Surficial Quartz Sand Deposits On The Atlantic Coastal Plain:

Eolian, Fluvial Or Marine?

The Case For A Catastrophic Delivery Mechanism

Paper No. 4-6
Southeastern Section – 61st Annual Meeting
1 April, 2012
Asheville, NC USA

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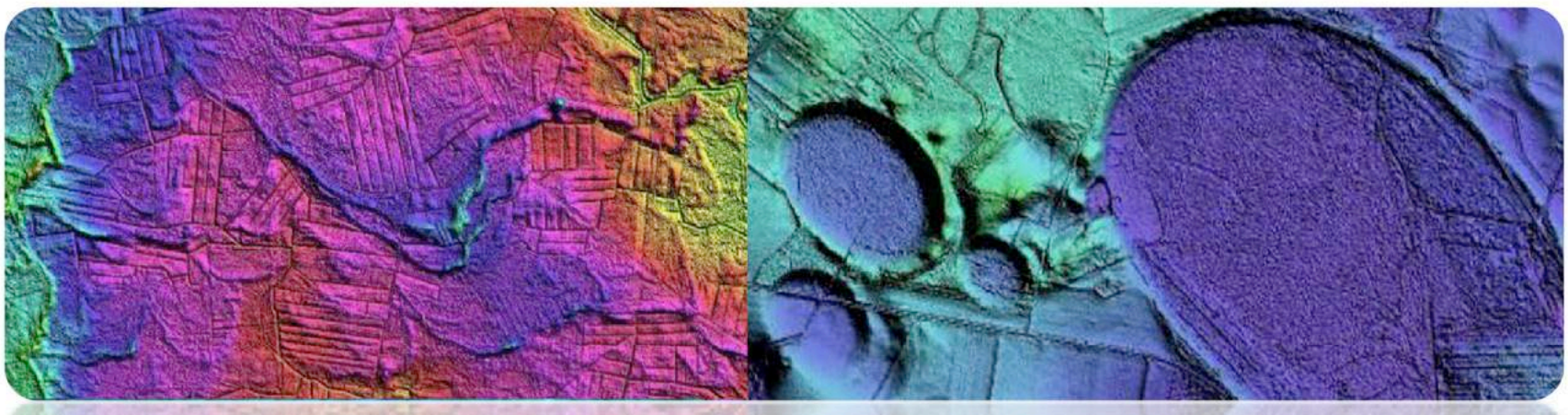
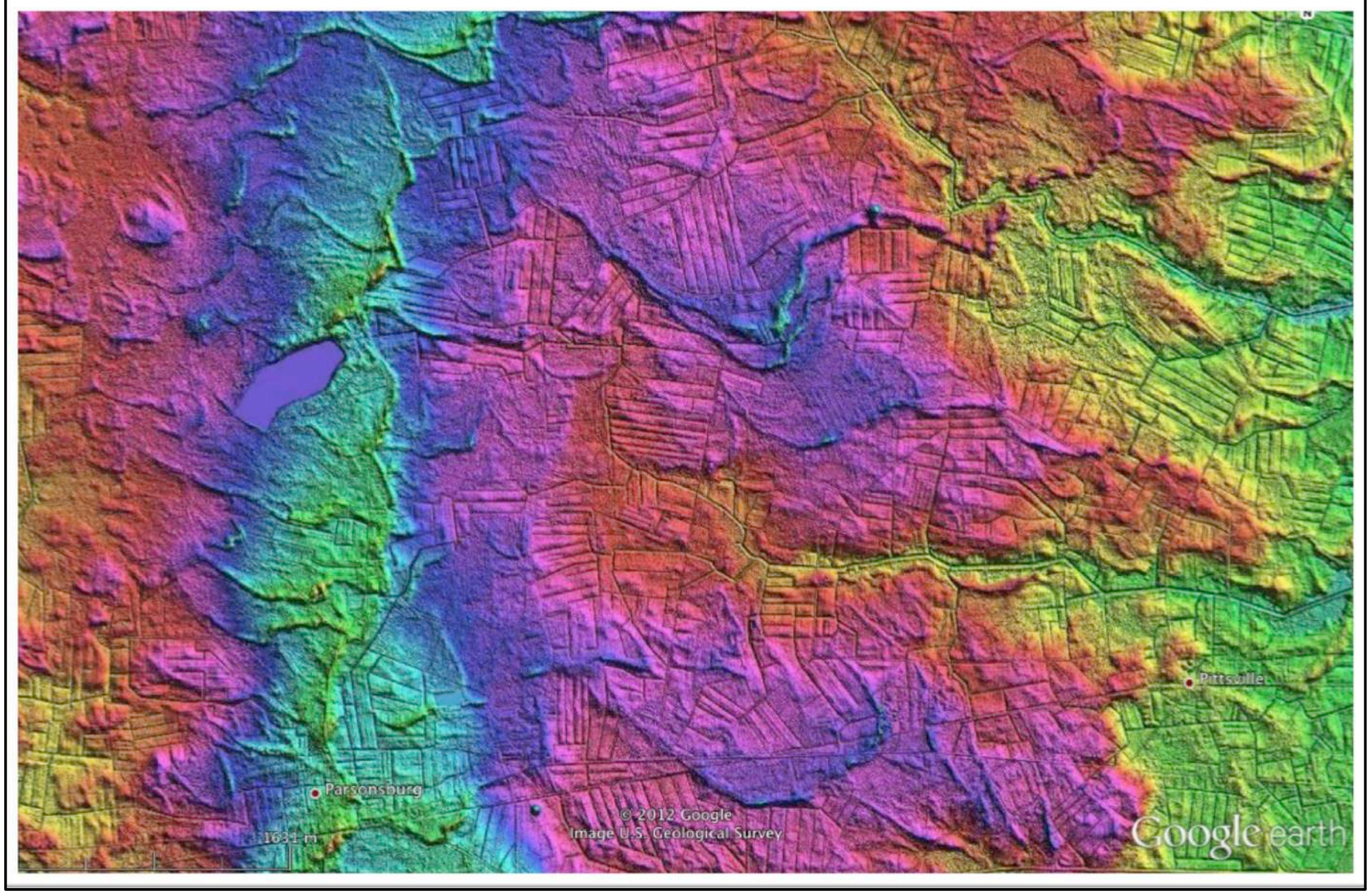


Greetings:

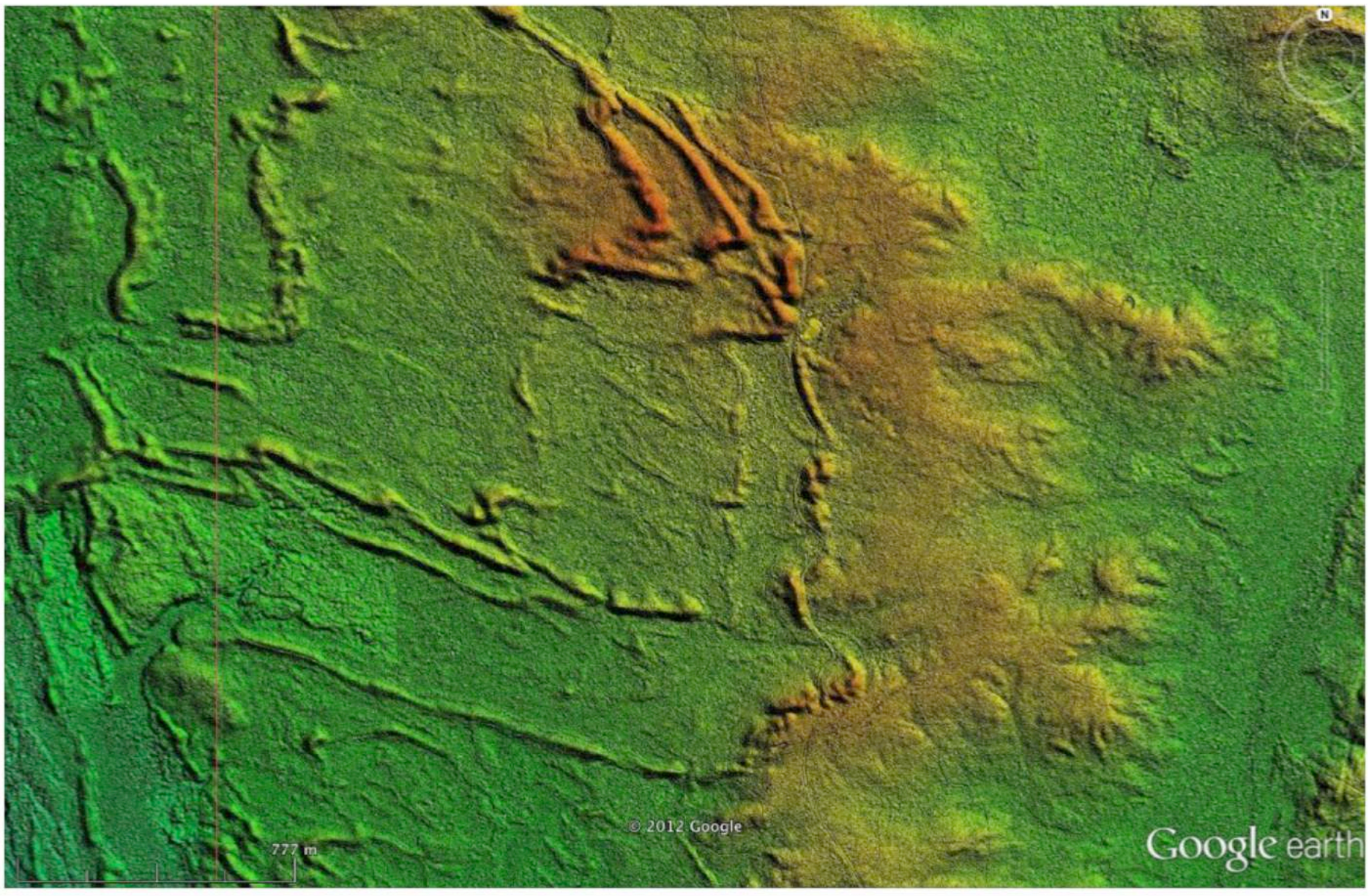
I do appreciate this opportunity to share our observations and speculations regarding the surficial sands of the Atlantic Coastal Plain. We begin by discussing two diverse populations of conspicuous landforms which arise from that sand .

Eolian Sand Sheets – Maryland



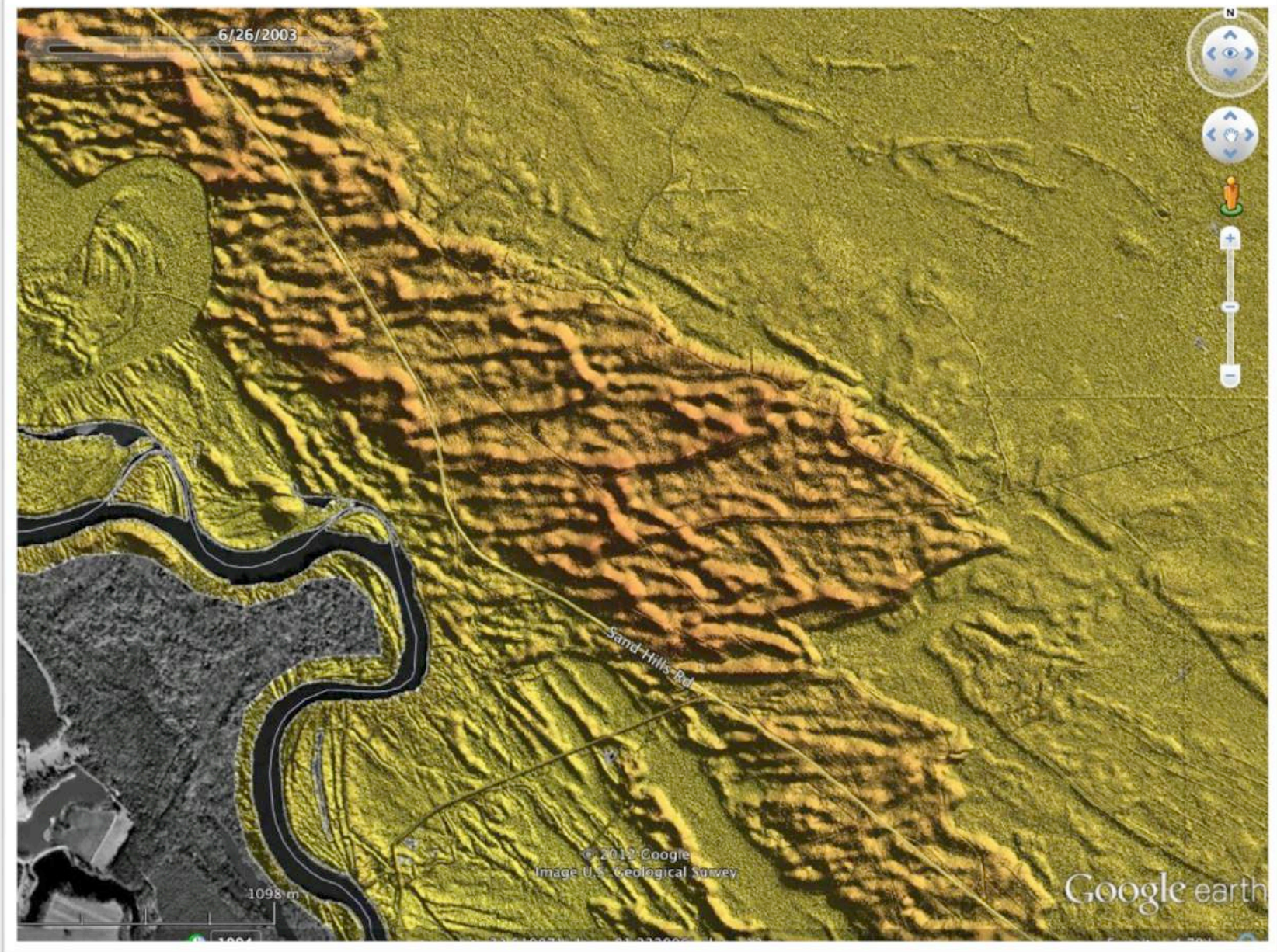
First are dunes, seen here on the Delmarva Peninsula. This is an hsv-hinted digital elevation map using USGS Data, processed in Global Mapper, and visualized in Google Earth. A 20x elevation exaggeration enhances our view.

Eolian Sand Sheets – New Jersey



This dune field is in south-central New Jersey.

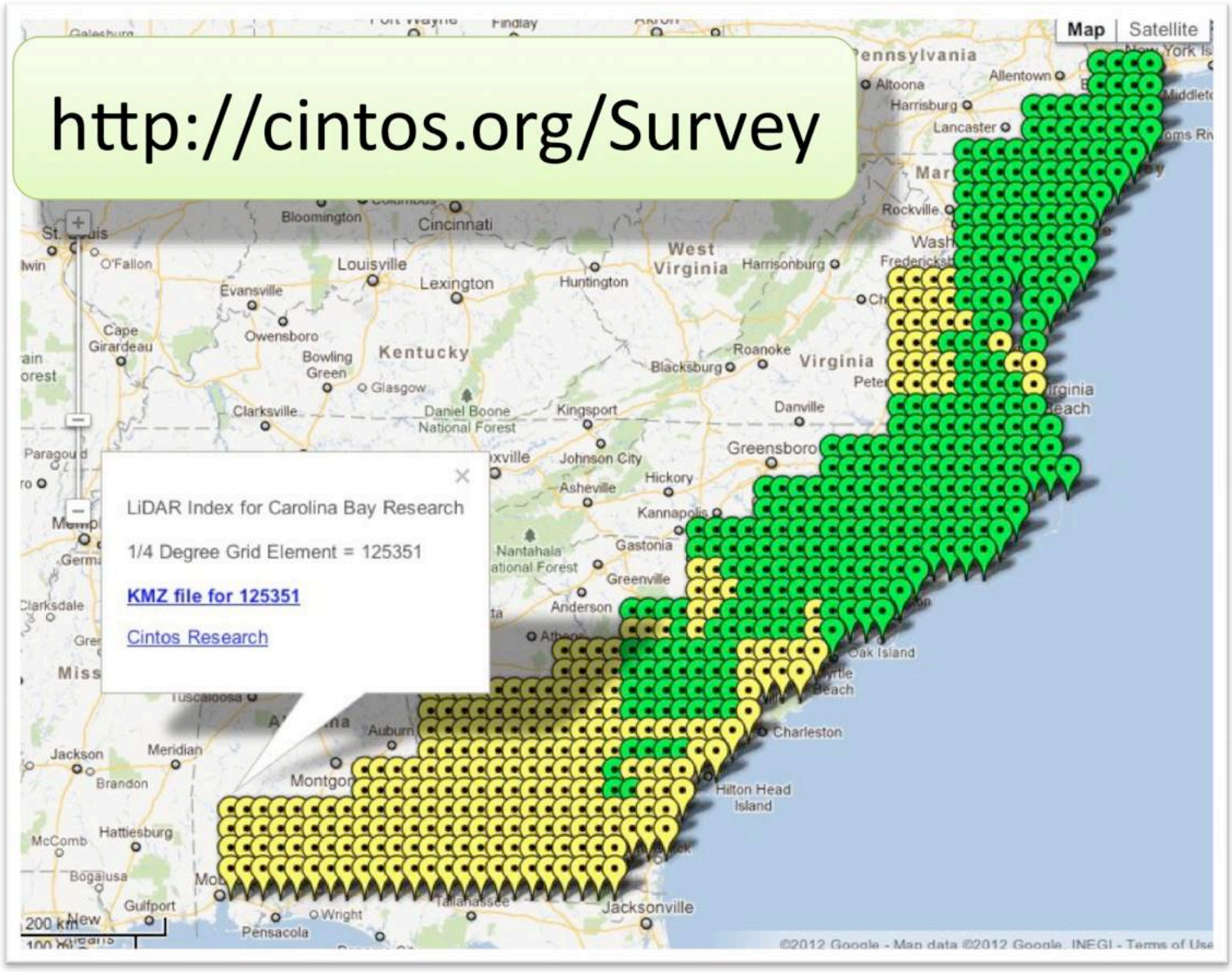
Eolian Sand Sheets – Jasper County, SC



Dunes are also common on the eastern banks of major braided channels across the coastal plain, here in Jasper County SC.

This LiDAR imagery is available for you to explore using data sets available from our commercially-hosted web server.

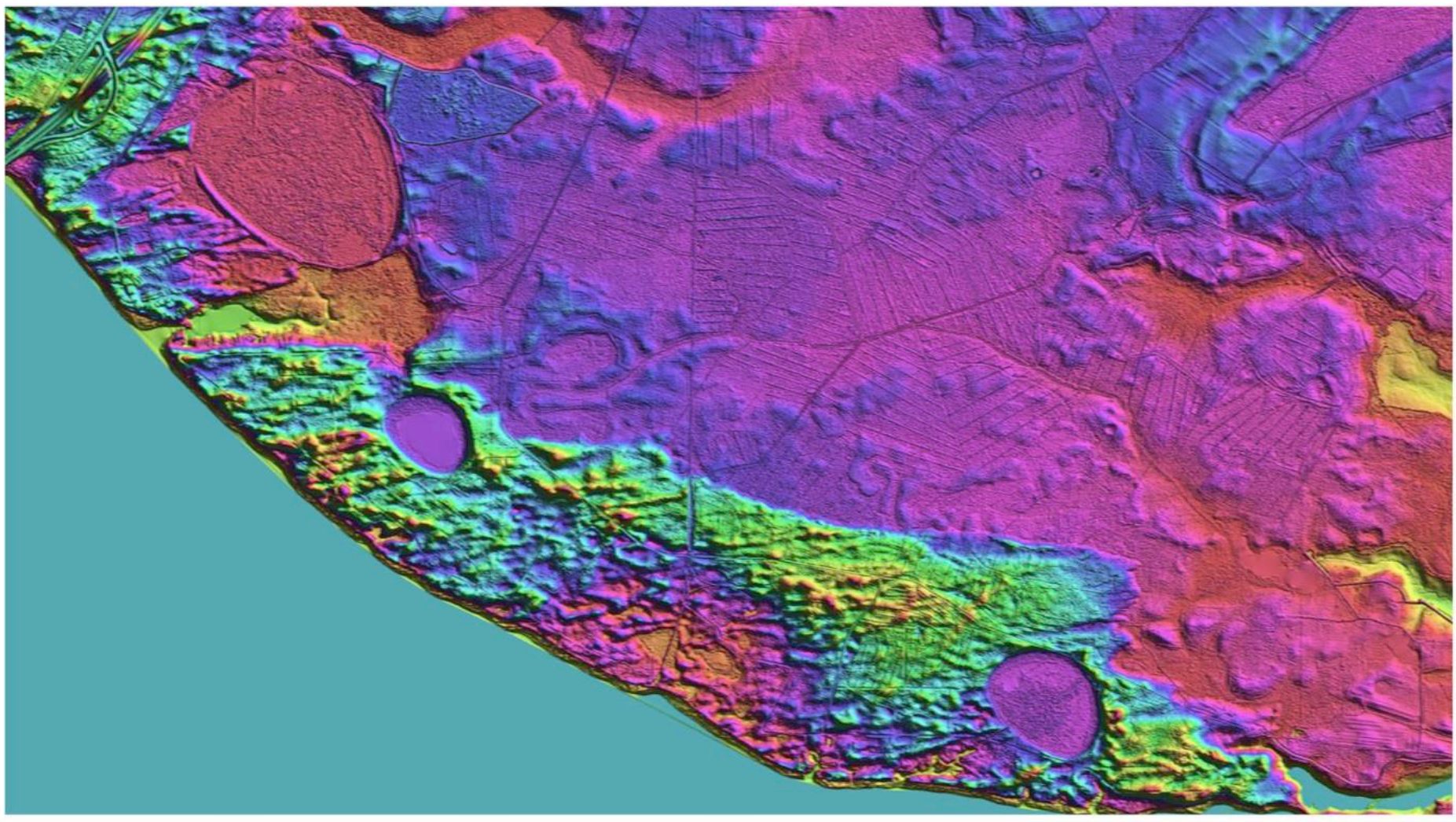
Carolina Bay LiDAR Survey Index



This is a Google Fusion Table geospatial map of our survey grid, available at the link shown. Placemarks identify ¼ degree by ¼ degree regions.

A hyperlink in their pop-up window opens the LiDAR in the Google Earth. Only the Green regions have LiDAR-resolution DEMs.

Dunes & Bays– Lake Marion



The second conspicuous landforms are closed depressions commonly referred to as “Carolina bays”. This LiDAR demonstrates a juxtaposition of dunes & bays along Lake Marion in South Carolina, suggesting to us that a relationship exists between the surficial sand, the dunes and the bays.

Sources of Surficial Quartz Sand Deposits On The Atlantic Coastal Plain

- ✓ Eolian
- ✓ Fluvial
- ✓ Marine
- ✓ Residual/Pedogenic/Weathering
- ✓ Catastrophic?

Among mechanisms proposed for these sand deposits are eolian, fluvial, marine, or residual. While these gradualistic processes are certainly applicable, I'd like to posit a 5th a source: a dis-continuous blanket up to 10 meters thick, CLICK catastrophically delivered.

I can hardly suggest that I will be making a persuasive defense here today; I simply hope to introduce a 5th option for you to consider. Along the way, I will explain my reasoning for proposing such a unorthodox concept.

Some Characteristics

- ✓ Quartz Sand
  - ✓ 98 to 99% SIO_2
  - ✓ Homogeneous grain size
  - ✓ Coarsely Skewed
- ✓ Lack of internal structure
  - ✓ Horizontally
  - ✓ Vertically
- ✓ Lack of Fossils
- ✓ Lack of Significant Clay
- ✓ Not related to underlying strata
- ✓ An Underlying Discontinuity exists

The posited blanket would be intriguing:

- ✓ High purity Quartz Sand
- ✓ Homogeneous grain size, coarsely skewed
- ✓ Lack of internal structure **Vertically**
- ✓ and **horizontally**.
- ✓ **A Total** Lack of Fossils
- ✓ Low Clay content
- ✓ Not related chemically to the underlying strata

Identification Challenges

- ✓ Lack of tracer Fossils
- ✓ “Shovel stops at State Line”
- ✓ Terrace Architecture Typically Limits Scope to Single Terrace
- ✓ Historical Restriction to Fluvial, Marine, Eolian, Pedogenic
- ✓ Ubiquity of Deposits

Your reaction might be “the terraces have been studied extensively, and this has not been noted.”

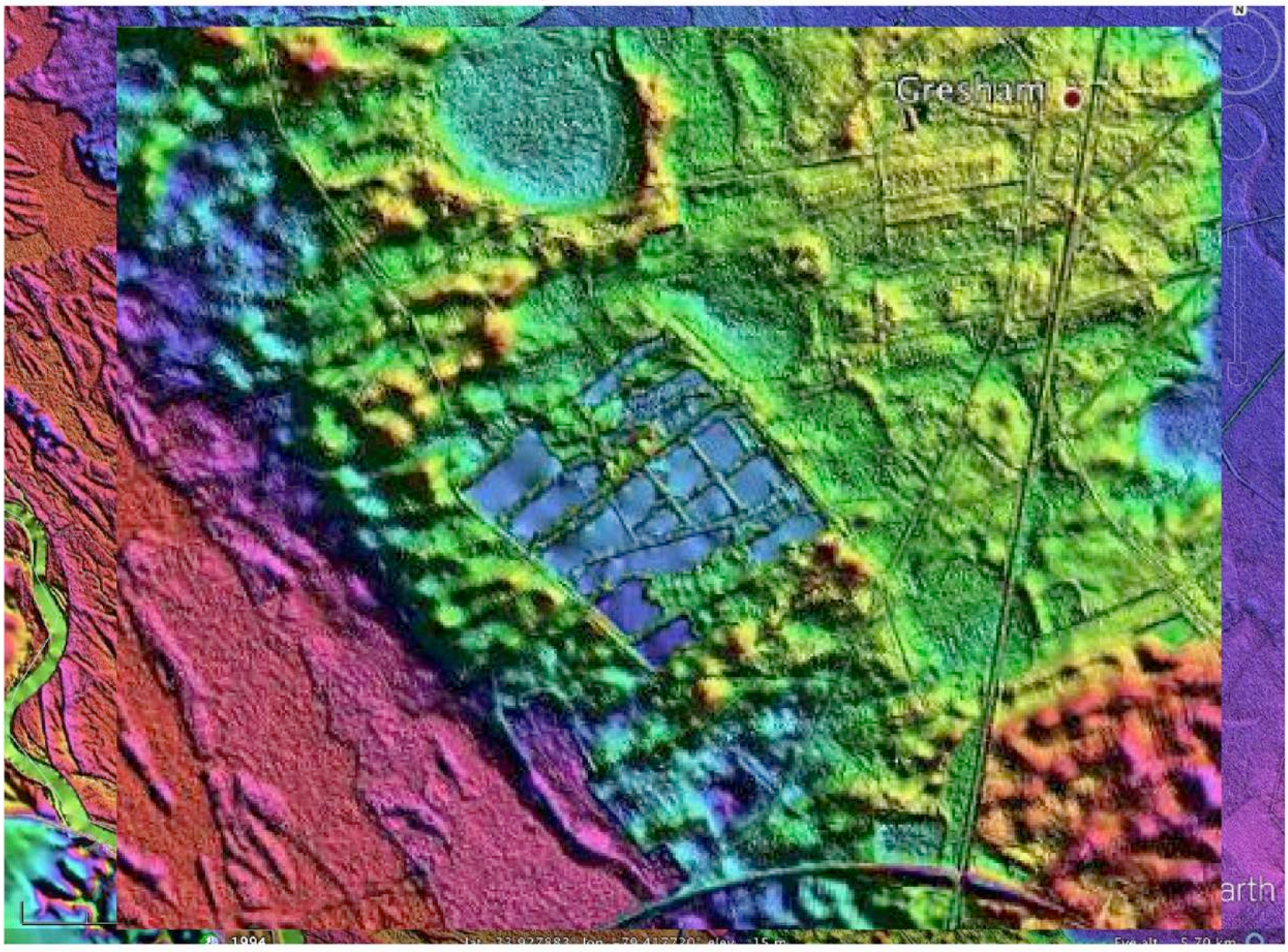
Perhaps the oversight was due to multiple factors, such as the lack of tracer fossils, regionalism of scope based on political and/or terrace boundaries.

No catastrophic option allowed in available choices

Perhaps , given the shear volume and extent of the sand, we “can’t see the forest for the trees.”

Let’s see if there is any support for such a concept in the literature and on the ground.

Dunes & Bays– Kingstree Quad



Here is another dune-bay interfaces, with crisp bays coexisting with parabolic dunes . Please note that the generic shape of these dunes in no way elicits a comparison to a bay landform.

Note the sand quarry in the center, it looks a bit like a stained glass window.

Carolina Bay Glass Sands

A significant feature of some of the bays is a sand rim around the southeast end of the depression. The sand is **rather pure and white, suitable for making White glass with little or no preparation**. … one of these deposits for several years was the source of sand for the Laurens Glass Works.

The deposit at Kingstree originally covered about 45 acres to a depth which exceeded 10 feet in some places but probably was less than that as an average. Much of this deposit has now been removed.

B.B. Buie and G.C. Robinson, 1958, SDB Division of Geology Bulletin #23, *Silica For Glass Manufacture In South Carolina*

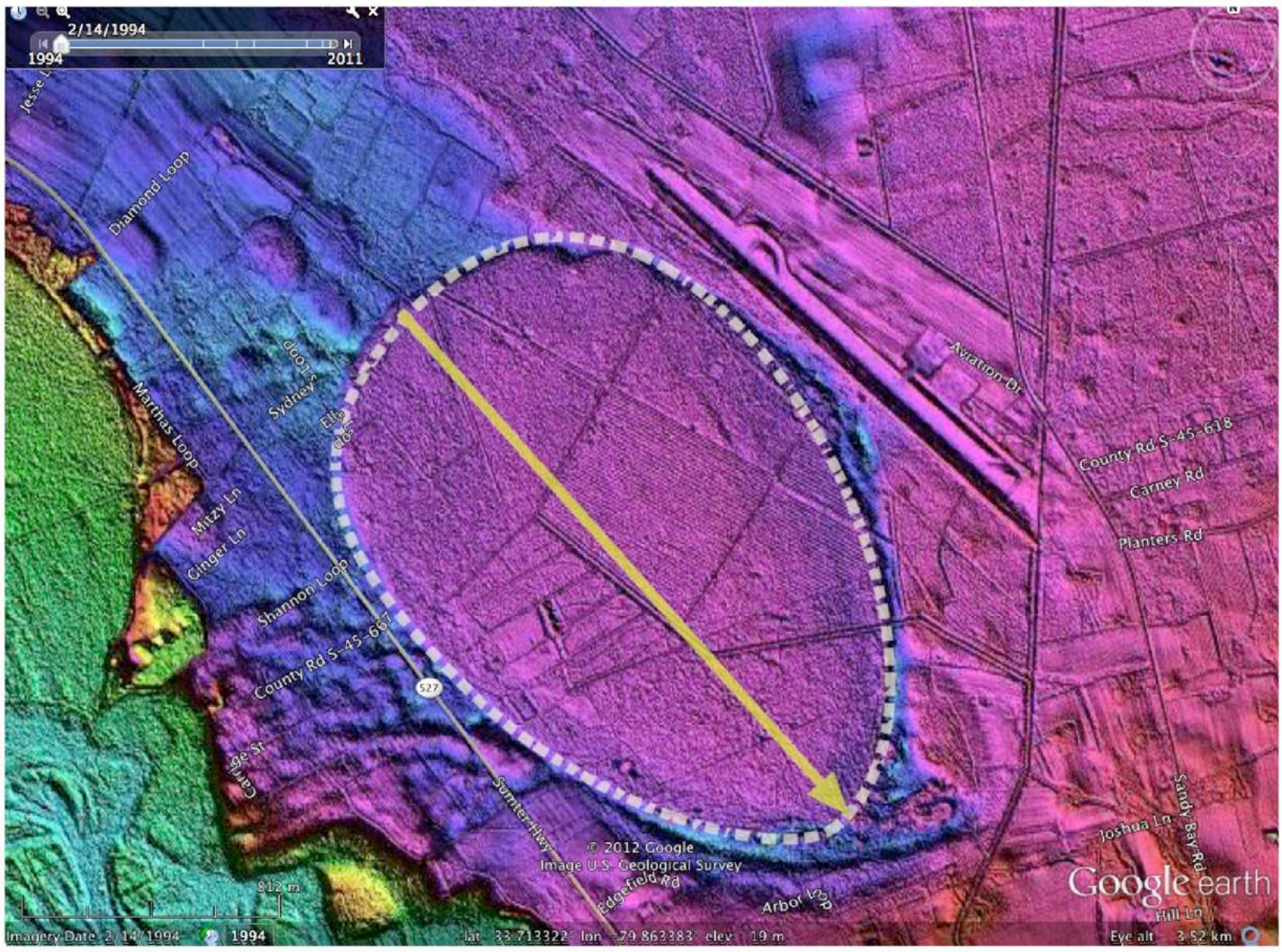
High purity quartz sand from the Carolinas has been of interest as an economic mineral for over half a century for its use in glassmaking.

A 1958 study by SC state geologists Buie and Robinson discussed a resource “rather pure and white, suitable for making White glass with little or no preparation”, covering 45 acres, about 10 ft deep.

Kingstree, Carolina Quarry

Here is the quarry site, near Kingstree, SC

Kingstree, Carolina Quarry



…in LiDAR we see it is a Carolina Bay's eastern rim, and the sheet of sand was extracted down to the level of the bay's interior. The planform shape is one of four found in our survey of the coastal plain.

Furman, SC Reclaimed Quarry

This reclamated quarry is near Furman, SC. The gently-rounded land surface seen in the surrounding terrain was shaved smooth to remove the surface sand.

but the two Carolina bay landforms and their pediments in the SW area of plot were spared. There are no obvious dunes in the area. Can we infer that the sand the bays were formed in is the same as the targeted high-quality glass feedstock?

High-Silica Sand of NC

Broadhurst (1954) described sands occurring as surficial deposits in the southern Coastal Plain region of North Carolina:

- ✓ Sandhills sands
- ✓ Bay sands
- ✓ Coastal sands

..”designations which reflect differences in their occurrence and geologic histories. Although varying locally, they **exhibit an overall uniformity of texture and composition**.”

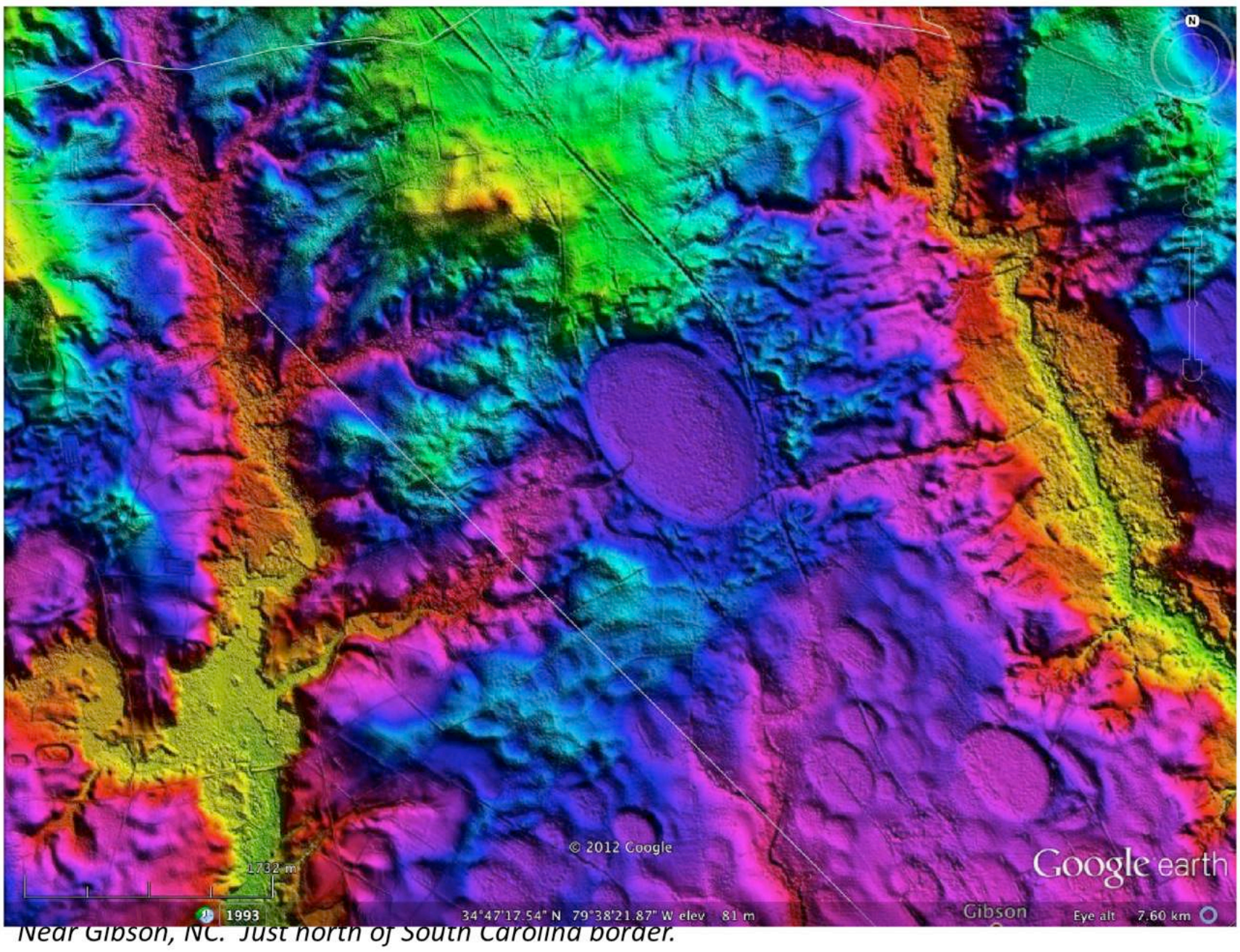
“Deposits are of both residual and dune types and **show little stratification or other structure**.”

Sam D. Broadhurst, 1954. *High-Silica Sand Resources of N.C.*, NC DC&D Information Circular II.

Sam Broadhurst, a NC State Geologist produced two papers on the high-silica sheet. He found that

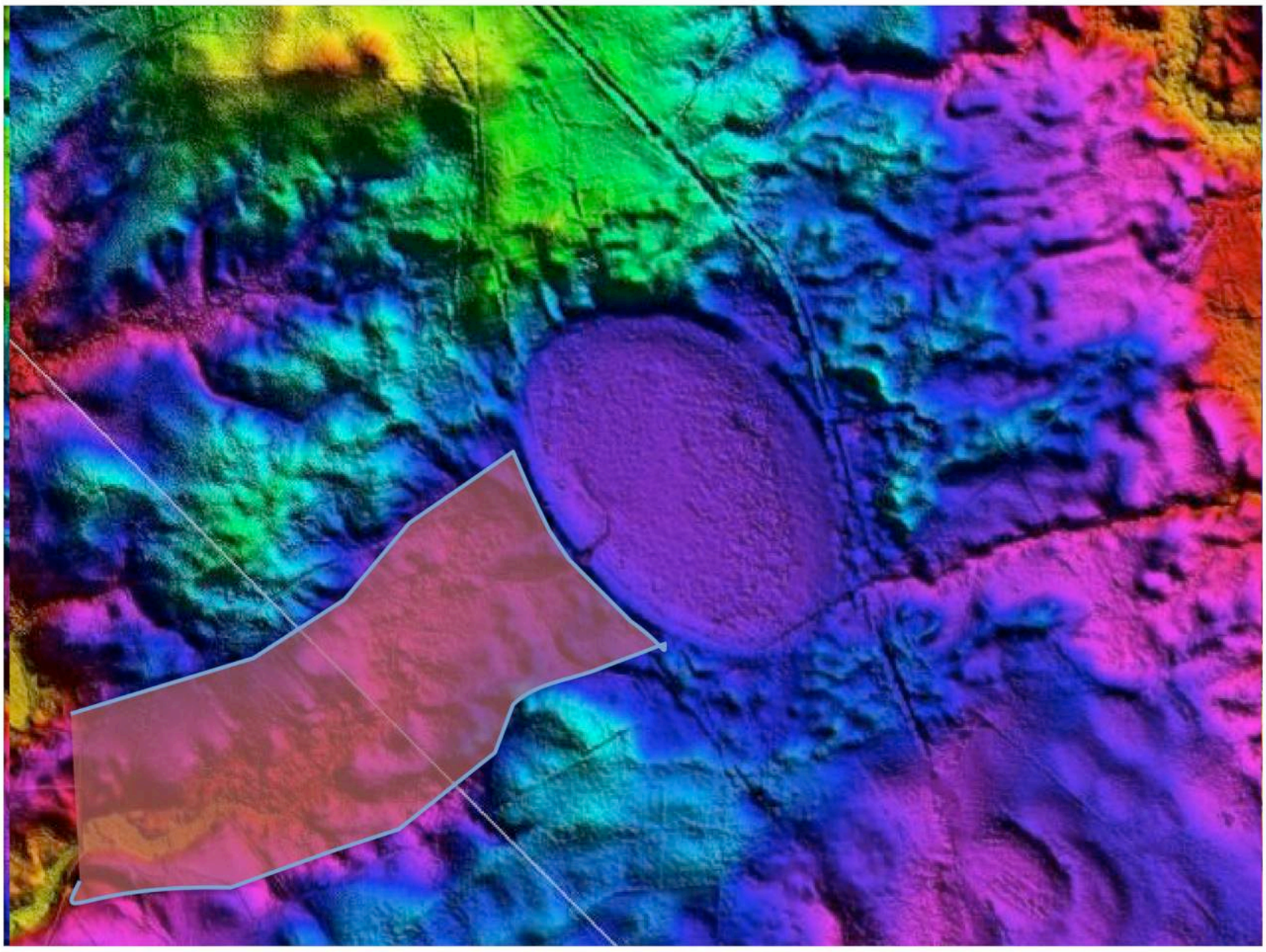
from the Sand Hills, across the region of Carolina Bays, and out to the coast - an “overall uniformity of texture and composition.” is seen.

He also notes that the sand shows little stratification or other structure.



Near Gibson, NC. Just north of South Carolina border.

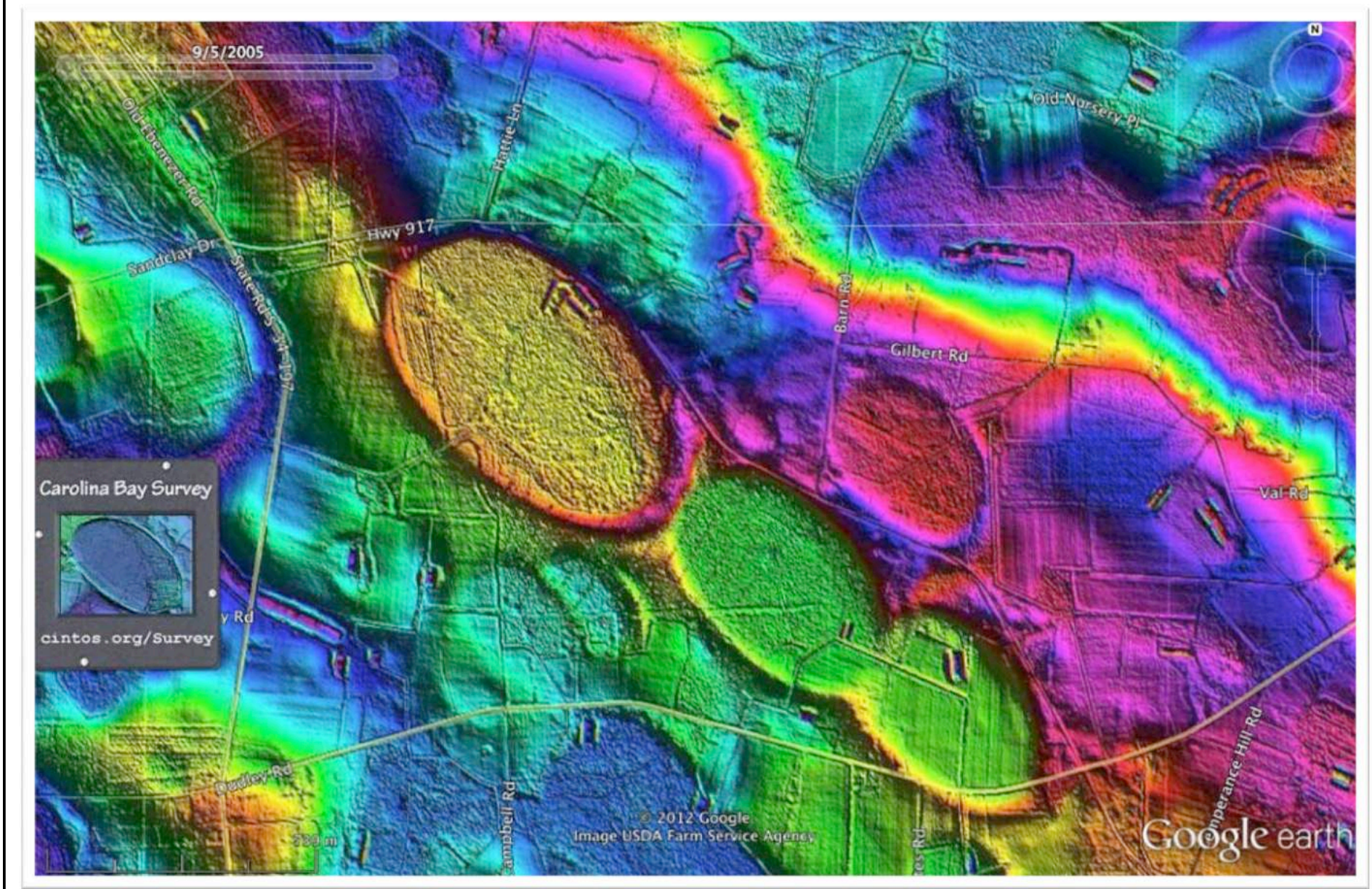
This is near Gibson, NC. Can't see much in the orthophotography, but numerous strikingly crisp bays are visible in the LiDAR, the large one looks to be the source of local dunes.



Near Gibson, NC. Just north of South Carolina border.

We might ask what keeps that delicate southwest rim intact when filled with water? I posit it was densely compacted when deposited with great heat and energy.

This basin is at the head of an misfit drainage channel, I see a lot of that.

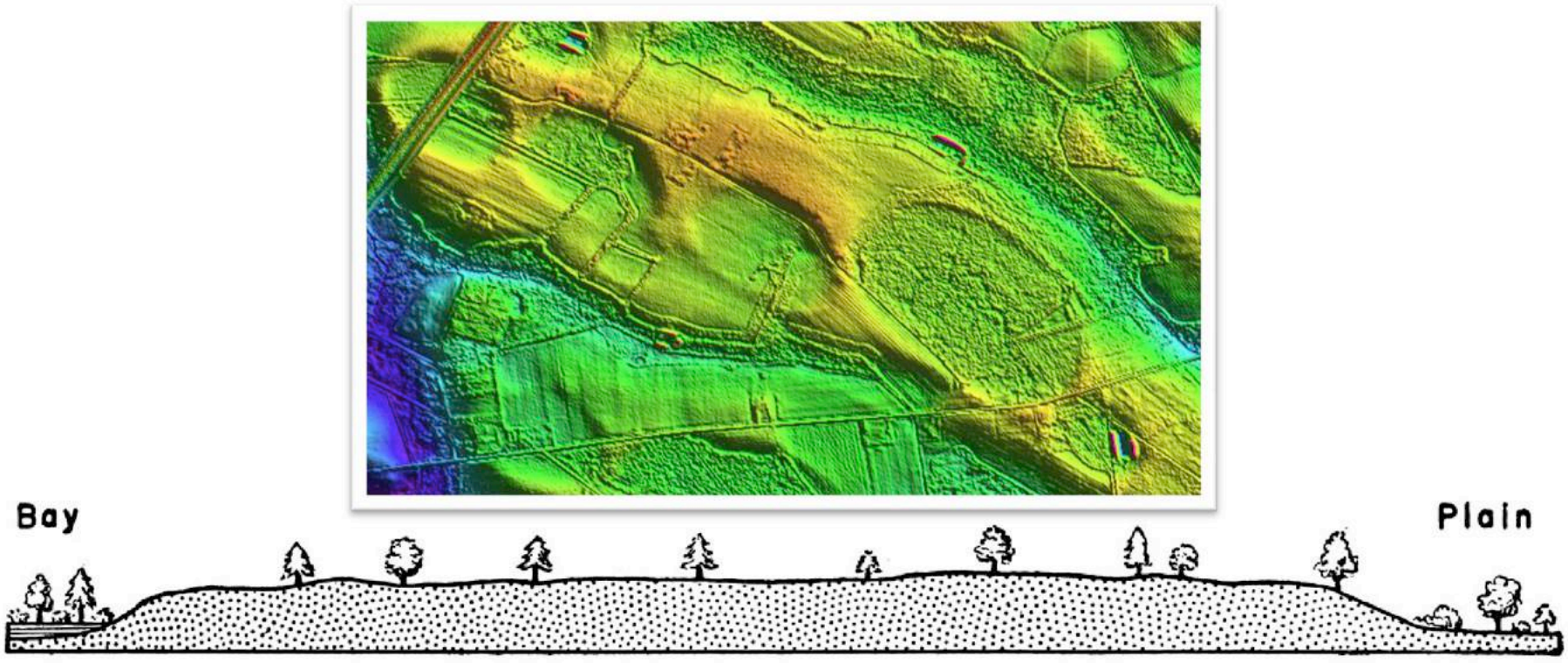


Perched above lower terrain, these crisp rims near Latta, SC are not constrained by local relief– a dozen bays at dissimilar elevations. The largest bay here is 1km long, the smallest under 100 meters, a 10:1 ratio, while maintaining the same orientation and shape.

The literature gives no mention of how robust these circumpherial rims are, focusing almost entirely on the SE end and what I interpret as minor eolian re-working there.

Please note that some of these basins are set into a surrounding pediment.

Rim Profiles

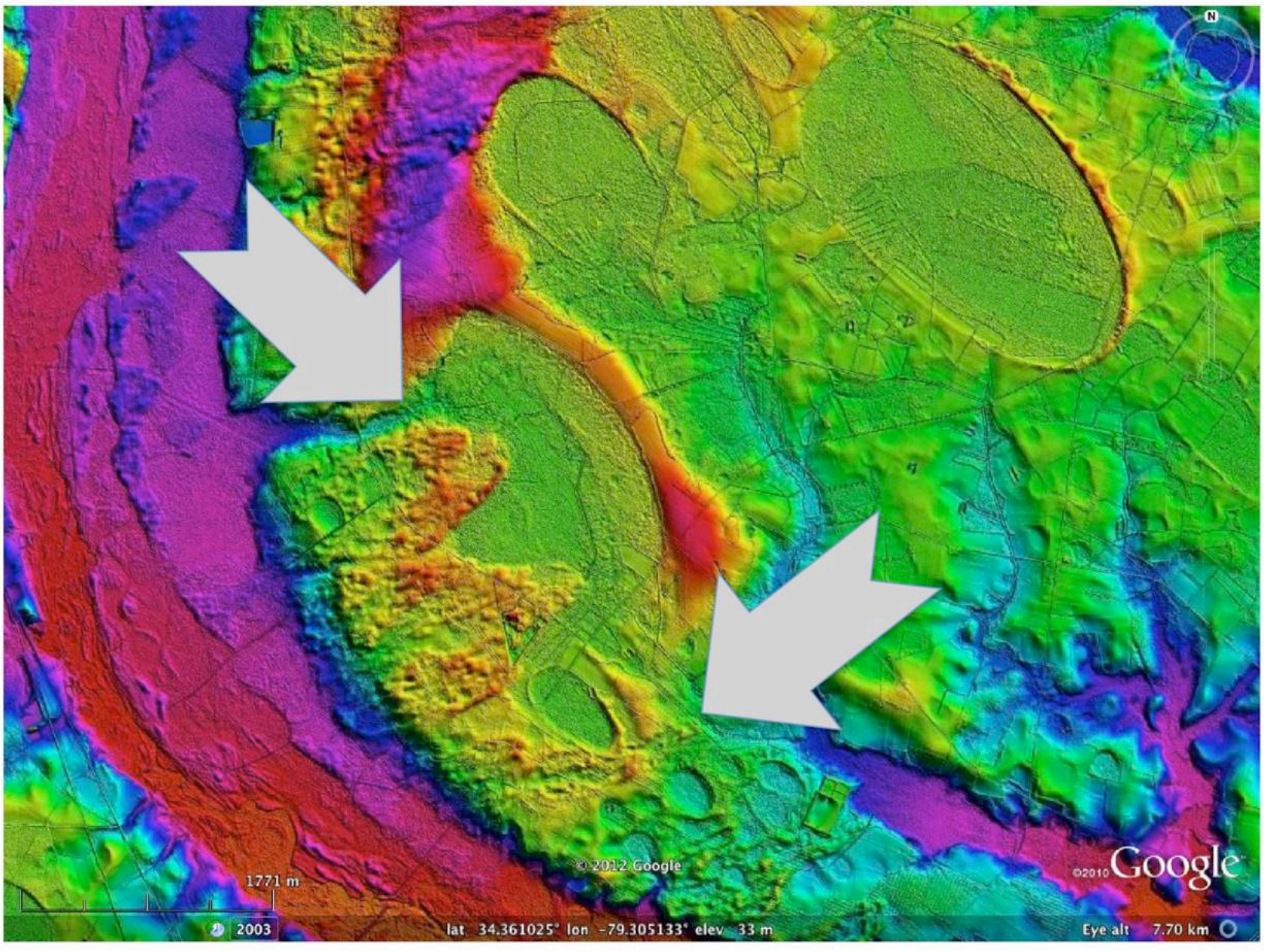


Douglas Johnson, 1942, *The Origin of the Carolina Bays,* No. IV of the *Columbia Geomorphic Series*, Columbia University Press, 341p

Douglas Johnson describes rims which include a great expanse of sand as a pediment surrounding the bays.

In his schematic and in the LiDAR, the bays effectively sets into the sand sheet with no raised rim.

Dunes & Bays– Little Pee Dee SP, SC



Here we see Dunes streaming off the Pee Dee River in SC.

I interpret that bays holding water, such as the sharply defined ones in the lower center, are not over ridden by eolian dunes, but instead adsorb and distribute the influx of fine loess.

If the bay is drained, such as the larger one here with an outlet, the dunes can successfully grow into the basin. Hence, my interpretation is that the bays predate the dunes.

Daniels & Gamble

In three separate publications, Daniels and Gamble researched three different thick sand sheet deposits and arrived at three different conclusions.

R. B. Daniels, E. E. Gamble, S. W. Boul, 1969, *Eolian Sands Associated with Coastal Plain River Valleys--Some Problems in their Age and Source*, *Southeastern Geology*, V11 No. 2, pp 97-110

Eolian

E. E. Gamble, Raymond . B. Daniels and R. J. McCracken, 1970, *AZ Horizons Of Coastal Plain Soils Pedogenic Or Geologic Origin?*, Southeastern Geology V11 No.3

Pedogenic

R. B. Daniels, E. E. Gamble and Wheeler, 1971, *The Goldsboro Ridge, an Enigma,* Southeastern Geology, Vol. 12 No. 3

Marine

Raymond Daniels and E.E. Gamble teemed with others to examined the genesis of three sand deposits over 3 successive years and arrived at three different conclusions –

but only after tortured discussions as to the geomorphology indicated. Lets explore these individually.

Eolian Sands -Some Problems

"These sand bodies **abruptly overlie** sediments … of the **Sunderland, Wicomico, and Talbot** surfaces in the Neuse drainage .

"… the **buried soil** at the top of the underlying sediment is neither channeled nor truncated.

"The sand bodies have **no sedimentary structure** where exposed in road cuts

"… **little vertical variation in sand size** above the buried surface.

".. **lack of horizontal variation in sand sizes**

"The **grain size contrasts** between the sand body and the underlying material is large.

" …**no relation** between feldspar content and the age of the surface the sands overly."

"They contain only **1- to 4- percent clay**, and silt contents are uniformly low.

R. B. Daniels, E. E. Gamble, S. W. Boul, 1969, *Eolian Sands Associated with Coastal Plain River Valleys--Some Problems in their Age and Source*, *Southeastern Geology*, V11 No. 2, pp 97-110

The first paper discusses large sand bodies, and "some Problems". The scope extends across three different terraces.

The Buried soil isn't channeled or truncated. No sedimentary structure is found

They note that the particle size lacks variation in both vertical and horizontal direction, and that it is easily differentiated because the grain size contrast between the sand body and the underlying material is large.

little clay or silt is present.

Eolian Sands -Some Problems

"These bodies occur on the **highest parts of the landscape** as well as **only slightly above the flood plain**.

"In places, the sand body **draped over scarps…"**

" There is an **abrupt vertical and horizontal contact** between the sand body and adjacent materials

"… are **not giant A2 horizons** because there is no associated argillic horizon.

"… **lack of definite associated shore lines** tends to discount deposition of these sands in a body of water.

"**Slope wash is not responsible** because these sand bodies are 10 to 15 feet above the highest part of the local landscape.

Eolian

R. B. Daniels, E. E. Gamble, S. W. Boul, 1969, *Eolian Sands Associated with Coastal Plain River Valleys--Some Problems in their Age and Source*, *Southeastern Geology*, V11 No. 2, pp 97-110

These Deposits occur on highest part of the local landscape, and also just above the flood plain.

In places it drapes over scarps

Giant A2 horizons aren't invoked due to lack of an agrillic horizon below.

They dismiss fluvial … and slope wash

and propose a wind-blown provenance.

Pedogenic or Geologic Deposit?

"**Virtually all of the North Carolina Coastal Plain is mantled by a sandy cover of varying thickness**. This sand is most prominent in the Sandhills and in the upper Coastal Plain and southern parts of the middle and lower Coastal Plain."

"**Some geologists have considered the A2 horizons as a separate deposit** (Pirkle et a, 1964; Howard, 1955; Clark, 1912; Conley, 1962)

"…whereas **other geologists have thought of them as a weathering phenomenon** associated with soil formation (Altschuler and Young, 1960; Hope, 1956).

"**Soil scientists also have had mixed feelings**."

E. E. Gamble, R. B. Daniels and R. J. McCracken, 1970, *AZ Horizons Of Coastal Plain Soils Pedogenic Or Geologic Origin?,* Southeastern Geology V11 No.3

In the second paper, they state: "Virtually all of the North Carolina Coastal Plain is mantled by a sandy cover of varying thickness… Some geologists have considered the A2 horizons as a separate deposit. … while other geologists have thought of them as a weathering phenomenon…Soil scientists also have had mixed feelings."

So much for a consensus

Pedogenic or Geologic Deposit?

Table 3. Phi Mean Sizes of Surface Sands and Underlying B Horizons on a Valley Side and Relation to Laboratory and Field Recorded Discontinuities.

Pair	Site #	Phi Mean A / B	Diff.	Field comments on discontinuity
1	11	2.1044		
		1.5414	0.5630*	Definite discontinuity at boundary
	12	2.1056		
		2.0269	0.0787**	Discontinuity below contact
2	13	2.0291		
		1.0785	0.0506**	Discontinuity below contact
	14	2.2404		
		2.1376	0.1028	Possible discontinuity at contact
3	15	2.1342		
		2.0376	0.0966	
	16	2.2628		
		2.1317	0.1411	Possible discontinuity at contact
4	17	2.1918		
		2.0629	0.1289	
	18	2.2467		
		2.1739	0.0728**	Discontinuity below contact
5	19	2.1464		
		1.9377	0.2087	Discontinuity above contact and surface sand sample
	20	2.3037		
		2.0366	0.2671*	Discontinuity likely at contact

E. E. Gamble, R. B. Daniels and R. J. McCracken, 1970, *AZ Horizons Of Coastal Plain Soils Pedogenic Or Geologic Origin?,* Southeastern Geology V11 No.3

In the majority of the cores they sampled, they note a discontinuity at the boundary between their A2 and the underlying B horizons.

Pedogenic or Geologic Deposit?

"The strongest argument for a geologic origin is that the A2 horizon **sand drapes across all parts of the landscape** (Figure 4)

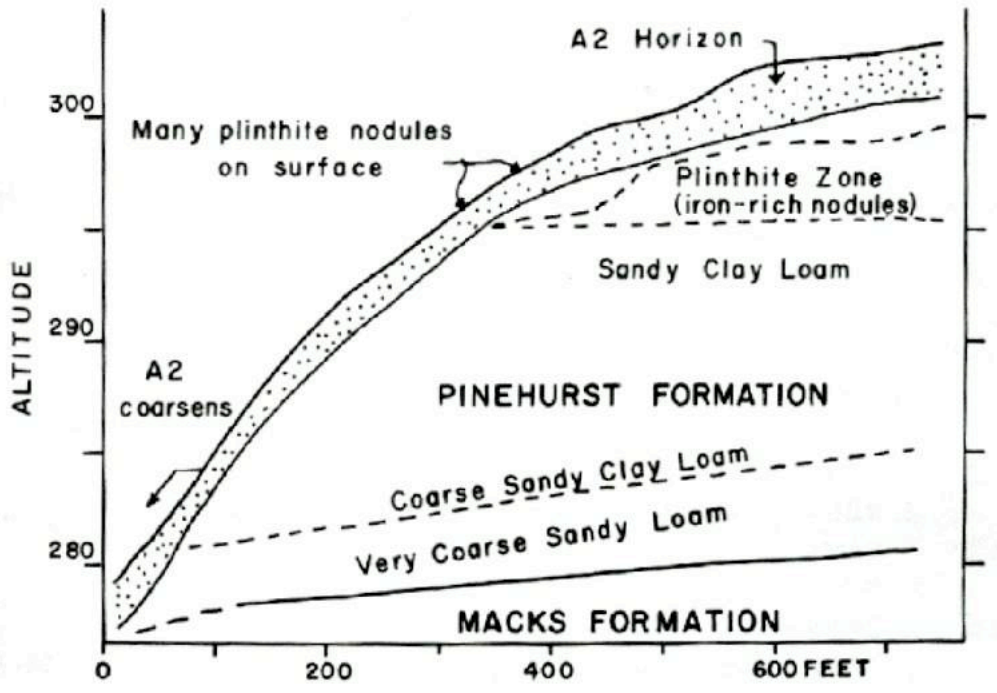


Figure 4. Relation of A2 horizons to sediments on side slopes.

Pedogenic

E. E. Gamble, R. B. Daniels and R. J. McCracken, 1970, *AZ Horizons Of Coastal Plain Soils Pedogenic Or Geologic Origin?,* Southeastern Geology V11 No.3

"The strongest argument for a geologic origin is that the A2 Horizon drapes across all parts of the landscape".

Including down the slopes

They settle on it being a pedogenic deposit.

Goldsboro Ridge, an Enigma

"The Goldsboro ridge is a unique feature on the **Sunderland** surface and **requires special explanation whatever its origin**. It must be either an erosional remnant of a once more extensive sediment or a depositional feature.

"Sediments at similar altitudes to the north and west always have the **upper fine and lower coarse sequence** typical of the Sunderland Formation overlying the Yorktown Formation or saprolite.

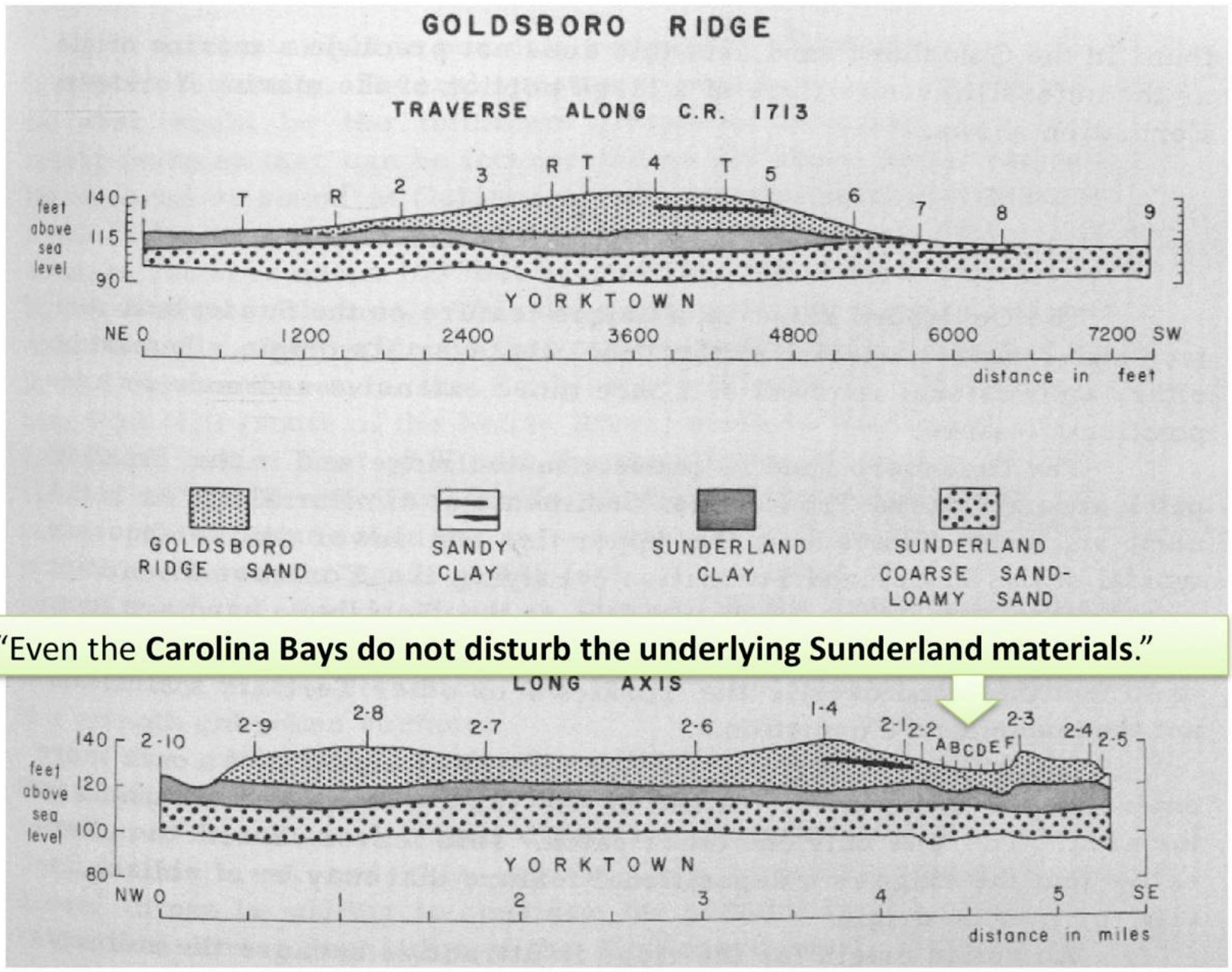
"Medium sands similar to the Goldsboro sand are found about 30 miles to the southeast near Pink Hill. But those sands are 20 to 40 feet thick and overlie the Yorktown or other Tertiary materials, not the Sunderland Formation.

R. B. Daniels, E. E. Gamble and Wheeler, 1971, *The Goldsboro Ridge, an Enigma,* Southeastern Geology, Vol. 12 No. 3

The third paper discusses Goldsboro Ridge in North Carolina, which "Requires special explanation whatever its origin"

It common upper fine and lower coarse sequence of other Sunderland surfaces.

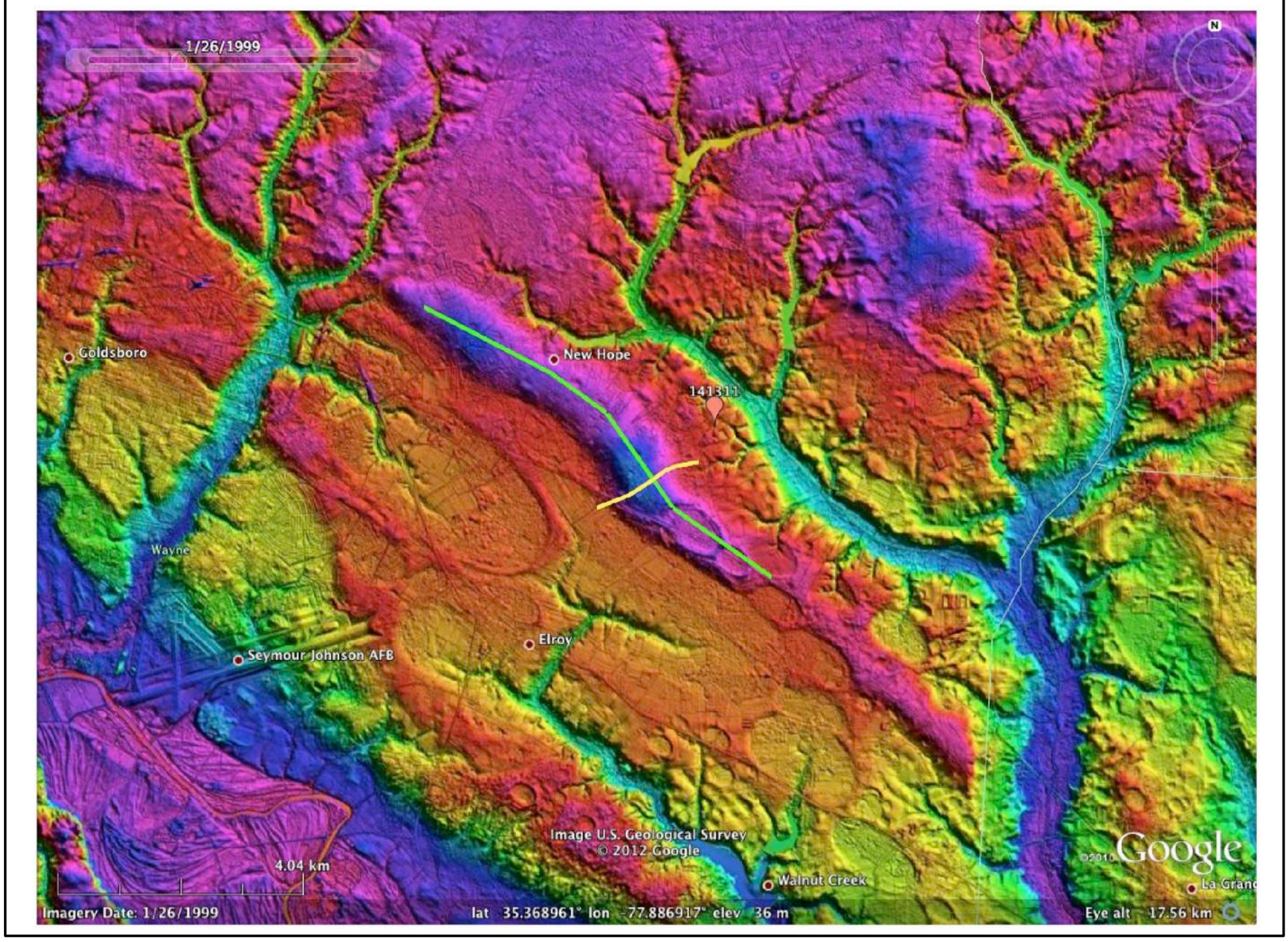
There are deposits similar to the Ridge's to the southeast, lying directly on the Yorktown Formation, yet they dismiss a relationship, as if the very fact of being on a different terrace mandates a different origin.



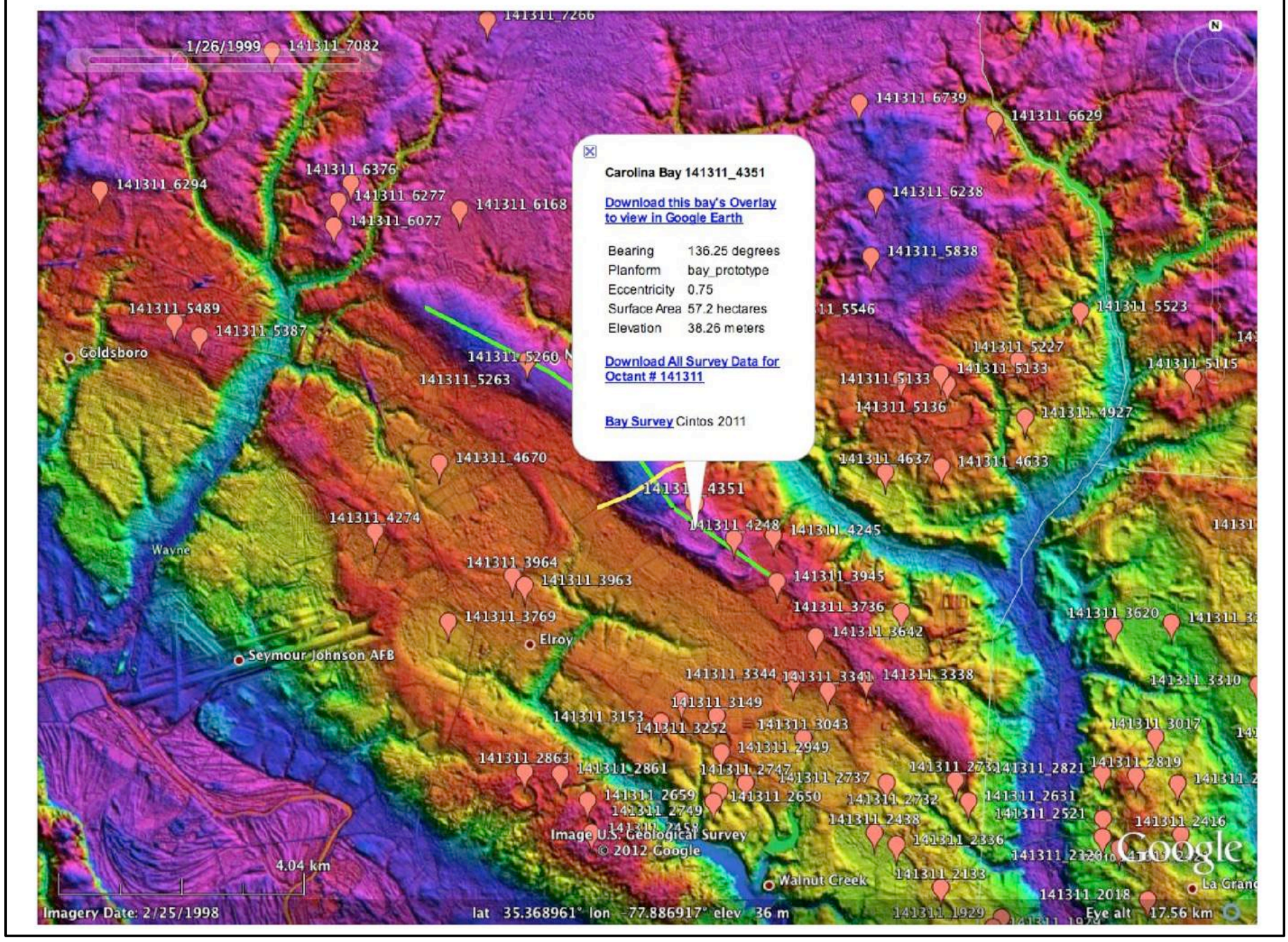
R. B. Daniels, E. E. Gamble and Wheeler, 1971, *The Goldsboro Ridge, an Enigma,* Southeastern Geology, Vol. 12 No. 3

Here are their drawings, with the Goldsboro sand resting on the Sunderland. A 7,000 ft traverse across the ridge, and a 5-mile run along the ridge were evaluated.

The A-F sequence notes cores across a Carolina Bay. Which they note does "not disturb the underlying Sunderland materials."

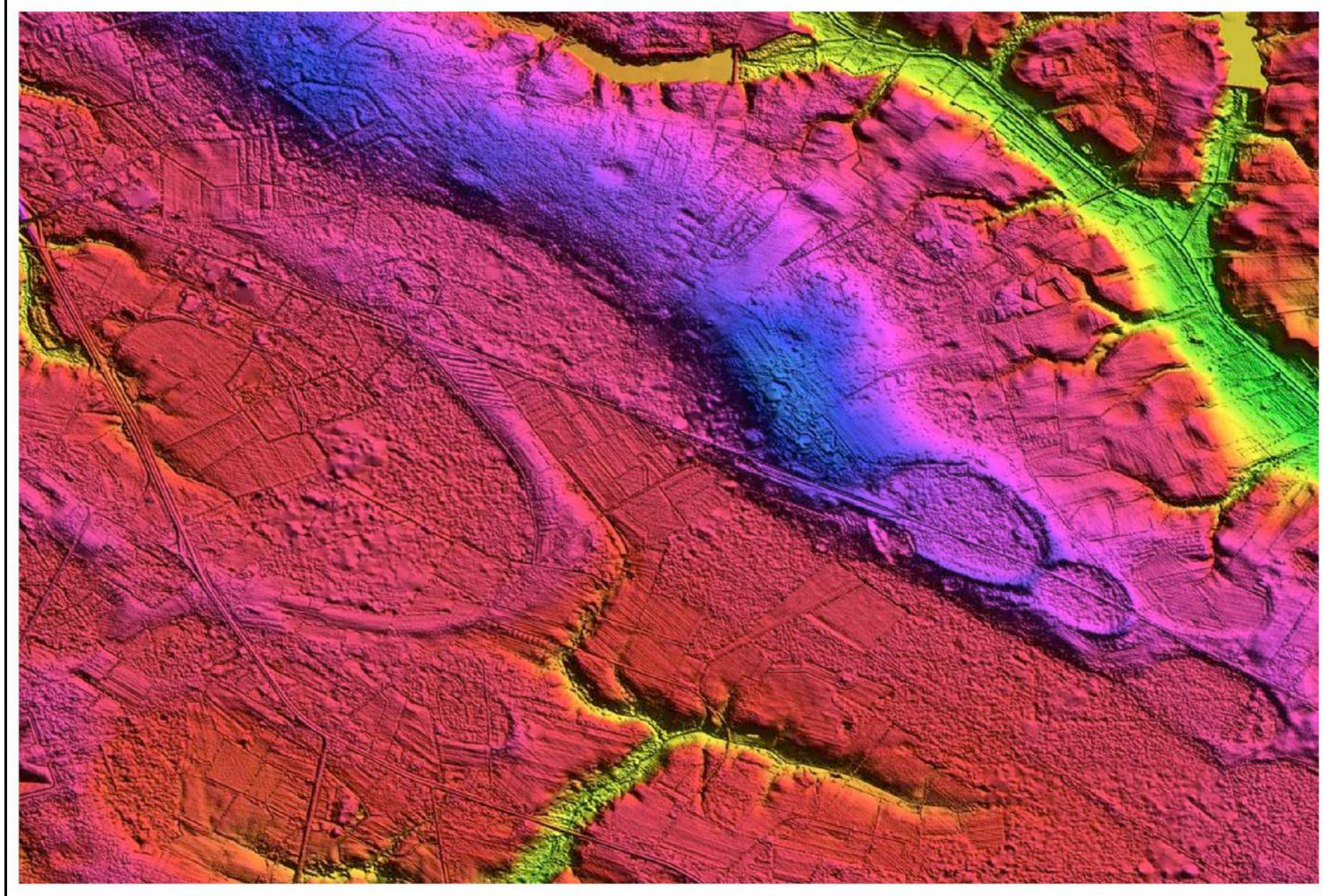


The two transects are identified in a Google Earth mash-up using our LiDAR. Note the Carolina bays along the southeast end of the transect.



Our survey of Carolina bays is geo-indexed in Google Earth using the markers shown, which loads from an on-line Google Fusion Table. Clicking on one brings up a display of our measurements.

The bay is 38 meters above sea level. A marine origin would require sea levels not attained since the **Pliocene**.



Zooming in on the bays embedded along the ridge, we see them literally perched above the surrounding terrace, with siblings present at various elevations.

Goldsboro Ridge

"If the Goldsboro ridge were an erosional remnant of a once more extensive sediment, there should be at least a few other remnants in the area. There is only one other patch. This leaves us with the alternative that the ridge is a depositional feature that **may be of eolian, fluvial, or marine origin**.

" An **eolian origin for the ridge is attractive** because the sediments to the south and southwest are sandy and could be a source area. **But** the sediments to the west and north are silty and could not provide sufficient sand.

"… the absence of dune topography **argue against an eolian origin** for the ridge."

R. B. Daniels, E. E. Gamble and Wheeler, 1971, *The Goldsboro Ridge, an Enigma,* Southeastern Geology, Vol. 12 No. 3

The authors dismisses erosional remnant, then chews through and rejects the eolian option,

Goldsboro Ridge

"There is little in the Goldsboro sand that argues against a fluvial origin except its very **uniform grains size**.

"There is **no Coarse basal sediment**, and except for the clay lenses the sand is **monotonously similar from top to bottom**. This, however, is not enough to reject a fluvial origin.

"The limited distribution of the Goldsboro sand indicates that if it is Fluvial, it must be similar to a natural levee. But **there is no companion levee, and no paralleling river channel**. Possibly traces of these features have been destroyed, but by what mechanism? The Goldsboro sand is post-Sunderland surface. How could a post-Sunderland surface river channel and matching levee be destroyed so the Sunderland surface is reconstructed without a trace of its being disturbed?

"Thus, **we must consider an alternative** to the fluvial origin for the ridge.

R. B. Daniels, E. E. Gamble and Wheeler, 1971, *The Goldsboro Ridge, an Enigma,* Southeastern Geology, Vol. 12 No. 3

Then they examine the very uniform grain size and proclaim the deposit to be "**monotonously similar from top to bottom"** and after much discussion, dismiss fluvial.

Goldsboro Ridge

Marine

"**A marine origin is our only remaining alternative but even this is difficult to justify**.

" Several questions come to mind immediately such as: what would be the minimum altitude of the ocean, are there any nearby features that can be interpreted as old shore lines, and **assuming an ocean or sound at Goldsboro, what condition or conditions would result in deposition** of the Goldsboro sand?

"**A marine origin for the Goldsboro ridge can be opposed on several grounds**.

"The **absence of marine fossils** is the most valid objection

"But, until much more is known about all the middle Coastal Plain, the Goldsboro ridge will remain, in the last analysis, an enigma."

R. B. Daniels, E. E. Gamble and Wheeler, 1971, *The Goldsboro Ridge, an Enigma,* Southeastern Geology, Vol. 12 No. 3

And are left with a Marine process, "but even this is difficult to justify," as it "can be opposed on several grounds"

Despite those, including the total lack of fossils, they propose Marine,

But close with: "until much more is known about all the middle Coastal Plain, the Goldsboro ridge will remain, in the last analysis, an enigma"

Theories of Origin (after Price, 1968)

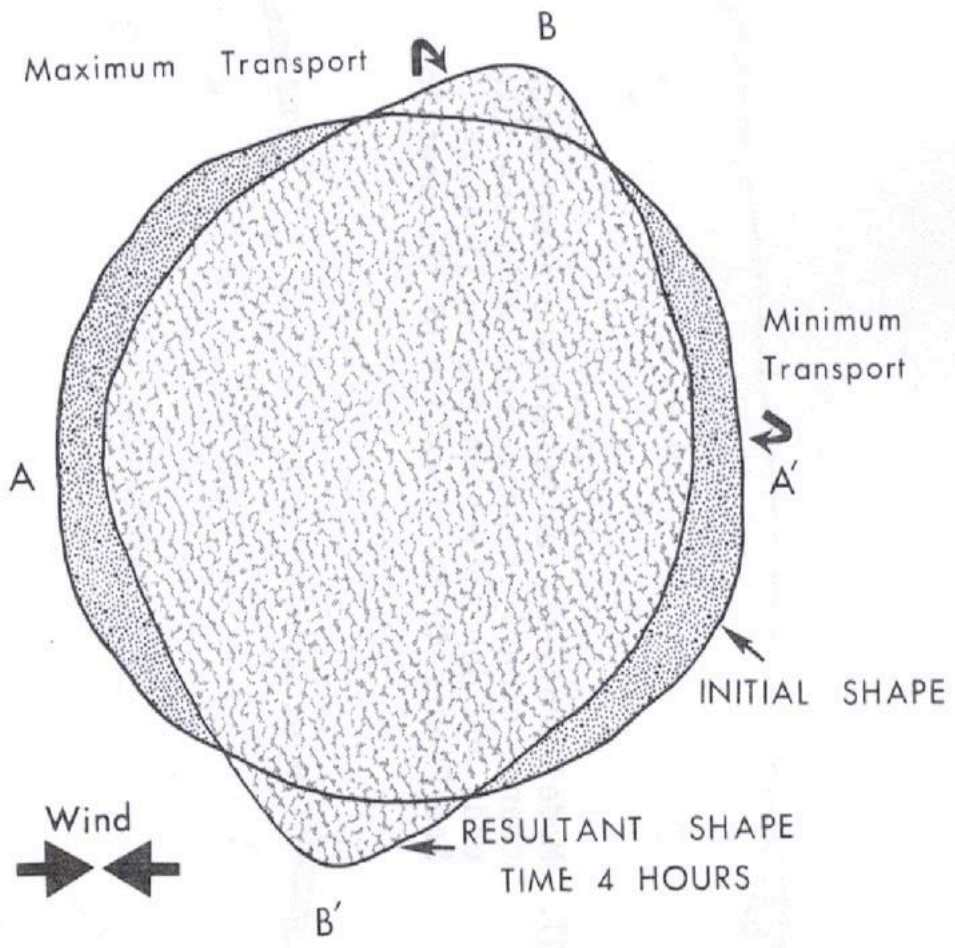
- ✓ Spring Basins (Toumey, 1848)
- ✓ Sand bar dams of drowned valleys (Glenn, 1895)
- ✓ Depressions dammed by giant sand ripples (Glenn, 1895)
- ✓ Craters of Meteor Swarm (Melton and Schriever, 1933)
- ✓ Submarine scour by eddies, currents or underflow (Melton, 1934)
- ✓ Segmentation of lagoons forming echelons of bays (Cooke, 1934)
- ✓ Lakes in sand elongated in direction of maximum wind velocity (Raisz, 1934)
- ✓ Solution depressions, with wind-drift sand forming the rims (Johnson, 1936)
- ✓ Solution basins of artesian springs, with lee dunes. (Johnson, 1942)
- ✓ Fish nests of schools of fish waving their fins in unison over springs (Grant, 1945)
- ✓ Eolian (deflation) blowouts (Prouty 1952)
- ✓ Original hollows at the foot of marine terraces between sand dunes (Cooke, 1954)
- ✓ Basins scoured out by confined gyroscopic eddies (Cooke, 1940, 1954)
- ✓ Cometary fragments exploding, shock creating depressions (Eyton &Parkhurst, 1975)
- ✓ Wind and wave driven by paleowinds (Kaczorowski 1977, Bliley and Burney, 1979)
- ✓ Ice-push Rims, as in Alaska and NWT – (Bliley and Burney, 1988)

A wide range of mechanisms have been suggested for the origin of Carolina bays, but the consensus seems to be “wind & wave”.

Kaczorowski's Model

Figure 40, p93

A diagrammatic representation of model lake changes from circular to elliptical perpendicular to the influence of opposing winds alternated every fifteen minutes for a total of four hours. Sediment removed from the maximum transport zones along with sediment derived from near shore areas produced a net accretion in the areas where wave approach angle was low. Initial lake diameter was 65 cm.



Raymond T. Kaczorowski, 1977, *The Carolina Bays: A Comparison With Modern Oriented Lakes,* Coastal Research Div. USC, Technical Report No. 13-CRD

Here is Kaczorowski's explanation of the process: Water in a depression is coaxed into an oval by opposing winds alternating on a 50% duty cycle.

Parenthetically, It should be noted that his well-regarded and often referenced paper was never published in a peer-reviewed journal, and the three copies I have located in Libraries are at USC.

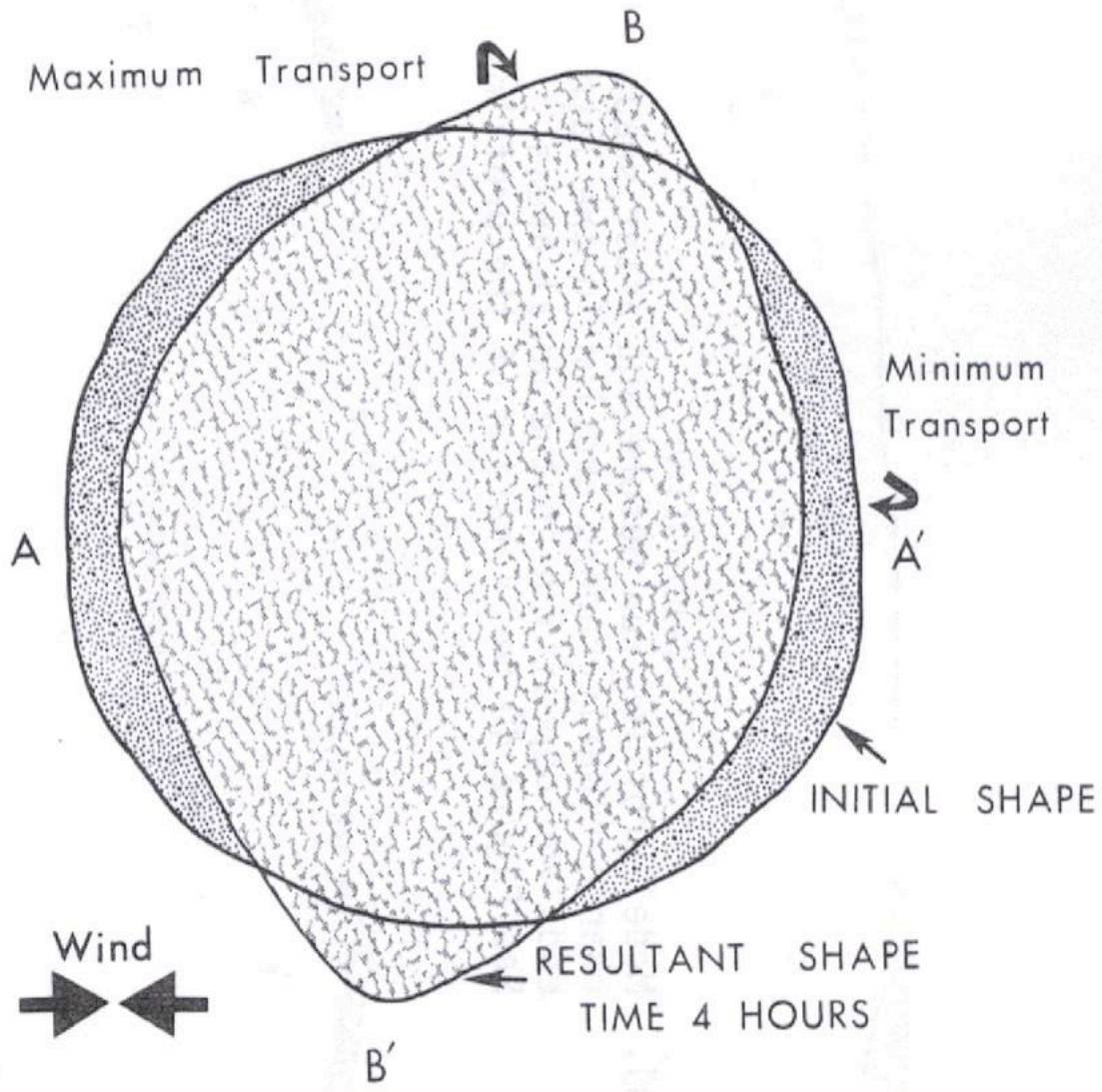
Antecedent Basin Required

"Although **not specifically addressed in the current study**, a number of processes could account for generation of the **initial basin that eventually evolves into a Carolina Bay**. These processes might include, among others, spring activity, solution, deflation, abandonment of channel segments, and/or excavation of original relief on the surface of the Upland Unit. No evidence was found to support basin formation by meteorite impact as suggested by Johnson (1942), and others."

John A. Grant, Mark J. Brooks, Barbara E. Taylor, 1998, *New constraints on the evolution of Carolina Bays from ground-penetrating radar,* Geomorphology 22

Most attempts at implicating wind and/or wave in the genesis of a Carolina bay mandates there being a pre-existing depression, as expressed here by Grant, et al. They note many mechanisms for that initial depression ….but specifically exclude meteorite, which is OK, so do I.

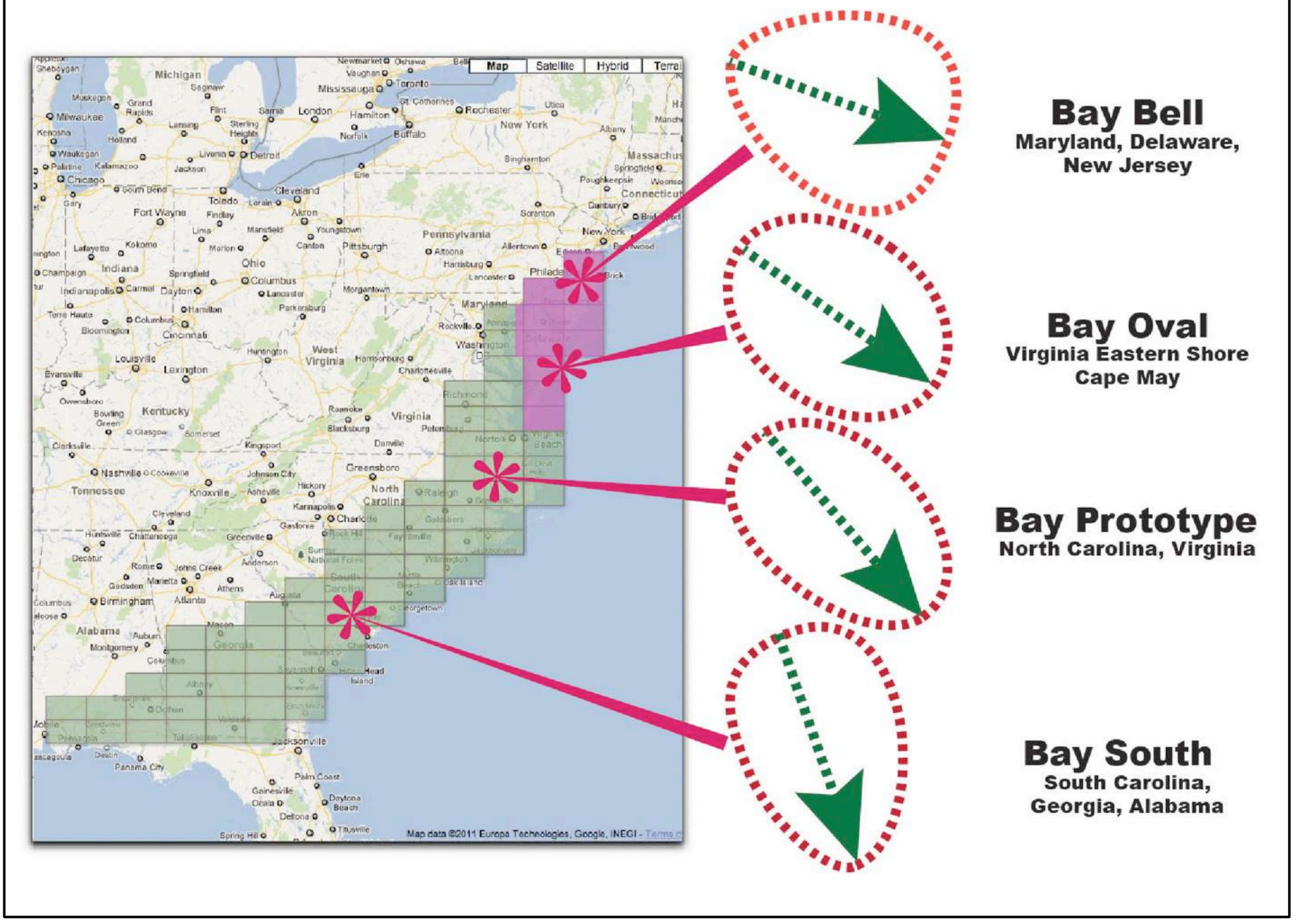
… and correcting the authors, Johnson in his 1942 book most certainly DID NOT suggest a meteorite impact origin. Quite the contrary, the first half is spent dismissing it using a long list of observations which I find instructional in my research.



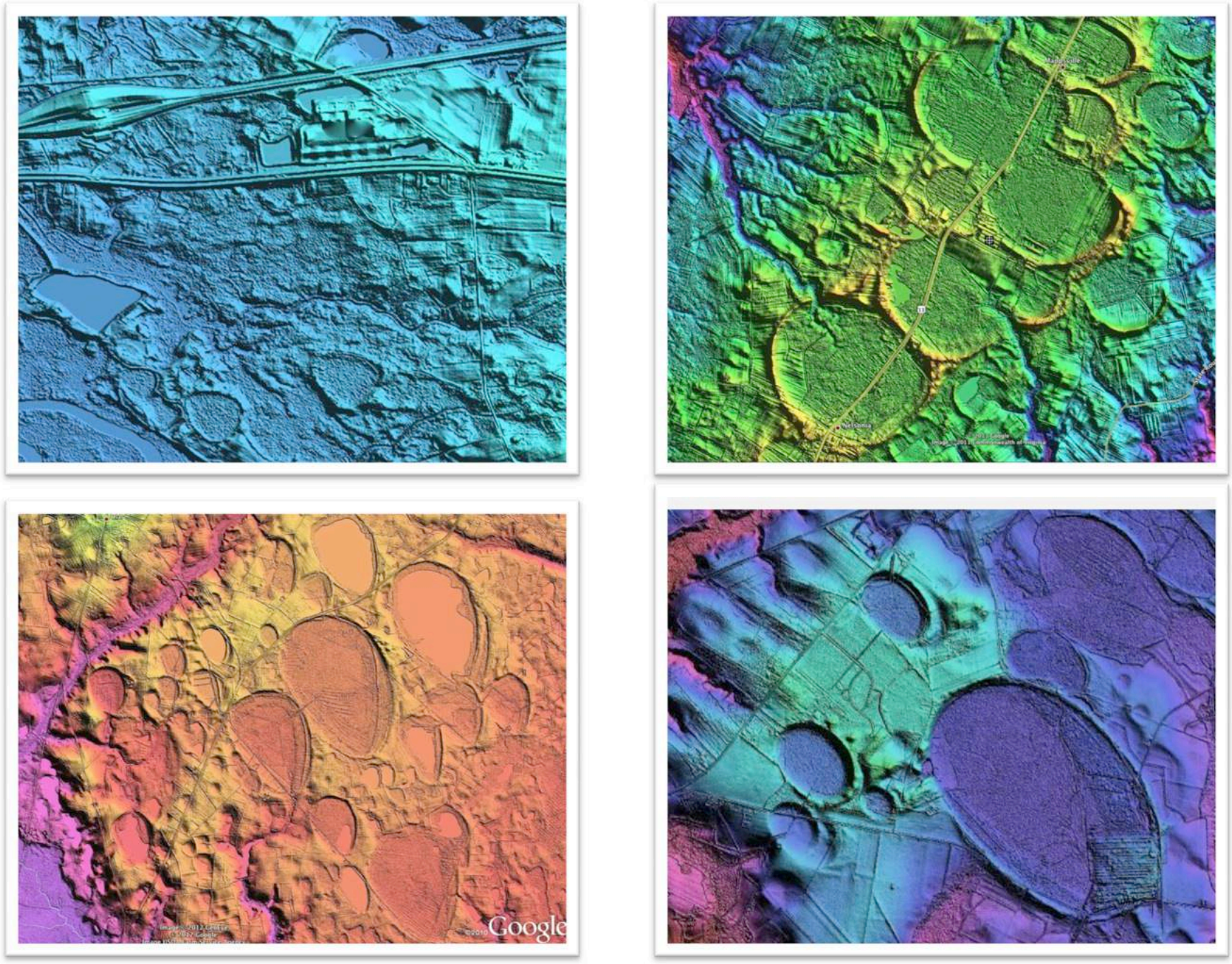
Raymond T. Kaczorowski, 1977, *The Carolina Bays: A Comparison With Modern Oriented Lakes,* Coastal Research Div. USC, Technical Report No. 13-CRD

Johnson spent the remainder of his book presenting a hybrid theory which also proposed wind & wave for the final bay shape.

Allow me to observe that this does not actually look like any Carolina Bay I have encountered in the LiDAR.



What do they look like? The survey has identified four archetype shapes on the east coast.



The shapes are evidenced in the LiDAR on a continuum, one blending into another.

Clockwise from upper left: Near Delaware Memorial Bridge in NJ; Eastern Shore of VA; Bennettsville, SC; Darlington, SC

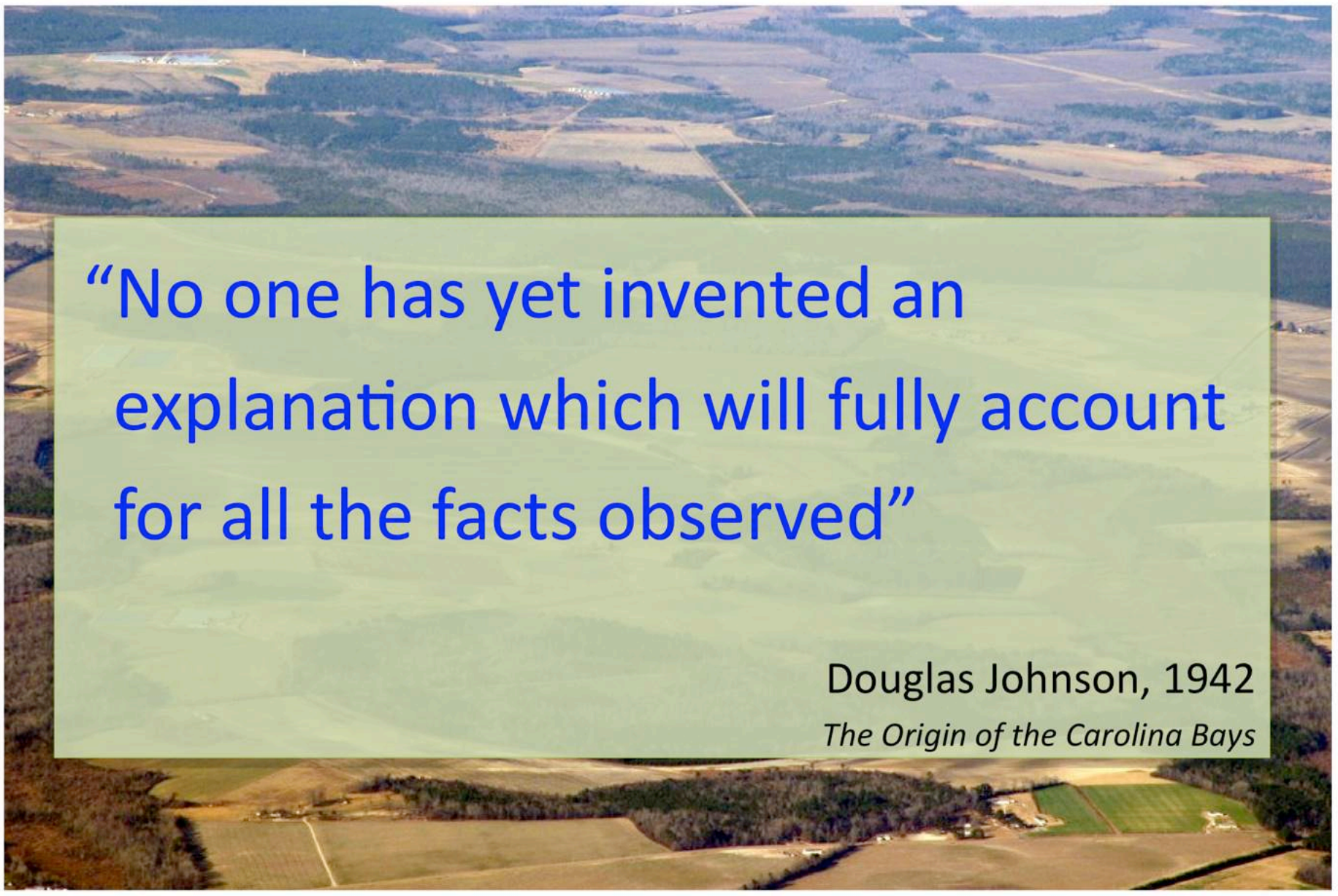


Photo by George Howard

Time for a checkpoint. Might we observe that all is not "settled"? Its 2012 … and we live here – this is not the moon.

Douglas Johnson's final take was:

"No one has yet invented an **explanation** which will fully account for **all** the facts observed".

I find that still applicable. So, I invented a novel one.

Inventing An Explanation

We speculate on a high-energy, catastrophic deposition mechanism, where a sheet of quartz sand was spread as a blanket of hydrated distal ejecta from a cosmic impact into the Laurentide Ice Sheet.

The bay depressions are posited to be surficial dimples or voids in the blanket, artifacts of superheated steam bubbles in a foamy slurry, frozen in time as the depositional energies relaxed and the sand transited from liquefaction to lock-up.

The ejecta's arrival vector would be evidenced in the orientation and distortion of the bubble.

Here is the working Hypothesis:

This image does not fit our hypothesis precisely, but allow me to evoke an image of a bubbles spreading across the landscape.

Given the obvious sand & bay inter-relationships, has anyone previously considered the possibility that bays were created during the deposition of the sand?

"The sand in the bay rim is not different from the Goldsboro sand. Therefore, these Carolina Bays are merely surface features associated with the formation of the ridge."

R. B. Daniels, E. E. Gamble and Wheeler, 1971, *The Goldsboro Ridge, an Enigma,* Southeastern Geology, Vol. 12 No. 3

Actually, Daniels, Gamble and Wheeler did , in 1971.

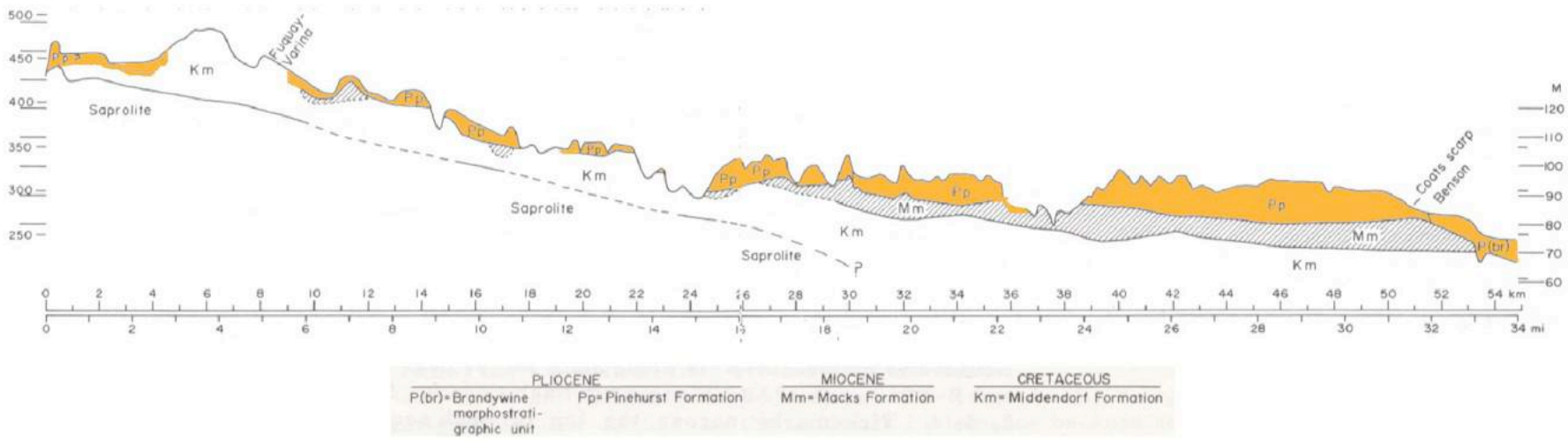
"The sand in the bay rim is not different from the Goldsboro sand. Therefore, these Carolina Bays are merely surface features associated with the formation of the ridge."

and that is the inspiration for our hypothesis.

Allow me to continue with hints in the literature

Constrained by Terraces - Not

"We recognize that the extension of the Pinehurst Formation east of the Coats scarp north of Bailey **imposes difficulties in interpretation**. But **we were unable to find any evidence of a break in sedimentation at and east of the Coats scarp**. Until such a break is found, the sediments east and west of the Coats scarp in the area north of Bailey are **one lithostratigraphic unit**. "



Daniels RB, Gamble EE, Wheeler WH, 1978, *Upper coastal plain surficial sediments between the Tar and Cape Fear rivers, North Carolina*, Southeastern Geol 19:69-81.

I mentioned that the presence of the Terrace architecture may be an impediment to correlating my posited sheet. When Daniels et al found an uninterrupted sheet of Pinehurst sand – here in orange - crossing the Coats scarp, they recognized that it … "… imposes difficulties in interpretation.

"But, we were unable to find any evidence of a break in sedimentation at and east of the Coats scarp"

Pinehurst Formation

"The Pinehurst Formation occurs as a northeast trending band of surficial, loose, poorly sorted quartz sand…. It unconformably overlies the Cretaceous Middendorf Formation and ***has been interpreted as eolian, fluvial, and marine*** *in origin.*

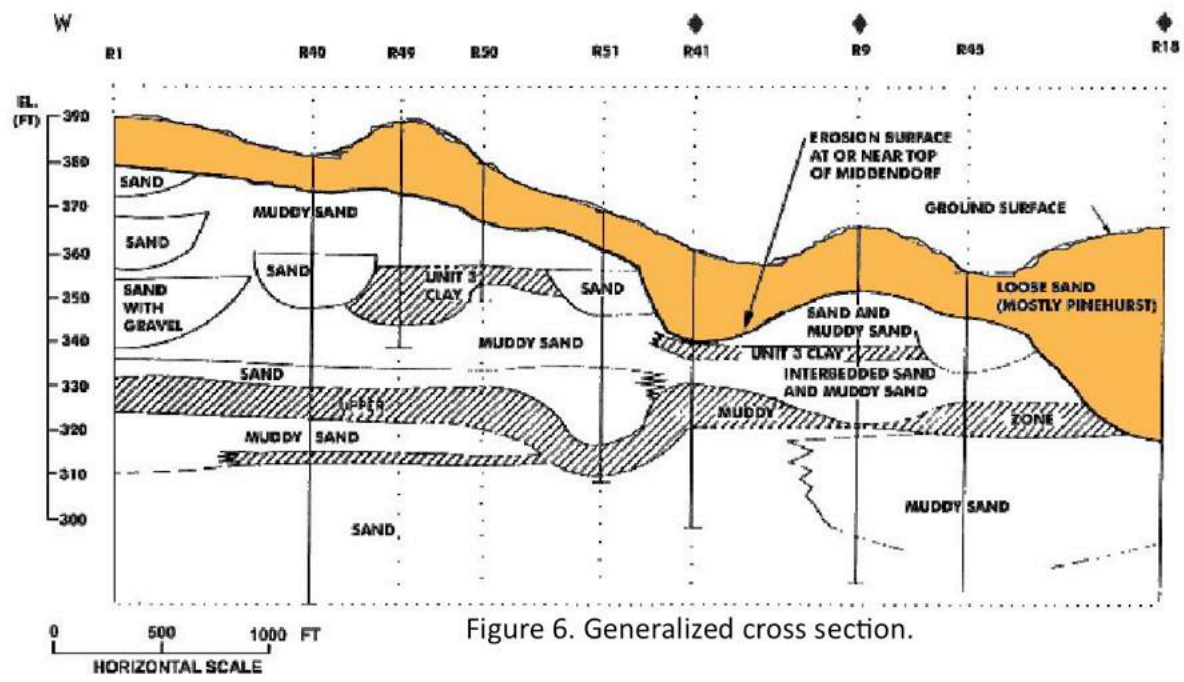


Figure 6. Generalized cross section.

Farrell, K.M.; Hoffman, C.W. (North Carolina Geological Survey, Raleigh, NC *The origin of the Pinehurst Formation: Geomorphic and sedimentologic evidence from the Sandhills, North Carolina Coastal Plain*

Recent work by Farrel and Hoffman suggest that a deposit of Pinehurst meets all the criteria of my posited sand sheet – coarse high purity quartz, no fossils…. They found it a good source of glass feedstock.

An erosional surface was recognized at the interface between the Pinehurst and the Middendorf. Notice, they view the deposit to be *eolian, fluvial, and marine in origin.*

Rim Sand Characteristics Invarient

"A preliminary study of grain-size properties of bay rims in Horry and Marion counties revealed very little variation in **mean, sorting, skewness, and kurtosis** values between bays on the same surface and within any given bay.

"Either the sampling design was inadequate, or differences in sand grading on rims are not highly variable."

Bruce G Thom, 1970, *Carolina Bays in Horry and Marion Counties, South Carolina*, Geological Society of America Bulletin, v. 81, p. 783-814

Thom's review of rim sands in Horry and Marion counties found their characteristics to be so tightly constrained that he actually questioned his sampling design.

Sand Sheet Scenarios

"Stratigraphy from the surface down in the vicinity of all four bays is similar (to first-order) and begins with **a thin, regional, medium-to-coarse-grained sand sheet** (typically ~ 1-3 m thick) that **exhibits minimal pedogenic alteration**, but whose emplacement likely predates bay formation (Willoughby, 1997).

Grant, Brooks, Taylor, 1998, New constraints on the evolution of Carolina Bays from ground-penetrating radar, Geomorphology, Volume 22, Number 3

Grant et al identified "A Thin, regional, medium to coarse grained sand sheet" in the vicinity of four bays they examined.

The catastrophic deposition of a multi-meter sheet of sand should create collateral damage to the local flora and fauna. Can we find any evidence?

Buried Cypress Forest

"Does the white sand unit represent a single depositional event or a slow process of accumulation over centuries to millennia of time?"

"Quarry operators have also noticed a **preferential alignment** to the subfossil cypress logs which may be relevant to the genesis of the deposit."

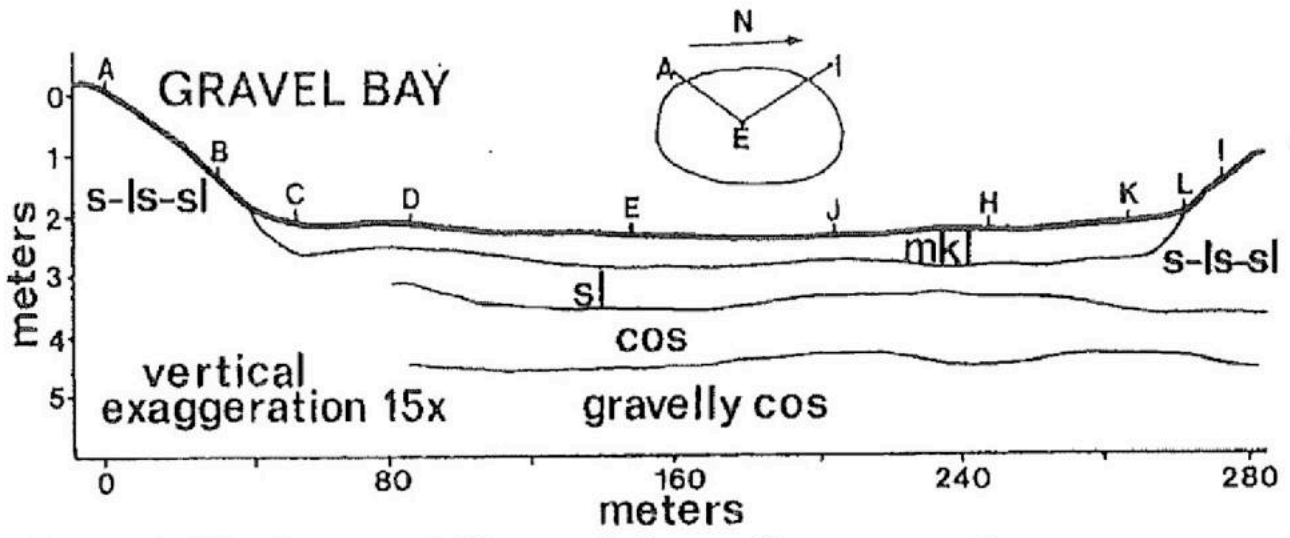
David W. Stahle, et al, 2005, *Ancient Baldcypress Forests Buried in South Carolina,* University of Arkansas Tree-Ring Laboratory Preliminary Report

Stahle, et al noted "The recovery of well preserved baldcypress logs from two separate deposits of late Pleistocene age in South Carolina raises many interesting research questions". They go on to question if this was a "single depositional event or a slow process of accumulation".

I have been attempting to get clarification on the "Preferential Alignment" observation they make, but if my catastrophic deposition were involved, they should align with the nearby Carolina bays.

Rim Sand Unrelated to Bed Strata

"Gravelly sediments that extended across most of the depression and under the rim on the northwest side were observed in the basin of Gravel Bay. These sediments were found at a depth of 200 cm and **did not rise with the rim but maintained an approximately level gradient** (Fig. 3). Similar findings have been reported by Gamble et al. (1977), Rasmussen (1958), Bryant (1964), and Thom (1970).



S = sand, LS = loamy sand, SL = sandy loam, coS = coarse sand, and MkL = mucky loam. Locations of sampling and transect points are indicated by A, B, C, etc.

M. H. STOLT AND M. C. RABENHORST, 1987. *Carolina Bays on the Eastern Shore of Maryland: II. Distribution and Origin*. Soil Science Society of America Journal 51:399-405.

Stolt and Ravenhorst reported Carolina bays in Maryland rested on top of an undeformed bed of gravel. Their schematic is suggestive of a sheet of sand being spread on an antecedent terrain, with the basins as voids.

Parsonsburg Sand, MD

"The Parsonsburg sand is the name given here to the **veneer of sand** and associated deposits which compose the rims and, in places, the interior of the "Maryland basins."

"The Parsonsburg sand is a veneer deposit, strewn upon the older deposits at all ranges in altitude, **from below sea level to the top of the Parsonsburg divide**. The maximum logged thickness is 26 feet (Wi-Cd 34), but the average in 23 wells is 12 feet. The thickest sections are on the rims of the "Maryland basins."

"The Parsonsburg sand is composed **predominantly of medium-grained sand…**

"The Parsonsburg sand … **rests unconformably on each of the earlier Pleistocene deposits**. It is overlain only by soils, alluvium, and peat of the Recent series.

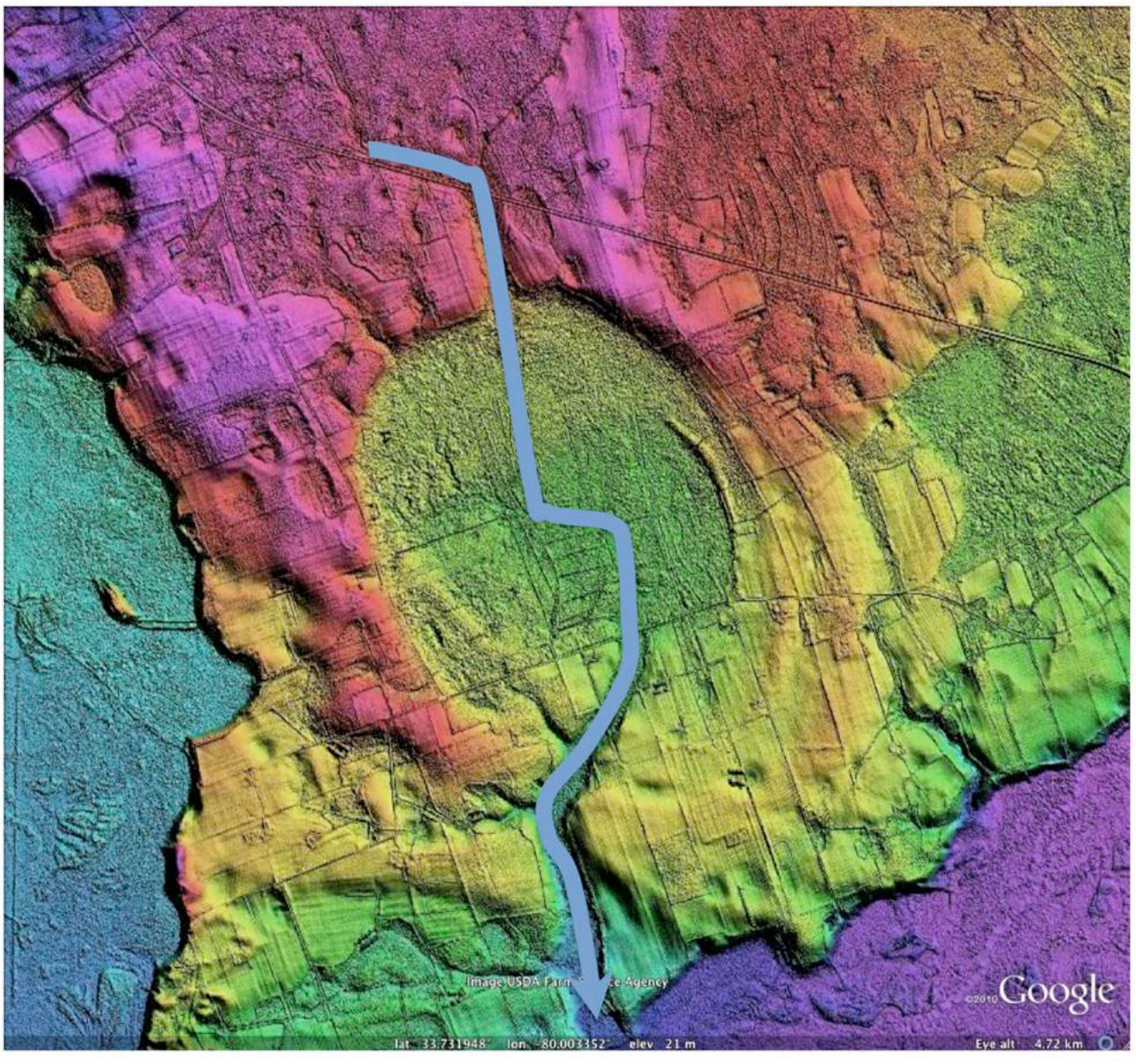
"There are many fensters, or "**windows**" in the surface of the Parsonsburg sand, in the central area of the larger 'Maryland basins,' through which the older formations, or their weathered soils, may be found..

W. C. Rasmussen, T. H. Slaughter, et al, 1955, Maryland Department of Geology, Mines and Water Resources Bulletin #16, Water Resources of Somerset, Wicomico, and Worcester Counties, , p118

Rasmussen and Slaughter reference Maryland's Parsenburg Sand as being a "veneer of medium-grained sand, strewn upon the older deposits … from below sea level to the top of the Parsonsburg divide". It is up to 26 ft thick, "The thickest sections are on the rims of the "Maryland basins."

The note that "windows" exist through the veneer, revealing older deposits in the center of the "Larger Maryland Basins".

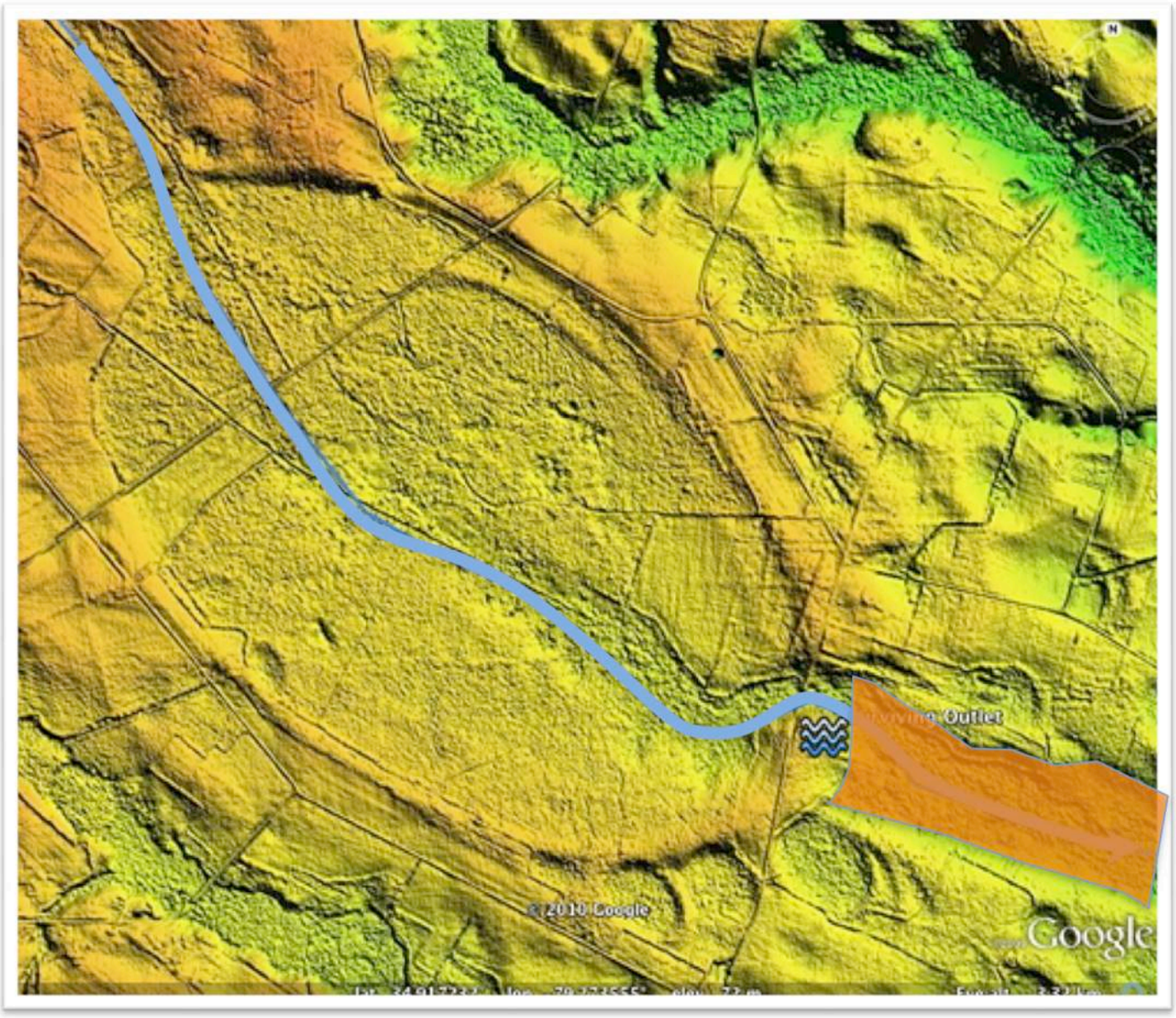
Antecedent Drainage



Using my hypothesis, a bay often represents a void in the ejecta sheet, which would allow a “window” to the antecedent surfaces.

Bays with antecedent drainage channels traversing them were noted by Douglas Johnson. This is near New Zion, SC. The antecedent channel is well-expressed.

Antecedent Drainage



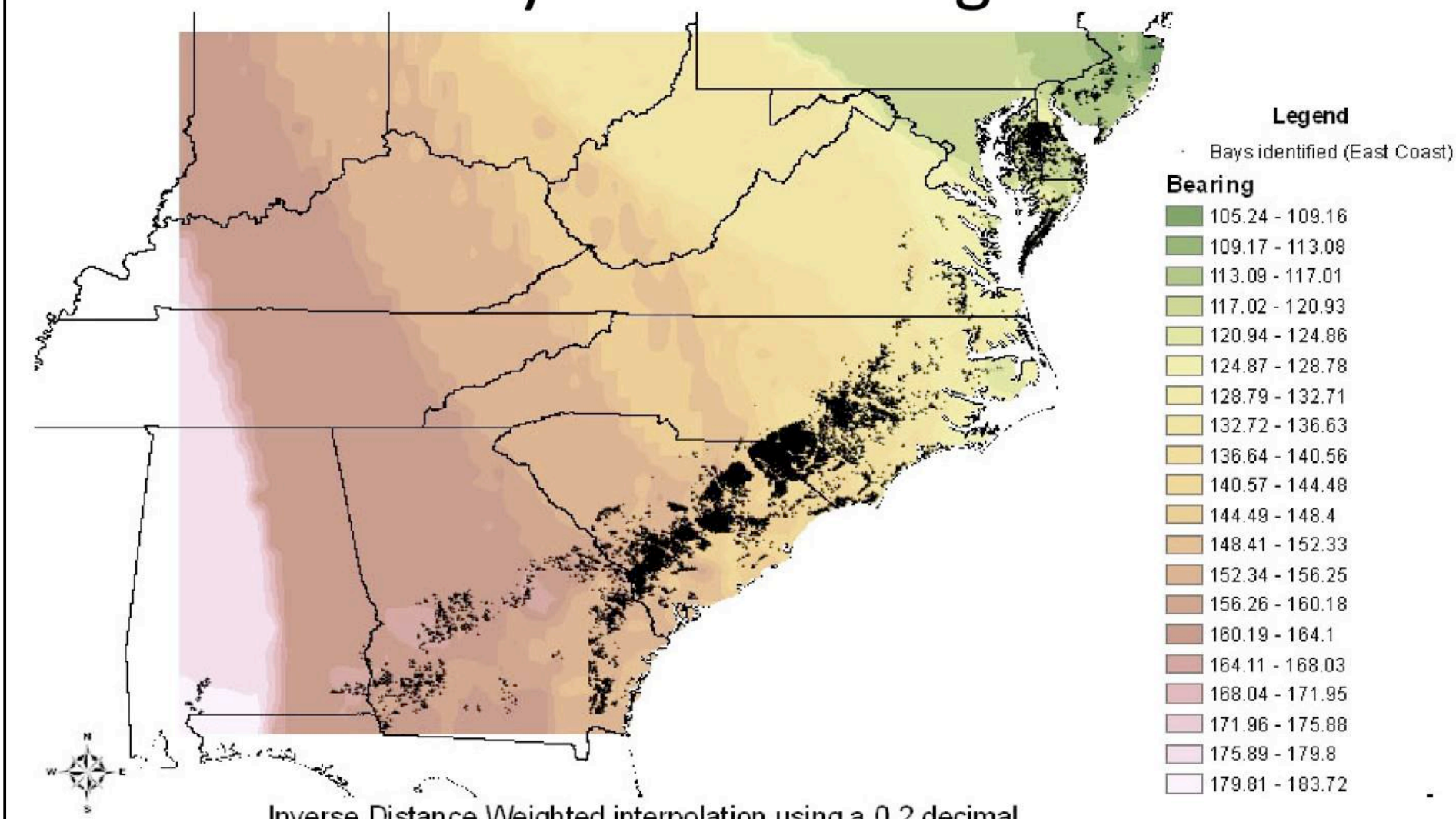
Here is another. I speculate that blanketing the antecedent landscape would allow substantial reliefs, such as this fluvial trace, to map through.

Note the misfit channel truncated at the bay rim.

I‘m Running out of time to share more hints in the literature which I found supportive,

… my personal confirmation biases acknowledged.

Bays and Bearings



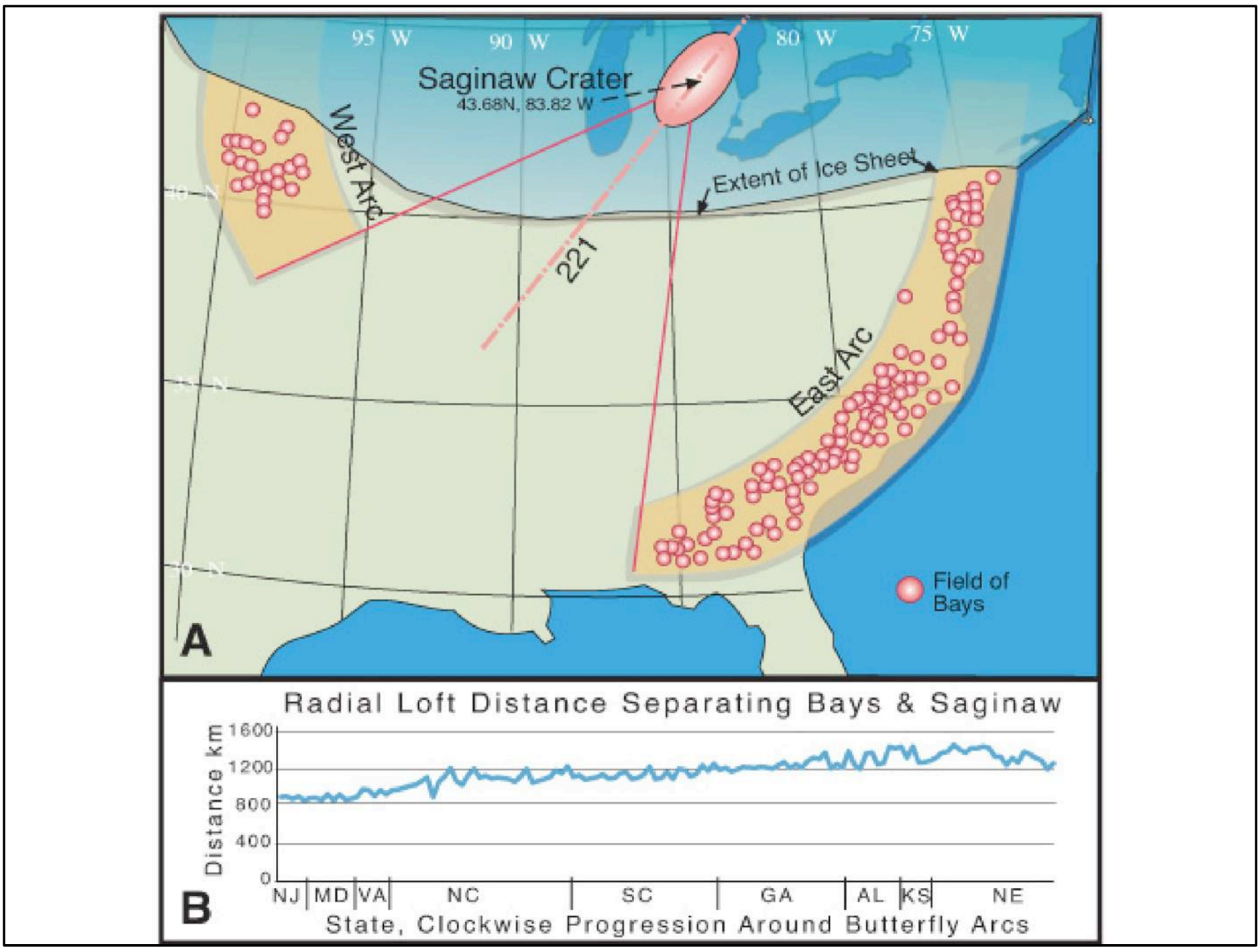
Inverse Distance Weighted interpolation using a 0.2 decimal degree search radius, minimum 3 points, and output grid size of 0.2 decimal degrees.

Clockwise Rotation of ~75º from NJ through Alabama

In closing, I'd like to share two work products of our own which suggest a unifying catastrophic solution to the source of the sand sheet and the Carolina bays contained within.

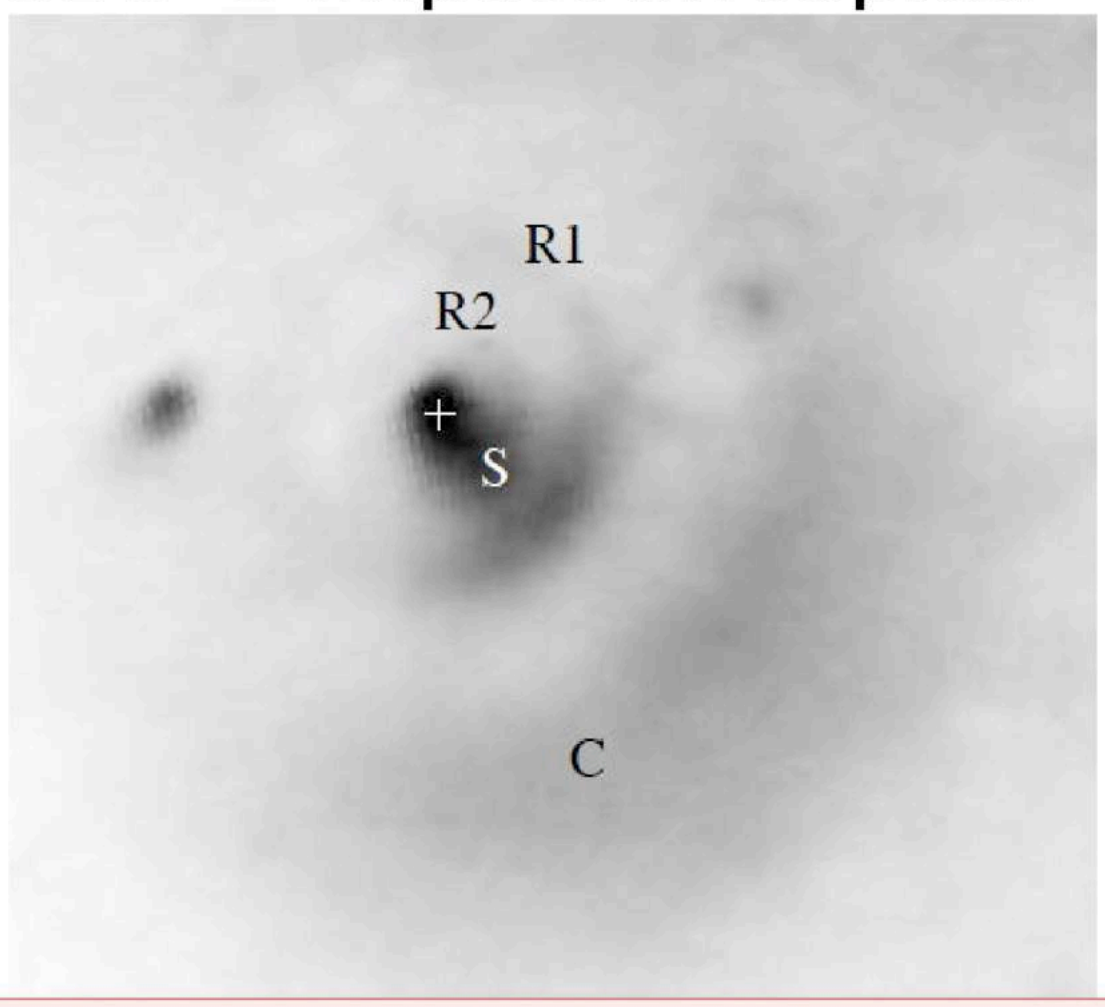
The orientation of 30,000 bays on this IDW map are shown to rotate Systematically ~75 degrees clockwise from New Jersey down to Alabama, perhaps triangulating a causal impact site.

We caution that straight lines on a flat map would not trace the ballistic trajectory of ejecta over a rotating sphere, as Coriolis-type kinematic effects would be steering it.



Saginaw Impact Manifold ejecta trajectory network triangulation test.

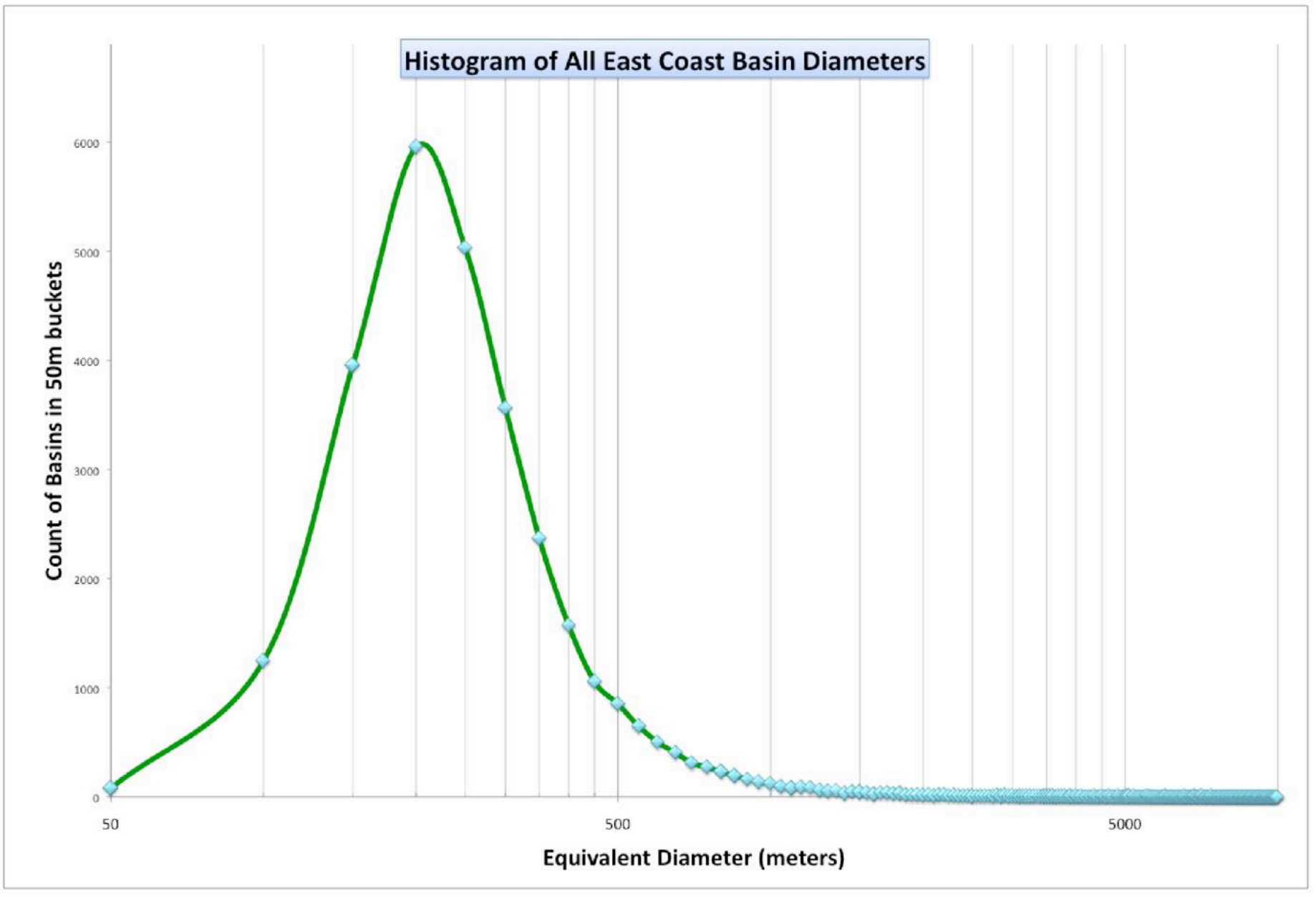
SL-9-G Impact on Jupiter



Joseph Harrington, et al, 2004, *Lessons from Shoemaker-Levy 9 about Jupiter and Planetary Impacts*, In: *Jupiter. The planet, satellites and magnetosphere*, Edited by Bagenal, Dowling & McKinnon, Cambridge University Press, ISBN 0-521-81808-7

And, pray tell, where did I come up with an annular distribution? A possible model for the distribution of debris at distances of 1,000km or more can be seen in the SL-9 Impacts on Jupiter. The scientific community, btw, failed to correctly model these cometary impacts prior to the event.

I would venture to say that we still have much to learn about the physics of impacts by low-density dirty snowballs.



This is a histogram of basins diameters in 50 meter buckets, displaying a log-normal frequency distribution with a long tail. I interpret this as suggestive of a unifying morphology for all 30,000 bays.

So what natural phenomenon exhibits a long-tailed log-normal distribution?

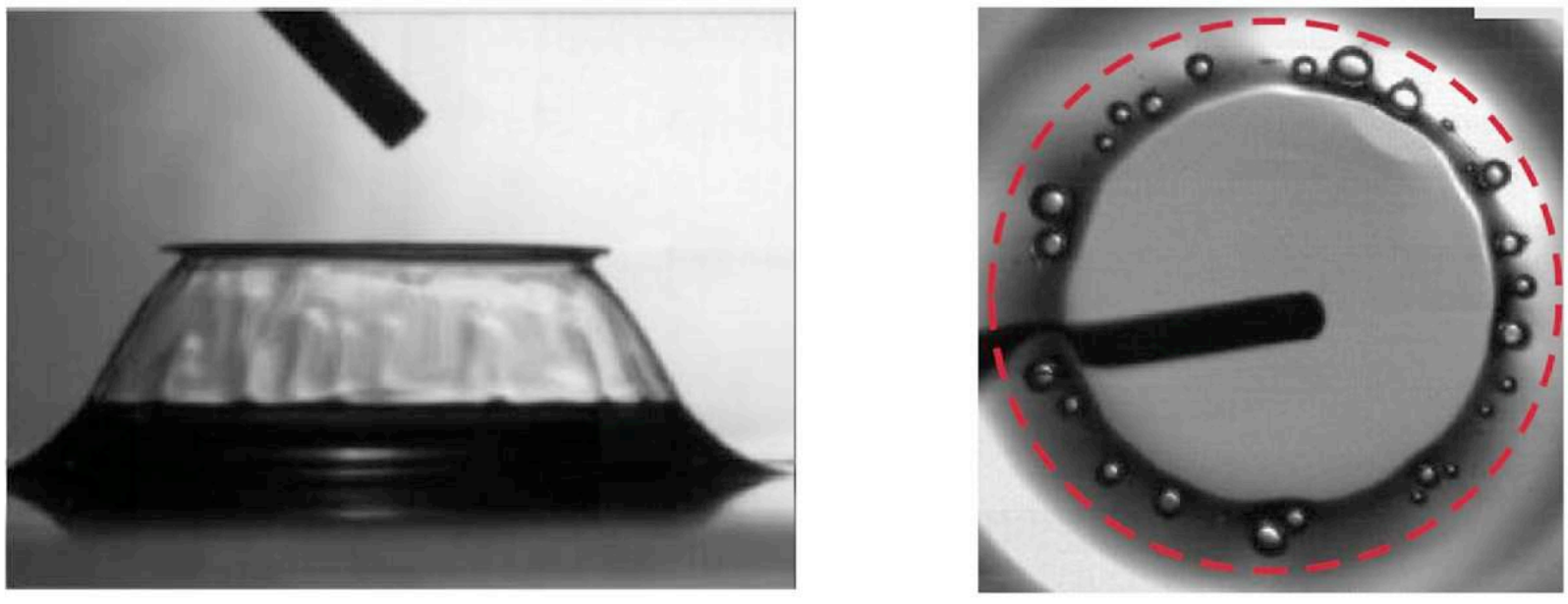
Double, double toil and trouble …

Bubbles, for one

Fire burn and cauldron bubble

Bubble size frequency distribution is well know, as their properties are investigated extensively in chemical reaction systems.

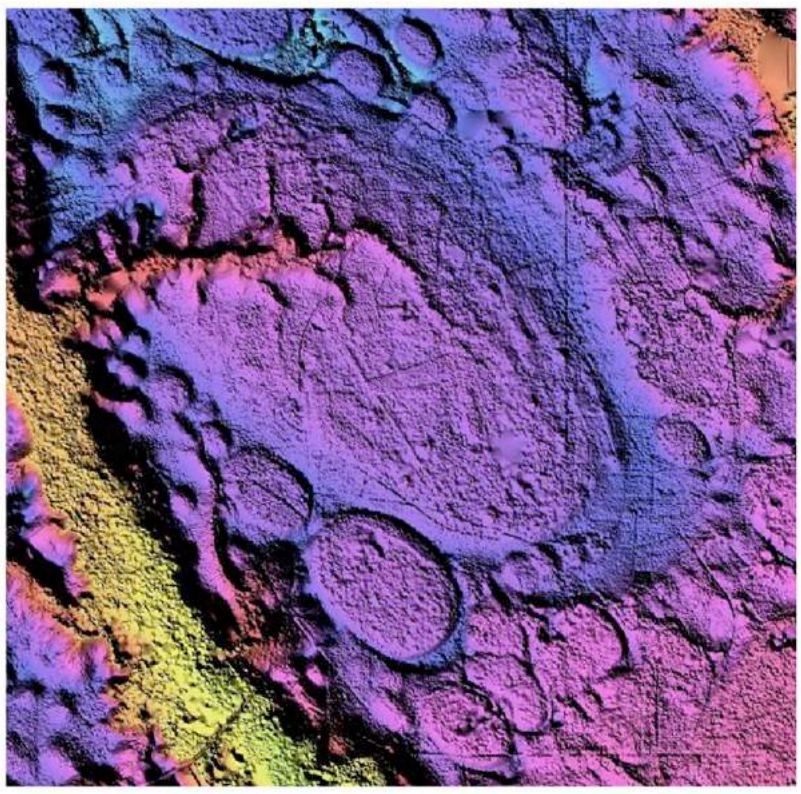
Daughter Bubble Formations

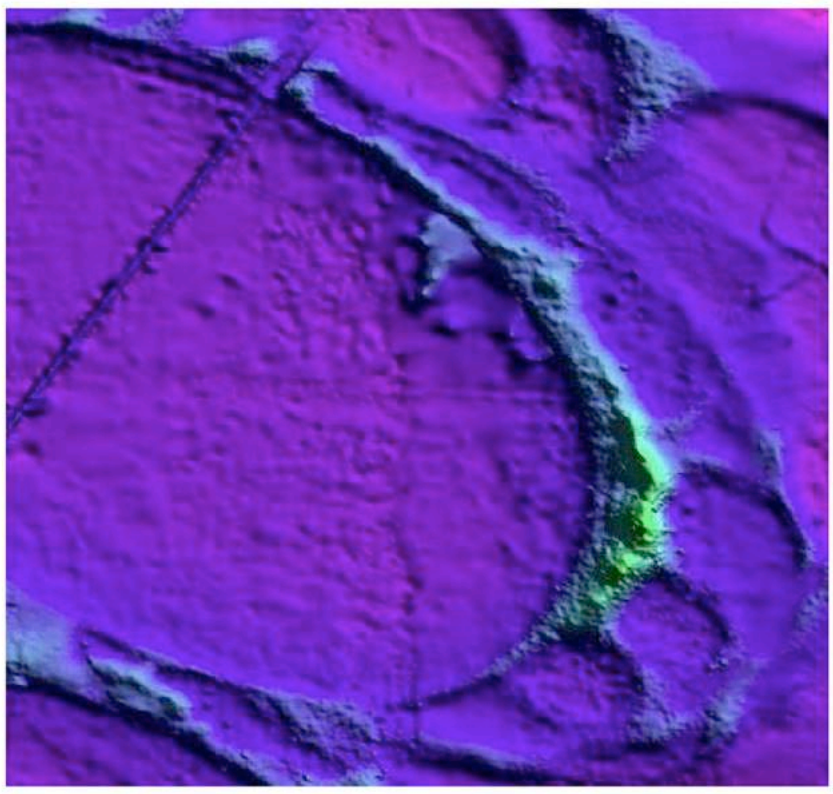


J. C. Bird, et al, 2010, Daughter bubble cascades produced by folding of ruptured thin films, Nature Vol 465

An interesting natural phenomena is the Daughter Bubble. When a bubble dome pops, air entrained in the collapsing wall creates small bubbles within the periphery of the parent bubble.

Daughter Bubble Formations





I mentioned earlier toe-like features. I interpret these as evidence of a bubble-popping genesis.

Dating the Deposit

- Pollen
  - Into last interglacial
- Carbon
  - Carbon Dead
- OSL date testing
  - Holocene to 100,000 +

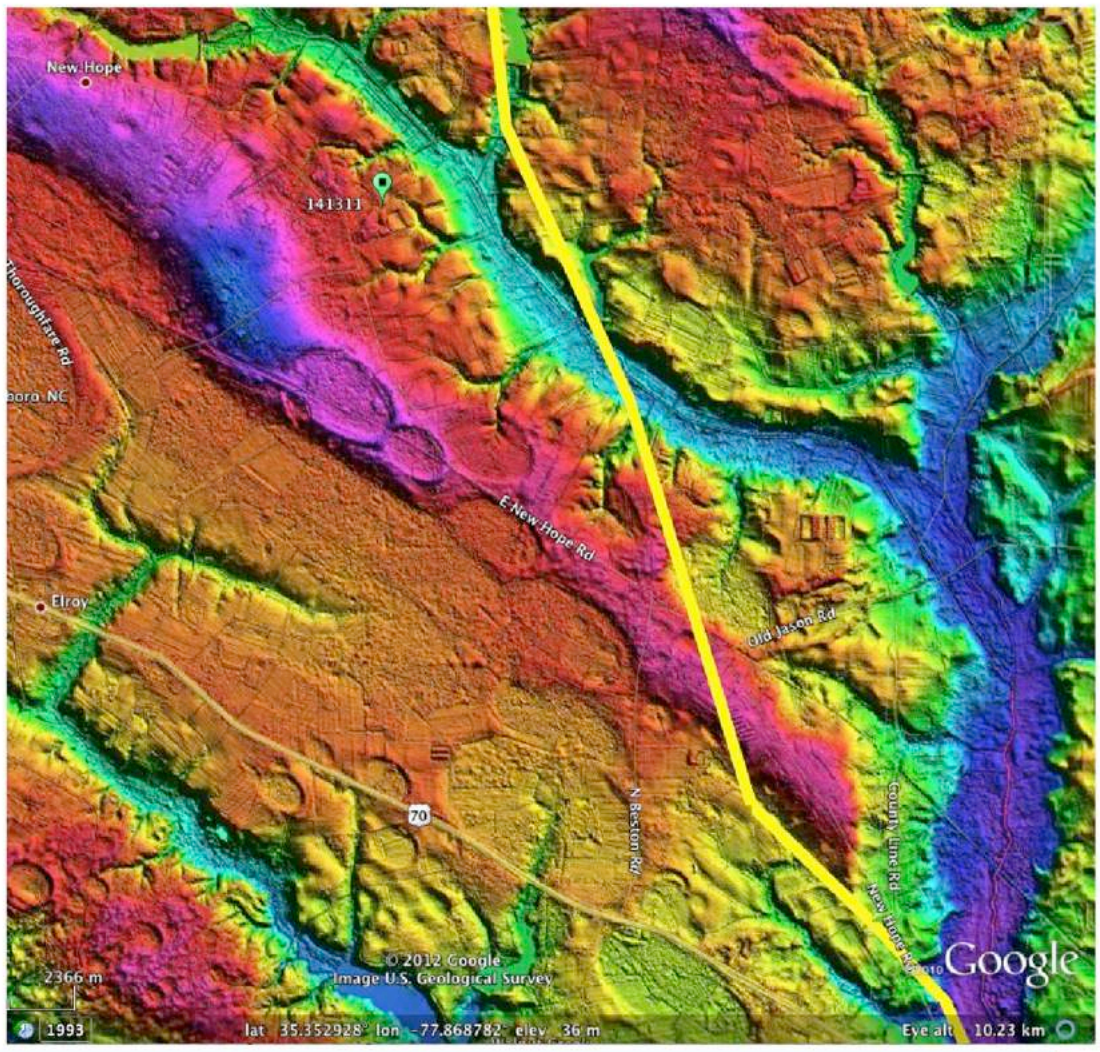
Marine Isotope Stage 3
40 to 45 kya

The bays' organic deposits have been inspected in attempts to date its age. These typically result in ages back into the last interglacial, and beyond the maximum range of Carbon dating (40,000 to 45,000 years ago). Please recognize that in a scenario where the bay's interior is a window into antecedent terrain's, any such dating will eventually be testing that antecedent surface.

The sand in and around bays has been OSL dated about 50 times across a collections of geographies, including rims, adjacent dunes and basin deposits, by multiple researchers using multiple techniques. This has led to a consensus opinion that bay formation processes are episodic, and not supportive of a single catastrophic event. I maintain that only a controlled set of test on actual bay rim structural deposits would show a consistent date, and differentiated from post-formation reworking or underlying antecedent materials. We see some support for a date of 40 to 45 kya, during MIS-3.

Suggestion: Revisit the Goldsboro Ridge

- US 70 Bypass
  - Fresh Exposure
  - Finished 2016
- Take new cores
- Sample sand
- OSL date testing



Test hypothesis: is this structure as homogeneous as it appeared to Daniels, Wheeler and Gambel?

So for future work, I fantasies on revisiting the Goldsboro Ridge to take dozens of OSL samples of actual structural rim sand. I'd execute a comprehensive and controlled set of samples from the to get a better understanding of its depositional history and homogeneity. The ridge will soon be sliced open for the US 70 Goldsboro Bypass project.

In conclusion, I propose that the literature , the sand and our research suggest the catastrophic sand sheet hypothesis deserves some additional attention.

Thank You

This LiDAR image is displayed as the November image on the GSA 2012 Wall Calendar. The url links to a KML file to view this regional LiDAR in Google Earth

Abstract

Southeastern Section - 61st Annual Meeting (1–2 April 2012) **Paper No. 4-6** **Presentation Time: 9:40 AM-10:00 AM**

SURFICIAL QUARTZ SAND DEPOSITS ON THE ATLANTIC COASTAL PLAIN: EOLIAN, FLUVIAL OR MARINE? THE CASE FOR A CATASTROPHIC DELIVERY MECHANISM

DAVIAS, Michael, Cintos Research, 1381 Hope Street, Stamford, CT 06907, michael@cintos.org and
GILBRIDE, Jeanette L., Cintos Research, Raleigh, NC 27613

Regions of the Atlantic Coastal Plain are often capped by a surficial sheet of quartz sand. For example, the Pinehurst Formation sands are mapped as a separate unit, distinct from the well-provenanced terraces below. The Goldsboro Ridge sand is also distinct, resting on the Sunderland formation. From the Carolina Sandhills eastward to the coast at Wilmington, a nearly continuous and occasionally thick (up to 10m) sheet of high purity quartz sand is blanketed across the intervening terraces and scarps. While the Coastal Plain surfaces show evidence of eolian reworking, studies of the deeper extents of these sandy deposits often mention difficulties in determining their geomorphology, although deemed as gradualistic eolian, fluvial or marine. Marine deposition is appropriate at the coastline, supported by glacial-driven sea level transgressions; but they contain no shell fragments. Inland, deposition on interfluvials during flooding of is reasonable; but these are coarsely skewed, showing no sorting or channeling and minimal clays. At higher elevations, workers implicate eolian deposition on undissected terrain; but delivering coarse sand upslope from distant drainage mandates powerful winds. Oriented ovoid Carolina bay depressions have evolved in these sand sheets, seemingly without deforming or altering the antecedent strata and paleosols they rest upon. They are present in prodigious quantities and may represent diagnostic markers for these distinct sand deposits. In an attempt to identify a universal mechanism for the materialization of these sand sheets, we speculate on an aerial deposition, mobilized and delivered as a "rain" of pulverized distal ejecta emanating from a cosmic impact. The bay depressions may be artifacts of steam outgassing, frozen in time as the sand transited from liquefaction to lock-up, preserving an arrival vector in their orientation. Using data from our LiDAR-augmented geospatial survey of 30,000 Carolina bays, we note systematically varying orientations and robust adherence to archetype planforms. A triangulation network, built using bay orientations and considering the Coriolis steering of trajectories, suggests a probable source impact site. While such a catastrophic mechanism is unorthodox, our survey data and analysis suggests further research is warranted.

Session No. 4: Ancient and Modern Eolian Systems of Eastern North America
Marriott Rennaissance: Windsor Ballroom, Salon 18:00 AM-10:20 AM, Sunday, 1 April 2012
Geological Society of America Abstracts with Programs, Vol. 44, No. 4, p. 13