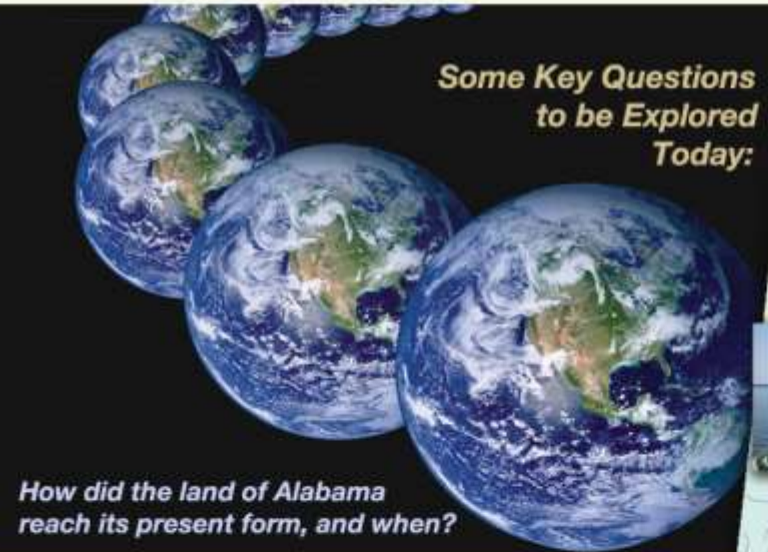
Unlocking the Geological History of Alabama Rivers:

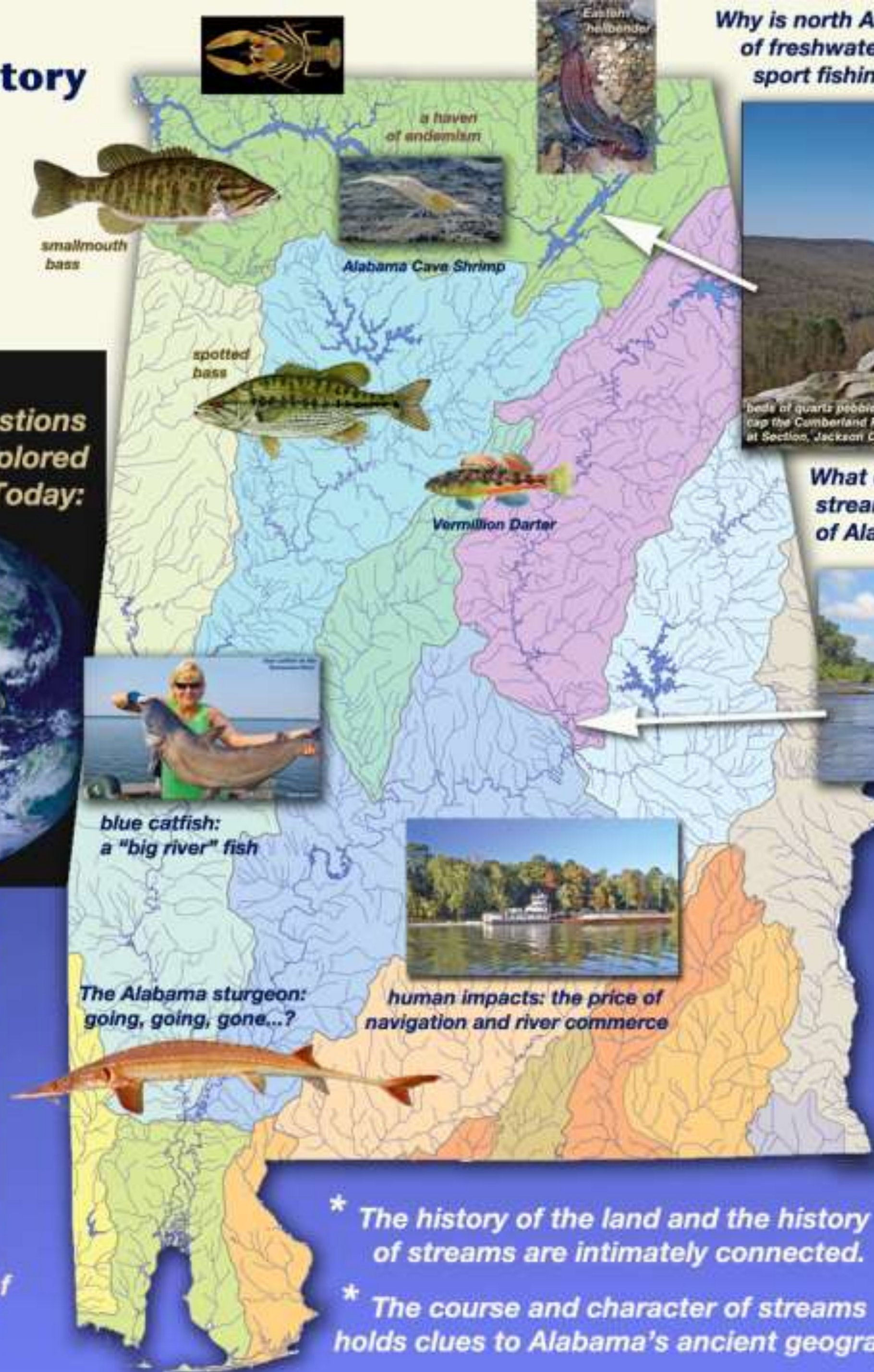
Probing the Ancient Origins of the State's Aquatic Biodiversity

Jim Lacefield



Some Key Questions to be Explored Today:

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



Why is north Alabama such a "hot spot" of freshwater biodiversity (and great sport fishing)?

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

What do rocks and the course of streams say about the evolution of Alabama's landscape?

What is the Fall Line, and why is it such a significant feature, both geologically and geographically?

conducting a survey of aquatic life on Shades Creek Jefferson County

Today's Major Focus: Alabama's Diversity of Freshwater Life is Tied to the Land's Long and Dynamic Geological History

- *The history of the land and the history of streams are intimately connected.*
- *The course and character of streams holds clues to Alabama's ancient geography.*

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

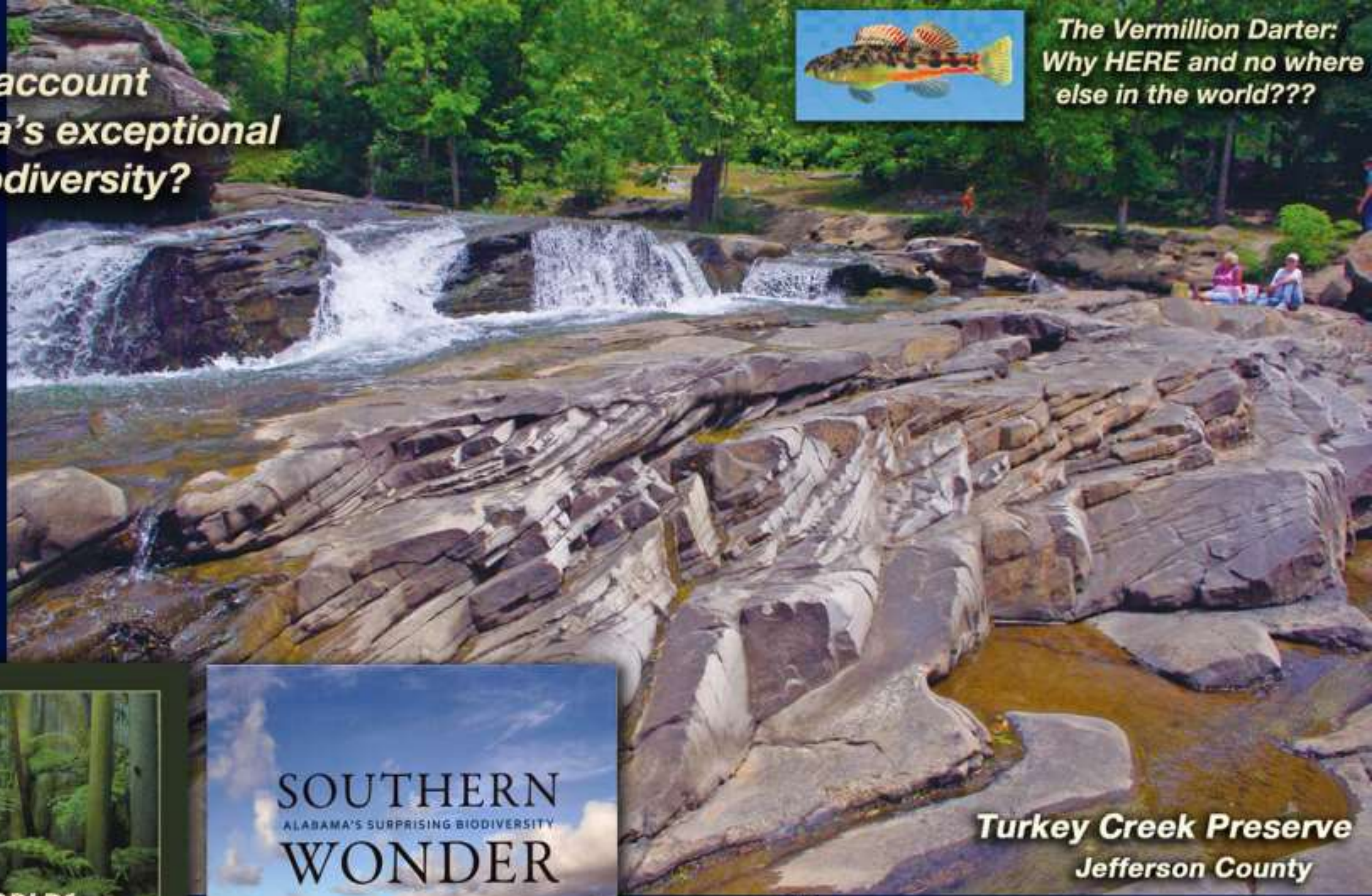
1st in crayfish @ 85 species

1st in turtles @ 27 species


A Comparison of Native Fish Diversity by Watershed Size
Columbia River watershed
33 native fish species
Columbia River
Colorado River
Colorado River watershed
25 native fish species
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
Mackenzie River
Fraser River
Pacific Ocean Seaboard
Hudson Bay Seaboard
Atlantic Ocean Seaboard
Columbia River
Great Basin
Mississippi River
St. Lawrence River
Ohio River
Arkansas River
Gulf of Mexico Seaboard
Rio Grande
El Salado
Caribbean Sea Seaboard
BRITISH COLUMBIA
MONTANA
OREGON
IDAHO
NEVADA
UTAH
WYOMING
COLORADO
NEW MEXICO
CALIFORNIA
ARIZONA

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

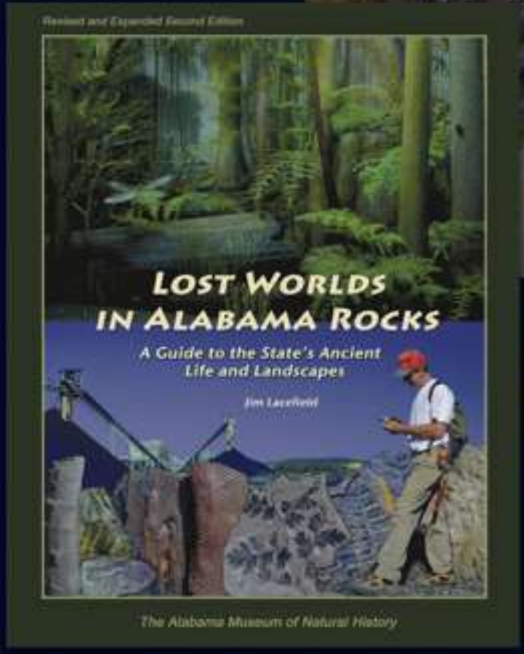
The Vermillion Darter: Why HERE and no where else in the world???

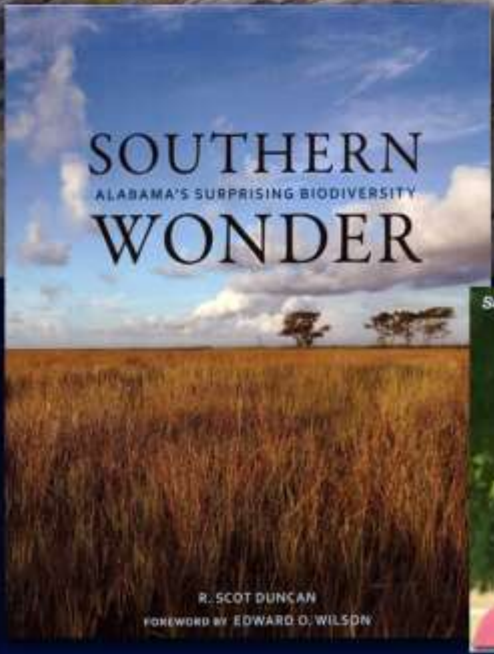


1.

Well, there are "historical" factors...

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





2. ...and there are ecological factors.

(adaptation, competition, etc.)

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

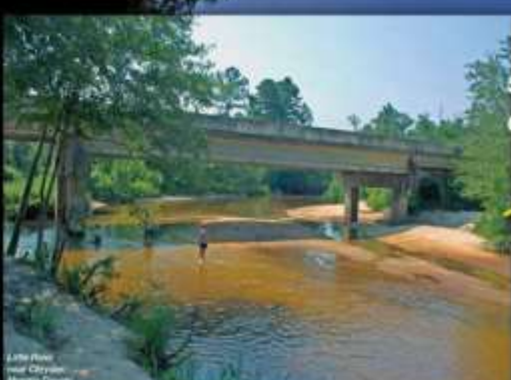

The basic ecological concept is simple:
A heterogeneous environment offers
many more opportunities for life
to gain a foothold (i.e. more niches).
Alabama's richness in aquatic life is
a direct product of its geological diversity.

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

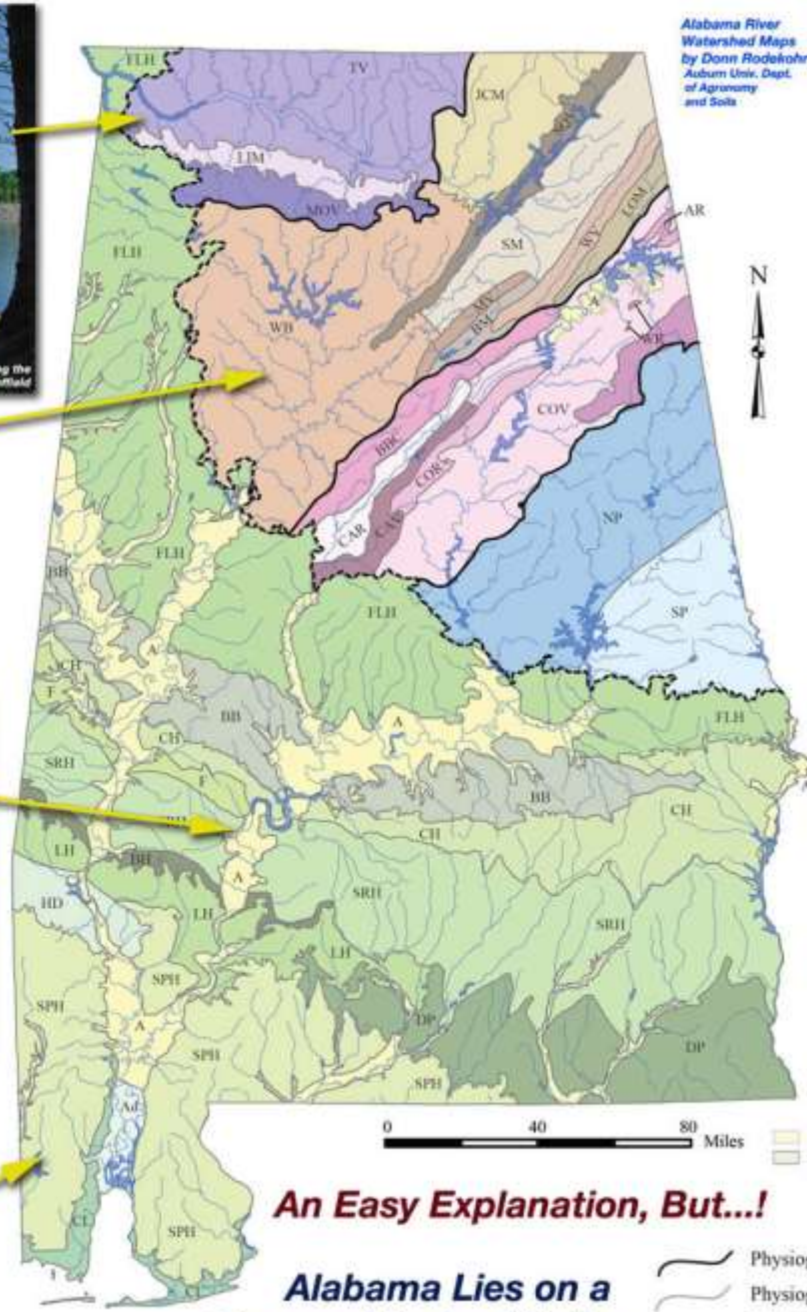
limestone valleys

hard rock uplands

large, meandering Coastal Plain rivers



sandy creeks



Highland Rim (HR)
- Tennessee Valley (TV)
- Little Mountain (LIM)
- Moulton Valley (MOV)

Cumberland Plateau (CP)
- Jackson County Mountains (JCM)
- Sequatchie Valley (SQV)
- Sand Mountain (SM)
- Wills Valley (WV)
- Lookout Mountain (LOM)
- Warrior Basin (WB)
- Murphrees Valley (MV)
- Blount Mountain (BM)

Alabama Valley and Ridge (AVR)
- Armuchee Ridges (AR)
- Birmingham-Big Canoe Valley (BBC)
- Cahaba Ridges (CAR)
- Cahaba Valley (CAV)
- Coosa Ridges (COR)
- Coosa Valley (COV)
- Weisner Ridges (WR)

Piedmont Upland (PU)
- Northern Piedmont Upland (NP)
- Southern Piedmont Upland (SP)

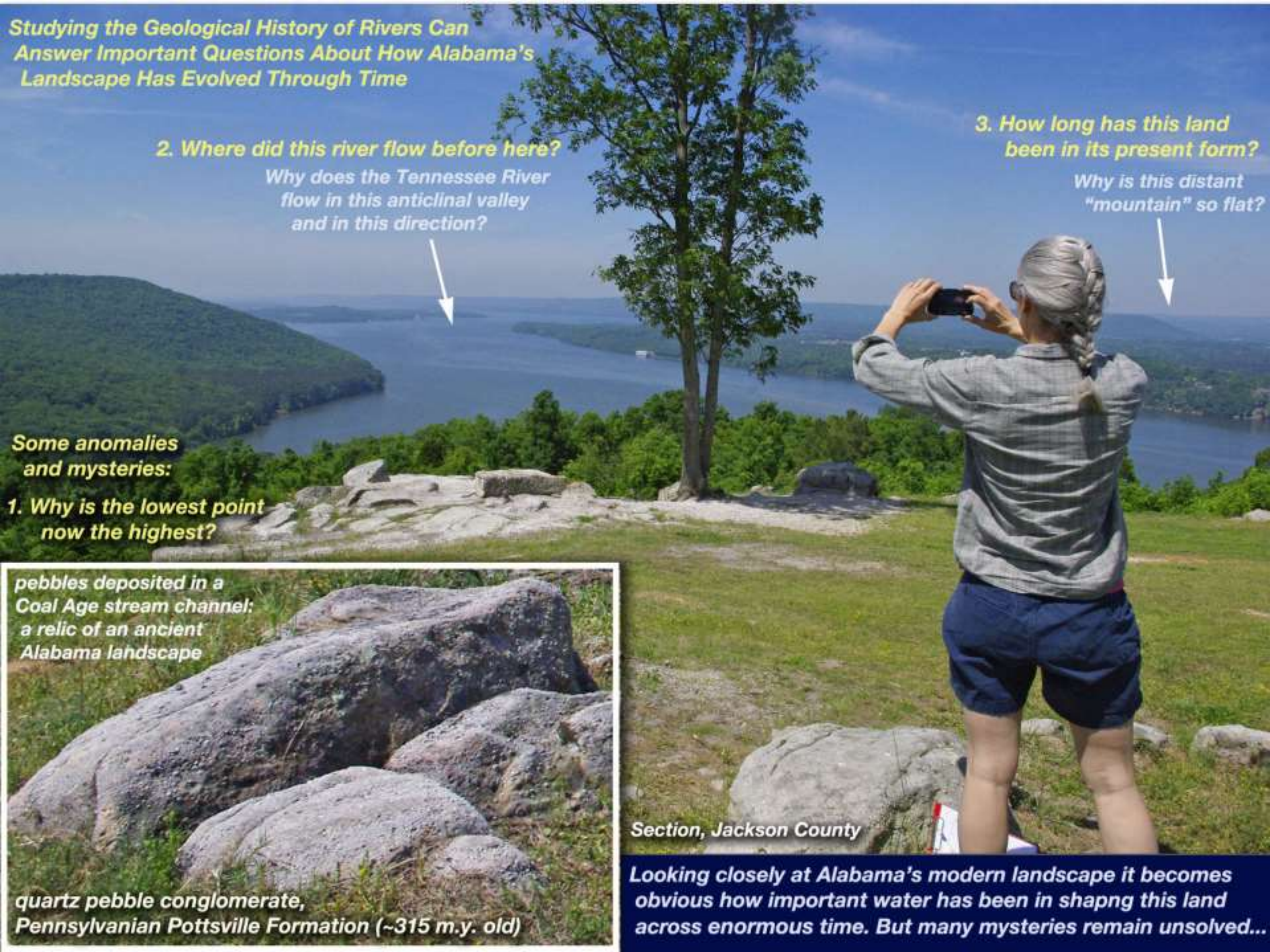
East Gulf Coastal Plain (EGCP)
- Fall Line Hills (FLH)
- Black Belt (BB)
- Chunnenuggee Hills (CH)
- Southern Red Hills (SRH)
  - Flatwoods Subdistrict (F)
  - Buhrstone Hills Subdistrict (BH)
- Lime Hills (LH)
  - Hatchetigbee Dome Subdistrict (HD)
- Southern Pine Hills (SPH)
- Dougherty Plain (DP)
- Coastal Lowlands (CL)

- Alluvial (A)
- Alluvial deltaic Plain (A

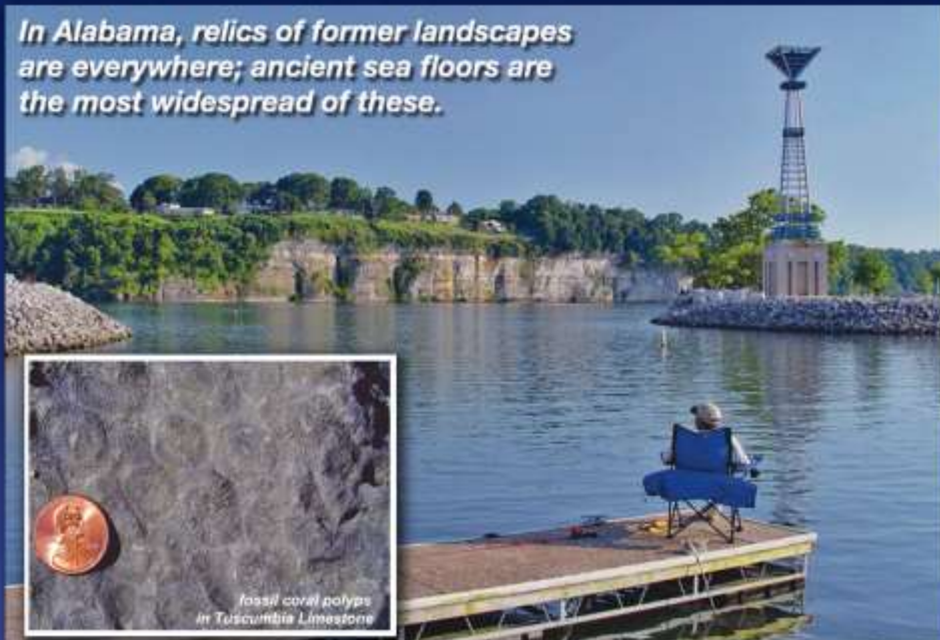
- Physiographic section line
- Physiographic district line
- Fall Line
- Streams

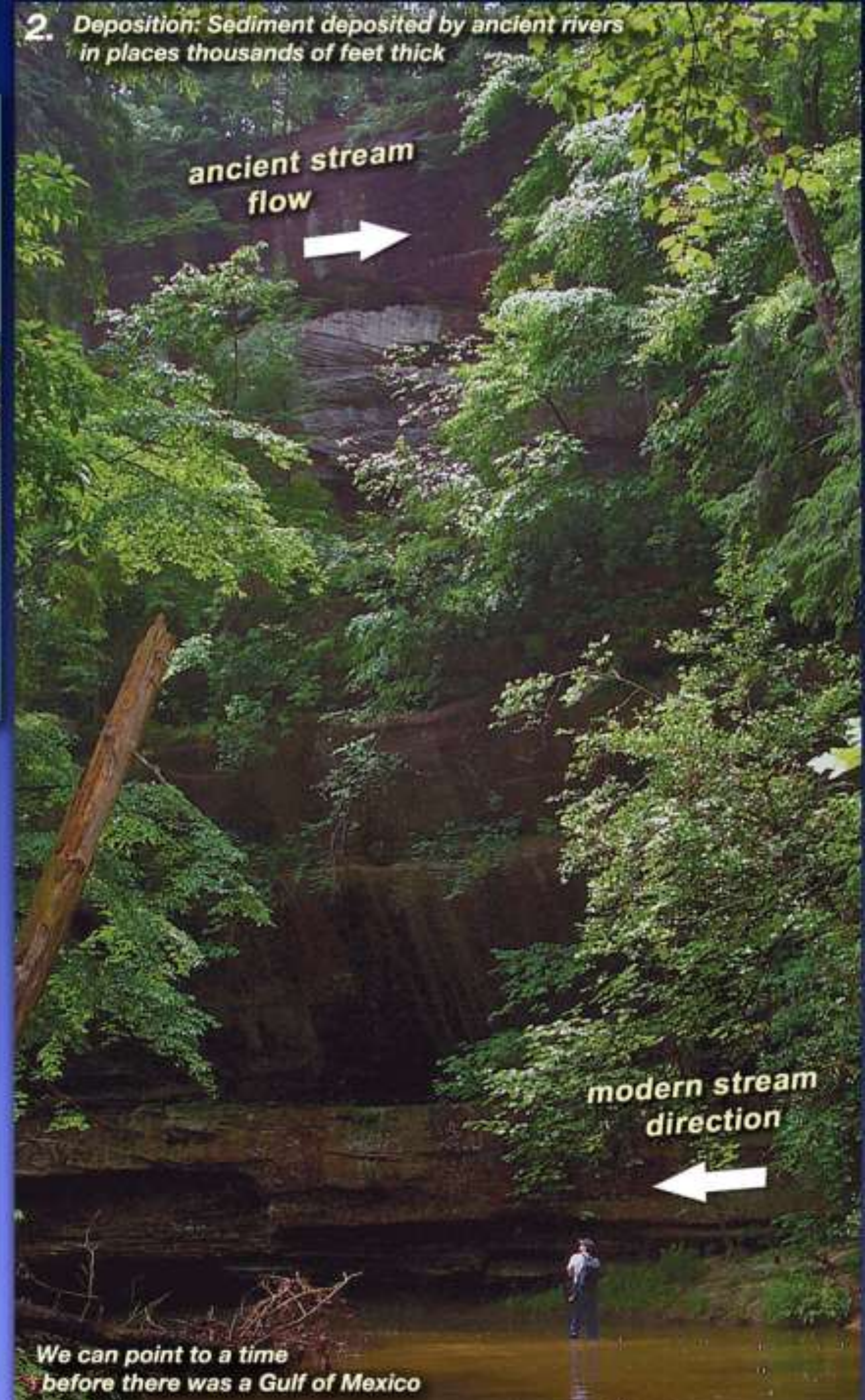
Physiographic sections

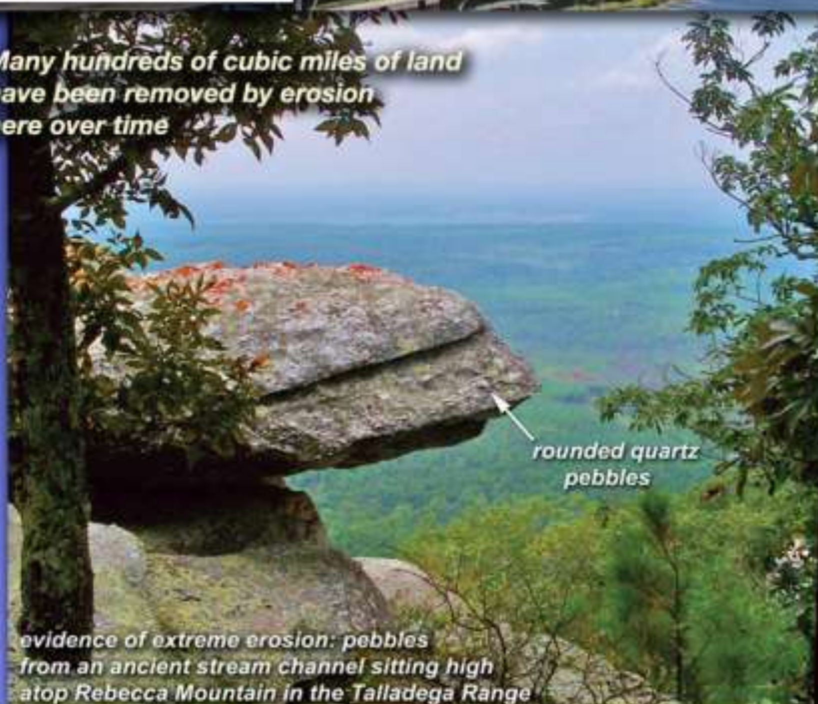
An Easy Explanation, But...!


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)
Section, Jackson County
Looking closely at Alabama's modern landscape it becomes obvious how important water has been in shapng this land across enormous time. But many mysteries remain unsolved...

Rocks Hold a Record of the Land's History



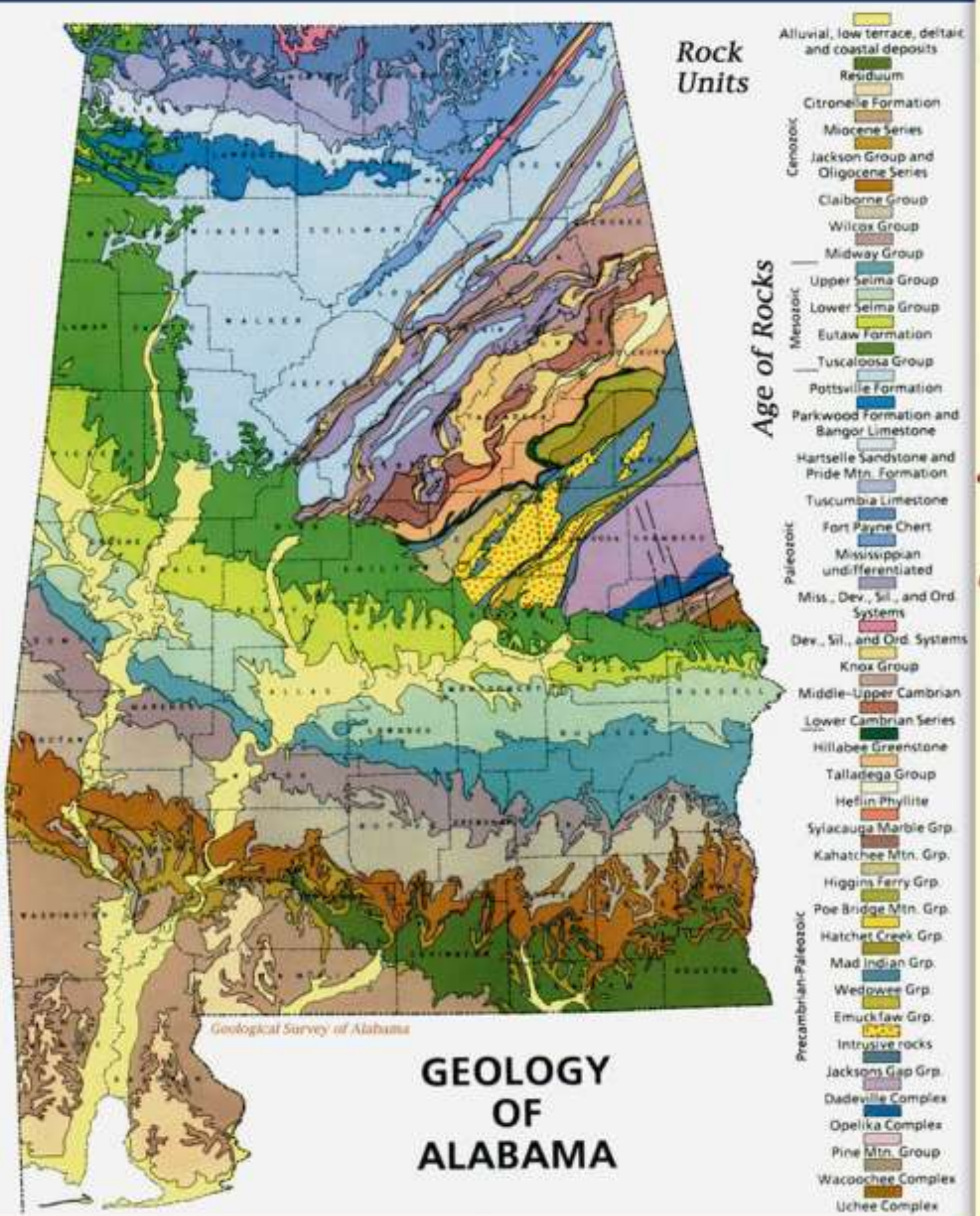


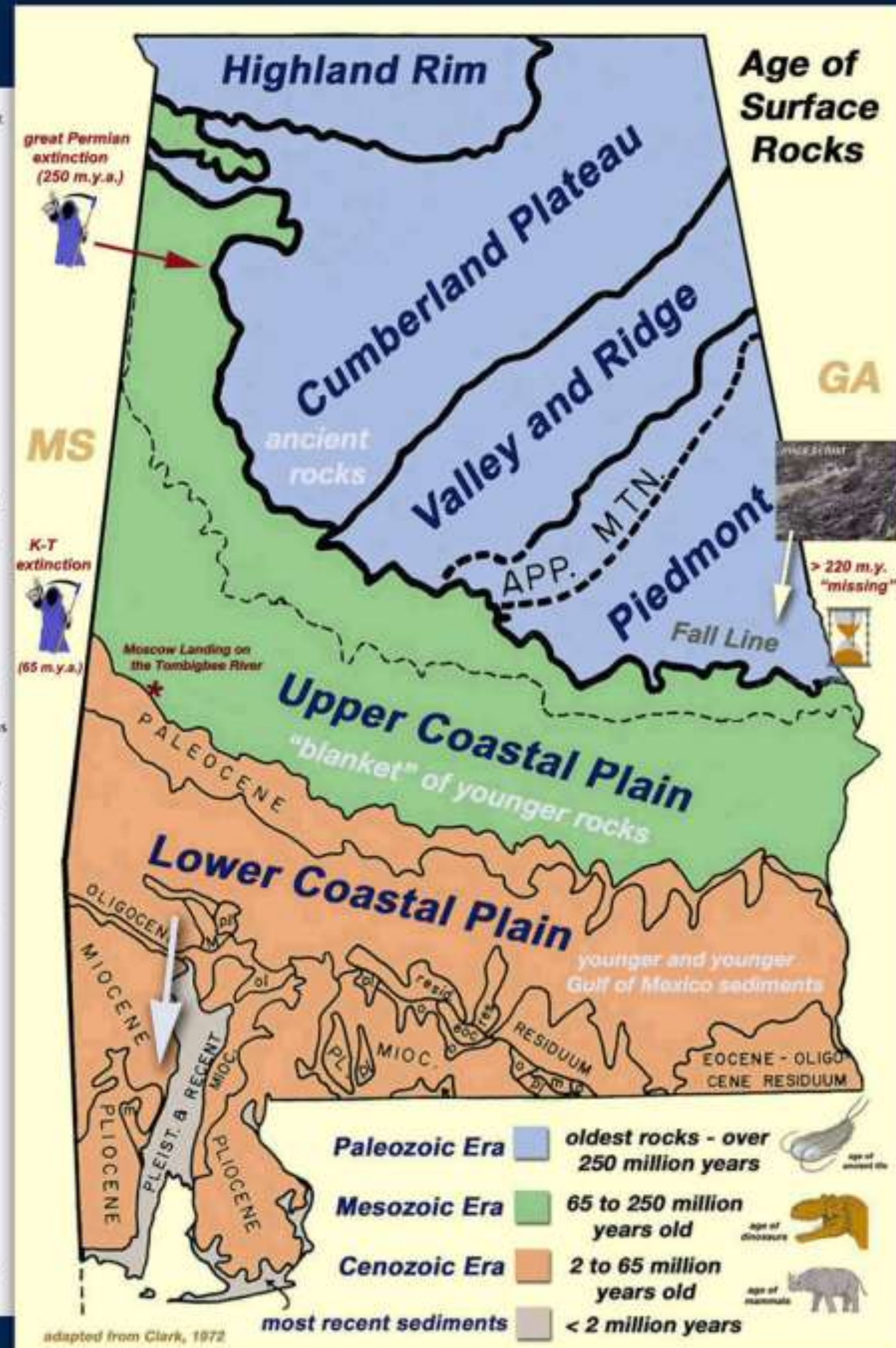


A Timetable of Alabama Geological History

Era	Time Period	Epoch	When Began (in millions of years)	Significant Events in Alabama's Geologic History
Cenozoic Era	Quaternary	Holocene	11,700 years	our present epoch of Earth history
Cenozoic Era	Quaternary	Pleistocene	2.6	the "Ice Age"; Alabama ecosystems unlike today—northern tree species, megafauna
Cenozoic Era	Tertiary Period	Pliocene	5.3	Alabama landscape undergoes slight uplift, deep erosion of uplands
Cenozoic Era	Tertiary Period	Miocene	23	Earth's climate becomes unstable; fossil pollen studies show deciduous trees start to dominate Alabama forests
Cenozoic Era	Tertiary Period	Oligocene	34	
Cenozoic Era	Tertiary Period	Eocene	56	Alabama climate warm and wet, forests still contain many tropical tree species:
Cenozoic Era	Tertiary Period (Epochs →)	Paleocene	66	lignite coal forms in Gulf coastal marshes
Mesozoic Era	Cretaceous		145	sea levels very high, warm oceans cover most of Alabama; "Selma chalk" forms offshore; dinosaurs roam tropical jungles
Mesozoic Era	Jurassic		201	opening of the Gulf of Mexico; Alabama climate still hot and dry; rich oil deposits form along edge of young, expanding Gulf
Mesozoic Era	Triassic		252	supercontinent of Pangaea begins to rift apart; Alabama moves north of the equator; state's climate and landscape desert-like
Paleozoic Era	Permian		299	probable peak of Appalachian Mtn. formation, Alabama locked within dry interior of Pangaea, no rocks from this time known from the state
Paleozoic Era	Carbon-iferous	Pennsylvanian	323	"Coal Age" forests; Pangaea forms
Paleozoic Era	Carbon-iferous	Mississippian	359	widespread limestones deposited
Paleozoic Era	Devonian		419	sometimes called the "age of fishes," but land plants and animals also diversify and move further from the water's edge
Paleozoic Era	Silurian		443	Birmingham's Red Mountain iron ores form; terrestrial (land) environments first invaded by plants and animals
Paleozoic Era	Ordovician		485	tropical seas cover most of the state; Alabama rocks show mountain-building, volcanic activity was nearby to the east
Paleozoic Era	Cambrian Period		541 million years ago	Alabama on passive margin of ancient North American continent Laurentia; earliest fossils appear in Alabama rocks
"Precambrian"	"Precambrian" (represents about 87% of the Earth's history)			first multicellular organisms appear in the fossil record; Grenville mountain-building episode; deep crust beneath Alabama added
"Precambrian"	Proterozoic Eon		2.5 billion	first "free" oxygen accumulates in the Earth's atmosphere
"Precambrian"	Archaean Eon		3.8 billion	earliest fossilized bacteria appear in the geologic record
"Precambrian"			4 billion	age of Earth's oldest known rocks

The diversity of surface rocks seen on the Alabama geologic map is reflected in the state's geographic divisions.





Rocks Create Landscapes

One of the most obvious effects of geology, or more specifically geological diversity, is that differences in weathering and erosional properties between different rock types creates differences in topography, or general shape of the land.

key idea: differences in rocks → a varied landscape

Through time this geological diversity creates uplands and lowlands, and sets the courses of streams and rivers as they make their way to the sea.

For example, instead of flowing directly toward the Gulf the Tennessee River follows softer limestones northward to the Ohio Valley before heading south.

✷ The landscape is always changing, but the rate of change is not constant. This idea has led to a recent revelation in our understanding of Alabama's geology.

So, Why is Alabama's Surface Geology So Colorful and Complex?

An Explanation of the "Mosaic Effect"

E
(most recent)
D
C
B
A
(oldest layer)

the present-day results of a dynamic planet

This colorful landscape mosaic is the product of Alabama's geologic history—the events and environments of long ago.

the blandness of an "undisturbed cake"

If the "layer cake" model of rock layers were truly accurate there would be little difference in geology or landscape type across the state.....

the "upset layer cake"

Instead, Alabama has a rich variety of surface rocks and a diversity of landscapes and habitats that result from them.

Geologic Map of Alabama

Alabama's geological diversity is the results of a combination of factors — a history of many different environments is only the first of these.....

There are many places in northeastern Alabama where several miles of rock have been eroded away that can now be measured by studying what's left on either flank of the uplifted strata.

Perhaps even more important to the overall geological diversity of the state are major events that have upset the "layer cake" of rock layers — they do not lie flat as they once did...

Tectonics and Erosion

Alabama's major stages of geologic development:

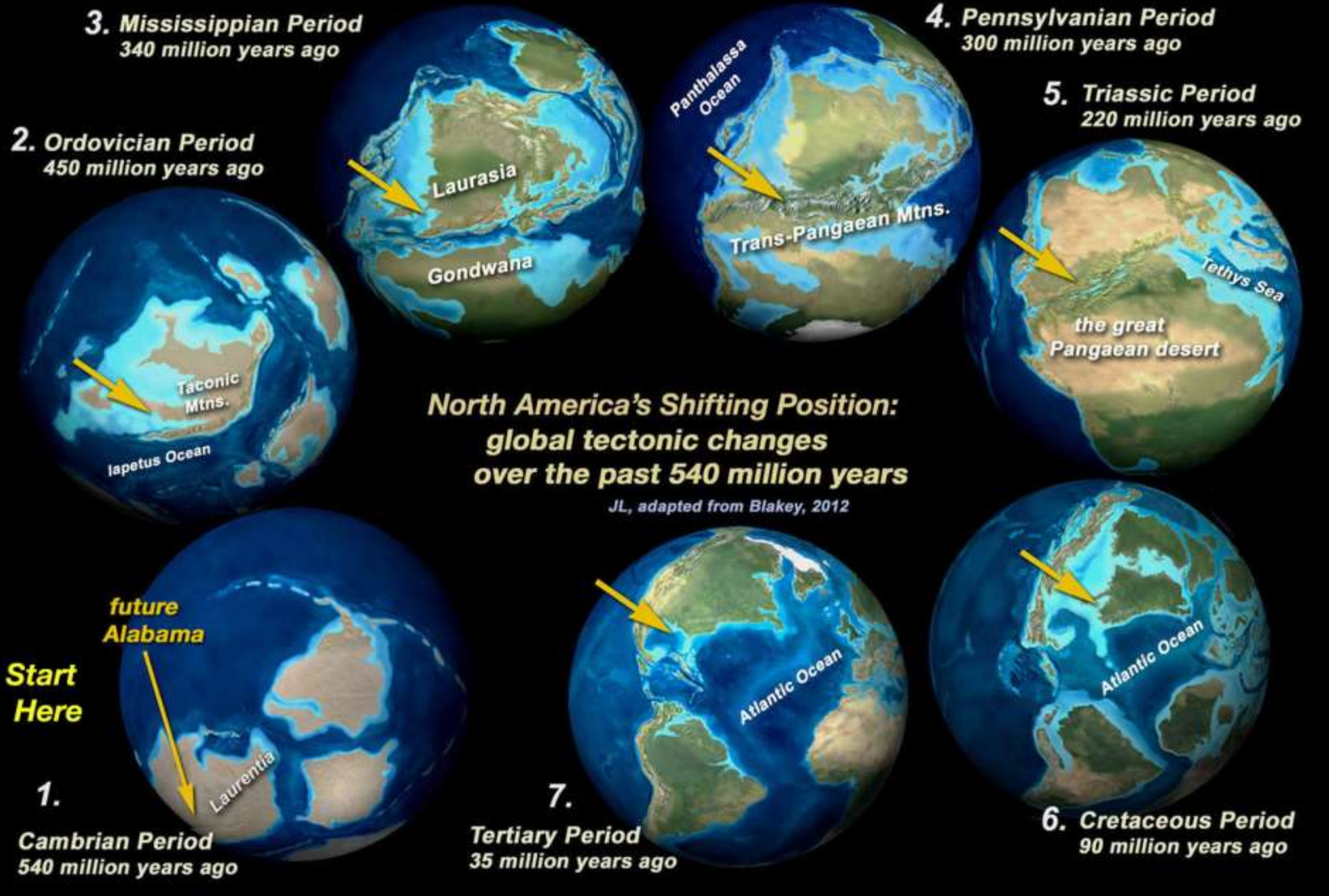
1. beneath Paleozoic oceans
2. continental collision and Appalachian mountain-building
3. opening of Gulf of Mexico

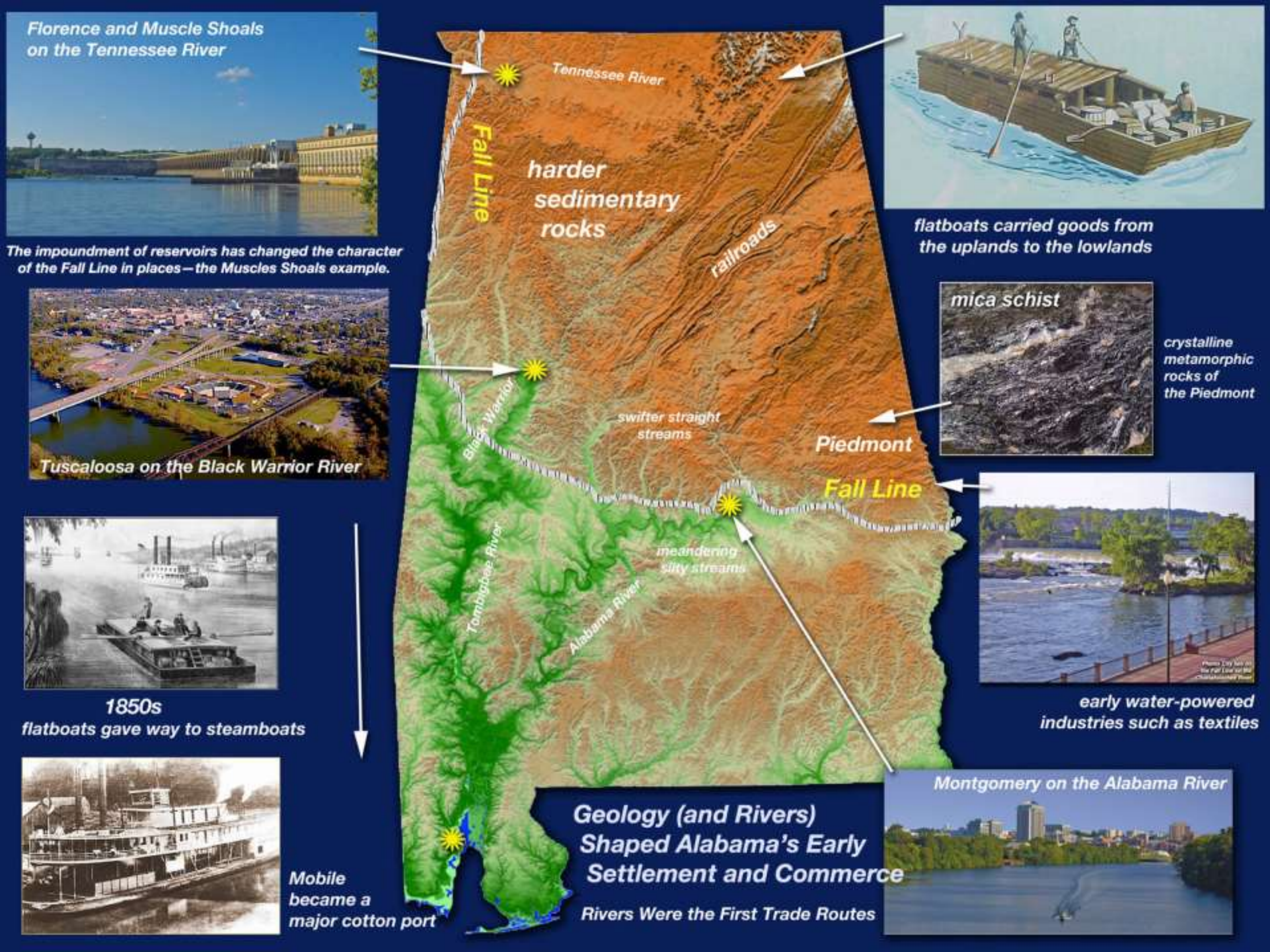
The crumpled and distorted rocks of the Valley and Ridge and Piedmont provinces represent damage to the Earth's crust caused by the collision with Africa that formed the Appalachians.

The stairstepped beds of the Coastal Plain represent a history of the development of the Gulf of Mexico.

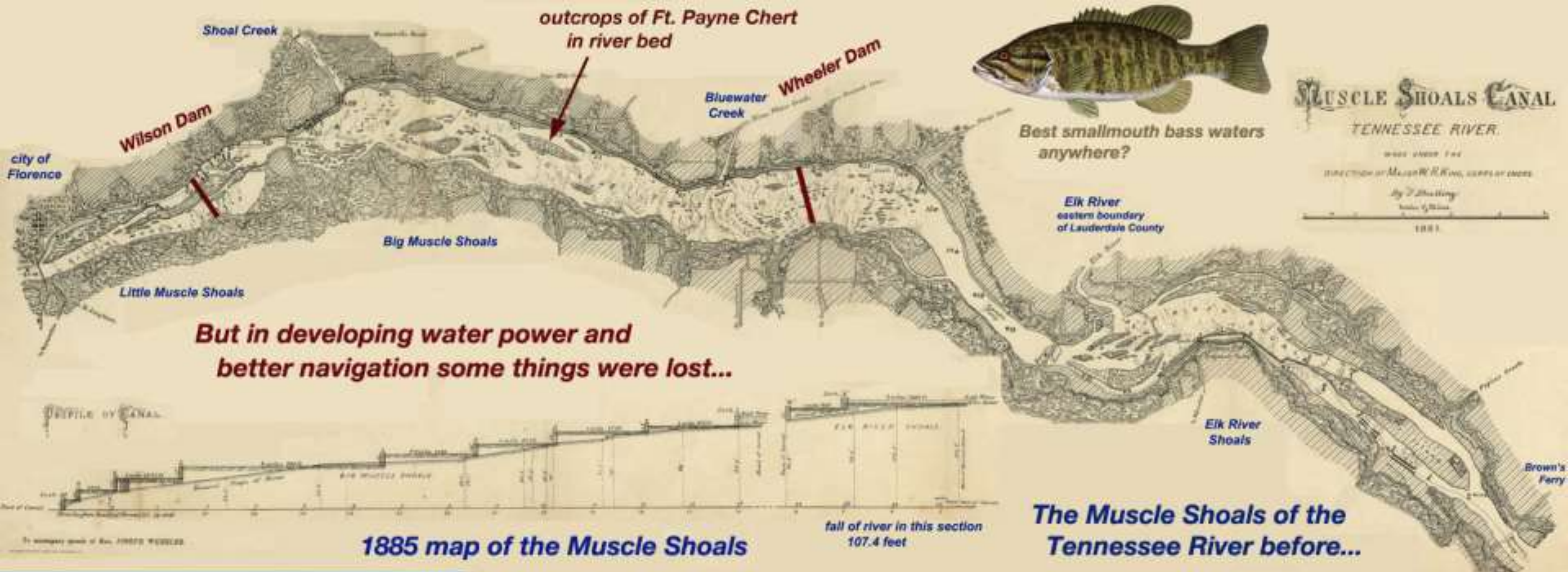
Geologists use the term tectonic events to describe large scale changes to the crust such as these.

Global Tectonic Events Recorded in Alabama's Rocks

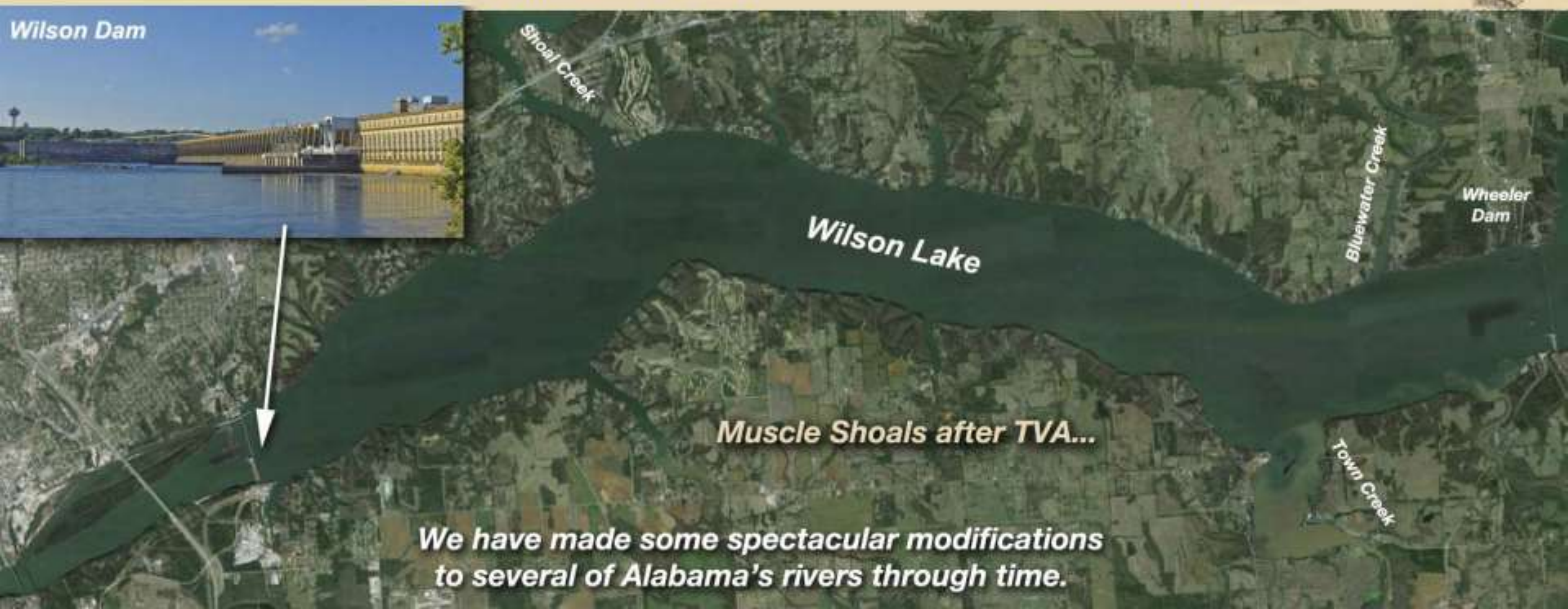




Geology (and Rivers) Shaped Alabama's Early Settlement and Commerce
Rivers Were the First Trade Routes
Florence and Muscle Shoals on the Tennessee River
The impoundment of reservoirs has changed the character of the Fall Line in places—the Muscles Shoals example.
Tuscaloosa on the Black Warrior River
1850s
flatboats gave way to steamboats
Mobile became a major cotton port
flatboats carried goods from the uplands to the lowlands
mica schist
crystalline metamorphic rocks of the Piedmont
early water-powered industries such as textiles
Montgomery on the Alabama River
Tennessee River
Fall Line
harder sedimentary rocks
railroads
Black Warrior
swifter straight streams
Piedmont
Fall Line
meandering silty streams
Tombigbee River
Alabama River



outcrops of Ft. Payne Chert in river bed
Shoal Creek
Wheeler Dam
Bluewater Creek
Wilson Dam
city of Florence
Big Muscle Shoals
Little Muscle Shoals
Best smallmouth bass waters anywhere?
Muscle Shoals Canal
Tennessee River
Elk River eastern boundary of Lauderdale County
But in developing water power and better navigation some things were lost...
Elk River Shoals
Brown's Ferry
fall of river in this section 107.4 feet
1885 map of the Muscle Shoals
The Muscle Shoals of the Tennessee River before...



Wilson Dam
Shoal Creek
Bluewater Creek
Wheeler Dam
Wilson Lake
Muscle Shoals after TVA...
Town Creek
We have made some spectacular modifications to several of Alabama's rivers through time.

We're Number One!!!

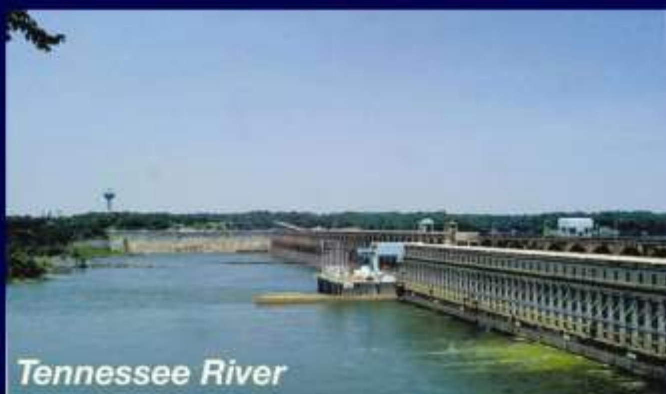
(but this is not so good)

Alabama has lost more native species to extinction than any state outside of Hawaii.....

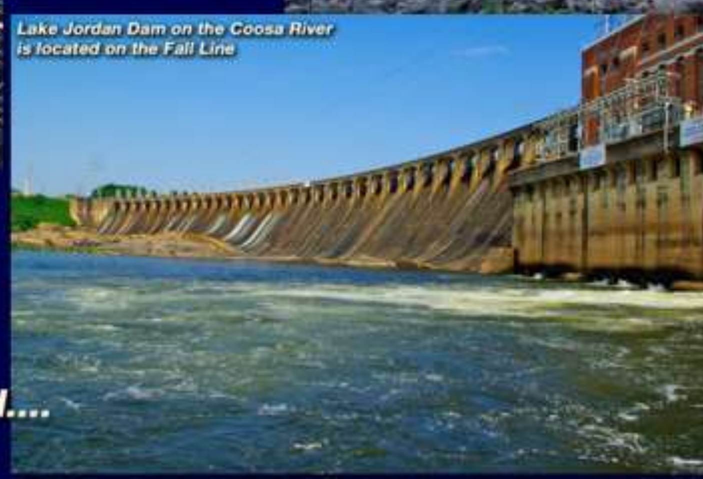
Some of the casualties: 27 species of mussels, 39 species of freshwater snails, at least 2 species of fish now extinct...

Bear Creek, Franklin County

Chattahoochee River



Tennessee River



Lake Jordan Dam on the Coosa River is located on the Fall Line

Thurlow Dam on the Tallapoosa River

Why?

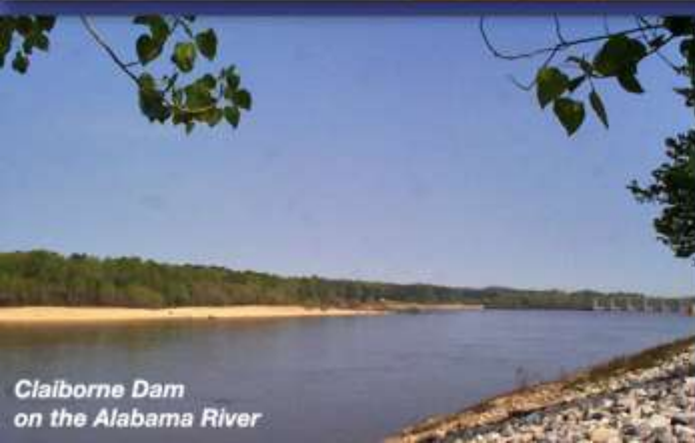
We've taken a heterogeneous landscape and made it more bland....

Cahaba Changes

A major threat to the Cahaba is increased sedimentation caused by urbanization, which eliminates ancestral spawning grounds.

Cahaba River below U.S. 280

As recently as the 1940s Gulf sturgeon > 400 pounds reached Centreville to spawn.



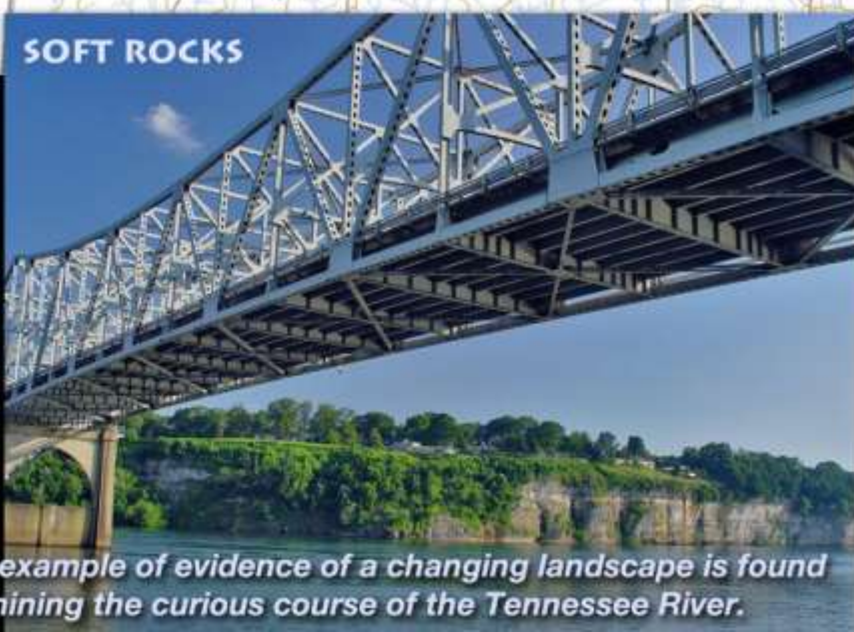
Claiborne Dam on the Alabama River

Although the Cahaba is largely free-flowing, dams downstream have eliminated fish that have been here since the Age of Dinosaurs.

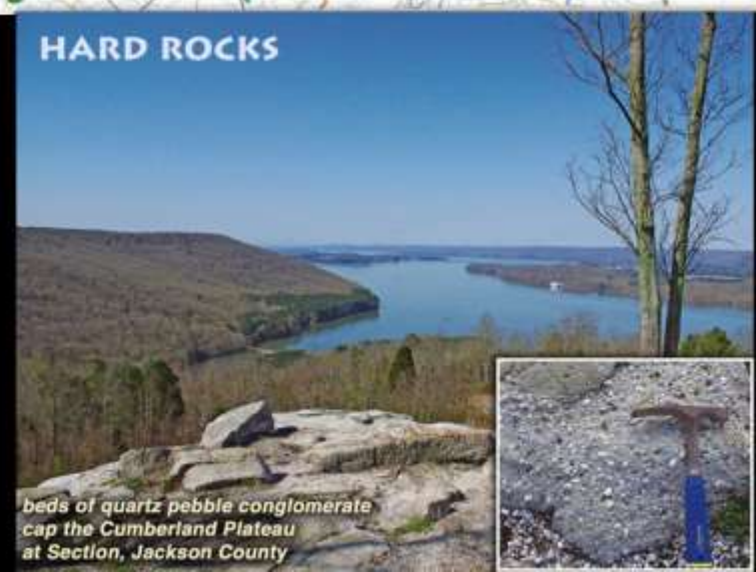
Threats to aquatic diversity

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?



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



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

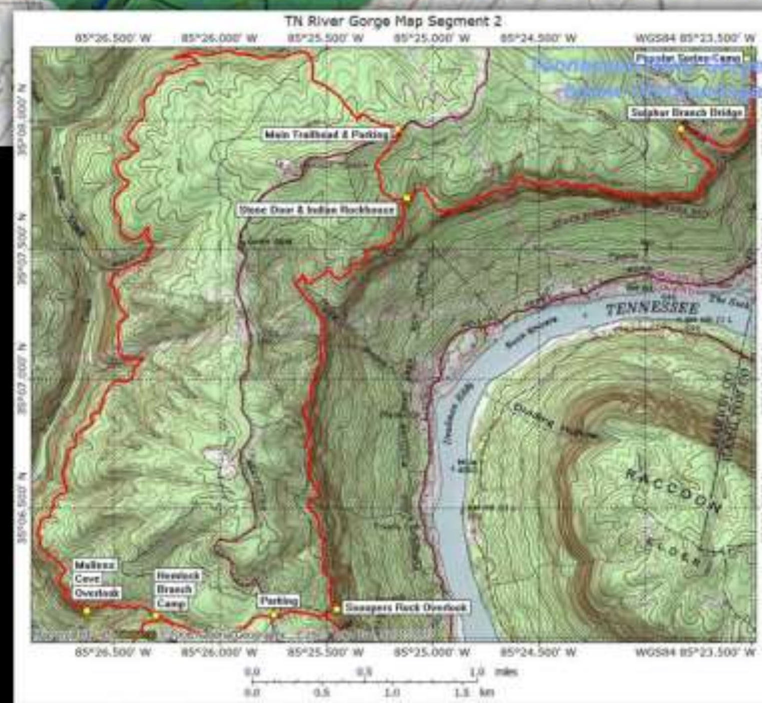
Geology and Time Guide the Course of the Tennessee River

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

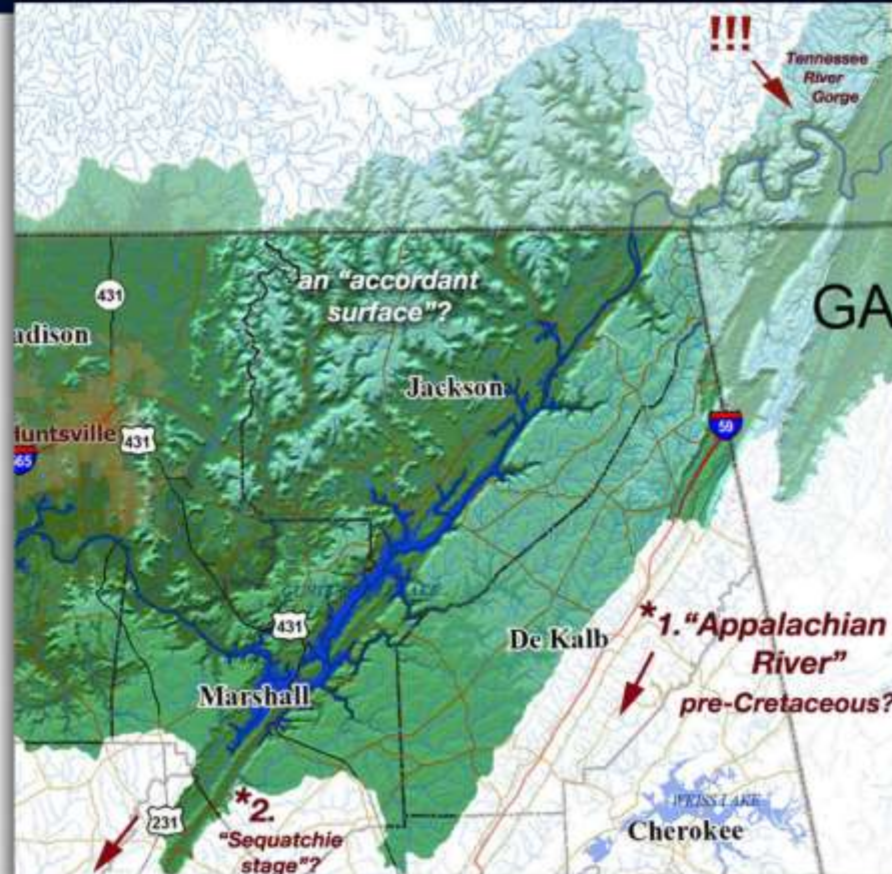
ABSTRACT

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!



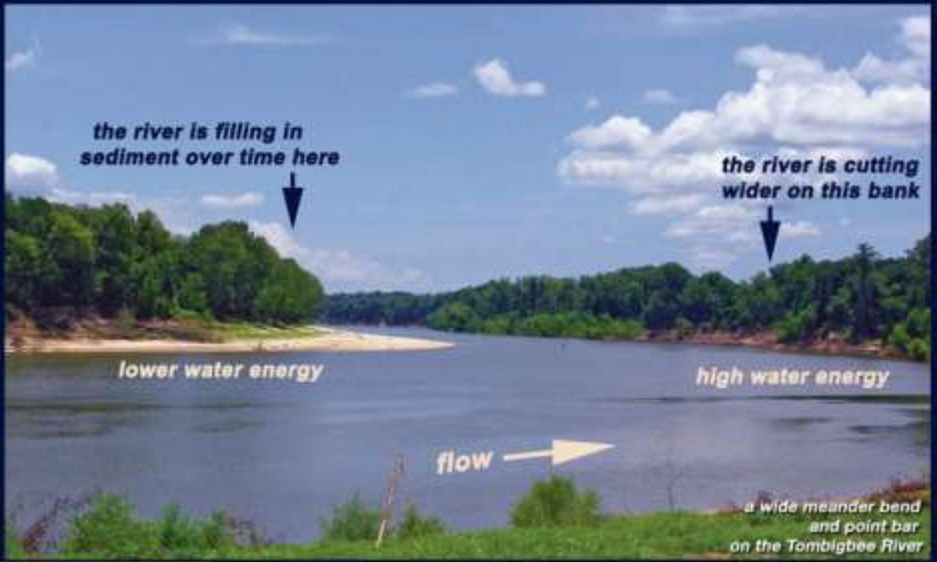
Great Mysteries Waiting to be Solved

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



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

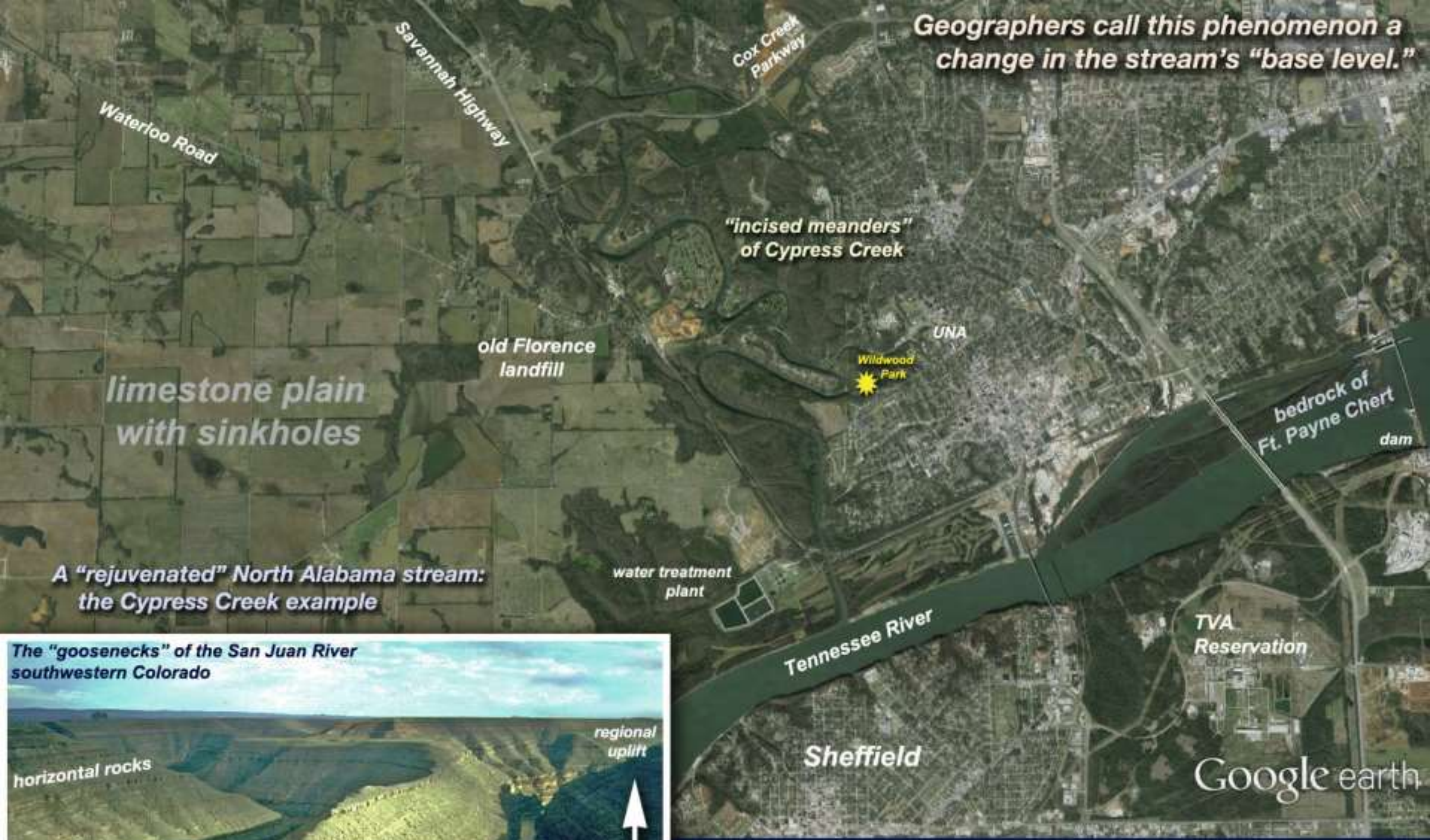
*Once a stream reaches "old age" it meanders back and forth in the same territory...

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

Features of Mature Streams

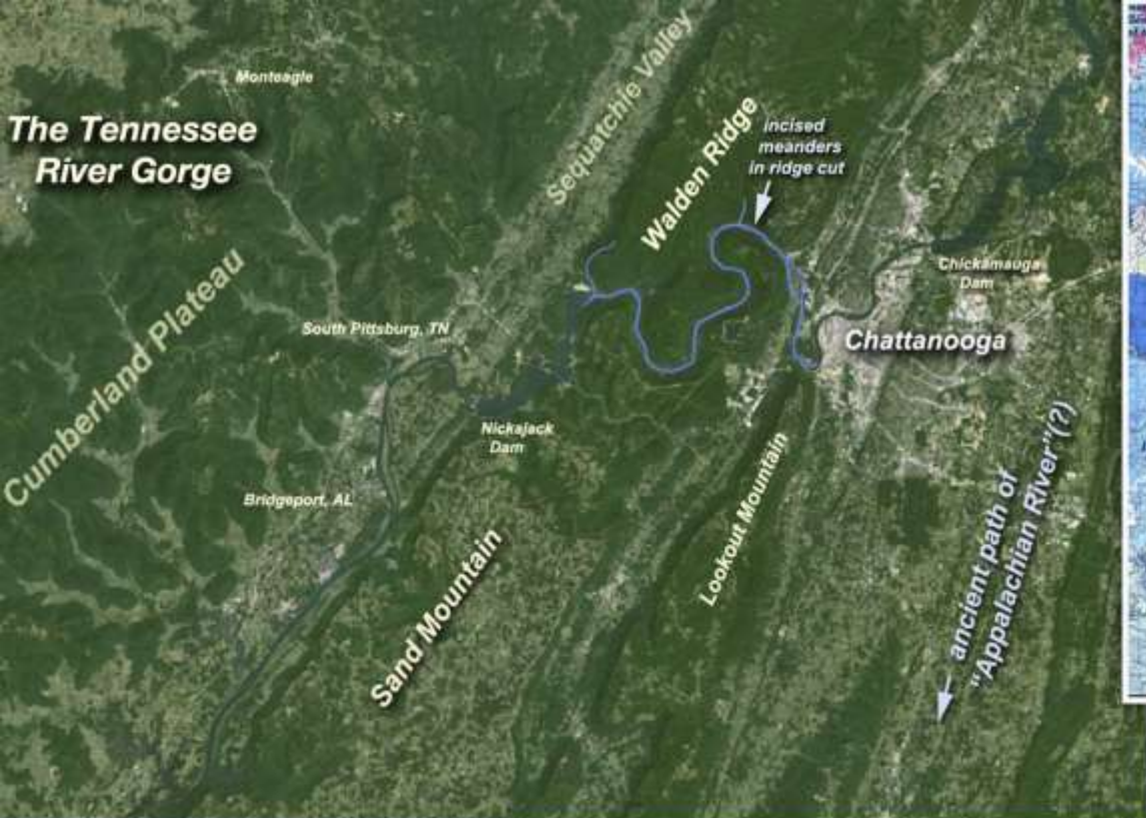
1. lower gradient = slower speed
2. widening bends called meanders
3. deposition of sediment over time
4. broad and fertile flood plain

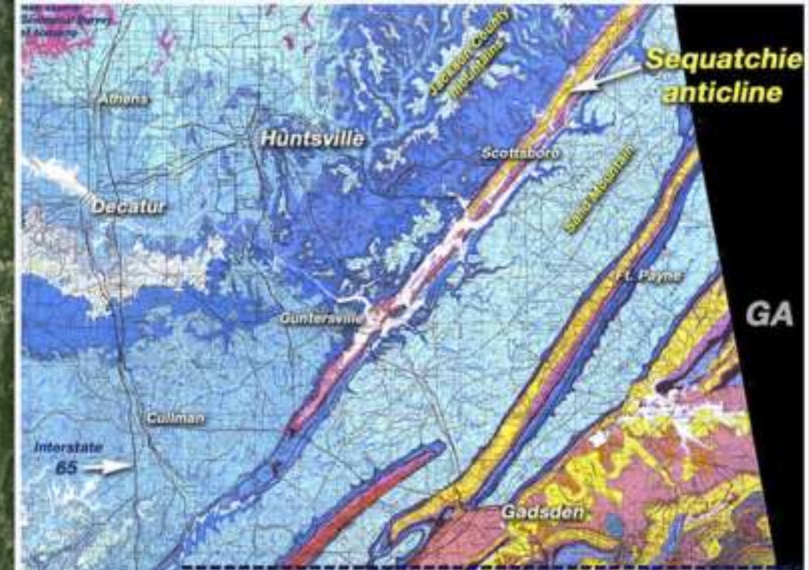
a cross section of a "base level" stream



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.



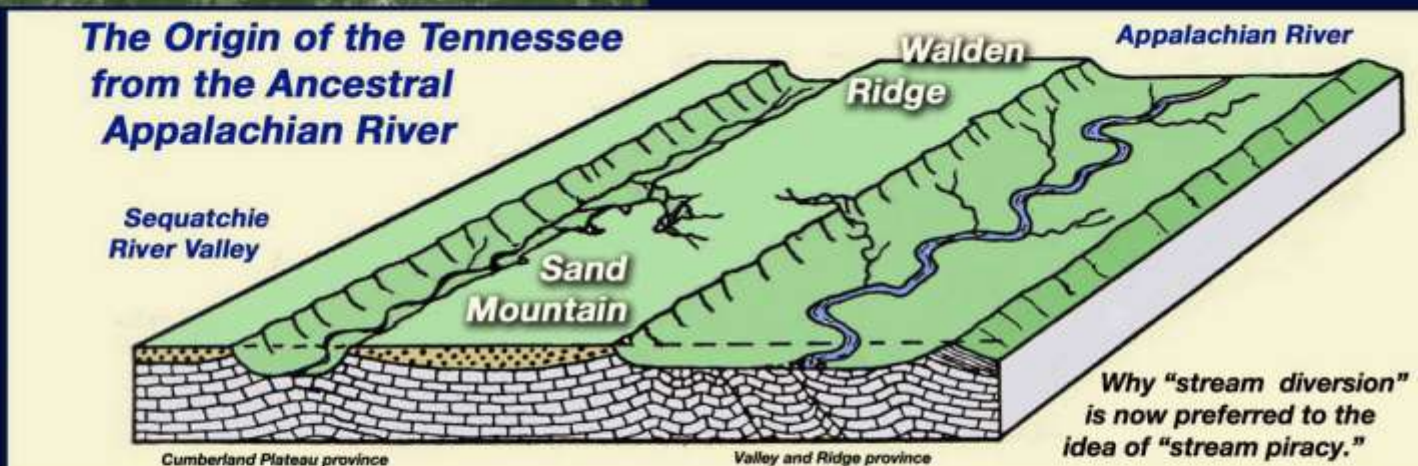


a geologic map of the **Sequatchie anticline** in North Alabama

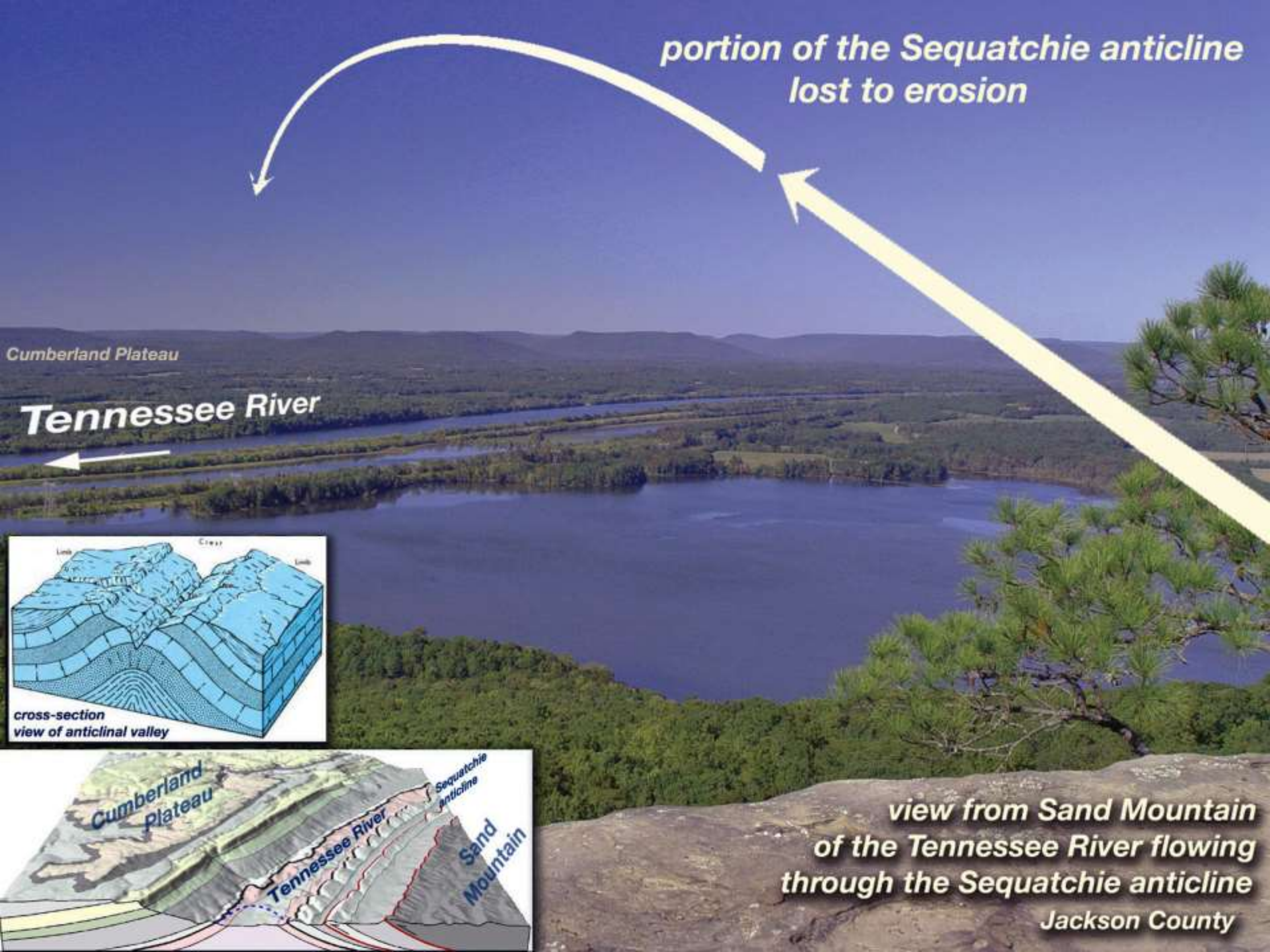
Wanderlust in a prehistoric river?

At some point long ago the Tennessee River seems to have made a fateful jog to the west, eventually bringing it to northwest Alabama.

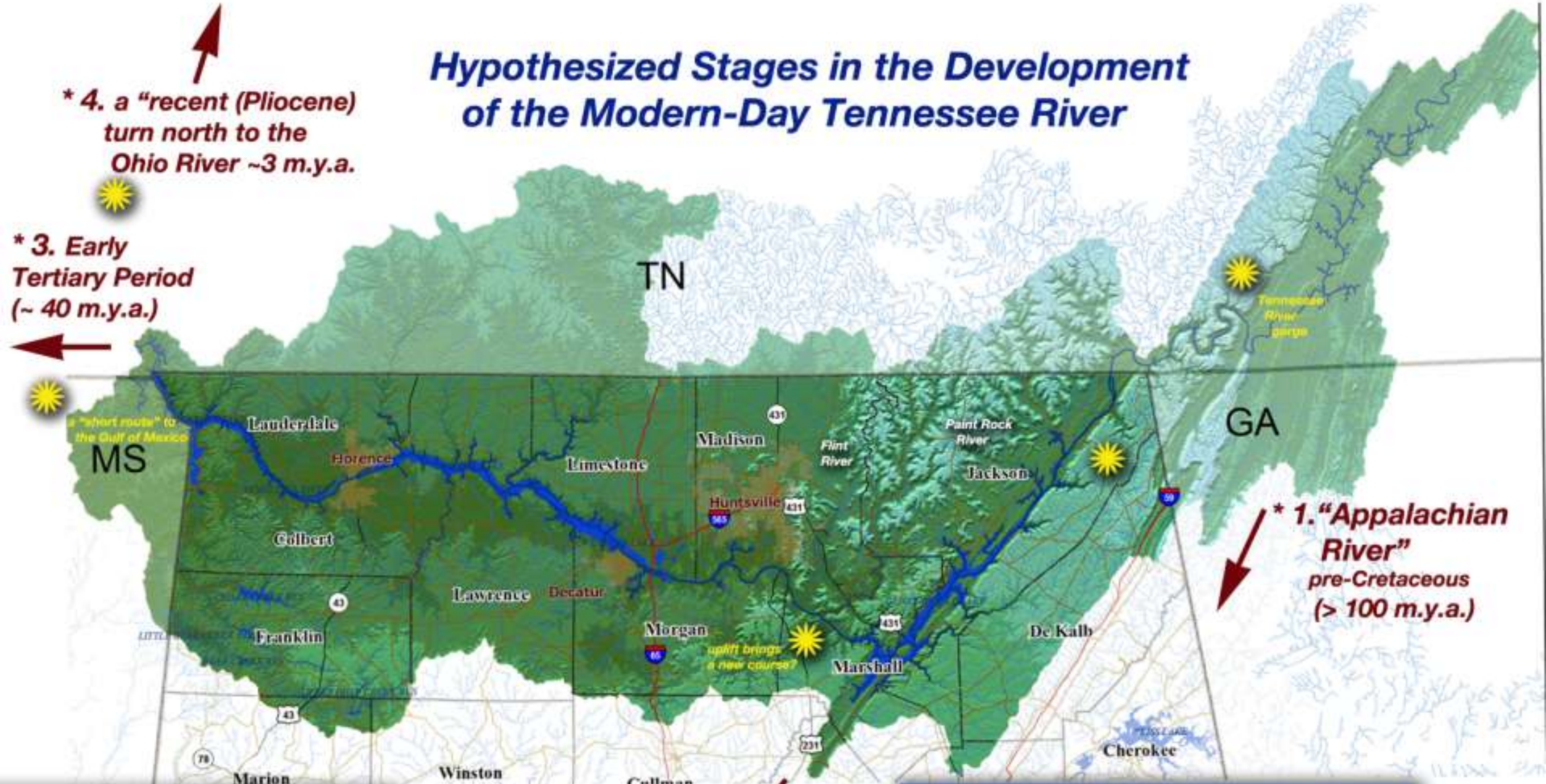
The most likely site of this hypothesized course change can still be identified today.

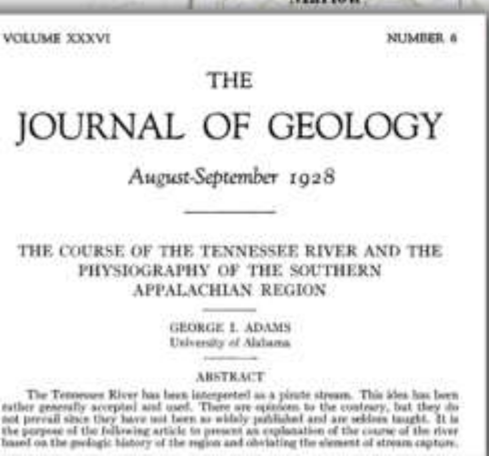


Some Hints as to How We May Have Gotten the Tennessee River in Northwest Alabama


portion of the Sequatchie anticline
lost to erosion
Cumberland Plateau
Tennessee River
cross-section
view of anticlinal valley
Cumberland Plateau
Sequatchie anticline
Tennessee River
Sand Mountain
view from Sand Mountain
of the Tennessee River flowing
through the Sequatchie anticline
Jackson County

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





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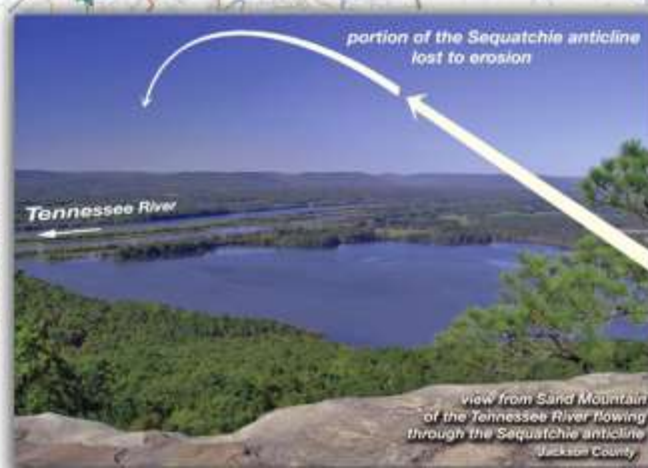
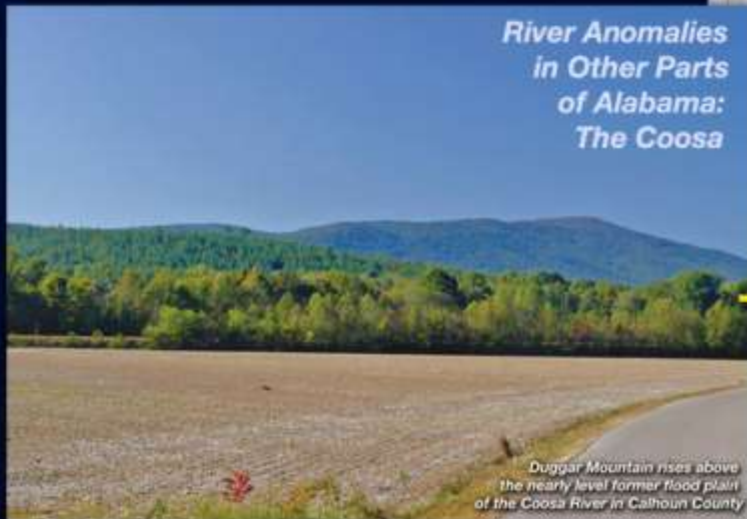
*** 2. "Sequatchie stage"**
exact timing uncertain

Reconstructing the history of rivers requires an awareness of the fact that huge portions of the ancient landscape are now "missing" and that these changes have impacted the course of rivers through time.



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".....

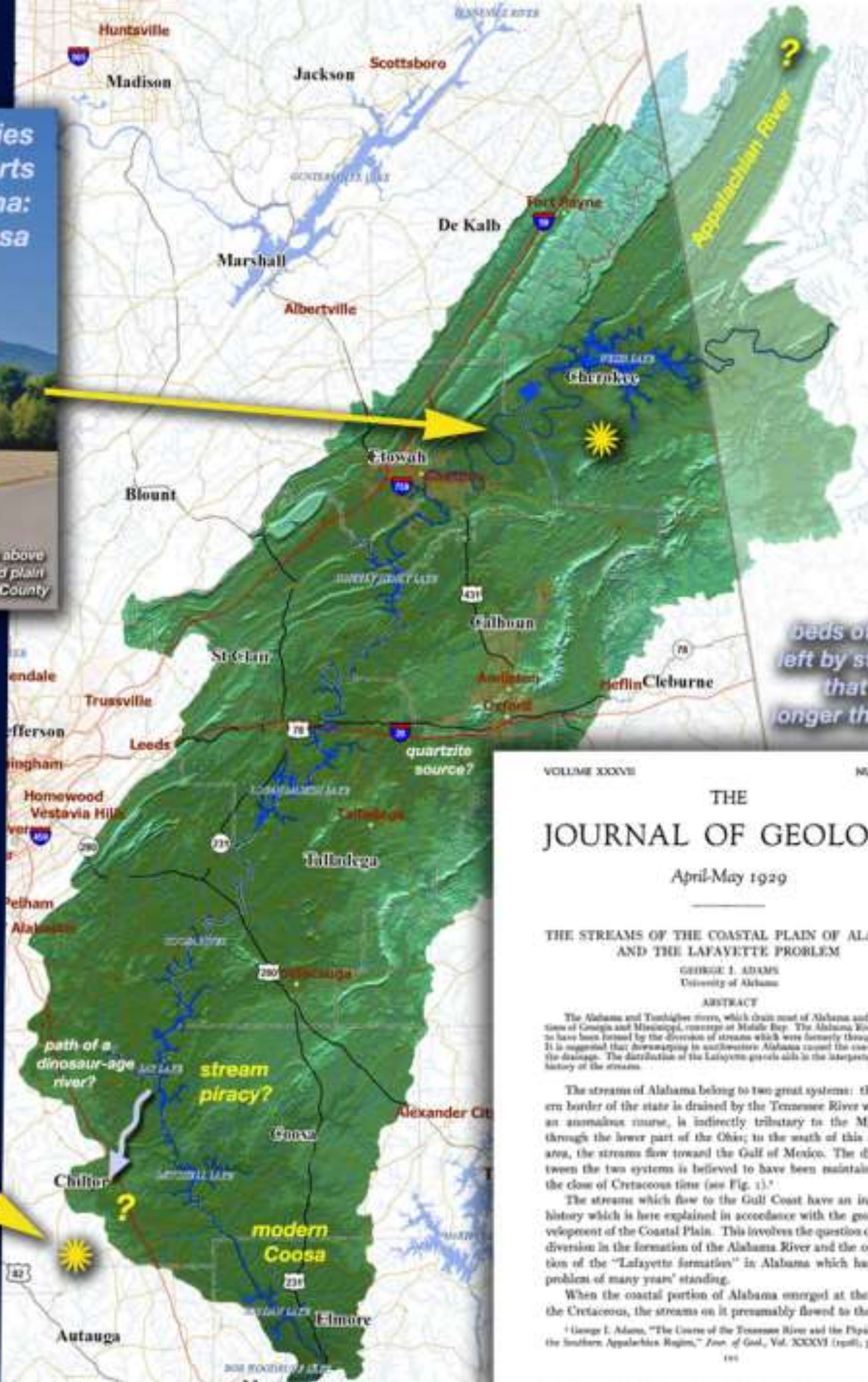


long-abandoned channels

Some geographers believe the size of the upper Coosa River valley is too large to have been formed by today's river.

"orphaned" pebble beds

Water-rounded pebbles left by streams long ago are one source of information on the path, provenance, and size of ancient rivers. No modern stream could have left these quartz gravels spread across northern Autauga County.



beds of gravel left by streams that are no longer there (?!)

VOLUME XXXVII NUMBER 3

THE

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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.

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

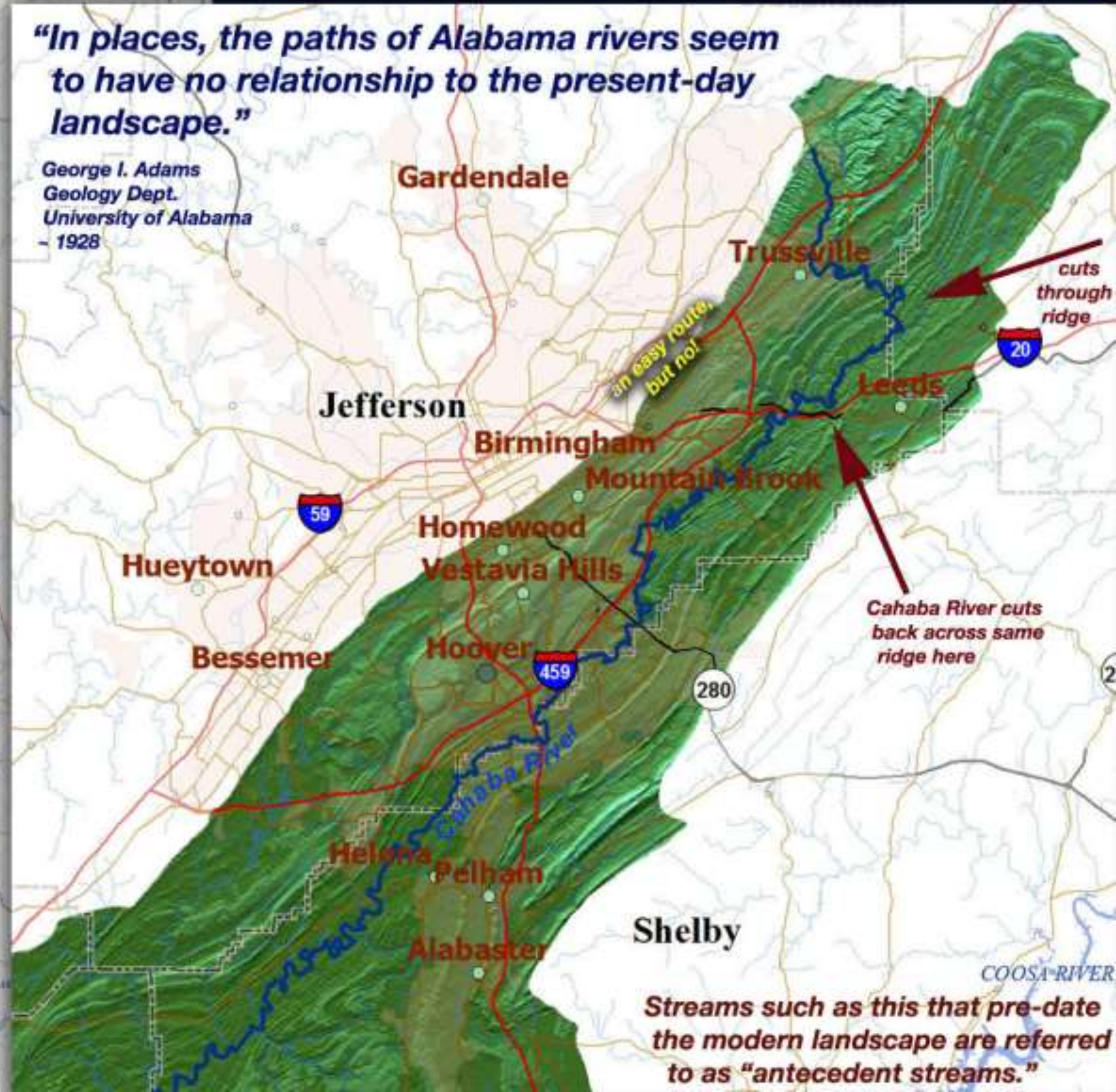
[1] George I. Adams, "The Course of the Tennessee River and the Physiography of the Southern Appalachian Region," *Jour. of Geol.*, Vol. XXXVI (1928), pp. 481-93.

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."



The geological history of Alabama's rivers can be divided into 3 stages (each is documented in different natural sources)...

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

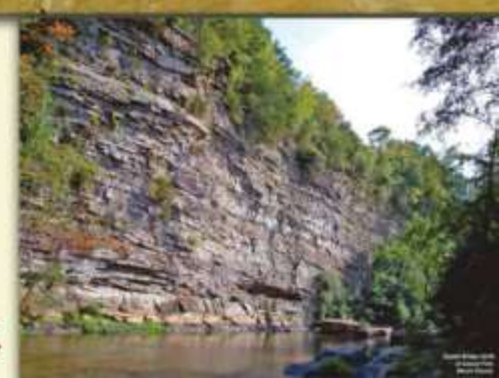
A long period of quiescence in which the land is eroded almost flat (beginning in the Pennsylvanian/Permian periods ~ 275 million years ago, ending unknown)

* 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!



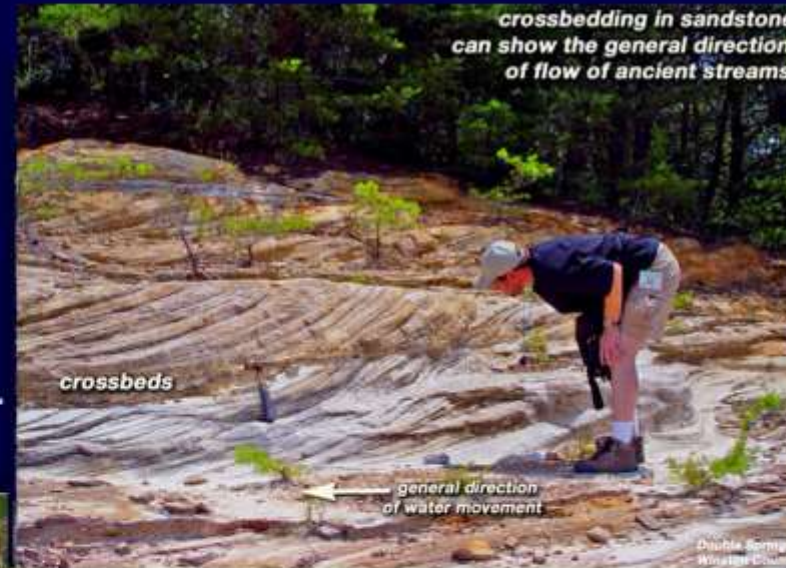
Pennsylvanian sandstones exposed on the Locust Fork River

Alabama's Earliest Rivers: A Soggy, Tropical Landscape During the Great "Coal Age"- the Pennsylvanian Period

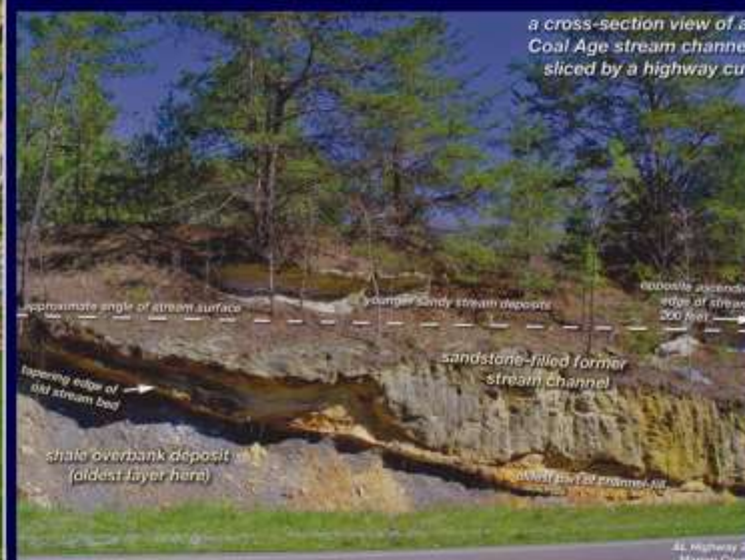
Study of the sedimentary rocks deposited during this period show spectacular changes were taking place to the landscape here.

The Earth's crust was being compressed and deformed by powerful tectonic forces originating from a southeasterly direction.

An enormous volume of new sediment from the erosion of rising mountains to the southeast was swept into the Black Warrior Basin. This event marks the birth of the Southern Appalachian Mountains.



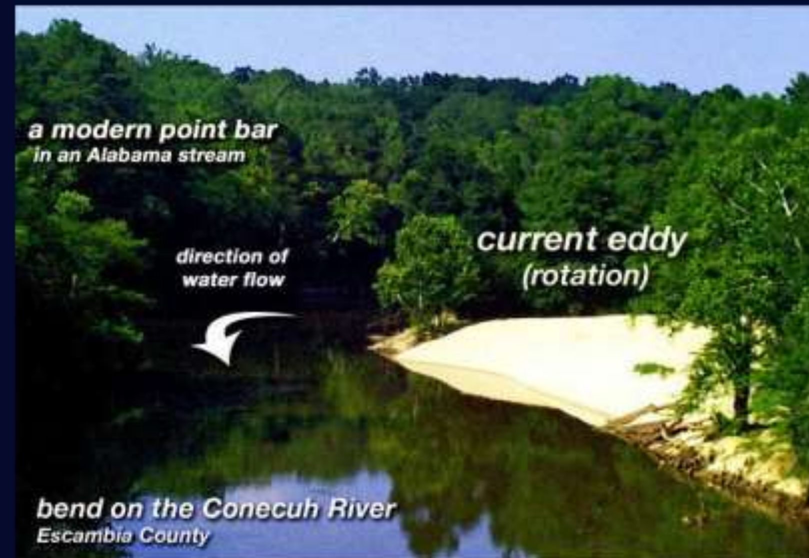
The direction of ancient stream flow offers a source of clues to the shape of the Coal Age landscape.



A large part of present-day North Alabama is built on the thick river-deposited sediment from this time.

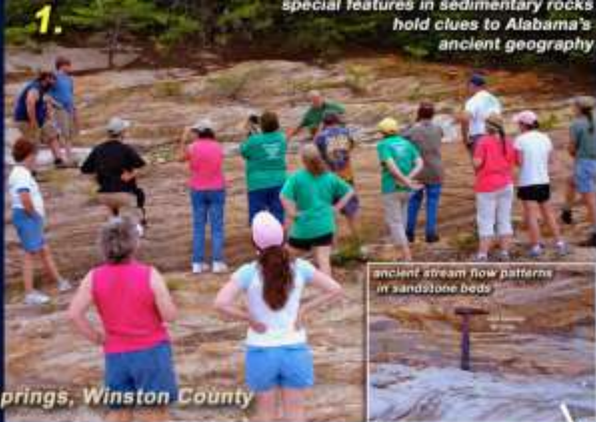
Stream-Deposited Sandstone

Sandstones can hold many clues to the ancient geography of an area: Where were the uplands and lowlands? Where did the stream originate? How large, how swift?



Point bars are common features of meandering streams.


modern
stream flow
ancient current direction marks
provide clues to paleogeography



Clues to ancient geography can be found in many places:

1. Direction of stream flow based on paleocurrent indicators
2. The types of sand grains (and their source) is important as well!

clean, quartz sandstone

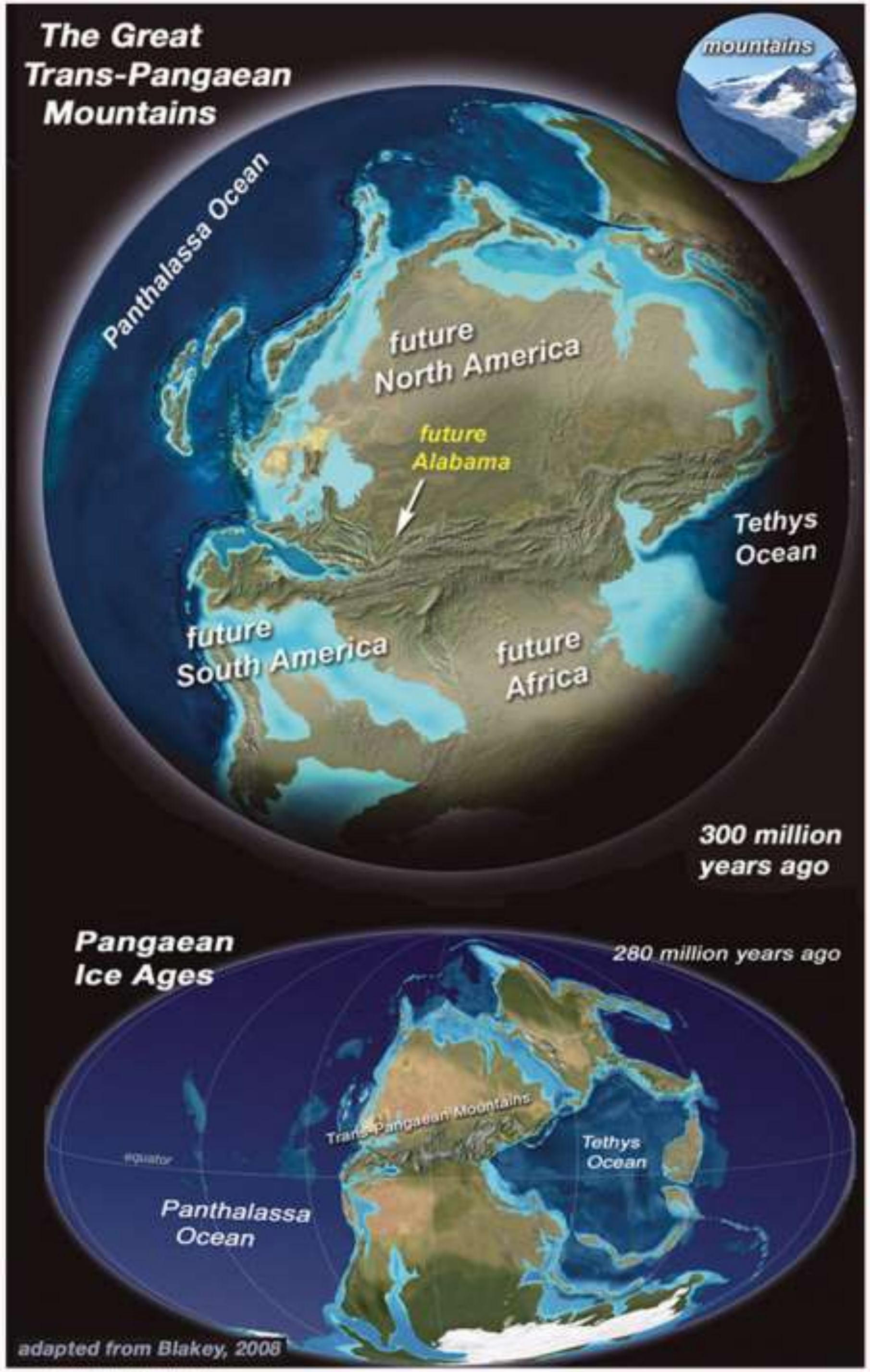
Dr. Bill Hames at Auburn has made some interesting discoveries on the origin of some of the Pottsville sand grains.

4.

a dirty, lithic sandstone

"~ 280 million years ago the Appalachians would have stood well above the height of the modern-day Himalayas."

Auburn University geologists Uddin and Hames, 2012

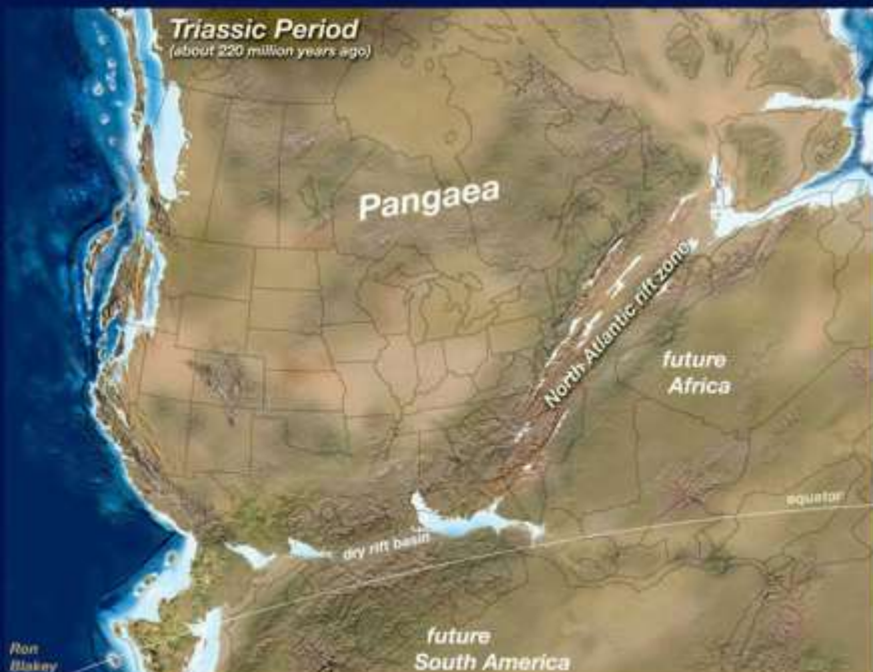

The Great Trans-Pangaean Mountains
mountains
Panthalassa Ocean
future North America
future Alabama
Tethys Ocean
future South America
future Africa
300 million years ago
Pangaean Ice Ages
280 million years ago
Trans-Pangaean Mountains
equator
Tethys Ocean
Panthalassa Ocean
adapted from Blakey, 2008


Ancient Alabama's Place in Pangaea
CHINA
RUSSIA
GREENLAND (DENMARK)
CANADA
Tethys Ocean
UNITED STATES
Joggins, Nova Scotia
ALGERIA
LIBYA
Suwannee terrane
EGYPT
SAUDI ARABIA
MEXICO
NIGER
CHAD
SUDAN
BRAZIL
CONGO
ANGOLA
ZAMBIA
INDIA
SOUTH AFRICA
ANTARCTICA
AUSTRALIA
modern geopolitical boundaries

Recovering Parts of Alabama's "Missing Years"

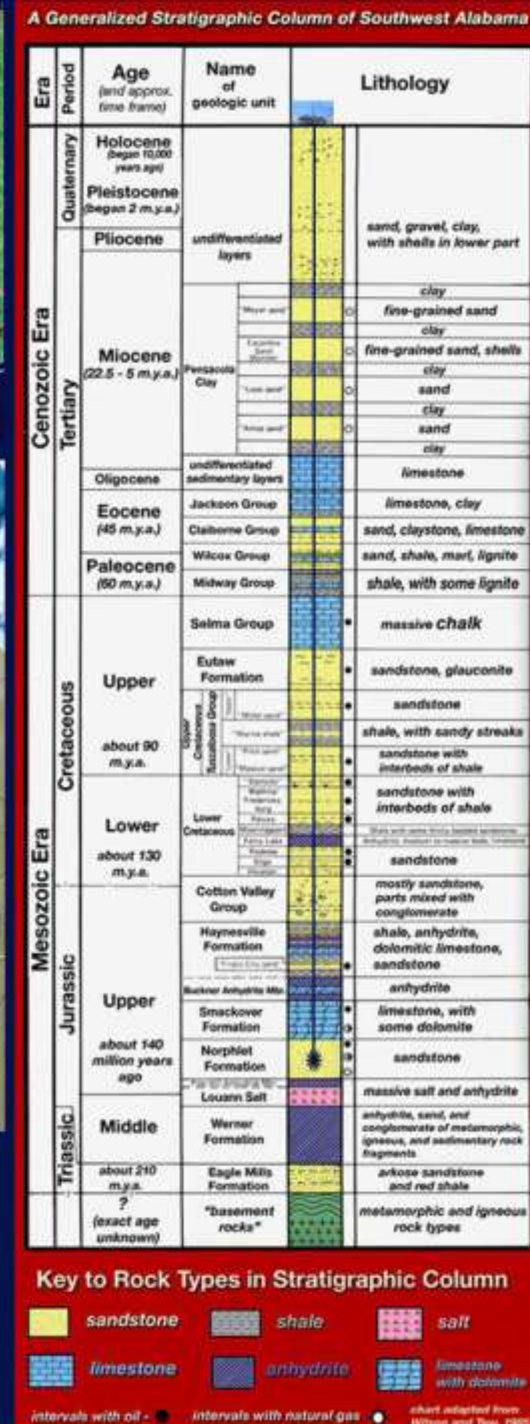
Strange tales from deep beneath Mobile Bay...

The complete history of the Gulf of Mexico told in 5 miles of drilling core...

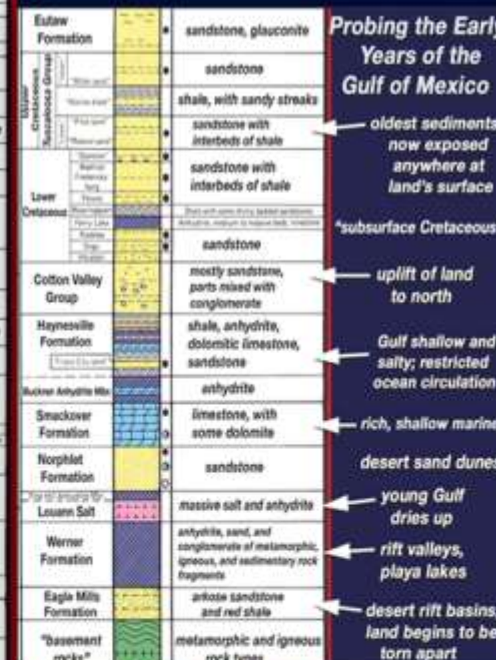


Oil and gas exploration beneath south Alabama has uncovered a wealth of clues to a once-mysterious missing chapter of the state's geological history.

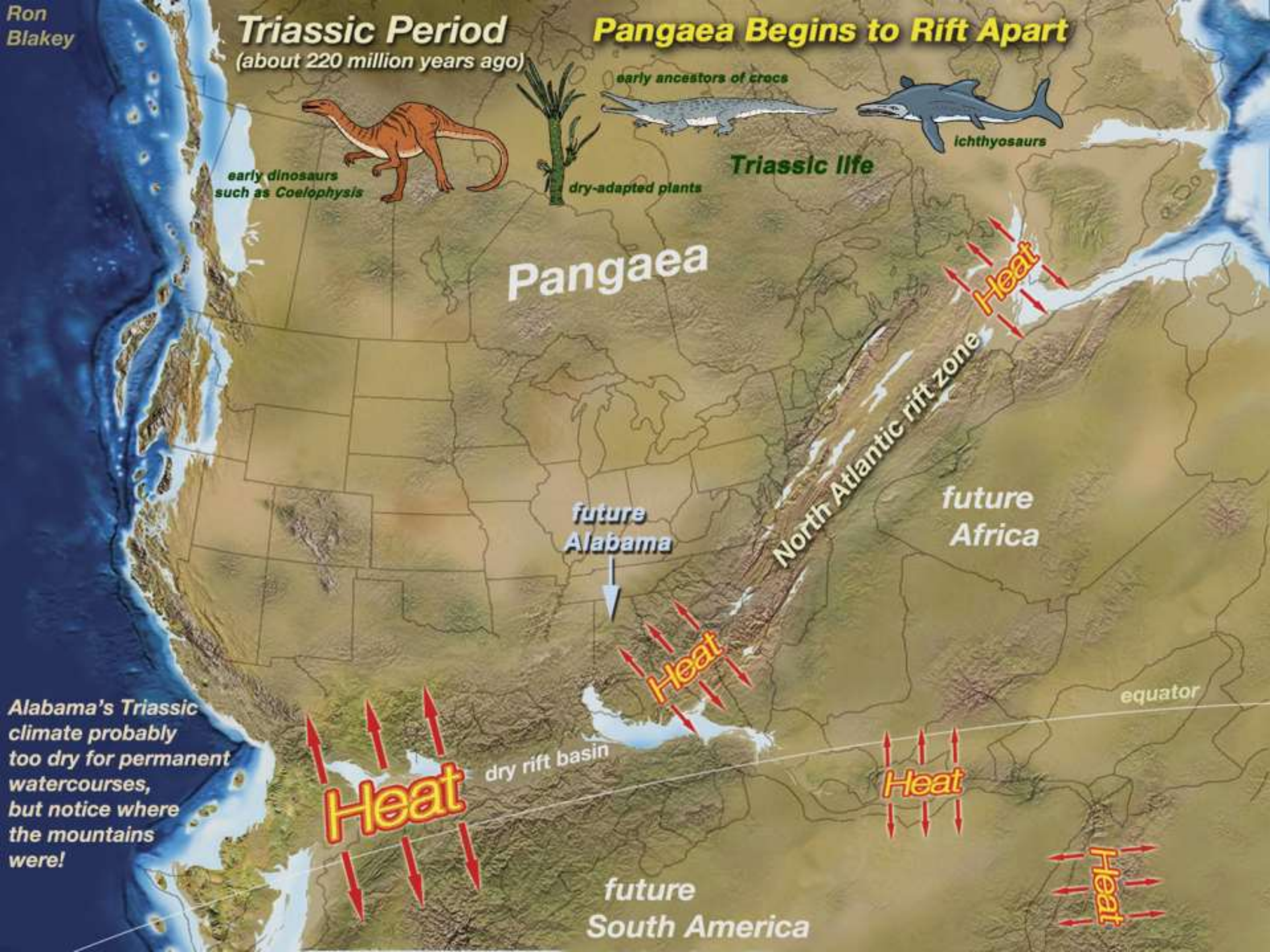
Drilling cores show that Alabama was part of a vast rift valley desert before the Gulf of Mexico formed.



Alabama's Pangaean Desert Years



drill core section from 19,000 feet down


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


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 (?)
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

The Cretaceous Period:

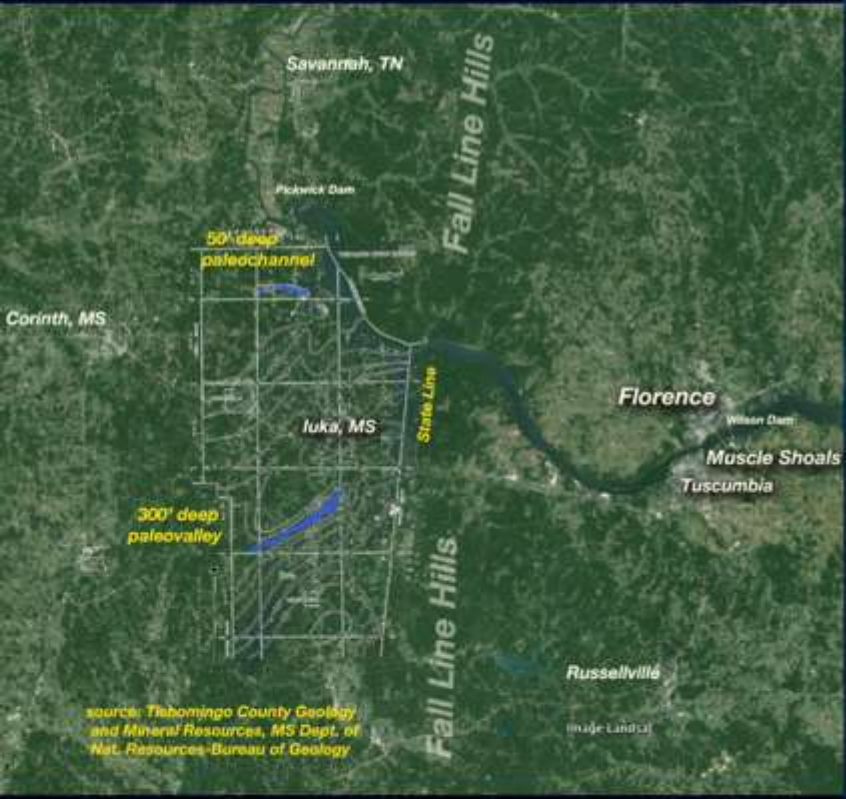
A "Greenhouse World" Marked by Great Biological and Geological Revolutions

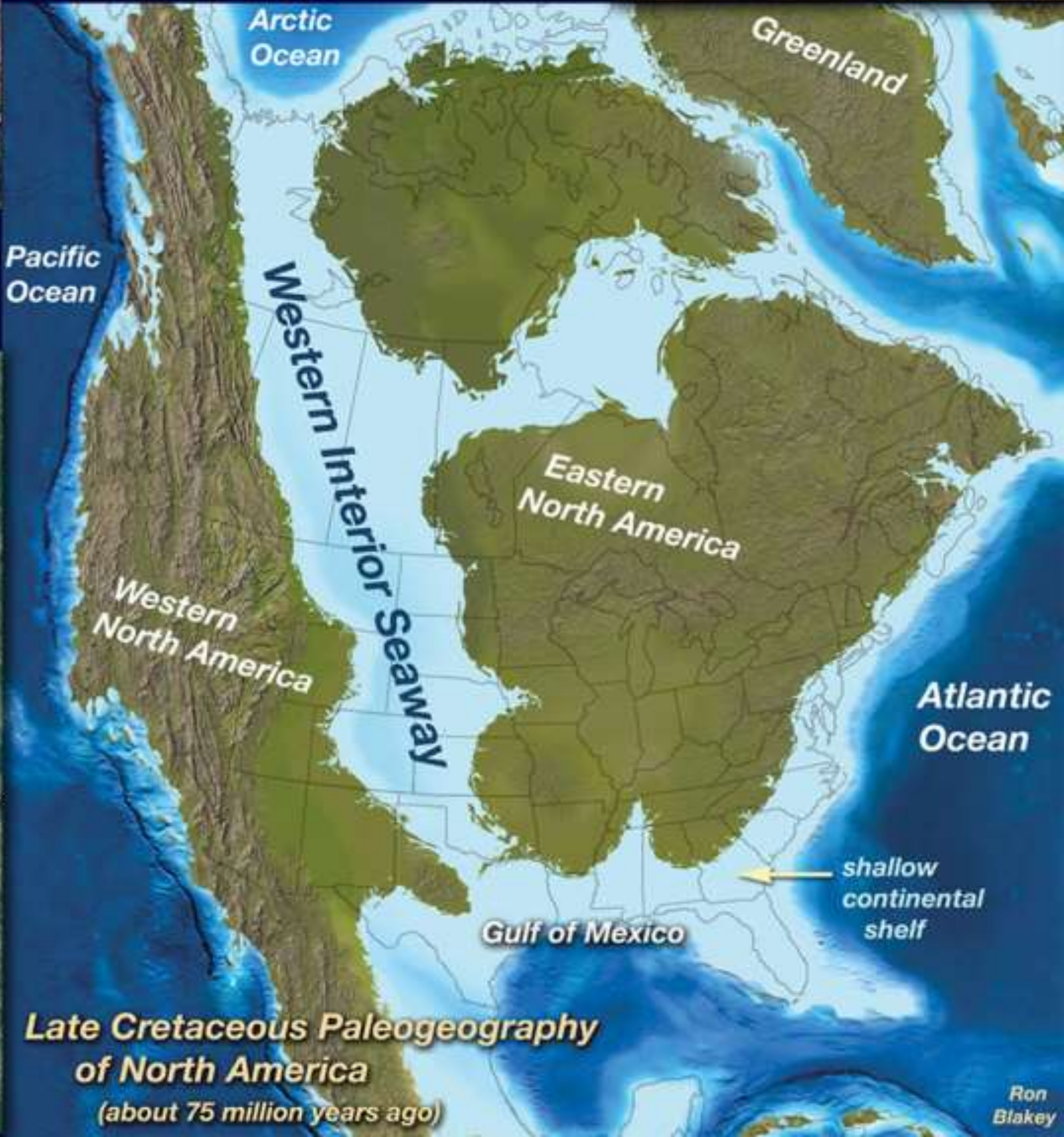
* lasted for 70 million years

"creta-" = chalk

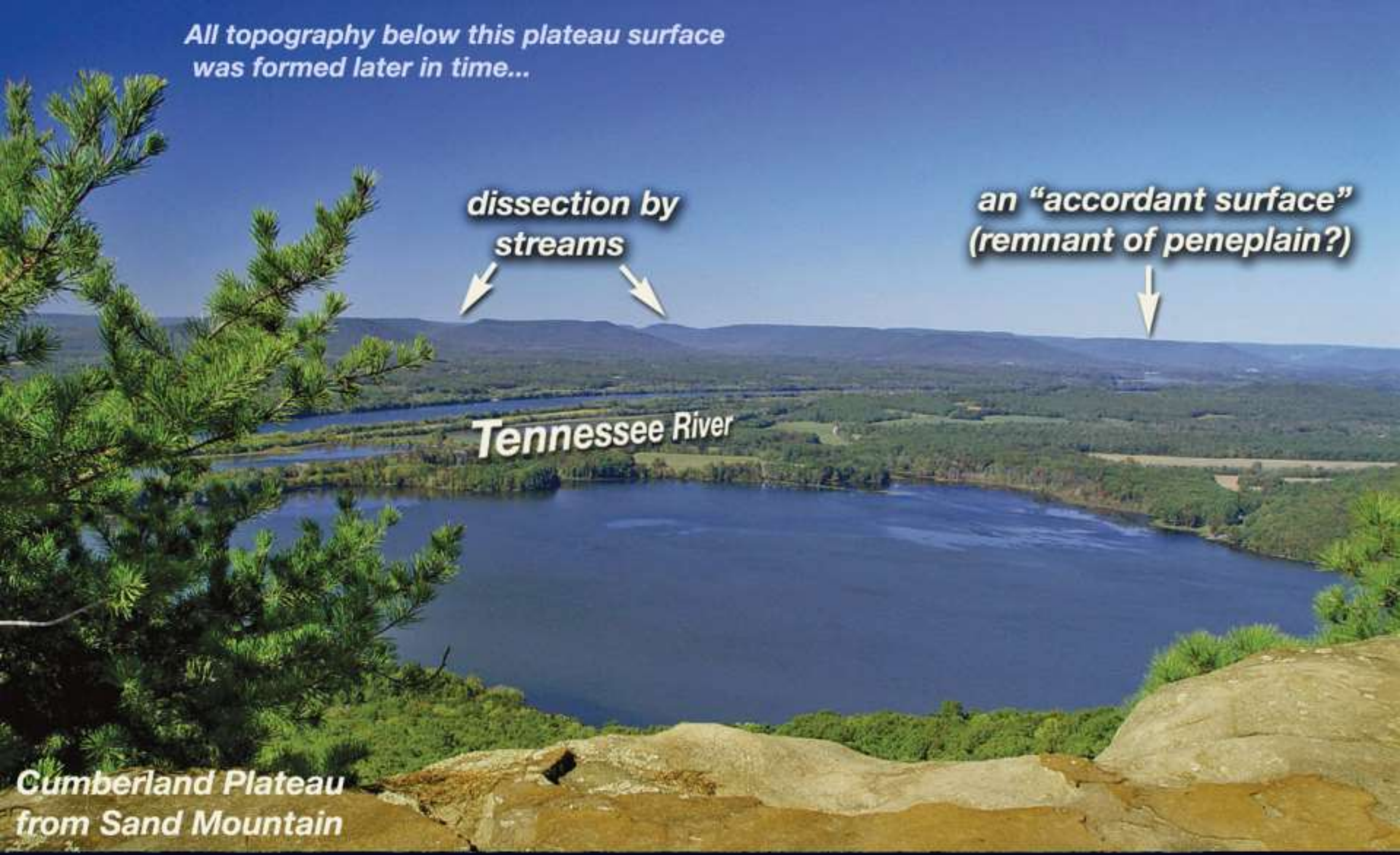
During the Late Cretaceous Period extremely high global sea levels brought an arm of the Gulf of Mexico known as the Mississippi embayment as far inland as today's Cairo, Illinois.

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






Probable Late Cretaceous Channels
of the Tennessee River
(Gulf of Mexico shoreline near Corinth, MS)
a reconstruction of
Appalachiosaurus
montgomeriensis
McWane Science Center,
in Birmingham
Tennessee River
Savannah, TN
Fall Line Hills
Pickwick Dam
Tennessee/Alabama State Line
50' deep
paleochannel
Corinth, MS
Lauderdale County, AL
Pickwick Lake
State Line
Florence
Wilson Dam
Iuka, MS
Muscle Shoals
Tuscumbia
Cherokee, AL
300' deep
paleovalley
Fall Line Hills
cross section view of
ancient river channel
now filled with gravel
ancient soil horizons formed
on top of channel-fill sediments
source: Tishomingo County Geology
and Mineral Resources, MS Dept. of
Nat. Resources-Bureau of Geology
Red Bay, AL
beds of Cretaceous gravel cap
the highest ridge tops in northwest Alabama



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.

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.

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.

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.

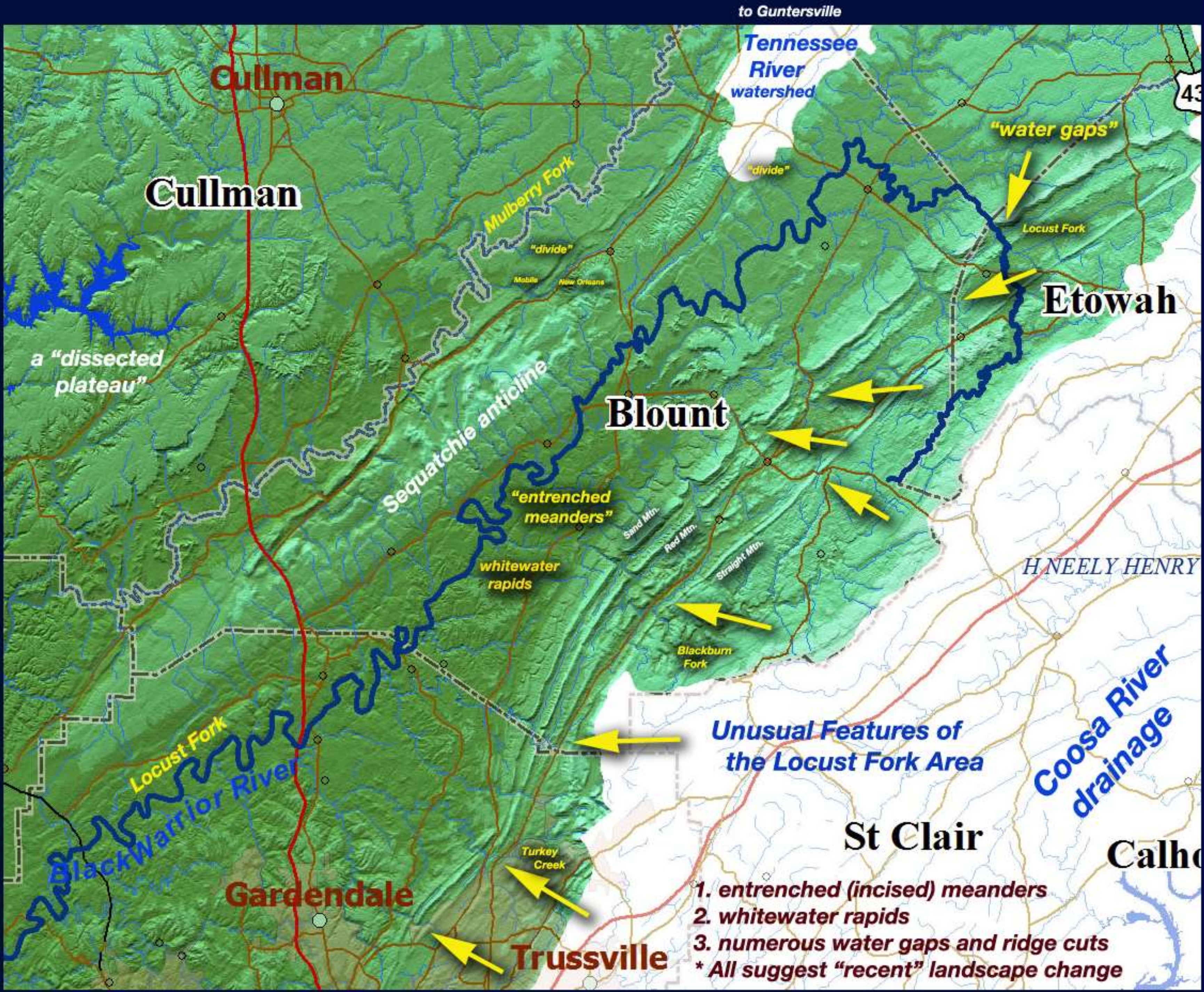
Incised streams such as the Locust Fork usually have steep banks and a narrow floodplain. During heavy rainfall, a huge volume of flood water may be funneled into the stream in a short period of time. Because of their narrow floodplains, streams such as these may undergo a rapid rise of many feet above 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.

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.


to Guntersville
Tennessee River watershed
Cullman
Cullman
"divide"
"water gaps"
Mulberry Fork
"divide"
Locust Fork
Etowah
a "dissected plateau"
Sequatchie anticline
Blount
"entrenched meanders"
Sand Mtn.
Red Mtn.
Straight Mtn.
whitewater rapids
H NEELY HENRY
Blackburn Fork
Locust Fork
Black Warrior River
Unusual Features of the Locust Fork Area
Coosa River drainage
St Clair
Turkey Creek
Gardendale
Trussville
1. entrenched (incised) meanders
2. whitewater rapids
3. numerous water gaps and ridge cuts
* All suggest "recent" landscape change

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

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diversion of existing streams to form the Alabama River

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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.

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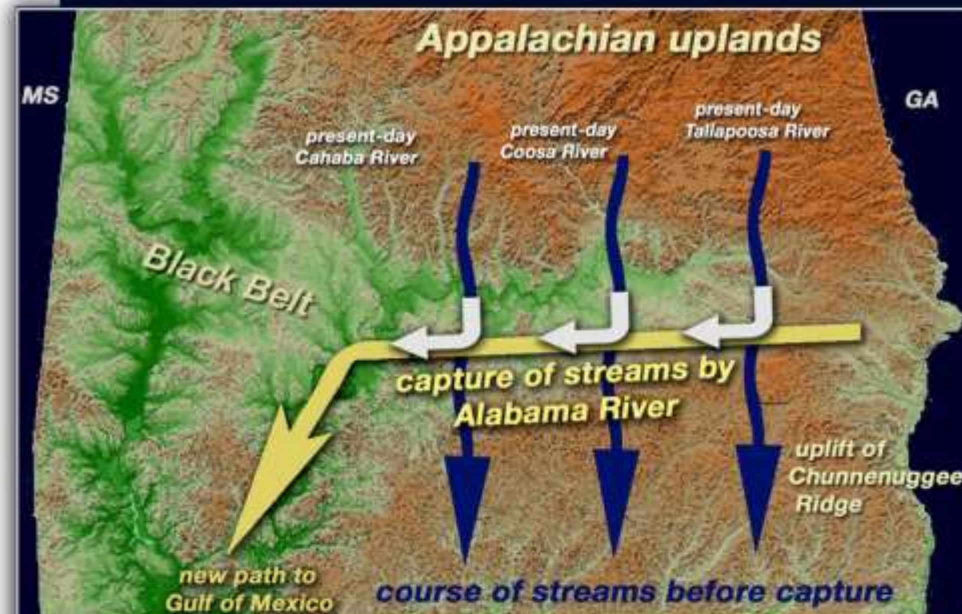
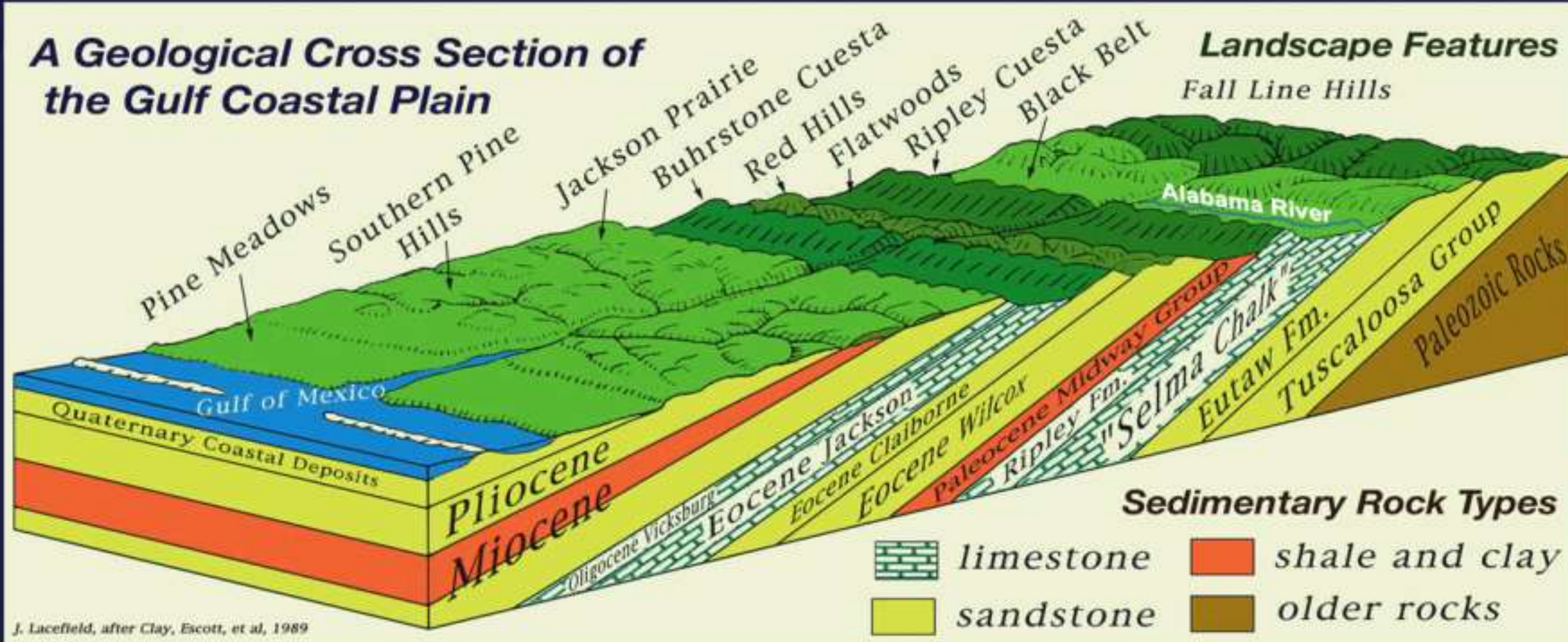


Geological uplift of the land has implications for the history of streams in the southern half of the state too.

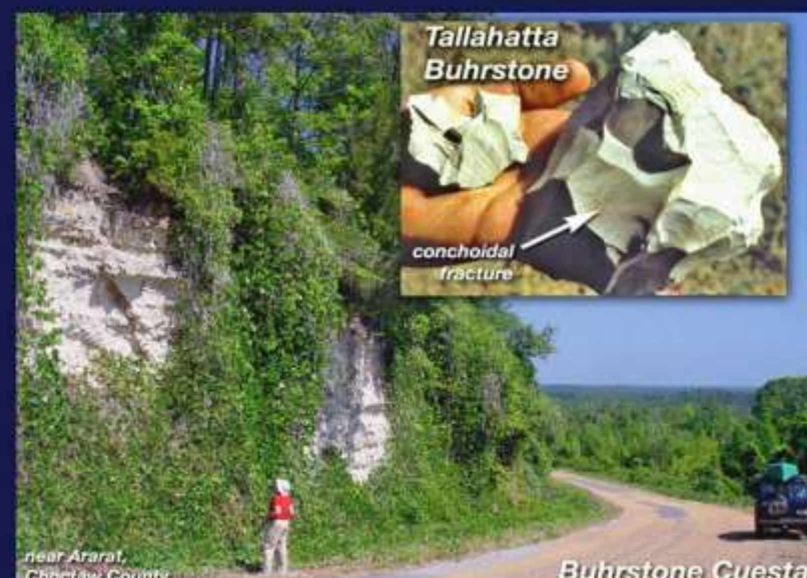
Again, these changes appear to be much more recent than previously known.



subsidence of coastal area

Tectonic Influences on Landscape Development

uplift of northern regions



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

Sean F. Gallen*, **Karl W. Wegmann**, and **DelWayne R. Bohnenstiehl**, *Dept. of Marine, Earth, and Atmospheric Sciences, North Carolina State University, 2800 Faucette Drive, Raleigh, North Carolina 27695, USA*

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

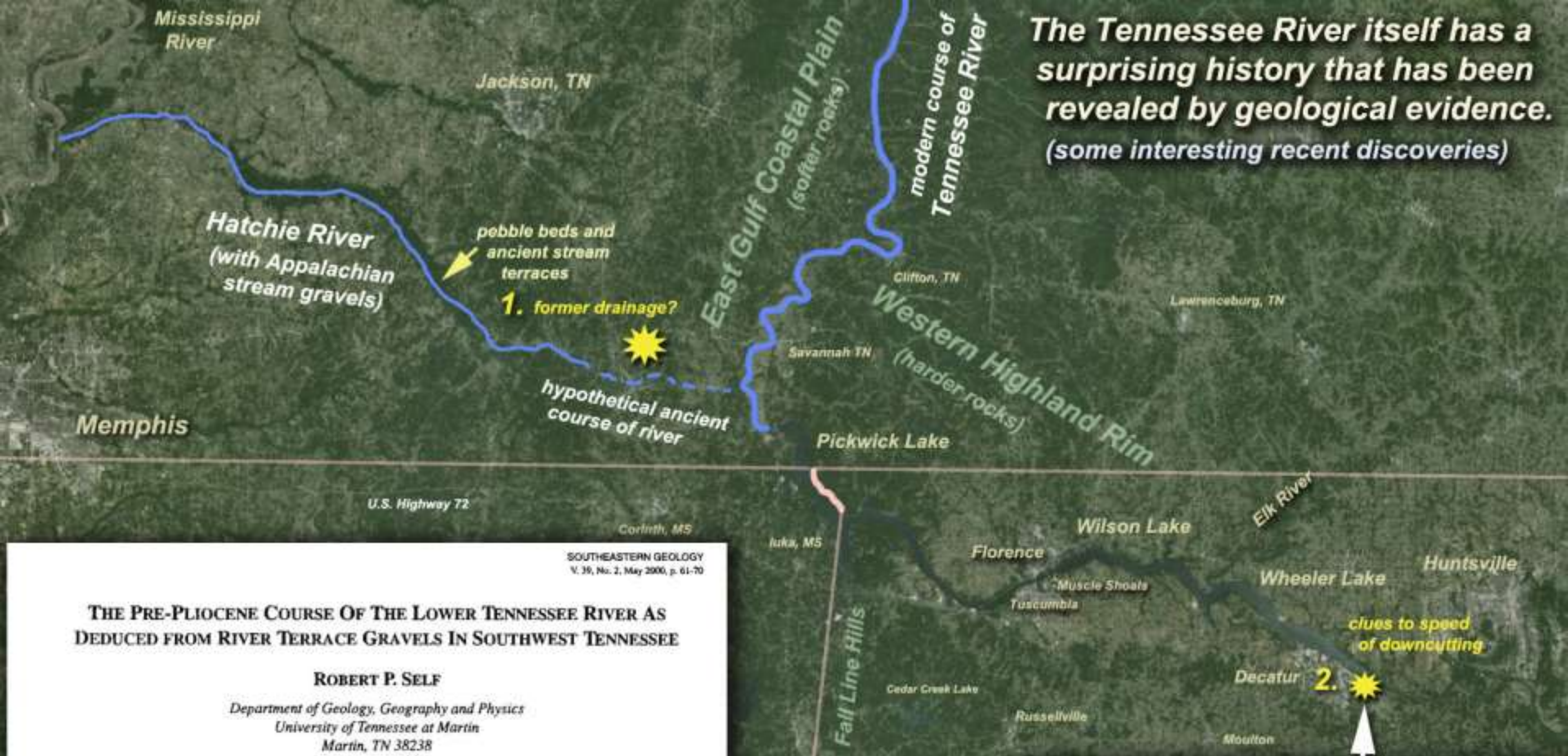
ceased shortly after Late Triassic rifting of the Atlantic margin (Hatcher, 1989).

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



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

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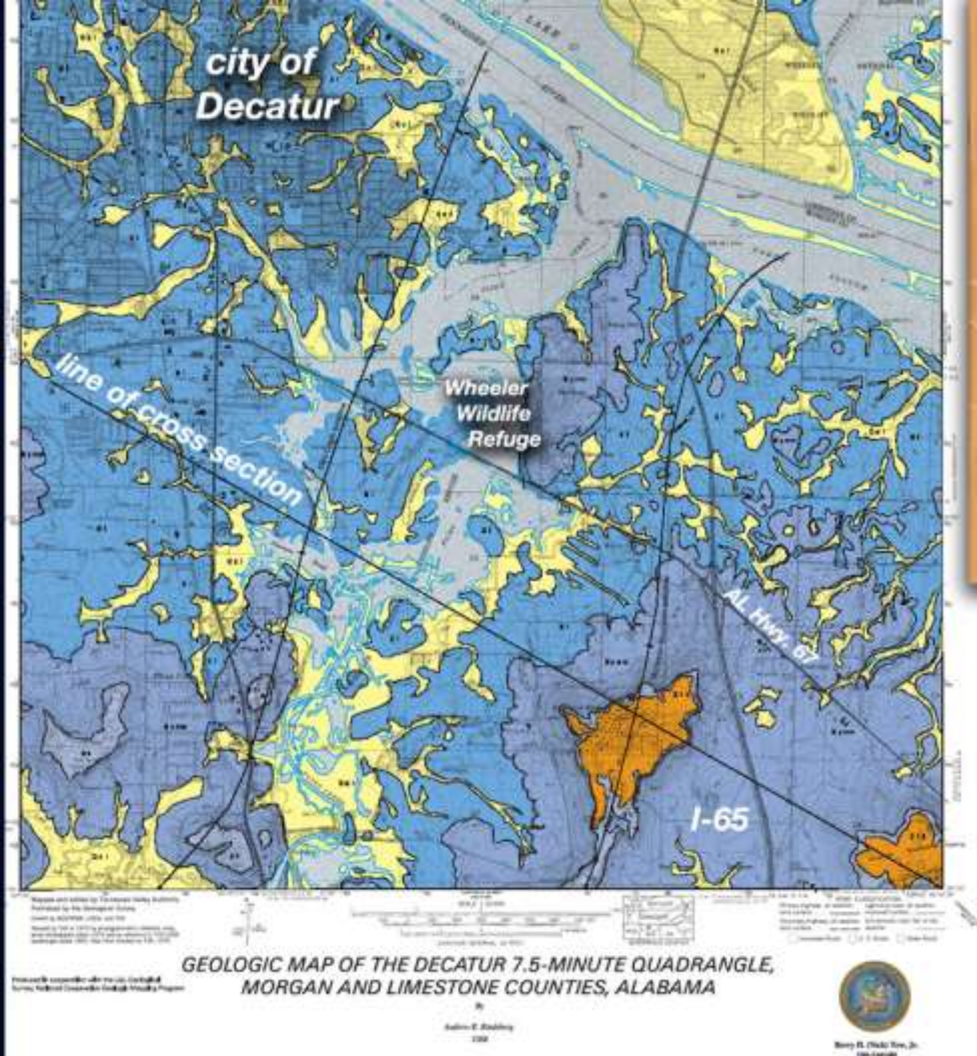
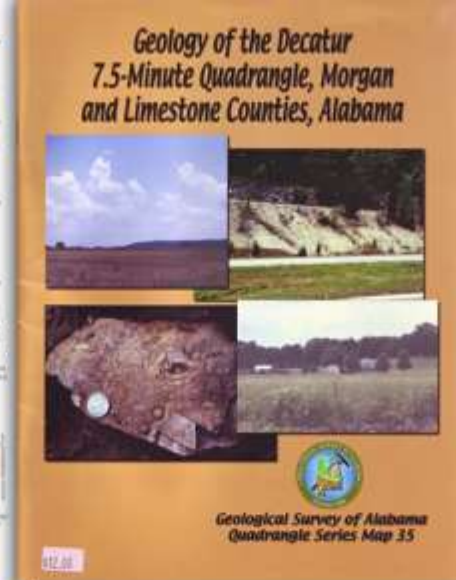
ABSTRACT

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-





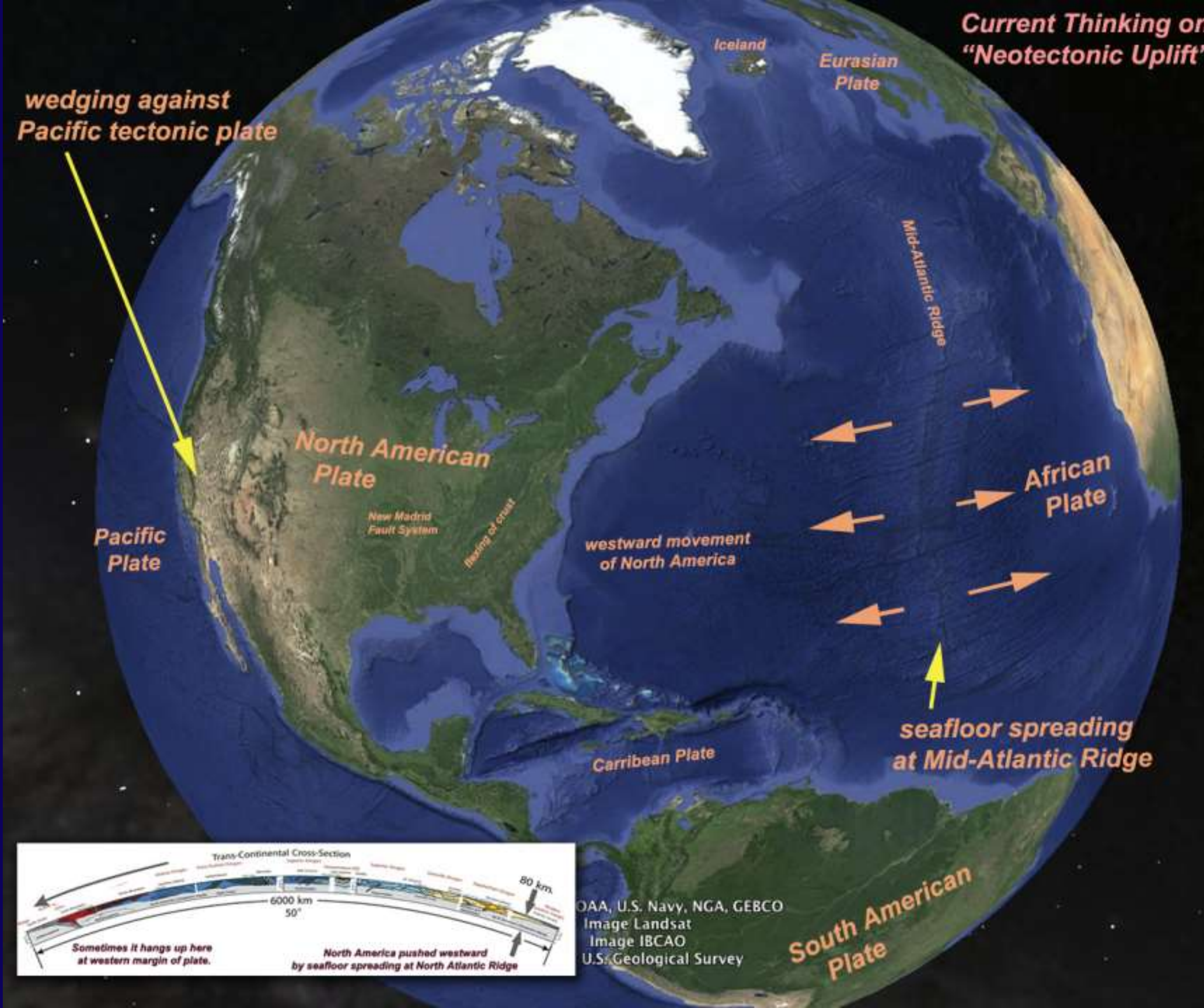
The Discovery of a Surprising Chapter of the Tennessee Valley's More Recent History

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

In Conclusion: So, how has this recently confirmed "neotectonic uplift" of the Southeast helped promote Alabama's unusually rich aquatic biodiversity?

The Paint Rock River example:

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

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

Knowing a bit about geological history is fundamental to understanding the roots of aquatic biodiversity — both the land and life are dynamic.