[redacted]

(*abridged presentation*)

[redacted]

Presentation Overview

- General geologic setting
- History of Oil and Gas Exploration
- Petroleum Geology of North Carolina State Waters areas
- USGS Oil & Gas Resource Assessment Process
- Current USGS Oil & Gas Resource Assessment Activities: East Coast Mesozoic Basins Study

USGS

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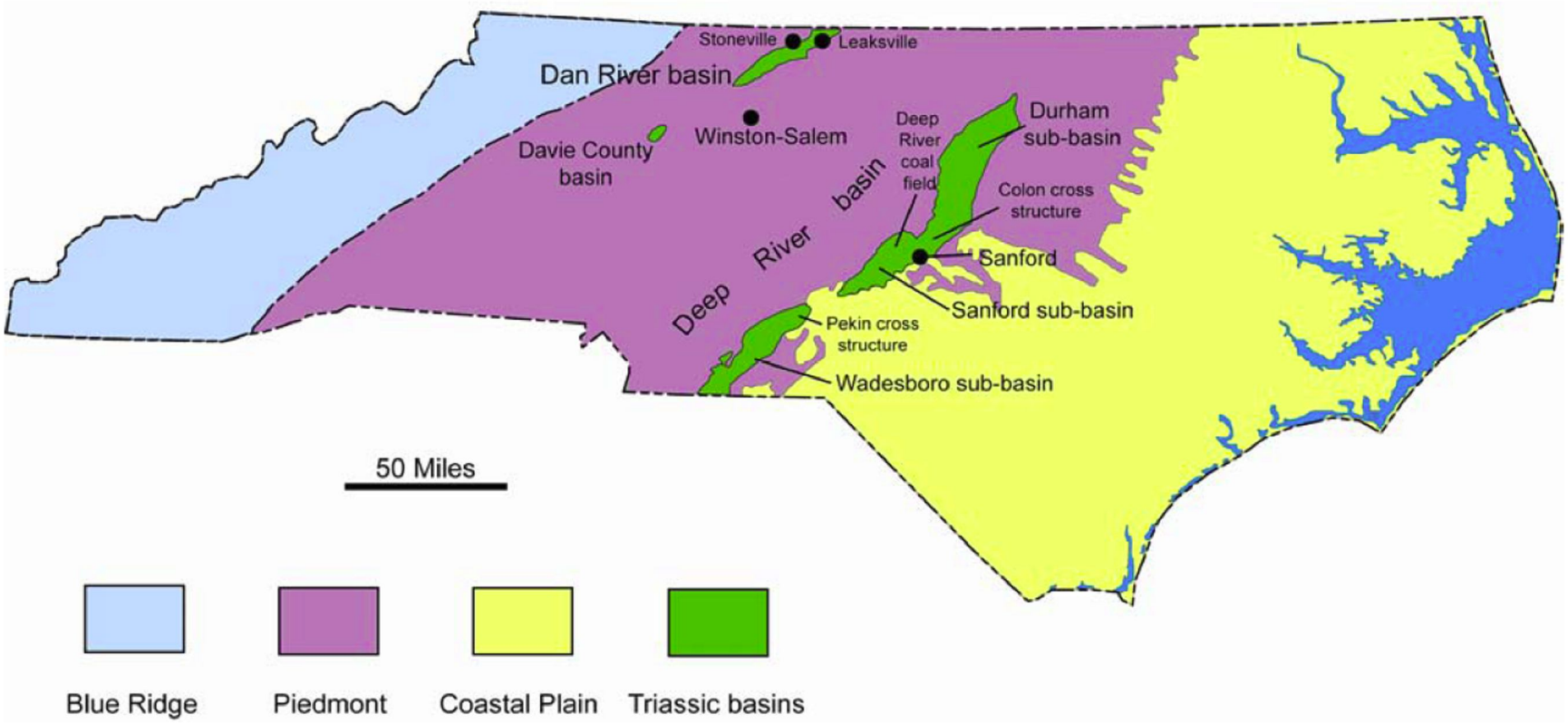
USGS

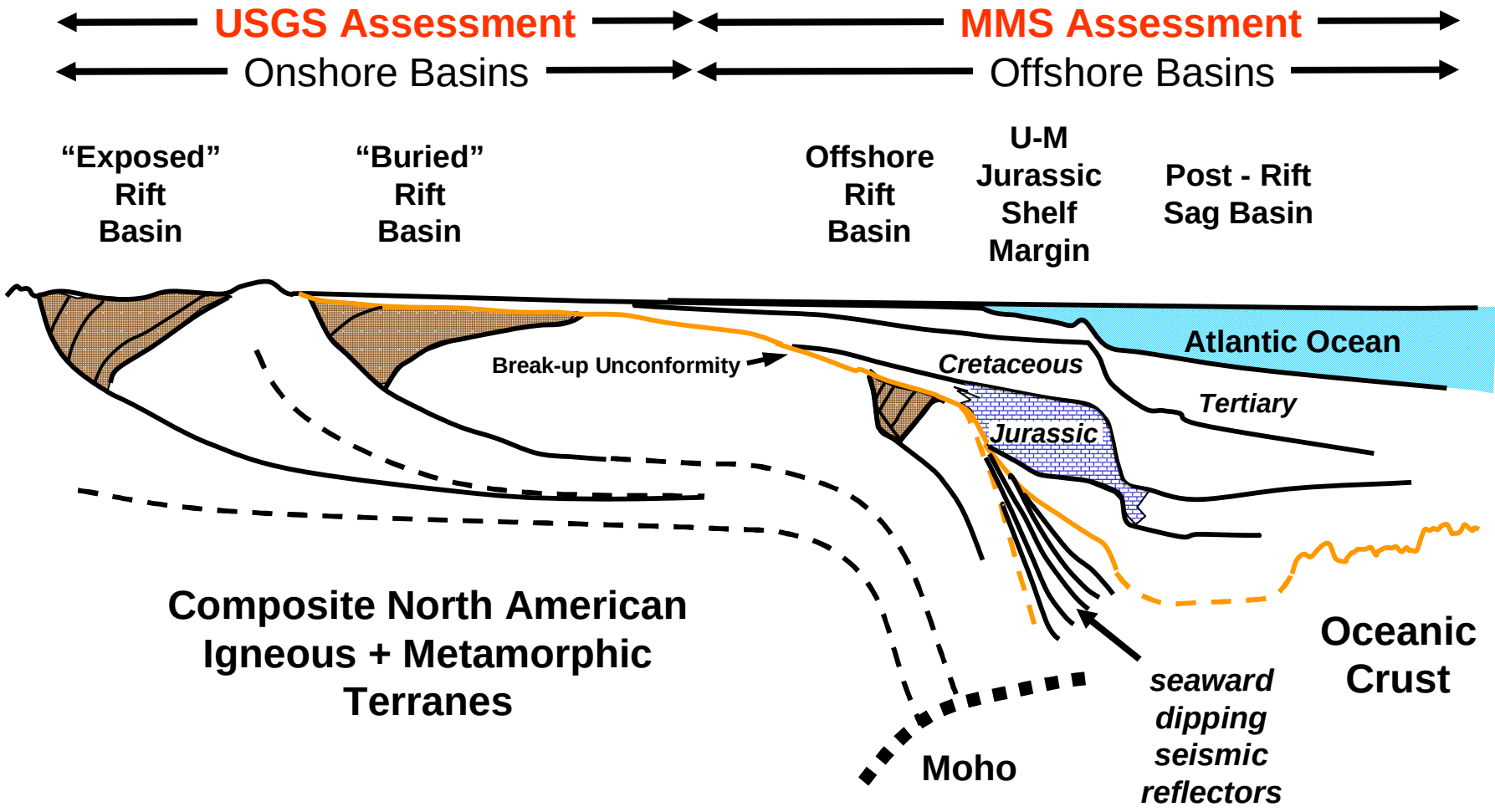
General Geologic Map of North Carolina



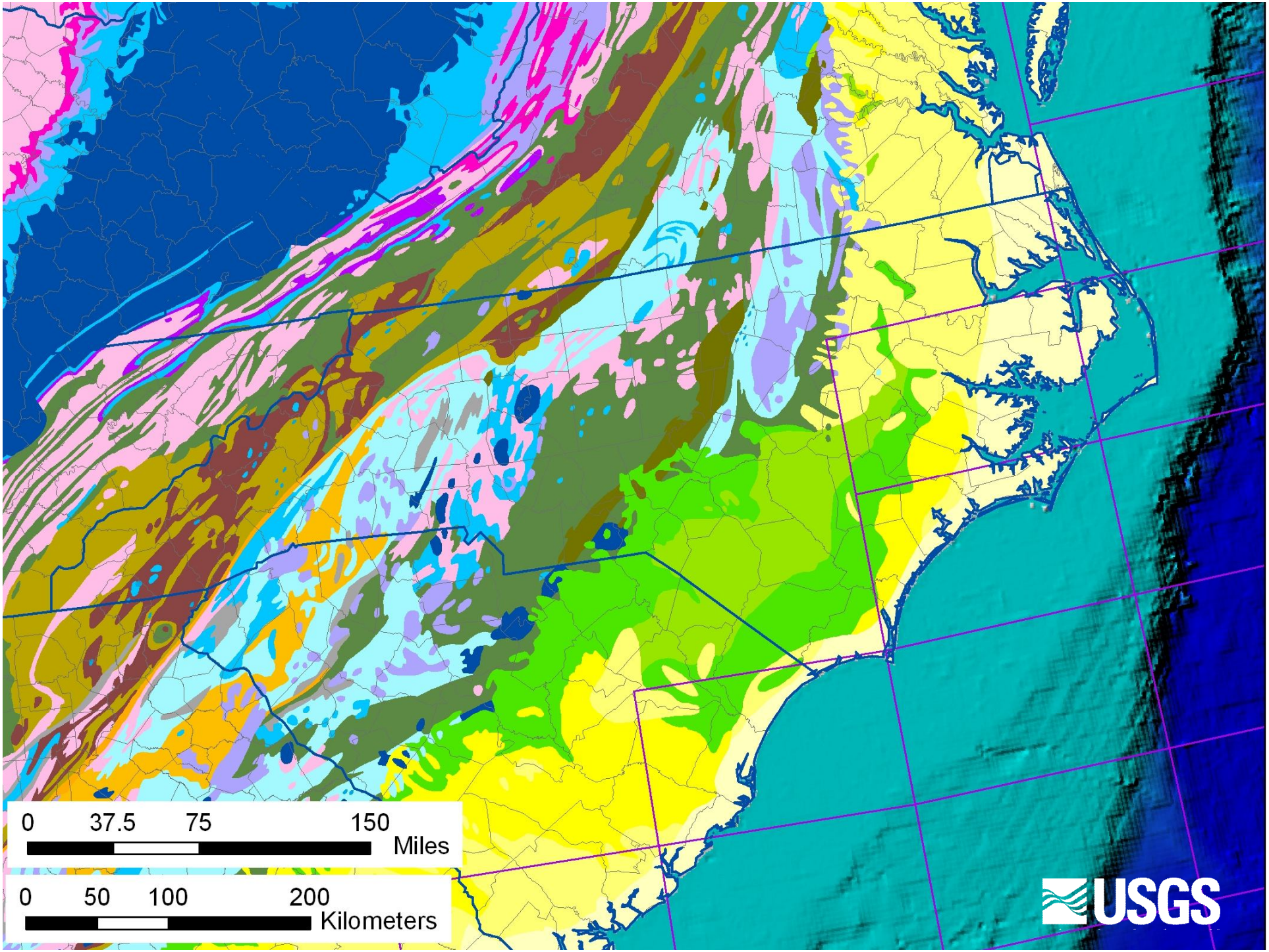
(from Reid and Milici, 2008)

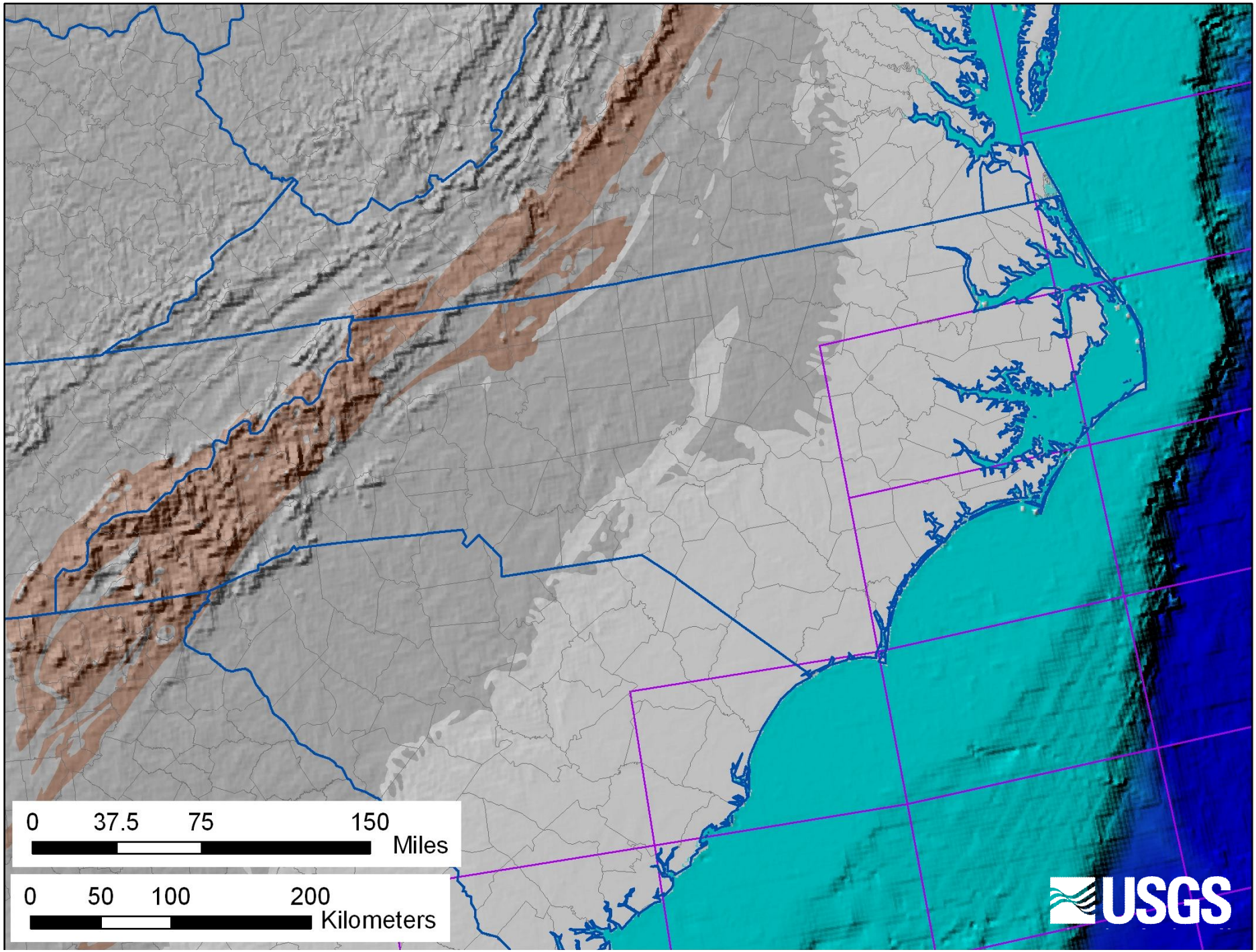
USGS

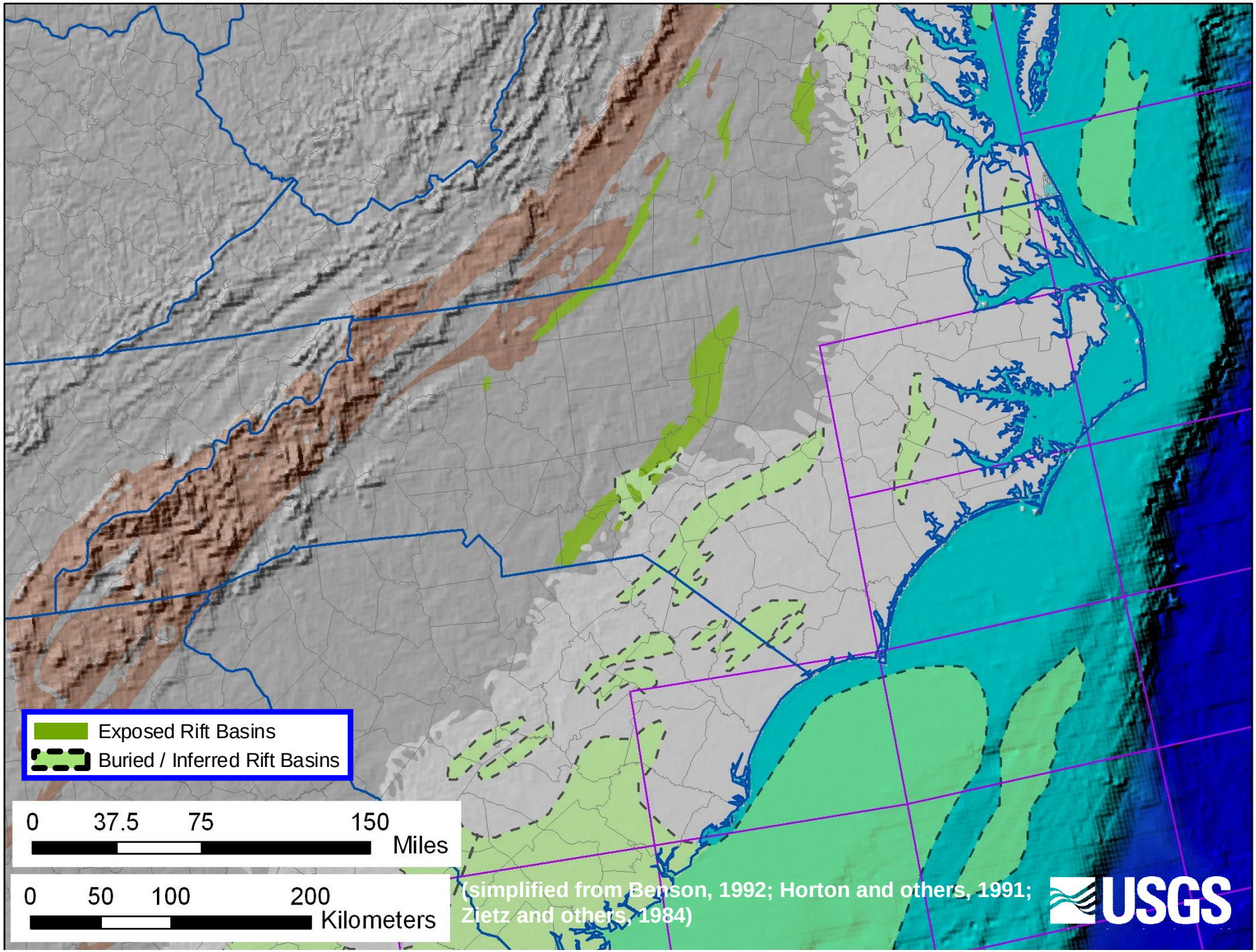
U. S. Atlantic Mesozoic Basin Types

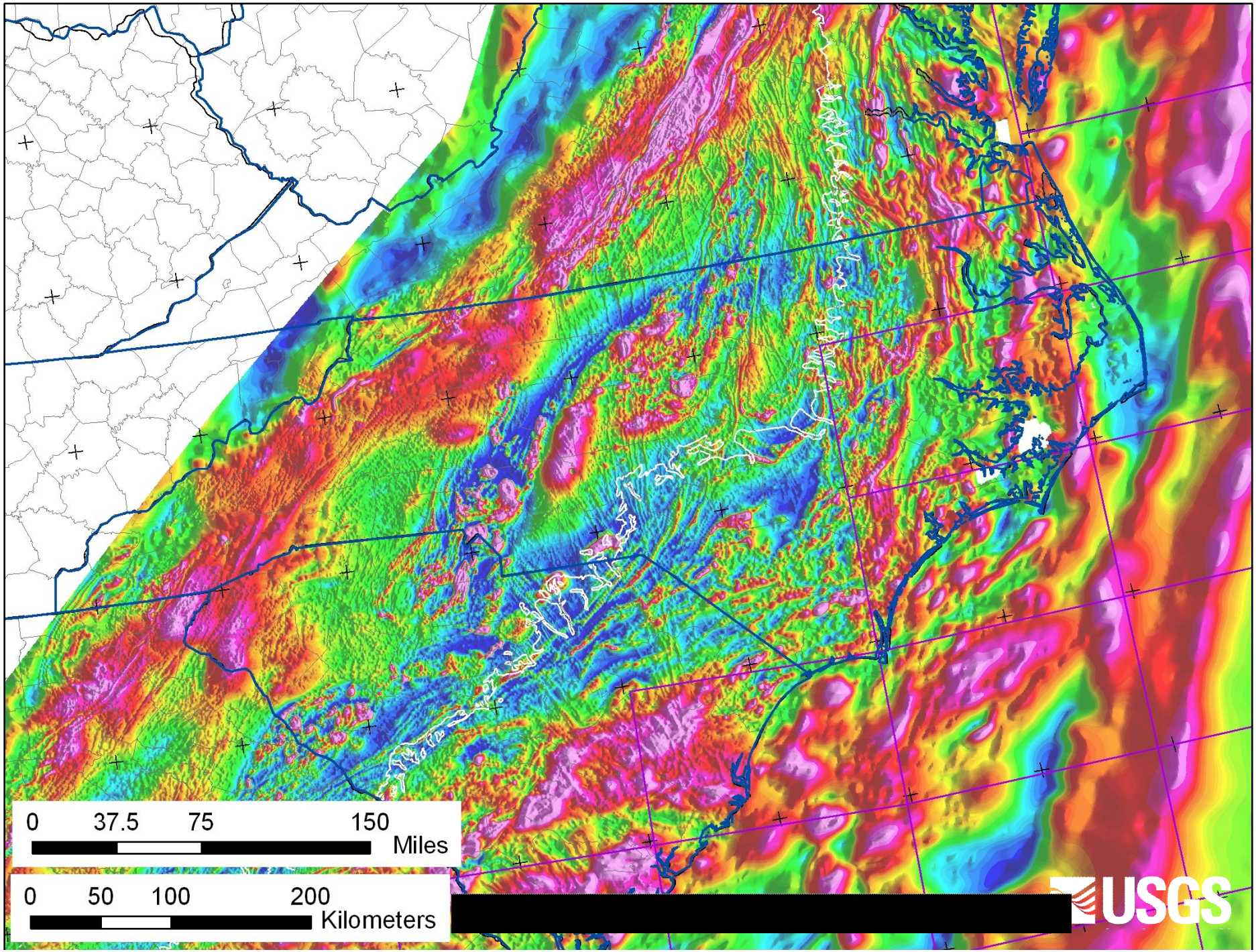


USGS


0 37.5 75 150
Miles
0 50 100 200
Kilometers
USGS


0 37.5 75 150
Miles
0 50 100 200
Kilometers
USGS


Exposed Rift Basins
Buried / Inferred Rift Basins
0 37.5 75 150
Miles
0 50 100 200
Kilometers
(simplified from Benson, 1992; Horton and others, 1991; Zietz and others, 1984)
USGS


0 37.5 75 150
Miles
0 50 100 200
Kilometers
USGS

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North Carolina Oil & Gas Drilling History (1925 – 2009)

- 129 wells drilled since 1925 (1925-1998)
- 116 dry holes; plugged and abandoned, with no shows
- 11 wells had oil and/or gas shows; all abandoned
- 1 well had oil and gas shows; shut-in
- 1 well plugged following mechanical failure

USGS

North Carolina Triassic Basin Tests

- Chevron #1 Groce (1974): 5348’ TD basement test; several oil & gas shows; thick gasey coals and organic shales; low P&P sandstones
- SEPCO (Seaboard) #1 Hall (1983): 4622’ TD; oil shows
- SEPCO (Seaboard) #1 Butler (1984): 4538’ TD basement; substantial oil & gas shows; acidized & frac’d; flowed low rates of gas + condensate before being abandoned
- Equitable Res. Energy #2 Butler (1991): 2012’ TD; frac’d; no data; P&A 1993.
- Amvest #3 Butler (2006): 2655’ TD; shut-in gas well
- Amvest #1 Simpson (2006): 3294’ TD; shut-in gas well
- Several wells in eastern NC have reported oil and/or gas shows from unspecified units

USGS

Deep River Basin Hydrocarbons

Butler #1 (above) – high paraffin oil, low flow temperature (~ext. body temp.); in geochem. testing at USGS

Butler #3 (right) – shut-in well head pressure; sampled for gas geochemistry; has liquids along with gas; in geochem. testing at USGS

(modified from Reid and Taylor, 2009)

USGS

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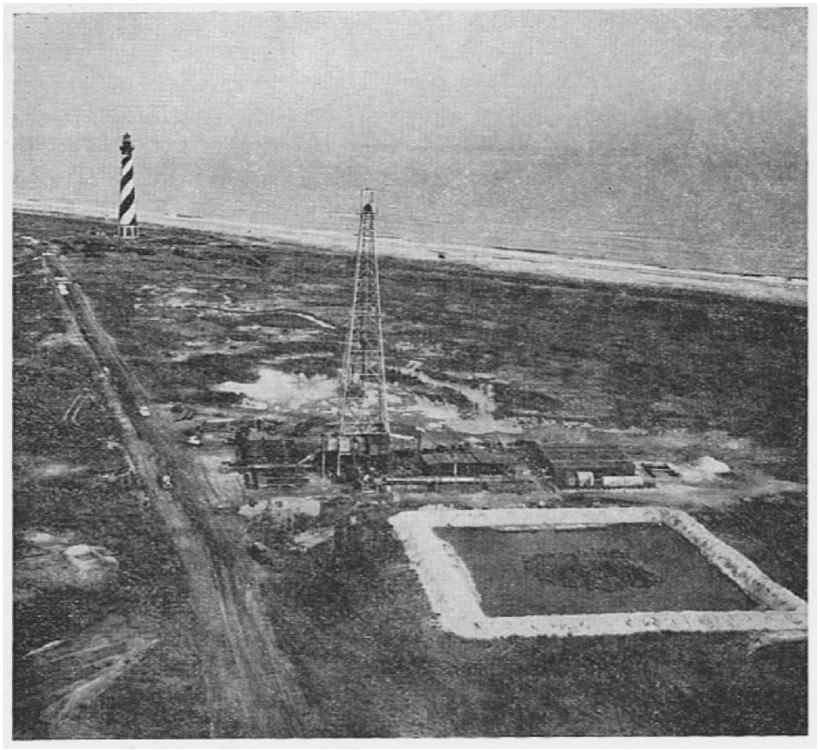
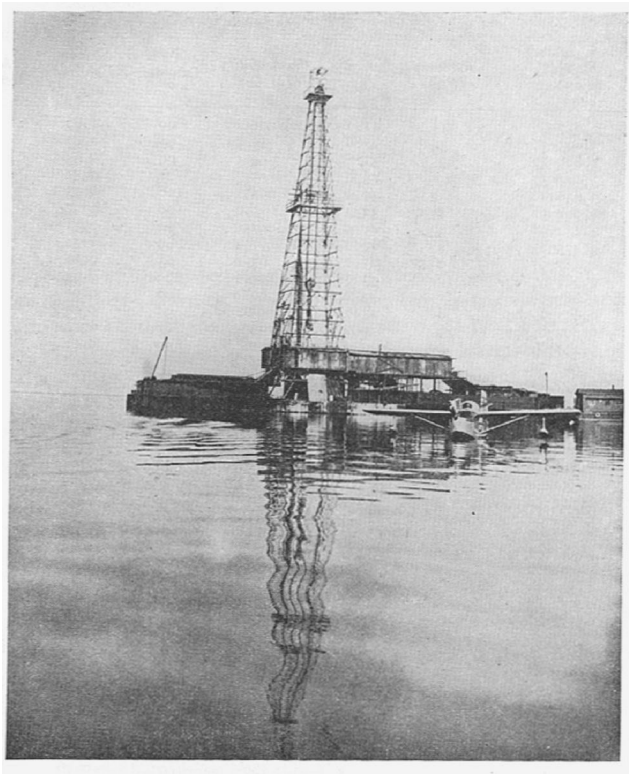
Early Deep Tests – North Carolina Coastal Plain & State Waters



Esso Hatteras Light No. 1
10,054 ft TD Xline Bsmt
D&A 1946
no shows of oil or gas



North Carolina Esso No. 2
6,410 ft TD L. Cret.
D&A 1947
no shows of oil or gas

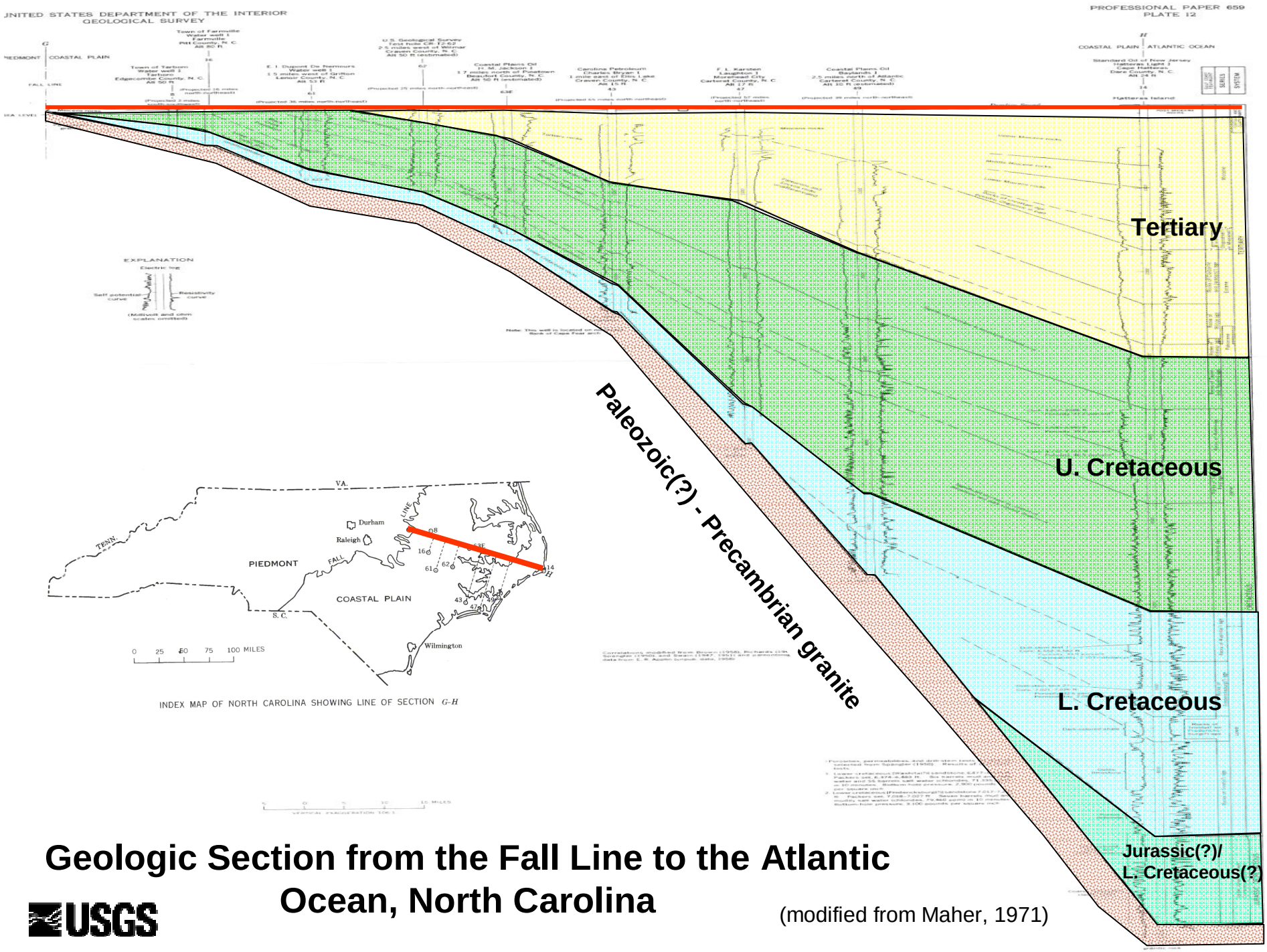
(from Spangler, 1950)

USGS

Eastern North Carolina Drilling History

- 1946 & 1947: 2 Deep Esso tests vic. Cape Hatteras
  - Drilled following major geophysical surveys (seismic, gravity, magnetics)
  - Both dry and abandoned
  - 1 cored crystalline basement at TD
  - No oil or natural gas shows
- 1953: 1 well drilled in Camden Co, NC into Triassic; 6421 ft TD; show of gas in Cretaceous Tuscaloosa Fm.; plugged & abandoned
- 1965: 7 basement tests drilled in & adj. to Albemarle & Pamlico Sounds
  - All dry and abandoned
  - 6 of 7 cored crystalline basement at TD
  - No oil or gas shows
- Approx. 86 wells drilled in vic. Albemarle & Pamlico Sounds; most drilled to basement; all dry and abandoned

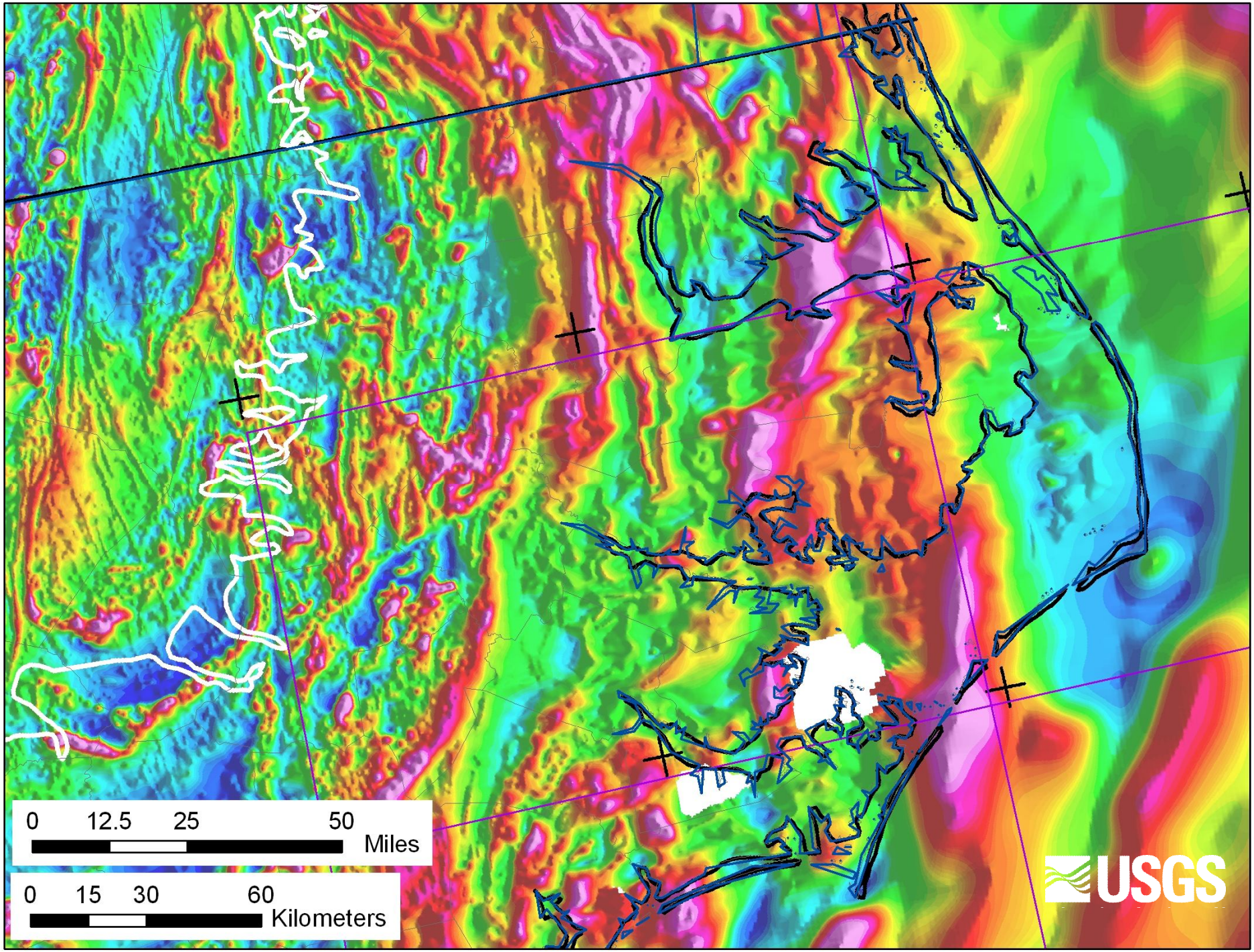
USGS

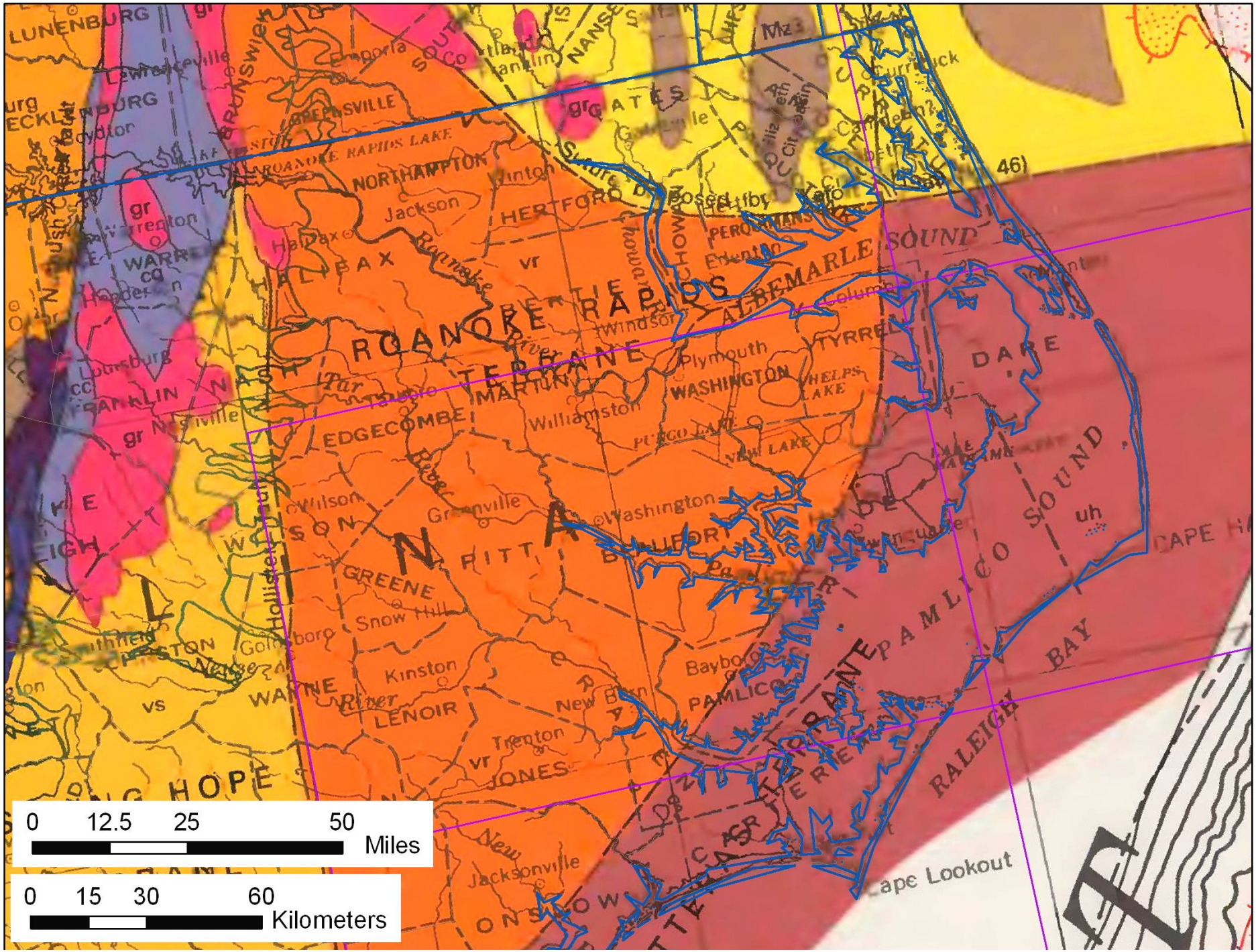


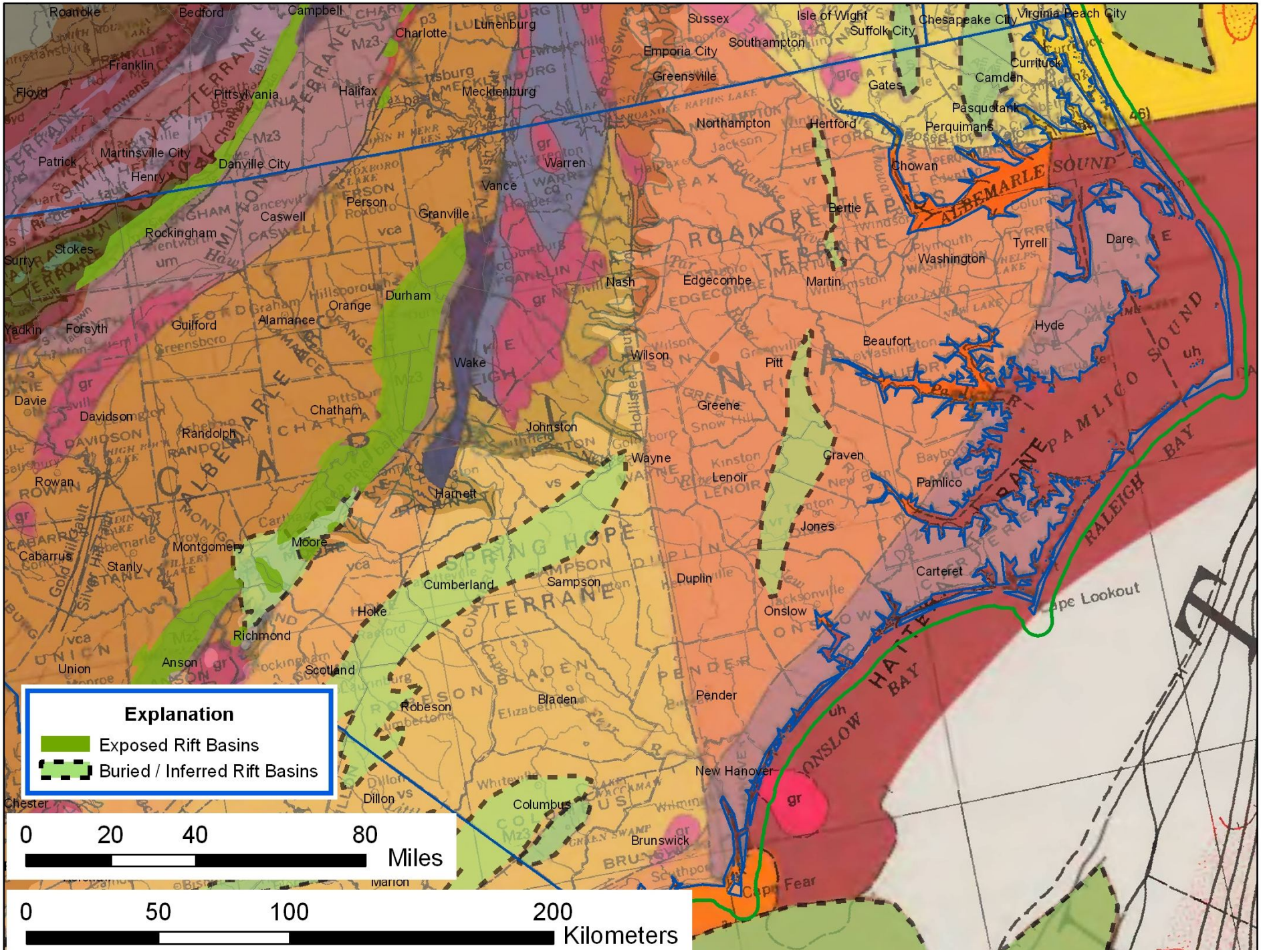
Geologic Section from the Fall Line to the Atlantic Ocean, North Carolina

(modified from Maher, 1971)

USGS


0 12.5 25 50
Miles
0 15 30 60
Kilometers
USGS


0 12.5 25 50
Miles
0 15 30 60
Kilometers
ROANOKE RAPIDS
ALBEMARLE SOUND
PAMLICO SOUND
NORTHAMPTON
HERTFORD
EDGECOMBE
MARTIN
WASHINGTON
TYRRELL
DARE
PITT
GREENE
LENOIR
JONES
CRAVEN
CARTERET
Cape Lookout
RALEIGH
BAY


Explanation
Exposed Rift Basins
Buried / Inferred Rift Basins
0 20 40 80 Miles
0 50 100 200 Kilometers
Roanoke
Bedford
Campbell
Charlotte
Lunenburg
Franklin
Floyd
Pittsylvania
Halifax
Mecklenburg
Patrick
Martinsville City
Danville City
Henry
Warren
Vance
Person
Granville
Caswell
Rockingham
Stokes
Surry
Durham
Orange
Alamance
Yadkin
Forsyth
Guilford
Wake
Davie
Davidson
Chatham
Randolph
Johnston
Rowan
Harnett
Wayne
Cabarrus
Stanly
Montgomery
Moore
Cumberland
Sampson
Hoke
Richmond
Anson
Union
Scotland
Robeson
Bladen
Pender
New Hanover
Columbus
Brunswick
Dillon
Chester
Marlon
Sussex
Isle of Wight
Suffolk City
Chesapeake City
Virginia Beach City
Emporia City
Southampton
Greensville
Gates
Currituck
Camden
Pasquotank
Northampton
Hertford
Perquimans
Chowan
Bertie
Tyrrell
Dare
Washington
Edgecombe
Nash
Martin
Hyde
Beaufort
Wilson
Pitt
Greene
Craven
Lenoir
Pamlico
Jones
Duplin
Carteret
Onslow
Cape Lookout
Cape Fear
ALBEMARLE SOUND
PAMLICO SOUND
RALEIGH BAY
HATTERAS
ONSLOW BAY
ROANOKE RAPIDS TERRANE
CHATHAM GROUP
SPRING HOPE
CUMBERLAND TERRANE
461

Eastern North Carolina Petroleum Show Reports

9 wells reported shows:

- Camden Co.: show of gas while drilling(?) in L. Cret. (?).
- Carteret Co.: show of gas in unk. fm.
- Dare Co.: show of gas in L. Cret.(?): prod. test, no details
- Hyde Co. Offshore: show of oil in U. Cret.(?): oil fluorescence in sidewall core
- Pamlico Co.: (1) show of oil & gas: many DST's - O&GCM from 1 (L. Tert.-?); many cores – gas from 1 (U. Cret.-?); (sidetrack/redrill?) Core & DST recovered oil (U. Cret.-?)
- Pender Co.: show of oil & gas: no details
- Tyrrell Co.: show of oil & gas, poss. in basement rock: prod. test, no details
- Unspecified locations: 2 wells drilled in 1966 reported mud logger gas shows

USGS

(adapted from data from IHS Inc., 2009, and Richards, 1947, 1954)

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USGS Oil and Gas Resource Assessment Process

- Geologically based
- Identification of Total Petroleum System(s) (TPS):
  - √ Source Rock
  - √ Reservoir Rock
  - √ Sealing Intervals
- Identification of Assessment Unit(s) (AU's):
  - √ Geologically-bounded areas with known or hypothetical production capabilities
  - √ Plays and known (or shut-in) fields

USGS

USGS Oil and Gas Resource Assessment Categories

- Conventional Accumulations:
  - Definable, field-wide hydrocarbon:water contact
- Continuous (“Unconventional”) Accumulations:
  - Ill-defined, field-wide hydrocarbon:water contact
  - i.e., coal bed methane, shale gas, tight gas sandstones
- Hypothetical:
  - Either conventional or continuous; however,
  - No historically or currently established production

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1995 USGS Oil and Gas Resource Assessment

- All plays deemed “hypothetical”
- Reservoirs: a variety, incl. conglomerates, sandstones, shales, and coals; ss = 2 – 12% Φ & <0.1 md – 18 md k
- Source rocks: lacustrine black shales and coals; thermally immature to (prob.) past-peak gas; generation prob. Late Triassic – Early Jurassic, poss. cont. into Cretaceous
- Traps: both extensional & compressional (transpression) structures
- Discoveries/shows: no production reported in 1995 assessment; many oil and gas shows reported
- Resource potential: “fair to poor”; no volumes assessed

USGS

(from Milici, 1995)

2009-10 USGS Oil and Gas Resource Assessment - Preliminary Status
(as it pertains to Eastern North Carolina Onshore and State Waters Areas)

- Only 2 positively identified rift basins in eastern part of state, although some geophysical evidence suggests others may be present
- No geochemically identified source rocks (yet?)
- Hydrocarbon shows not confirmable (yet?)
- Highly porous potential reservoir rocks
- No data on capabilities of potential seal intervals
- No identified structures

USGS