Fluid Properties Indicated by Natural Gas Isotopes in Gulf of Mexico*

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Abstract

Fluid properties in the petroleum reservoirs changes rapidly along both horizontal and depth profile of Gulf of Mexico (GOM) shore; the heterogeneous distributions of associated gas, wax, and asphaltene increase the exploration risks. Detailed understanding of the processes of petroleum generation, migration, and reservoir alteration is necessary to predict the occurrence of these hazardous substances and to lowering the risks of exploration.

Kinetics of oil and gas generation from different source rocks in GOM were investigated by pyrolysis of various organic matters. The samples for primary cracking (oil and gas generation from kerogen) include several types of immature sources rocks from Cretaceous and Jurassic formation of Garden Banks 754 #1 well, and other comparable immature source rocks such as the Monterey Shale. The samples for secondary cracking (gas generation from oil) include several oil samples from Gulf of Mexico. Hydrocarbon potential, including gas/oil ratio, are derived from the kinetic model for the petroleum plays from different source rocks under different thermal history.

For the alteration of petroleum reservoirs, we investigated the natural gas data and fluid properties, and revealed that the extent of biodegradation can be quantitatively expressed by the relation between the carbon isotope composition of methane and ethane. Meanwhile, the relation between the carbon isotope composition of propane and ethane provides quantitative results of oil cracking. These results are further related to the amounts of asphaltene and associated gas in reservoirs.

As a result, we established the calibrated model to predict the fluid properties in offshore Gulf of Mexico based on geochemistry of associate gas. The results were tested in several case studies.

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Daniel (Xinyu) Xia[1], Daniel Jarvie[2], Yongchun Tang[1]

1 PEER Institute; GeoIsoChem Corp.

2 Worldwide Geochemistry

Why to predict fluid properties?

Risk of Deep Water Exploration

Oil found, but ...

Photo credit: Schlumberger

Risk of Deep Water Exploration

Oil Viscosity
API

Photo credit: Schlumberger

Risk of Deep Water Exploration

Wax

Oil Viscosity API

Photo credit: Schlumberger

Risk of Deep Water Exploration

Wax

Oil Viscosity
API

Asphaltene

Photo credit: Schlumberger

Risk of Deep Water Exploration

Wax

Oil Viscosity API

Asphaltene

Associated Gas

Photo credit: Schlumberger

Our approach

- Advanced chemistry basin modeling

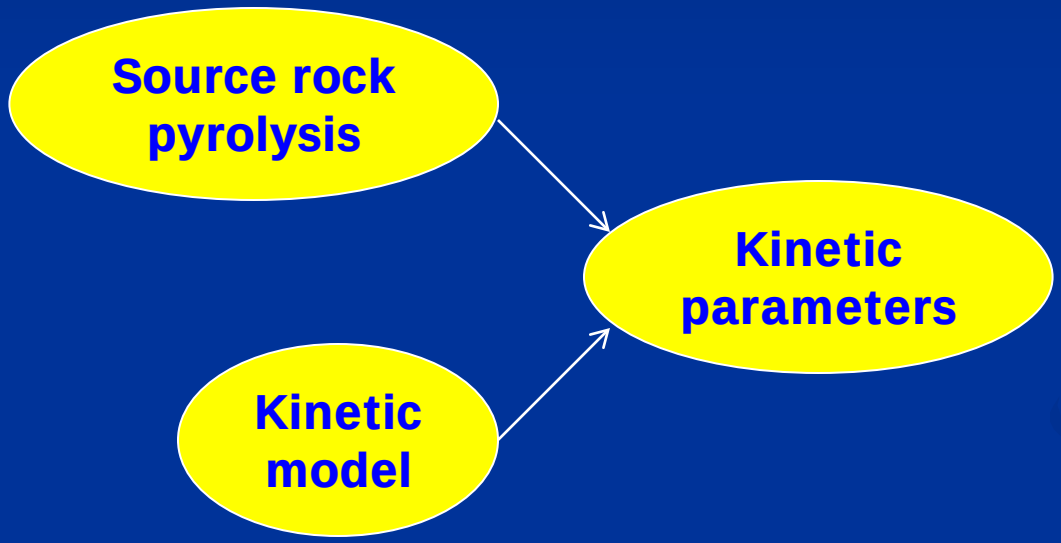
Our approach

- Advanced chemistry basin modeling

Source rock pyrolysis

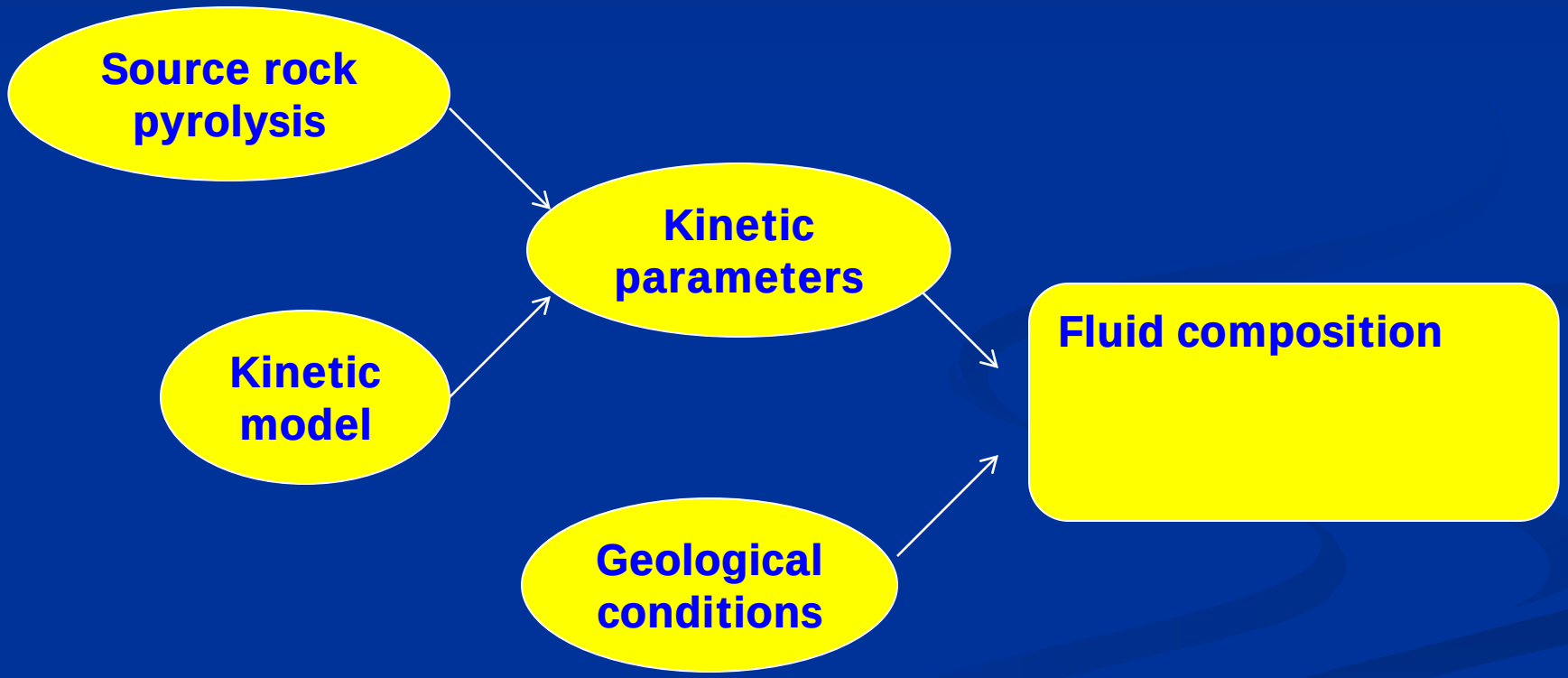
Our approach

- Advanced chemistry basin modeling



Our approach

- Advanced chemistry basin modeling



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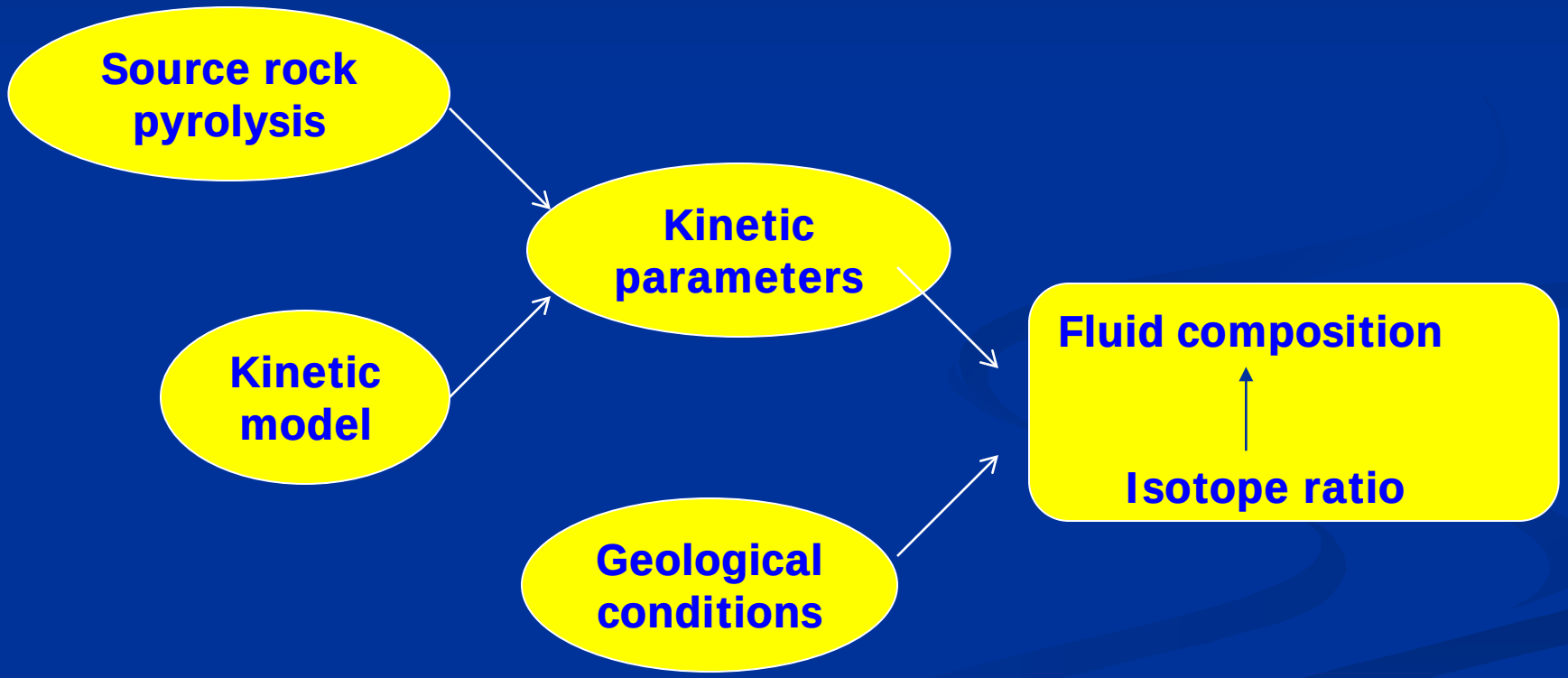

Why Gas Isotope?

- Model well established and calibrated

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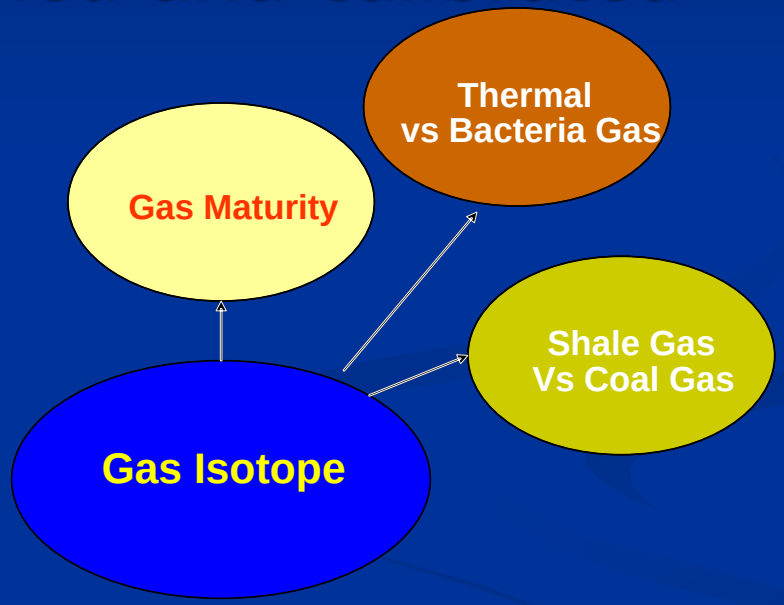

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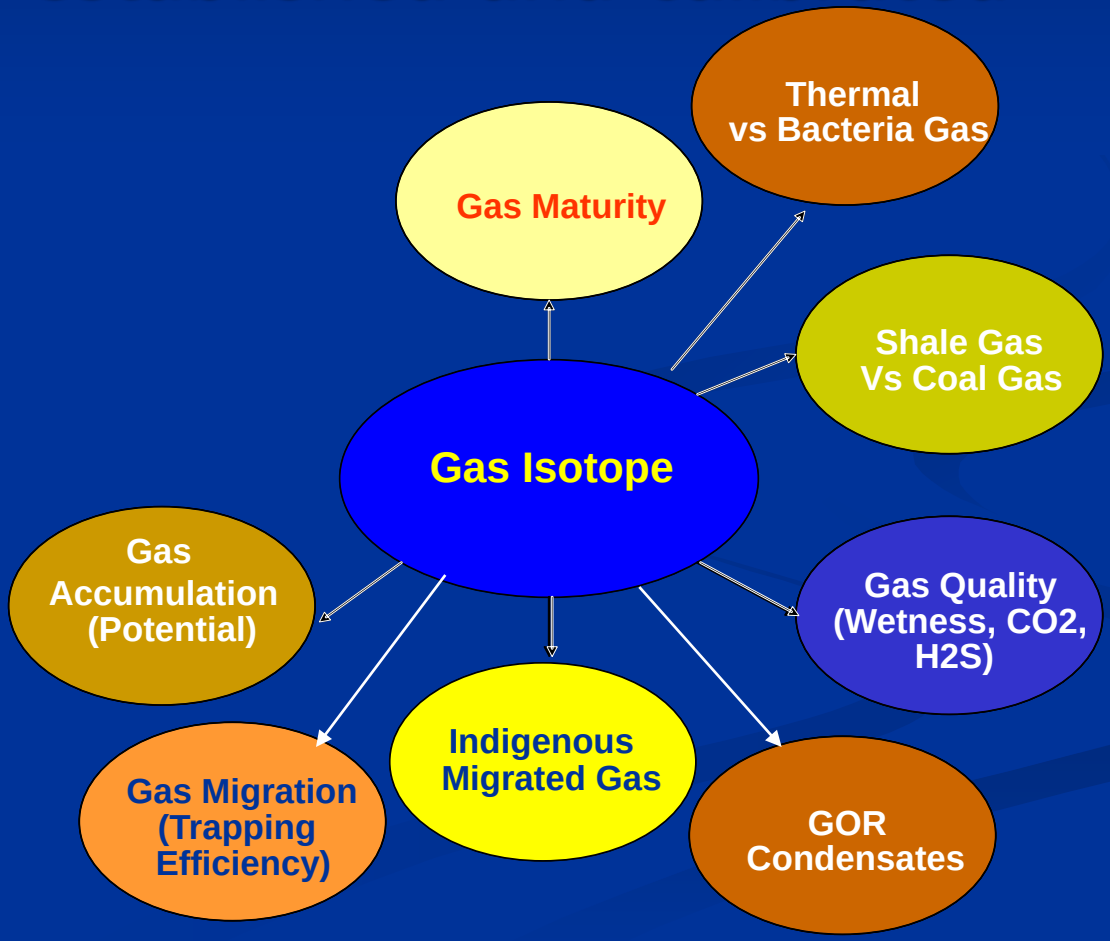

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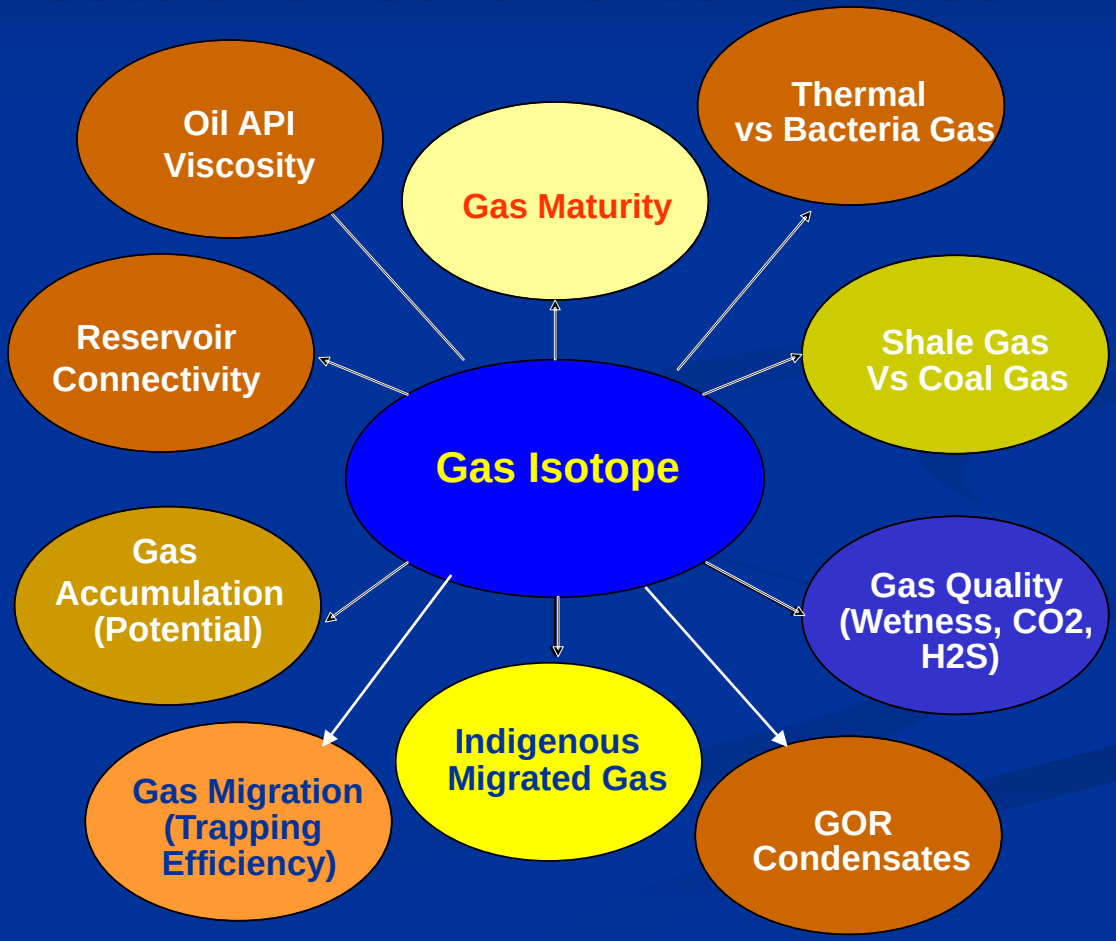
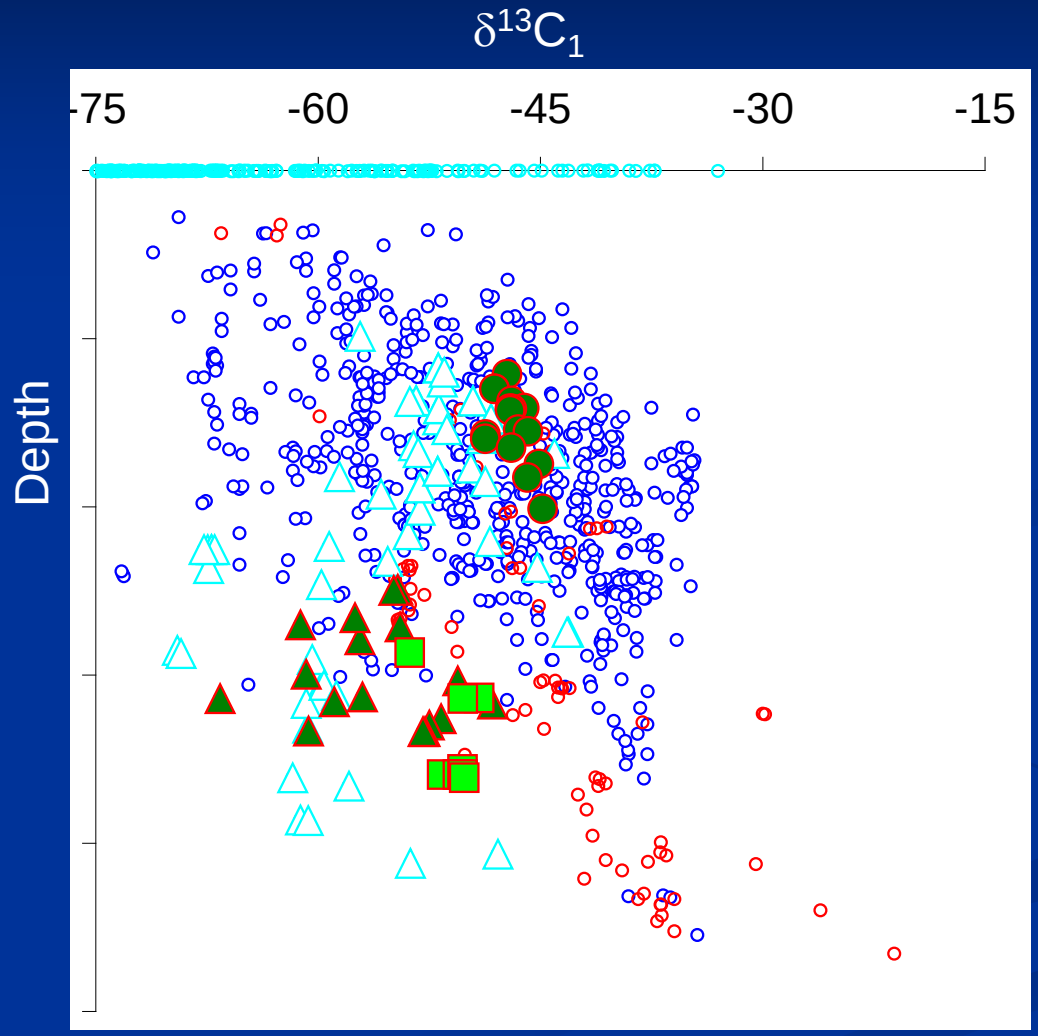


Why Gas Isotope?

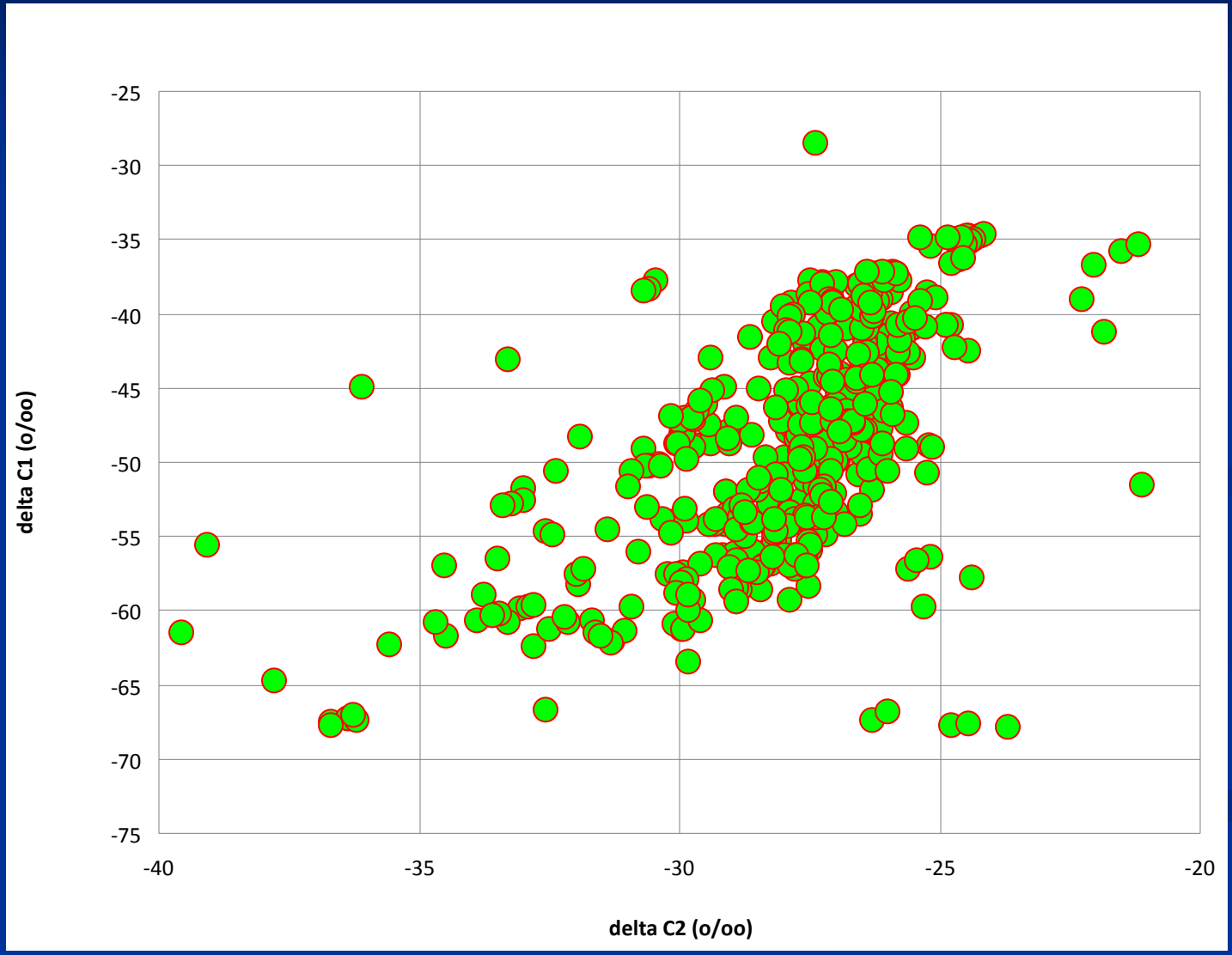
- Model well established and calibrated
- Convenient and accurate

Example 1: mixing ratio of biogas



Data source: GeoMark

Quantifying the mixing ratio of biogas



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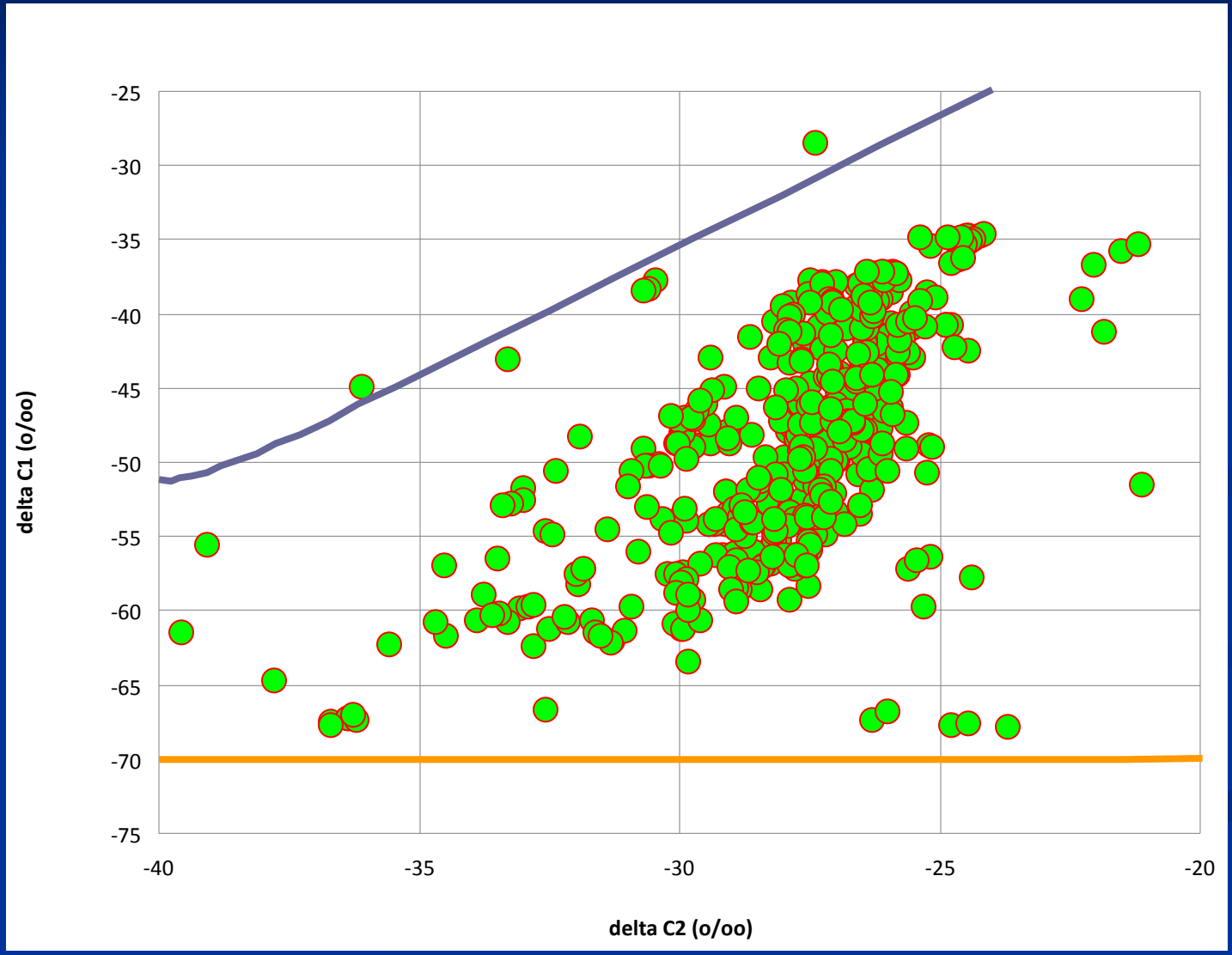

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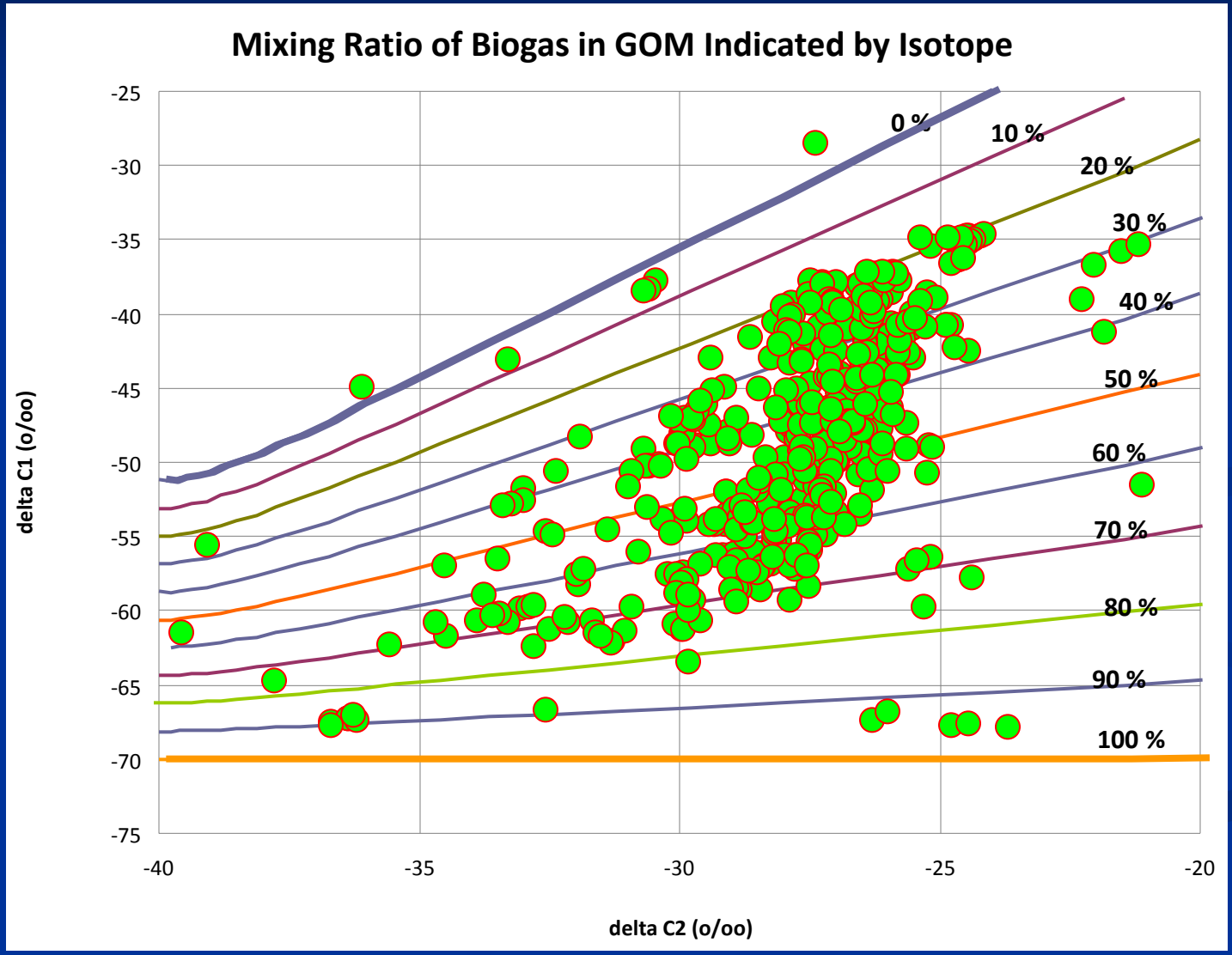
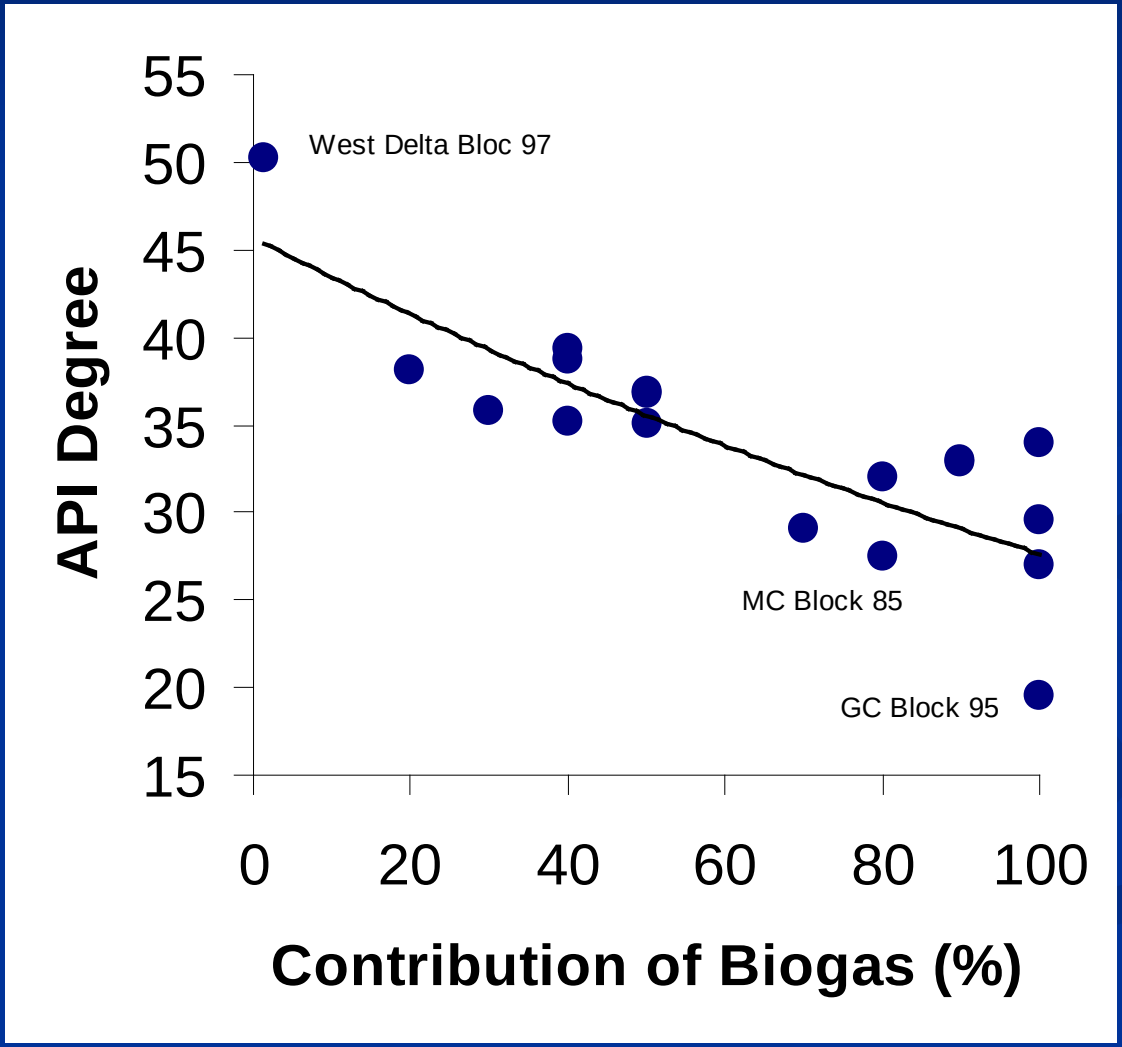
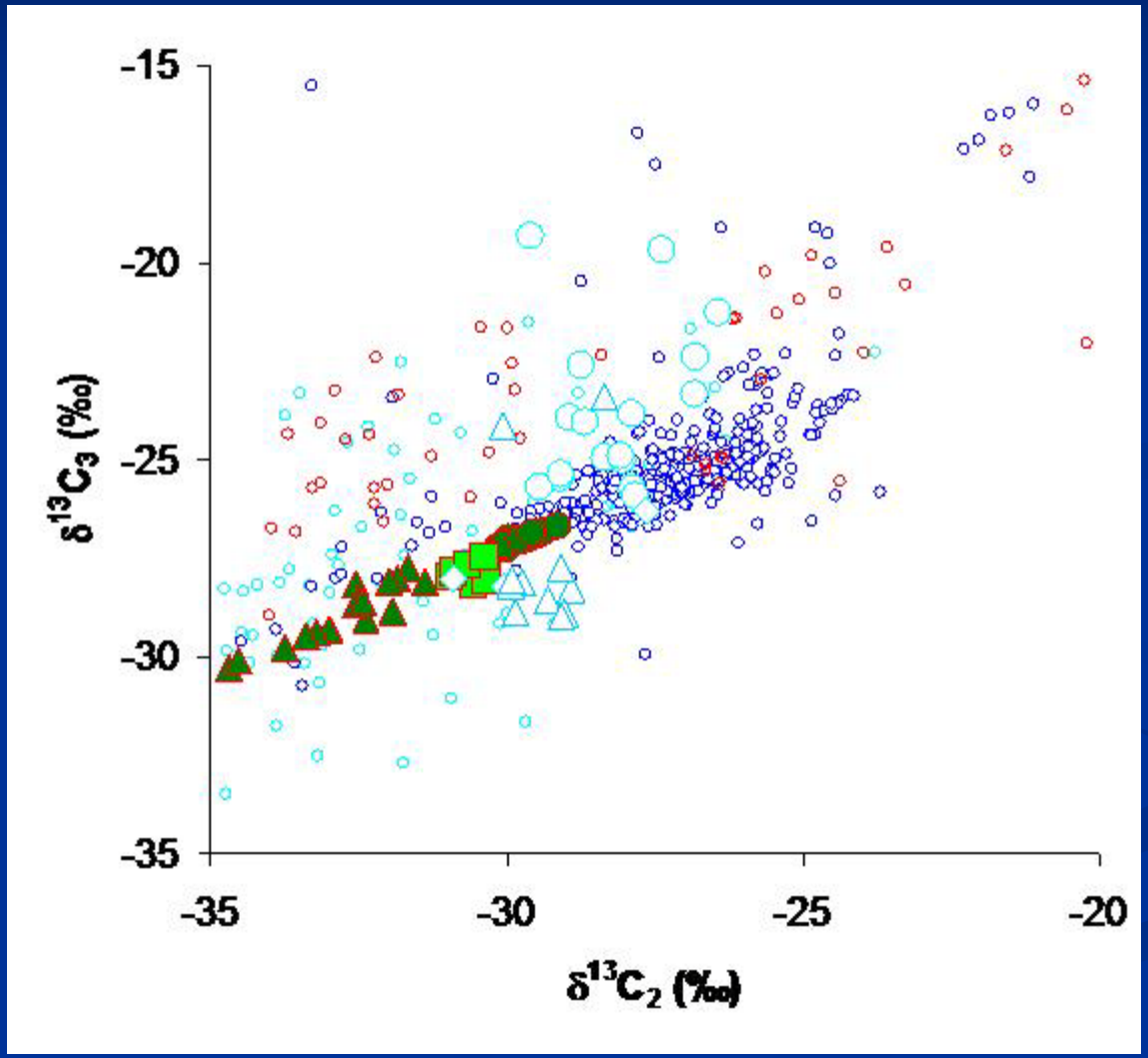


Data source: GeoMark

API indicated by Biodegradation



Example 2: oil-cracking gas



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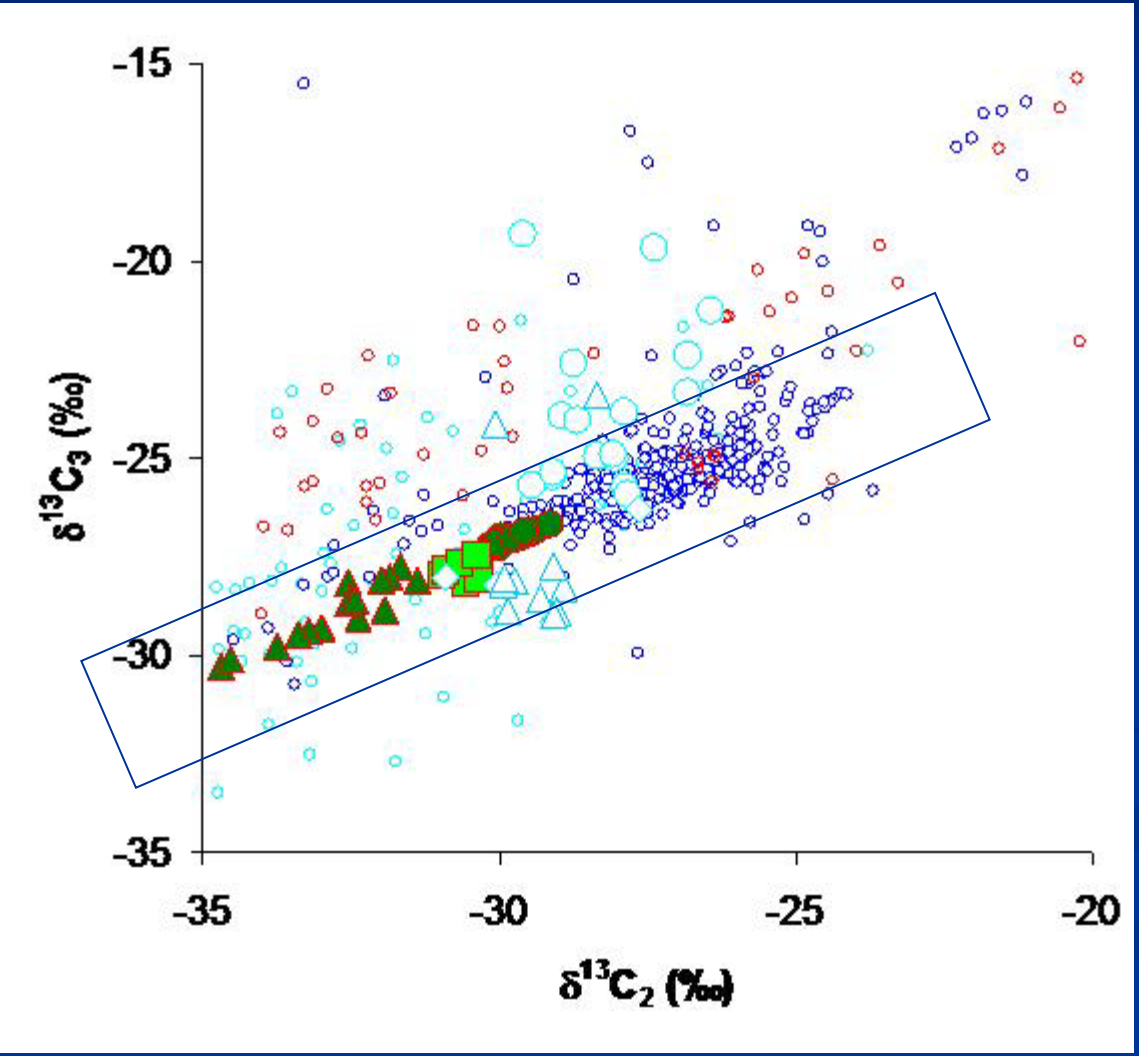
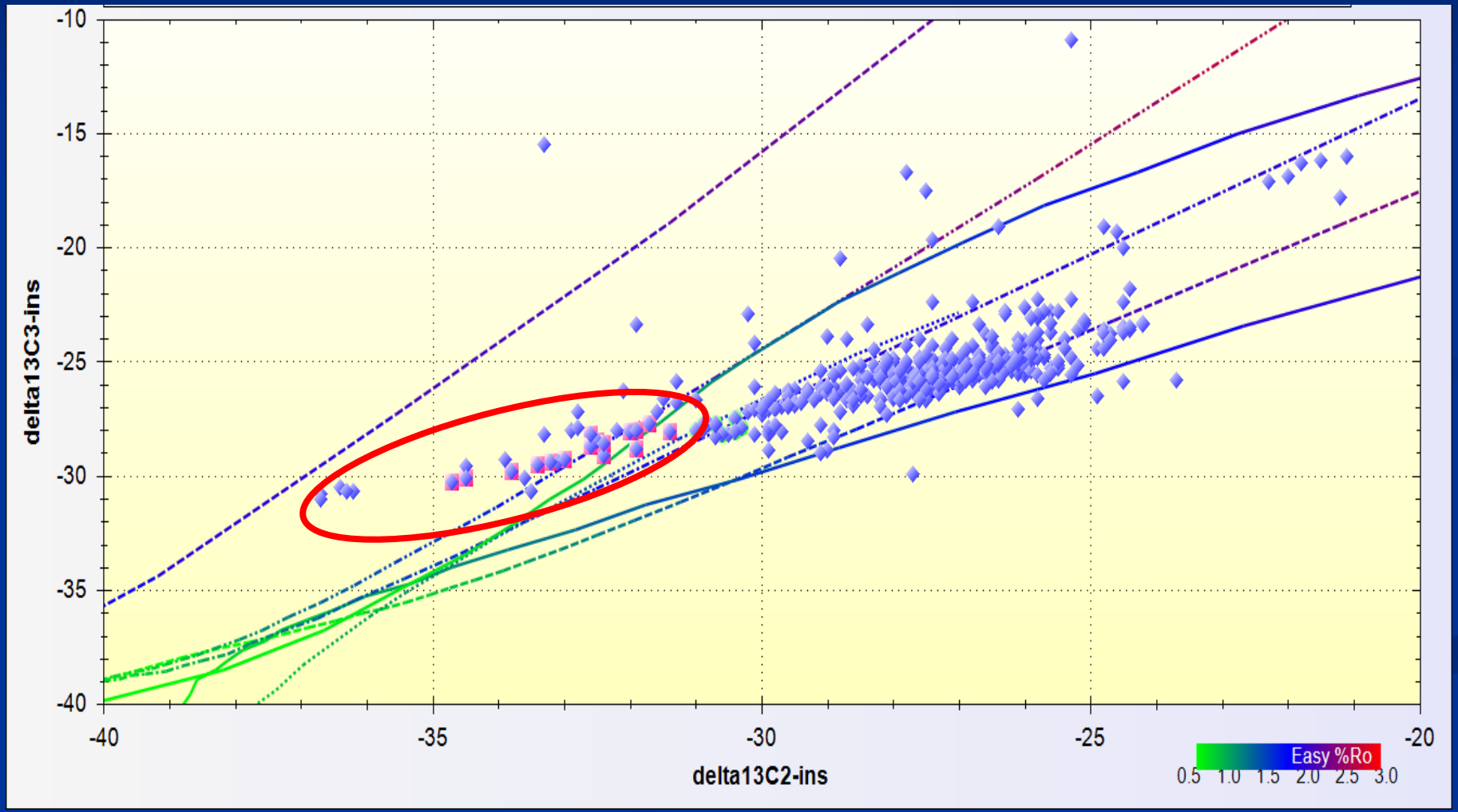
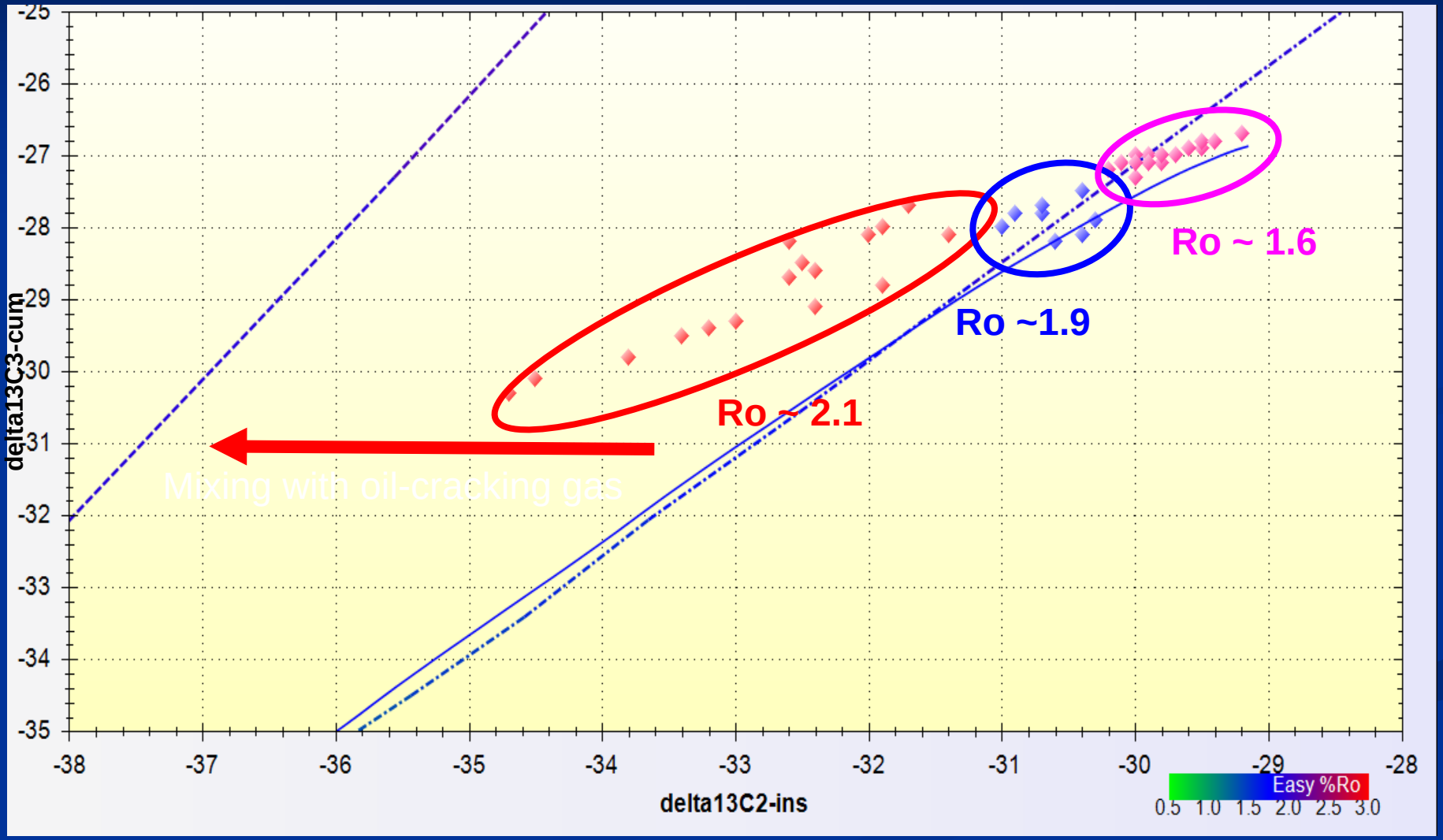


Data source: GeoMark

Deconvolution of oil-cracking gas



Deconvolution of oil-cracking gas



Example of deconvolution

Region	Carbon Isotope Composition (per mil)			Source of Natural Gas		
	C_1	C_2	C_3	Biogenic	Kerogen Thermogenic	Oil Cracking
A	-64.2	-27.9	-15.5	55 %	5 %	40 %
B	-51.5	-32.5	-26.1	21 %	53 %	26 %
C	-38.0	-26.6	-20.9	15 %	76 %	9 %

% of biogenic gas will lead oil alteration process (such as GOR, SARA and API)
% oil cracking gas will lead to the change of GOR and API

Example 3: predicting SARA

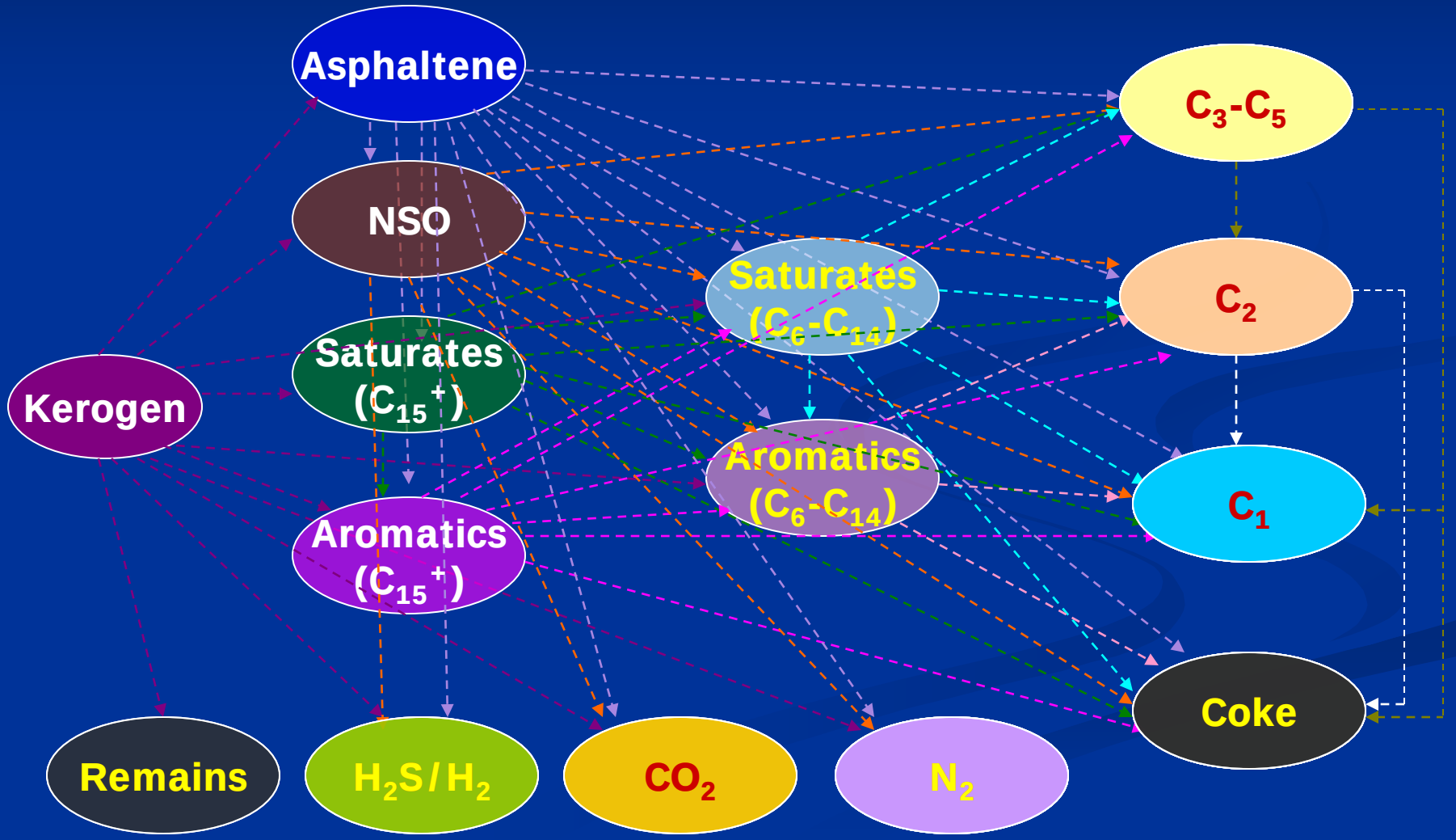
- SARA (saturates, aromatics, resin and asphaltene) composition relates closely to oil property

Why to predict SARA

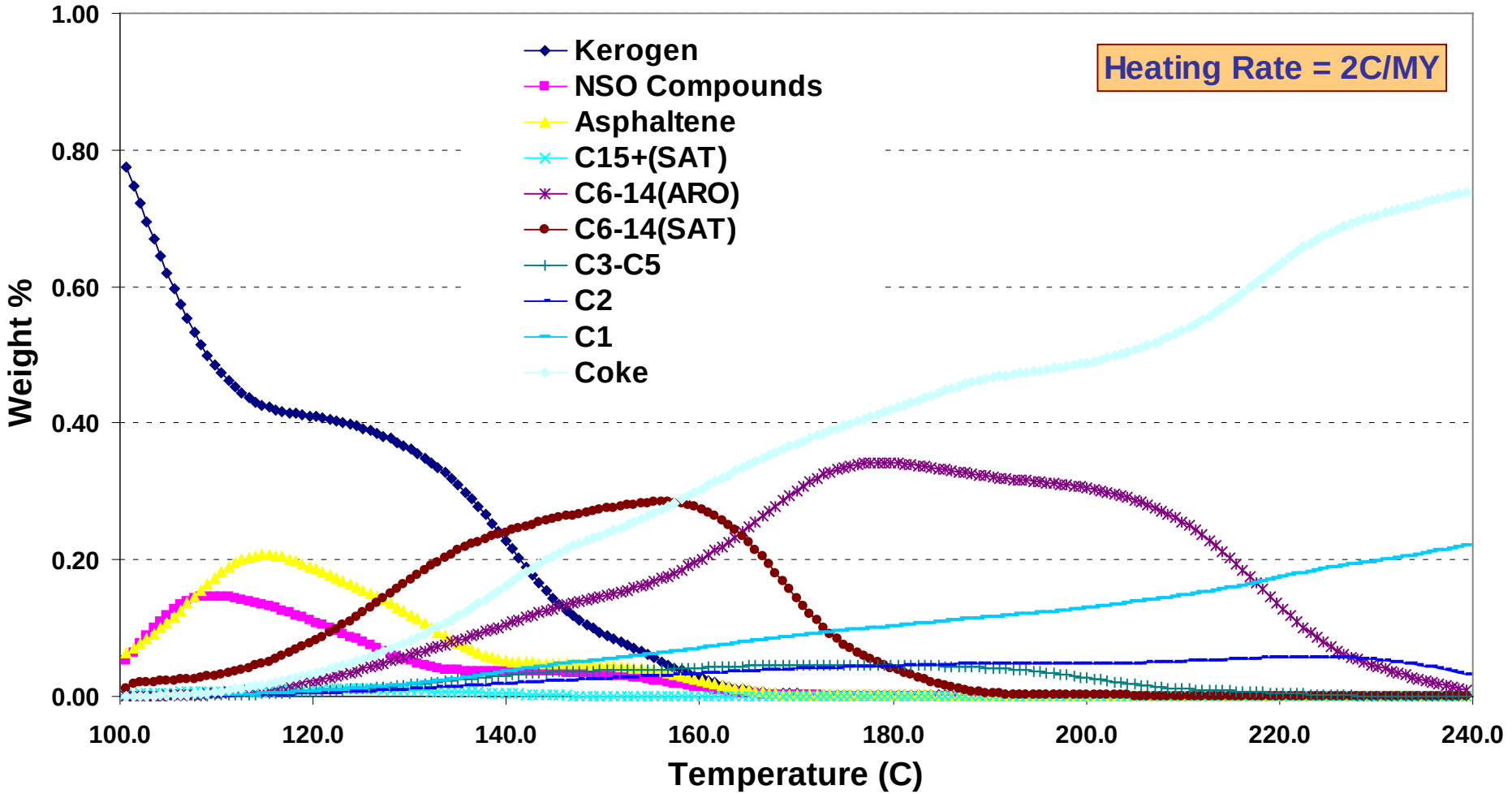
- Early prediction of flow property (viscosity)
- Early prediction of wax precipitation
- Early prediction of asphaltene precipitation
- Early prediction of emulsion problems

How to predict SARA?

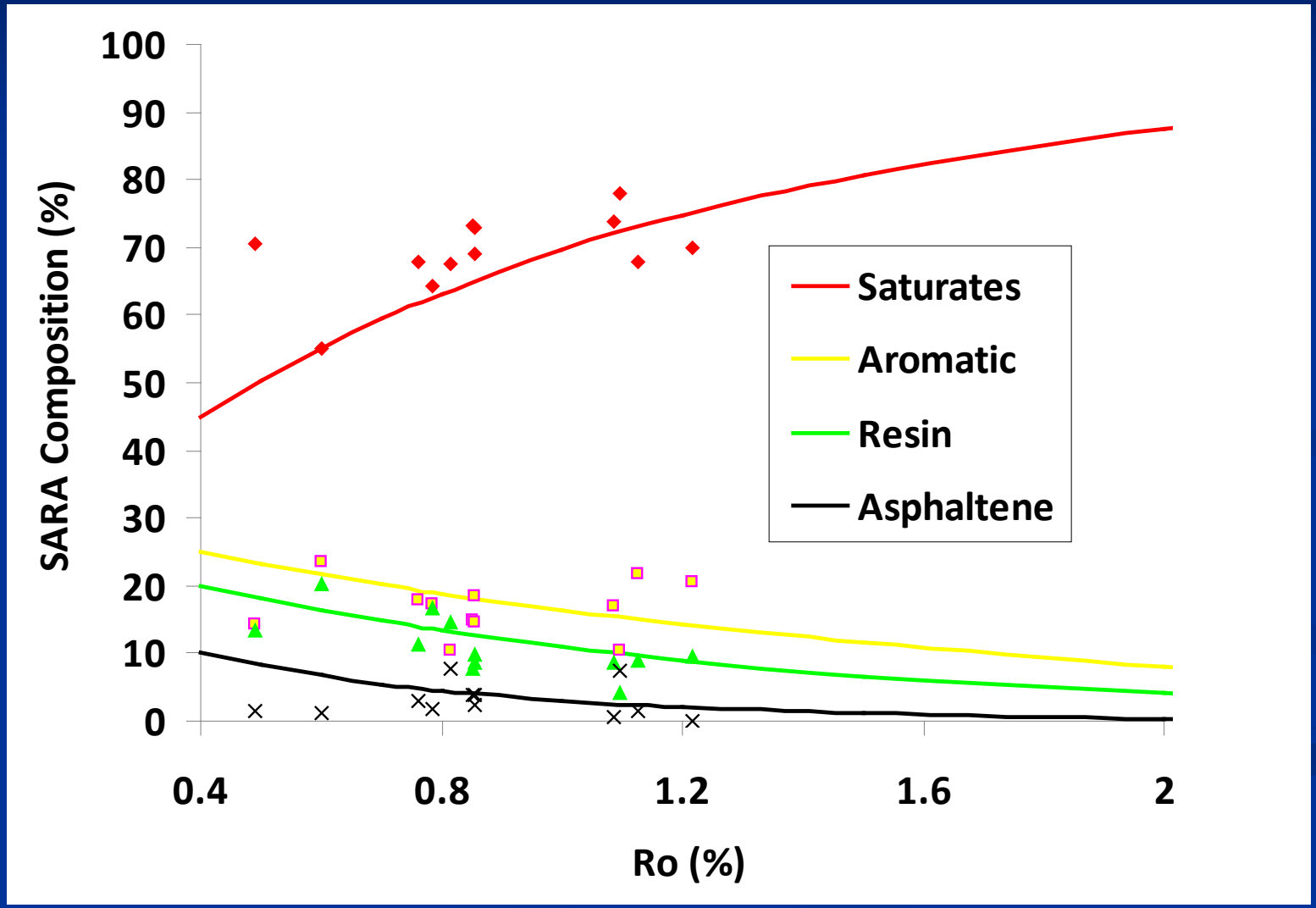
Standard Compositional Cracking Model



Composition Prediction



Predicting SARA



Summary

- Isotope as efficient tool to predict fluid property:
  - Biodegradation
    - Increases asphaltene and NSO
    - Reduces API
    - Increases oil viscosity
  - Oil-cracking
    - Increases asphaltene
    - Increases GOR
    - Reduces API
  - SARA composition

Thanks for your attention!