

PS Confirmation of Hydrocarbon Shows in the Mobil #3 Offshore Hyde County Well, North Carolina*

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Abstract

In 1965, Socony Mobil Oil Company drilled the #3 State of North Carolina well (NCGS #HY-OT-01-65; API 32-095-00009; Hyde County, North Carolina) to a total depth of 7,309 ft in Pamlico Sound. The well penetrated 7,222 ft of Cenozoic and Mesozoic strata before ending in Paleozoic (?) leucogranodiorite. Well data and thermal modeling examined prior to this study indicated that the entire section penetrated in the well bore was thermally immature for the local generation of thermogenic petroleum. However, mud log reports while drilling indicated that insoluble asphaltenes were encountered within the Lower Albian - Berriasian interval at 6,710 ft, 6,750 ft, and 7,160 ft. Drill cuttings between 1,007 ft and 7,336 ft were collected from this well archived at the North Carolina Geological Survey repository, prepared, and examined using fluid inclusion stratigraphic analysis technology and fluid inclusion petrography. The results of this initial examination indicate both liquid and gaseous petroleum throughout much of the well bore.

Mixed biogenic and thermogenic gas indications as well as thermogenic oil responses were observed in the Tertiary and Cretaceous shallow and intermediate intervals. Responses within the deeper Lower Cretaceous intervals show thermogenic gas and liquid indicators. Occurrences of gas- and oil-prone kerogen were also observed. Rare occurrences of mature oil-prone kerogen were observed, as well as rare instances of low gravity (possibly immature) oil inclusions. Specific responses, which might have confirmed the recorded observation of asphaltenes, were not observed; however, a rare, dead hydrocarbon stain was observed in thin section from samples near total depth.

Finally, organic acid anomalies are indicated, which, among other possibilities, can reflect reservoired charge within a several kilometer radius. The indications of petroleum within this analysis do not necessarily imply the presence of a missed or bypassed hydrocarbon discovery at the borehole location, but they do suggest that a petroleum system may be present within the Atlantic Coastal Plain and continental rise area of eastern North Carolina.

by James L. Coleman*, Jr., Jeffrey C. Reid**, and Don L. Hall***

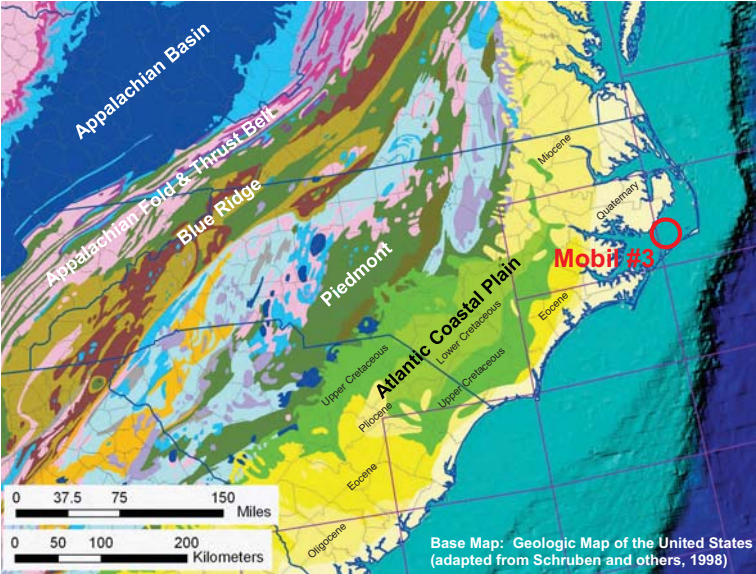
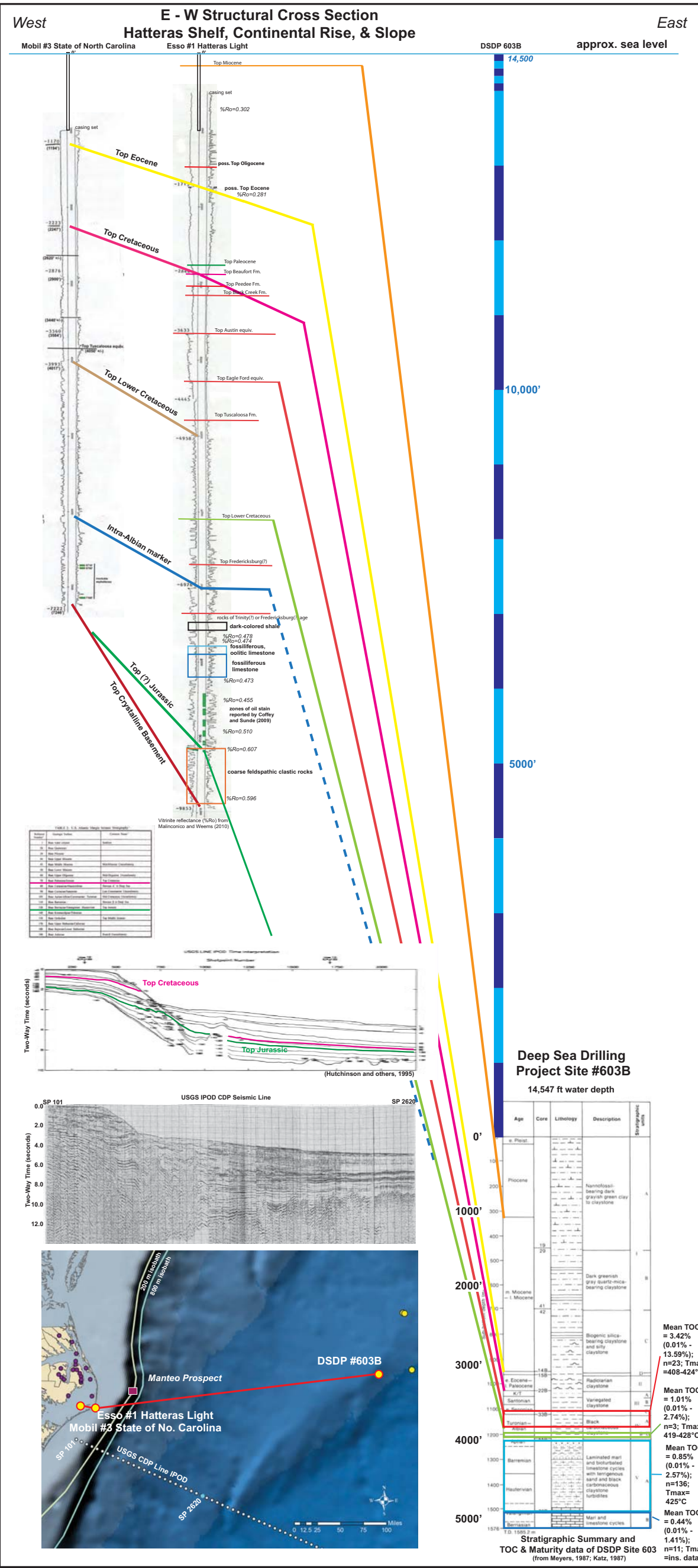
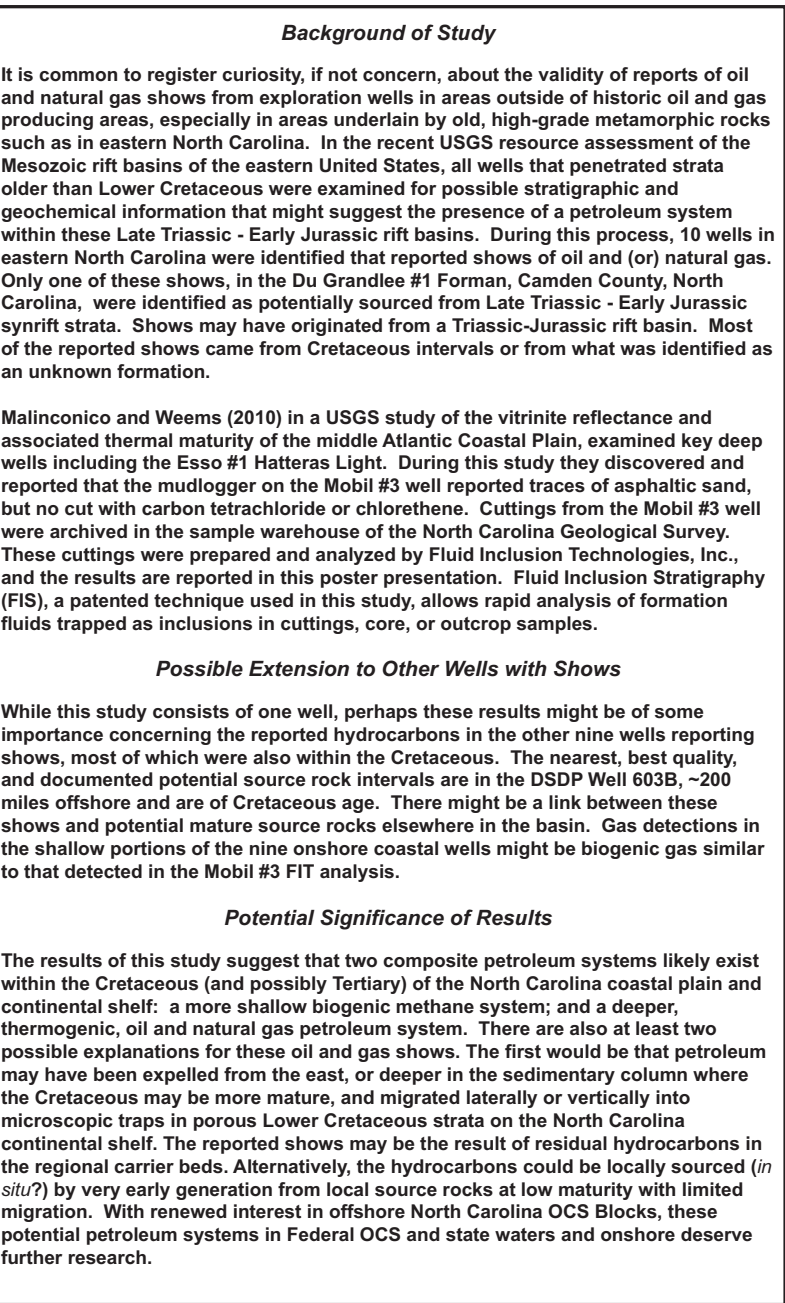
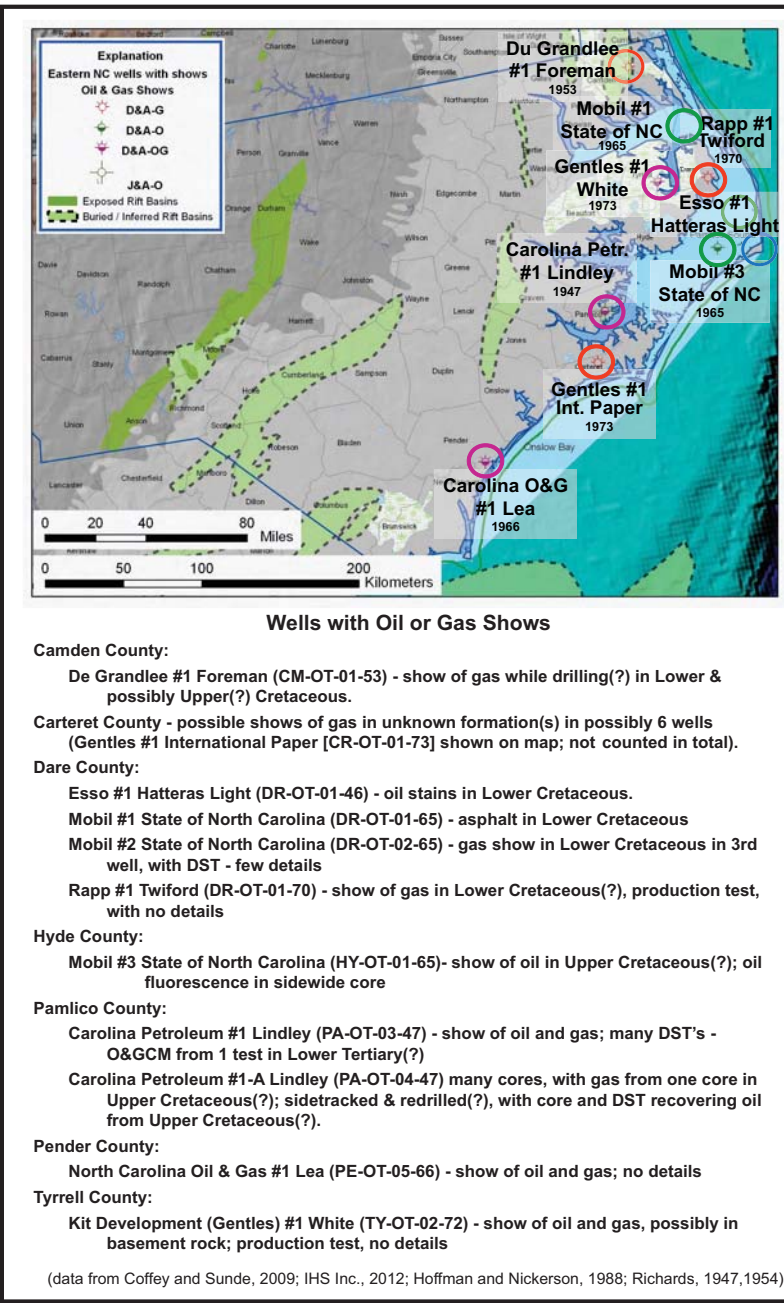
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Abstract

In 1965, Socony Mobil Oil Company drilled the #3 State of North Carolina well (NCGS #HY-OT-01-65; API 32-095-00009; Hyde County, North Carolina; also discussed here as the **Mobil #3** well) in Pamlico Sound. The well penetrated 7222 ft of Cenozoic and Mesozoic strata before reaching a total depth of 7309 ft in Paleozoic (?) leucogranodiorite. Well data and thermal modeling examined prior to this study indicated that the entire section penetrated in the well bore was thermally immature for the local generation of thermogenic petroleum. However, while drilling, mud log reports indicated that insoluble asphaltenes were encountered within the Lower Albion – Berriasian interval at 6710 ft, 6750 ft, and 7160 ft. Drill cuttings from this well archived at the North Carolina Geological Survey repository from between 1007 ft and 7336 ft were collected, prepared, and examined using fluid inclusion stratigraphic analysis technology and fluid inclusion petrography. The results of this initial examination indicate both liquid and gaseous petroleum throughout much of the well bore.

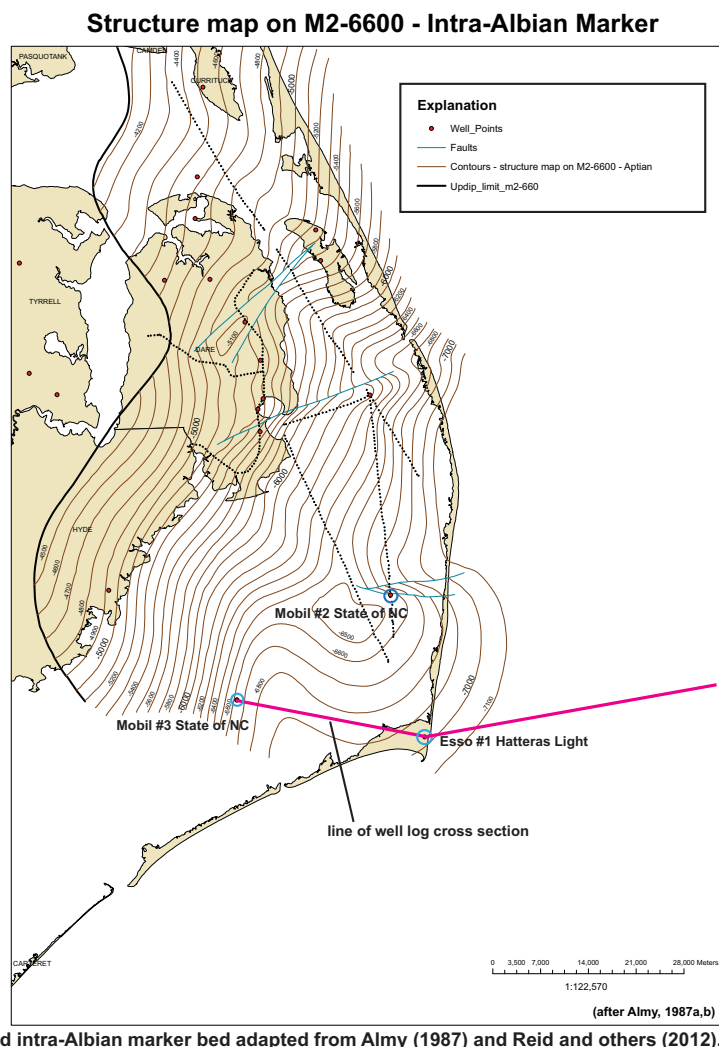
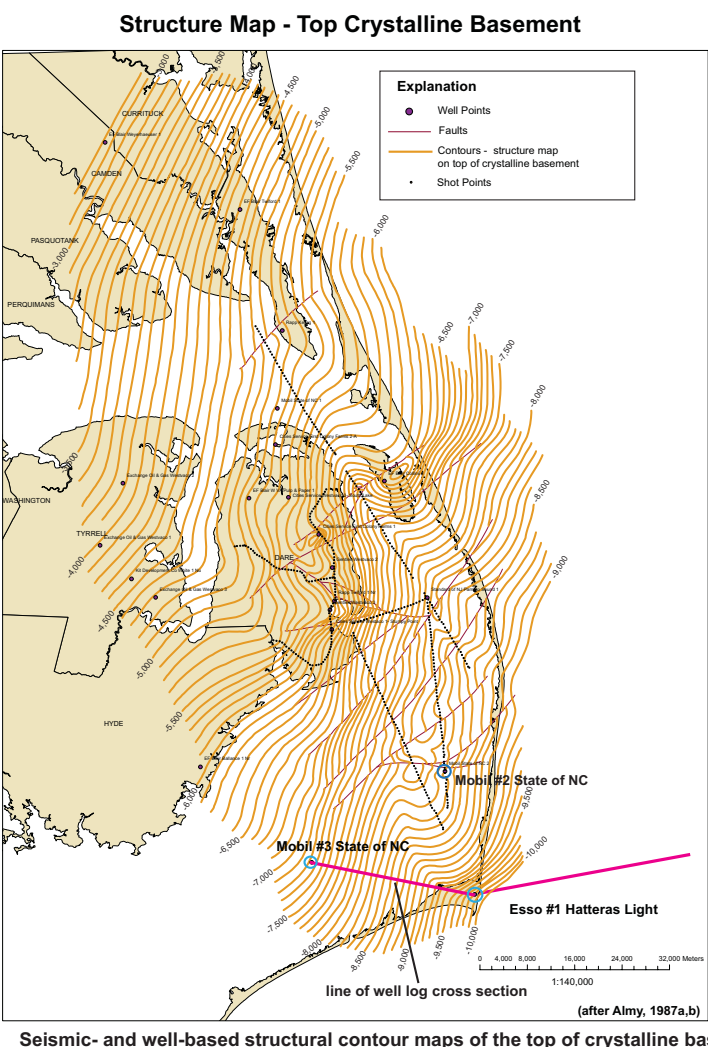
Mixed biogenic and thermogenic gas indications as well as thermogenic oil responses were observed in the Tertiary and Cretaceous shallow and intermediate depths. Within the deeper Lower Cretaceous intervals thermogenic gas and liquid indicators were found. Occurrences of gas- and oil-prone kerogen were also observed. Rare occurrences of mature oil-prone kerogen were also observed, as well as rare instances of low gravity (possibly immature) oil inclusions. Specific responses which might have confirmed the recorded observation of asphaltenes were not observed; however, a rare occurrence of “dead” hydrocarbon stain was observed in thin section from samples near total depth.

Finally, organic acid anomalies are indicated, which, among other possibilities, can reflect possible reservoir charge within a several kilometer radius. The indications of petroleum within this analysis do not necessarily imply the presence of a missed or bypassed hydrocarbon discovery at the borehole location. However, they suggest that a petroleum system may be present within the sedimentary strata of Atlantic Coastal Plain and continental shelf area of eastern North Carolina.

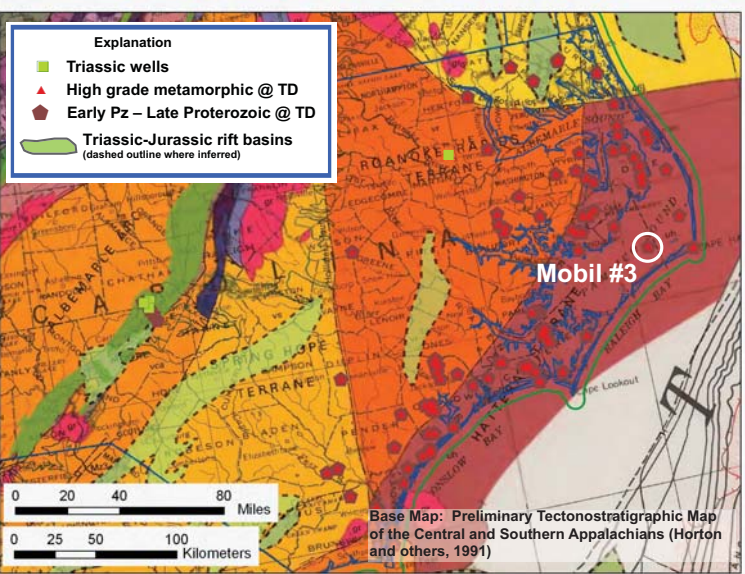
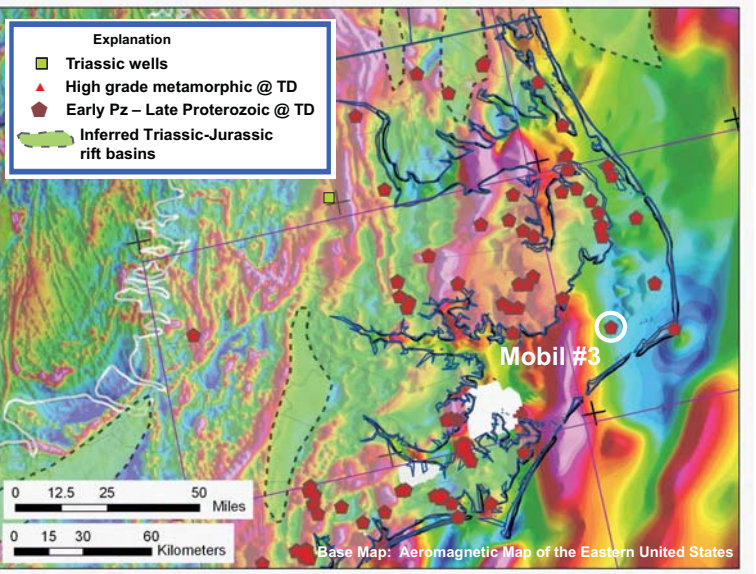


The geology of eastern North Carolina consists of a eastward thickening veneer of siliciclastic and carbonate sedimentary rocks and coastal plain sediments, which range in age from Upper Jurassic to Recent. This coastal plain section has a relatively simple structural geology, with few faults and structures. These strata overlie a complex folded and faulted meta-igneous and meta-sedimentary rocks of Early Paleozoic to Late Proterozoic age, which in turn are punctuated in places by narrow, Late Triassic (?) to Early Jurassic (?) rift basins.

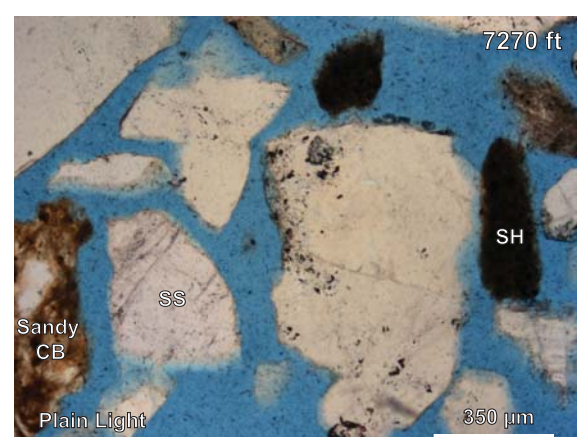
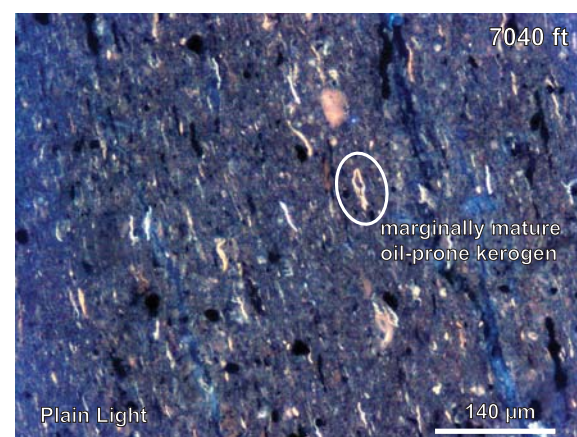
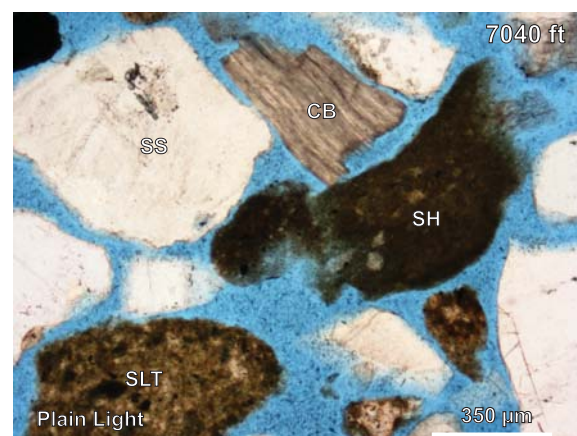
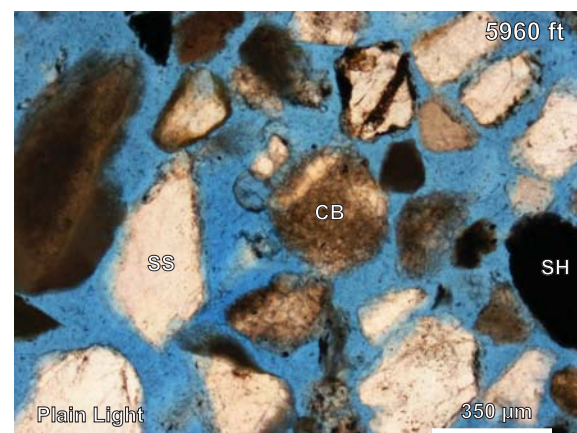
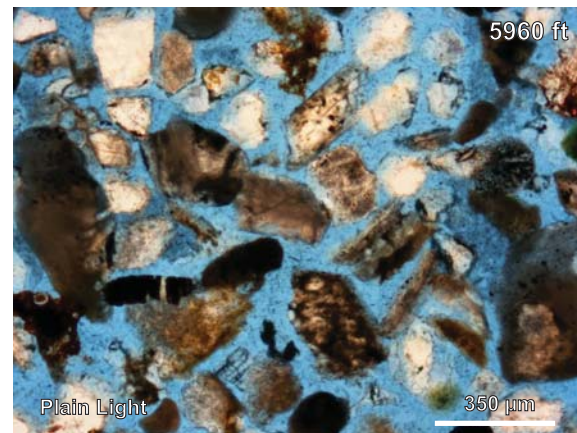
This geologic motif is present throughout the area of Pamlico Sound, where the Mobil #3 well was drilled. Identified and possible Triassic - Jurassic rift basins are not present in easternmost North Carolina based on drilling, seismic, and potential fields geophysical information. Almost all of the wells drilled within and around Pamlico Sound reached total depth in a high grade metamorphic basement composed of metavolcanic and volcanogenic meta-sedimentary rocks of the Roanoke Rapids terrane and metamorphic plutonic rocks of the Hatteras terrane (Horton and others, 1991). With the possible exception of a hypothesized and undrilled Triassic-Jurassic rift basin in Jones, Craven, and Pitt Counties, NC, there is no likely local source rock kitchen to provide petroleum to available reservoirs.



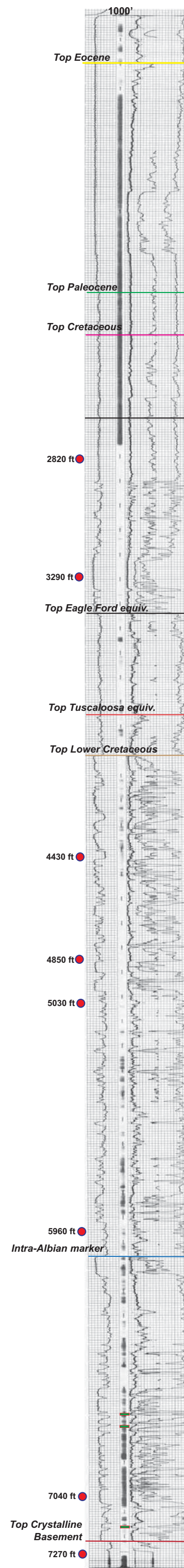
The structural geology displayed on sparse seismic profiles and potential field data over the eastern North Carolina coastal plain is essentially ramp dip to the east, punctuated in places by normal faults with relatively minor throw within the sedimentary section. A structural high near the location of the Mobil #2 State of North Carolina well persists. By middle Aptian time, the effect of fault displacement on the sedimentary section all but disappeared (Almy, 1987a).



(SS = sandstone; SH = shale; SLT = siltstone; CB = carbonate; GL = glauconite)



**Mobil Oil Company
#3 State of North Carolina
Offshore Hyde County**

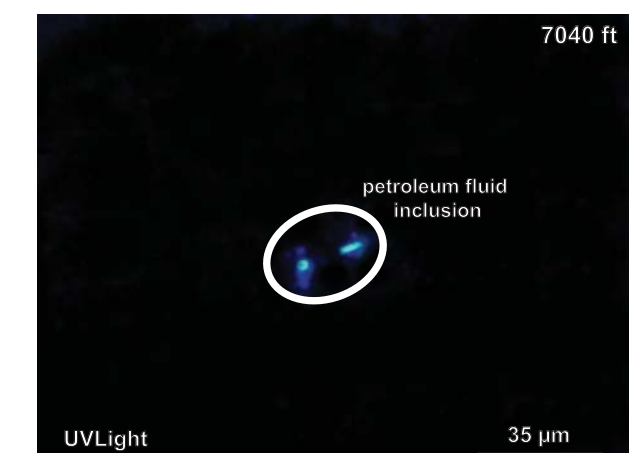
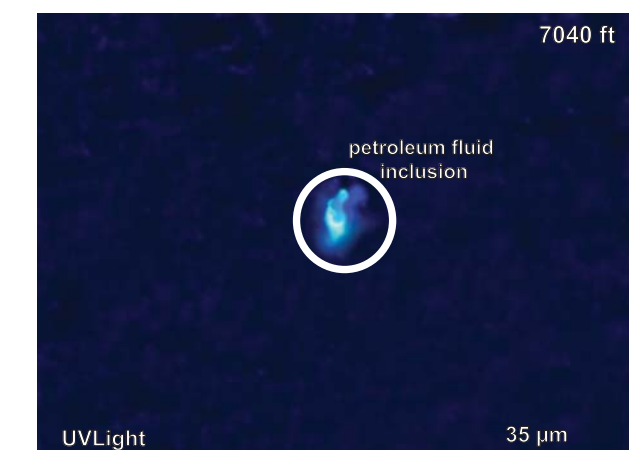


In 1965, Socony Mobil Oil Company, Inc. drilled the Mobil #3 State of North Carolina in Pamlico Sound, in the state waters offshore Hyde County, North Carolina to a depth of 7314 feet in a water depth of approximately 20 feet. This well was the third of three wells Socony Mobil drilled in the state waters of eastern North Carolina. The Mobil #1 well was drilled in eastern Albemarle Sound reaching a total depth of 5155 feet where the well bottomed in weathered granite. A single trace of asphalt was reported in the Upper Cretaceous at 2800 feet. The Mobil #2 well was drilled in eastern Pamlico Sound to a depth of 8360 feet bottoming in meta-igneous plutonic rocks. A drill stem test run in this well between 6502 and 6547 feet just above the Intra-Albian marker M2-6600 of Almy (1987) resulted in a "fair blow." The mud log from the No. 3 well reported that traces of asphaltic material were encountered in drill cuttings between 6700 and 7200 feet. Otherwise, no reports of significant oil or gas shows were reported.

A total of 120 wells have been drilled in eastern North Carolina by various companies. The Mobil #3 well was one of ten wells within which oil or gas shows were reported. The cuttings with the shows in the Mobil #3 were from the Lower Albion to Berriasian interval. This is approximately the interval that contained oil stains and geochemical evidence of petroleum in the Esso #1 Hatteras Light between the depths of 8410 and 9190 feet (Coffey and Sunde, 2009).

A study of the thermal maturity of the area by Malinconico and Weems (2010) showed that the basal sedimentary sequences in the state waters west of the Outer Banks approach the thermal maturity levels near the onset of oil generation: approximately 0.6% mean random vitrinite reflectance (%Ro) at a depth of approximately 9000 feet in the Esso #1 Hatteras Light, Dare County, North Carolina. Their work suggests that the entire section penetrated in the Mobil #3 well (0 to 7314 feet) is thermally immature for the local generation of petroleum.

However, the results of this study indicate that the lower section (7040 to 7232 feet) of the Mobil #3 well, which contains oil-prone kerogen and low API gravity oil inclusions generally equivalent to the early mature section from the #1 Hatteras Light, may contain either very early *in situ* hydrocarbons, or hydrocarbons that may have migrated laterally or vertically into the well.

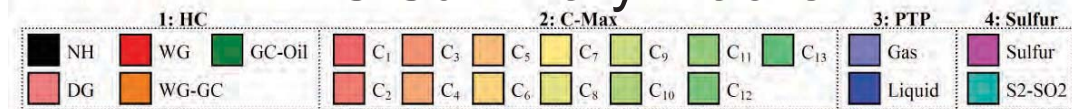


Fluid Inclusion Petrography from Mobil #3

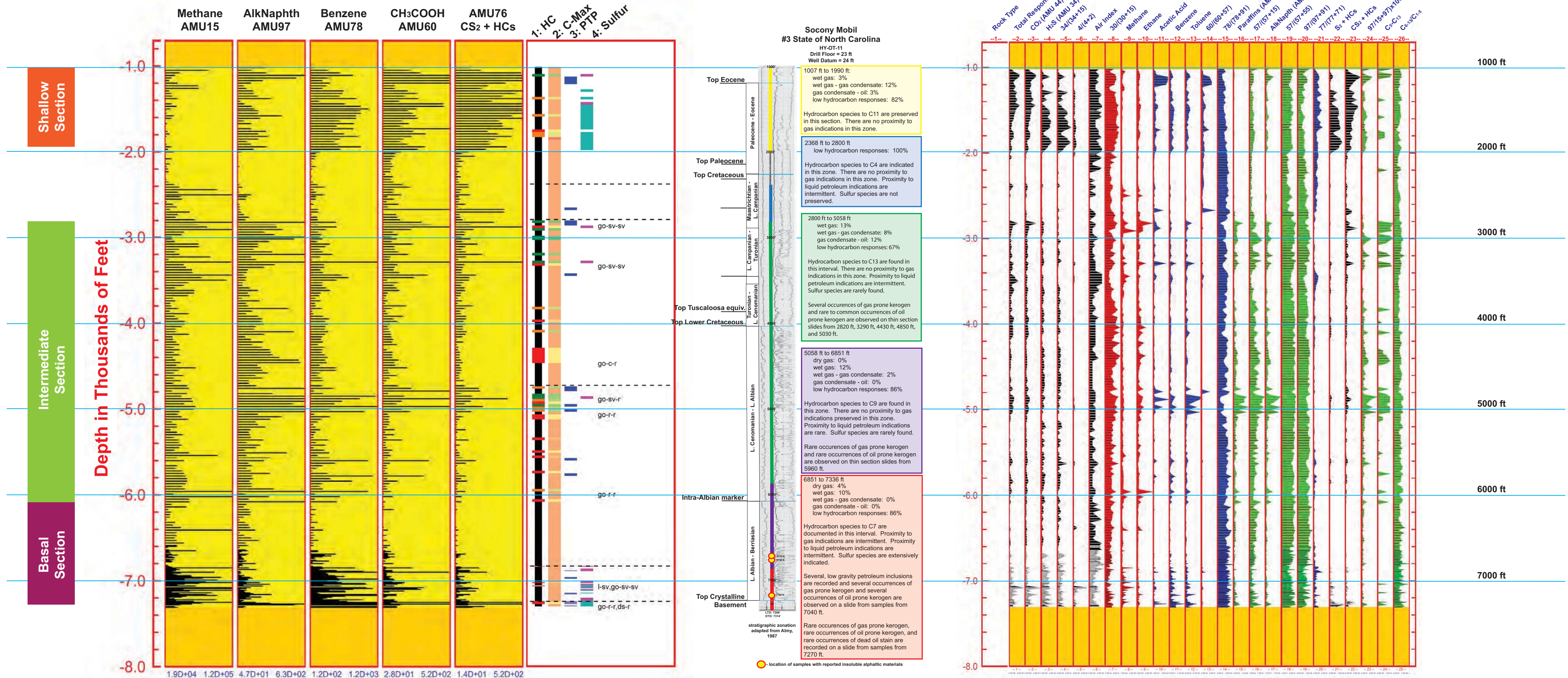
Well Name: Mobil 3		Fluid Inclusion Petrography from Mobil 3																			
Sample Depth	Rock Type	Petroleum Fluid Inclusion Populations									Kerogen (possible source rk)				Bitumen						
		Population 1				Population 2				Population 3											
Units: (Feet)	Dominant	Subordinate	Fluorescence Color	API Gravity (estimated)	Host Mineral & occurrence	Abundance	Fluorescence Color	API Gravity (estimated)	Host Mineral & occurrence	Abundance	Fluorescence Color	API Gravity (estimated)	Host Mineral & occurrence	Abundance	Host Rock	Type	OP Fluor Color	GP Abundance	OP Abundance	Type	Abundance
2820	cb,sh,tr ss														sh	go	yl	sv	sv		
3290	cb,ss,sh														sh	go	yl	sv	sv		
4430	cb,sh,ss														sh	go	yl	c	r		
4850	cb,ss,sh														sh	go	yl	sv	yl		
5030	cb,ss,sh														sh	go	yl	r	r		
5960	cb,ss,sh														sh	go	yl	r	r		
7040	ss,sh,cb	yl	l	dq	sv										sh	go	or	sv	sv		
7270	ss,sh,tr cb														sh	go	or	r	r	ds	r
ss: sandstone	mt: metamorphic rock	m: moderate	r: rare	ds: dead petroleum stain																	
si: siltstone	no: none	um: upper-moderate	sv: several	pb: pore-occluding bitum.																	
sh: shale	br: brown	h: high	c: common	po: pyrobitumen																	
cb: carbonate	or: orange	dq: frac in detrital quartz	a: abundant																		
sa: salt	yl: yellow	dr: quartz dust rim	xa: very abundant	Notes:																	
an: anhydrite	wt: white	qc: quartz cement	go: oil and gas prone																		
cb: chert	bl: blue	df: frac detrital feldspar	op: oil prone																		
co: coal	l: low	cm: matrix carbonate	gp: gas prone																		
iq: igneous rock	ul: upper-low	cc: carbonate cement	ls: live petroleum stain																		

Confirmation of Hydrocarbon Shows in the Mobil #3 Offshore Hyde County Well, North Carolina

FIS Summary Tracks



Mobil #3: All FIS Data



Fluid Inclusion Stratigraphy (FIS) data record intermittent hydrocarbon anomalies throughout the well, with most spectra resembling wet gas to gas-condensate.

The results are discussed in three sections, based on the stratigraphic distribution of anomalies.

The shallow section (1007 to 1970 feet): Eocene -

The section between 1007 and 1970 feet contains intermittent dry gas to wet gas spectra with evidence of biodegradation. These features can indicate microseepage of hydrocarbons from deeper in the basin. The interval appears to represent an unconsolidated sandy and carbonate bearing interval. The base of the section corresponds to an increase in shale.

The intermediate section (2820 to 6080 feet): Cretaceous -

The section between 2820 and 6080 feet contains intermittent gas and liquids indications, with some decoupled C1 and C7 responses. In this case a separate charge of dry gas (possibly bacterial in part) and heavies (possibly from indigenous kerogen or mixed migrated + kerogen sourced) is suggested. Highest methane responses are noted at 2440 to 3500 feet while highest responses on liquid-range species are noted at 2820 to 3290 feet and 4760 to 5030 feet. Intermittent acetic acid anomalies are recorded at 2670 to 3440 feet and 4760 to 5780 feet. Although complicated by the possible presence of co-eluting sulfur species, these so-called proximity to pay indicators may be sensing lateral oil or condensate charge in the vicinity. Thin sections were prepared from six samples in this middle portion of the borehole (see petrography table, poster panel 2). All are carbonate dominated with subordinate sandstone and shale and none were found to contain visible liquid petroleum inclusions. Shale contains minor gas- prone and oil-prone kerogen, with the latter appearing immature based on kerogen fluorescence color.

The basal section (6080 to 7314 feet): Cretaceous -

The section between 6080 and 7314 feet presents minor dry gas to wet gas spectra with significant sulfur species and possible proximity indicators to gas or oil/condensate. Sulfur species may be thermally derived in this case, and would imply influx of mature gas from deeper in the basin. Two thin sections were prepared (see petrography table). Both show intervals that are sandstone dominated with lesser shale and trace carbonate. Shale appears to contain rare, mature oil-prone kerogen in both samples. Rare to several, yellow-fluorescent, low gravity oil inclusions are noted at 7040 feet, possibly indicating immature oil. No visible oil inclusions are noted at 7270 feet, but rare dead hydrocarbon stain is recorded.

Summary and Conclusions:

Recent fluid inclusion stratigraphic analysis of cuttings from the Mobil #3 well revealed the microscopic presence of hydrocarbons throughout the well, with most spectra resembling wet gas to gas-condensate. Two zones of significance are (1) an upper zone between 2820 and 6080 feet in the Maastrichtian to Lower Albian Cretaceous where possible biogenic gas is mixed with heavier hydrocarbons likely from a more distant rather than indigenous source, and (2) a lower zone between 6080 and 7314 feet in the Lower Albian to Berriasian Cretaceous containing significant sulfur species that may be thermally derived and imply an influx of geothermally mature gas from deeper in the basin. Several low gravity oil inclusions were noted at 7040 feet. As previously noted, the Cretaceous of eastern North Carolina state waters is regionally thermally immature (Malinconico and Weems, 2010) and probably not a major source for these hydrocarbons. However, local areas of sufficient burial may have resulted in local generation of early mature petroleum species.

The microscopic presence of hydrocarbons and associated organic compounds throughout the well suggests that a petroleum generation and migration event occurred east of the well site either downdip, or deeper on the shelf, where increased burial depth and geothermal conditions created a more favorable generation environment. The presence of shows within essentially the same Lower Cretaceous interval in both the Mobil #3 and the Esso #1 Hatteras Light wells suggests that the petroleum detected in the Mobil #3 well could have been derived from a Cretaceous age Turonian and (or) Albian to Valanginian organic-rich interval, similar to that found in the downdip, deep water DSDP 603B well. Further geochemical research is needed to understand more completely how these elements may integrate fully into an understanding of a total petroleum system for the North Carolina continental shelf and slope.

Acknowledgements:

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Any use of trade, product, or firm names herein is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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