Jurassic Condensate of the Hudson Canyon Area, U.S. Atlantic: Insight to Deep Sources *

Roger Sassen[1]

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[1]Geology and Geophysics, Texas A & M University, College Station, TX. (rsassen@verizon.net)

Abstract

Molecular and isotopic properties of condensate samples from Kimmeridgian to Albian sandstone reservoirs of Hudson Canyon area provide evidence of vertical migration from Lower to Middle Jurassic carbonate and shale source rocks. Age of source rocks appears similar in U.S. and Canadian Atlantic. Visual kerogen assessment of the rocks shows mixed algal and higher-plant kerogen, explaining several diagnostic features of the condensate. The carbon isotopes of whole-condensate samples correlate to the Middle to Lower Jurassic rocks, reflecting mantle methane from rifting of Pangaea. Biomarkers are absent or present in low relative abundance indicating thermal maturation near the "deadline" for preservation of liquid hydrocarbons. The most powerful evidence of advanced maturation is concentration of the diamondoids, the most thermally stable complex hydrocarbons in the Earth's crust. The relatively high abundance of diamondoids indicates oil was almost totally cracked to form gas-condensate. Star diagrams (adamantane, diamantane, methyl and ethyl derivatives) imply a single source of condensate samples. Oceanographic research has established the presence of numerous sea-floor seeps of microbial methane. Deep traps may contain gas-condensate, shallow traps may contain microbial methane.

Selected References

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JURASSIC CONDENSATE OF THE HUDSON CANYON AREA, U.S. ATLANTIC: INSIGHT TO DEEP SOURCES

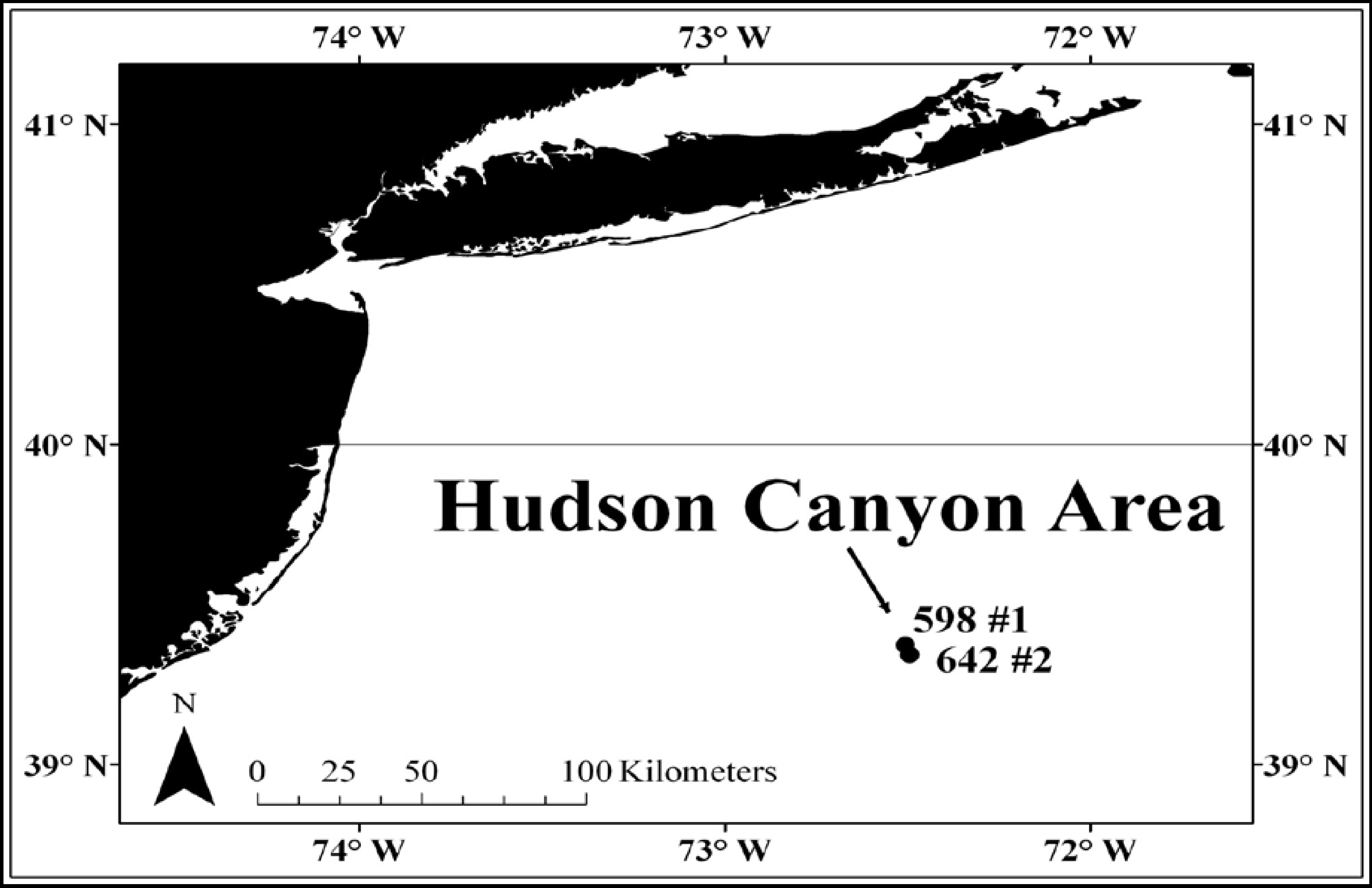
Roger Sassen
Department of Geology and Geophysics
Geochemical and Environmental Research Group
Texas A&M University

IN MORATORIUM

Of 32 wells drilled in the Baltimore Canyon area, 8 wells encountered shows and 5 tested gas, gas-condensate, or condensate. Other wells drilled in the U.S. Atlantic were not as successful…

Condensate from Hudson Canyon Under Fluorescence

LOCATIONS OF KEY HUDSON CANYON WELLS



CONDENSATE SAMPLES ANALYZED (7)

- Hudson Canyon 598 #1 DST 1 (1)
- Hudson Canyon 598 #2 DST 2 (2)

- Hudson Canyon 642 #2 DST 1A (1)*
- Hudson Canyon 642 #2 DST 3A (1)*
- Hudson Canyon 642 #2 DST 4 (2)

- *Lesser quality samples

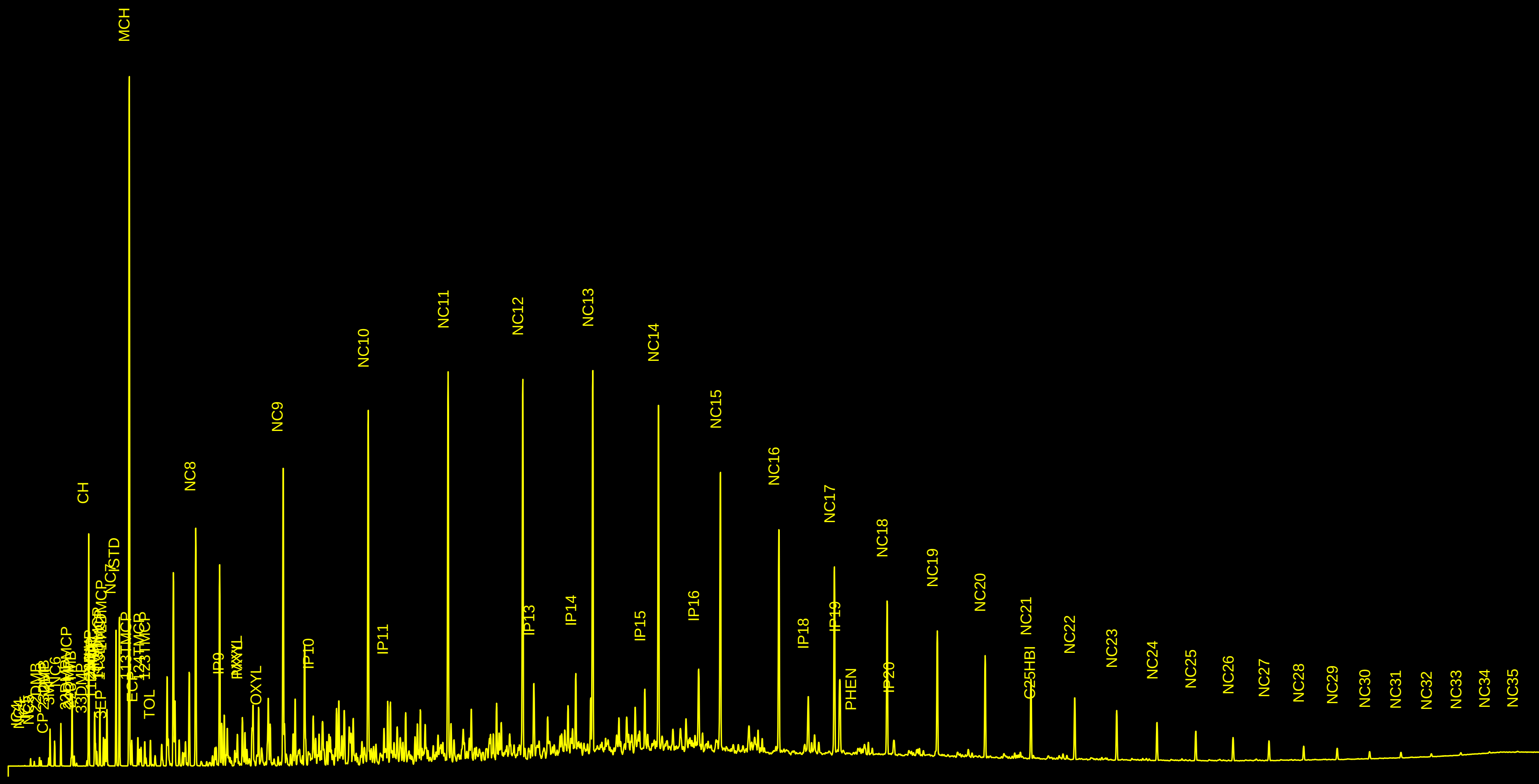
MOST USEFUL HUDSON CANYON SAMPLES

HC 598 #1 Well	DST 1	Kimmeridgian	4,285-4,297 m
HC 598 #1 Well	DST 2	Tithonian	4,109-4,121 m
HC 642 #2 Well	DST 4	Albian	2,535-2,536 m

ALL HUDSON CANYON CONDENSATES ARE ALTERED

- Oil was thermally cracked at depth before vertical migration from M.-L. Jurassic source to Upper Jurassic reservoirs
- Diamondoids were concentrated as 99% of oil cracked to CH_4
- Liquids were greatly fractionated
- Gas chromatography shows differences between all reservoir compartments

Hudson Canyon 642 No. 2 Well
Albian Reservoir



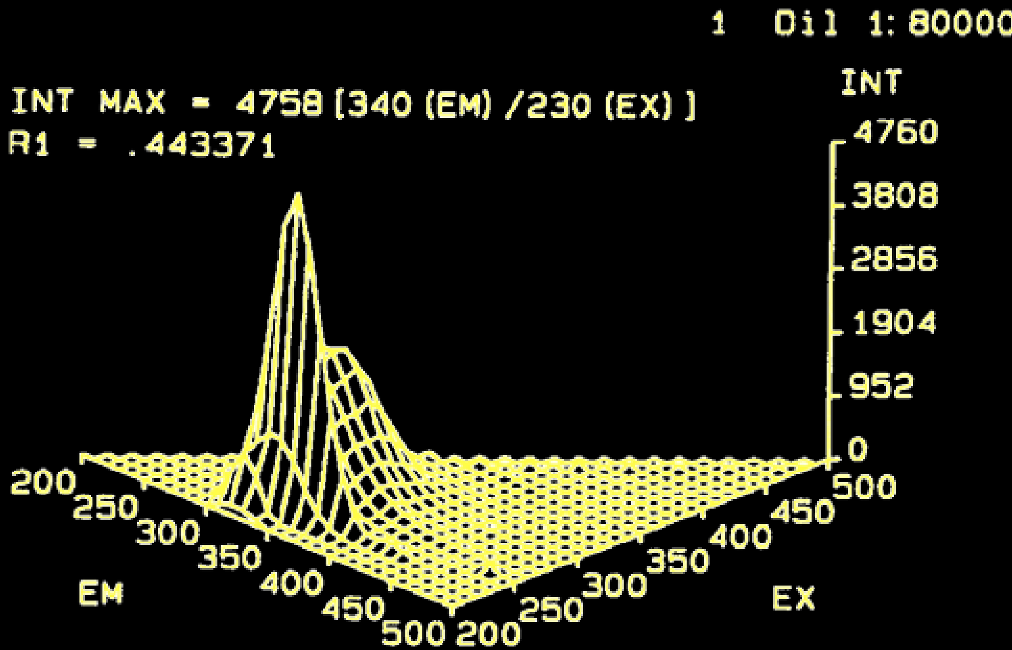
Whole Condensate GC Trace

Thermal Maturity Framework

- Gas-condensate is far more thermally mature than Upper Jurassic reservoirs
- The gas-condensate was not generated by coaly shale adjacent to reservoirs; source rock was deeper and hotter
- Gas-condensate migrated vertically from depth to the trap

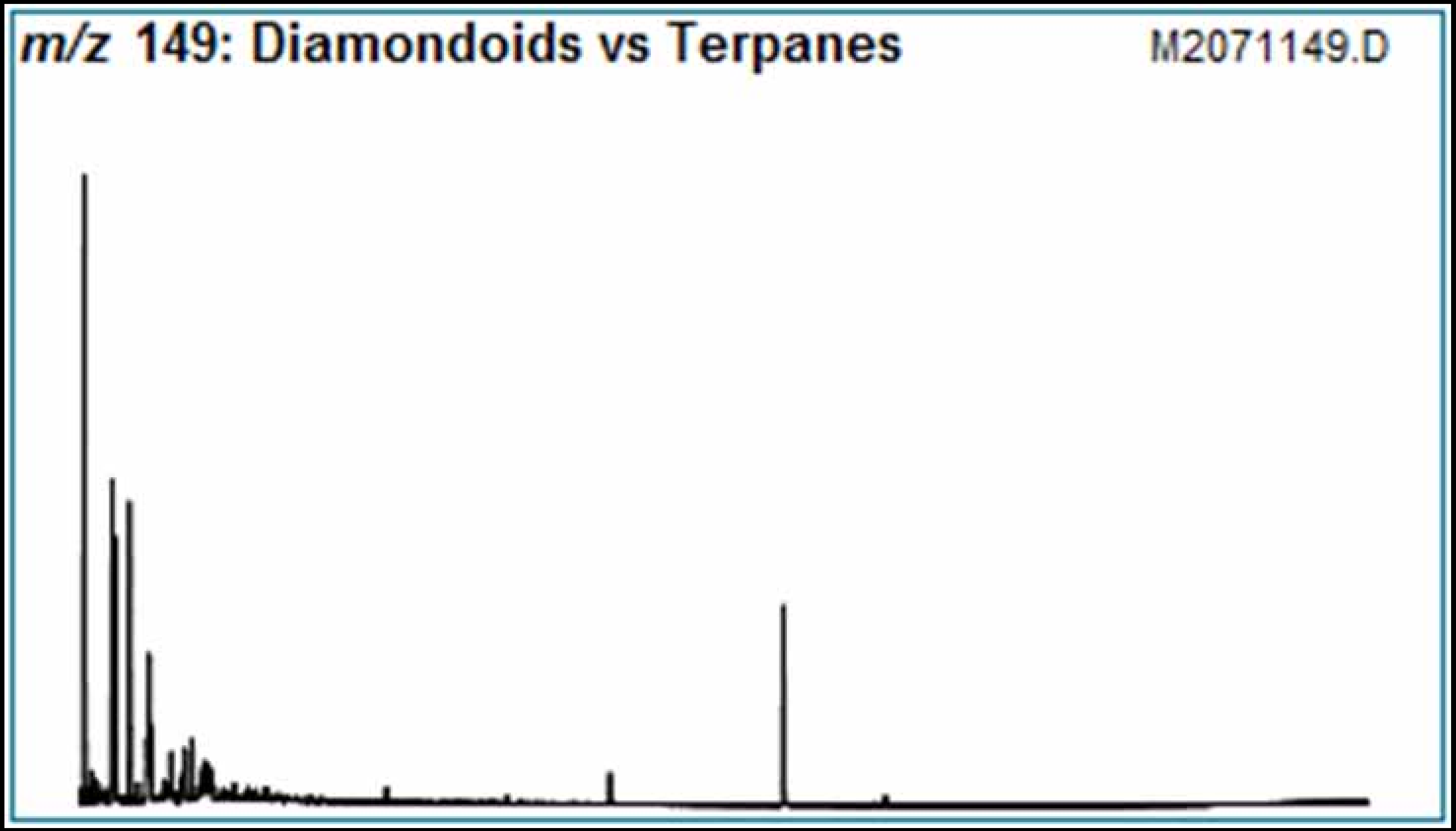
(Miller, 1986; Sassen and Post, 2008, OG)

Hudson Canyon 598 No.1 Well
Tithonian Reservoir



Total Scanning Fluorescence (TSF) indicates intense Thermal Cracking

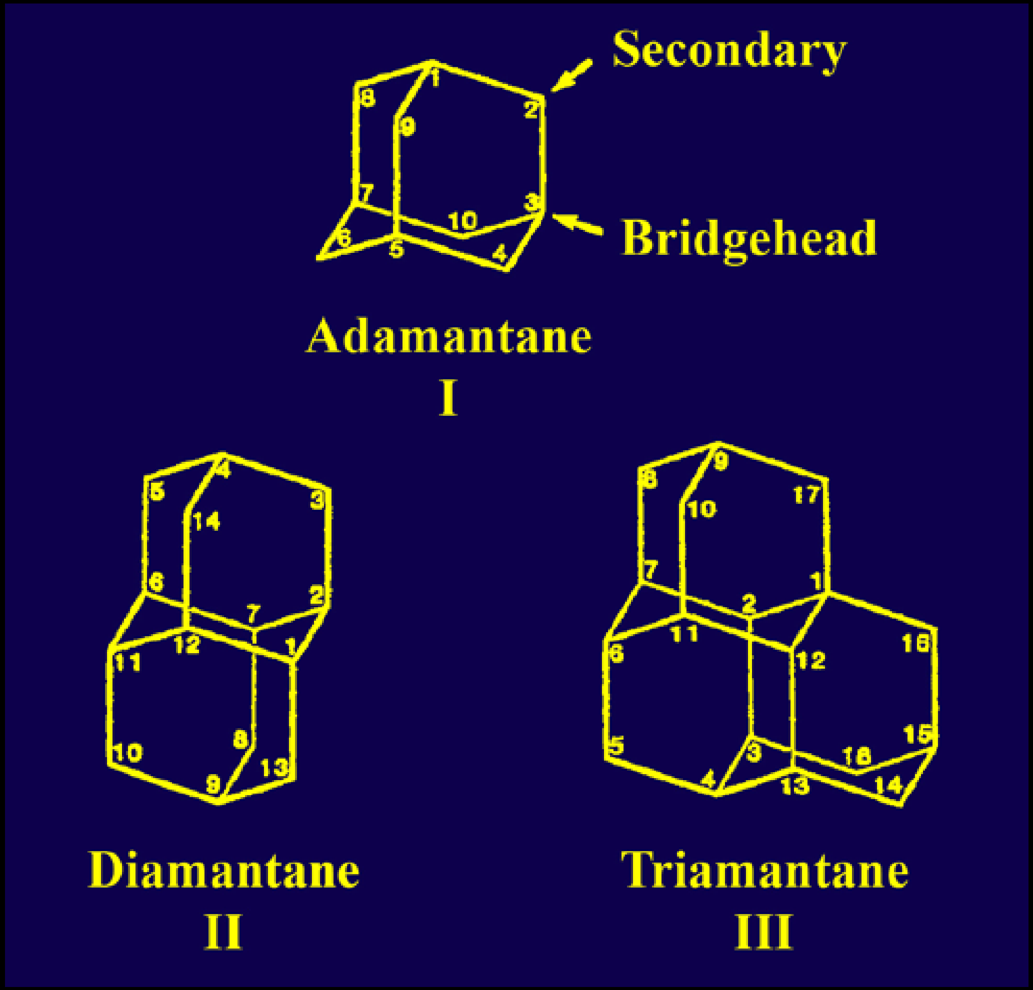
Minimum Maturity = 1.3 to 1.4% Ro



DIAMONDOIDS

The most thermally stable of all complex hydrocarbons in Earth's crust…

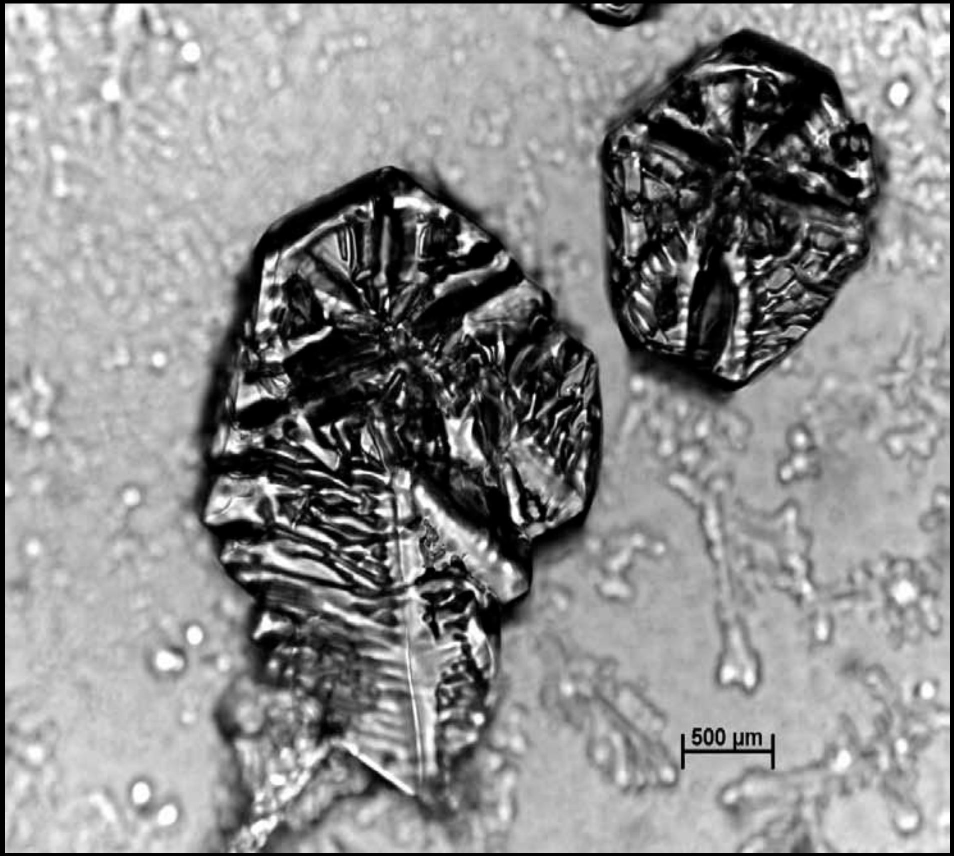
Diamondoid Parent Compounds



After Wingert, 1992

Solid Diamondoids that Stopped Production at Gas Field

Adamantane – The Simple Diamondoid



Crystals of pure adamantane
grown in laboratory

Chemical Properties

- $C_{10}H_{16}$
- Molecular weight = 136.24
- Density = 1.07 gm/cc
- Melting Point = 268^{o}C (sealed)
- Crystal System = isometric
- Vapor pressure similar to jet fuel

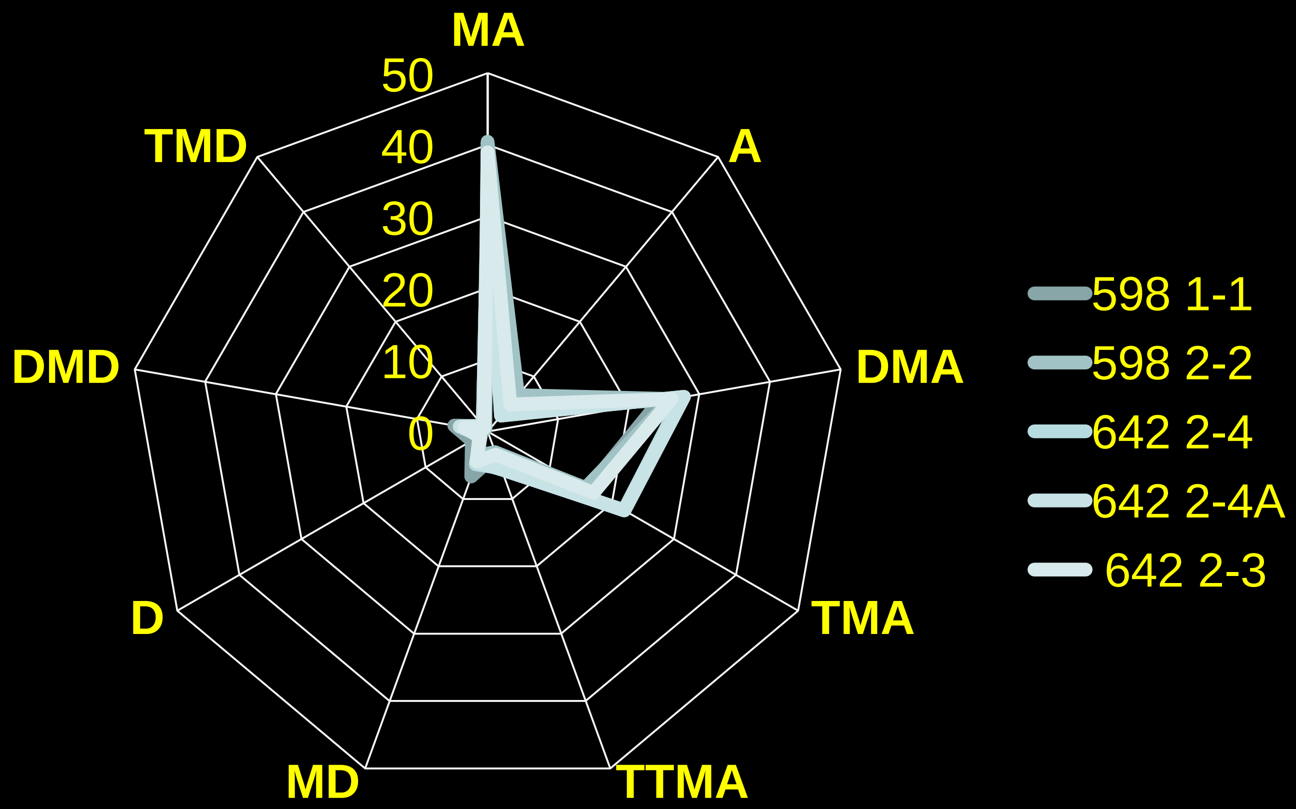
TOTAL DIAMONDOID CONCENTRATIONS

- **Concentrations similar to other over-mature condensates from shale (Wilcox, Tuscaloosa) and clay-rich carbonate (Smackover) sources:**

- **Albian (HC 642 #2-4) = 4,774 ppm**
- **Tithonian (HC 598 #1-2) = 4,790 ppm**
- **Kimmeridgian (HC 598 #1-1) = 4,742 ppm**

- *Analyses by former Baseline Resolution Inc. (Weatherford Laboratories)*

FINGERPRINTING DIAMONDOIDS OF HUDSON CANYON CONDENSATE



THERMAL MATURITY

The diamondoids estimate the thermal maturity of over-mature condensate samples

Diamondoid Thermal Maturity Ratios

Methyladamantane Index =
1MAM / (1MAM + 2MAM)

Methyldiamantane Index =
4MDI / (1MDI + 3MDI + 4MDI)

Diamondoid Ratios of Hudson Canyon Condensate

	MINIMUM	MAXIMUM
MAI	0.70	0.75
MDI	0.47	0.54

Maximum thermal maturity equivalent to 1.5% to 1.6% Vitrinite Reflectance

(Chen et al., 1996; Jinggui et al., 2000)

Carbon Isotope Fingerprint

The $d^{13}C$ of Hudson Canyon condensates are consistent with an extreme Jurassic depositional environment

BULK CARBON ISOTOPES (d^{13}C) OF HUDSON CANYON CONDENSATES ARE UNUSUAL

KIMMERIDGIAN	-23.7‰ PDB
TITHONIAN	-24.7‰ PDB
ALBIAN	-24.6‰ PDB

The mean d^{13}C of 47 Smackover oils is -24.8‰ PDB (Claypool and Mancini, 1990).

Heavy d[13]C = Restricted shallow sea, high temperature, constant wind, low biodiversity, anoxic-hypersaline water column, evaporites

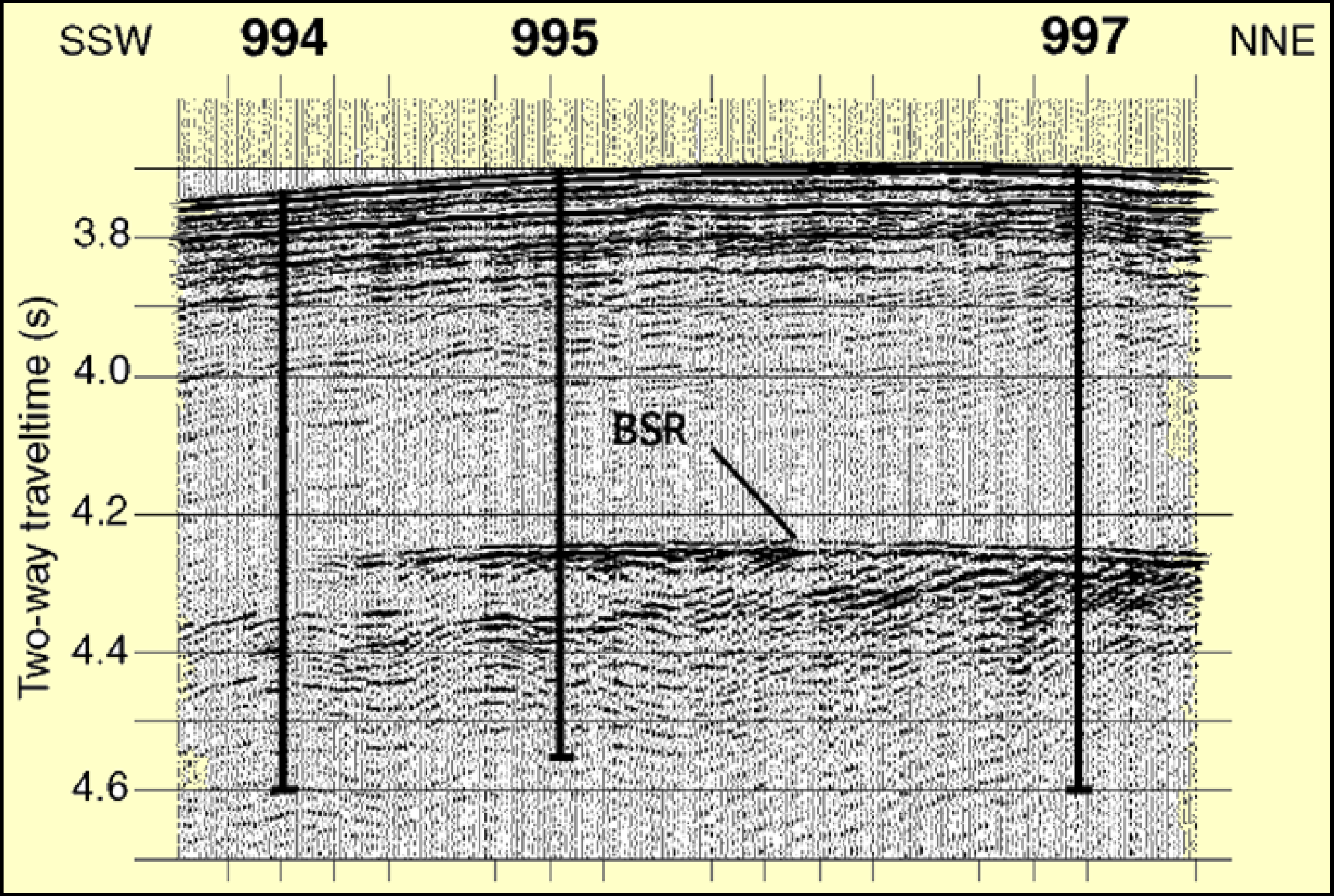
Links to Middle-Lower Jurassic Carbonate Samples

- Condensate and the carbonate kerogen share similar d^{13}C of about -24‰
- Condensate and carbonate rock extracts share high pristane/phytane ratios
- VKA shows mixed kerogen in the rock
- Condensate and the deep carbonate rock share similar thermal maturity

MICROBIAL METHANE VENTS IN U.S. ATLANTIC

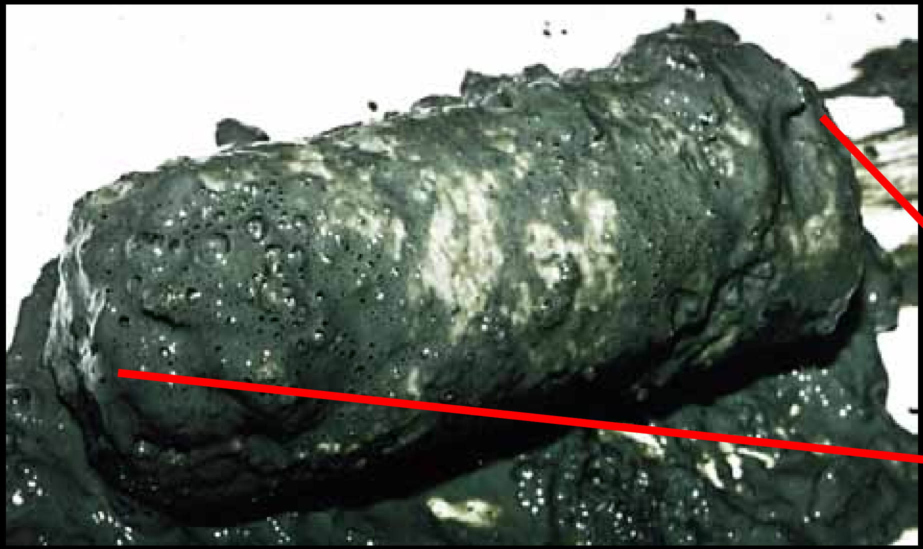
- Gas vents were identified decades ago on the Atlantic sea floor
- A shallow microbial petroleum system generated huge volumes of microbial methane in sediment
- Are there large traps with microbial methane in U.S. Atlantic?
- Potential for methane hydrate production?

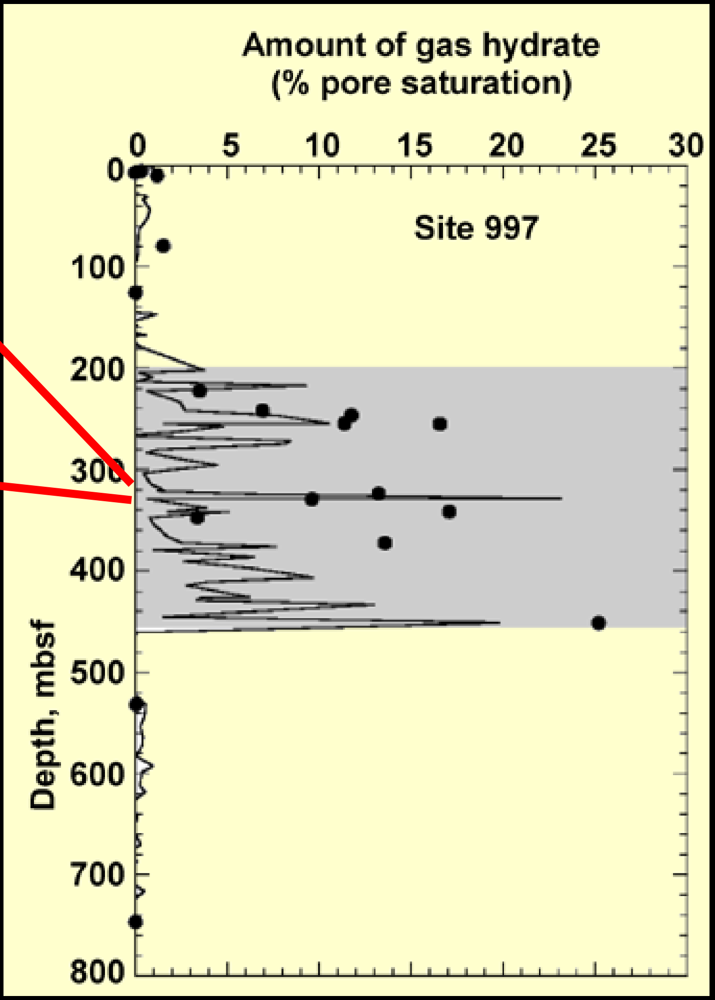
Example of BSR from the Blake Ridge



After Paull and Matsumoto, 2000

Gas Hydrate Estimates at Blake Ridge





Total gas hydrate resource:

~28x10^{12} m^{3} or ~990 TCF

(Dickens et al, 1997)

After Matsumoto and Borowski, 2000

CONCLUSIONS

HUDSON CANYON PETROLEUM SYSTEMS: THERMOGENIC AND MICROBIAL

EXPLORATION SIGNIFICANCE

- **Deeper, older traps need to be tested for gas-condensate, Middle Jurassic to Triassic**
- **Reservoir properties may be preserved at great depth…**
- **Potential for shallow traps with microbial methane should not be overlooked**

Acknowledgments

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THE END