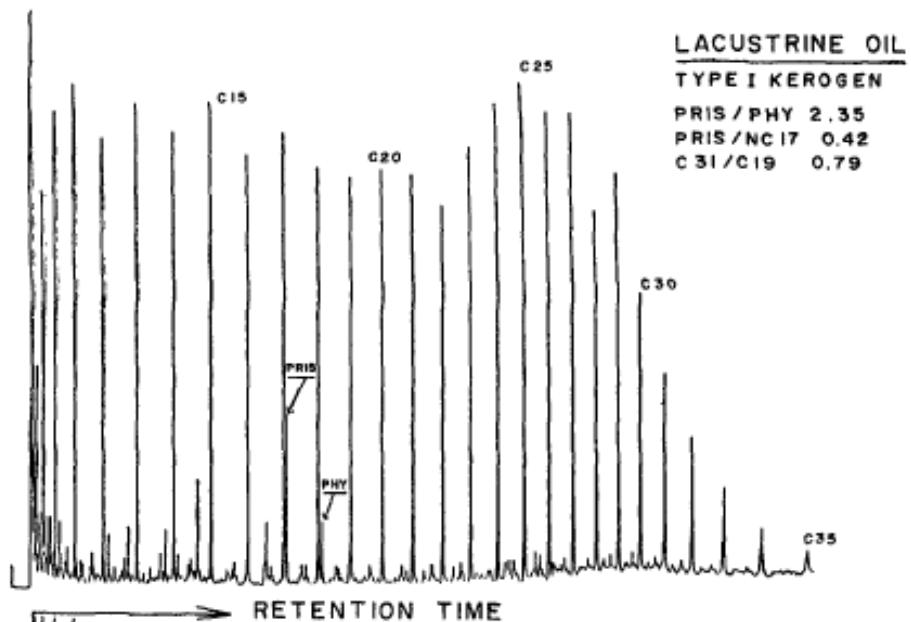
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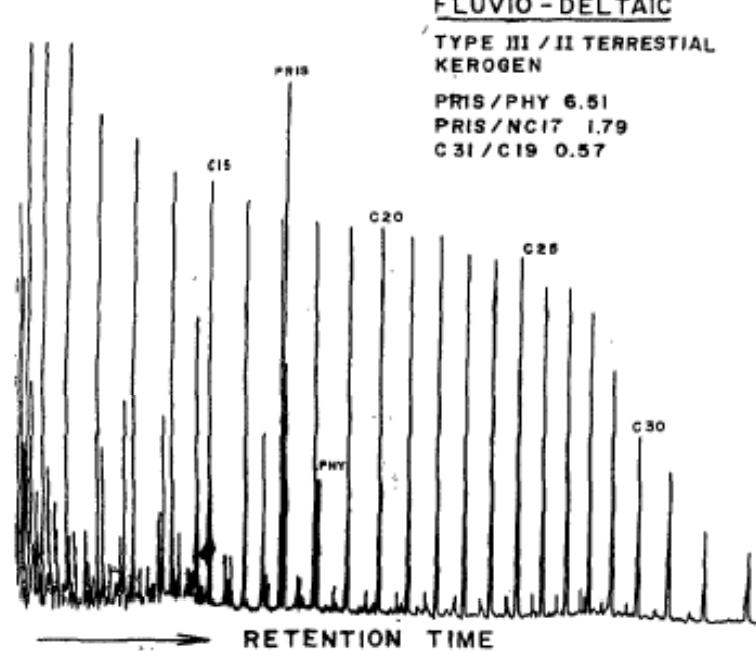
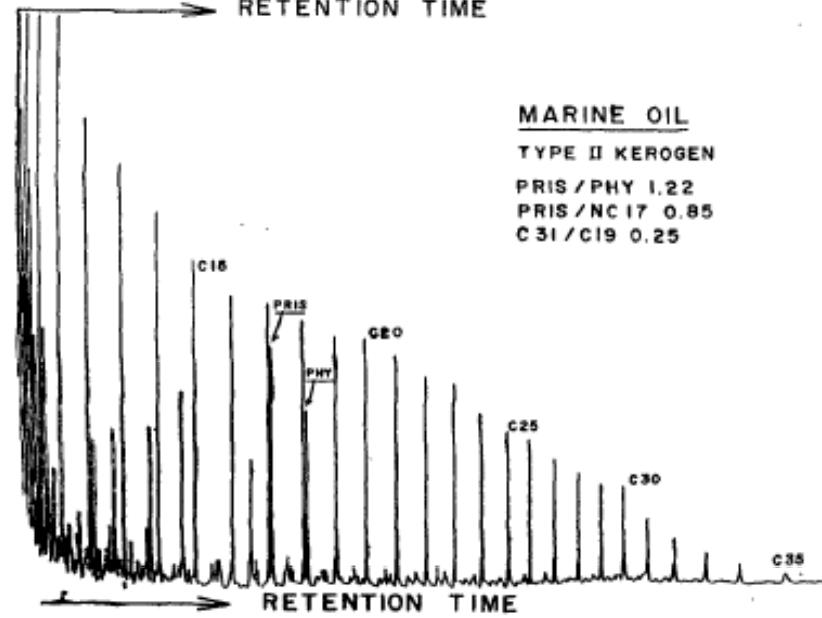


Major Source Rock Types in Productive Basins of Indonesia



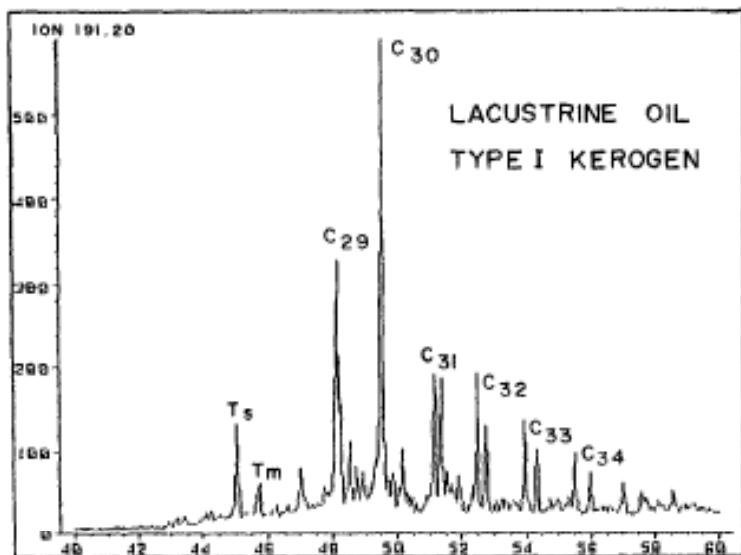


GAS CHROMATOGRAMS
C₁₀+ SATURATED HYDROCARBON FRACTION



Crude Oil Types of Indonesia

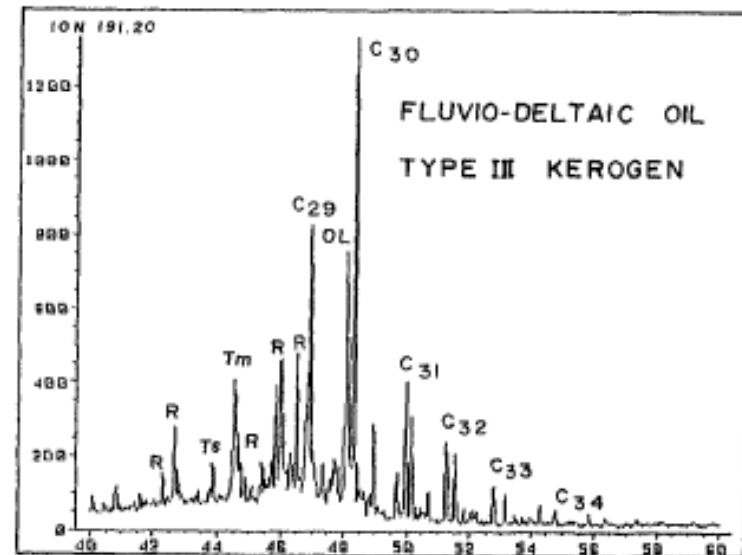
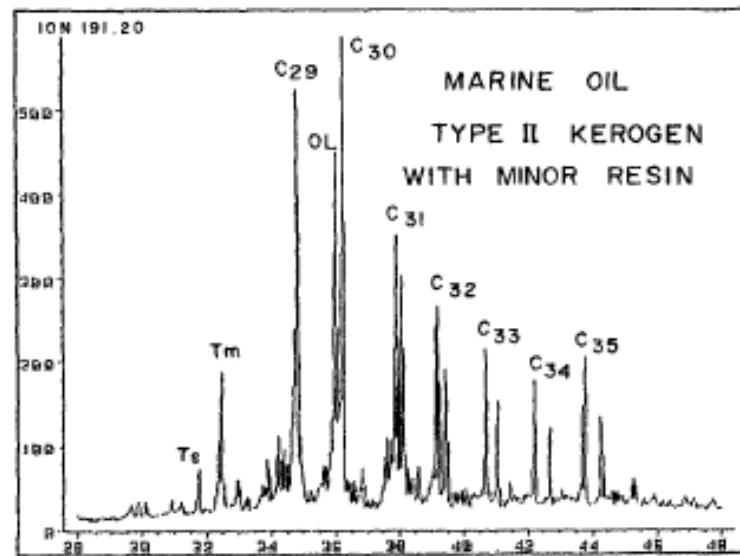
Robinson (1987)



TRITERPANES M/Z 191

LEGEND

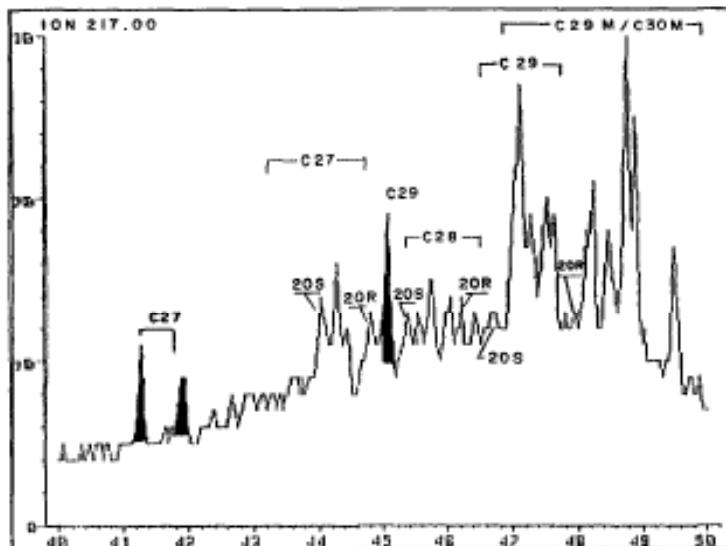
- C₂₉ = HOPANES
- T_s = C₂₇ 18 α HOPANE
- T_m = C₂₇ 17 α HOPANE
- OL = 18 α OLEANANE
- R = C₃₀ RESIN DERIVED CYCLIC ALKANE



Crude Oil Types of Indonesia

Robinson (1987)

LACUSTRINE OIL
TYPE I KEROGEN

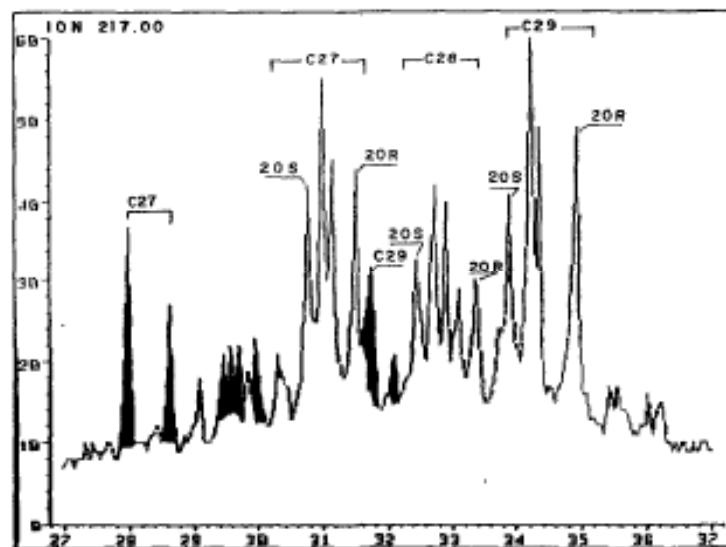


STERANES M/Z 217

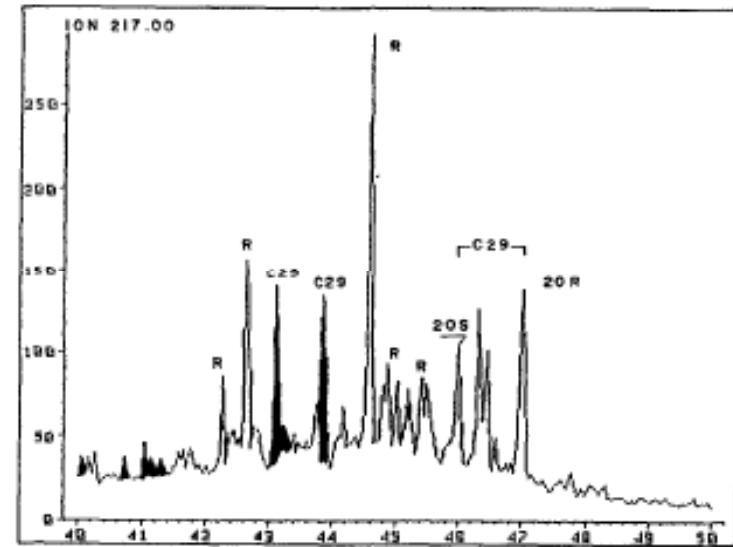
LEGEND

- C27 = REGULAR STERANES
- C29 M/C30M = 4-METHYL STERANES
- R = C30 RESIN DERIVED CYCLIC ALKANES
- C27 ■ = DIASTERANES

MARINE OIL
TYPE II KEROGEN



FLUVIO-DELTAIC OIL
TYPE III KEROGEN



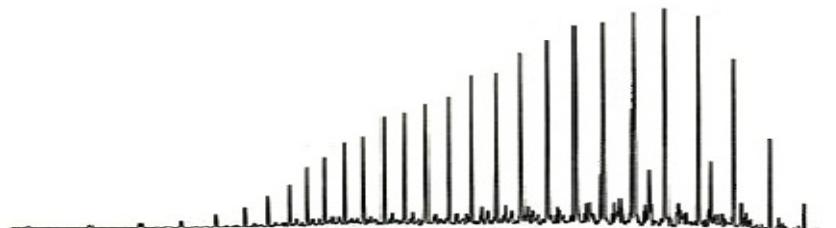
Crude Oil Types of Indonesia

Robinson (1987)

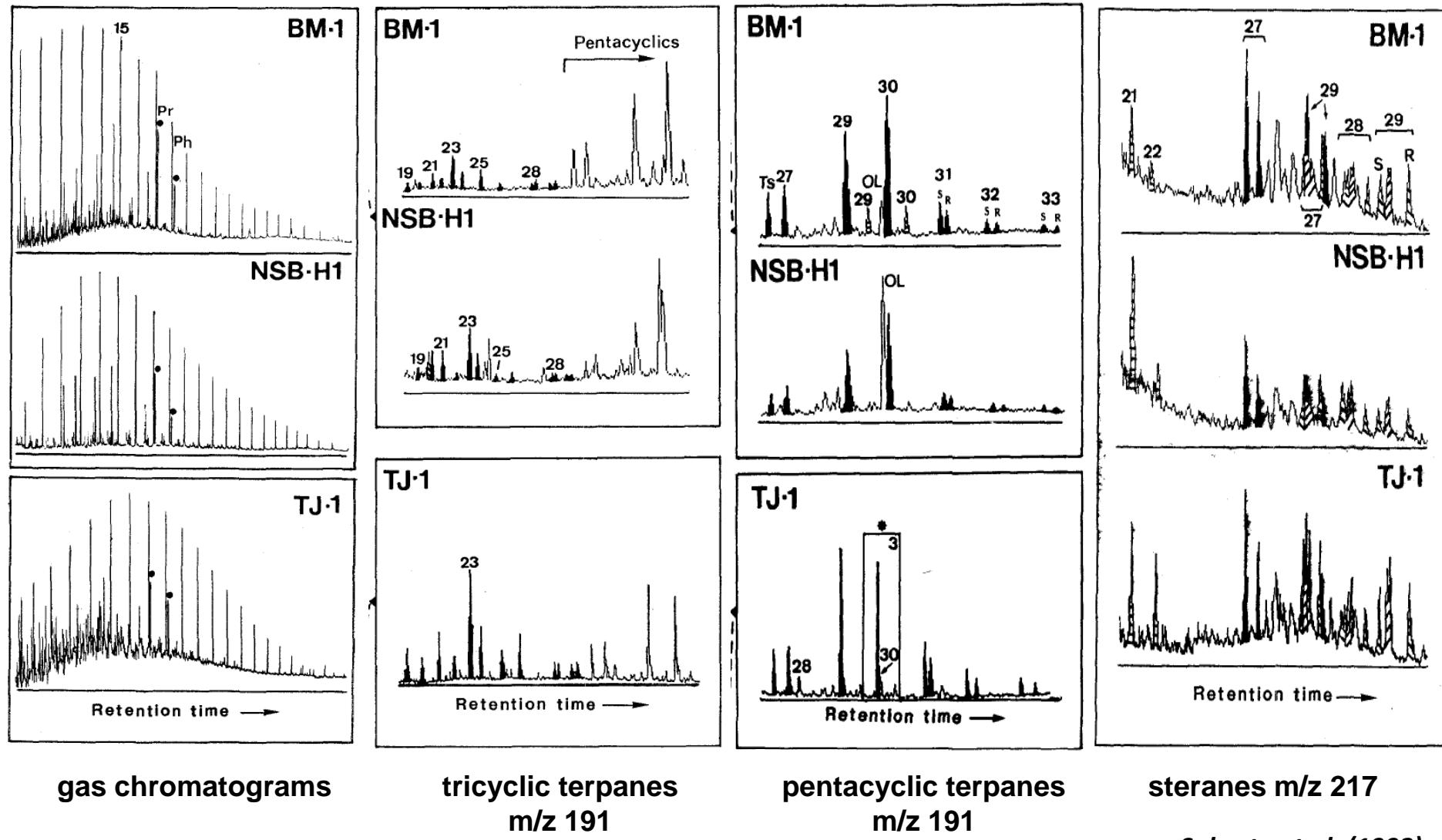
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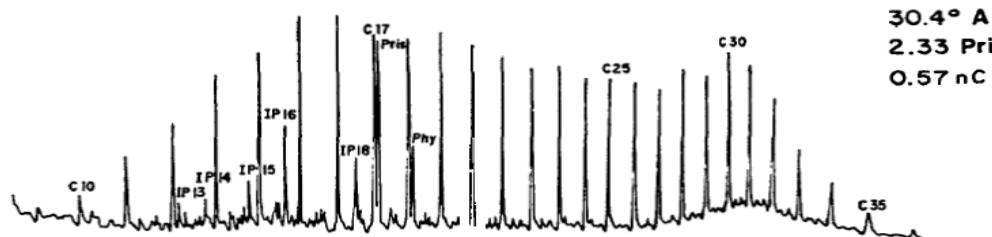
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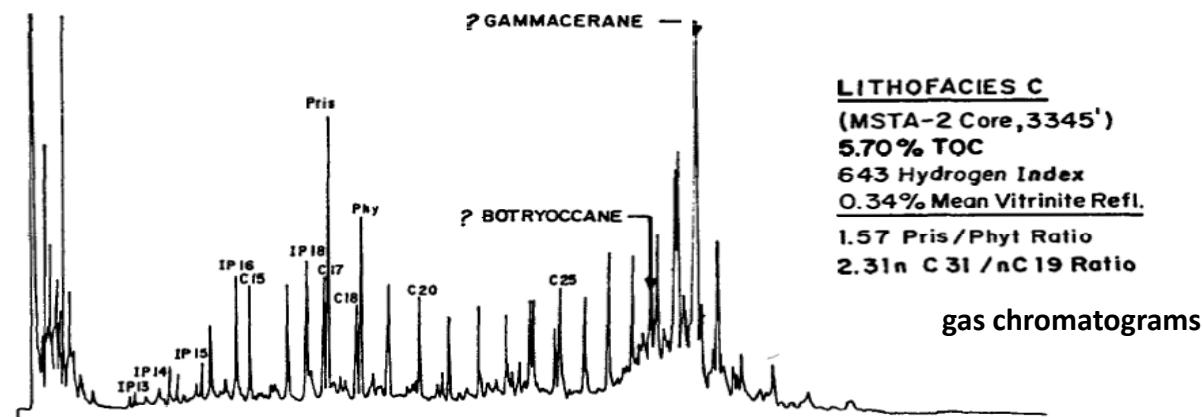
Biomarker Characteristics of North Sumatra Oils: Marine Shales and Carbonates Source Facies



gas chromatograms

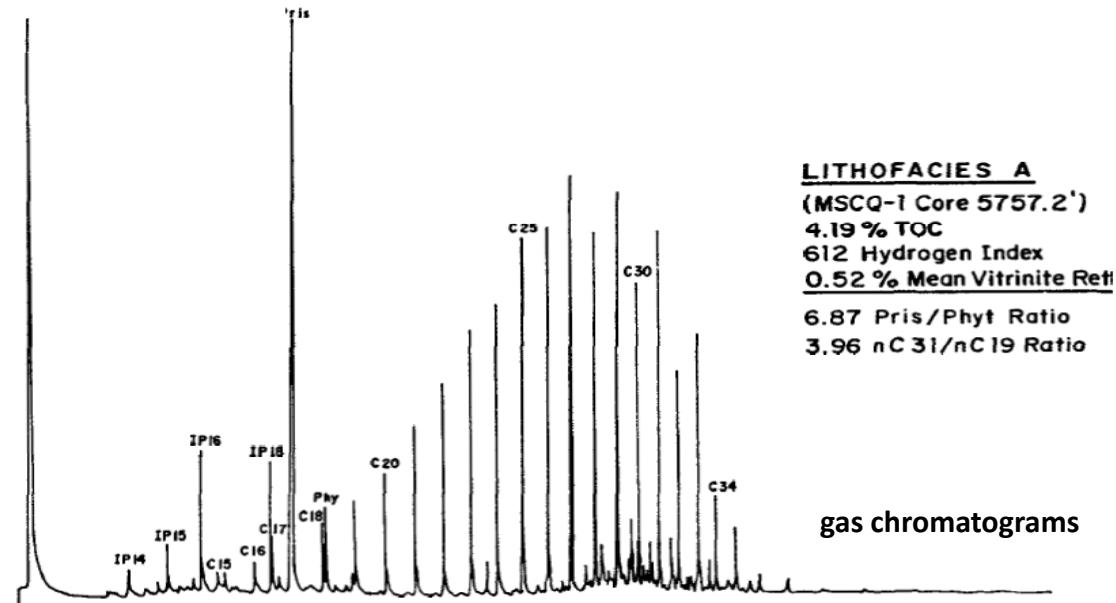


MSTB-1 SIHAPAS OIL
R_c from MPI index = 0.67
(Robinson, 1988 constants)
30.4° API
2.33 Pris/Phyt Ratio
0.57 nC₃₁/nC₁₉



LITHOFACIES C
(MSTA-2 Core, 3345')
5.70 % TOC
643 Hydrogen Index
0.34% Mean Vitrinite Refl.
1.57 Pris/Phyt Ratio
2.31 nC₃₁/nC₁₉ Ratio

gas chromatograms



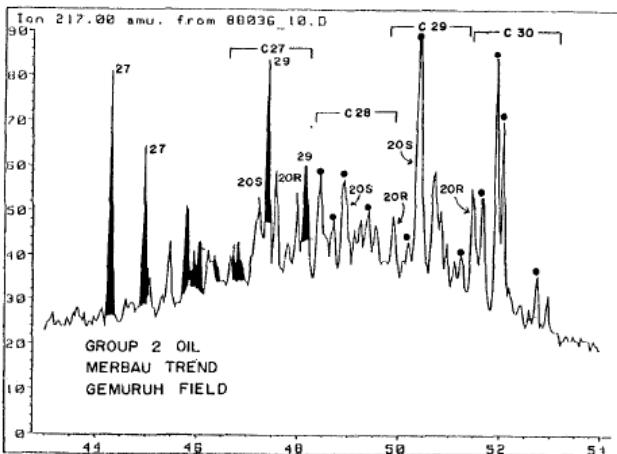
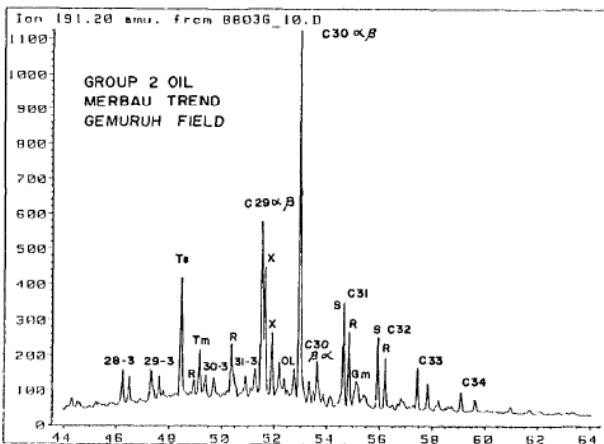
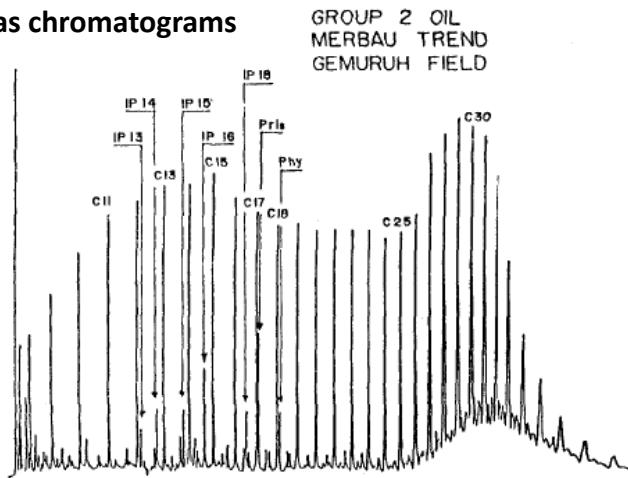
LITHOFACIES A
(MSCQ-1 Core 5757.2')
4.19 % TOC
612 Hydrogen Index
0.52 % Mean Vitrinite Refl.
6.87 Pris/Phyt Ratio
3.96 nC₃₁/nC₁₉ Ratio

gas chromatograms

Biomarker Characteristics of Central Sumatra Oils: Lacustrine & Fluvio- Deltaic Source Facies

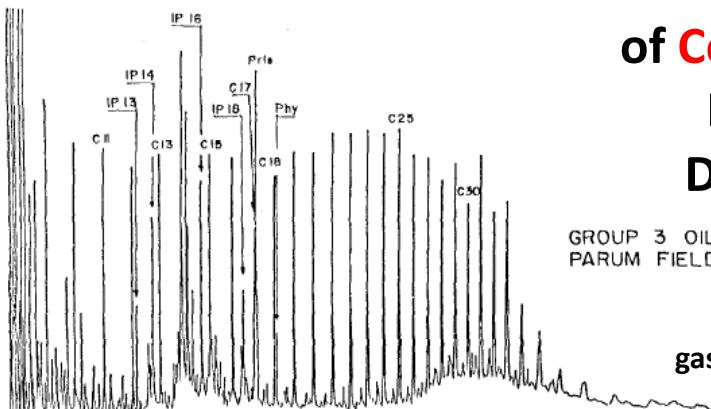
Longley et al. (1990)

gas chromatograms

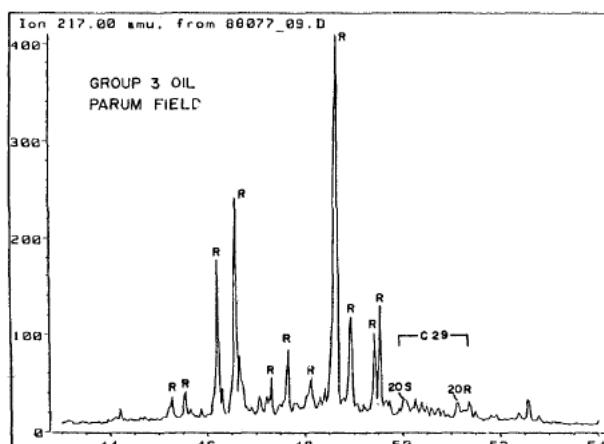
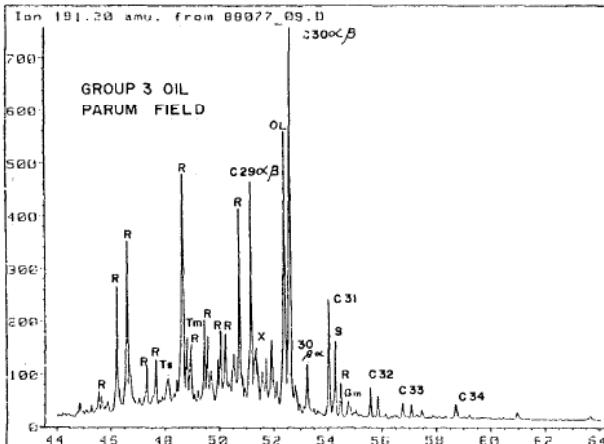


Biomarker Characteristics of Central Sumatra Oils: Lacustrine & Fluvio- Deltaic Source Facies

GROUP 3 OIL
PARUM FIELD



gas chromatograms

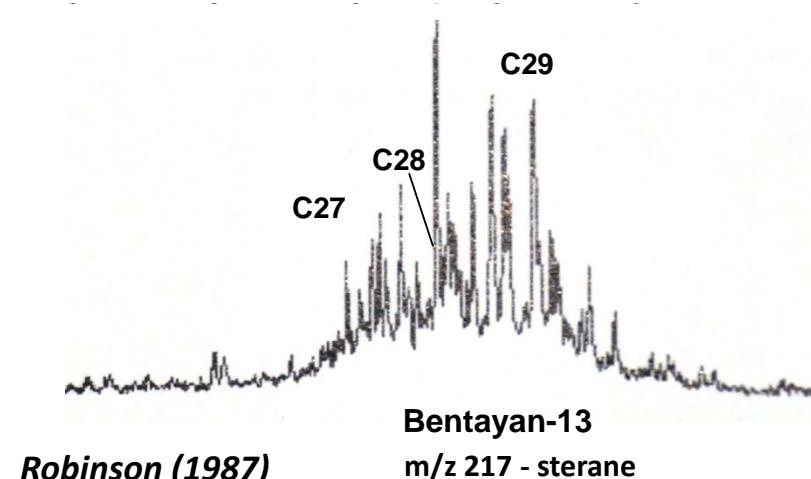
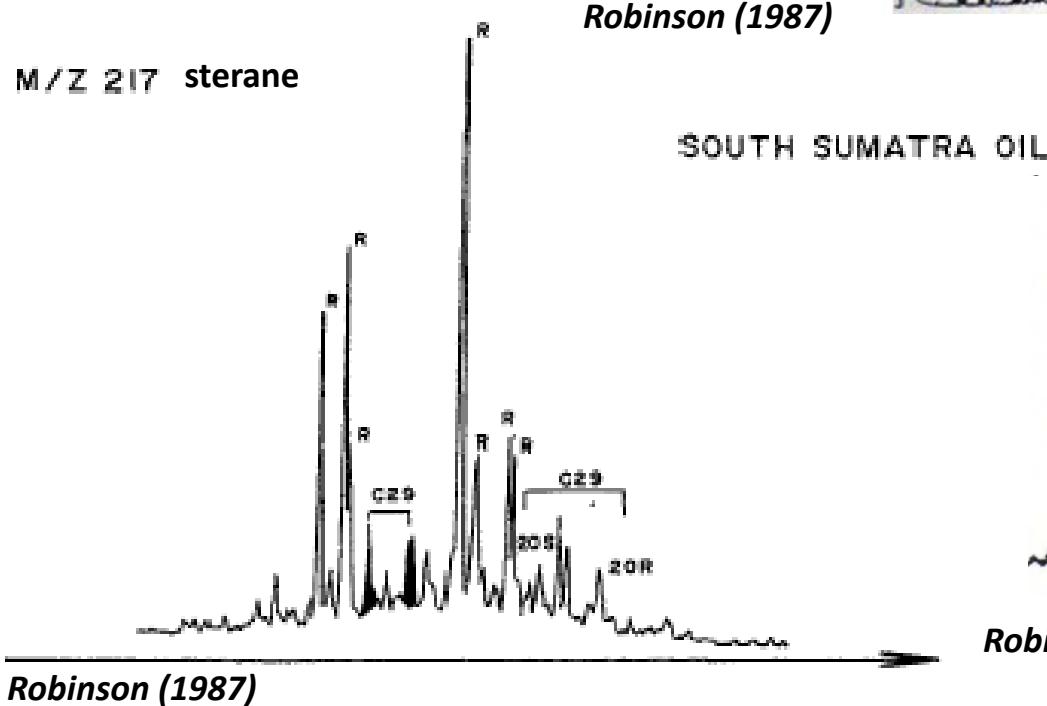
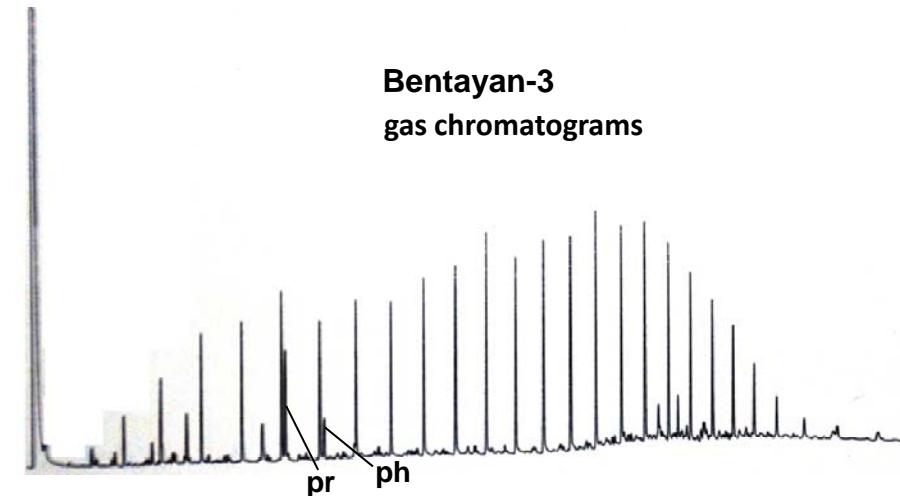
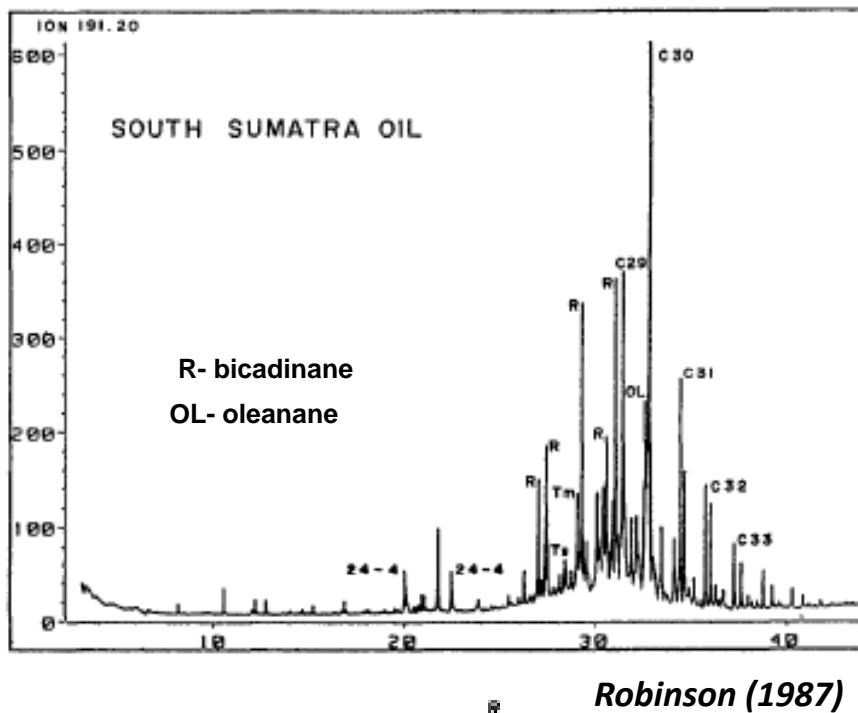


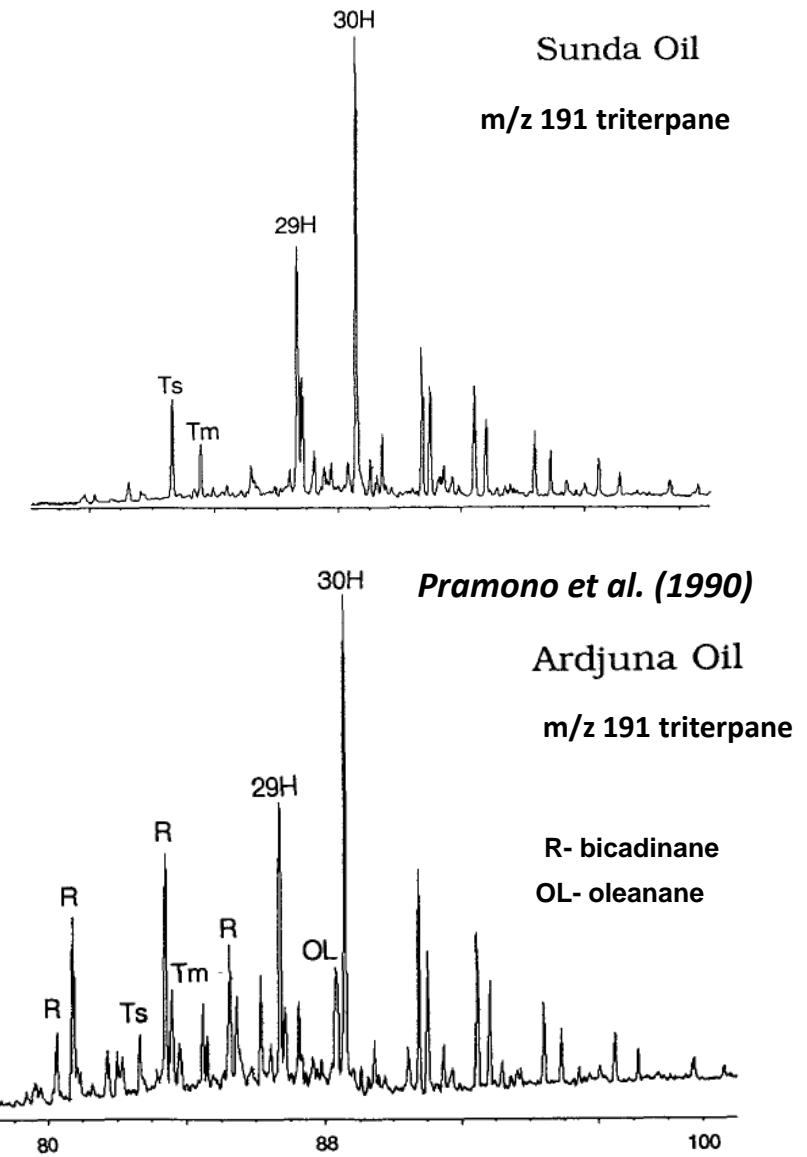
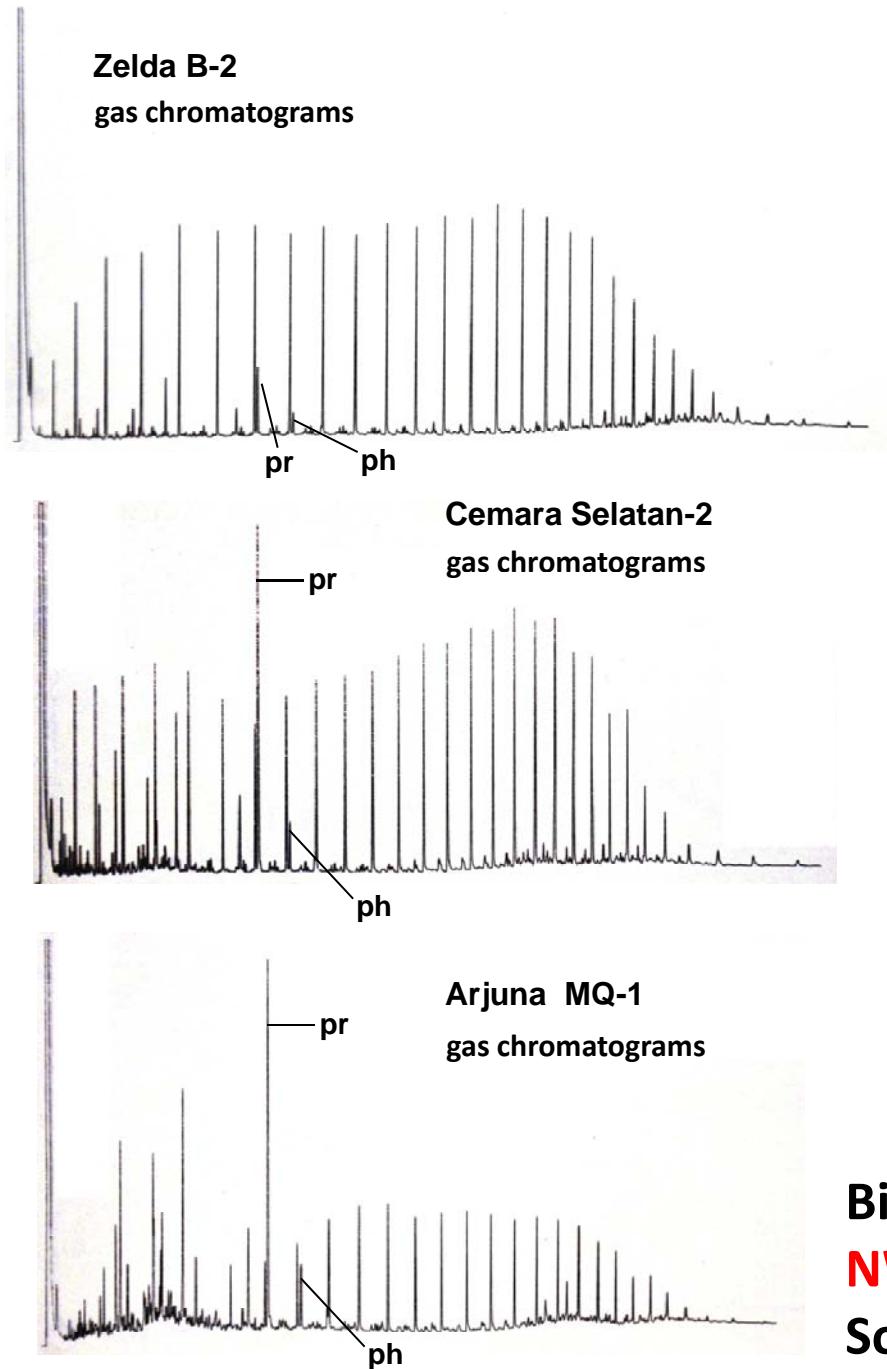
m/z 191 triterpane

m/z 217 sterane

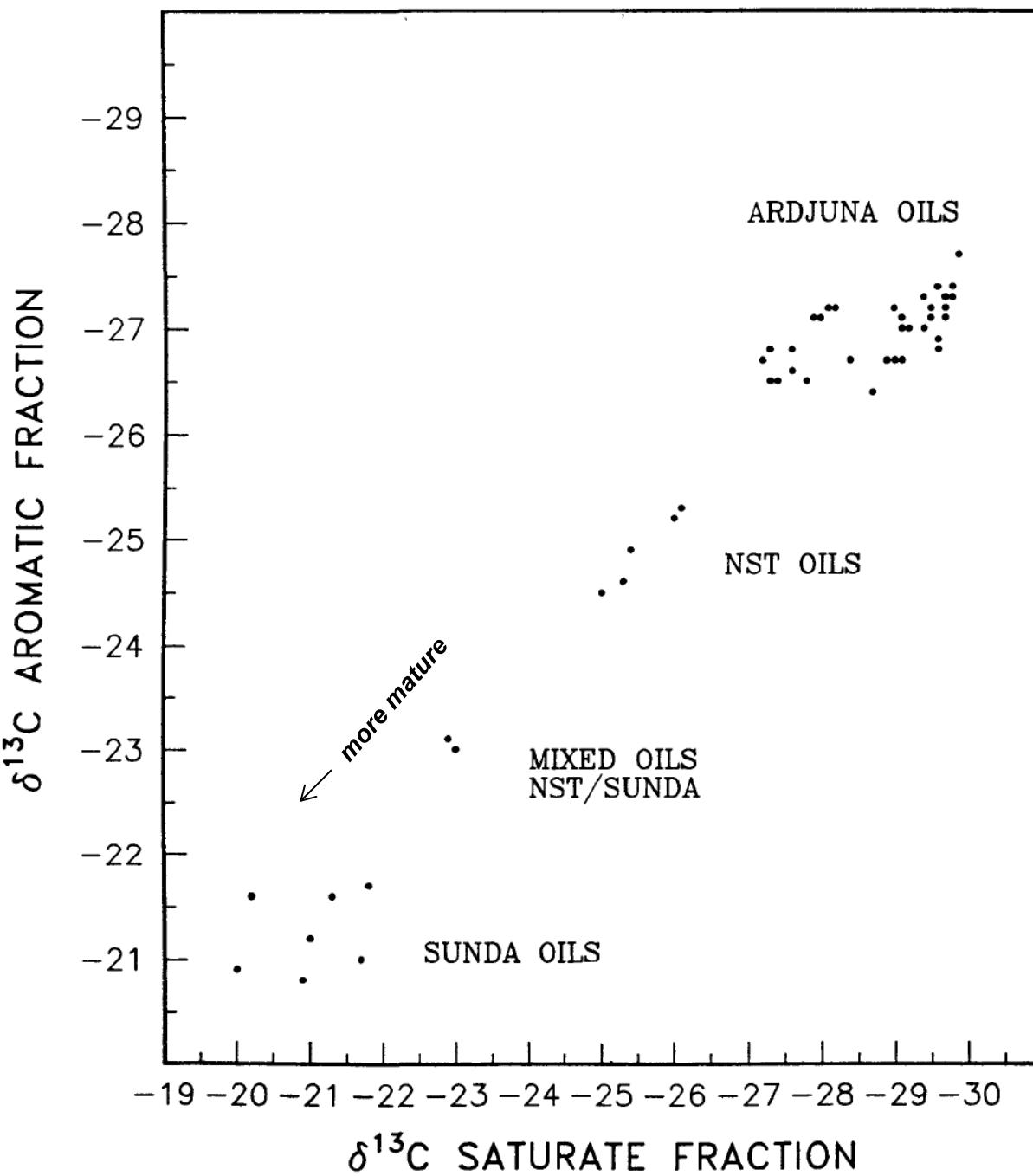
Robinson & Kamal (1988)

Biomarker Characteristics of South Sumatra Oils: Fluvio-Deltaic & Lacustrine Source Facies





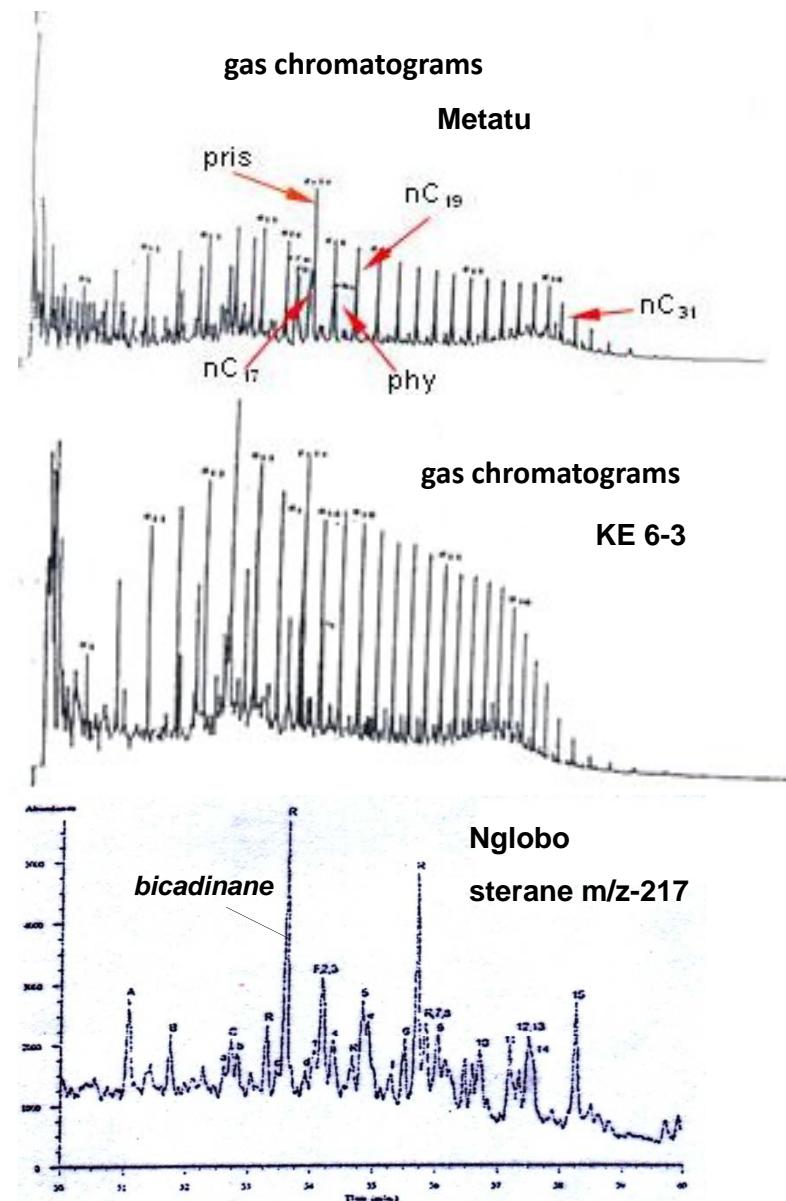
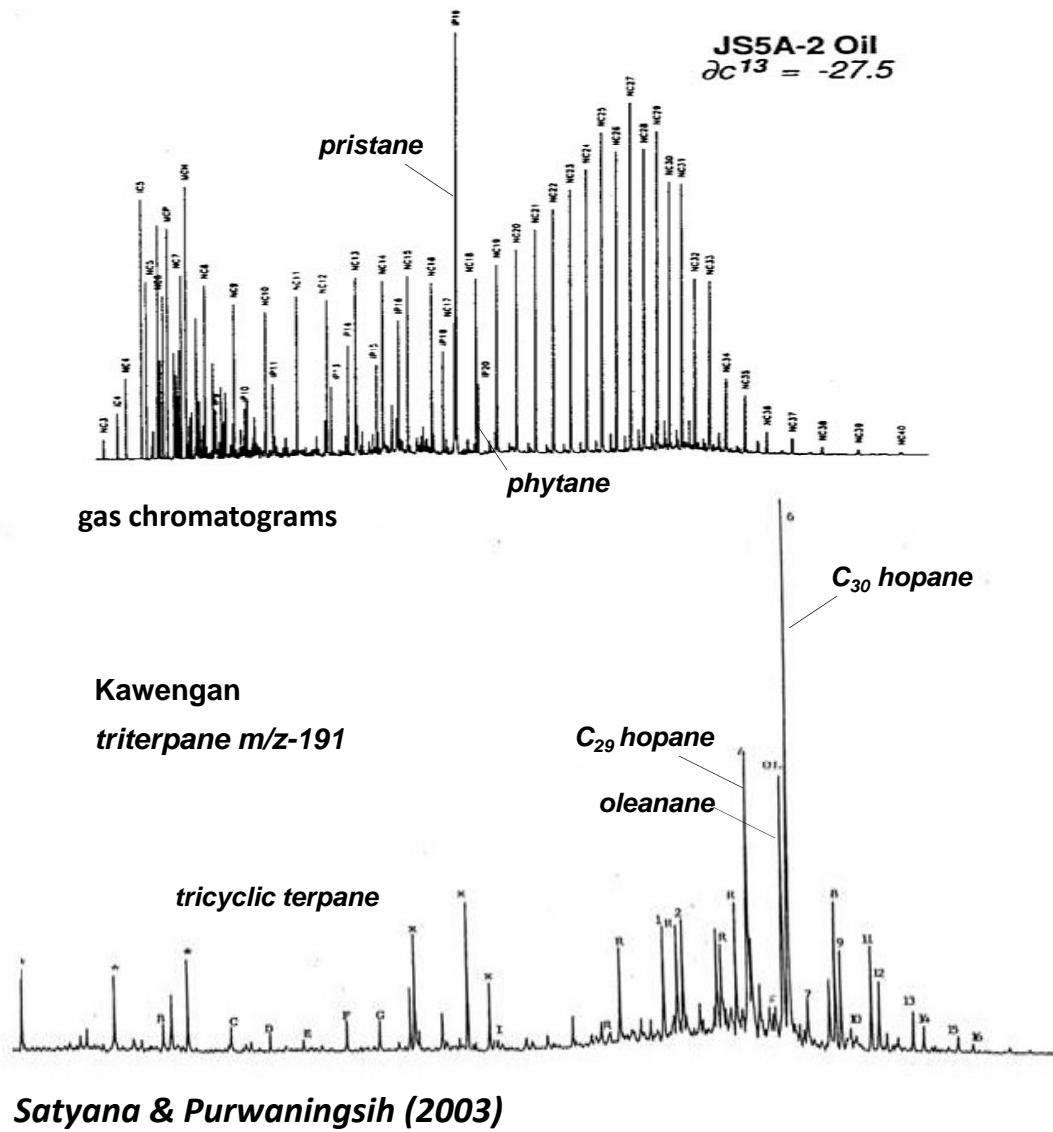
**Biomarker Characteristics of Sunda, Asri,
NW Java Oils: Lacustrine - Fluvio-Deltaic
Source Facies**



Carbon Isotope Values for Sunda and NW Java Oils: Lacustrine & Terrestrial Source Facies

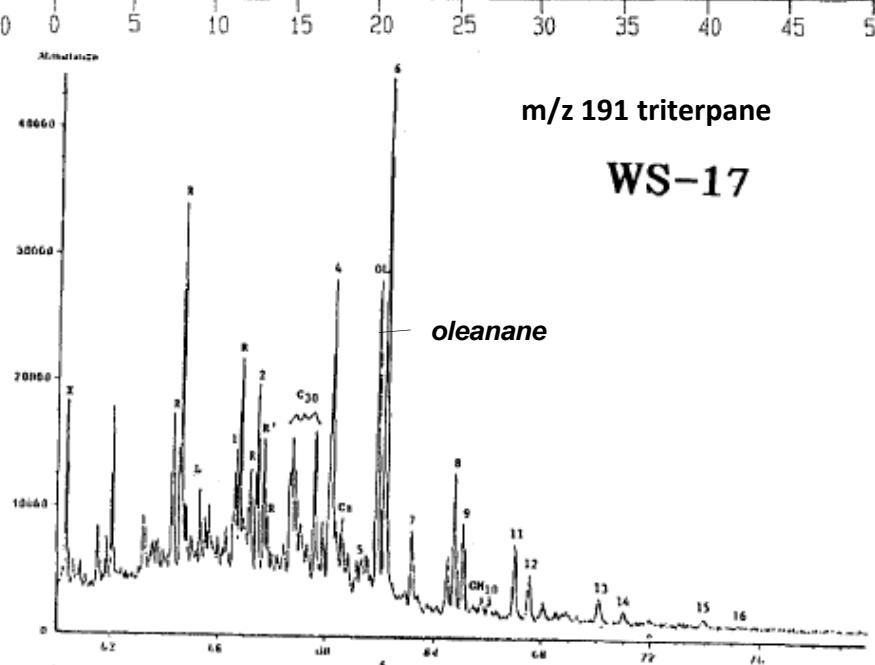
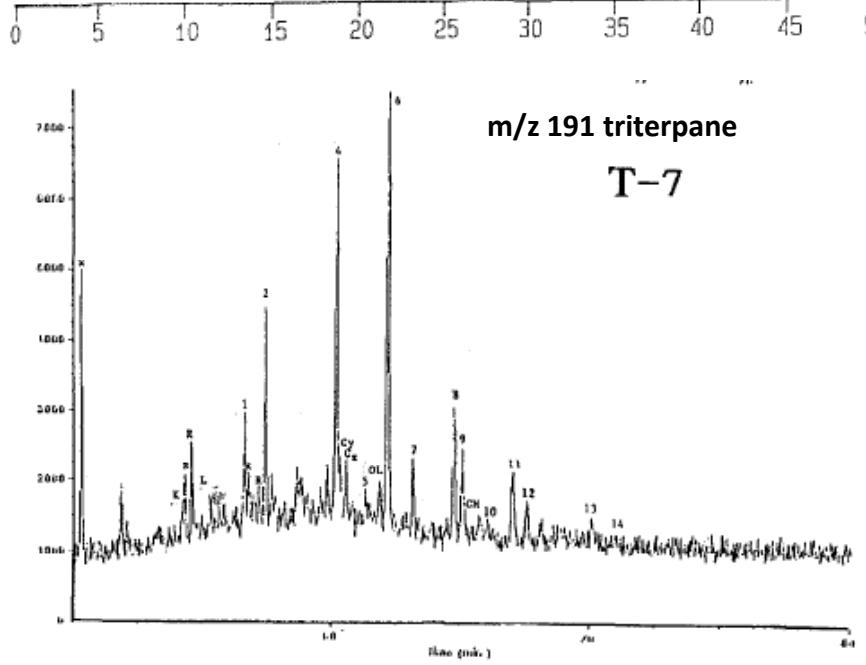
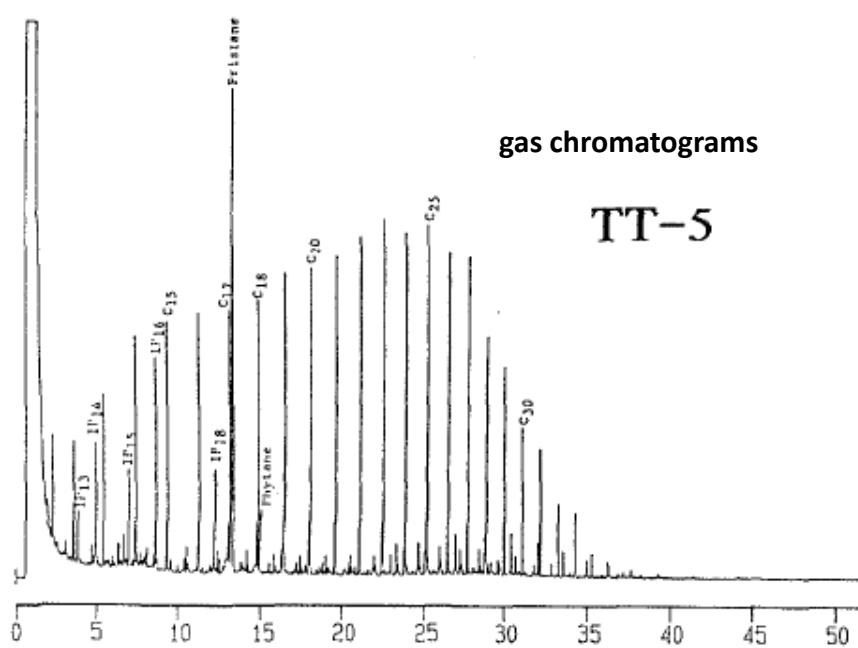
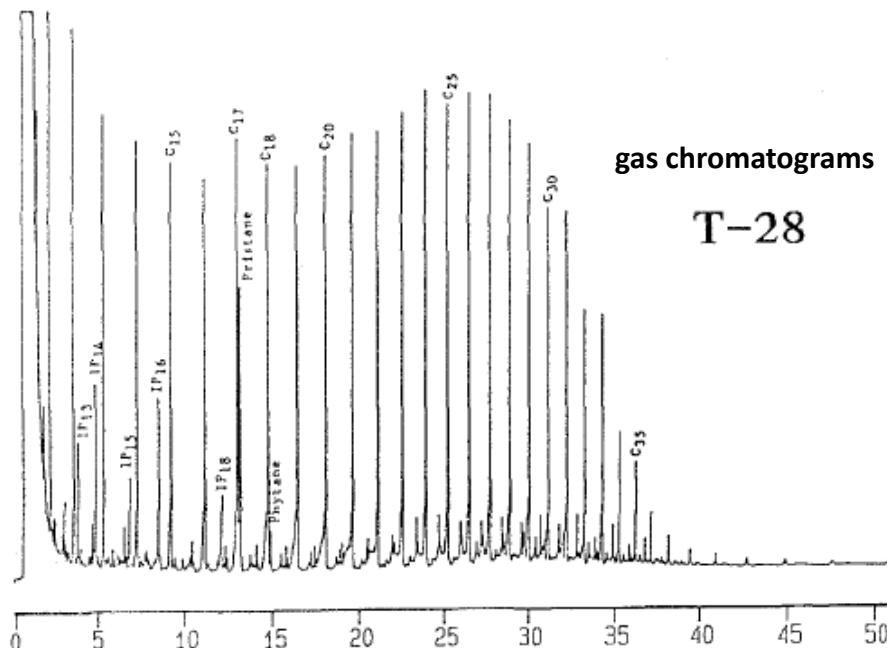
Pramono et al. (1990)

Biomarker Characteristics of East Java Oils: Fluvio-Deltaic Source Facies

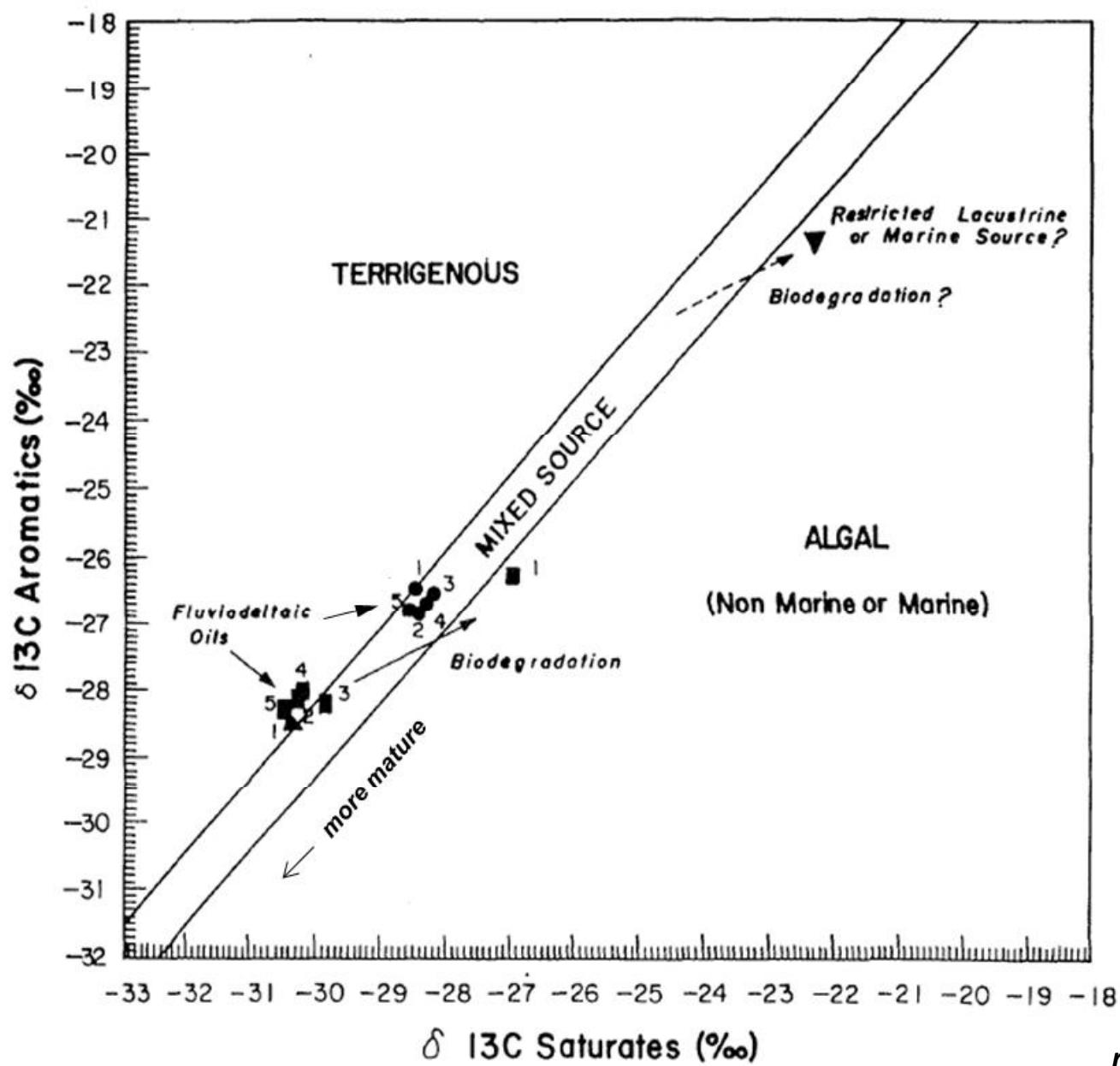


Rotinsulu et al. (1993)

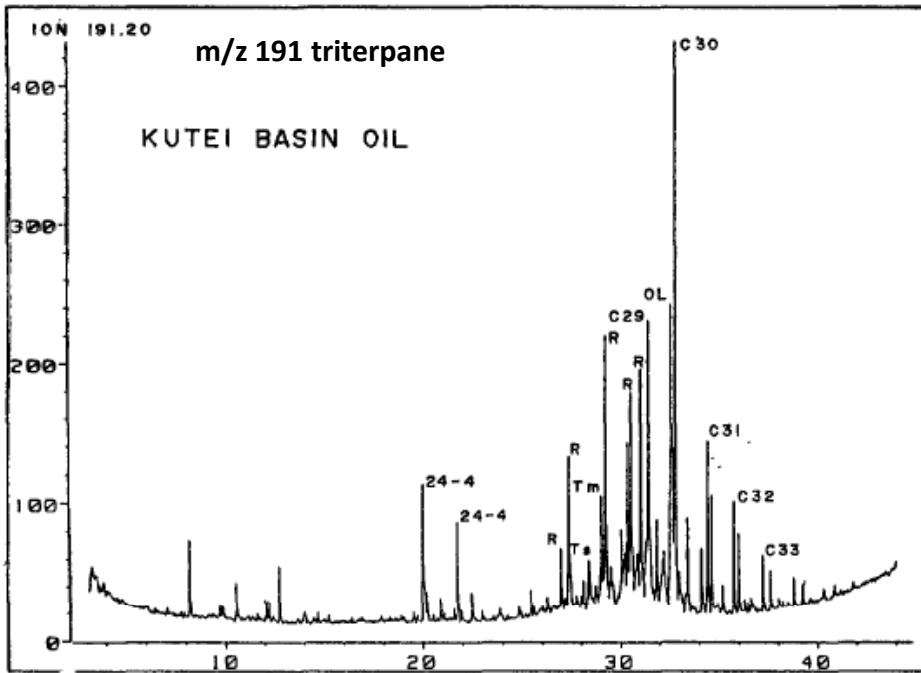
Biomarker Characteristics of Barito Oils: Fluvio-Deltaic Source Facies



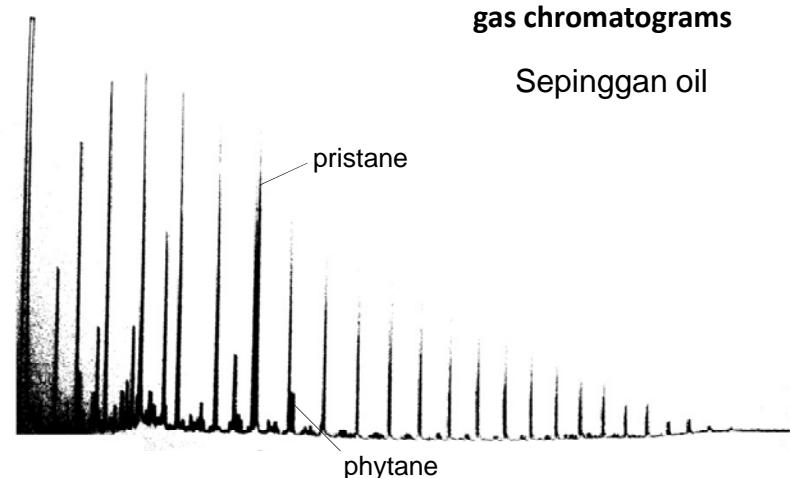
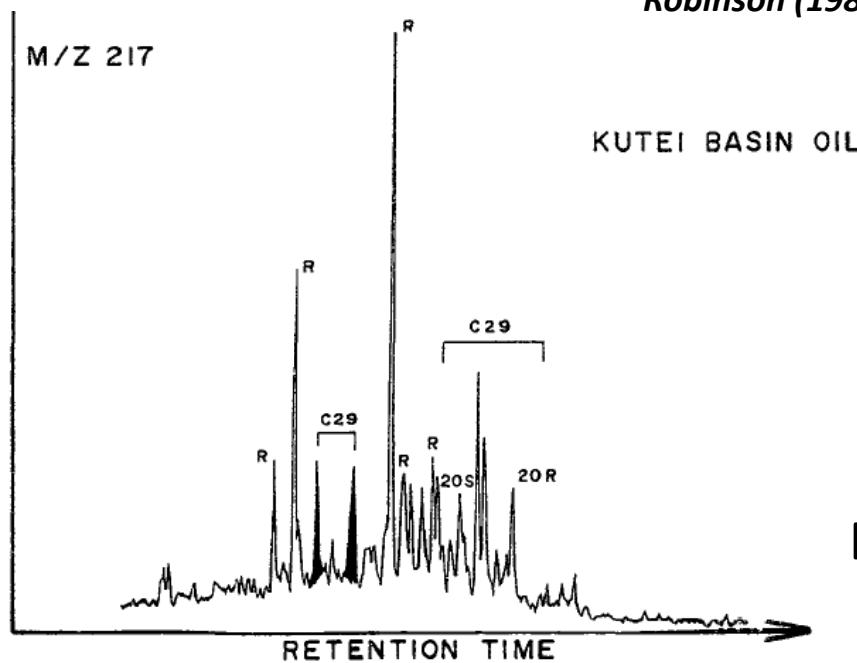
**Carbon Isotope
Values for Barito Oils:
Fluvio-Deltaic Source
Facies**



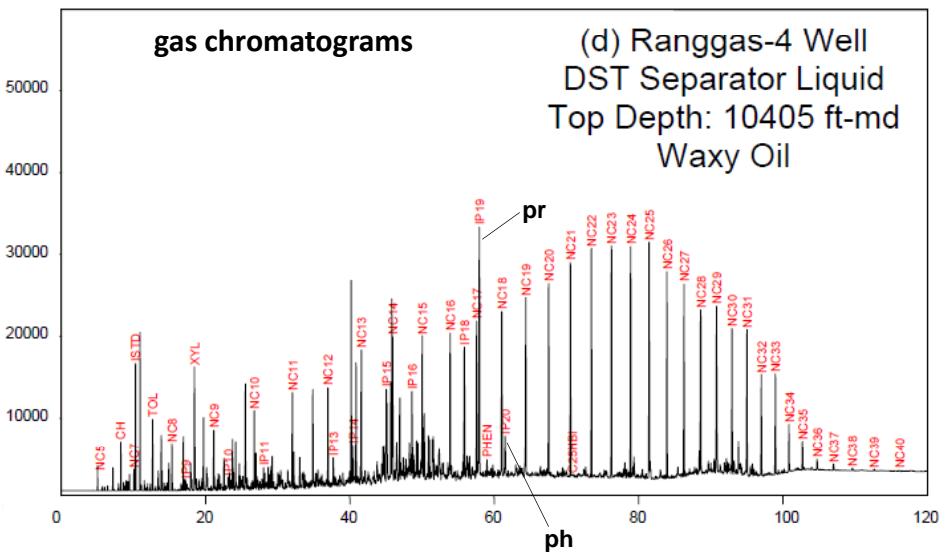
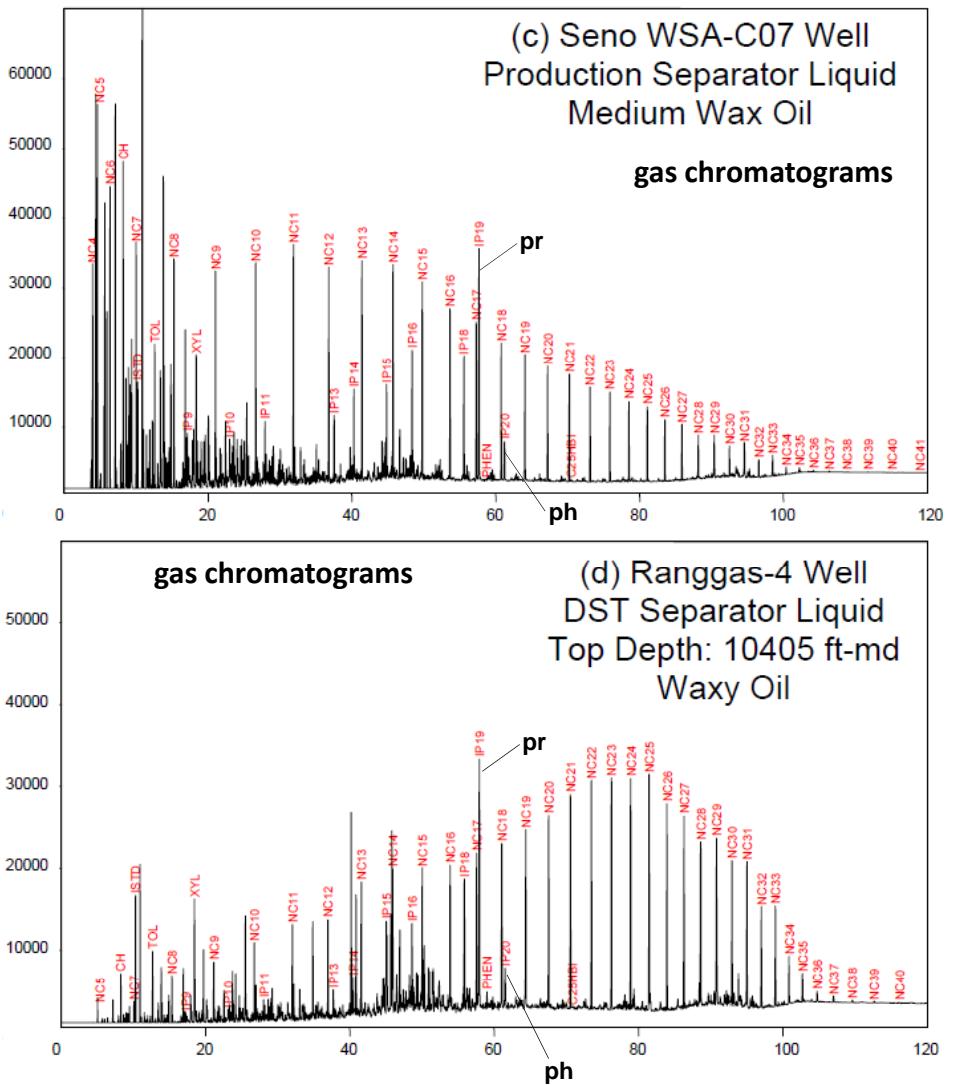
mod. after Rotinsulu et al. (1993)



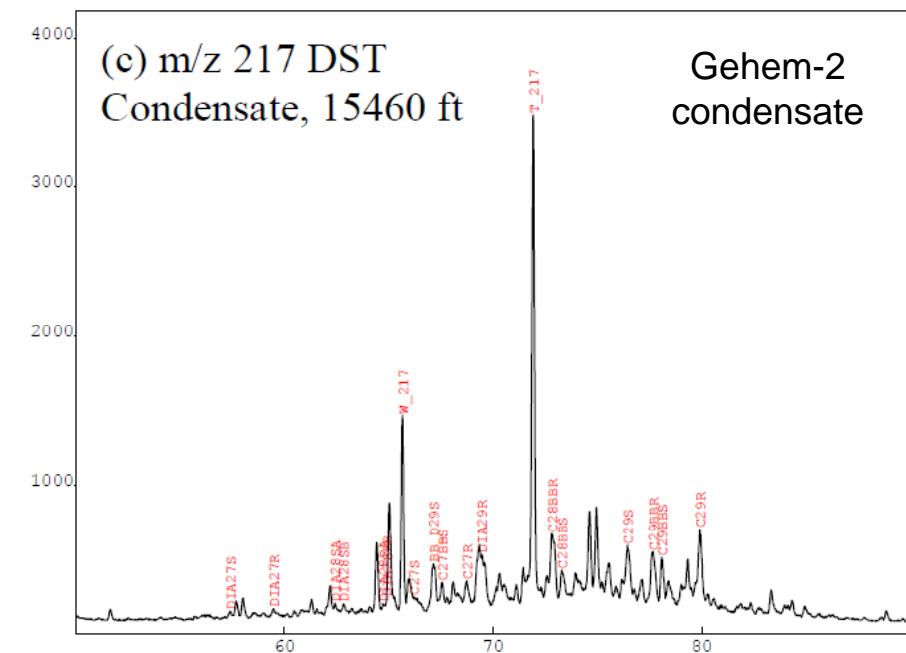
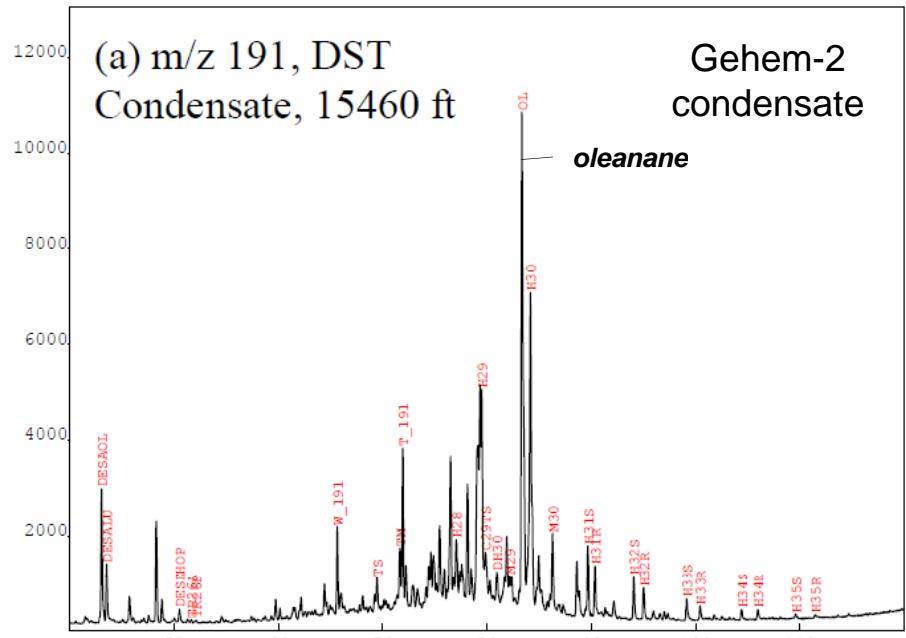
Robinson (1987)



Biomarker Characteristics of **Kutei** Oil:
Fluvio-Deltaic Source Facies

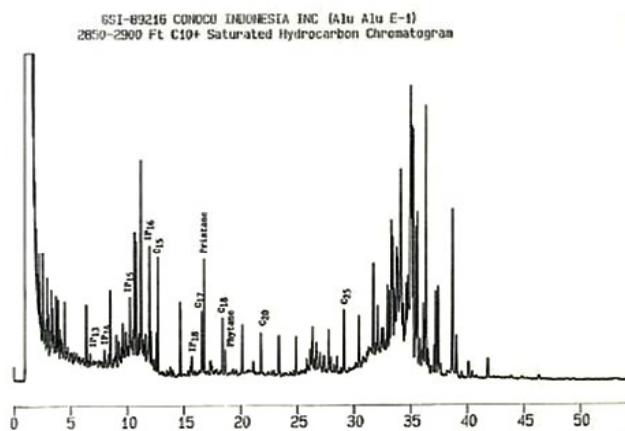


Biomarker Characteristics of Deepwater Kutei Oils: Fluvio-Deltaic Source Facies

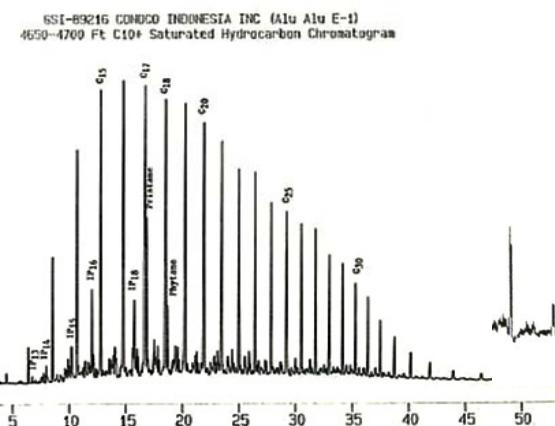


Lin et al. (1990)

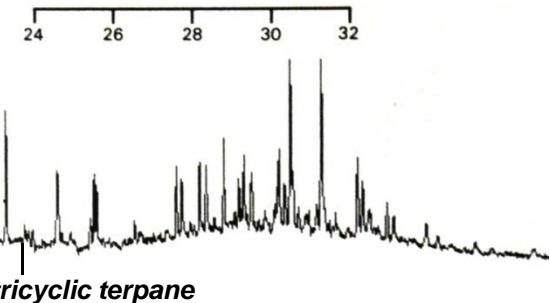
Alu-Alu E-1
gas chromatograms



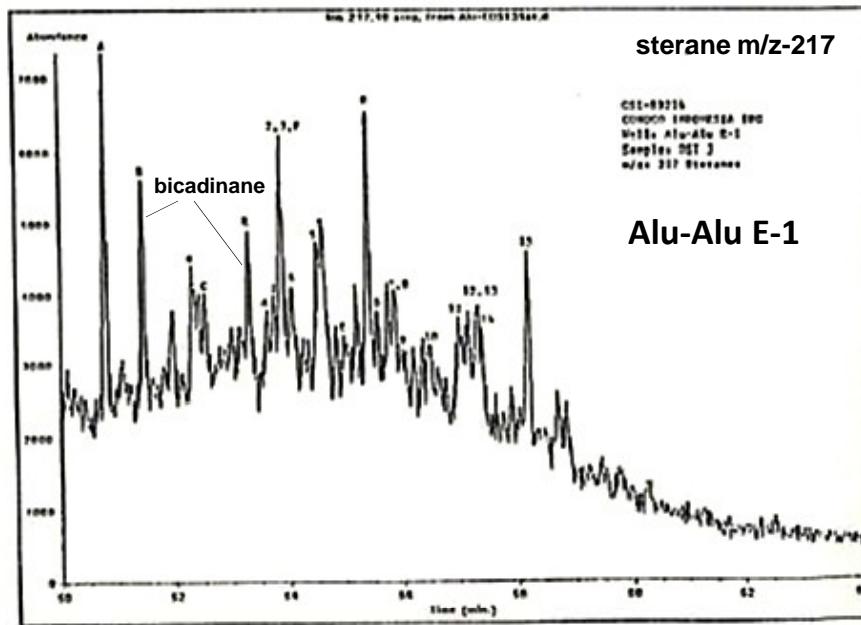
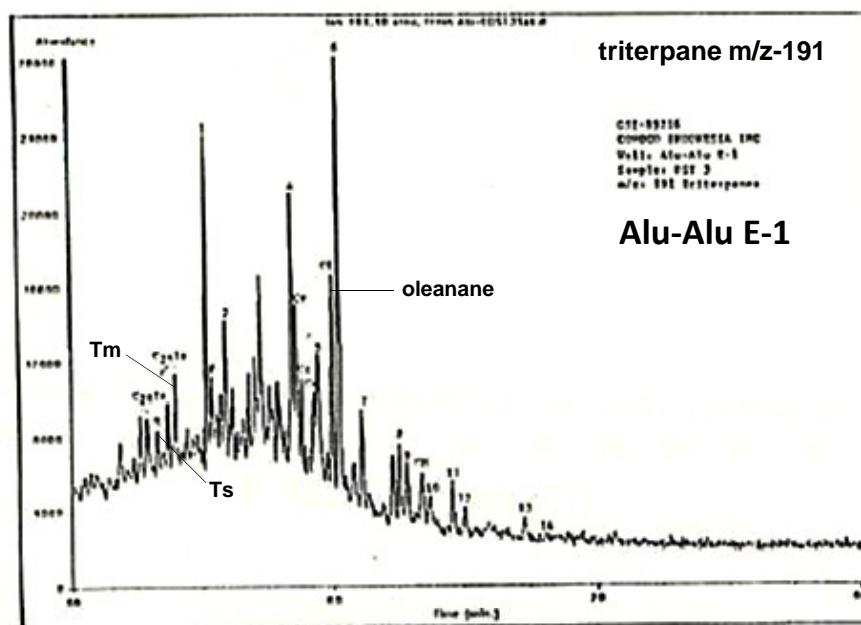
Alu-Alu E-1
gas chromatograms



Belanak-2
m/z 191-triterpane



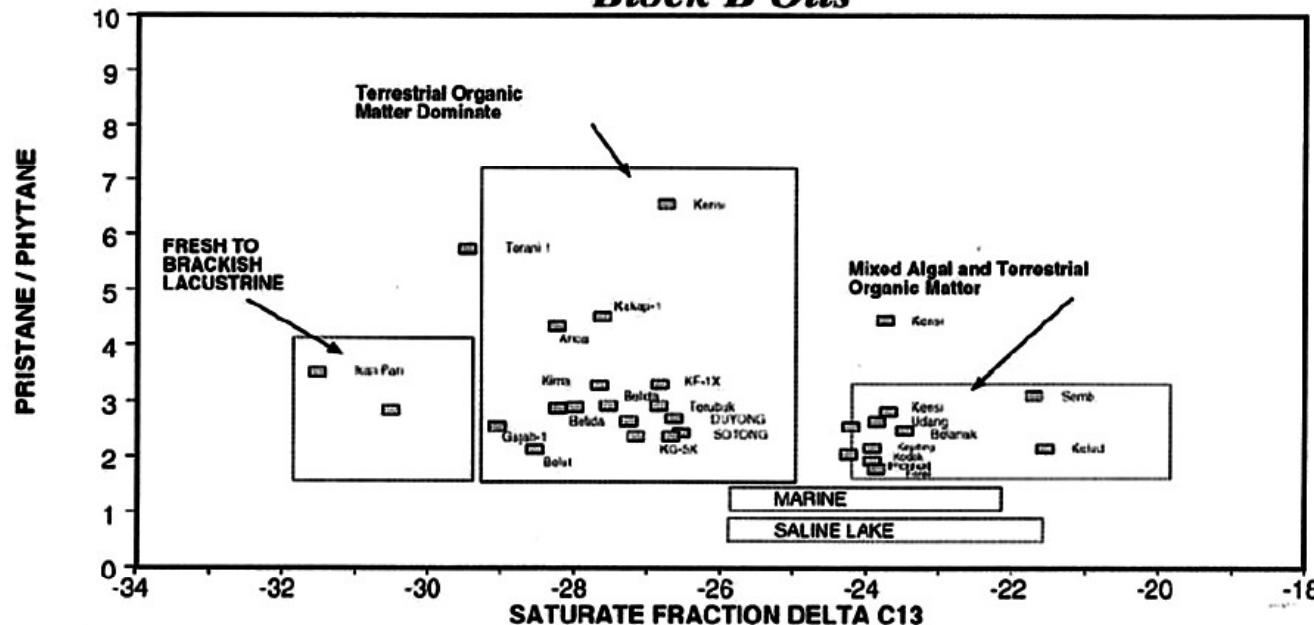
tricyclic terpane



Robertson Research (1986)

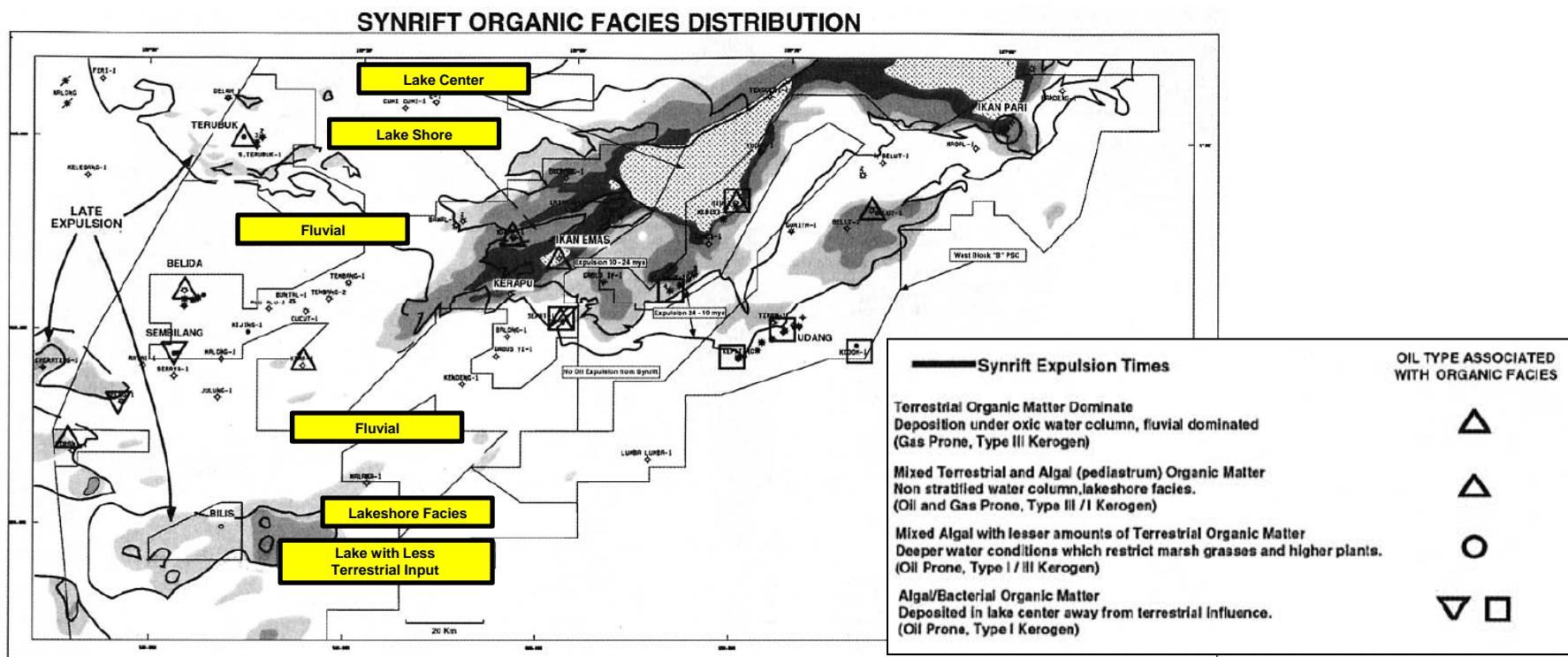
Biomarker Characteristics of West Natuna Oils: Lacustrine & Fluvio-Deltaic Source Facies

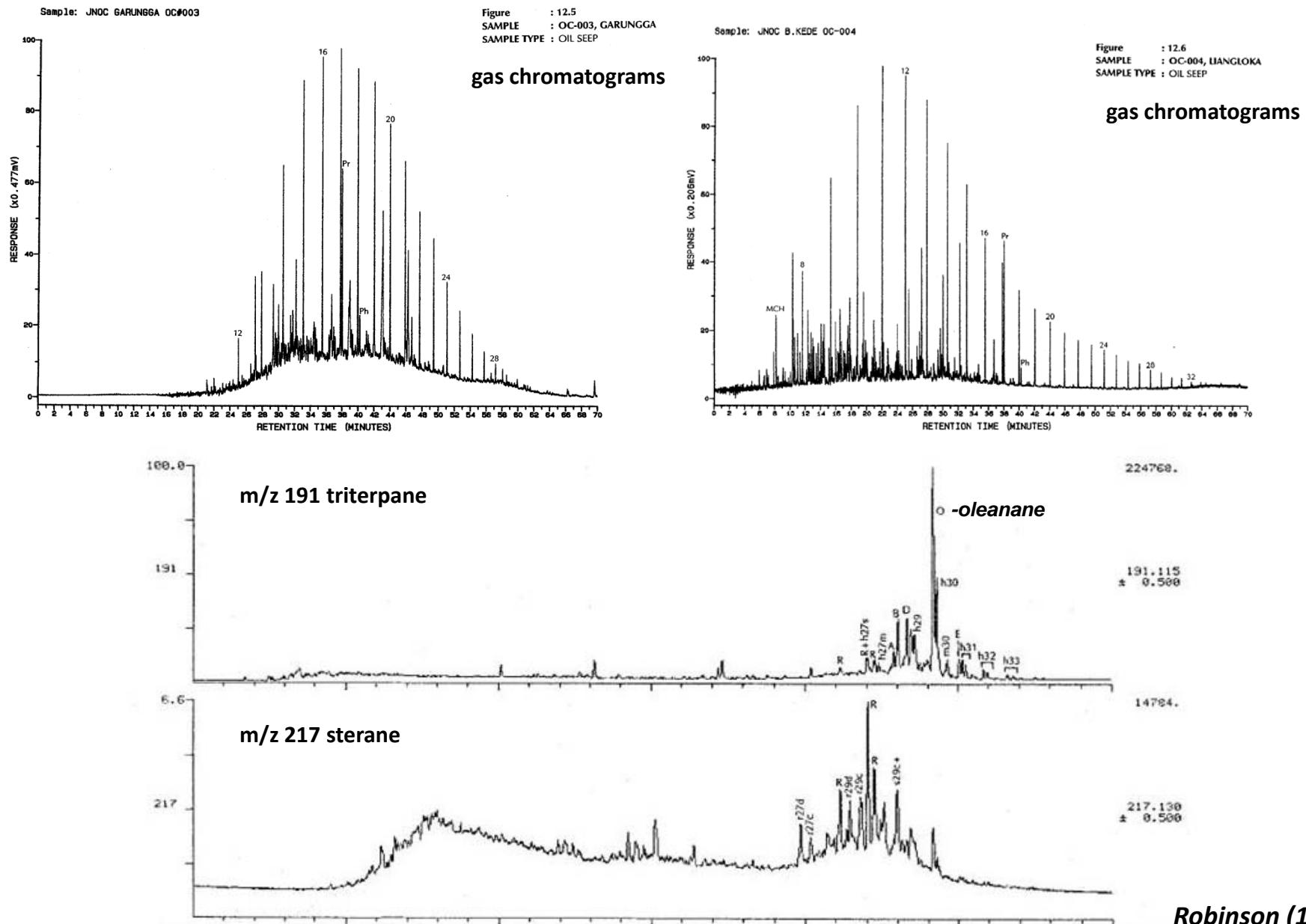
Block B Oils



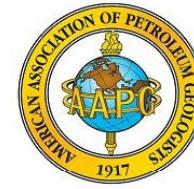
Oil Family in Block B, West Natuna Based on Biomarker and Carbon Isotope-13: Lacustrine & Fluvio-Deltaic Source Facies

modified after Michael & Adrian (1996)



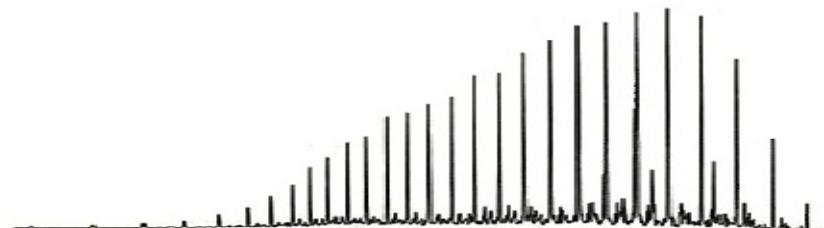


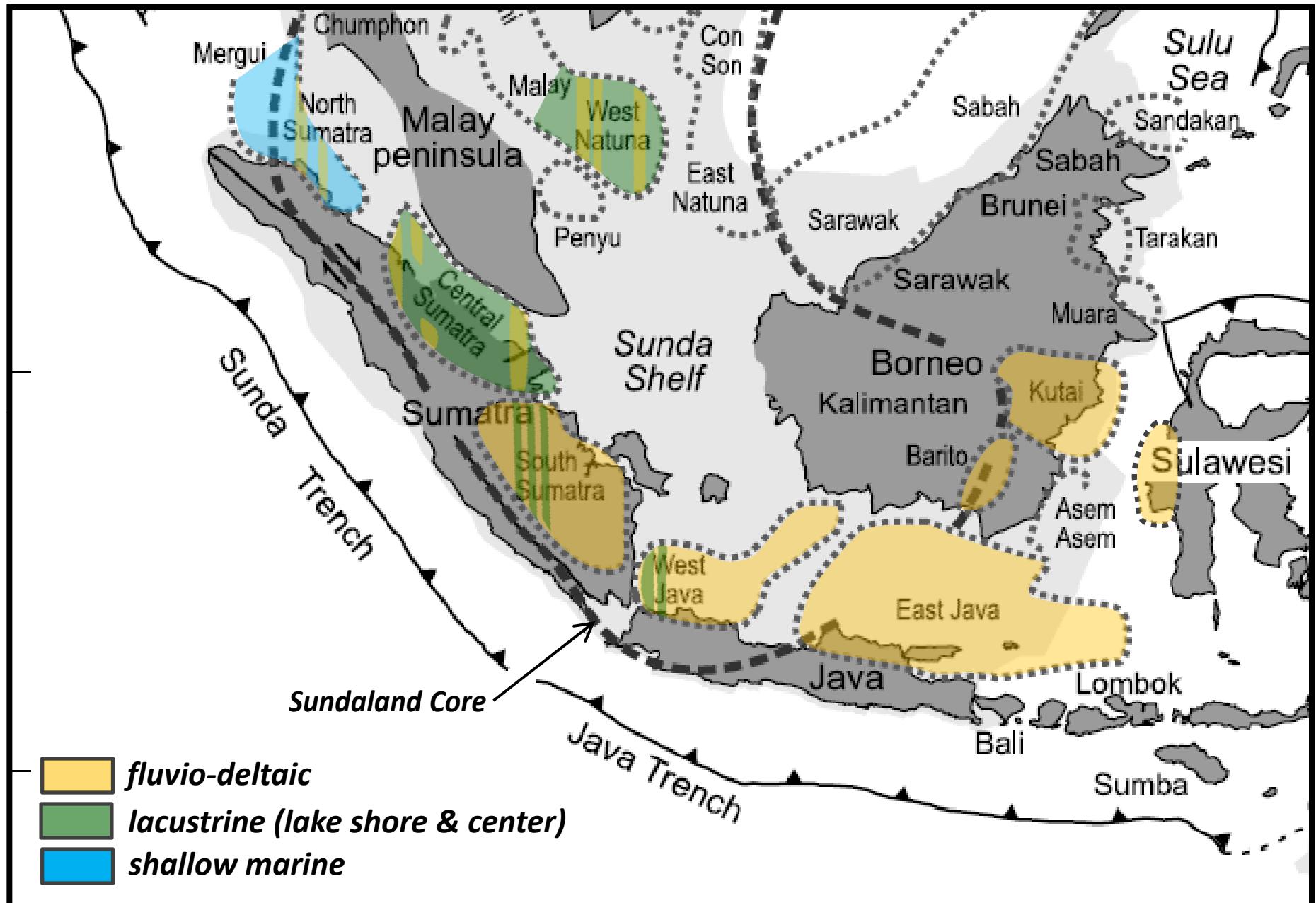
Biomarker Characteristics of West Sulawesi Oil Seeps: Terrestrial Source Facies



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2. Regional Tectonics and Stratigraphy
3. Major Source Types of Indonesia's Oils
4. Biomarkers and Carbon-13 Isotopes of Circum- and Drifted Sundaland Basins
- 5. Conclusions**





Major Source Facies of Circum- and Drifted Sundaland Basins



Thank you for your attention.

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