Exceptional Color/Color Pattern Retention in 30 Million Year Old Oligocene, River Bend Formation Invertebrate Specimens from North Topsail Beach, NC

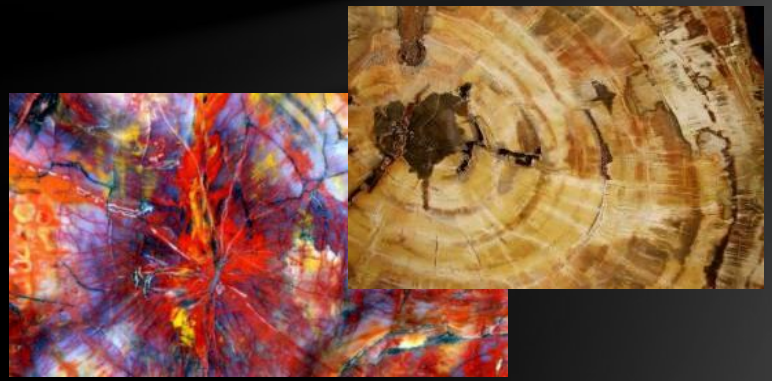
Linda McCall, NCFC; University of Texas – Austin

Fossil Color

Is preserving fossil color even possible??

Color is fragile and deteriorates quickly

Colors present typically are the result of minerals incorporated during diagenesis



Fossil Color Patterns

Older, more altered…..

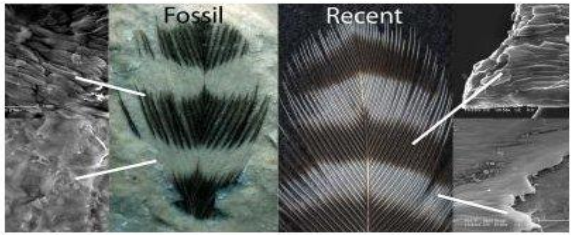
Fossil Color

monochromatic

visualizations

Fossil Color

Striped Fossil Feather and Recent Woodpecker Feather



Caption: Striped fossil feather and recent woodpecker feather. Under the scanning electron microscope there are melanosomes in the dark but not the light areas (left arrows) of the fossil. For comparison, melanosomes from a broken black feather and a white feather are shown (right arrows).

Credit: J.Vinther/Yale

Melanosomes

Proteins in *Ecphora*

Bleach and Black Light

North Topsail Beach

December 18, 2014
to June 30, 2015

The Process

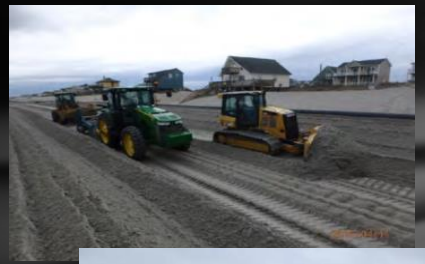
Charleston

7′ and rotates at 36 rpm

30″ pipe

Rock on the Beach

No One Likes the Rock



Moved a Lot of Rock

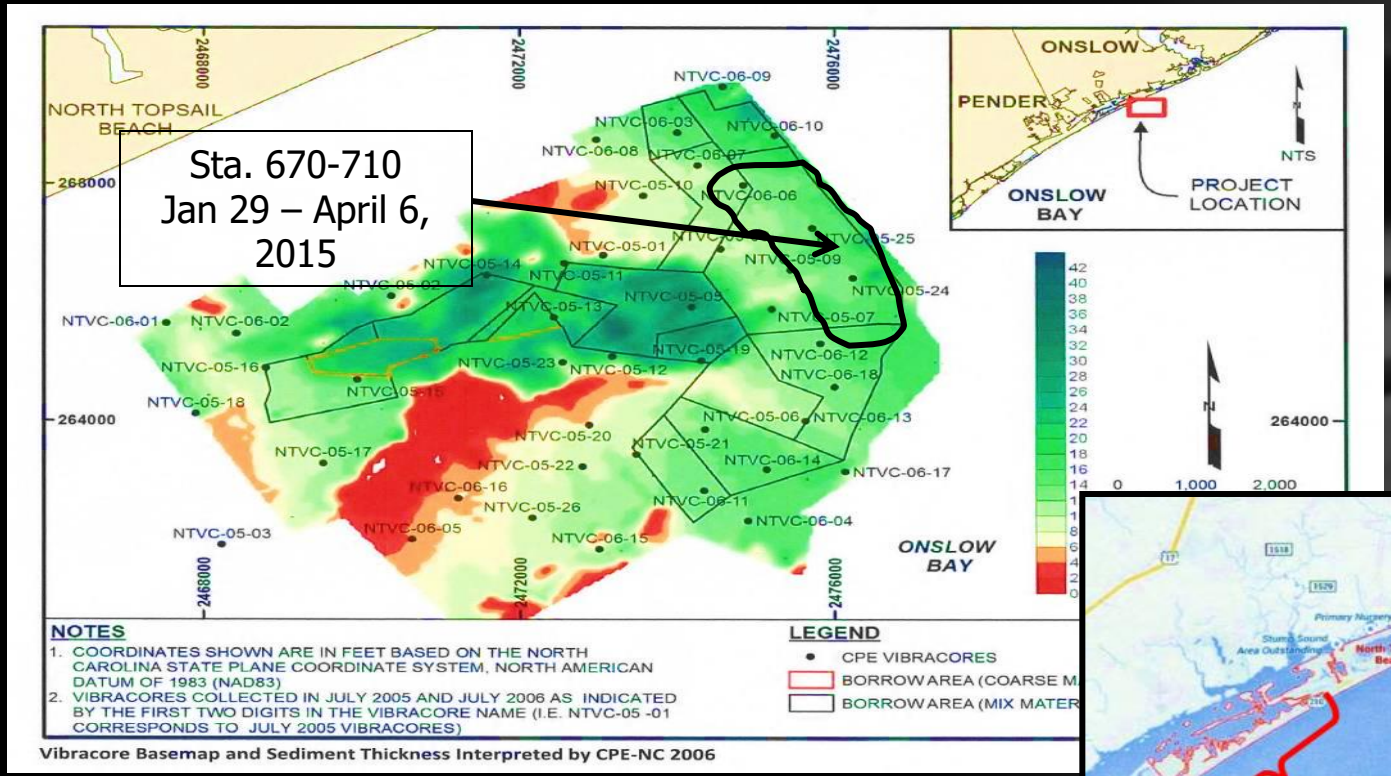
"grooming"

Still Rock on the Beach

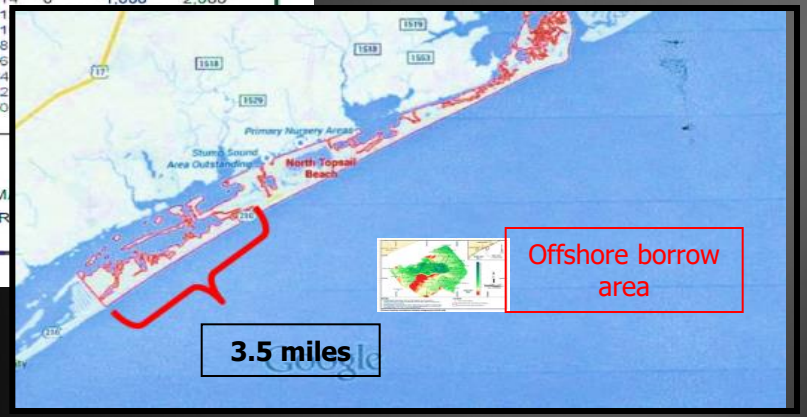
Modern Shells / Sub Fossils / Fossils

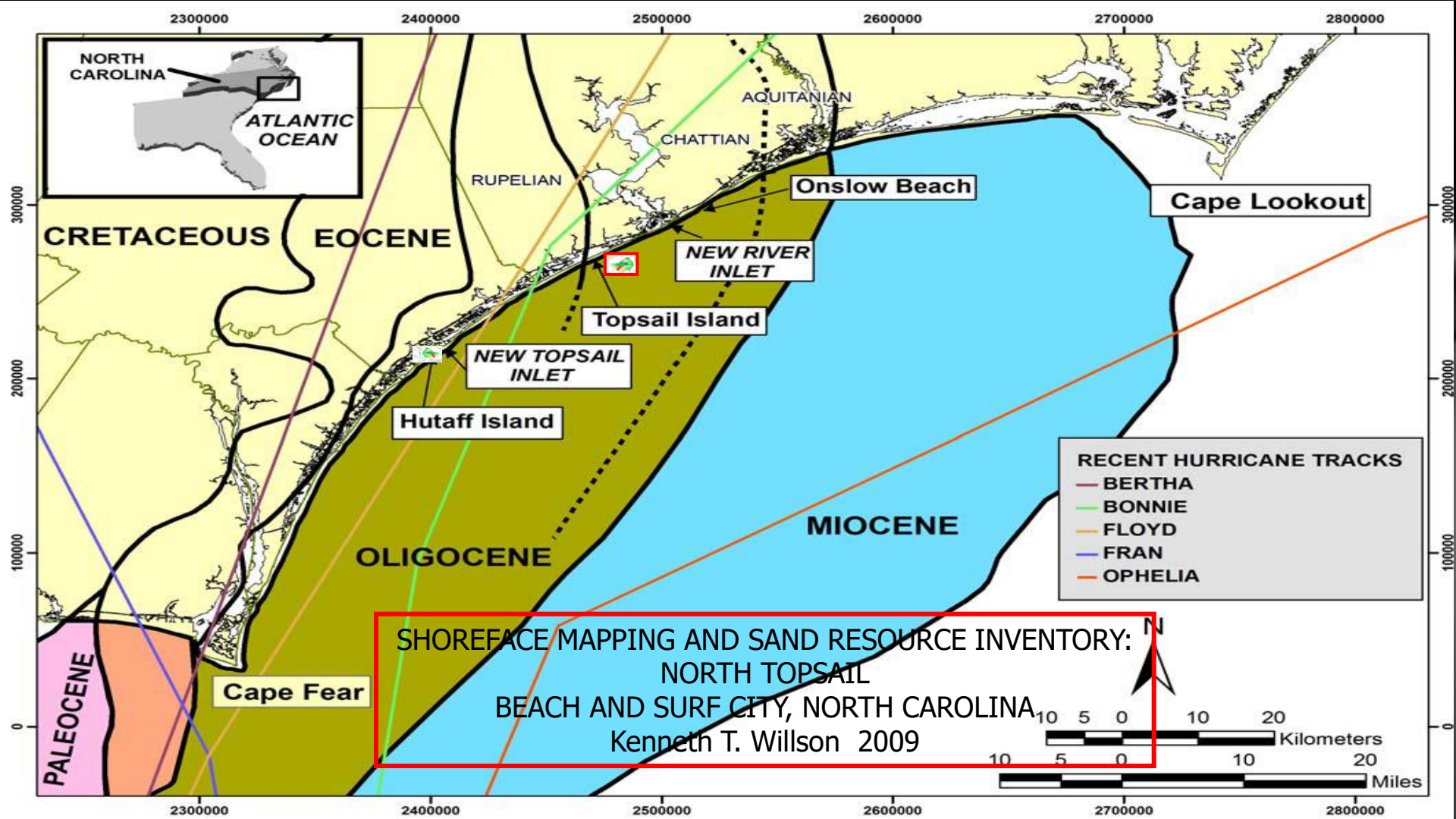
Most Productive Beach Section

Offshore Borrow Area



Vibracore Basemap and Sediment Thickness Interpreted by CPE-NC 2006




2300000
2400000
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NORTH CAROLINA
ATLANTIC OCEAN
AQUITANIAN
CHATTIAN
RUPELIAN
Onslow Beach
Cape Lookout
CRETACEOUS
EOCENE
NEW RIVER INLET
Topsail Island
NEW TOPSAIL INLET
Hutaff Island
MIOCENE
OLIGOCENE
PALEOCENE
Cape Fear
RECENT HURRICANE TRACKS
BERTHA
BONNIE
FLOYD
FRAN
OPHELIA
SHOREFACE MAPPING AND SAND RESOURCE INVENTORY:
NORTH TOPSAIL
BEACH AND SURF CITY, NORTH CAROLINA
Kenneth T. Willson 2009
N
10 5 0 10 20
Kilometers
10 5 0 10 20
Miles
300000
200000
100000
0

River Bend Formation- Oligocene

River Bend Formation – 30 Ma

Hemipatagus carolinensis

Primitive Whale Brain Casts/Teeth

Echinoderms, Oysters and more

Fossil Variety

Right Whale
right periotic

Diagenetic Alteration….

External Mold

Internal Cast

30 Million Year Old Fossils with COLOR??

30 MA Color Patterns

Old and Altered…

Black Light








Real color? Mineral Replacement? How Fragile?

More Stable than Thought

Colors Fade When Dry

Wet

Dry

Wet

Dry

Bleach to UV Radiation

August 9, 2015

April 7, 2018

UV Radiation WILL remove the color

Bleaches in the sun

August 9, 2015

May 15, 2016

April 7, 2018

UV Radiation WILL remove the color

Bleaches in the sun

August 9, 2015

May 15, 2016

April 7, 2018

Lots of Color/Color Patterns

Crustacean Patterns

Balanus sp. (Acorn Barnacle)

30 MYA Barnacles

Brittle Stars

Gagaria mossomi tests & spines

Hemipatagus carolinensis














Pycnodonte paroxis (Oyster)








Something is going on here….
Real Color? Mineral Replacement??

Modern Acorn Barnacle

30 MYA Barnacle

Topsail Beach Barnacles

Modern Topsail Barnacle

30 MYA Topsail Barnacle

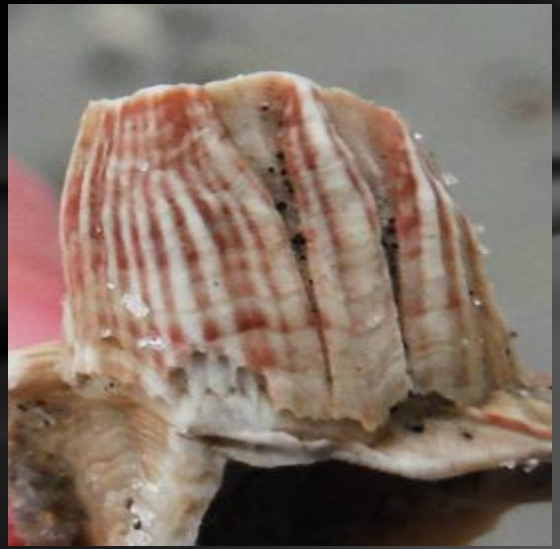
Close-ups

Modern Topsail Barnacle

30 MYA Topsail Barnacle

Topsail Beach Barnacles

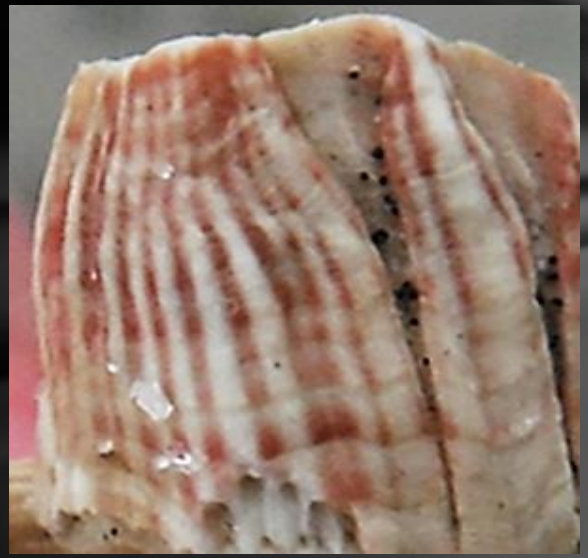
Modern Topsail Barnacle



30 MYA Topsail Barnacle

Close-ups

Modern Topsail Barnacle



30 MYA Topsail Barnacle

Topsail Beach Oysters




Modern Topsail Oysters




Extinct Topsail *Pycnodonte paroxis*

Close-ups

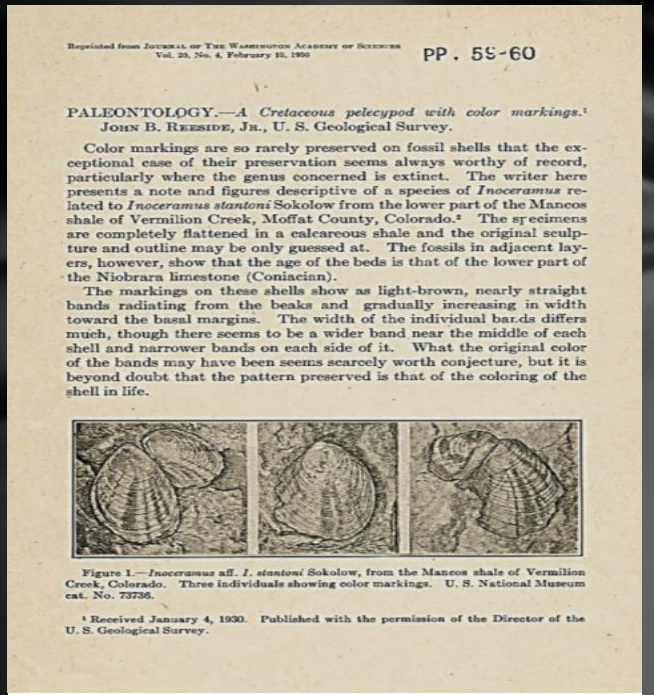
Close-ups

Other Fossil Oysters

Pycnodonte mutabilis
Ripley Formation / MS
Glauconitic sandstone
Late Cretaceous

Pycnodonte paroxis
River Bend Formation
Sandy, silty limestone
Oligocene / NC

Pycnodonte convexa
Navesink Fm. / NJ
Muddy glauconitic sands
Late Cretaceous



Reprinted from JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES
Vol. 20, No. 4, February 15, 1930

PP. 58-60

PALEONTOLOGY.—*A Cretaceous pelecypod with color markings.*[1]
JOHN B. REESIDE, JR., U. S. Geological Survey.

Color markings are so rarely preserved on fossil shells that the exceptional case of their preservation seems always worthy of record, particularly where the genus concerned is extinct. The writer here presents a note and figures descriptive of a species of *Inoceramus* related to *Inoceramus stantoni* Sokolow from the lower part of the Mancos shale of Vermilion Creek, Moffat County, Colorado.[2] The specimens are completely flattened in a calcareous shale and the original sculpture and outline may be only guessed at. The fossils in adjacent layers, however, show that the age of the beds is that of the lower part of the Niobrara limestone (Coniacian).

The markings on these shells show as light-brown, nearly straight bands radiating from the beaks and gradually increasing in width toward the basal margins. The width of the individual bands differs much, though there seems to be a wider band near the middle of each shell and narrower bands on each side of it. What the original color of the bands may have been seems scarcely worth conjecture, but it is beyond doubt that the pattern preserved is that of the coloring of the shell in life.

Figure 1.—*Inoceramus* aff. *I. stantoni* Sokolow, from the Mancos shale of Vermilion Creek, Colorado. Three individuals showing color markings. U. S. National Museum cat. No. 73736.

[1] Received January 4, 1930. Published with the permission of the Director of the U. S. Geological Survey.

Inoceramus sp.
Mancos shale / Vermilion Creek, CO
Mudrock
Late Cretaceous 1930

Maretia vs. *Hemipatagus*

Maretia

Hemipatagus

Hemipatagus carolinensis

Repeating Color Patterns - Aboral









Aboral Pattern – Petaloid Ambs

"Lined" Ambs

Color striping various widths inside adradiad sutures, perradid sutures clear

496 specimens

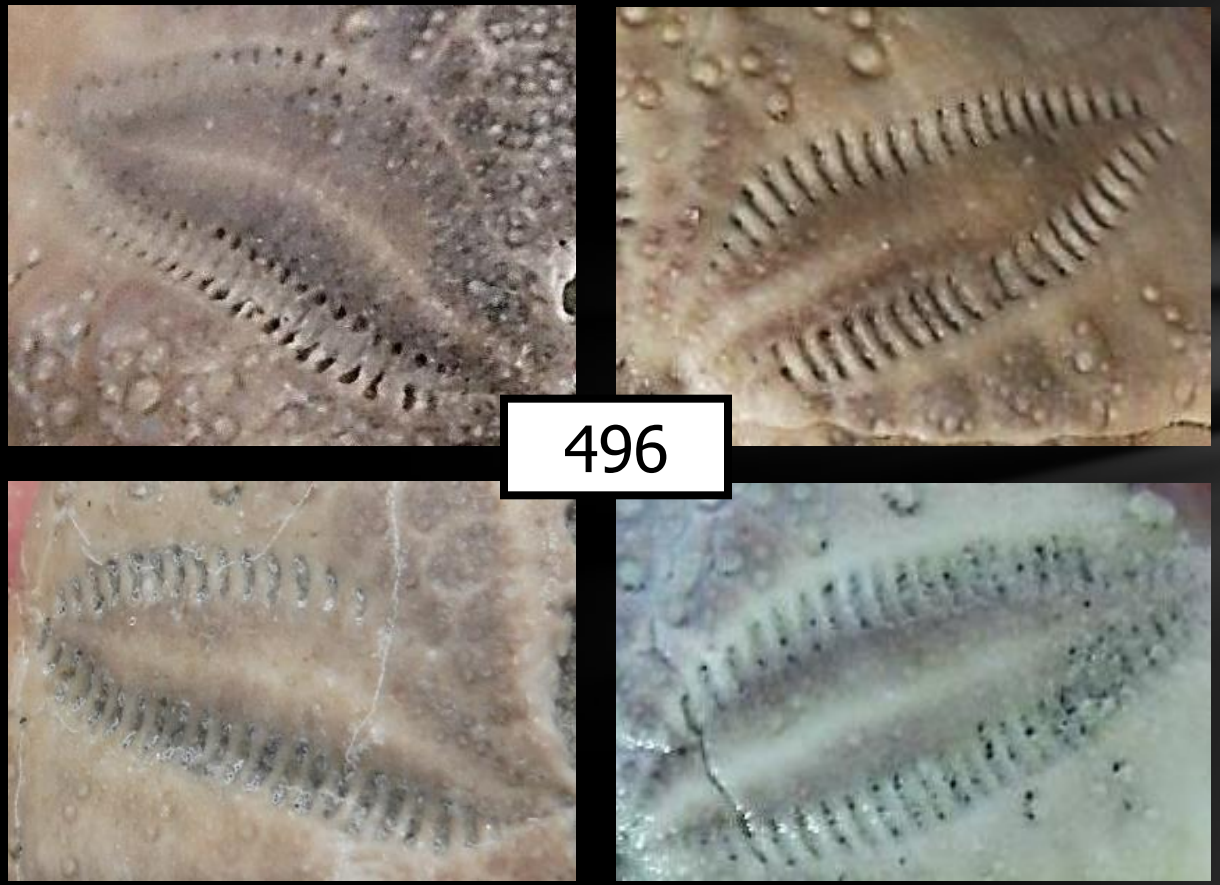
"Filled" Ambs

Petals entirely color filled

213 specimens

“Lined ambs”

“Filled ambs”



Aboral Pattern – Upper Test

"Dashed"

Ambulacral & interambulacral plates colored

All meridonal sutures lacking color

207 specimens

"Shaded"

All plates between the two upper adradiad sutures colored including most sutures

338 specimens

"Mixed"

As implied, a mix of "Dashed" and "Shaded" coloration

164 specimens

207

338

Pattern Correlation Ambs/Upper Test

Lined Ambs with Dashed tops

190 specimens

Lined Ambs with mixed tops

144 specimens

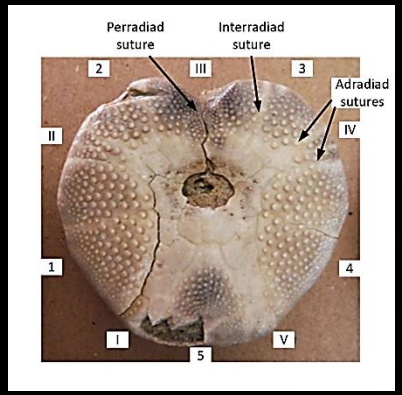
Lined Ambs with shaded tops

162 specimens

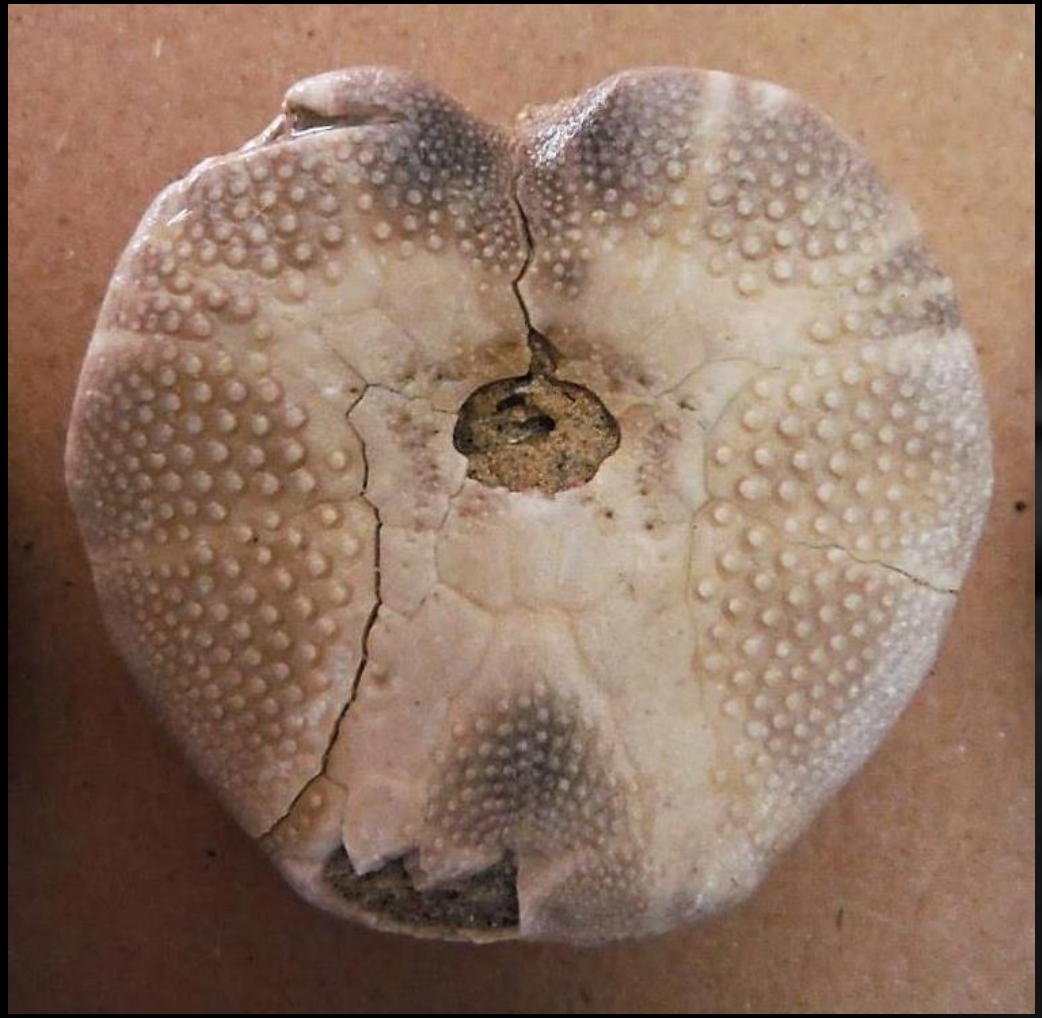
Filled Ambs with shaded tops

176 specimens (213 total)

Lined Ambs – Adoral Color Pattern



Patterns wrap around specimens



Maretia vs *Hemipatagus*

Maretia - extant



Maretia color

- Epidermal pigmentation
- Not present in mesodermal tissue
- Not retained in dead, cleaned specimens

Hemipatagus - extinct



Hemipatagus color

- Had to originate post mortem
- How?
- When?
- Why?

Maretia with Color on Test

Into the Realm of Speculation

- Wrap in cellophane? Unlikely
- Initial transfer, post-mortem, pre fossilization:
  - Rapid burial – alive or shortly after death
  - Fine non-permeable coating
  - Pressure
  - Allows transfer of colors into the pores in the test
- Transfer retained during diagenisis:
  - Recrystallization of the stereom microstructure of the plates (High Mg to Low Mg)
  - Minimal sediment permeability w/o significant fluid movement
- This also helps explain how the oysters and barnacles are retaining their color

Common Theme - Calcite?

Calcite might to be a good medium for preserving color

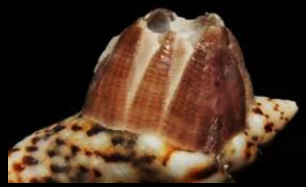
- Study of proteins in *Ecphora* concluded, "the organic material was able to be protected within the calcite"
  - Nance, et.al; 2015 European Assoc. of Geochemistry
- 340 Ma old organic molecules identified in crinoids
- All 6 Topsail species showing color/color patterns were calcitic
- Pigment remnants incorporated during diagenesis?

Ecphora
18Ma

What are the Right Conditions?

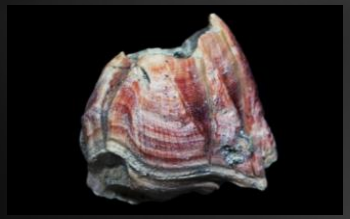
- 1 Rapid burial
- 2 Optimal preservational conditions
- 3 Rapid matrix removal
- 4 Rapid retrieval

Ecphora
18MYA



Modern Barnacle

James City Formation
2MYA



James City Formation
2MYA

River Bend Formation
30MYA

1 Evidence of Rapid Burial

Echinoids with spines

More Evidence of Rapid Burial

Double valve oysters, barnacles with opercular valves, intact asteroids








Additional Supporting Evidence

Frequently one side of the Hemipatagus retains better color than the other – gravity would pull the color down, giving the side facing up a better transfer.

Some Hemipatagus show incomplete color transfer, not a good seal – incomplete silt coating – not enough pressure above long enough for the transfer… Color can be great, blotchy, pale, or no color at all. Whether these issues occurred during the initial transfer or during subsequent digenesis needs to be researched.





Botched Transfer / Good Transfer

2 Optimal Preservational Conditions

Mid-shelf location

Submerged– Oligocene – Modern, only exposed briefly during the Pliocene/Pleistocene

Silty coating

Fine Silt Covering

"Cellophane" lock in/out allowing epidermal pigments stain test post-mortem

3 Rapid Removal from matrix

7′ auger rotating at 36 rpm

Sandblasted

- 30 in. pipe
- 3 miles
- 100 psi
- 30 – 45 min

Larger rock mostly hardground

- matrix below mostly disintegrated, fist sized & smaller
- sturdier fossils survived, though often damaged & "frosted"
- "spine hash"

Spine and Test Hash

Broken *Gagaria* spines
Broken echinoid test pieces

4 Rapid Retrieval

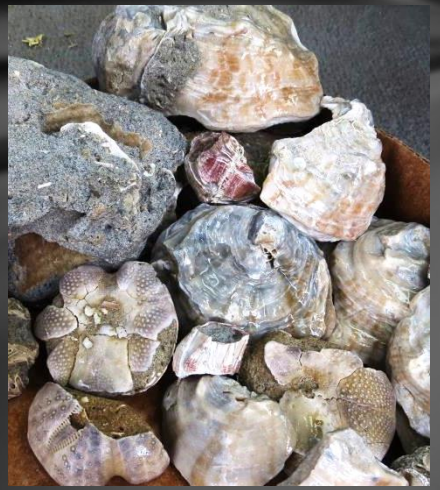
Erosional beach – each new tide uncovers new material

Collected
Sunday
October 18, 2015

4 Rapid Retrieval

October 18, 2015

April 24, 2016



March 4, 2018

Summary

30 million year old color?

- Maybe – needs chemical analysis / Compelling evidence
  - Rapid burial
  - Optimal preservational conditions
  - Unorthodox rapid matrix removal
  - Rapid retrieval

Ongoing Research

Further physical and chemical analysis/testing needed

- Staining modern *Maretia* and leaching in varying conditions
- Thin sectioning *Hemipatagus* plates to view recrystallized stereom
- XRF analysis to determine elemental composition of staining
- Analyze composition of silt covering

Color is there…..



























Thanks…

Dedicated to: Dr. Ann Molineux late Director of Museum Operations for the Nonvertebrate Paleontology Laboratory, Jackson School of Geosciences, UT Austin

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Bret Bennington, Hofstra University

David Campbell, Lenoir-Rhyne University

Lyle Campbell, University of South Carolina

David Dockery, Mississippi Office of Geology

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NCFC members

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Adam Priest, Engineer Coastal, Ports and Marine Environmental & Infrastructure

Lou Zachos, University of Mississippi

Topsail Beach

- Stuart Turille, Town Manager
- Tom Best, Fire Marshal
- Bill Poe, Deputy Fire Chief

QUESTIONS?