Expanded mid-Atlantic Deep Water Allostratigraphy

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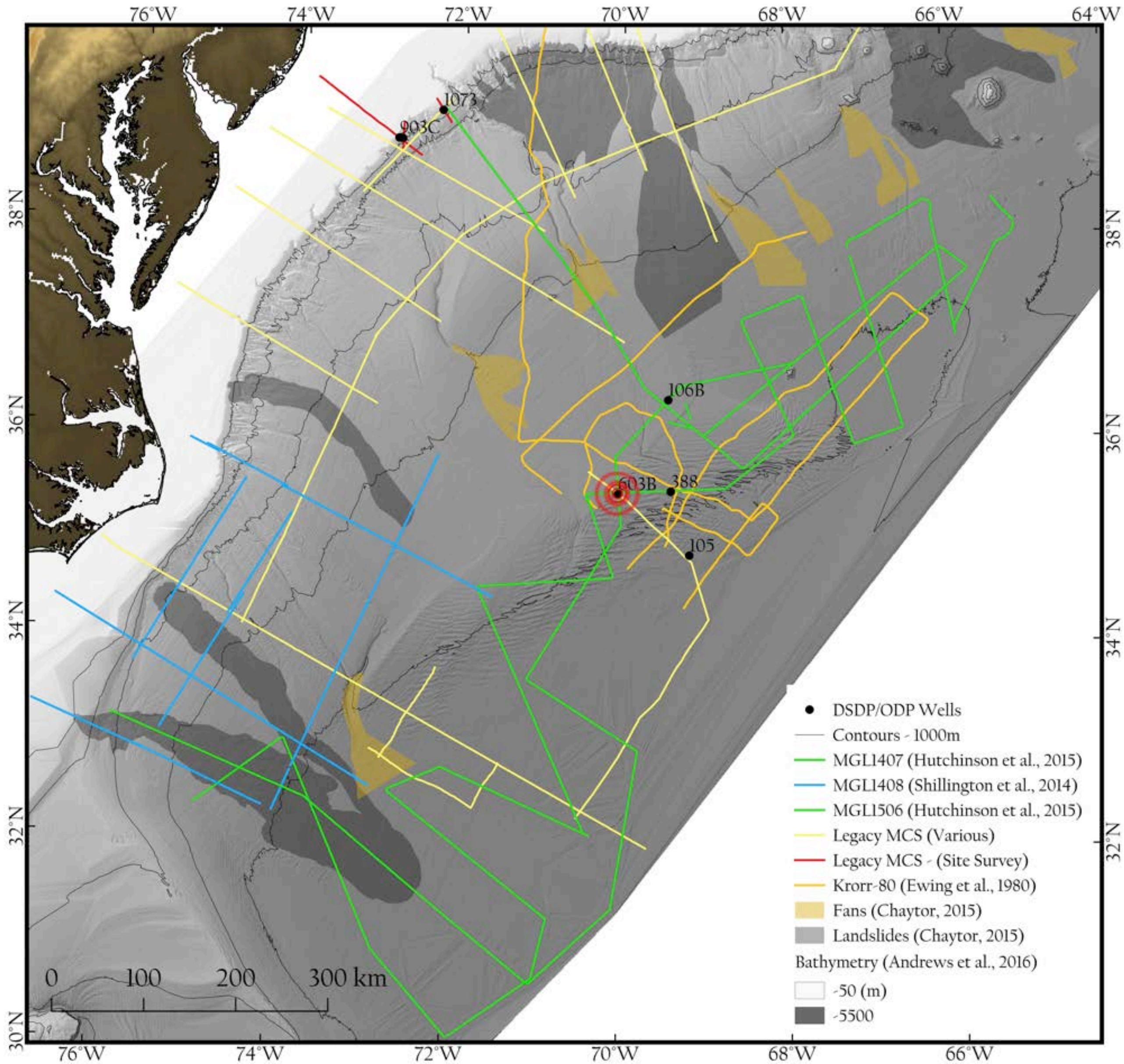
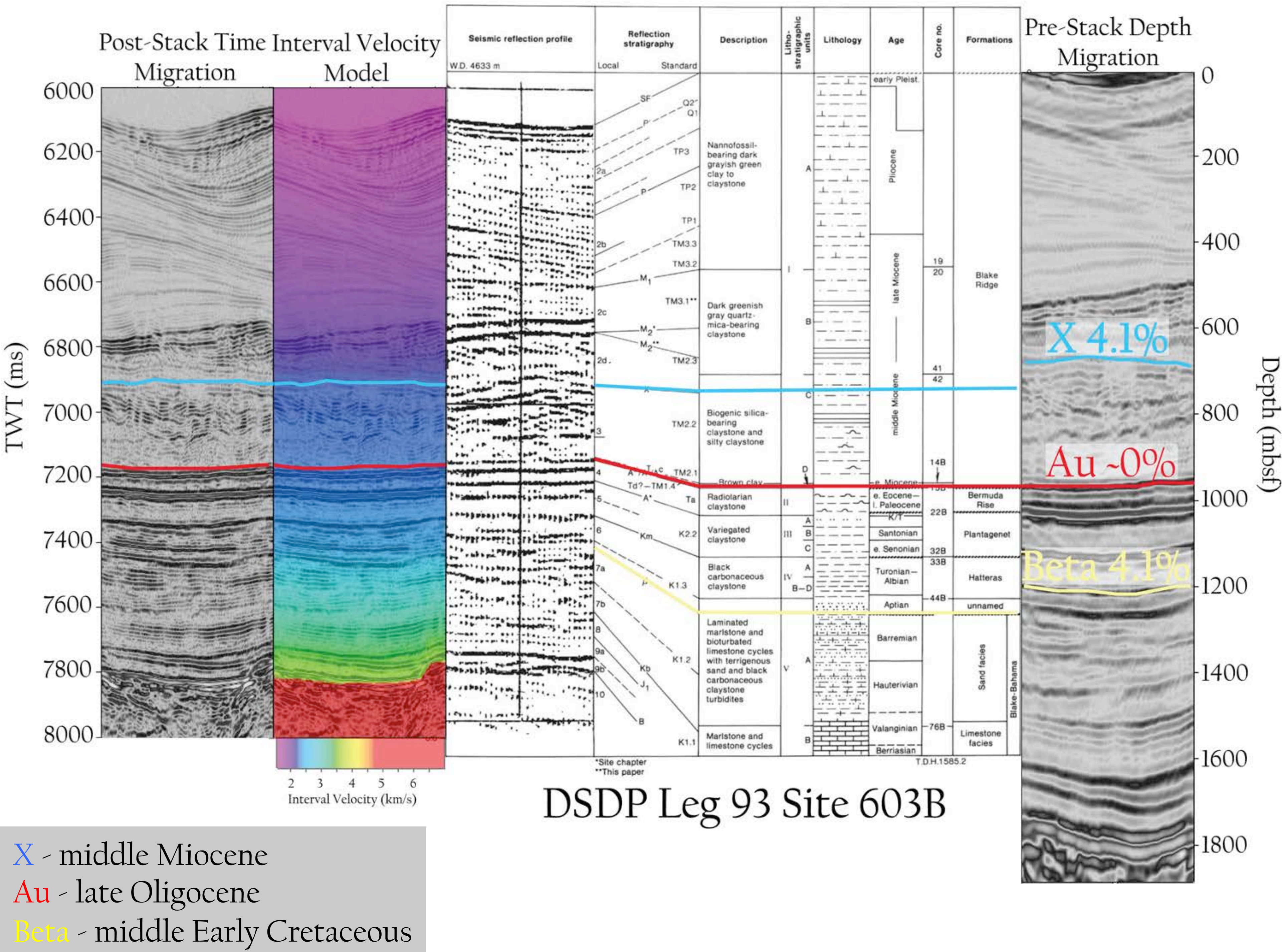
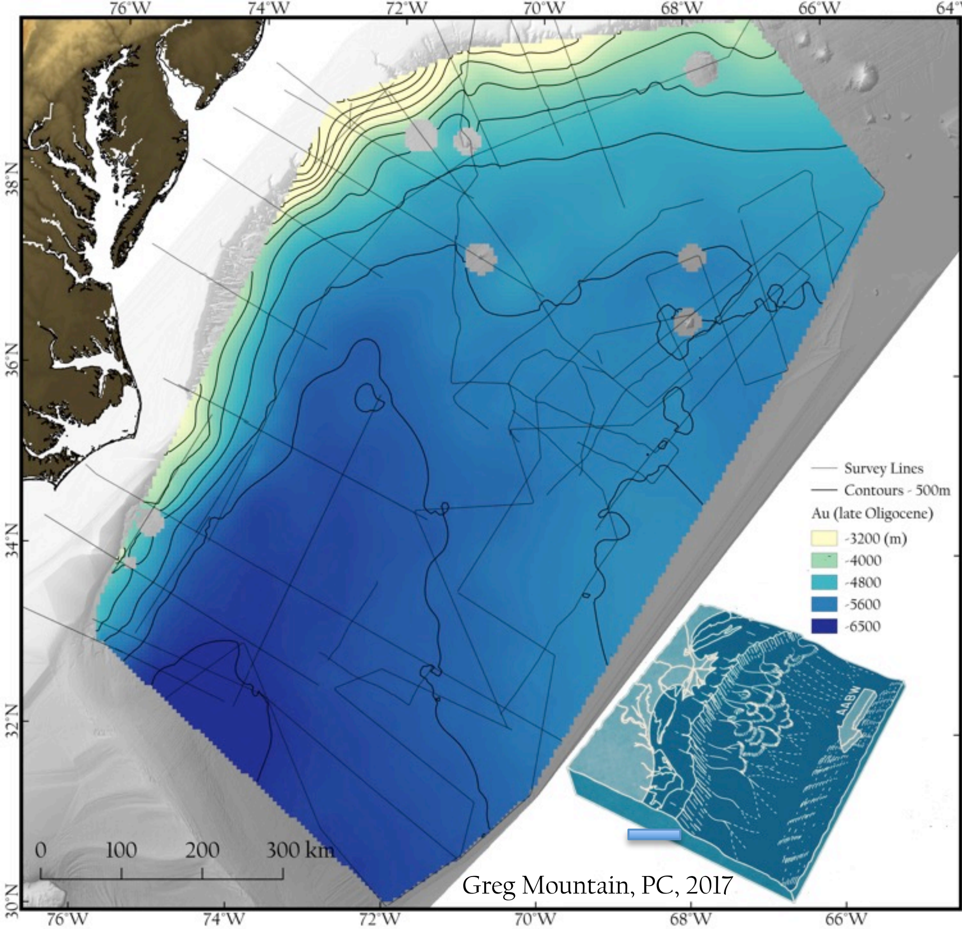
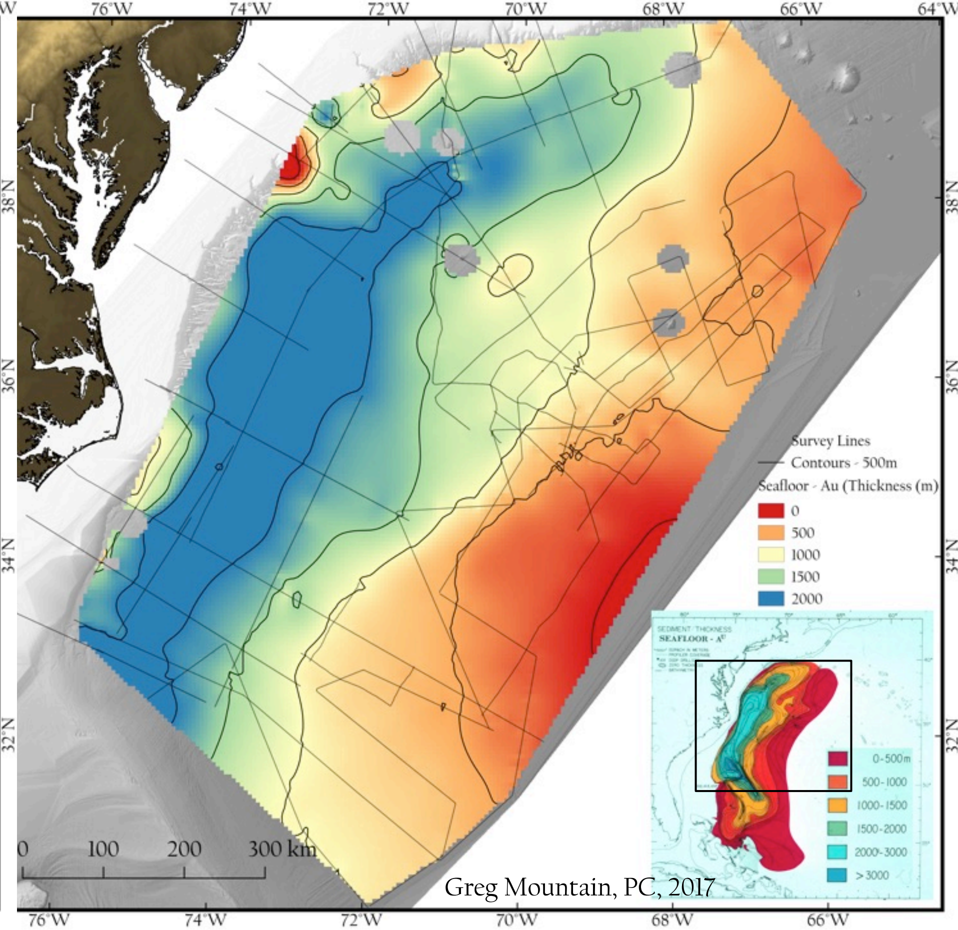




Post-Stack Time Migration
Interval Velocity Model
TWT (ms)
6000
6200
6400
6600
6800
7000
7200
7400
7600
7800
8000
2 3 4 5 6
Interval Velocity (km/s)
Seismic reflection profile
W.D. 4633 m
Reflection stratigraphy
Local
Standard
Description
Litho-stratigraphic units
Lithology
Age
Core no.
Formations
Nannofossil-bearing dark grayish green clay to claystone
Dark greenish gray quartz-mica-bearing claystone
Biogenic silica-bearing claystone and silty claystone
Brown clay
Radiolarian claystone
Variegated claystone
Black carbonaceous claystone
Laminated marlstone and bioturbated limestone cycles with terrigenous sand and black carbonaceous claystone turbidites
Marlstone and limestone cycles
early Pleist.
Pliocene
late Miocene
middle Miocene
e. Miocene
e. Eocene–l. Paleocene
K/T
Santonian
e. Senonian
Turonian–Albian
Aptian
Barremian
Hauterivian
Valanginian
Berriasian
Blake Ridge
Bermuda Rise
Plantagenet
Hatteras
unnamed
Sand facies
Limestone facies
Blake-Bahama
T.D.H.1585.2
*Site chapter
**This paper
DSDP Leg 93 Site 603B
Pre-Stack Depth Migration
X 4.1%
Au ~0%
Beta 4.1%
Depth (mbsf)
0
200
400
600
800
1000
1200
1400
1600
1800
X - middle Miocene
Au - late Oligocene
Beta - middle Early Cretaceous





- Late Oligocene (Au) bottom current erosion is highest in the southern portion of the margin resulting in a steeper slope (relative to the northern portion of the margin).
- In the south, down-slope creep along steepened rise surfaces may have played a role in producing large, retrogressive failures from Au to present.
- In the north, seafloor fans are prevalent and larger in post-Au sedimentary units.
- The presence of fans in the north vs. large slope failures in the south indicates that late Oligocene bottom current erosion played a key role in controlling how sediments have since been transported to the deep sea along the U.S. mid-Atlantic margin.

Expanded U.S. mid-Atlantic Margin Deep-Water Allostratigraphy; Bottom-Current Controls on Margin Evolution

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Key Points:

- Expanded allostratigraphic units reveal extensive erosion across the US mid-Atlantic margin. Erosion is most pronounced in the south.
- Late-Oligocene bottom-current erosion caused slope steepening and possibly lead to increased Miocene-Pleistocene Mass Transport Deposit (MTD) frequency and run-out distance.
- Slope angle may control variations in post-Oligocene seafloor sediment transport and depositional processes (e.g., stacked MTDs in the south vs fan formation in the north).

Abstract:

There is a long history of seismic stratigraphic interpretation/analysis of the sedimentary sequence along the U.S. mid-Atlantic Margin (MAM). Here we expand the allostratigraphic (unconformity-bound) framework from the outer continental shelf to the Hatteras Abyssal Plain by correlating recently acquired 2D multi-channel seismic reflection data with existing drill sites and legacy 2D seismic data collected over the past 42 yrs. The new 2D post-stack Kirchhoff time migrated seismic data were acquired using R/V Marcus G. Langseth in 2014-2015 during USGS ECS surveys MGL1407 & MGL1506 and NSF-funded ENAM-CSE survey MGL1408. We map six seismic horizons along ~17x10³ km of 2D data and tie each to stratigraphic unconformities sampled at DSDP site 603 (lower rise). From shallow to deep they are: (1) M2, latest Miocene; (2) X, middle Miocene; (3) Au, late Oligocene; (4) A*, Late Cretaceous; (5) Km, early Late Cretaceous; and (6) Beta, middle Early Cretaceous. The horizons were converted to depth (mbsl) using high-resolution interval velocity models generated for each 2D survey line and isopachs were produced using the depth-converted stratigraphic framework for each allostratigraphic unit. The time-to-depth function was confirmed to be within 5% of drilling results at DSDP Sites 603 and nearby 105. Additionally, we tied horizon Au to upper-slope ODP Sites 902 & 1071, and traced it to the outer shelf. Interpretation of the framework and resulting isopachs show total sediment thickness uniformly decreasing seaward from the shelf edge, and overall thickening to the south. Regional depositional trends display a combination of both down slope and along slope processes (e.g. mass wasting, submarine fan formation, contourite and sediment drift deposits). The unit bound by horizons Au & Beta confirms pervasive erosion from the mid-slope to the continental rise and across the central and southern MAM (from New Jersey to North Carolina). Where the removed sediments are re-deposited is unknown, but the magnitude and spatial extent of the bottom-current erosion are well constrained by our study. The southern MAM has experienced a number of significant mass wasting events spanning the Miocene-Pleistocene, suggesting that bottom-current erosion may have played a role in over-steepening the slope.

Acknowledgement:

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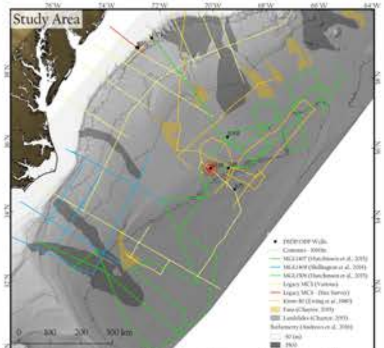
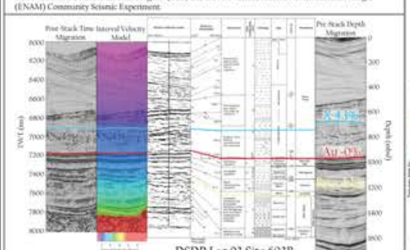
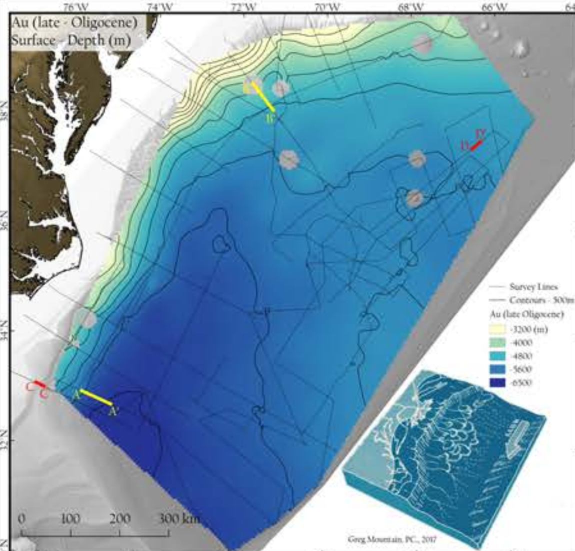


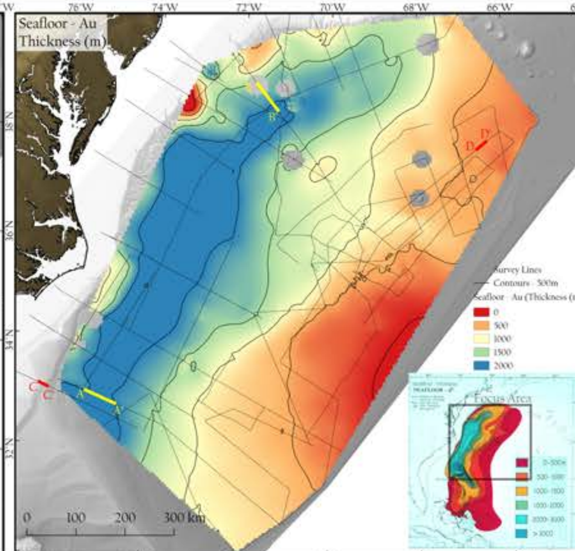
Survey Area:
Focus area spans the U.S. mid-Atlantic Margin from North Carolina to New Jersey and extends from the shelf-break to the Hatteras Abyssal Plain. New 2D MCS data (MGL1407, 1408, & 1506) were collected as part of the USGS Extended Continental Shelf Program (ECS) and the NSF funded Eastern North American Margin (ENAM) Community Seismic Experiment.



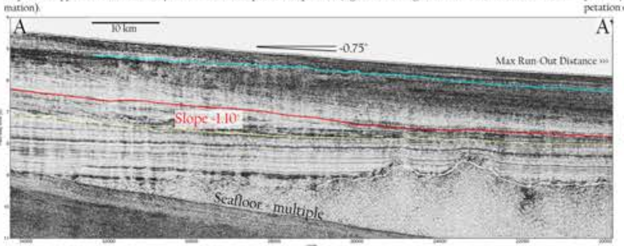
Seismic - Well Tie:
Allostratigraphic (unconformity-bound) framework are correlated with drilling results from DSDP Leg 93 Site 603B and mapped onto a combination of new 2D post-stack Kirchhoff time migrated data and legacy 2D data collected over the past 42 yrs. Framework is then used to create starting interval velocity models for pre-stack depth migration. Resulting depth data are checked against site 603B and correlation is calculated as % difference. Depth correlation errors of <5% are considered acceptable.



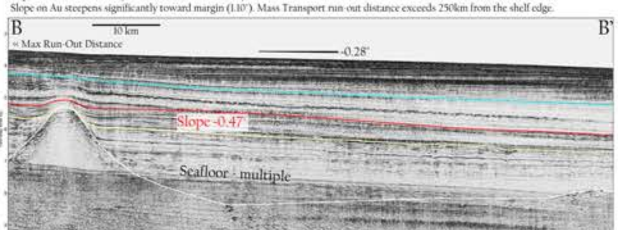
Au (late Oligocene):
Au is a prominent reflection across the mid-Atlantic margin and marks significant erosion by bottom currents in the late Oligocene (inset). Erosion/removal of the underlying Eocene-Paleocene unit is greatest in the south, resulting in relatively steep slopes. Slope of Au appears to control subsequent sediment transport and deposition (e.g. mass wasting, submarine fan, and contourite formation).



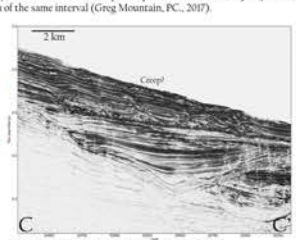
Seafloor - Au (late Oligocene):
Significant infilling of the eroded Eocene-Paleocene unit produced upper-rise post late Oligocene (seafloor-Au) sediment thickness >2km. This interval is thickest in the south, where erosion was most pronounced. This unit contains both fan and ridge deposits, primarily in the north. Mass transport deposits account for a majority of the southern sediment package. Inset shows a 1981 interpretation of the same interval (Greg Mountain, PC., 2017).



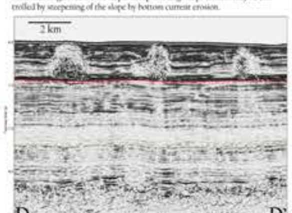
Cape Fear - MGL1407-15 (~75-175km from shelf-break):
Slope on Au steepens significantly toward margin (1.10°). Mass Transport run-out distance exceeds 250km from the shelf edge.



Hudson Apron - MGL14107-01 (~75-175km from shelf-break):
Slope on Au steepens slightly toward margin (0.47°). Mass Transport run-out distance does not exceed 75km from the shelf edge.



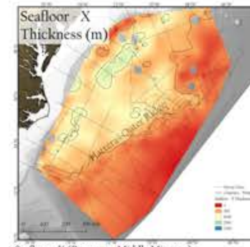
Above Cape Fear Slide Headwall - MGL1408-34:
Pleistocene section appears to be creeping where the Cape Fear Submarine Landslide originated on the slope. Creep and large slope failures may be controlled by steepening of the slope by bottom current erosion.



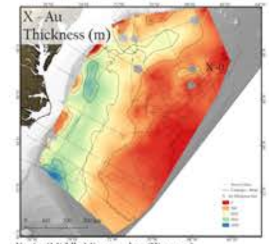
Buried/eroded submarine fan - MGL1407-06A:
Fan sits directly above Au and contains lenticular sediment geometry indicating channel cut fill.

Conclusions:

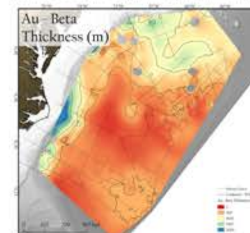
- We map slope erosion across the margin associated with a late-Oligocene period (Au). The erosion is highest in the southern portion of the margin resulting in a relatively steeper slope on post-Oligocene surfaces (south vs. the north).
- In the south, down-slope creep along steepened rise surfaces may have played a role in producing large, retrogressive failures from late Oligocene to present.
- The steeper rise in the south may have also contributed to the longer slide run out distances and a larger volume of mass transport deposits as compared to the north.
- Unroofing by post-Oligocene erosion may have promoted salt diapirism, which in turn could also have contributed to slope steepening and failure. Additionally, changes in slope angle can also be affected by other factors (e.g., crustal structure, sediment supply, sediment bypass of steep slopes, and sediment reworking).
- In the north, seafloor fans are more prevalent and larger in post late-Oligocene-present sedimentary units. The presence of fans in the north, where surfaces have lower slopes, vs. large mass transport deposits in the south, where slopes are greater, indicates that erosion by bottom currents played a key role in controlling how sediments were transported to the deep sea along the U.S. mid-Atlantic margin.



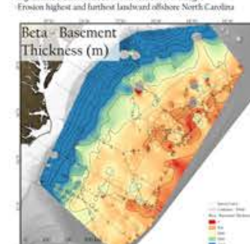
Seafloor - X (Present to Middle Miocene):
- Significant submarine fan building associated with Pleistocene glacial intervals
- Hatteras Outer Rige contains stacked sets of contourites translating north



X - Au (Middle Miocene - late Oligocene):
- Significant infilling of the resultant depression made by Au
- Horizon X does not exist along the northern lower continental rise (D-D')



Au - Beta (late Oligocene - middle Early Cretaceous):
- Significant erosion of Eocene-Paleocene across margin
- Erosion highest and furthest landward offshore North Carolina



Beta - Basement (middle Early Cretaceous - Jurassic):
- Relatively even sediment distribution
- Thickness variations controlled by basement roughness and proximity to the margin

Thank-You!