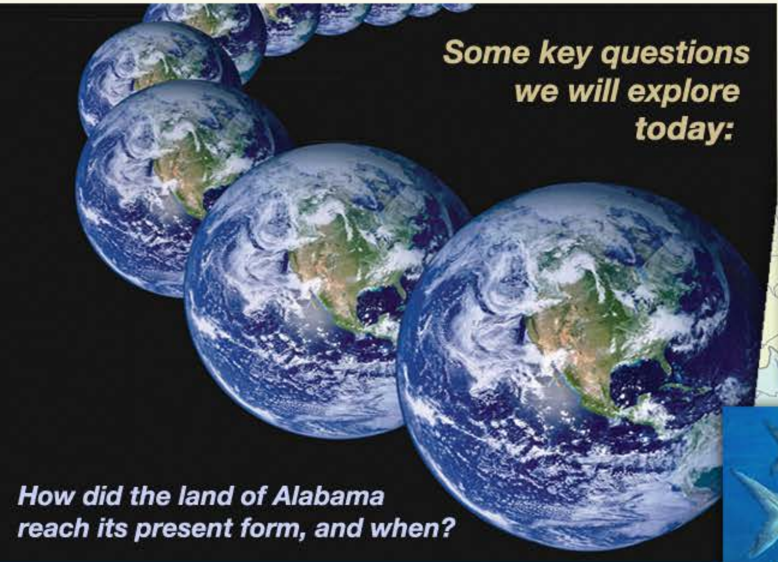
A Geological History of Alabama Rivers:

Probing the Ancient Origins of the State's Aquatic Biodiversity

Jim Lacefield



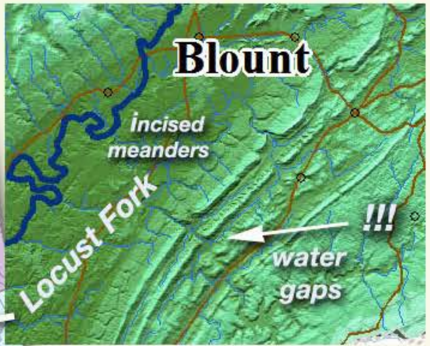
Some key questions we will explore today:

How did the land of Alabama reach its present form, and when?

Birmingham-area streams contain unique clues to great changes in this land through time.

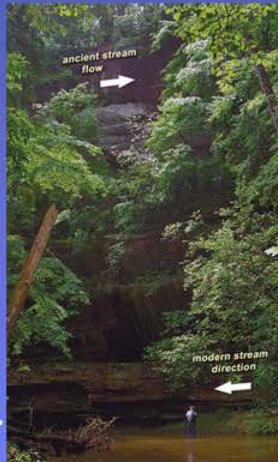
Why is north Alabama such a "hot spot" of freshwater biodiversity?

(short version: some biological evidence removed)

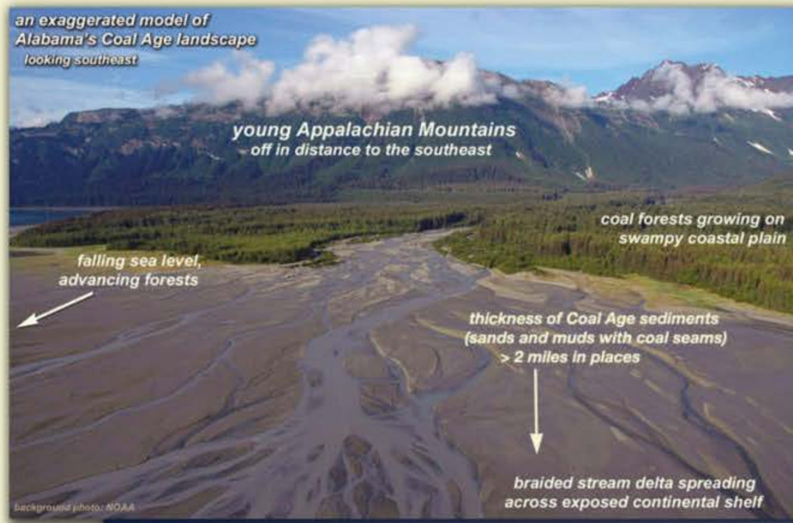


What do rocks and the course of streams say about the evolution (and age) of the state's landscape?

* *Geological history can be discovered in sources other than just rocks.*
* *The course and character of streams holds clues to Alabama's ancient geography.*



A Quick History of Alabama Rivers derived from the 3 Primary Sources of Geological Information



1. The Story Written in the Rocks

The "Coal Age" - The land rises above the sea. Future North Alabama blanketed by layers of sediment left by a complex of sandy, northwest-flowing streams with swampy floodplains flowing into a subsiding basin.

*** At one time Pennsylvanian rocks covered all of north Alabama**

2. The Story Written in the Landscape

A long period of quiescence in which the land is eroded almost flat (beginning in the Pennsylvanian/Permian periods ~ 275 million years ago, ending unknown)

*** The end of geologic history (except for those nagging questions)?**

3. The Story Written in the Rivers : "Neotectonic Uplift"

A geologically recent period of uplift in which streams are rejuvenated and the modern drainage pattern is established (began Middle Miocene Epoch: ~ 15 m.y.a.)

*** Key Idea: These recent geological dynamics are the driving force behind Alabama's modern aquatic biodiversity!**

Pennsylvanian sandstones exposed on the Locust Fork River

Alabama is Number One! (But Why?)

This state is home to some of the highest aquatic biodiversity in all of North America.

1st in freshwater fish @ 317 species

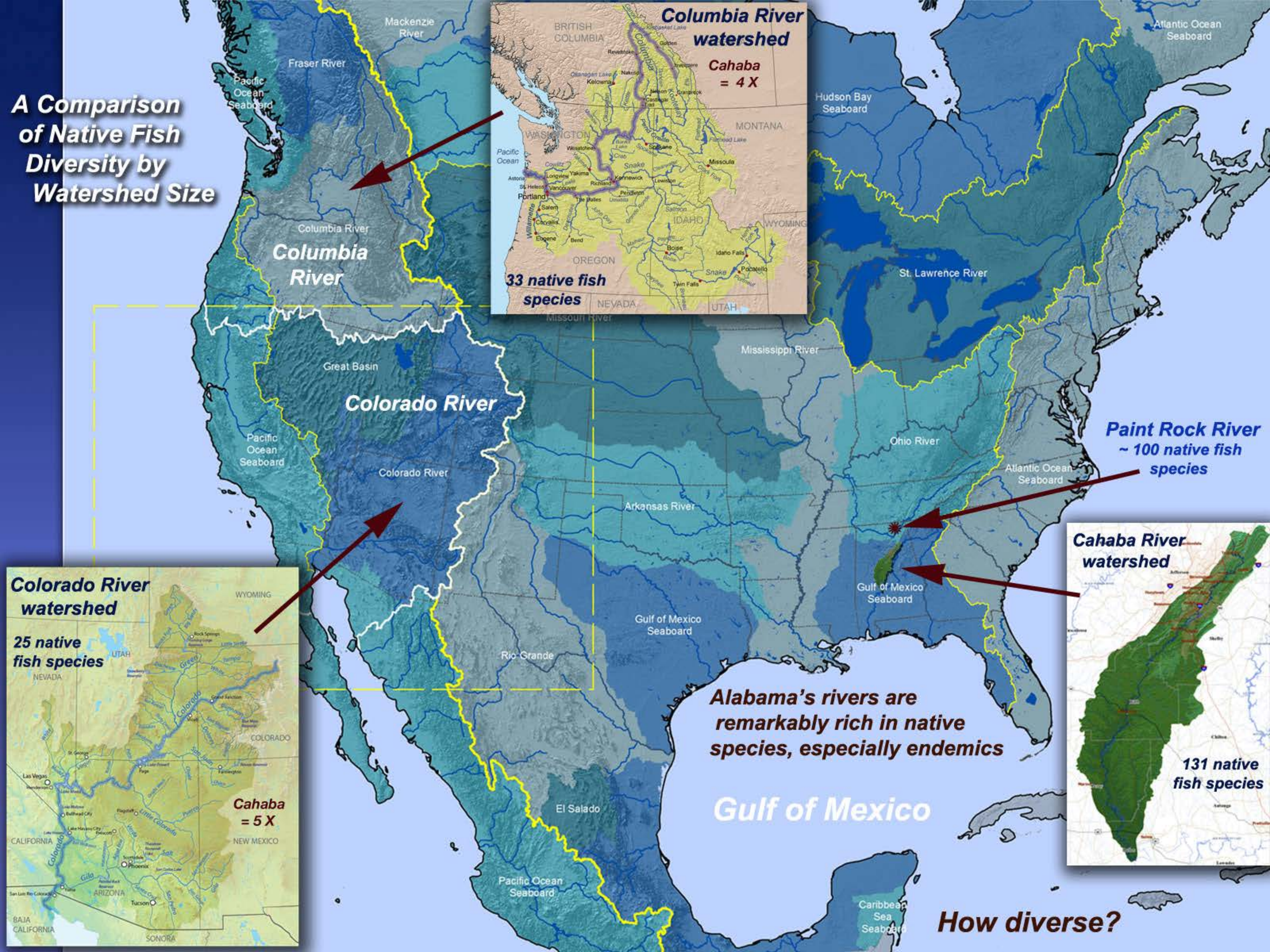
1st in freshwater snails @ 174 species

* *The secret to this biodiversity lies in the ancient history of Alabama's streams!*

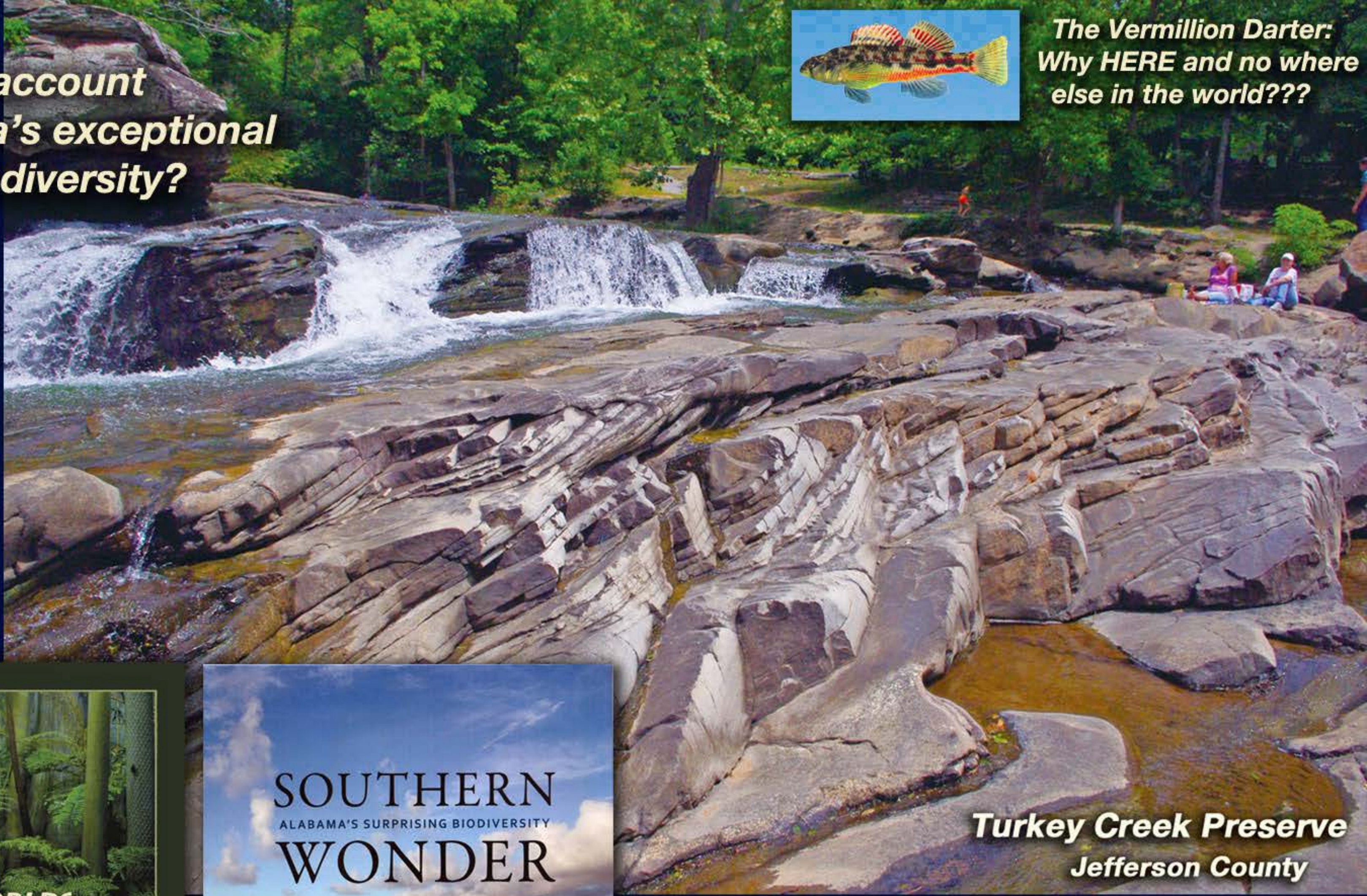
1st in freshwater mussels @ 178 species

1st in crayfish @ 85 species

1st in turtles @ 27 species



A Comparison of Native Fish Diversity by Watershed Size
Columbia River watershed
Cahaba = 4 X
33 native fish species
Columbia River
Colorado River
Colorado River watershed
25 native fish species
Cahaba = 5 X
Paint Rock River
~ 100 native fish species
Cahaba River watershed
131 native fish species
Alabama's rivers are remarkably rich in native species, especially endemics
Gulf of Mexico
How diverse?
Mackenzie River
Fraser River
Pacific Ocean Seaboard
Hudson Bay Seaboard
Atlantic Ocean Seaboard
Columbia River
Missouri River
Great Basin
Mississippi River
St. Lawrence River
Ohio River
Arkansas River
Rio Grande
Gulf of Mexico Seaboard
El Salado
Caribbean Sea Seaboard



How do we account for Alabama's exceptional aquatic biodiversity?

The Vermillion Darter: Why HERE and no where else in the world???

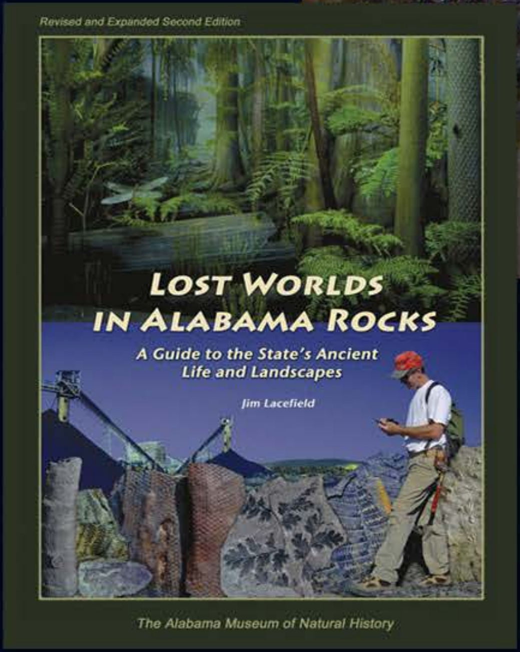
1.

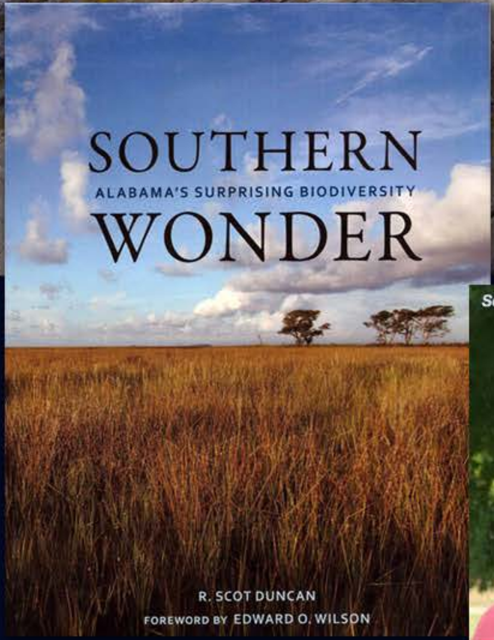
Well, there are "historical" factors...

...things that have led up to today.

(evolution of the area's landscape, stability over time)

Turkey Creek Preserve
Jefferson County



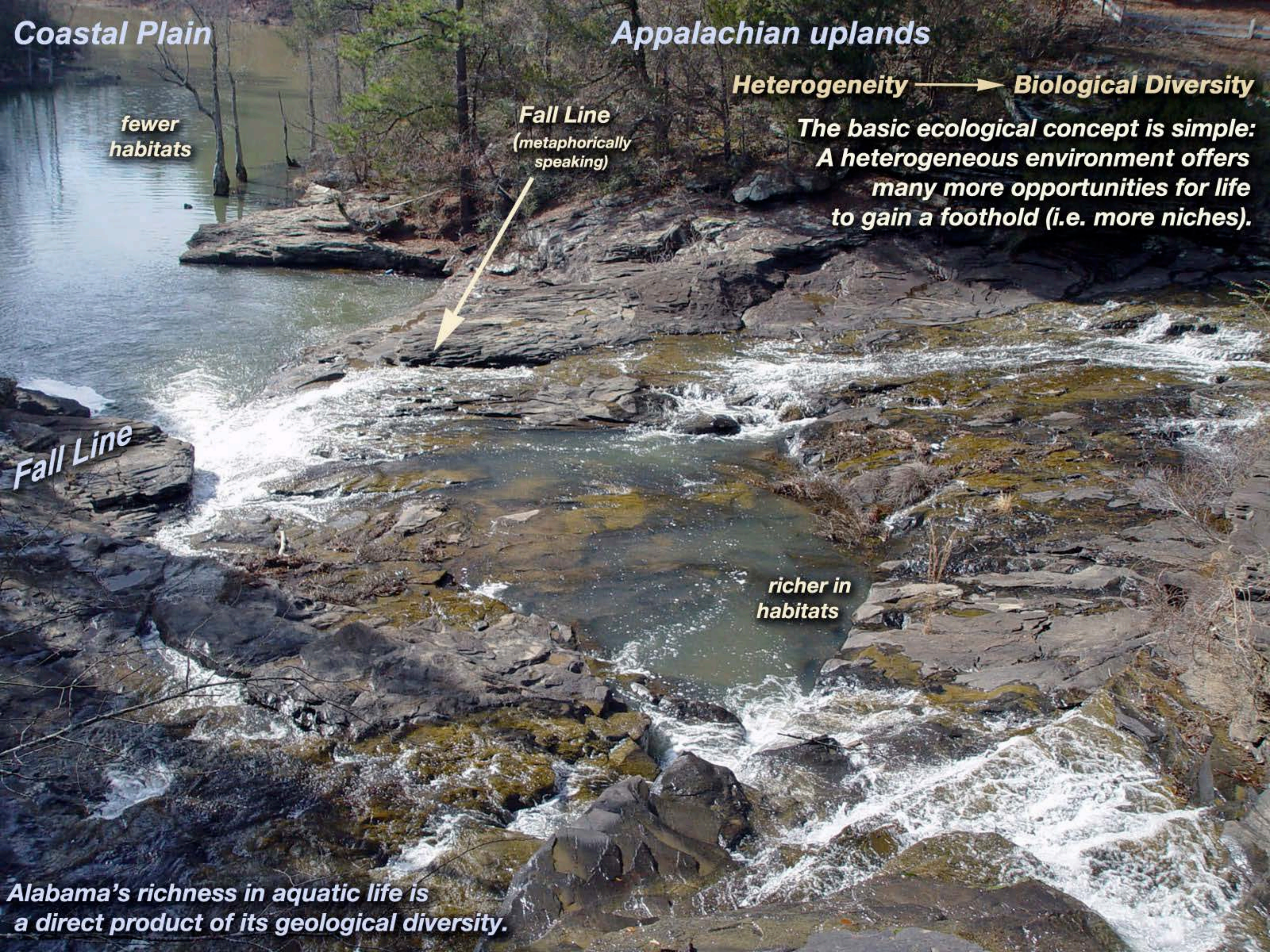


2. ...and there are ecological factors.

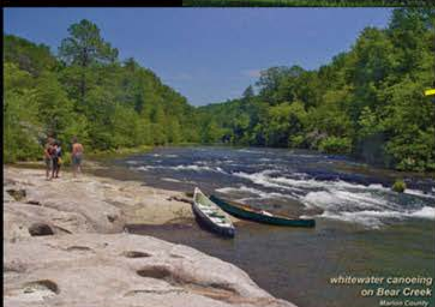
Modern ecological dynamics

(adaptation, competition, etc.)

These things work together—understanding WHY requires some understanding of both!

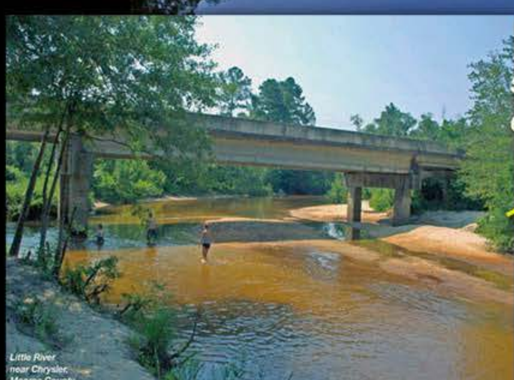

Coastal Plain
Appalachian uplands
Heterogeneity → Biological Diversity
fewer habitats
Fall Line (metaphorically speaking)
The basic ecological concept is simple: A heterogeneous environment offers many more opportunities for life to gain a foothold (i.e. more niches).
Fall Line
richer in habitats
Alabama's richness in aquatic life is a direct product of its geological diversity.

limestone valleys

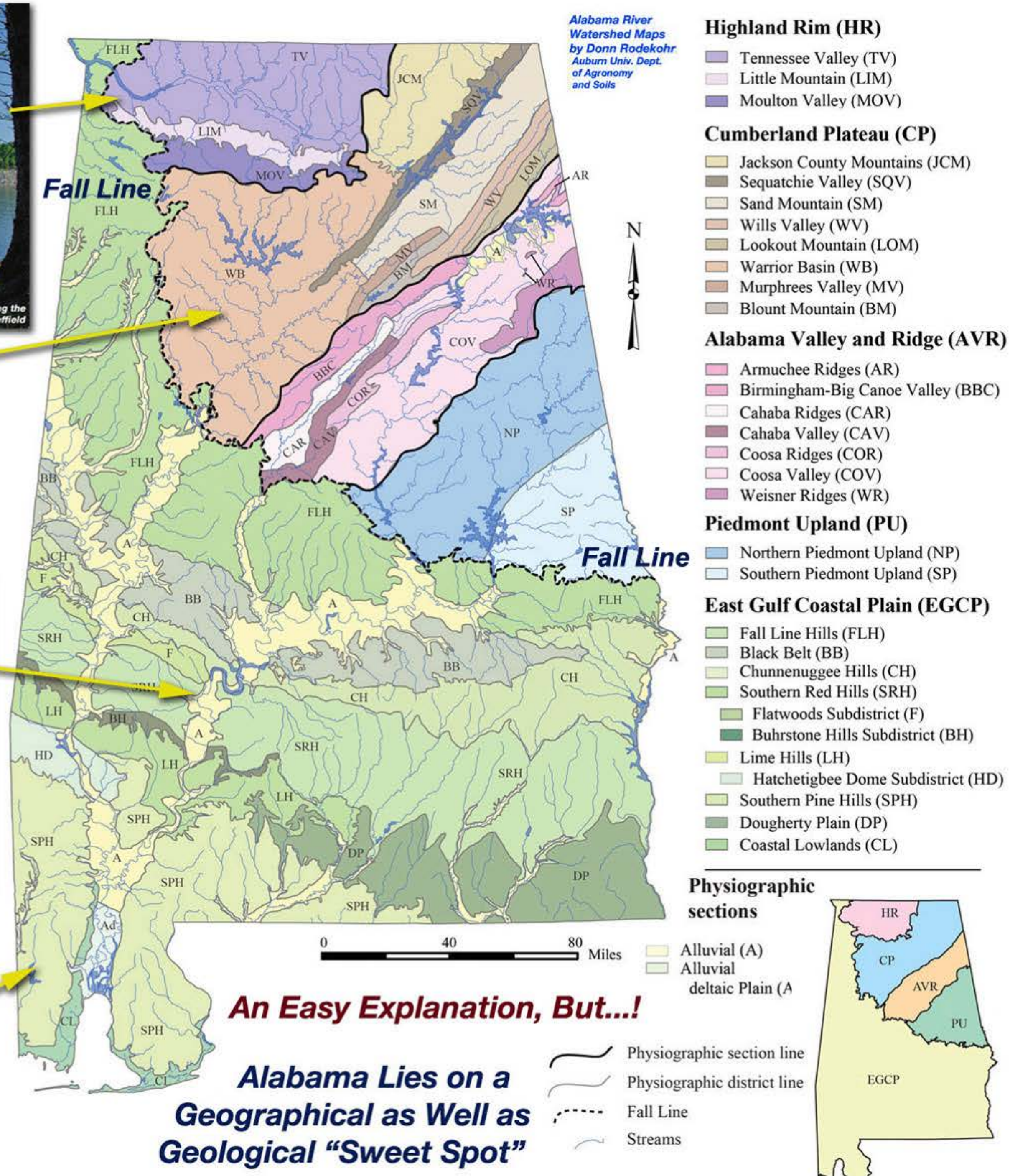


hard rock uplands

large, meandering Coastal Plain rivers



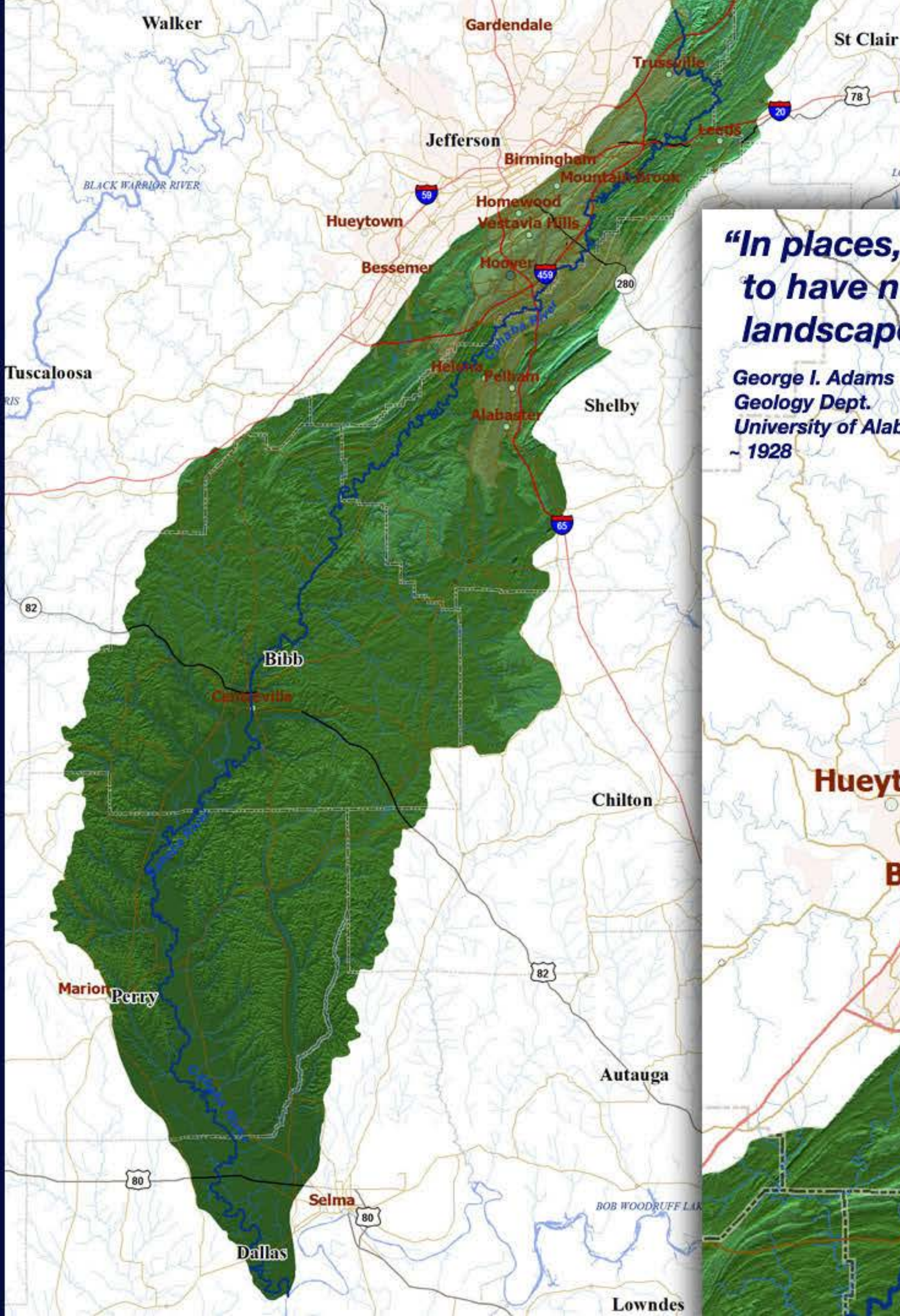
sandy creeks



An Easy Explanation, But...!

Alabama Lies on a Geographical as Well as Geological "Sweet Spot"

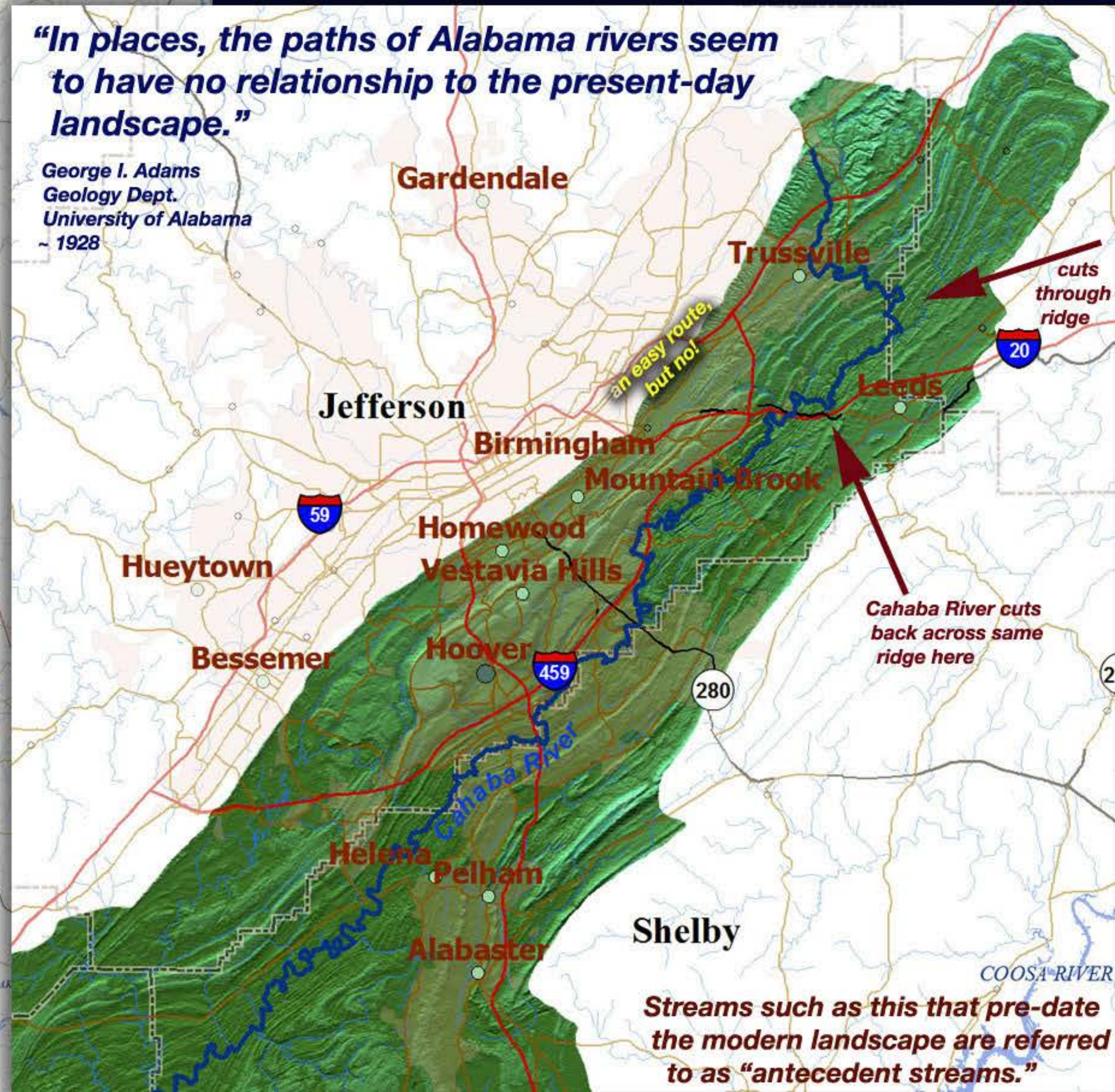
The Cahaba River

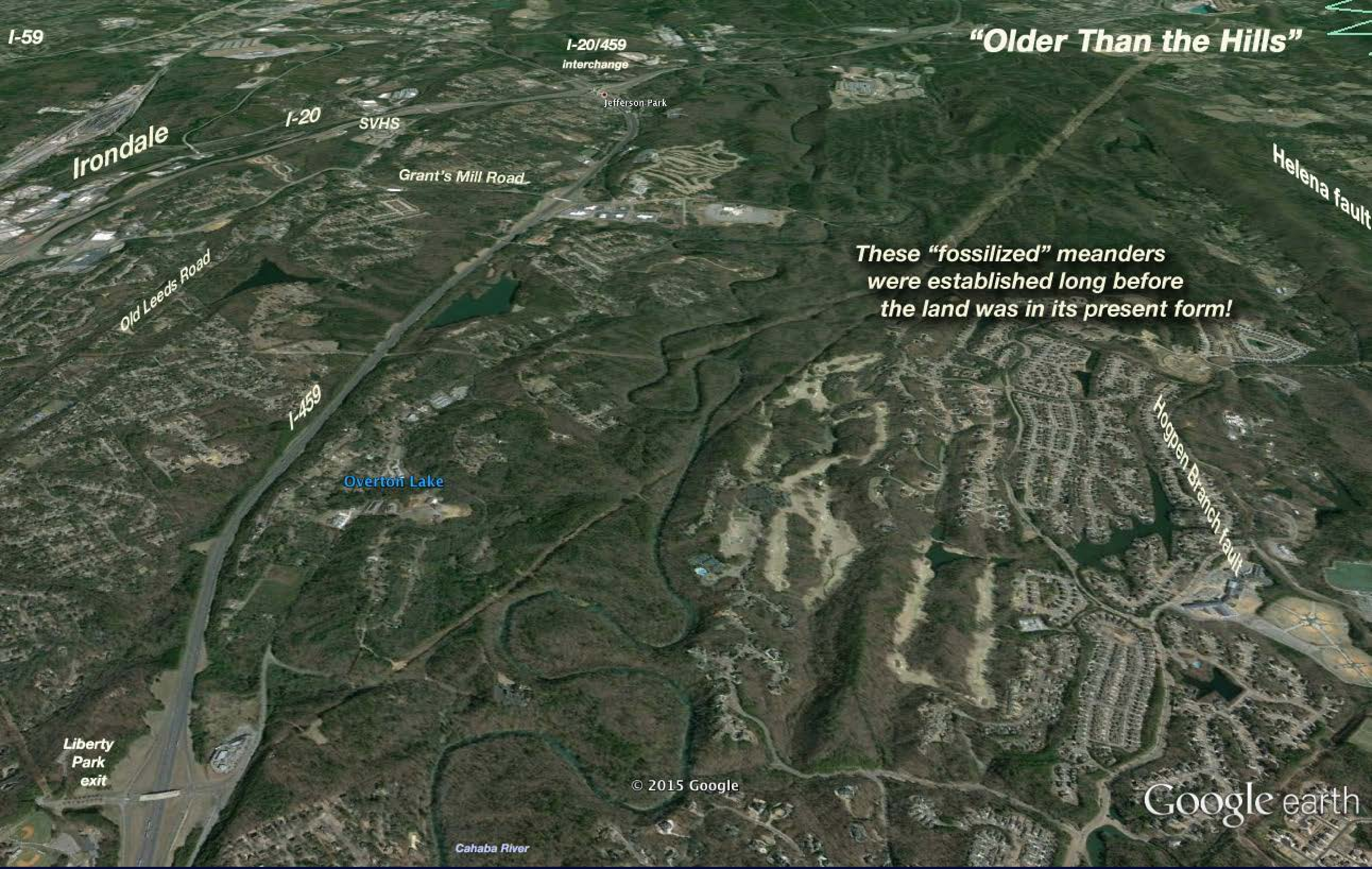


Which Came First—The River, Or the Land it Flows Through?

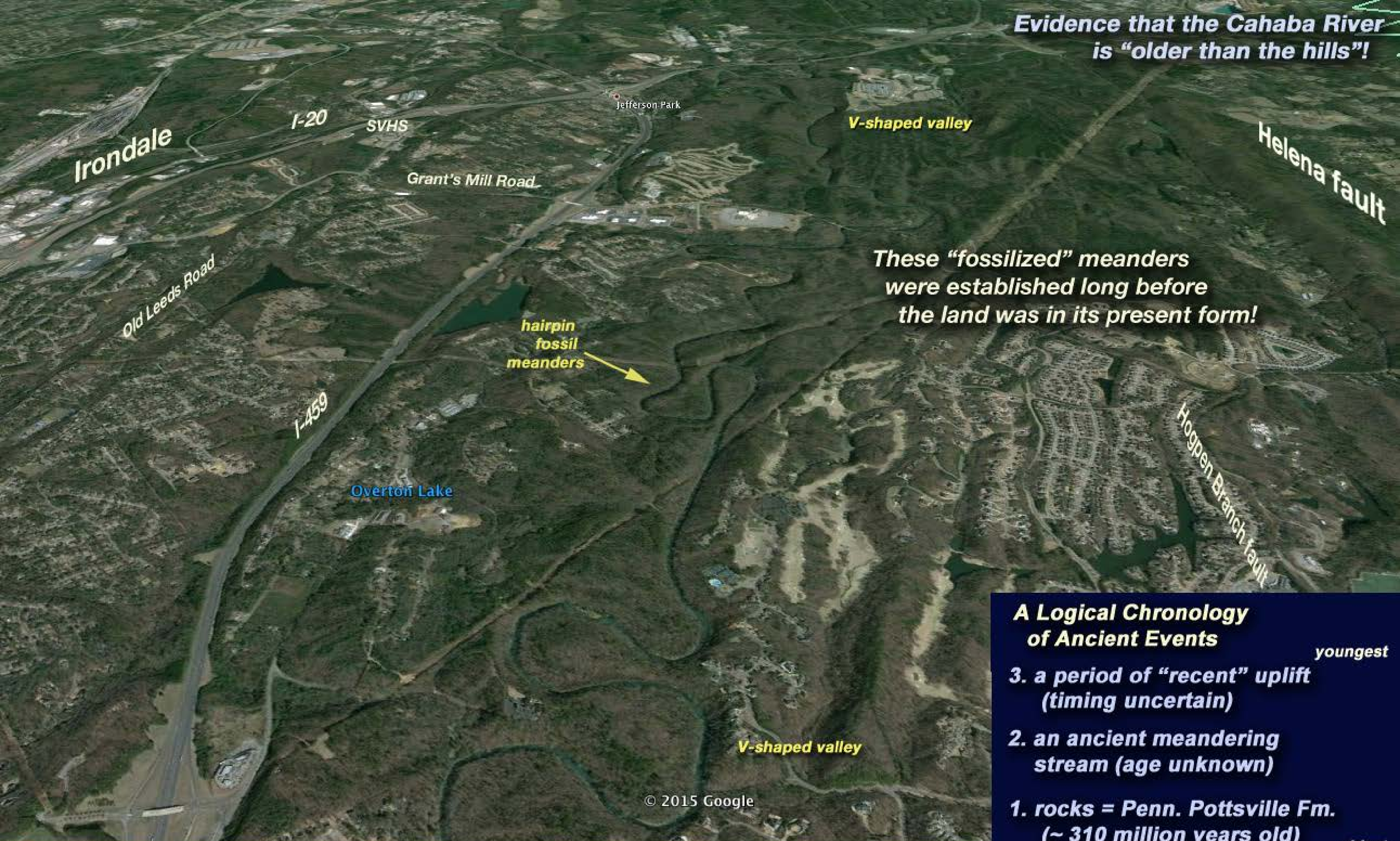
The upper portion of the Cahaba River also cuts through numerous ridges, but eventually does develop a trellis-style drainage pattern typical of the Valley and Ridge Province.

"Water does not flow uphill, never has, never will."





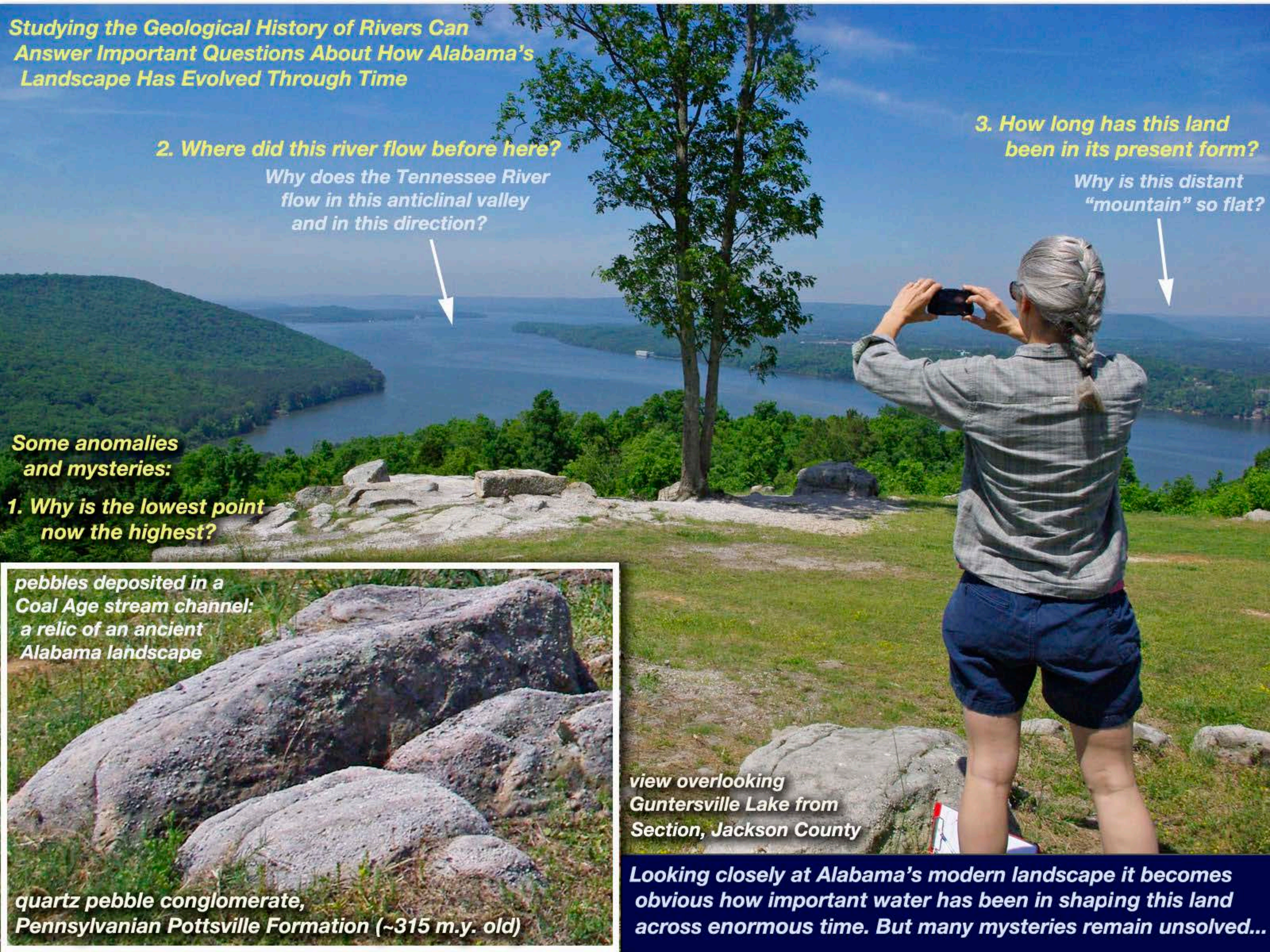
In many places the Cahaba River contains anomalous features that show its history is far more complex than is seen at first glance. Strange tales about the land's ancient history are written in the curving path it takes among these gentle ridges.

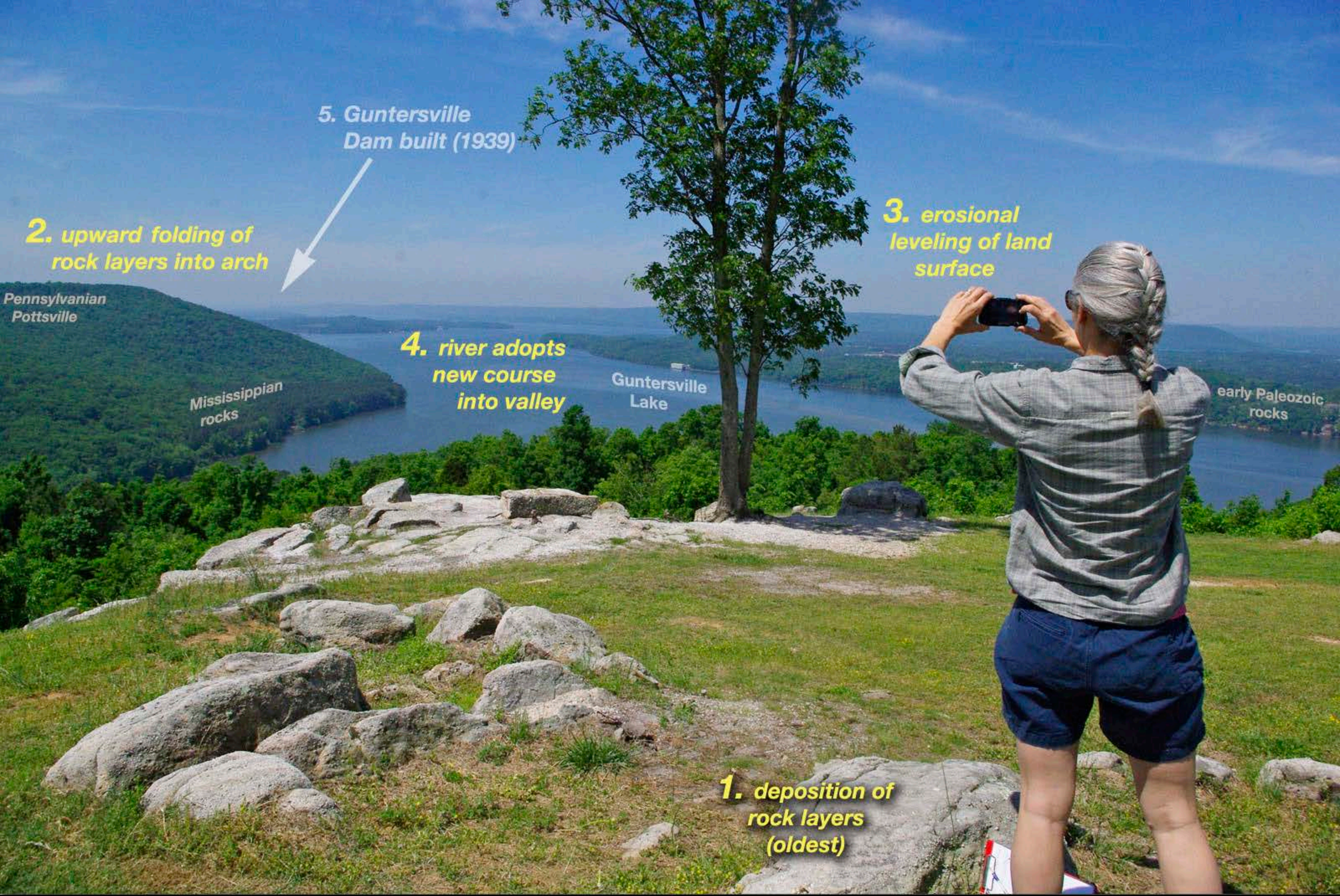


*** Deciphering stream features can reveal "lost chapters" of an area's geological history!**

These anomalous features in the course of the Cahaba River hint at a very different Alabama landscape that existed here at some point far in the past. But how long ago, and what could have caused this land to undergo such a profound change???

This portion of the upper Cahaba Valley contains classic features of a rejuvenated stream


Studying the Geological History of Rivers Can Answer Important Questions About How Alabama's Landscape Has Evolved Through Time
2. Where did this river flow before here?
Why does the Tennessee River flow in this anticlinal valley and in this direction?
3. How long has this land been in its present form?
Why is this distant "mountain" so flat?
Some anomalies and mysteries:
1. Why is the lowest point now the highest?
pebbles deposited in a Coal Age stream channel: a relic of an ancient Alabama landscape
quartz pebble conglomerate, Pennsylvanian Pottsville Formation (~315 m.y. old)
view overlooking Guntersville Lake from Section, Jackson County
Looking closely at Alabama's modern landscape it becomes obvious how important water has been in shaping this land across enormous time. But many mysteries remain unsolved...



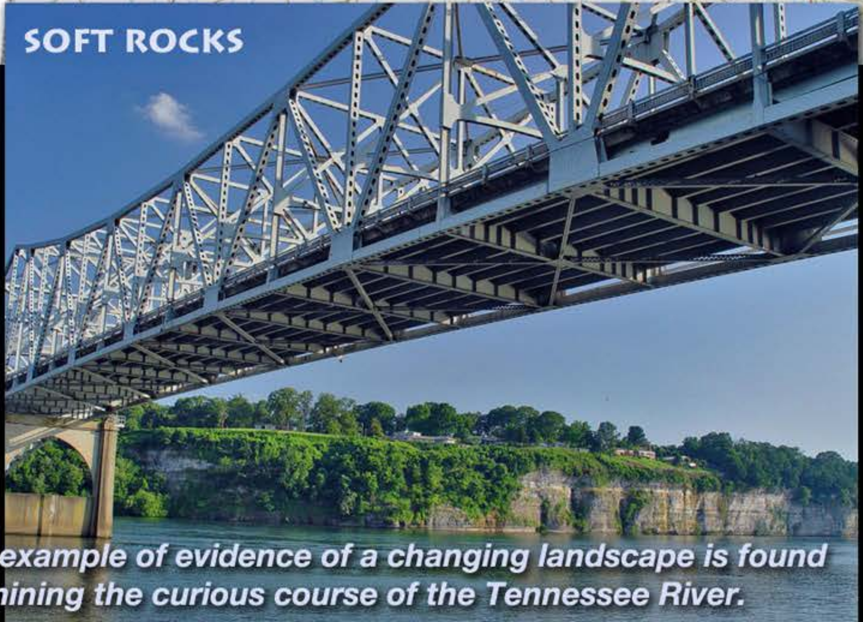
This scenic view can be logically interpreted to represent a sequence of ancient events, but only their relative age can be deduced. To understand WHEN these events occurred you have to call upon other lines of evidence...

Geology and Time Guide the Course of the Tennessee River

How can the flow of rivers hold clues to the evolution of our modern landscape?

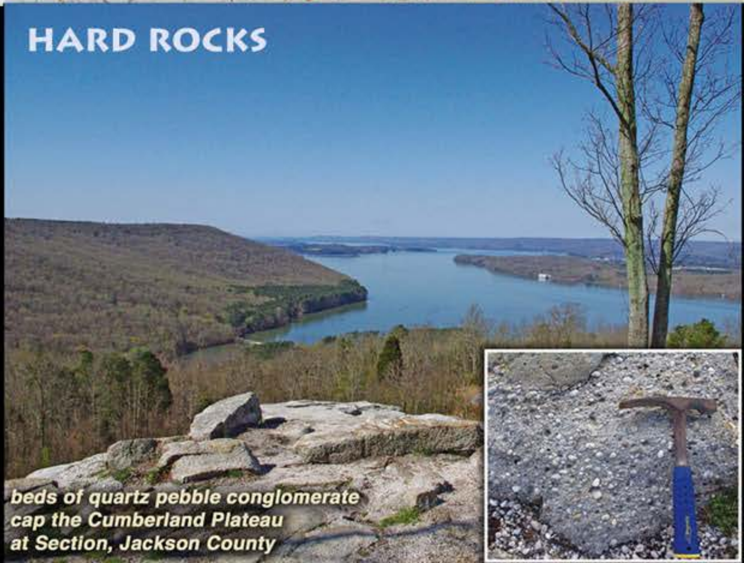
At first glance the Tennessee River seems to be "pieced together" from unrelated segments.

Soft Rocks



A good example of evidence of a changing landscape is found by examining the curious course of the Tennessee River.

Hard Rocks



beds of quartz pebble conglomerate cap the Cumberland Plateau at Section, Jackson County

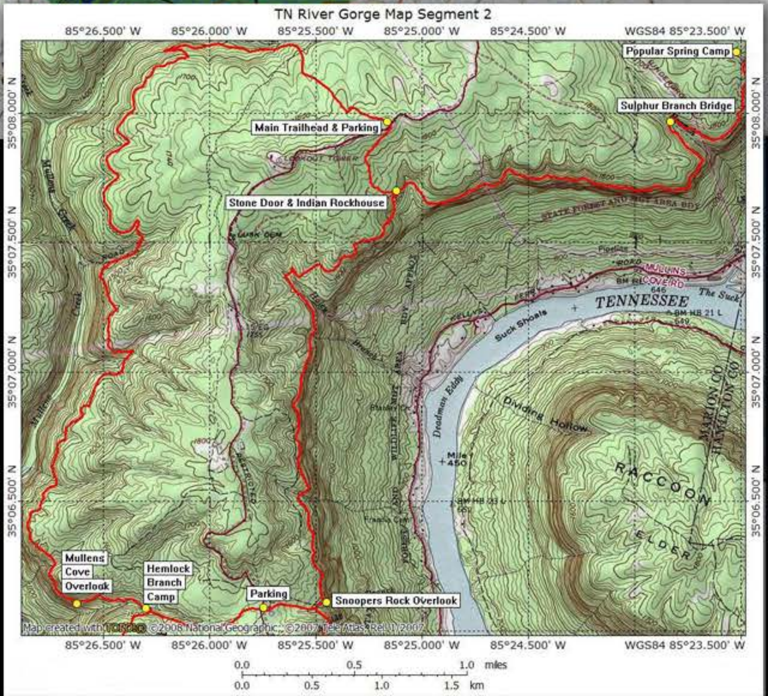
Geology and Time Guide the Course of the Tennessee River

Most river flow is easy to understand, but some represent profound mysteries that hold subtle clues to the land's past.

Great Mysteries Still to be Solved

The west end of the Tennessee Valley makes perfect sense; the Tennessee is a consequent stream, flowing down a limestone valley bounded by resistant chert and sandstone uplands.

Upstream, however, it is clearly an antecedent stream that has cut through a 1,000-foot wall of resistant sandstone to form the Tennessee River Gorge.



Many now consider George Adams to be the “father of geomorphology” in Alabama—a man well ahead of his time.

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THE COURSE OF THE TENNESSEE RIVER AND THE PHYSIOGRAPHY OF THE SOUTHERN APPALACHIAN REGION

GEORGE I. ADAMS
University of Alabama

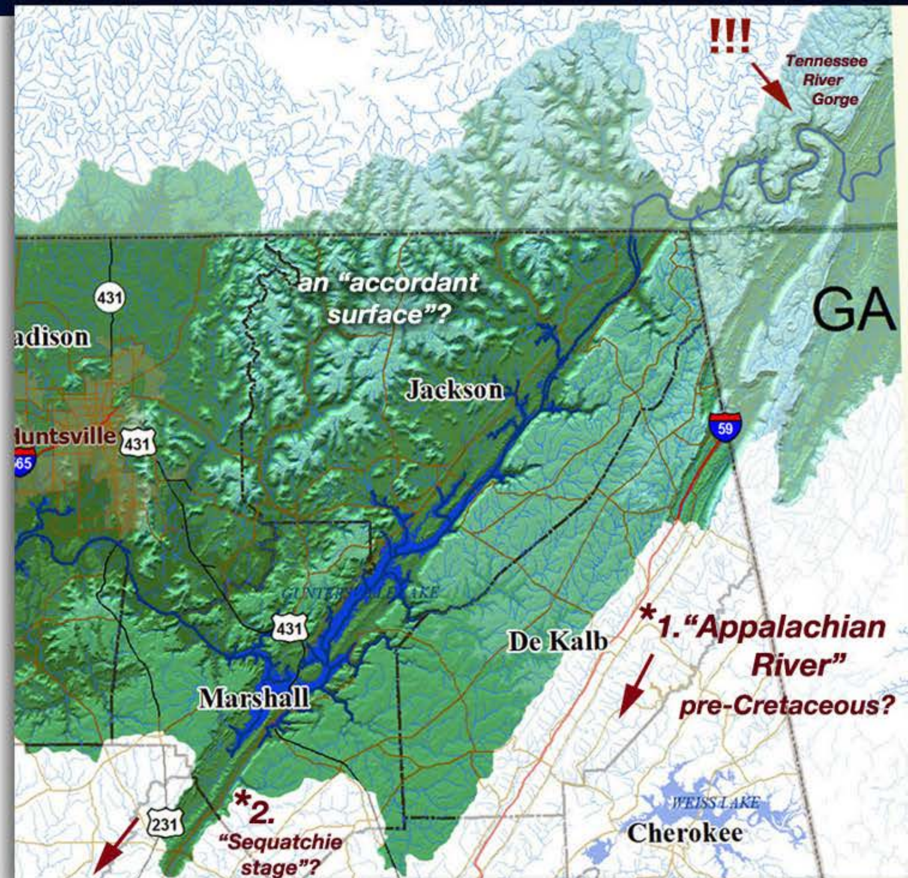
ABSTRACT

The Tennessee River has been interpreted as a pirate stream. This idea has been rather generally accepted and used. There are opinions to the contrary, but they do not prevail since they have not been so widely published and are seldom taught. It is the purpose of the following article to present an explanation of the course of the river based on the geologic history of the region and obviating the element of stream capture.

The course of the Tennessee River is anomalous and has given rise to various conjectures concerning its possible previous courses and as to how its present position was established. The headwaters of the Tennessee are in the Appalachian Valley, and, since this region is well defined structurally and physiographically, it is natural to speculate as to why the river does not continue within it in a southwesterly direction to the Coastal Plains and the Gulf of Mexico. The name Appalachian River has been given to a stream which is supposed to have held such a position at the close of the Cretaceous cycle of erosion and in its lower portion followed approximately the present Coosa Valley. The existence of this hypothetical stream has been affirmed and denied.

Below Chattanooga the Tennessee flows westward through a gorge which has been described as having a youthful appearance.

(?) notice this!



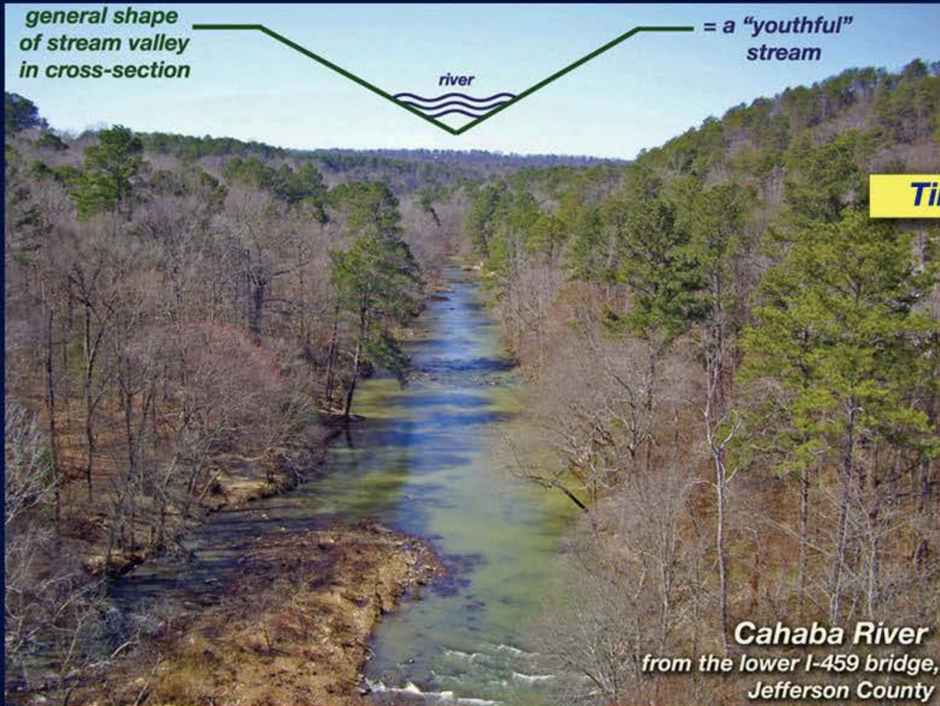
Great Mysteries Waiting to be Solved

The idea of river basins evolving over geologic time is not a new one.

Geographers have been noticing tantalizing evidence for changes in the course of major rivers in Alabama for many years.

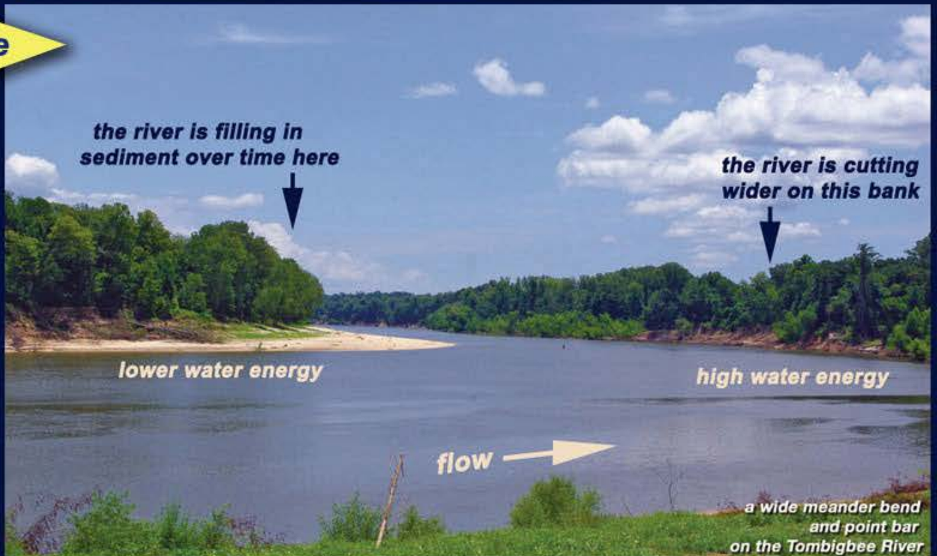
Viewed from a geological perspective the landscape is dynamic. These changes have implications for how the land and its life have reached their present form.

How Geographers Define the "Age" of a Stream



youthful — mature

Time



A. Features of Youthful Streams

1. higher gradient = faster speed
2. more direct course of flow
3. continue to carve downward into the land beneath them
4. narrow flood plain, steep banks

*Once a stream reaches "old age" it meanders back and forth in the same territory...

*Many streams in north Alabama today seem to be youthful ones superimposed on an ancient land surface.

B. Features of Mature Streams

1. lower gradient = slower speed
2. widening bends called meanders
3. deposition of sediment over time
4. broad and fertile flood plain

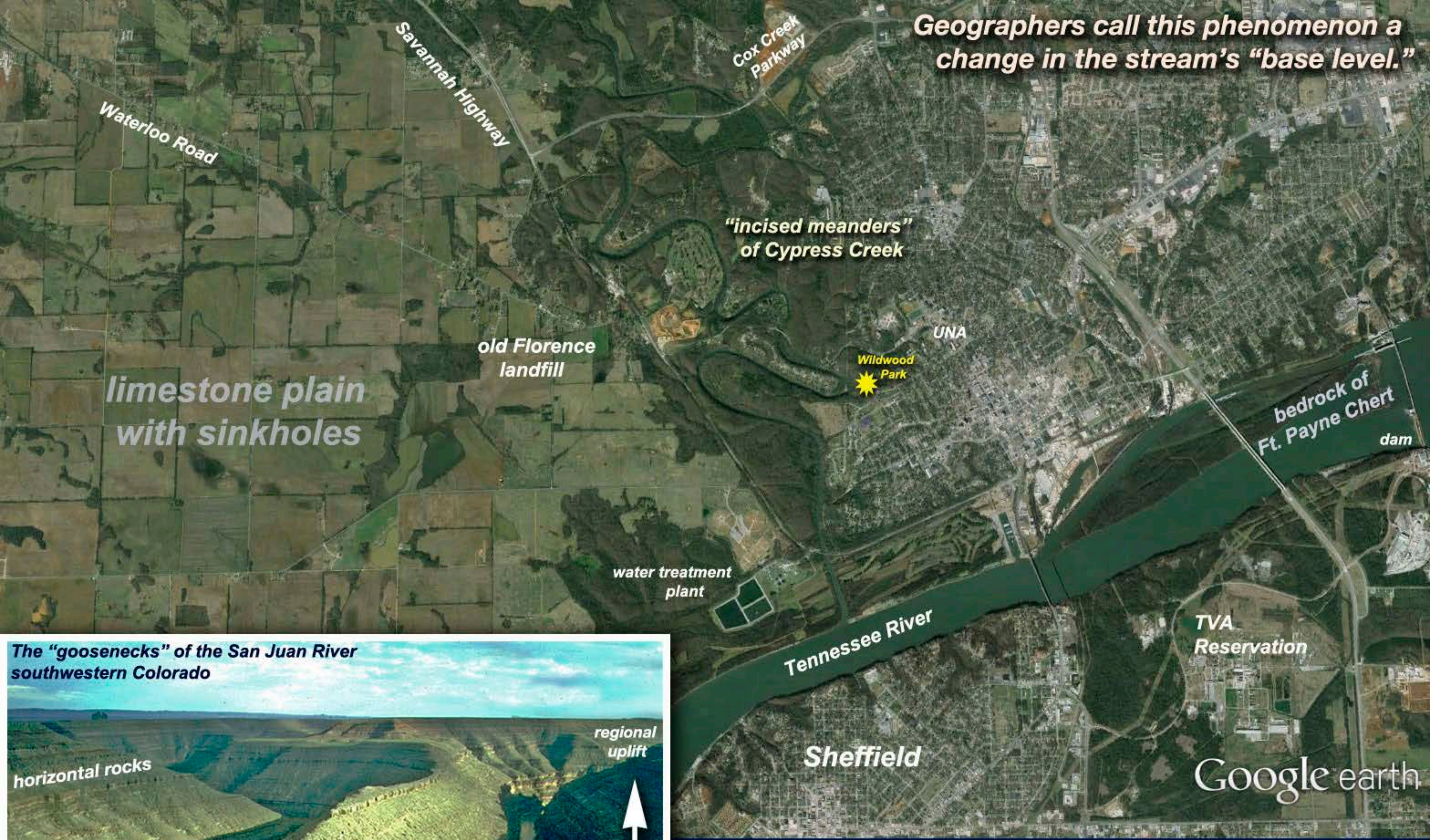
The Puzzle of Cypress Creek: Evidence of "Rejuvenation" in a North Alabama Stream

Some anomalous features:

1. "fossilized" meanders, 2. deep shadows show steep banks and tall bluffs in places 3. very narrow floodplain (no farming, wooded except where residential development) 4. stretches of whitewater

What historical factors or past landscape changes could produce these anomalous features?

Geographers call this phenomenon a change in the stream's "base level."



The "goosenecks" of the San Juan River southwestern Colorado

As in the Colorado Plateau out West, some hitherto unknown geological forces must have caused an uplift of the land here at some time in the recent past and "rejuvenated" area streams.

There are clues to this regional uplift of the land in other parts of Alabama, too, and we'll examine these.

Evidence suggests each river system has its own unique history different from the present day.

Clues to stream history are often "hidden in plain sight"…..

long-abandoned channels

Adams and other geographers believed the size of the upper Coosa River valley was too large to have been formed by today's river.

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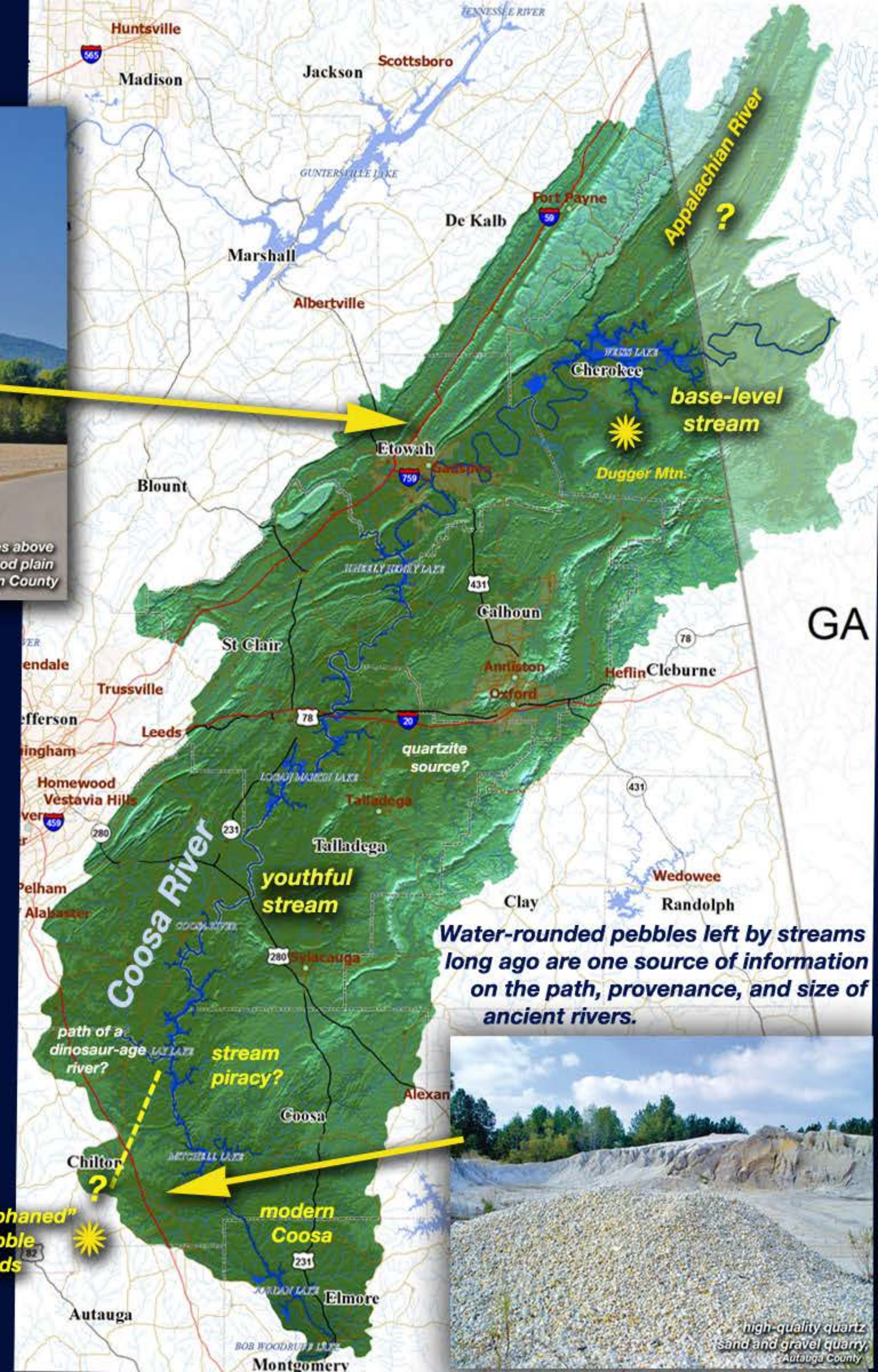
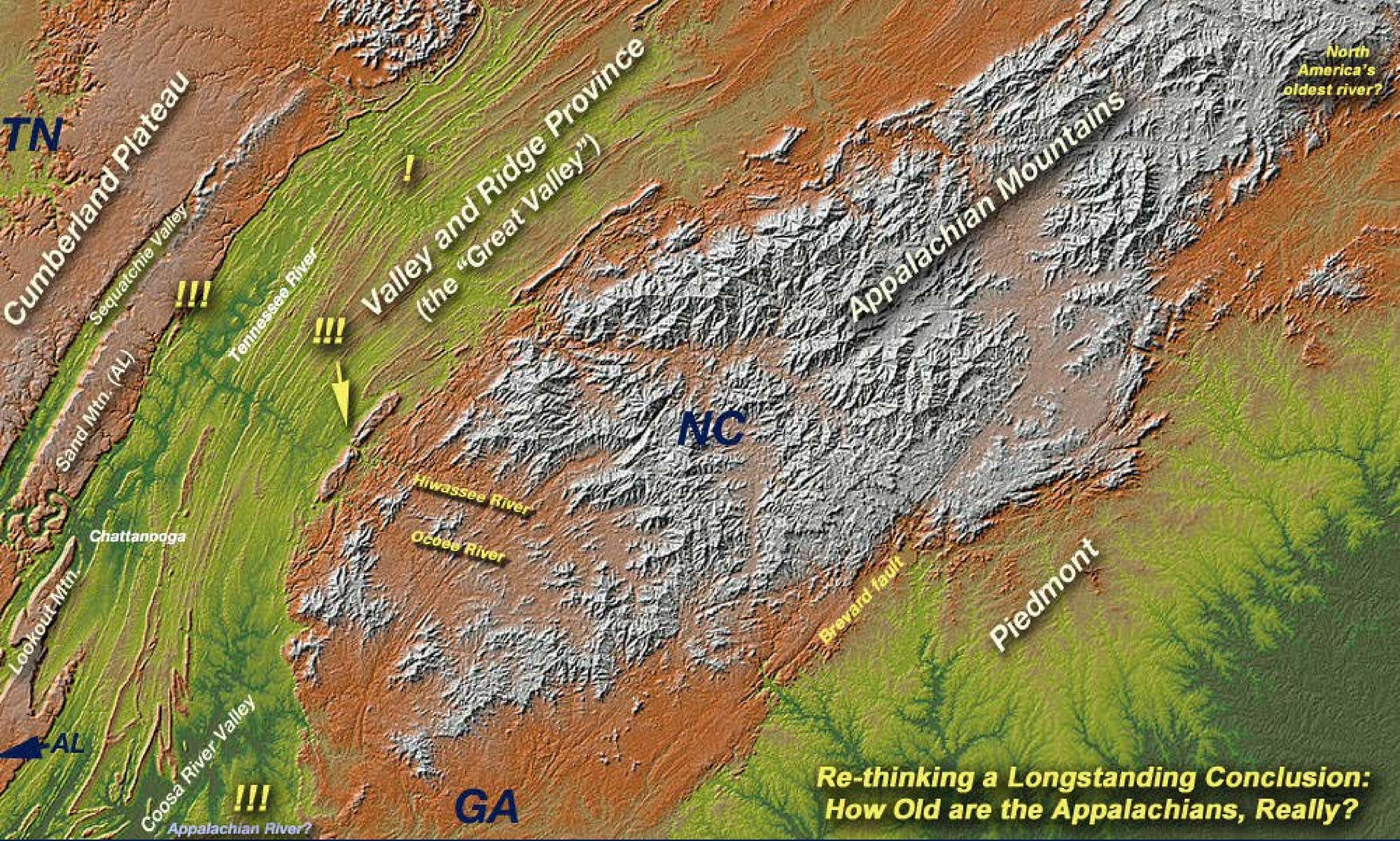
THE STREAMS OF THE COASTAL PLAIN OF ALABAMA AND THE LAFAYETTE PROBLEM

GEORGE I. ADAMS
University of Alabama

ABSTRACT

The Alabama and Tombigbee rivers, which drain most of Alabama and small portions of Georgia and Mississippi, converge at Mobile Bay. The Alabama River appears to have been formed by the diversion of streams which were formerly through-flowing. It is suggested that downwarping in southwestern Alabama caused the convergence of the drainage. The distribution of the Lafayette gravels aids in the interpretation of the history of the streams





Each province of the Appalachian region represents a different response to the collision with Africa:

* Cumberland Plateau - sedimentary rocks mostly uplifted vertically
* Valley and Ridge - mostly unaltered sedimentary rocks folded and faulted (anticlines, synclines, thrust sheets)
* Appalachian Mountains proper - highly folded and overthrust metamorphic, igneous, and sedimentary rocks
* Piedmont - the eroded roots of the crystalline Appalachians

Where did Ancient Alabama's Earliest Rivers Flow, and Why?

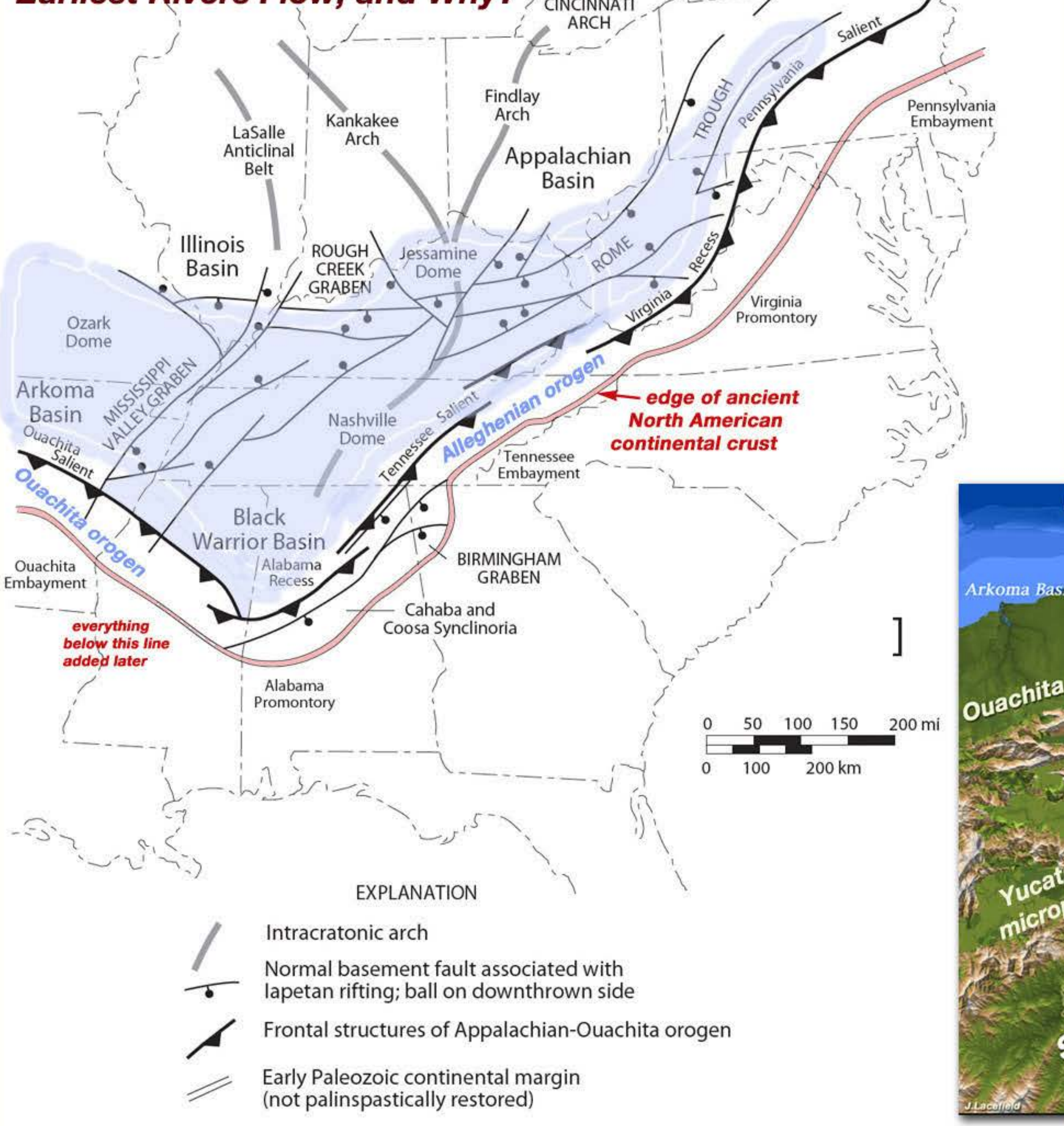


Figure 2.1. Tectonic setting of the Black Warrior foreland basin (after Thomas, 1988). Reprinted with permission of Geological Society of America.

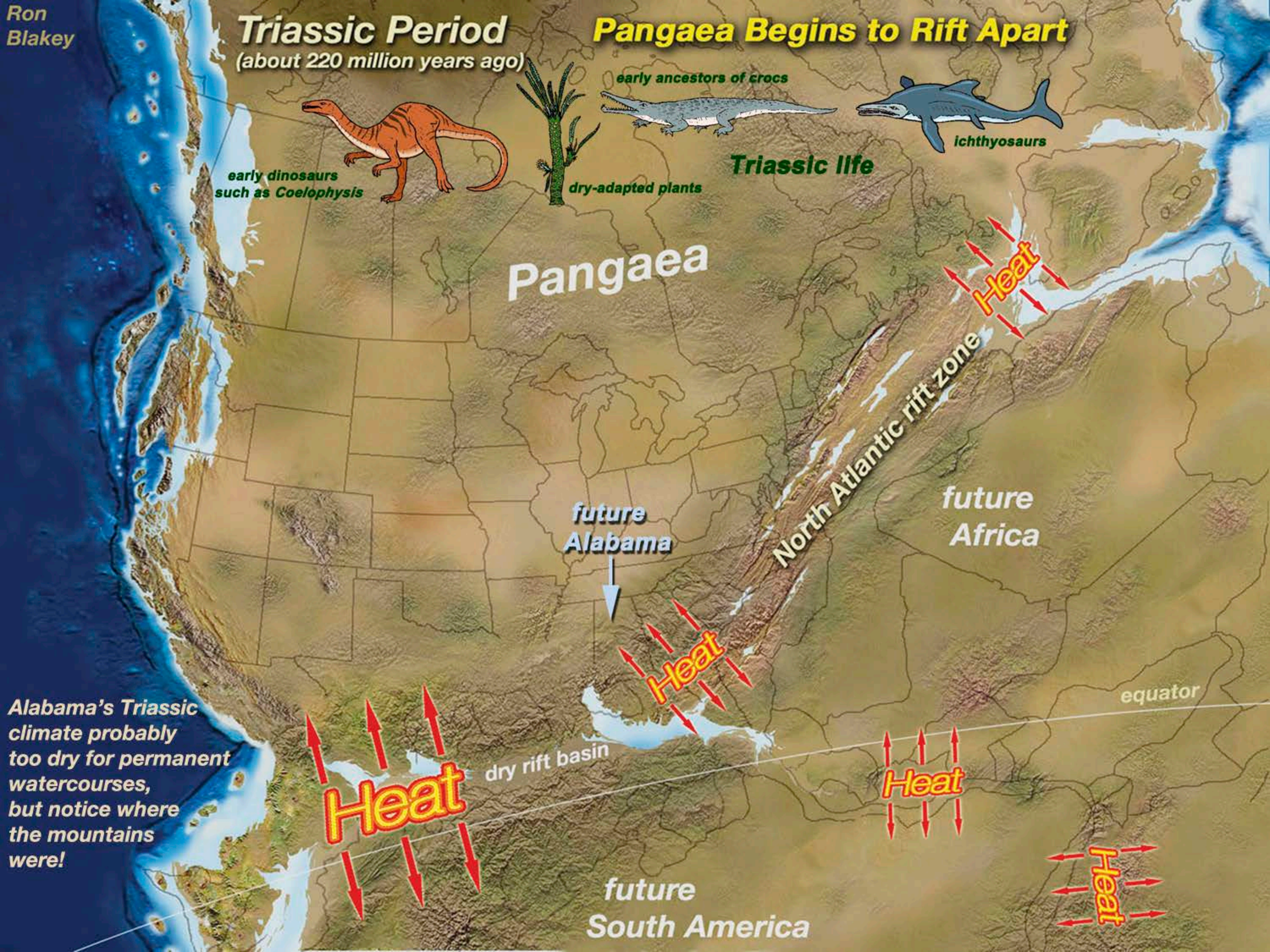
Clues to Alabama's Earliest Rivers

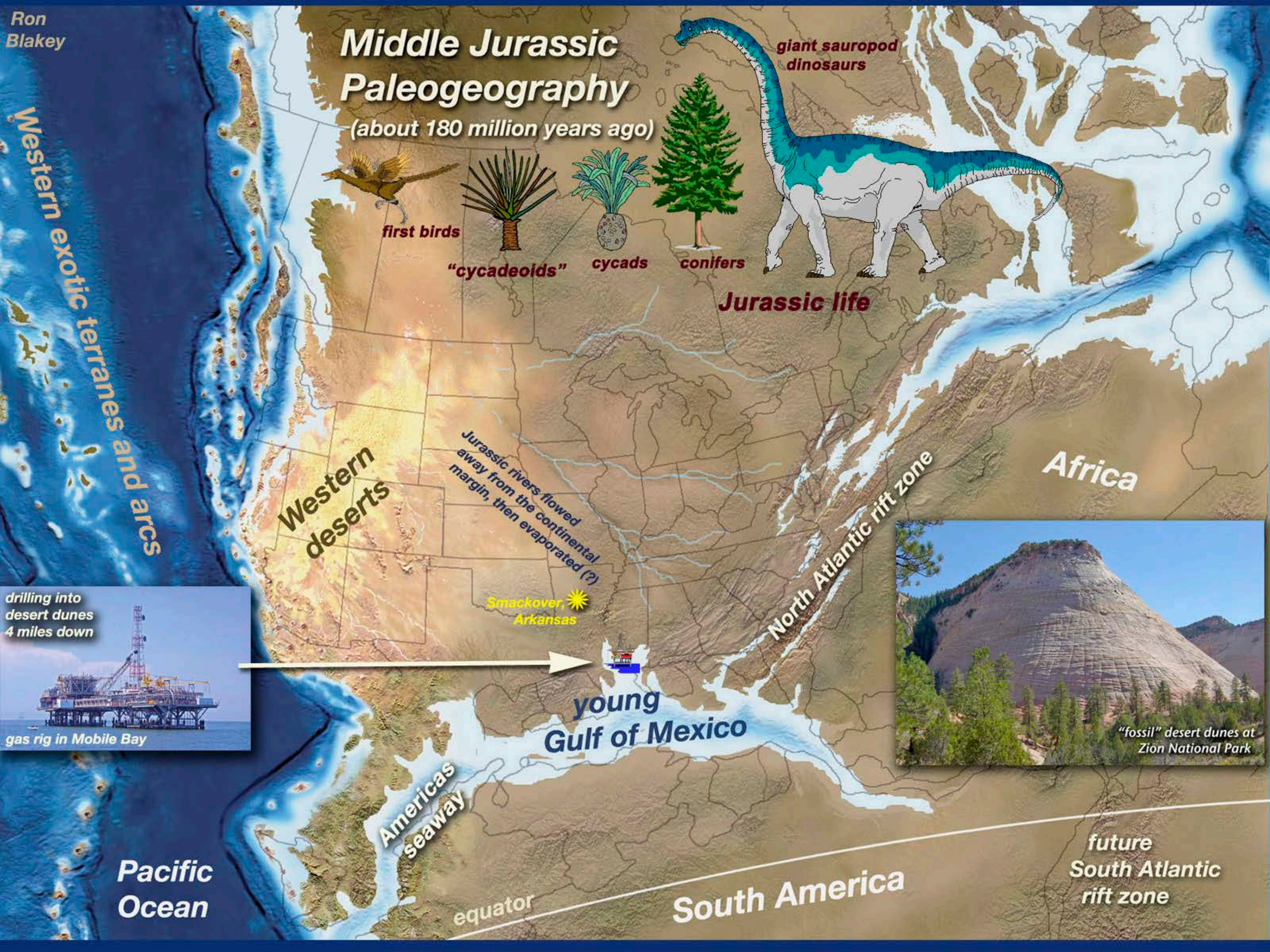
The "Coal Age" (~ 310 million years ago)

1. thrust faults show where the land was being compressed
2. mountains were being uplifted where North American continental crust was being over-run (by thrust sheets, etc.)
3. a foreland basin was formed by down-warping of the crust on the interior side of the collision zone

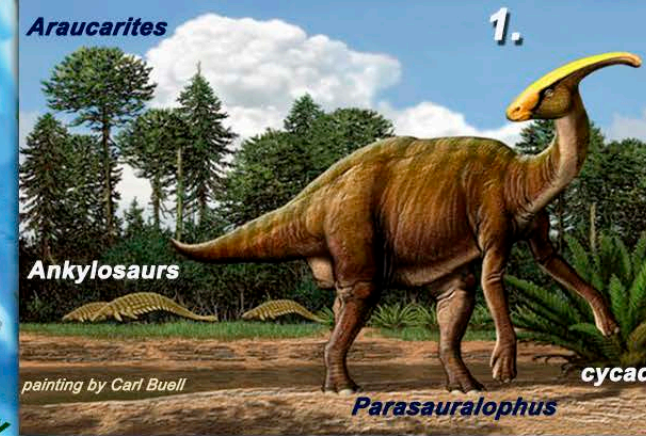
Because of the continental collision taking place along North America's southern margin streams drained differently than today.

In a very exaggerated way, here is what was going on in Alabama during the Pennsylvanian Period.......


Ron
Blakey
Triassic Period
(about 220 million years ago)
Pangaea Begins to Rift Apart
early ancestors of crocs
ichthyosaurs
Triassic life
early dinosaurs
such as Coelophysis
dry-adapted plants
Pangaea
Heat
North Atlantic rift zone
future
Africa
future
Alabama
Heat
equator
Alabama's Triassic
climate probably
too dry for permanent
watercourses,
but notice where
the mountains
were!
dry rift basin
Heat
Heat
Heat
future
South America


Ron Blakey
Middle Jurassic Paleogeography
(about 180 million years ago)
giant sauropod dinosaurs
first birds
"cycadeoids"
cycads
conifers
Jurassic life
Western exotic terranes and arcs
Western deserts
Jurassic rivers flowed away from the continental margin, then evaporated (?)
Smackover, Arkansas
North Atlantic rift zone
Africa
drilling into desert dunes 4 miles down
gas rig in Mobile Bay
young Gulf of Mexico
"fossil" desert dunes at Zion National Park
Americas seaway
Pacific Ocean
equator
South America
future South Atlantic rift zone

Late Cretaceous Paleogeography of North America
(about 75 million years ago)

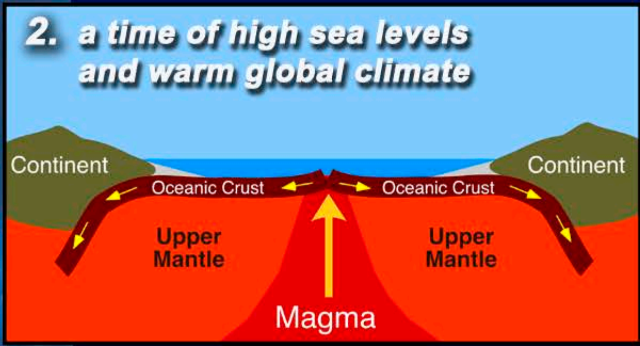


The Cretaceous Period:

A "Greenhouse World" Marked by Great Biological and Geological Revolutions

* lasted for 70 million years

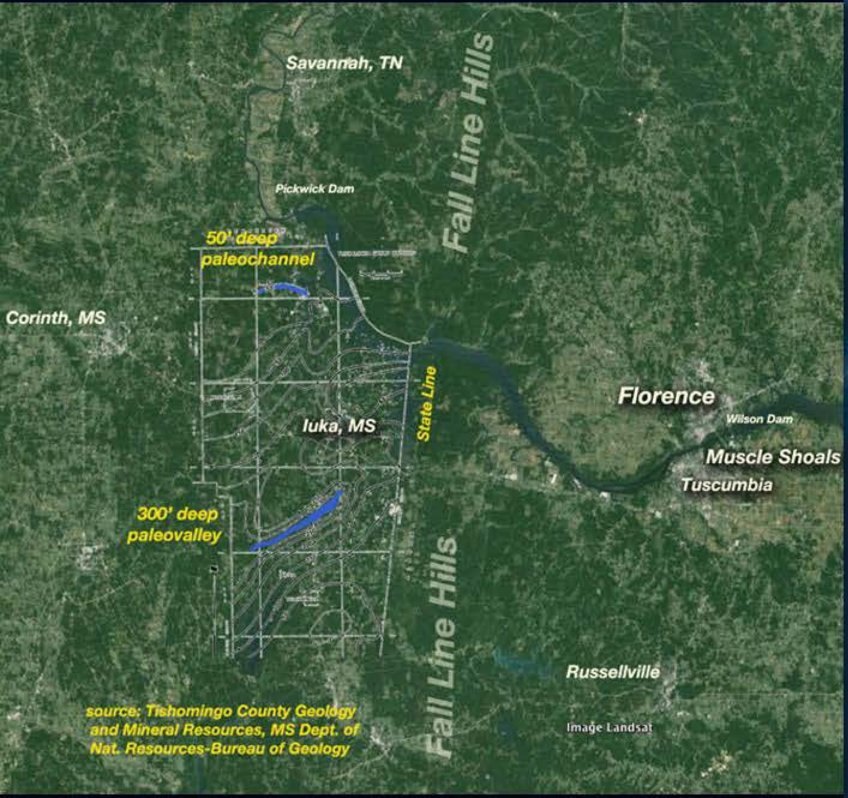
"creta-" = chalk



During the Late Cretaceous Period extremely high global sea levels brought an arm of the Gulf of Mexico known as the Mississippi embayment as far inland as today's Cairo, Illinois.

But, notice the character of the Appalachians by this point in time!!!

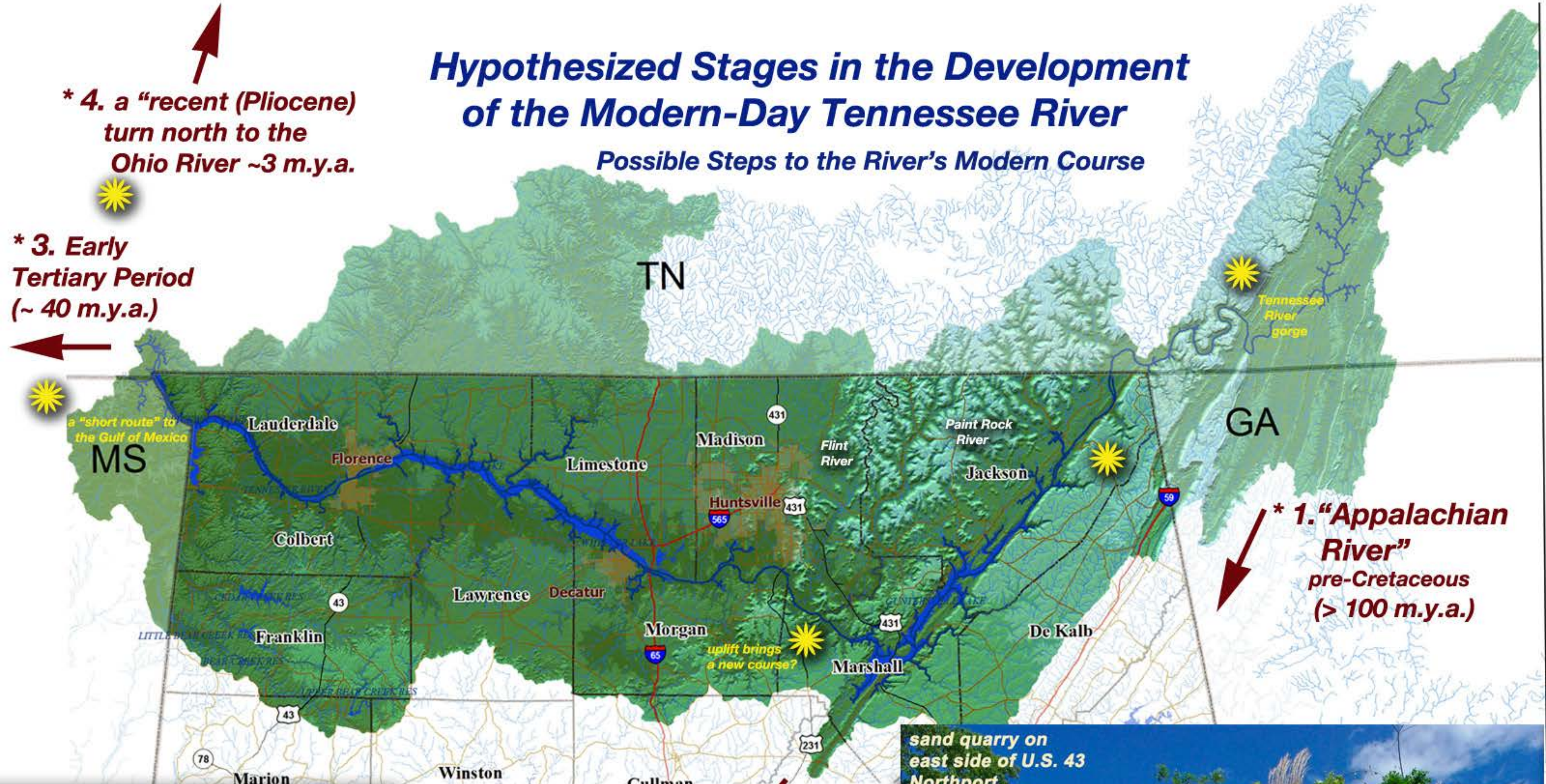
During late dinosaur times the Tennessee River may have entered the Gulf of Mexico somewhere near present-day Iuka, Mississippi.



Late Cretaceous Paleogeography of North America (about 75 million years ago)

Hypothesized Stages in the Development of the Modern-Day Tennessee River

Possible Steps to the River's Modern Course



*** 2. "Sequatchie stage"**
exact timing uncertain

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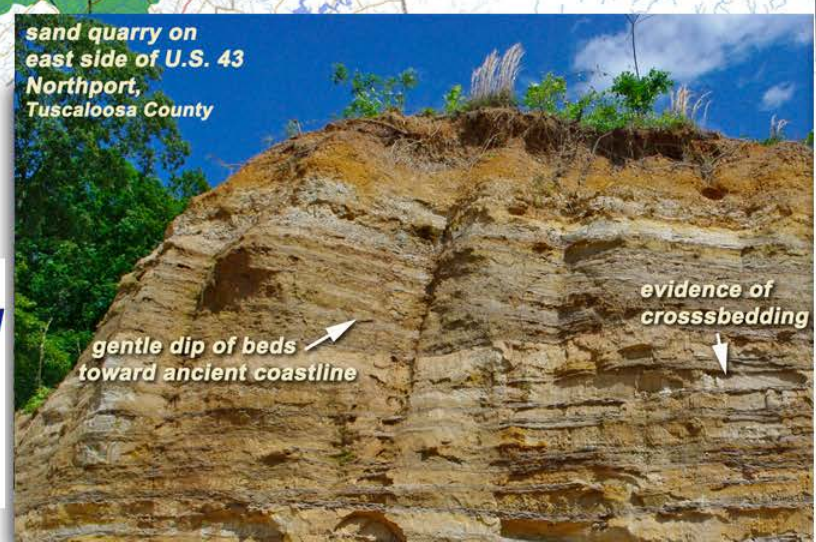
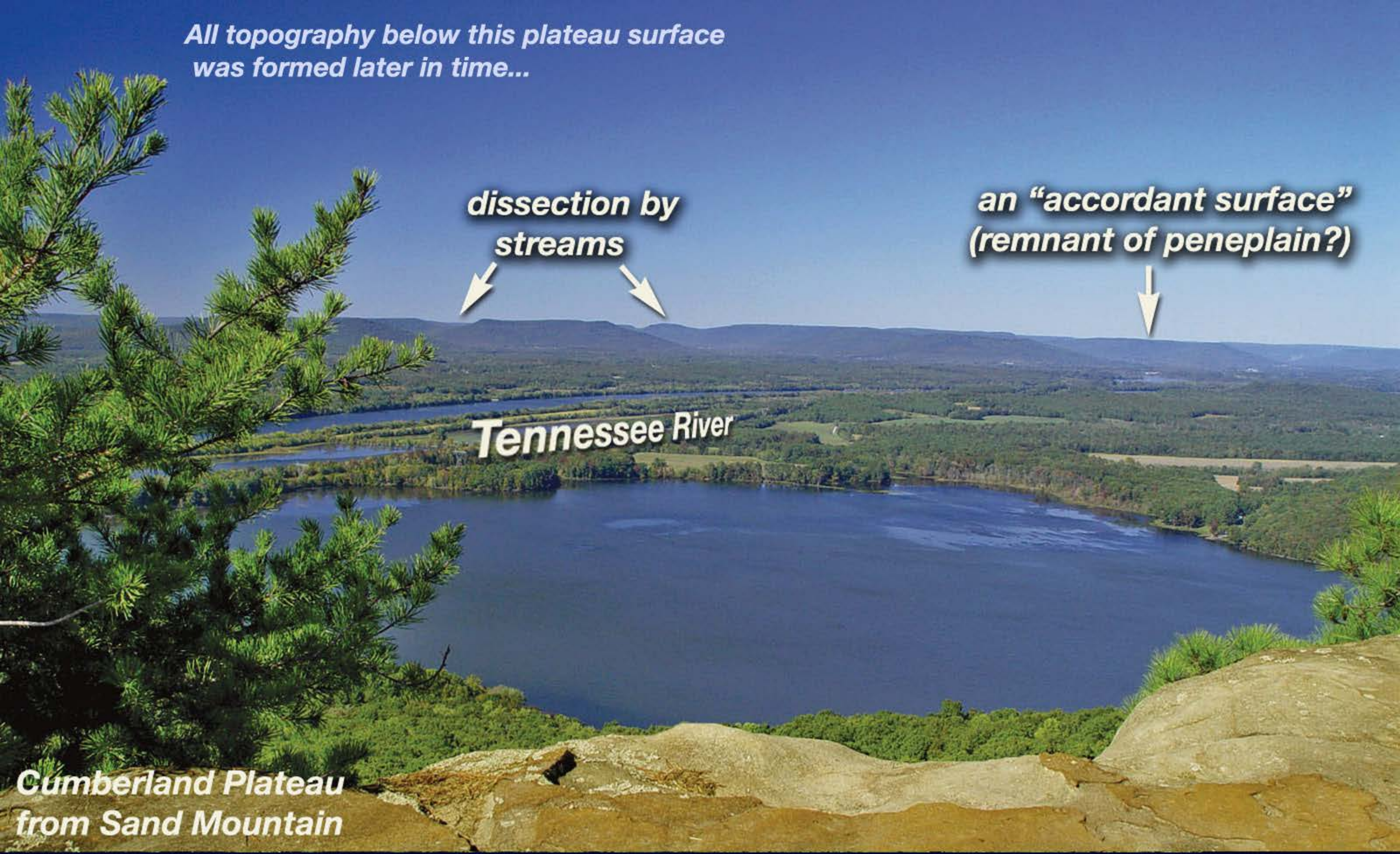
The evolution of the Tennessee River drainage is fraught with mysteries and uncertainties. Based on Appalachian pebbles geologists once thought the Black Warrior River basin may have even held its flow for a time...





There is a body of evidence that suggests that by late in the Cretaceous Period the North Alabama landscape was beveled nearly flat by erosion, but then uplifted again at a later point in time.

Geologists refer to this new episode of landscape change as a period of "neotectonic uplift," in which streams became "rejuvenated" and rapidly carved downward into the older land's surface.

"Older than the Hills" — My Plunge Into Alabama River History

In 2004 I was invited to Blount County by the "Friends of the Locust Fork" to talk about the geology of the Locust Fork River area. More and more as I studied this little river I saw classic features of a rejuvenated stream, but I had never seen anything in the scientific literature about the so-called "neotectonic uplift" as it relates to Southeastern rivers. Without the support and documentation of a scientific paper I could not use it in the second edition of my book that I was assembling at the time.

Evidence of Recent Changes in North Alabama's Landscape Recorded in the Course of Streams

As we have seen, geological history can be discovered in sources other than just rocks. The paths that streams follow can sometimes hold clues to geological changes that affected the land in the distant past. A number of streams in north Alabama contain special features that show that the landscape through which they flow has not always been in its present form. The character of these streams has changed over time as the land beneath them has undergone periods of uplift. These changes in the landscape are recorded in the course and gradient of these streams as they attempt to carve their way downward into the rocks beneath them. What might appear as mere curiosities on a map actually hold important clues to geologically recent changes that have taken place in Alabama's landscape.

One north Alabama stream that displays evidence of recent changes to the land beneath it is the Locust Fork of the Black Warrior River. The Locust Fork originates in the rolling hills of the Valley and Ridge Province northeast of Birmingham. The river begins its route by flowing northeastward near the Blount and Etowah County line. After collecting water from several tributary streams, it then turns in the opposite direction southwestward along the gently folded southern edge of the **Cumberland Plateau**. The relief map of the upper Locust Fork watershed at the top of the next page identifies several places where the river or one of its major tributaries has cut its way through a ridge of resistant rock. But how could this be possible? Since water cannot flow uphill, the only way for this to have occurred is for the stream to have already been flowing in-place before these ridges began to be uplifted.

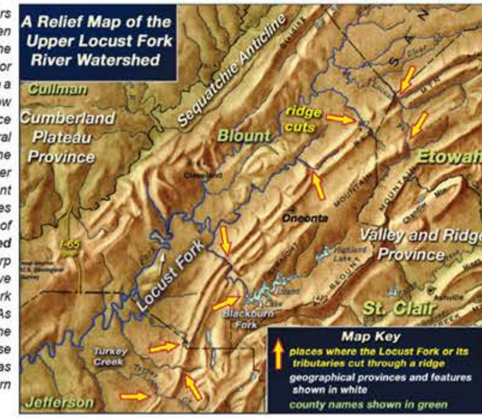
The Locust Fork *(or its ancestral stream)* must have already been flowing here when this part of the Appalachians underwent a period of uplift. This uplift of the Cumberland Plateau took place so slowly that the river was able to cut its way down through the underlying rocks. Through the process of streambed erosion, this ancient river was able to maintain its original position instead of being diverted into the valleys that formed between the newly uplifting sandstone ridges. The flow of this ancestral stream may have been toward the northwest instead of to the southwest as today.

The pre-uplift course of this ancient river may be preserved in the "fossil" meanders that the Locust Fork has today. These hairpin curves are thought to mark the position of ancient channels when the river was at "**base level**"—flowing over an almost level plain at some time before the plateau rose. As the land began to be uplifted, these bends became "**incised**," or "**entrenched**," **meanders**—they were cut downward into the underlying sandstone but still maintained their original curving shape. This uplift must have been fairly recent, geologically speaking, because the river still has a steep gradient.

The upper Locust Fork is enjoyed by many canoeists and kayakers each year for its whitewater rapids and cascading waterfalls. These features show the river is still trying to erode down the land beneath it to reach a new base level, as its ancestral stream seems to have done long ago. Boulder-strewn, whitewater rapids are signs that the Locust Fork is still a "youthful" stream, having been rejuvenated by this uplift of the land beneath it.

Like many north Alabama streams, the Locust Fork displays signs that it has been "rejuvenated" by uplift of the land beneath it. These tall bluffs suggest that the river has maintained its ancient course even as the land around it has risen hundreds of feet.

A relief map of the Locust Fork watershed offers clues to geological changes that have taken place in this part of the state through time. The yellow arrows identify spots where the river or one of its major tributaries has carved through a ridge of resistant rock. Since water cannot flow uphill, these ***ridge cuts*** *must have taken place after the river had already established its general direction of flow and as the land was in the process of undergoing uplift. The erosive power of the river allowed it to maintain its ancient course toward the northwest even though ridges were being uplifted in its path. Another sign of recent landscape change here are* ***entrenched meanders*** *in the river's course. These sharp bends and hairpin curves are believed to have formed long ago as the ancestral Locust Fork wandered across a nearly level floodplain. As the surrounding land began to be uplifted, the stream became rejuvenated. The shape of these ancient meander bends is still visible today as the stream carves slowly down into the modern landscape of the Cumberland Plateau.*



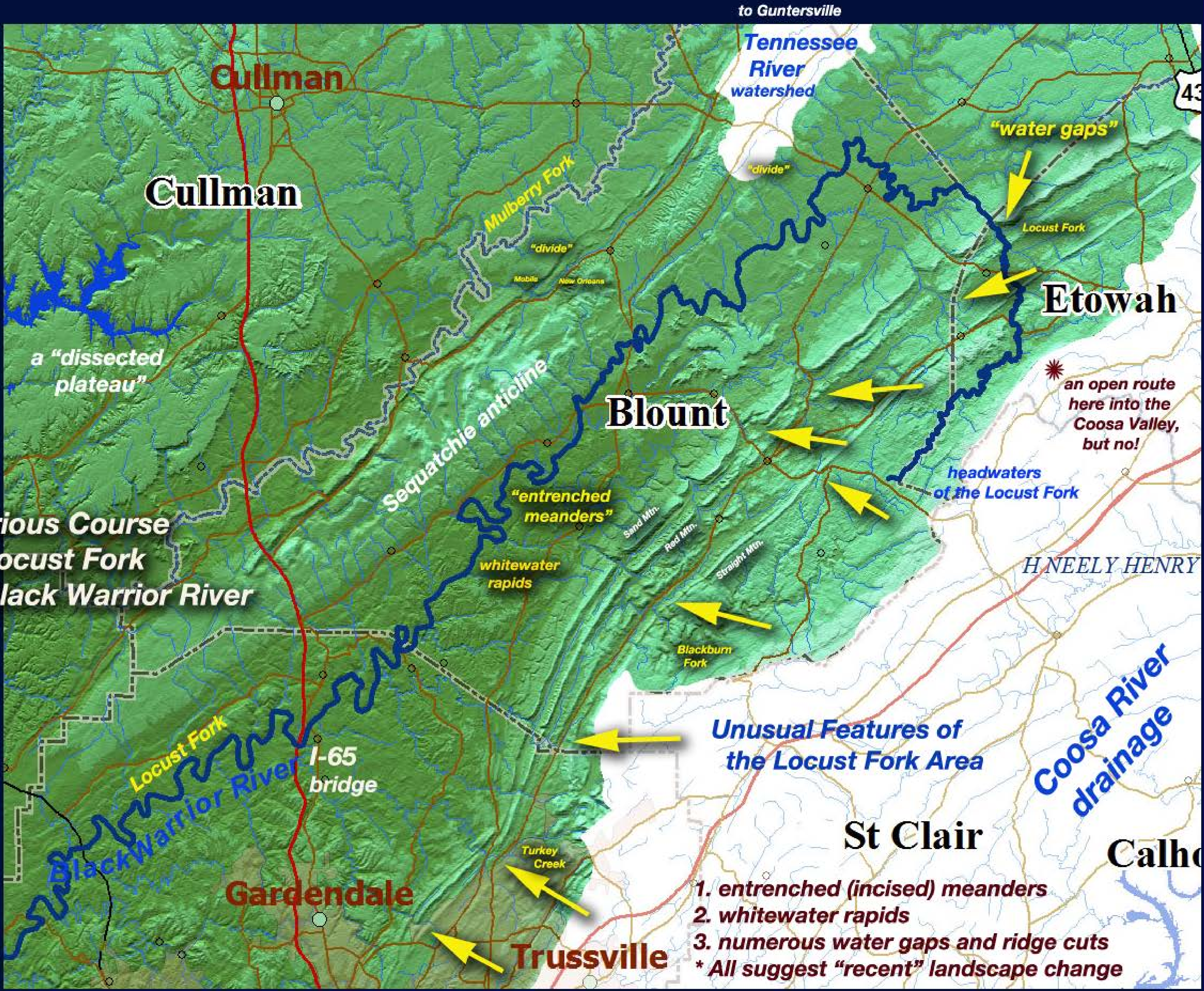
Fortunately for whitewater enthusiasts, this uplift took place so recently that the stream has not had sufficient time to flatten itself out again, as it is certain to do at some point in the future. This small river is an ancient one, and the power of its water carving into the land over time has created some fine natural scenery in this part of the state.

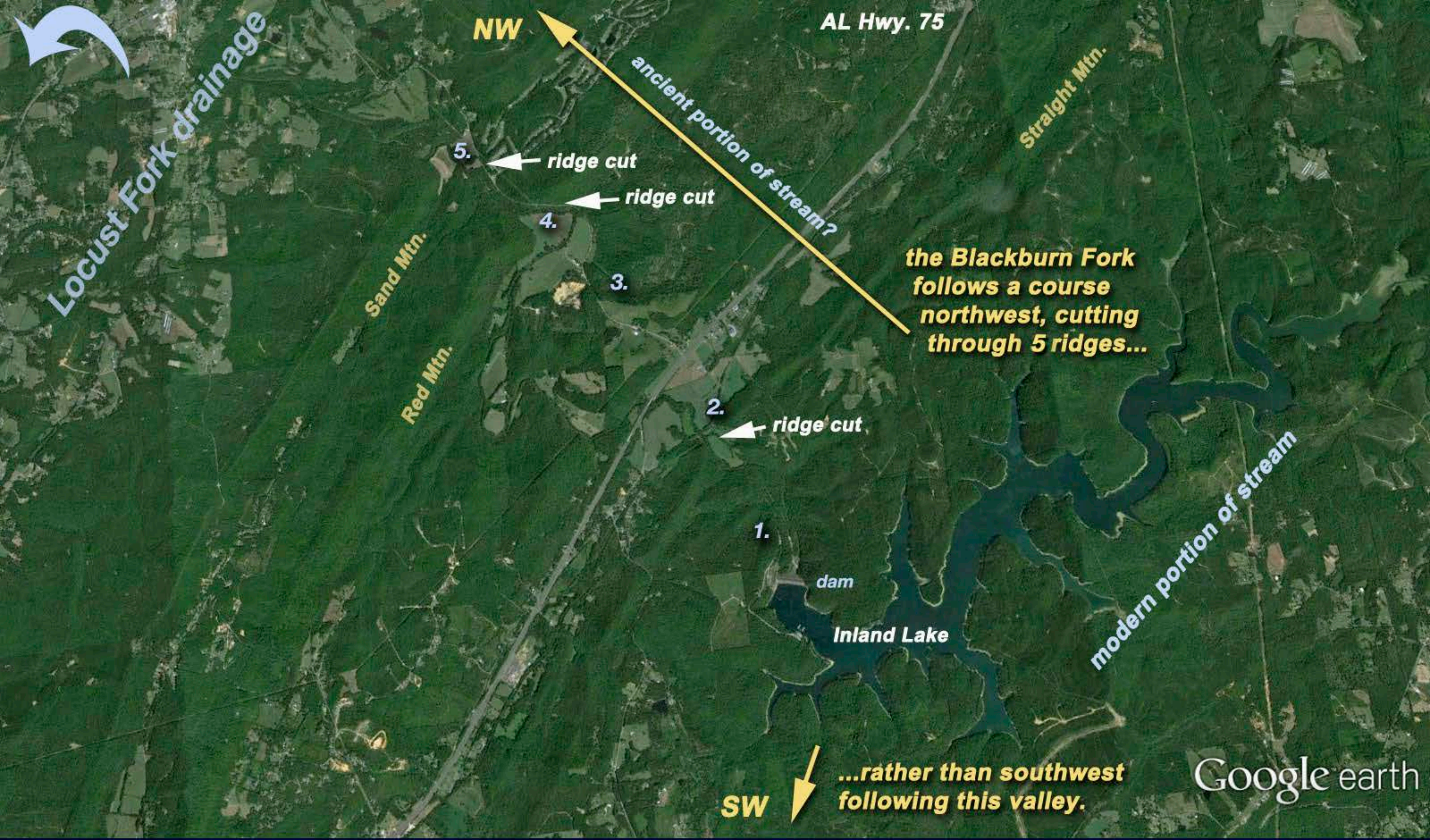
Incised streams such as the Locust Fork usually have steep banks and a narrow floodplain. During heavy rainfall, a huge volume of flood water may be funneled into the stream in a short period of time. Because of their narrow floodplains, streams such as these may undergo a rapid rise of many feet above normal flow following heavy rain. Bridges over them must be built to stand high above peak flood levels, or they would soon be destroyed by uprooted trees, boulders, and other large debris swept downstream during floods. Fortunately, the "V"-shape of youthful stream valleys permits bridges to be anchored well above the level of most flooding. Several historic covered bridges many decades old are still in use along the tributaries of the Black Warrior River. Because they stand well above the level of most floods, a few of these covered bridges have survived into the present day. Farther south in the Coastal Plain, where stream banks are lower and flooding extends across a broader area, bridges such as these would not have been practical to build and maintain.

The "youthful" character of the Locust Fork makes it a favorite of kayakers and whitewater canoeists. Where the river is still in the process of carving its way down into its resistant sandstone bedrock, there are churning rapids and tumbling cascades.

The historic covered bridges on the upper Black Warrior River were designed to stand above the extreme flooding that occurs on the youthful, incised streams of the Cumberland Plateau.

The Curious Course of the Locust Fork of the Black Warrior River





For me, one of the most intriguing features in the Locust Fork's watershed were places where the river or one of its tributaries has cut through a ridge of solid, very resistant rock.

- *Since water never flows uphill, these ridge cuts (a.k.a. "water gaps") must be places where the river flowed at some time before the land began to be uplifted. Question: But how far back in time???*
- *I was also interested in the fact that many of these ancient stream segments flowed toward the northwest.*

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THE

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THE STREAMS OF THE COASTAL PLAIN OF ALABAMA AND THE LAFAYETTE PROBLEM

GEORGE I. ADAMS
University of Alabama

diversion of existing streams to form the Alabama River

ABSTRACT

The Alabama and Tombigbee rivers, which drain most of Alabama and small portions of Georgia and Mississippi, converge at Mobile Bay. The Alabama River appears to have been formed by the diversion of streams which were formerly through-flowing. It is suggested that downwarping in southwestern Alabama caused the convergence of the drainage. The distribution of the Lafayette gravels aids in the interpretation of the history of the streams.

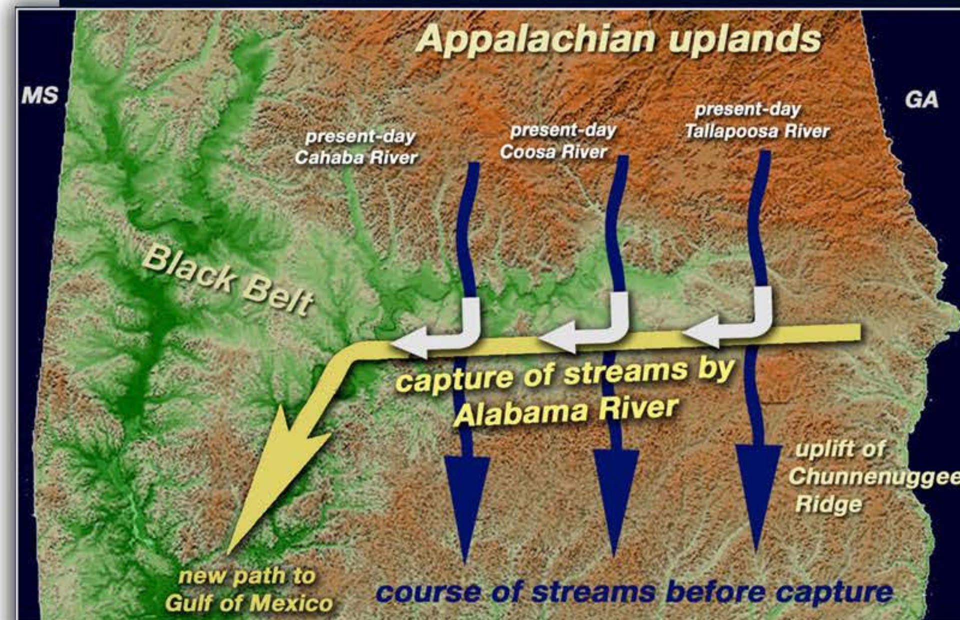
The streams of Alabama belong to two great systems: the northern border of the state is drained by the Tennessee River which, by an anomalous course, is indirectly tributary to the Mississippi through the lower part of the Ohio; to the south of this drainage area, the streams flow toward the Gulf of Mexico. The divide between the two systems is believed to have been maintained since the close of Cretaceous time (see Fig. 1).[1]

The streams which flow to the Gulf Coast have an interesting history which is here explained in accordance with the geologic development of the Coastal Plain. This involves the question of stream diversion in the formation of the Alabama River and the consideration of the "Lafayette formation" in Alabama which has been a problem of many years' standing.

When the coastal portion of Alabama emerged at the close of the Cretaceous, the streams on it presumably flowed to the Gulf of

[1] George I. Adams, "The Course of the Tennessee River and the Physiography of the Southern Appalachian Region," *Jour. of Geol.*, Vol. XXXVI (1928), pp. 481–93.

FARTHER SOUTH: A NEW RIVER FORMS BY PIRACY



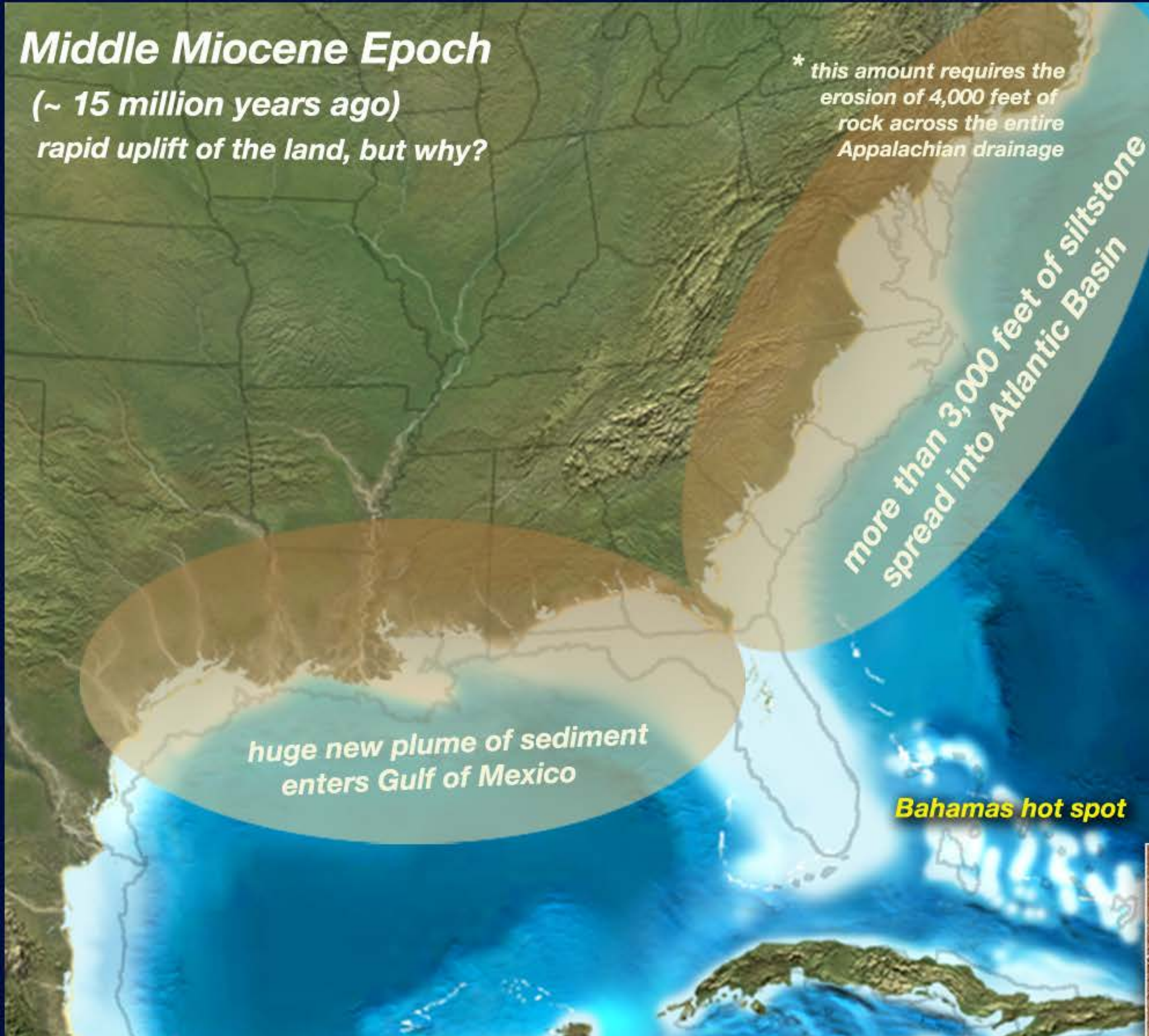
Geological uplift of the land has implications for the history of streams in the southern half of the state too.

Again, these changes appear to be much more recent than previously known.

Middle Miocene Epoch

(~ 15 million years ago)

rapid uplift of the land, but why?



Clues to this Tectonic Event in the Southeast's Sedimentary Record

A huge increase in the amount of sediment being carried to the sea by Southeastern rivers began about 15 million years ago.

Thick deposits of sand and gravel were spread across south Alabama. Once the low points of the Miocene and Pliocene landscape, they now sit at the high points of the modern one.

Where are the uplands that produced all of this South Alabama gravel today?

Some important change seemed to be taking place to the landscape, but no one could understand why.

Without a plausible theory to explain these changes the mystery was set aside for several decades.

So, after accumulating all of this evidence about recent changes to the Alabama landscape, (finally!) a paper was published that verified what I had observed in my travels.

From: ***GSA Today***, v. 23, no. 2, p. 4-10 (Feb. 2013)

Miocene rejuvenation of topographic relief in the southern Appalachians

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ABSTRACT

Conventional wisdom holds that the southern Appalachian Mountains have not experienced a significant phase of tectonic forcing for >200 myr; yet, they share many characteristics with tectonically active settings, including locally high topographic relief, steep slopes, incised river gorges, and frequent mass-wasting events. Two competing hypotheses are commonly used to explain their modern topographic expression. One suggests that relief is largely controlled by variable lithologic resistance to weathering and that their modern form has long persisted in a dynamic equilibrium. The second postulates that their relief is a product of recent rejuvenation, driven either by climate change or the epeirogenic uplift of the land surface driven by mantle forcing. Within portions of the Cullasaja River basin of the southern Appalachians, we show that relief has increased by >150% since the Miocene. Evident within the basin are a set of retreating knickpoints that delineate a rugged, actively incising landscape from lower-relief relict topography. Constraints on the timing of knickpoint entry into the basin suggest that the process of landscape rejuvenation began well prior to the late Cenozoic (<4 myr) transition to a more oscillatory (glacial-interglacial) climate regime. Furthermore, the geomorphology of the Cullasaja River basin is difficult to reconcile in the context of a transition to a more erosive climatic regime but is consistent with an epeirogenically uplifted landscape. Consequently, these observations lend new support to the idea that the rugged topography of the southern Appalachians has developed in response to post-orogenic regional uplift in the Miocene.

INTRODUCTION

Topographic relief exerts an essential control on the rates and processes involved in landscape denudation (Ahnert, 1970; Montgomery and Brandon, 2002), influencing feedbacks between

ceased shortly after Late Triassic rifting of the Atlantic margin (Hatcher, 1989).

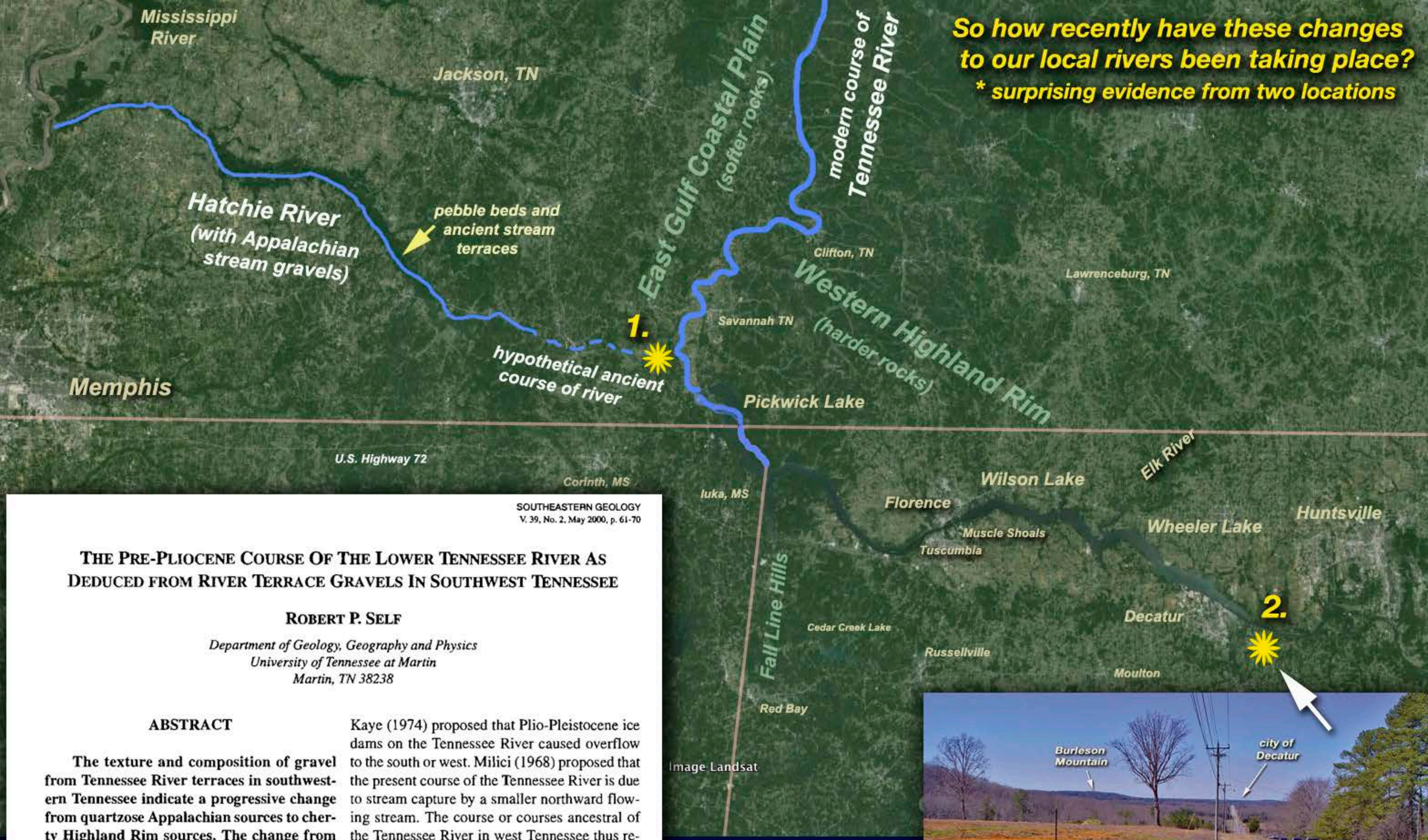
Two hypotheses have been put forth to explain the occurrence of locally high topographic relief, steep slopes, incised river gorges, and frequent mass-wasting events along the passive margin of the southern Appalachians (e.g., Gallen et al., 2011; Wooten et al., 2008). One suggests that topography has persisted though time in a dynamic equilibrium, with relief largely controlled by the variable erodibility of rock units (Hack, 1960; Matmon et al., 2003). The second posits that modern relief is a product of recent rejuvenation (Hack, 1982); however, whether the process governing this resurgence is climate change (Molnar, 2004; Hancock and Kirwan, 2007) or dynamic mantle processes forcing epeirogenic uplift (Pazzaglia and Brandon, 1996) is debated. Recent results obtained from the application of thermochronology (Boettcher and Milliken, 1994) and terrestrial cosmogenic radionuclides (CRNs; Matmon et al., 2003; Hancock and Kirwan, 2007) have not led to a consensus regarding the processes governing the evolution of relief within this landscape—a result of contrasting interpretations drawn from different datasets.

We test the competing hypotheses of dynamic equilibrium and topographic rejuvenation with a study of the geomorphology of the ~300 km^2 Cullasaja River basin of the southern Appalachian Mountains in western North Carolina (Figs. 1A and 1B). The Cullasaja is a tributary to the Little Tennessee River, its waters traveling >1500 river kilometers before discharging into the Gulf of Mexico (Fig. 1A). The timing and magnitude of changes in relief within the basin are quantified through the analysis of a 6-m horizontal resolution LiDAR elevation dataset. Results indicate that the Cullasaja basin landscape has undergone a period of rejuvenation, with relief increasing >150% since the Miocene. The timing of this rejuvenation and the geomorphic expression of the Cullasaja basin landscape, however, suggest that climate change is not the fundamental driving process (cf. Molnar, 2004). Rather, observational evidence favors a model where relief develops as the landscape is epeirogenically uplifted.

STUDY AREA

The Cullasaja River basin contains the geomorphic features

So how recently have these changes to our local rivers been taking place?
* surprising evidence from two locations



SOUTHEASTERN GEOLOGY
V. 39, No. 2, May 2000, p. 61-70

The Pre-Pliocene Course Of The Lower Tennessee River As Deduced from River Terrace Gravels In Southwest Tennessee

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ABSTRACT

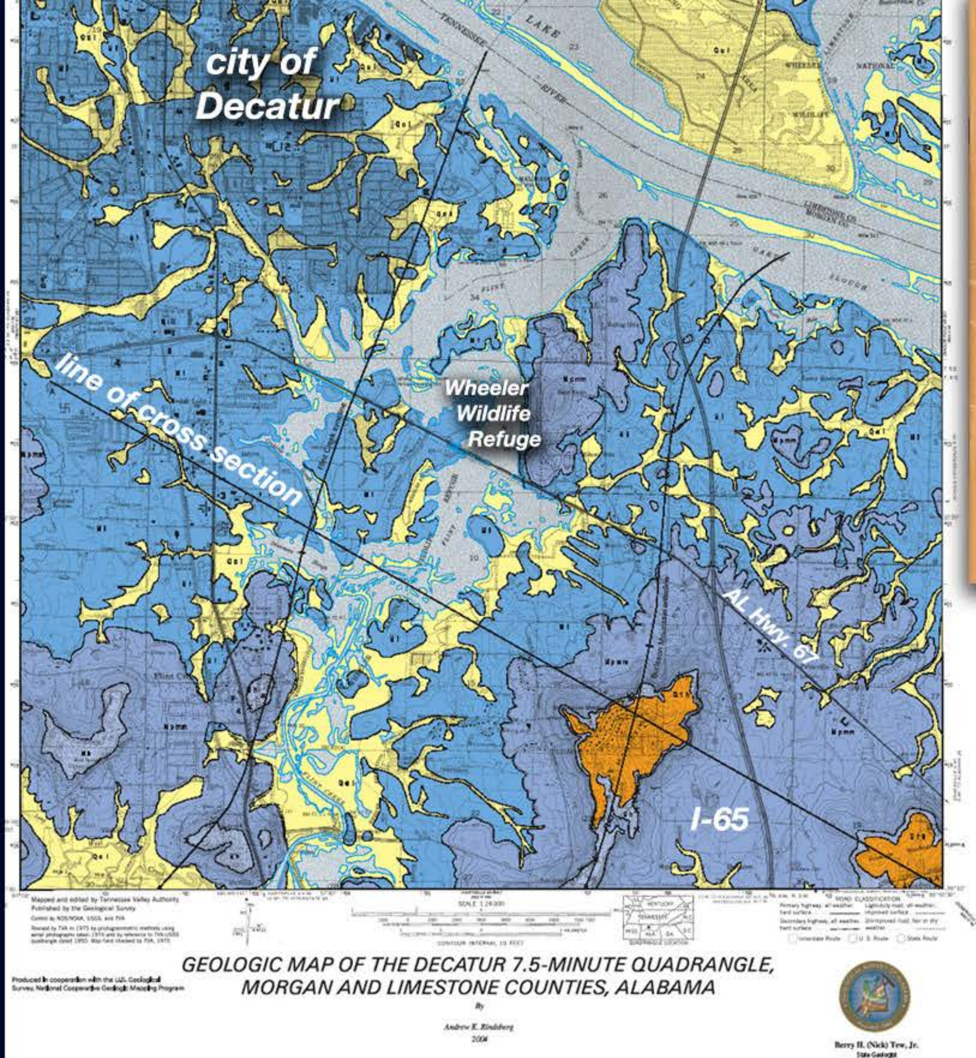
The texture and composition of gravel from Tennessee River terraces in southwestern Tennessee indicate a progressive change from quartzose Appalachian sources to cherty Highland Rim sources. The change from quartz dominated to chert dominated gravels may mark the breaching of the Ft. Payne Chert (Miss.) during the rejuvenation of the Nashville Dome (possibly 5.0 mya, late Miocene – early Pliocene). Comparison of the Tennessee terrace gravels with those of terraces and the Claiborne Formation (middle Eocene) in the Hatchie River Valley to the west suggest that an ancestral Tennessee River, with Appalachian sources flowed westward through the Hatchie River Valley prior to the breaching of the Ft. Payne Chert.

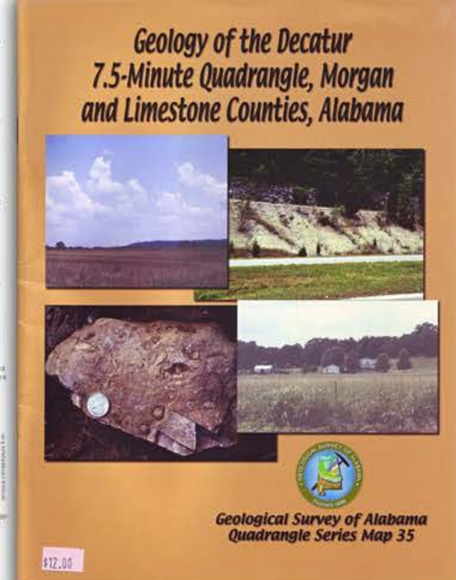
Kaye (1974) proposed that Plio-Pleistocene ice dams on the Tennessee River caused overflow to the south or west. Milici (1968) proposed that the present course of the Tennessee River is due to stream capture by a smaller northward flowing stream. The course or courses ancestral of the Tennessee River in west Tennessee thus remains uncertain.

A series of graveliferous fluvial terraces associated with the Tennessee River are exposed in southwest Tennessee, just north of the bend at Pickwick (Figure 1). These terraces are mapped as Qfl (fluvial deposits) on quadrangle and state maps (Russell, 1964, 1967, 1968, Russell and others, 1970, 1971 1972; Wilson, and others, 1982; and Miller, and others) and are discussed by Russell and Parks, (1975) and Russell (1979). The Terraces are strategically located relative to proposed course changes in the an-

One set of terrace deposits of the Tennessee River sit > 325 feet above the modern level of the river.....

....and this has important implications—the face of the land is much younger than once thought.

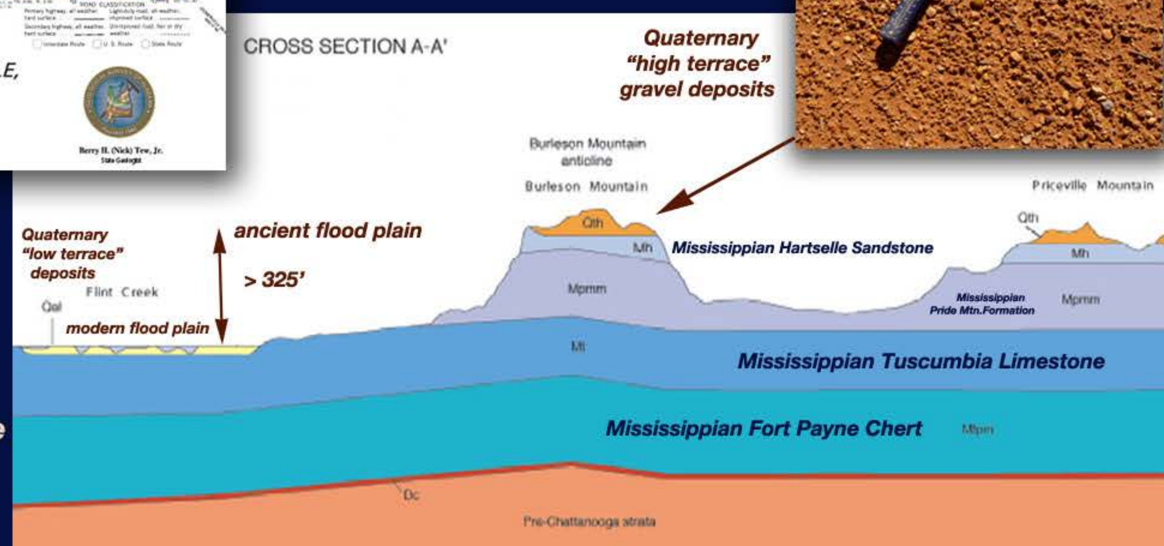




The Discovery of a Surprising Chapter of the Tennessee Valley's More Recent History

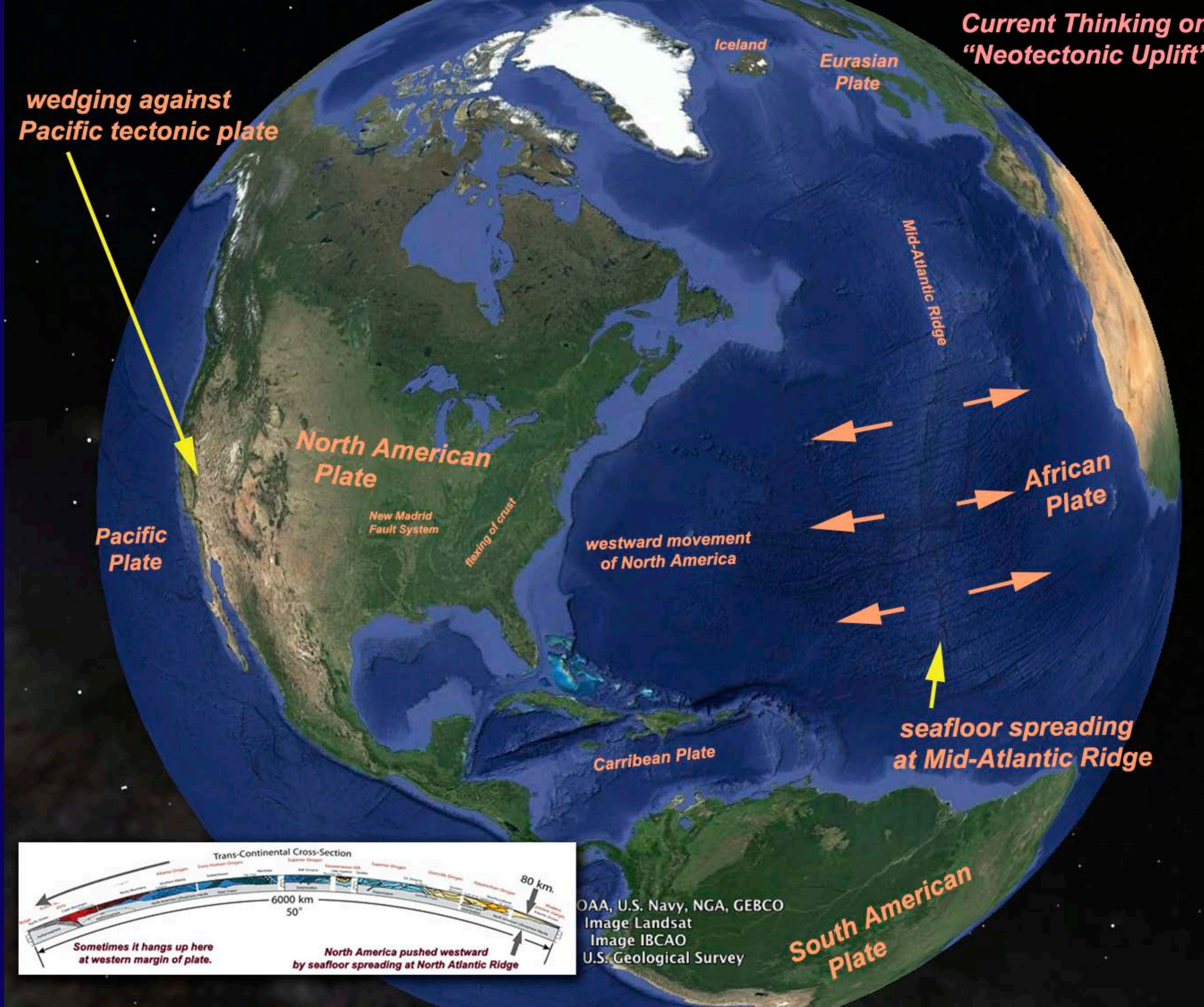
Some recent chapters of the river's history were discovered unexpectedly during a 2004 mapping project conducted by geologists from the Geological Survey of Alabama.

These orange-colored sand and gravel beds are the barest remnants of a "lost landscape" of Late Pliocene age in the Tennessee Valley.

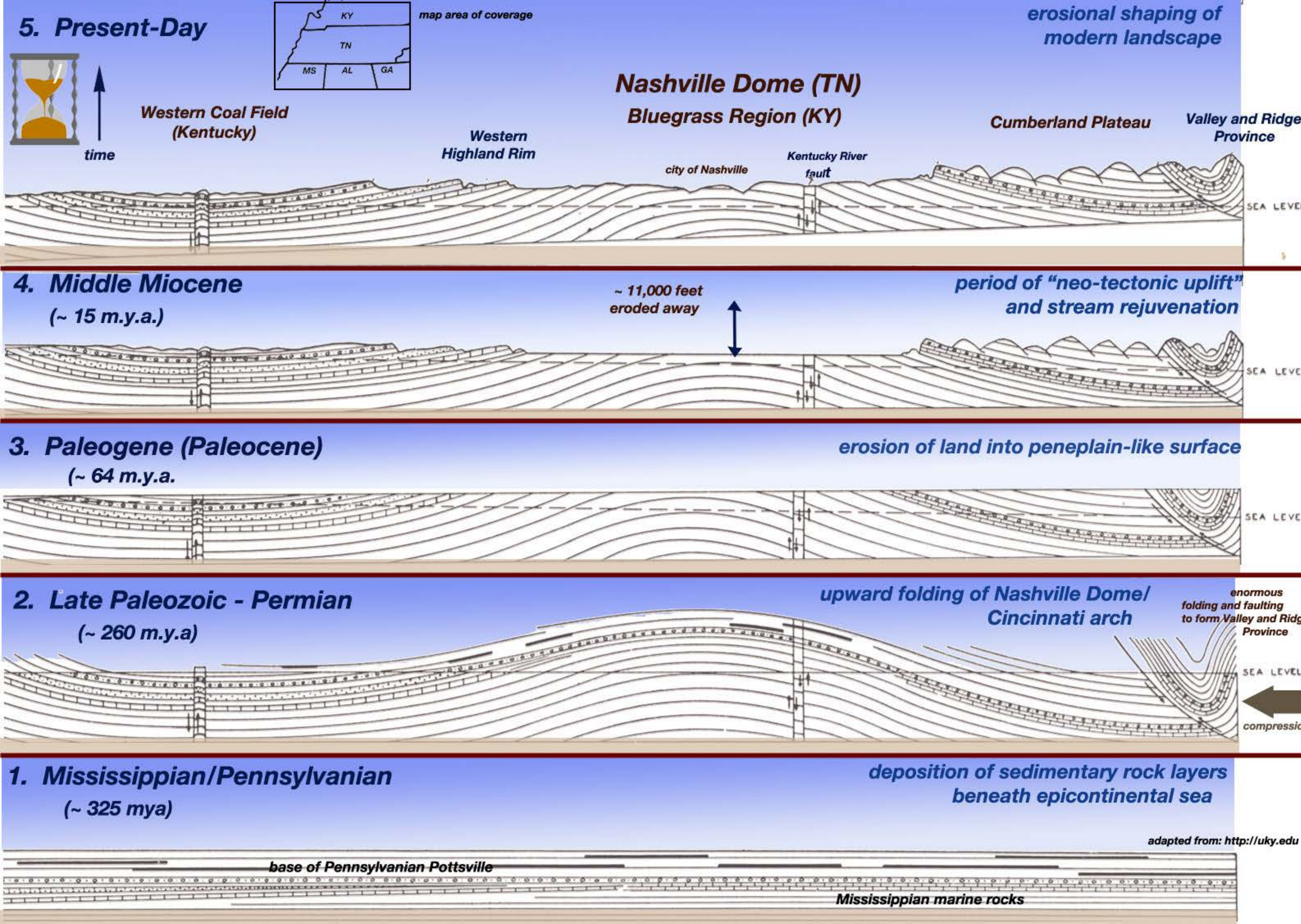


This geological mapping uncovered evidence of just how dramatically the Tennessee Valley has been re-sculpted in just the last ~ 3 million years.

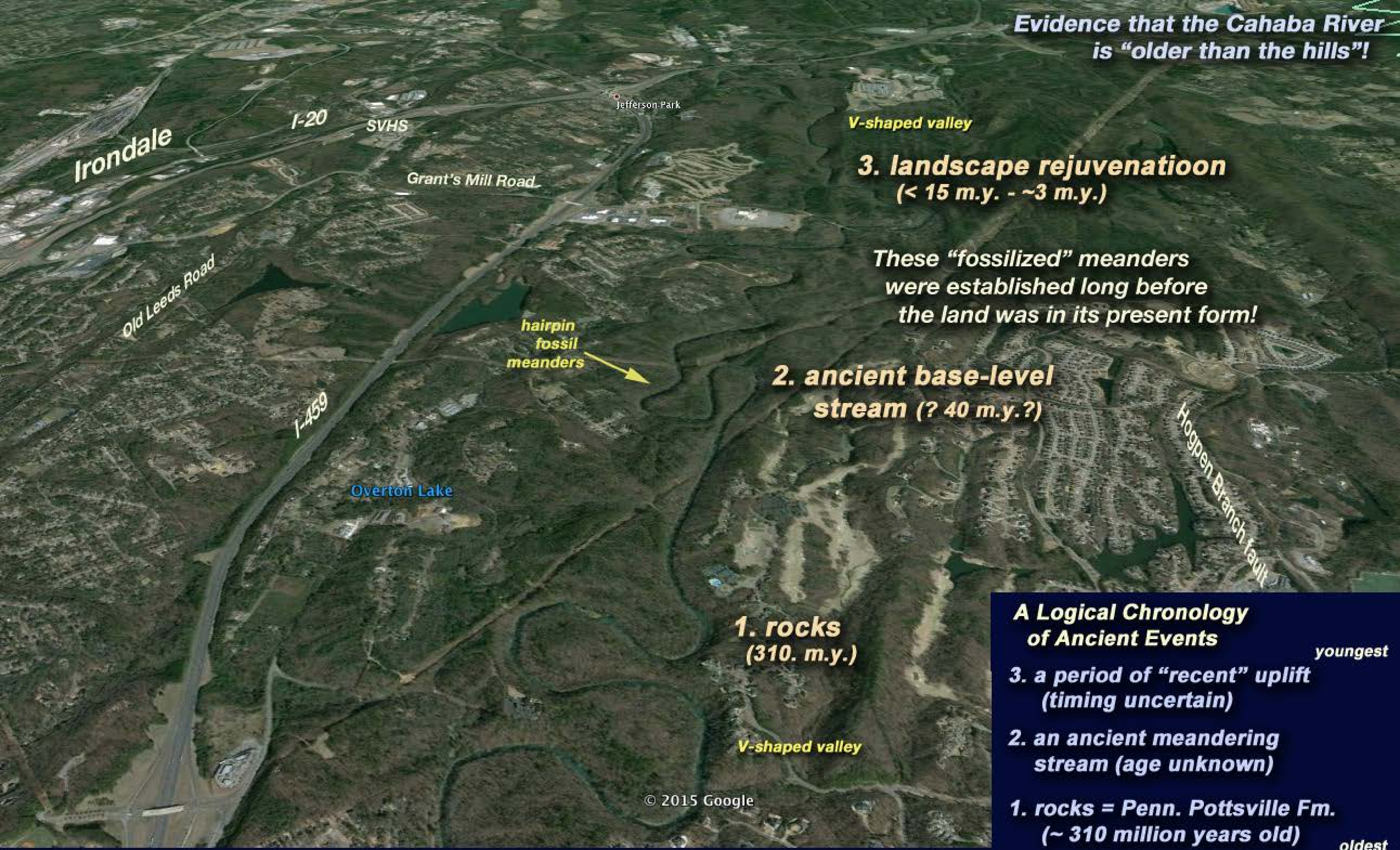
If the age-dates on these high terrace deposits holds up (confidence is high!) these gravel beds show downcutting by the river has transformed the face of the land in a geologically brief period of time... but how could this happen?



Current Thinking on "Neotectonic Uplift"
wedging against Pacific tectonic plate
Iceland
Eurasian Plate
Mid-Atlantic Ridge
North American Plate
New Madrid Fault System
flexing of crust
Pacific Plate
westward movement of North America
African Plate
seafloor spreading at Mid-Atlantic Ridge
Carribean Plate
South American Plate
Trans-Continental Cross-Section
80 km.
6000 km
50°
Sometimes it hangs up here at western margin of plate.
North America pushed westward by seafloor spreading at North Atlantic Ridge
OAA, U.S. Navy, NGA, GEBCO
Image Landsat
Image IBCAO
U.S. Geological Survey



A peek at a work in progress: A cross-section view through time looking north into the Nashville Dome.



A Logical Chronology of Ancient Events

youngest

3. a period of "recent" uplift (timing uncertain)
2. an ancient meandering stream (age unknown)
1. rocks = Penn. Pottsville Fm. (~ 310 million years old)

oldest

* Deciphering stream features can reveal "lost chapters" of an area's geological history!

These anomalous features in the course of the Cahaba River hint at a very different Alabama landscape that existed here at some point far in the past. But how long ago, and what could have caused this land to undergo such a profound change???

This portion of the upper Cahaba Valley contains classic features of a rejuvenated stream

Conclusion: *Let's return to that question about why north Alabama is a "hotspot" of aquatic biodiversity and how this richness is connected to geologic history...*

The Paint Rock River example:

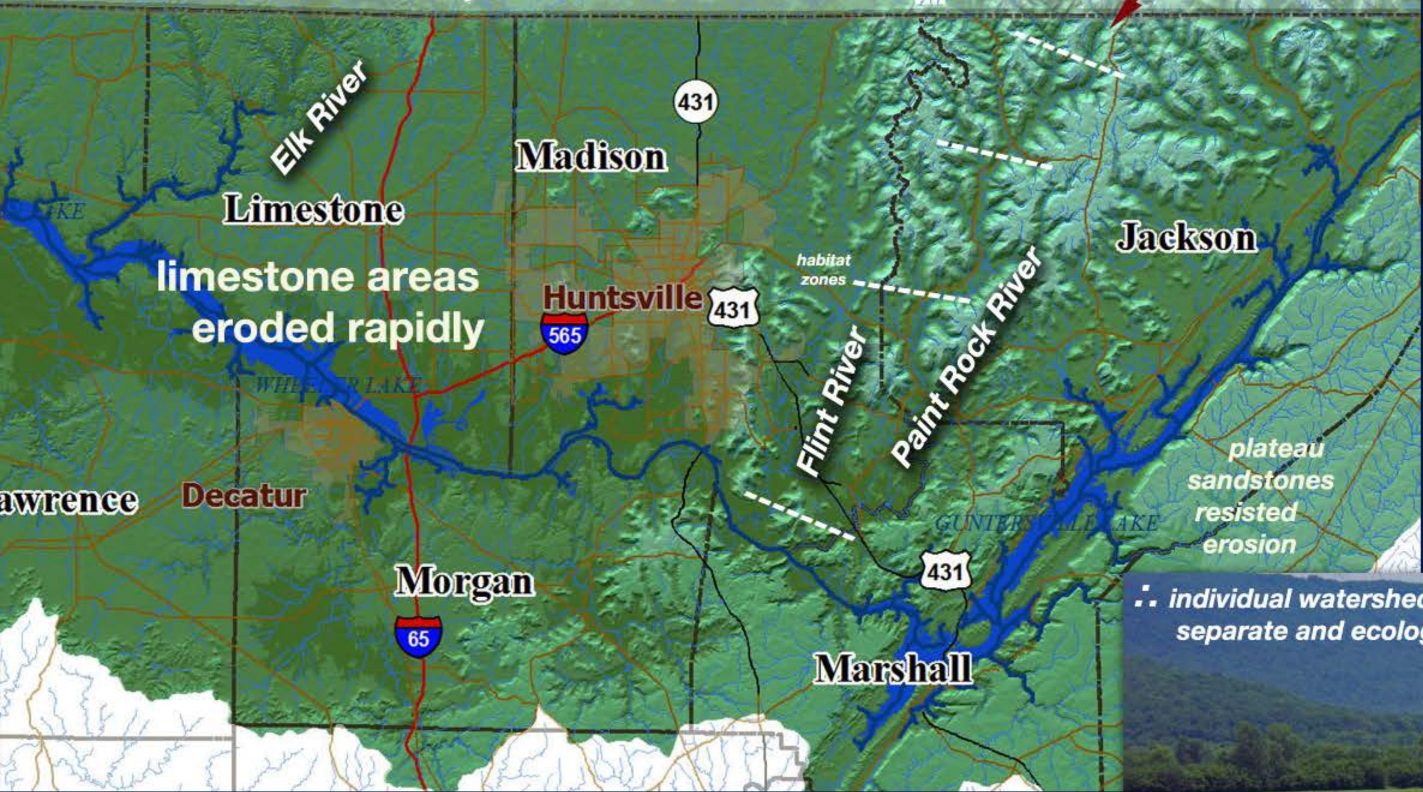
The Key: Youthful streams promote biodiversity.

1. *Maintaining habitat diversity* = Lots of opportunity for life to gain and then maintain a foothold...

2. *Promoting evolution through allopatric speciation* isolated populations = genetic drift = new species (the Galapagos Islands example)

The Importance of Ecological Barriers

keys to rich aquatic biodiversity: "partitioning" of streams, isolated headwaters, and habitat stability over time



∴ individual watersheds continue to remain physically separate and ecologically isolated

Understanding "Hotspots" of Aquatic Biodiversity: The Role of Geology

The recently discovered "neotectonic uplift" has maintained physical as well as ecological barriers that preserve and promote aquatic diversity.