



# LATE CRETACEOUS TO MODERN GENESIS OF KARST IN THE APPALACHIAN GREAT VALLEY

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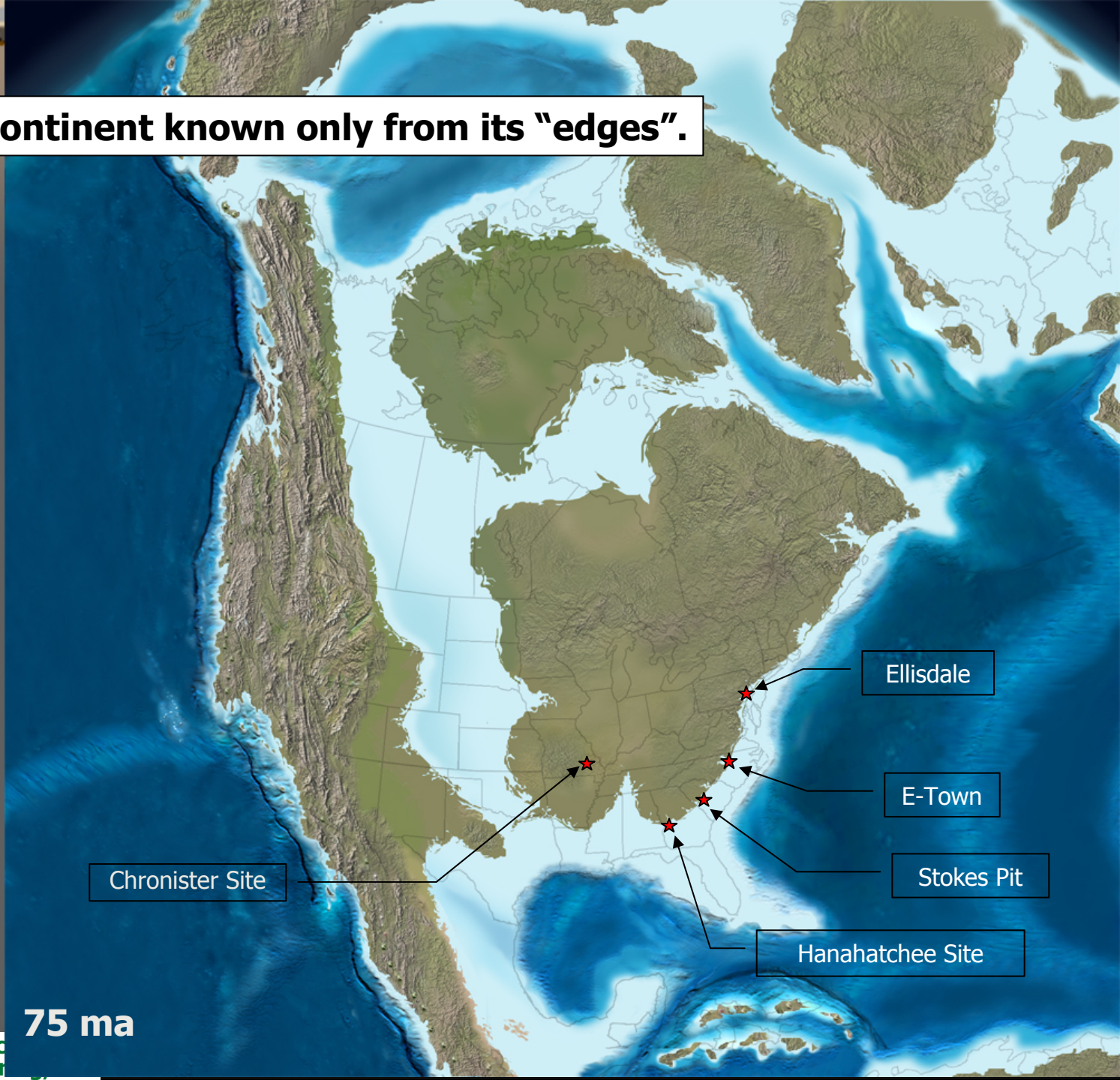


Laramidia

Appalachia

75 ma

...a continent known only from its "edges".



Chronister Site

Ellisdale

E-Town

Stokes Pit

Hanahatchee Site

75 ma

# A dinosaur in a sinkhole?



Charles Gilmore, 1874 - 1945



**Chronister Site**

# Chronister Site Chronology

- ⇒ A series of dinosaur caudal (tail) vertebrae were found in a cistern excavation in 1940 on the Chronister Farm in Bollinger County, MO.
- ⇒ First reported in the literature by Charles Gilmore (NMNH) in 1945 (published posthumously).
- ⇒ Reviewed and commented upon by Baird and Horner (Princeton Univ.) in 1979.
- ⇒ Renewed excavation by local amateurs and the NJSM started in 1985 and is continuing to date.

USNM  
16735



Chronister  
Site  
1987






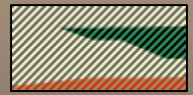








-  Platin limestone (Middle Ordovician)
-  Residual clay and gravel unit
-  Cotter dolomite (Lower Ordovician)



Red & Yellow clay – illite/smectite mixed layer lattice silicate major clay phase, 15 – 25% well-ordered quartz, kaolinite, no calcite.

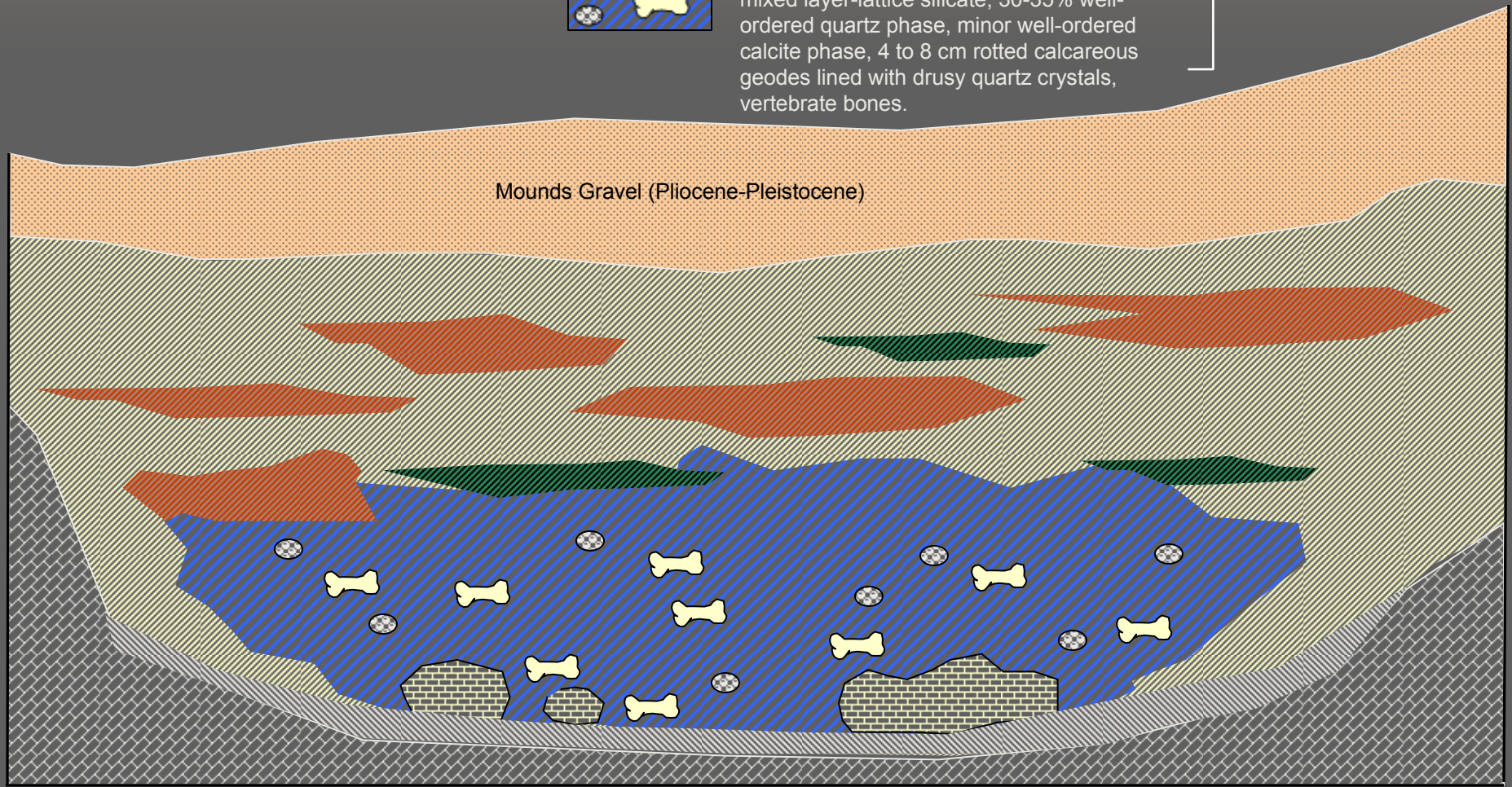
Green clay – mixed illite/smectite, 15% well-ordered quartz, no calcite.



Blue-Black clay - illite and illite/smectite mixed layer-lattice silicate, 30-35% well-ordered quartz phase, minor well-ordered calcite phase, 4 to 8 cm rotted calcareous geodes lined with drusy quartz crystals, vertebrate bones.

} Cretaceous

Mounds Gravel (Pliocene-Pleistocene)







So the geological setting of the Chronister Site begged the question:

**“...if there were Cretaceous age sediments and fossils in a karst feature in Missouri, could some of the karst of the Appalachian region date back to the Cretaceous as well?”**

**Dis my shock face!**



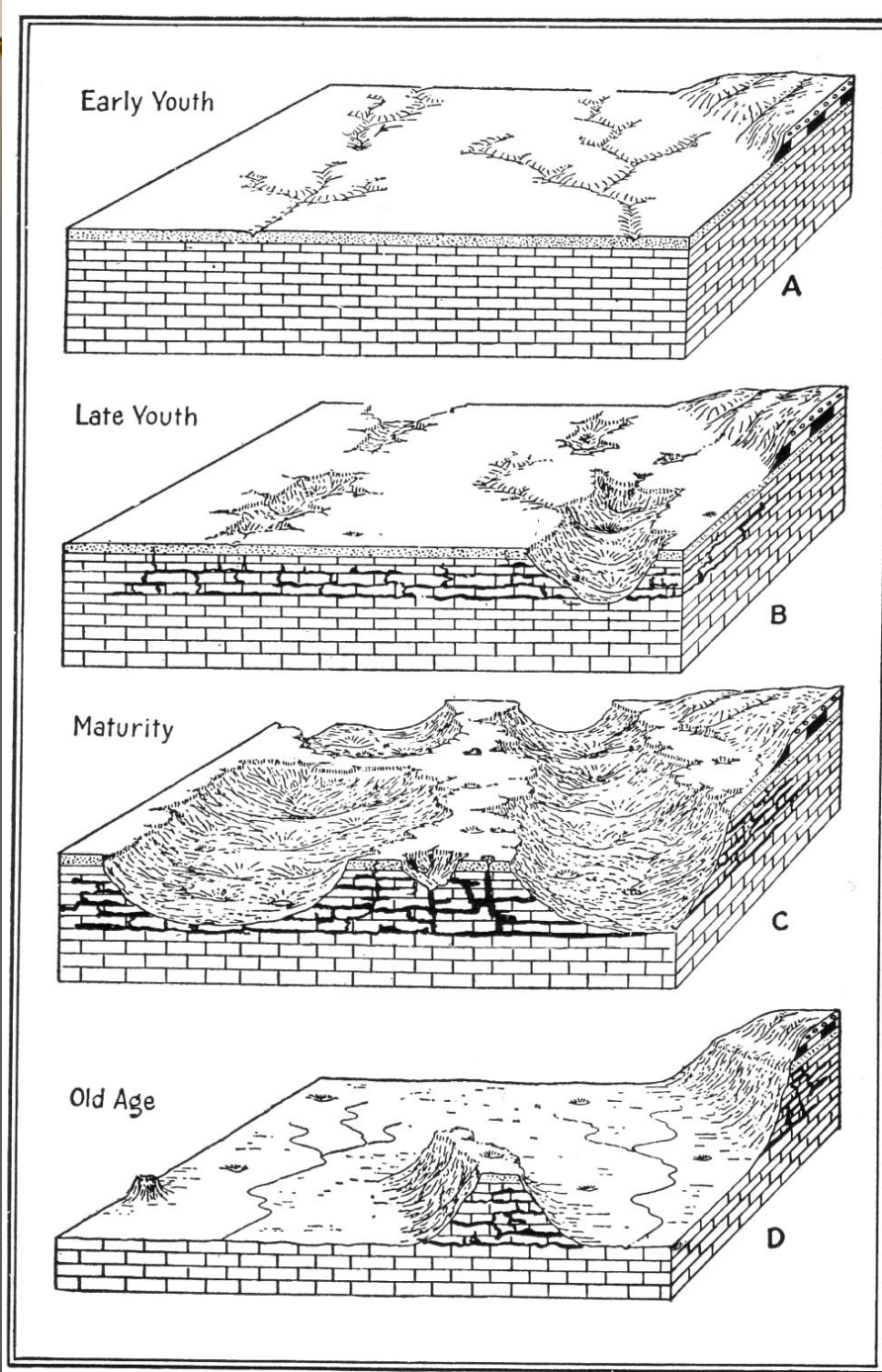
**See?**

[ICANHASCHEEZBURGER.COM](http://ICANHASCHEEZBURGER.COM)

The existing paradigm had always been that speleogenesis was a function of an ever-lowering base level, tied to denudation rates.

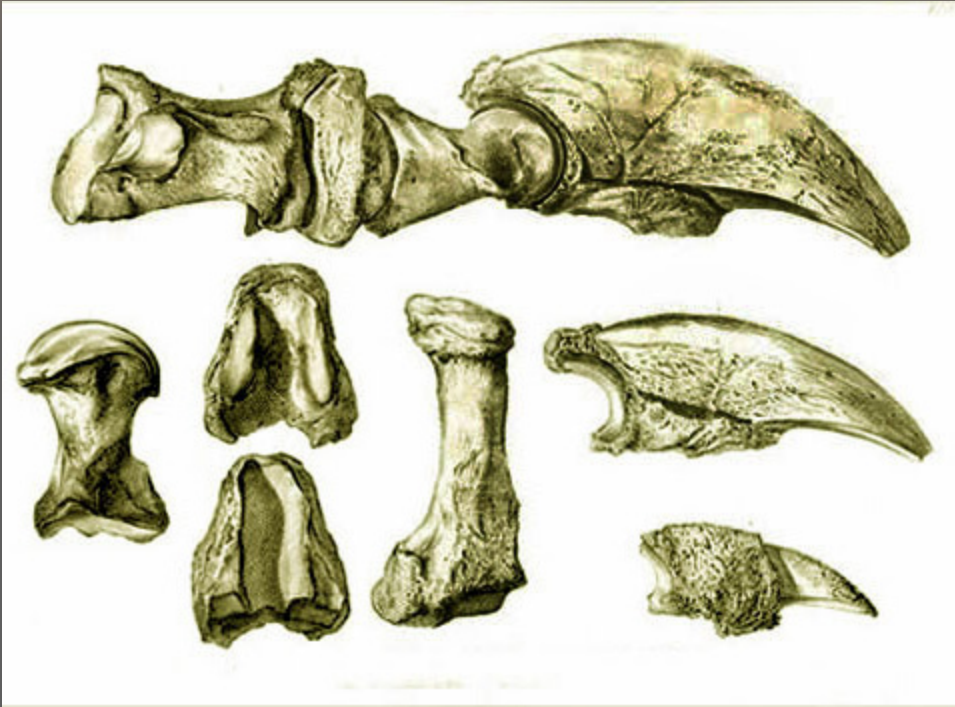
If true, the Appalachian karst could be no older than the Late Miocene.

The paleontological evidence seemed to support this contention.



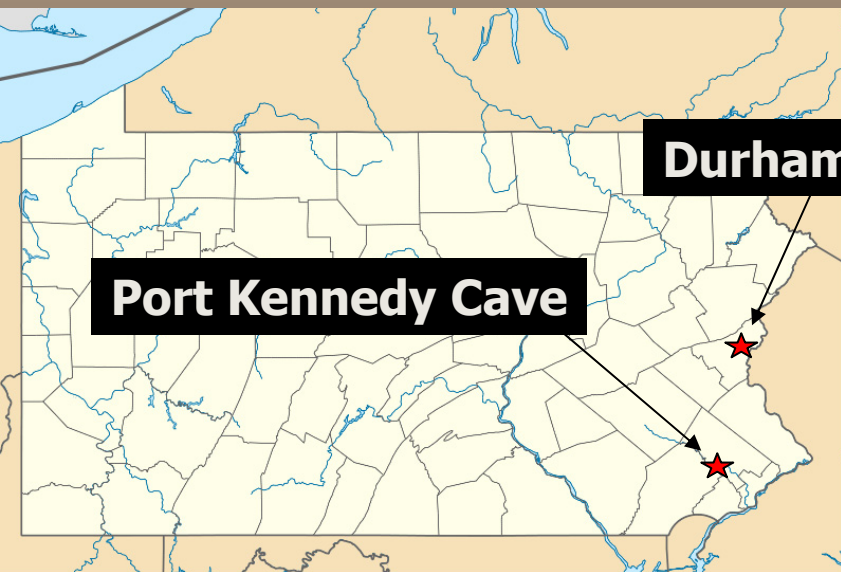


# Megalonyx (Jefferson's "Lion")



Presented to the American Phil. Society in 1797 by Thomas Jefferson, the type specimen was discovered in Haynes Cave in Greenbrier County, WV, the occasion of which is considered to be the advent of vertebrate paleontology in the United States.



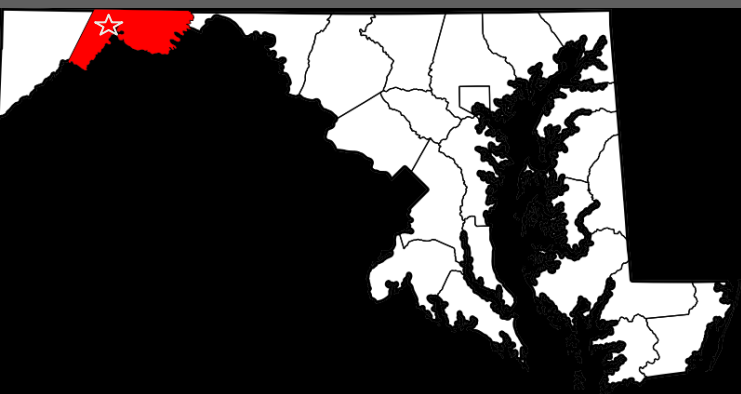


**Durham Cave**

**Port Kennedy Cave**



**Cumberland Bone Cave**



## NORTH AMERICAN LAND MAMMAL AGES Characterizing Assemblages

|               |   |                |
|---------------|---|----------------|
| RANCHOLABREAN | <i>Bison</i> , <i>Mammuthus</i> , <i>Equus</i> , Modern taxa  | 10 Ka - 0.5 Ma |
| IRVINGTONIAN  | <i>Mammuthus</i> , <i>Equus</i> , <i>Euceratherium</i> , <i>Smilodon</i> ,<br><i>Mocrotus</i>   | 0.5 - 1.8 Ma   |
| BLANCAN       | <i>Equus</i> , <i>Nannippus phelgon</i> , <i>Stegomastodon</i> ,<br><i>Borophagus diversidens</i> , <i>Trigonictis</i> , <i>Nekrolagus</i> ,<br><i>Procastoroides</i> , <i>Sigmodon</i> . | 1.8 - 4.5 Ma   |
| HEMPHILLIAN   | <i>Machairodus</i> , <i>Agriotherium</i> , <i>Plesiogulo</i> , <i>Osteoborus</i> ,<br><i>Osbornoceros</i> , <i>Prosthennops</i> , <i>Pliohippus</i> ,<br><i>Astrohippus</i>               | 4.5 - 8.2 Ma   |

Nevertheless....



PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR

PROMOTING USEFUL KNOWLEDGE

Vol. IX

JANUARY 1862 TO DECEMBER 1864

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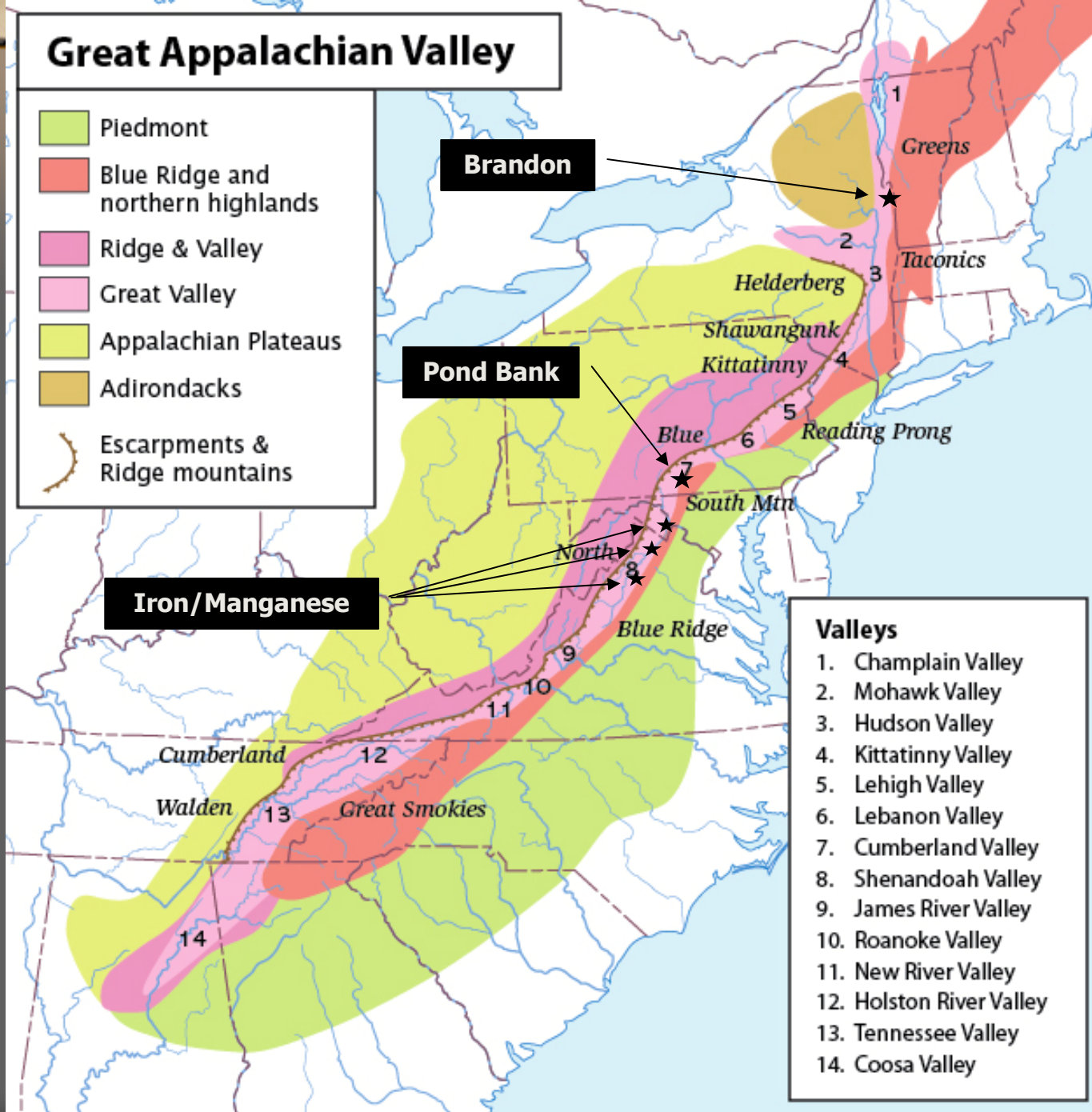
The proverbial  
“fly in the ointment...”

Lesley, 1864

Mr. Lesley described a recent discovery of Lignite in iron ore at Pond Bank, ten miles east of Chambersburg, in Franklin County, Pennsylvania, and described the importance of the discovery in a theoretical point of view, its analogy with the Brandon deposit in Vermont, and its influence on the determination of the age of the present surface of the land. Specimens from the deposit were exhibited

# Great Appalachian Valley

-  Piedmont
-  Blue Ridge and northern highlands
-  Ridge & Valley
-  Great Valley
-  Appalachian Plateaus
-  Adirondacks
-  Escarpments & Ridge mountains

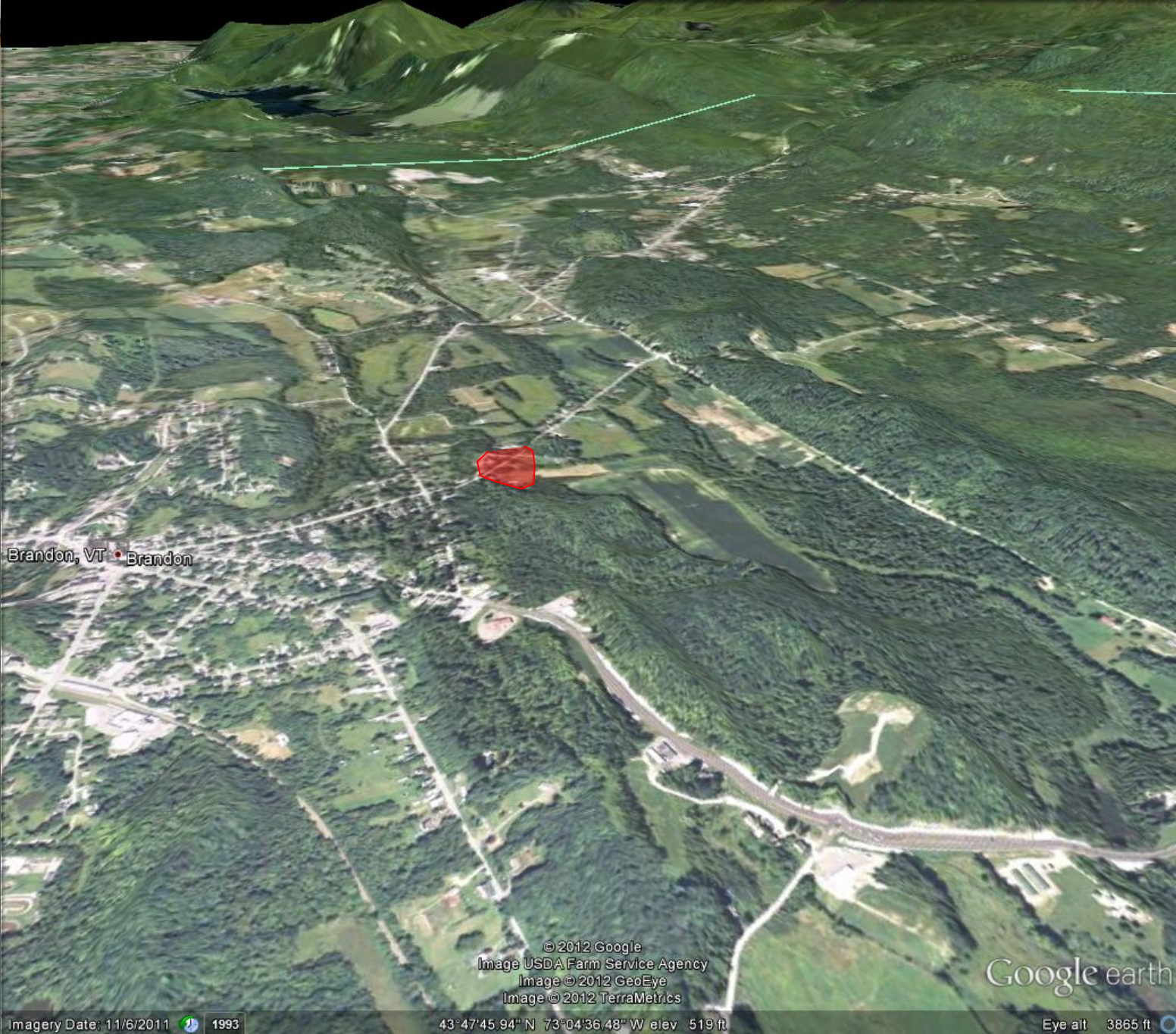


**Brandon**

**Pond Bank**

**Iron/Manganese**

- Valleys**
1. Champlain Valley
  2. Mohawk Valley
  3. Hudson Valley
  4. Kittatinny Valley
  5. Lehigh Valley
  6. Lebanon Valley
  7. Cumberland Valley
  8. Shenandoah Valley
  9. James River Valley
  10. Roanoke Valley
  11. New River Valley
  12. Holston River Valley
  13. Tennessee Valley
  14. Coosa Valley



Brandon, VT • Brandon

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Image © 2012 GeoEye  
Image © 2012 TerraMetrics

Google earth

Imagery Date: 11/6/2011 1993

43°47'45.94" N 73°04'36.48" W elev 519 ft

Eye alt 3865 ft



Imagery Date: 2/28/2007 1994

39°52'40.12" N 77°32'14.77" W elev 867 ft

Eye alt 4621 ft

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Image © 2012 TerraMetrics

Google earth







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Google earth

Imagery Date: 12/31/2008  1994

38°23'04.58" N 78°37'31.52" W elev. 1061 ft

Eye alt 10511 ft 

- ➔ Lesley correctly pointed out that all of these deposits consisted of unconsolidated sediments located within “cavernous depressions” in the Early Paleozoic carbonate rocks, and in a lineament along the southeastern side of the AGV.
- ➔ Lesley postulated a Late Tertiary age for the deposits.
- ➔ His observations would remain mostly ignored, with the occurrence at Pond Bank viewed as an “anomaly”.

# “The Formation of Bauxite in Sinkholes”

- ⇒ Adams correctly identified karst bauxite deposits, stating they formed “under peculiar physiographic and climatic conditions, and that all are of the approximate same age.”
- ⇒ “...these deposits are related to a definite physiographic stage of development, being formed contemporaneously with those of the Coastal Plains which are *associated with Eocene sediments.*”

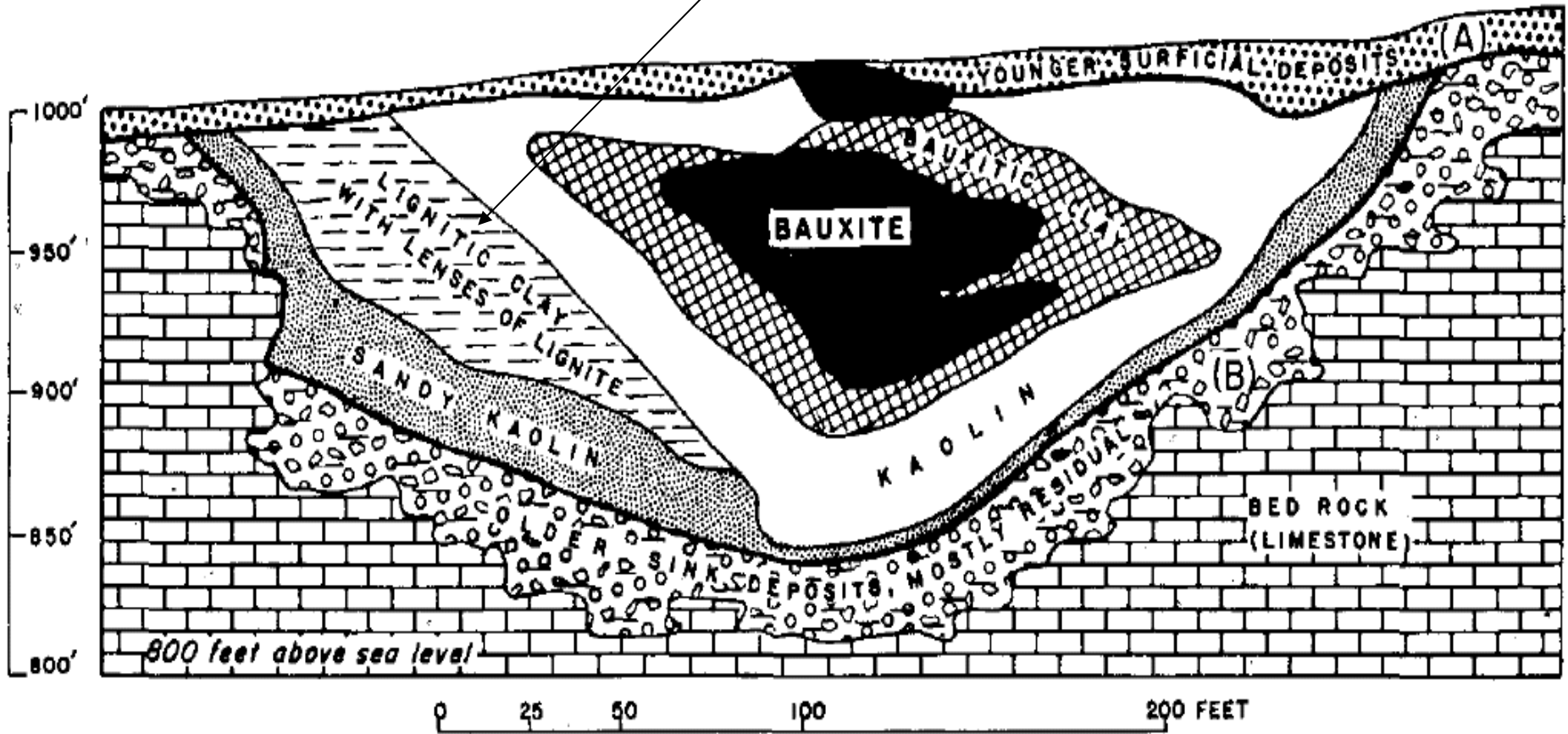
*from Adams, 1923, Journal of Economic Geology 18(4)*

# King, 1949

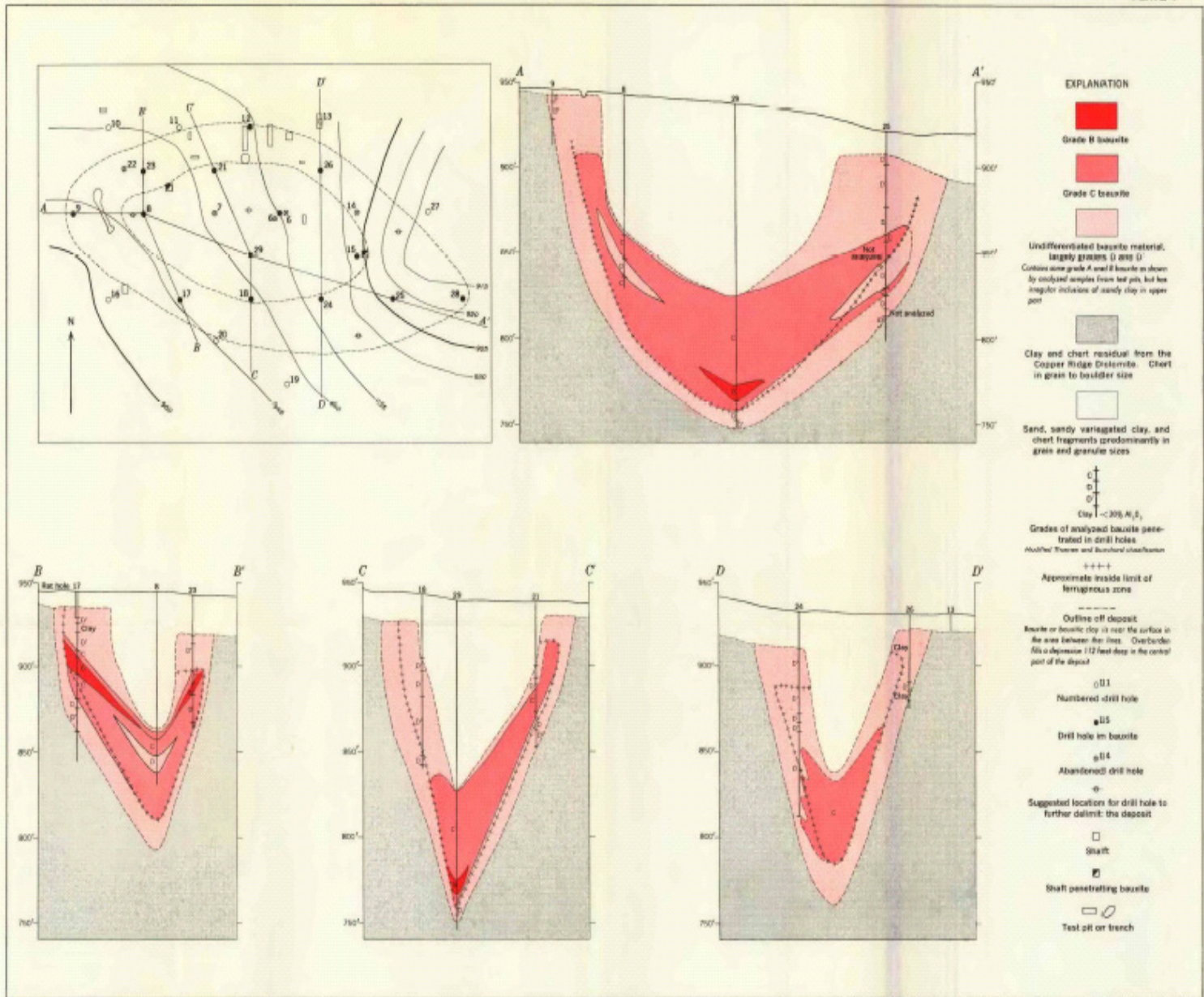
The history of the valley floor before the deposition of the gravels evidently occupied a long period of geologic time, even though the land surface itself was not notably lowered by erosion. First, residuum accumulated slowly as a result of rock weathering, probably in a warm and moist climate, under conditions of peneplanation. Afterwards, deposits such as the ancient gravels were laid down locally on the surface. In Georgia and Alabama, fossil plants in deposits on the valley floor surface indicate that these deposits are of early Tertiary age. The deposits in Virginia may be as ancient, but their age has not been proved. After the deposition of the ancient deposits, both their surface and that of the residuum was eroded before the older gravels were deposited. If the older gravels are Pleistocene, the events which preceded their deposition would seem to require a considerable span of Tertiary time.

# Cherokee County Alabama Karst Bauxite Deposit

Midwayan (Early Paleocene)  
pollen in the lignite



J. Bridge, 1950



TOPOGRAPHIC MAP AND SECTIONS OF THE J. F. SMITH PROSPECT, SUMMIT KNOBS AREA, CHATTANOOGA DISTRICT, TENNESSEE

INTERIOR—GEOLOGICAL SURVEY, ALBANY, N. Y.—1965

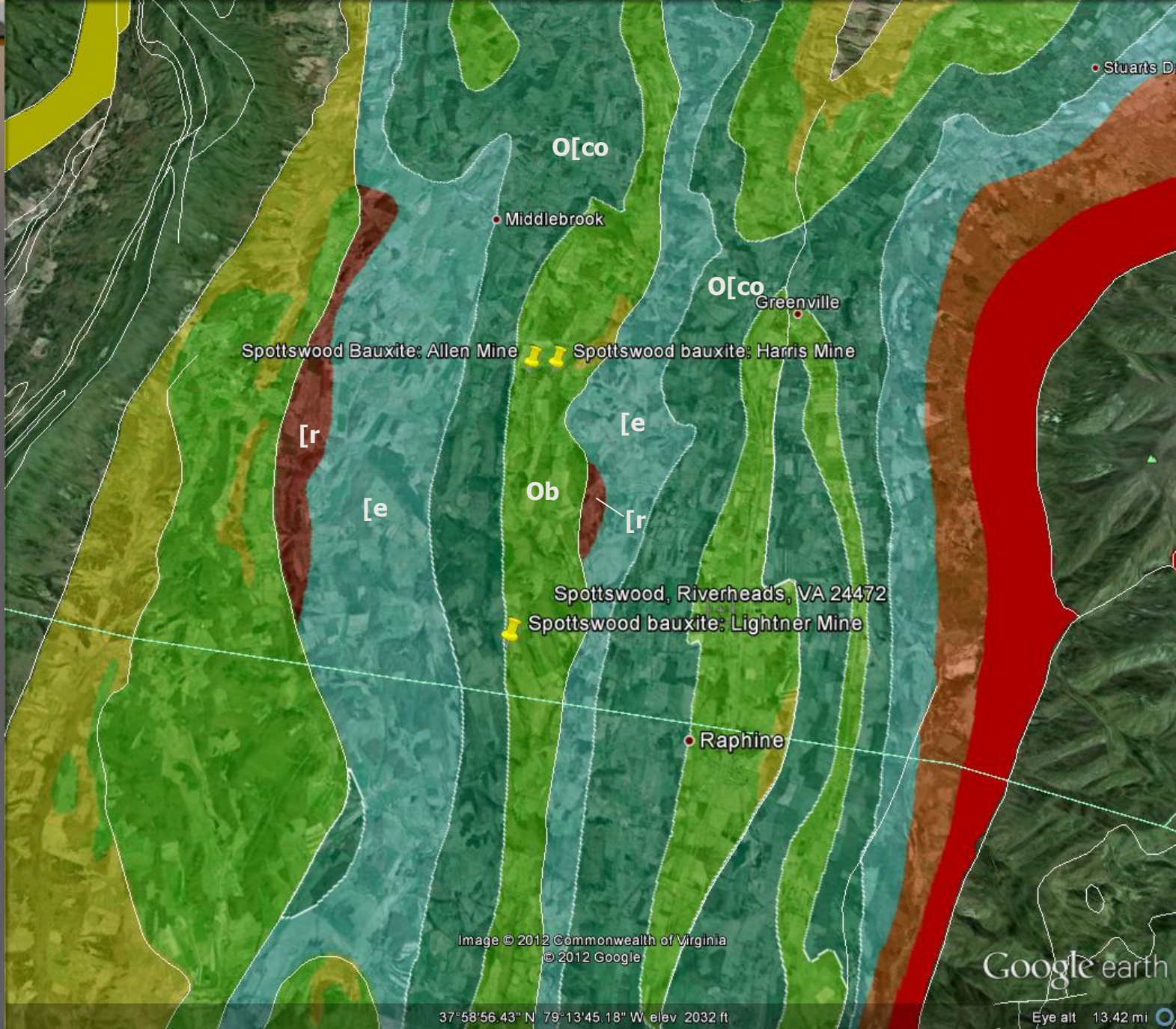
Geology by J. C. Dunlap, 1943



FIGURE 2.—The Lightner mine, Virginia. View to the south from north rim of pit. Photograph by J. Bridge, July 1942.



## Lightener Mine 2012







# Calcite-indurated pisolitic clay fill in Linville Quarry Cave



# Sears, 1957 – Brushy Mountain K Lignite

## LATE CRETACEOUS EROSION SURFACE IN SOUTHWEST VIRGINIA

Charles E. Sears

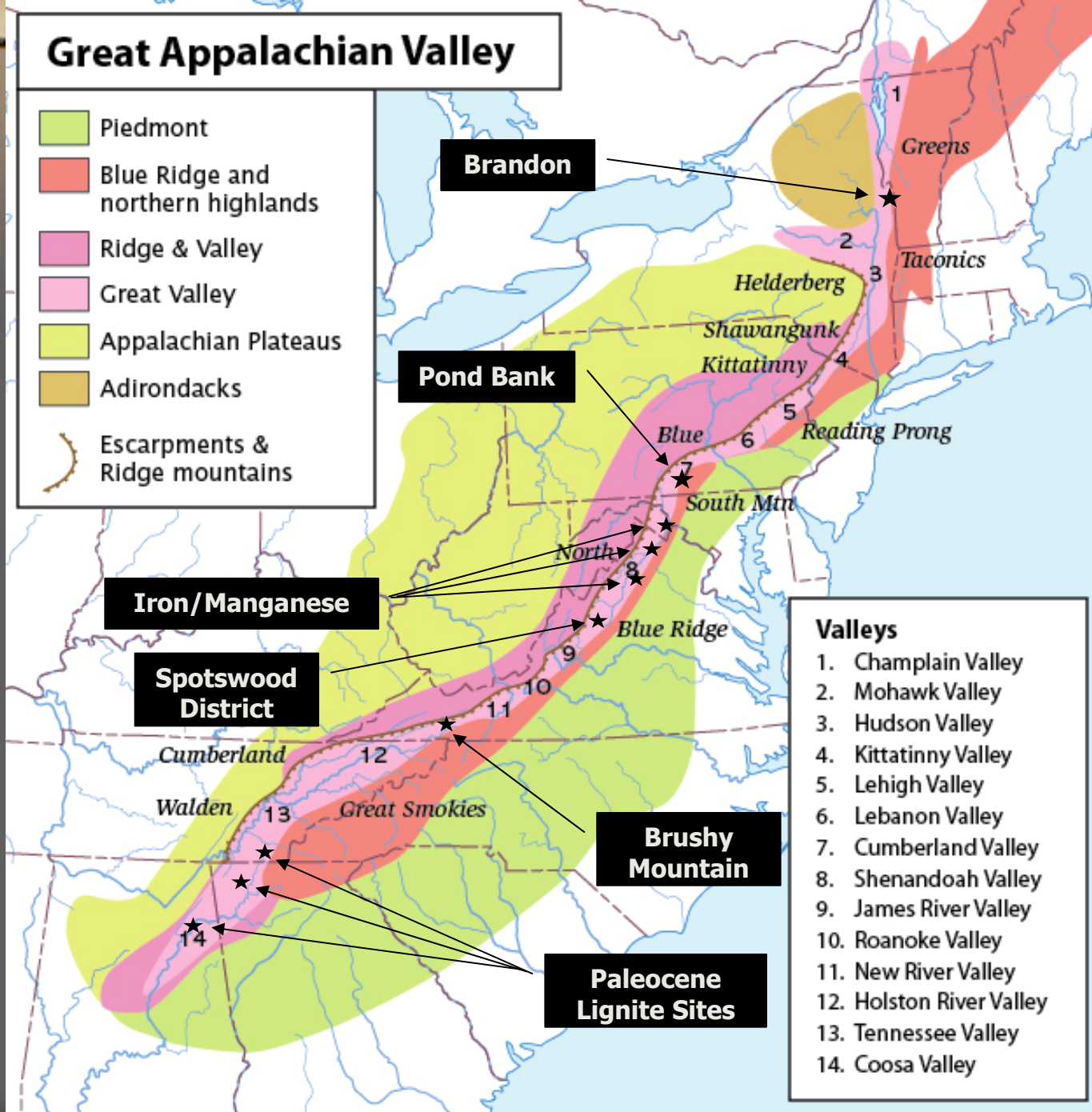
*Department of Geological Sciences, Virginia Polytechnic Institute, Blacksburg, Va.*

A late Cretaceous or Early Tertiary erosion surface in southwestern Virginia is indicated by the presence of a lignite lens in colluvium overlying a belt of Shady dolomite at an elevation of 3150 feet on Brushy Mountain, Smyth County, Virginia. On discovery, specimens of the lignite were submitted to Dr. Elso S. Barghoorn of Harvard who established their age by botanical means. The surface on which the plant remains accumulated appears to have been a fairly low-lying erosional surface drained by northwestward-flowing streams.

Apparently many deposits of manganese, residual silica sand, and clay and gossans were formed during this time; for example, formation of the manganese-bearing clays appears to be related to long chemical weathering of colluvium and rocks overlying the Shady dolomite with subsequent engulfment of the resulting materials as the underlying Shady dolomite underwent chemical leaching. These deposits now occur in areas that appear to represent parts of the erosion surface that have experienced the least subsequent erosion and thus may be considered to be erosional remnants of the once more extensive erosion surface. Recognition of this erosion surface is of special significance to the understanding of many of the mineral deposits of the region. It is believed that deposits of manganese, silica sand, and clay, gossans on metallic sulphides, and possibly other materials in the area can be discovered more readily and worked more intelligently if the erosional history of the area is made a primary consideration.

# Great Appalachian Valley

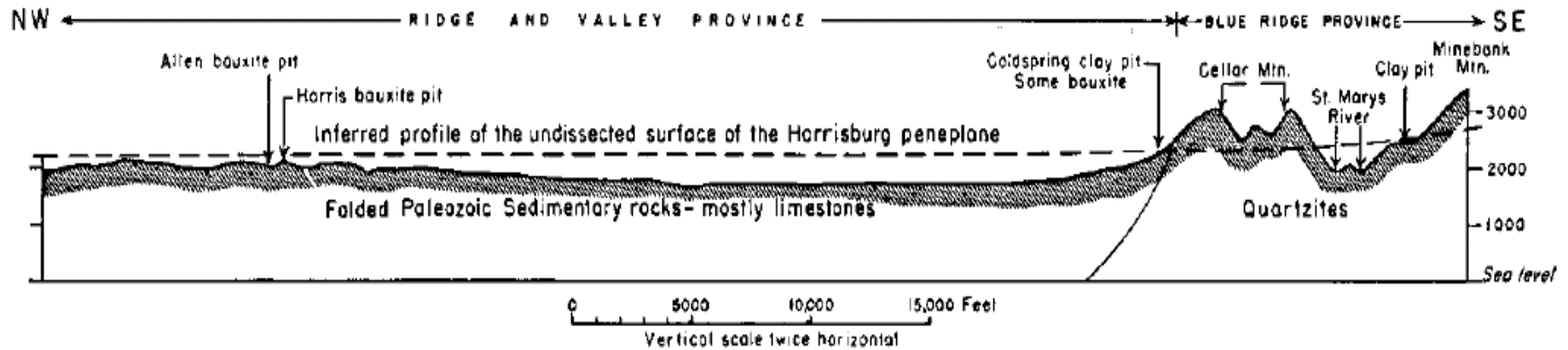
-  Piedmont
-  Blue Ridge and northern highlands
-  Ridge & Valley
-  Great Valley
-  Appalachian Plateaus
-  Adirondacks
-  Escarpments & Ridge mountains



## Valleys

1. Champlain Valley
2. Mohawk Valley
3. Hudson Valley
4. Kittatinny Valley
5. Lehigh Valley
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8. Shenandoah Valley
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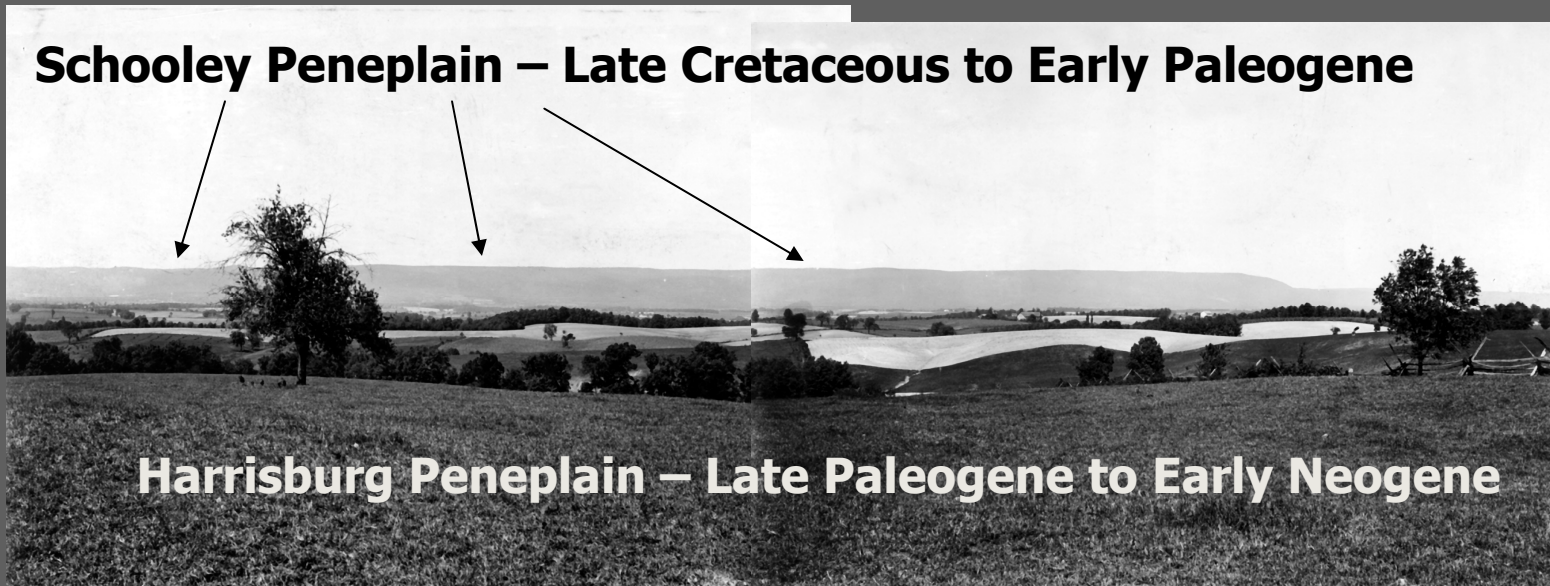
## Josiah Bridge reviewed the known AGV bauxite deposits, and proposed a model for their genesis in 1950



- ⇒ Bridge's model built upon the "Davisian" concept of peneplanation (geomorphological punctuated equilibrium).
- ⇒ He viewed the bauxite, kaolin and lignite as preserved in sediment "traps" remnants of the ancient Harrisburg Peneplain and dating from the Late Cretaceous or Paleogene.

# The Legacy of Wm. Davis

⇒ In the late 19<sup>th</sup> century, Davis proposed a four-stage evolution of the Appalachian landscape, based on the concept of “peneplanation”.

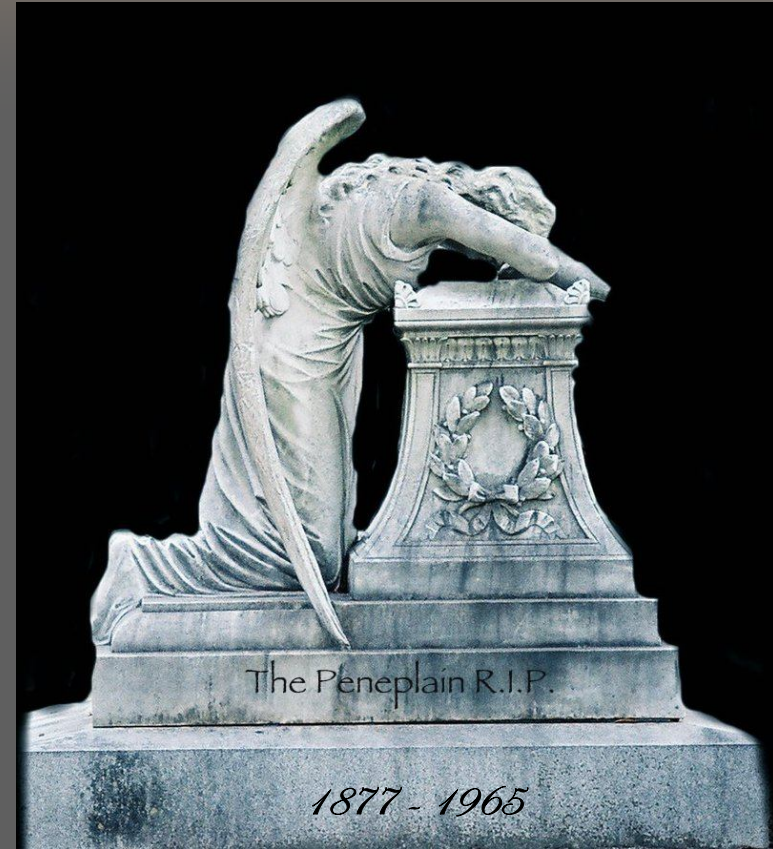


# Hack, 1965

By JOHN T. HACK

GEOLOGICAL SURVEY PROFESSIONAL PAPER 484

*A geomorphological study in which it is assumed that the erosion and downwasting of the central Appalachians were continuous and uninterrupted by periods of baseleveling*



- ➔ Hack's hypothesis reposed upon the idea that the Davisian "peneplains" were a function of differential erosion, controlled by the lithologies of the rock as downcutting occurred.
- ➔ Hack rejected the idea of Davis' "punctuated equilibrium" model, which assumed short periods of intense weathering and transport, punctuating lengthy periods of quiescence.

# Tschudy, 1965

- ⇒ Studied pollen samples obtained from lignitic clay on the Pond Bank spoils heap.
- ⇒ Concluded that the pollen was deposited in a freshwater environment.
- ⇒ All fossils were triporate “Normapolles” zone angiosperm taxa, and established a Turonian through Campanian (Late Cretaceous) age for the deposit.



**Normapolles Zone**

**Appalachia**

**Laramidia**

**75 ma**



# Pierce, 1965

- ⇒ In concurrence with Hack's hypothesis, Pierce concluded that the Pond Bank Deposit had been “lowered” hundreds of feet.

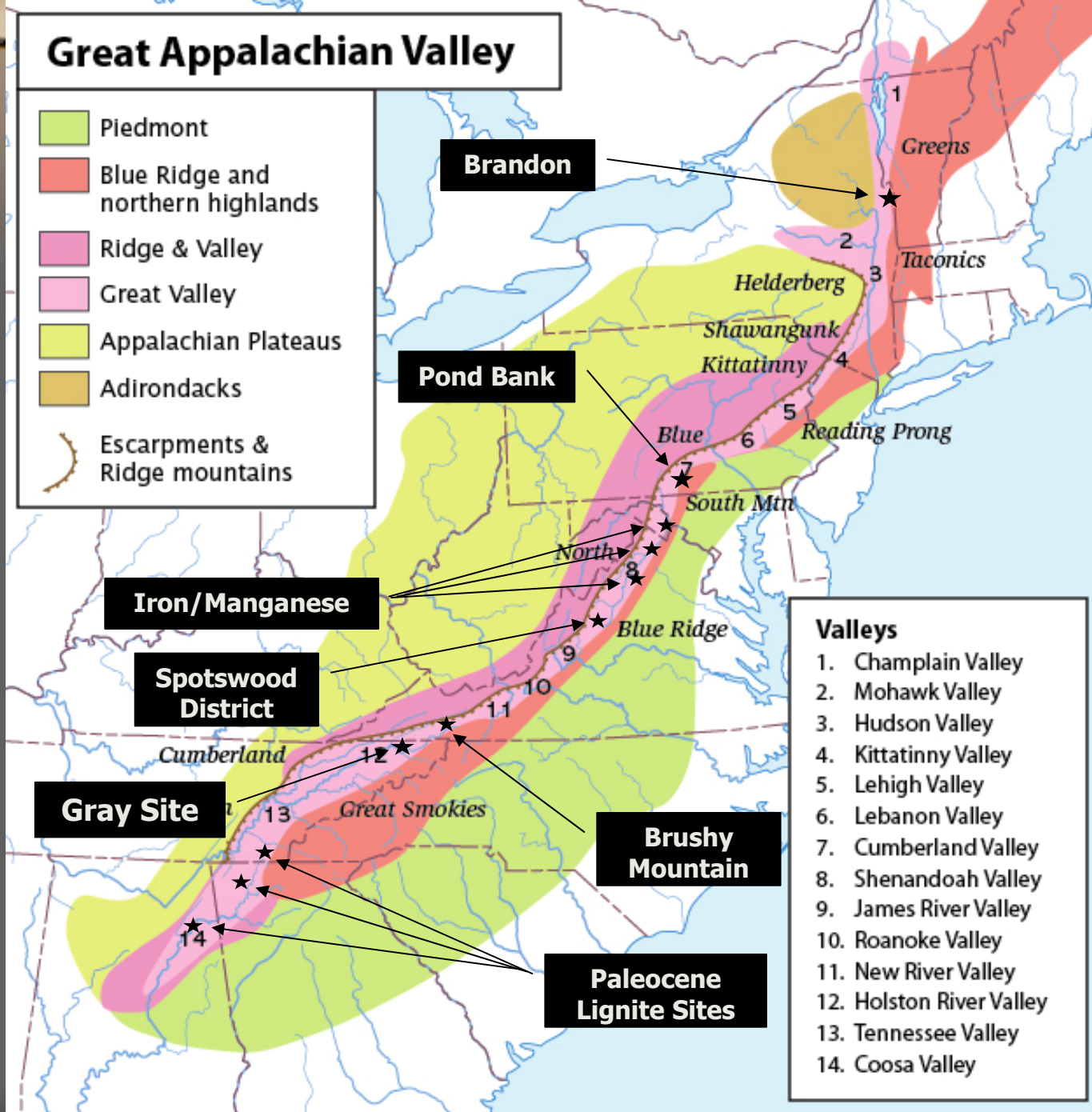
*Abstract.*—A lignitic terrestrial deposit of Late Cretaceous age appears to rest on more than 170 feet of residuum from carbonate rocks. After accumulation, probably in a sink, this deposit may have been lowered hundreds of feet by solution of the underlying carbonate rocks. This lowering of the deposit is consistent with regional rates of erosion and with evidence of lowering of other Appalachian surficial deposits.

# But...

- ⇒ The Pond Bank lignite contained intact logs and other woody megafossils, which would have been expected to be crushed, distorted and/or obliterated by continuous “lowering” of unconsolidated sediments for “hundreds” of feet.
- ⇒ Coring at the Pond Bank site in 2004 revealed hundreds of feet of colluvium below the lignite layer, and not carbonate residuals, as Pierce had proposed.

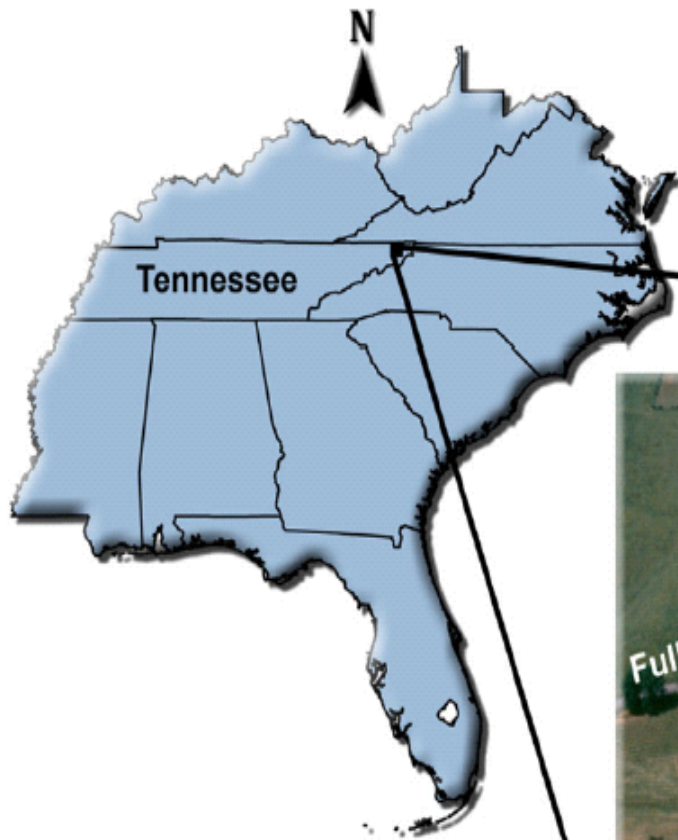
# Great Appalachian Valley

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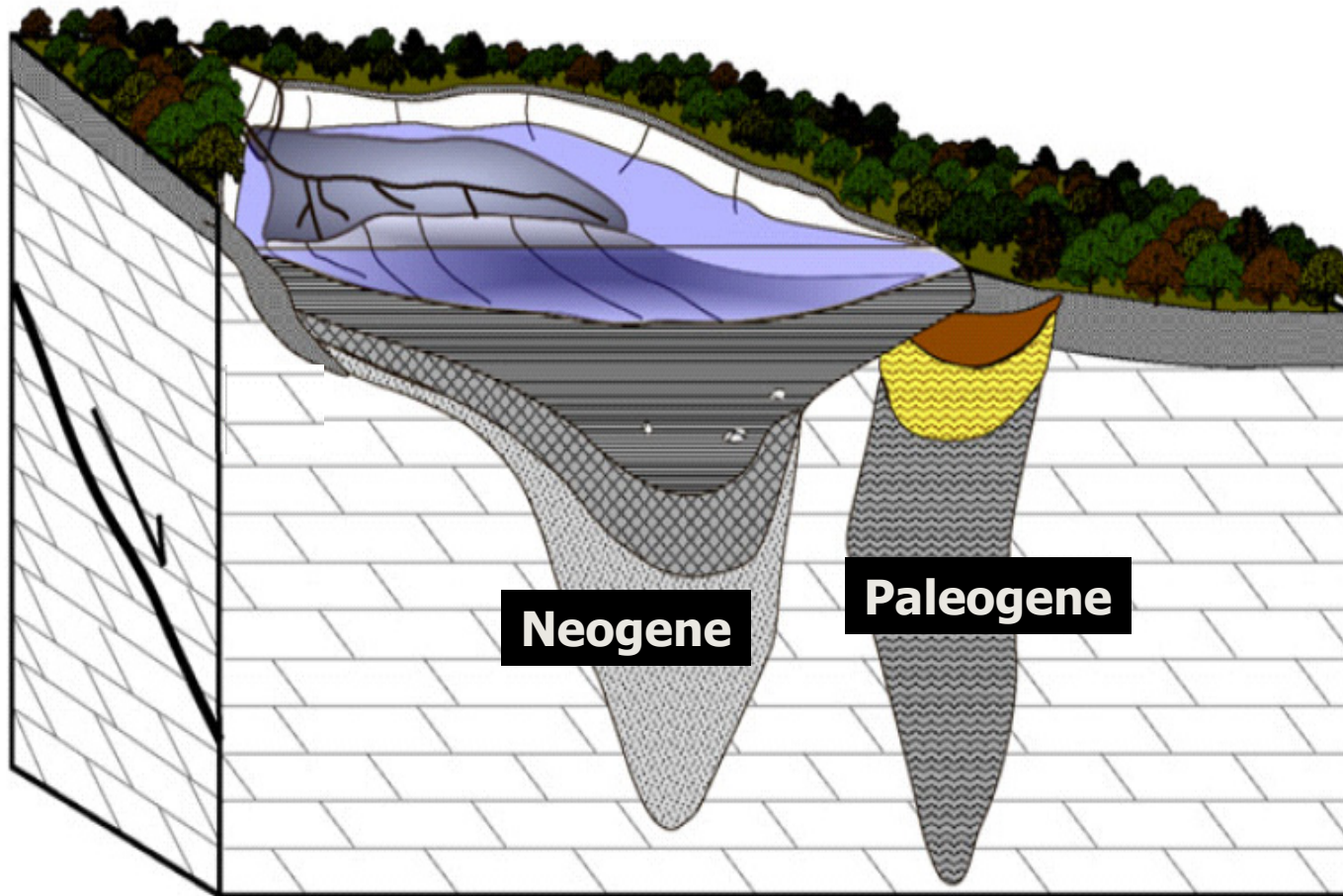


## Valleys

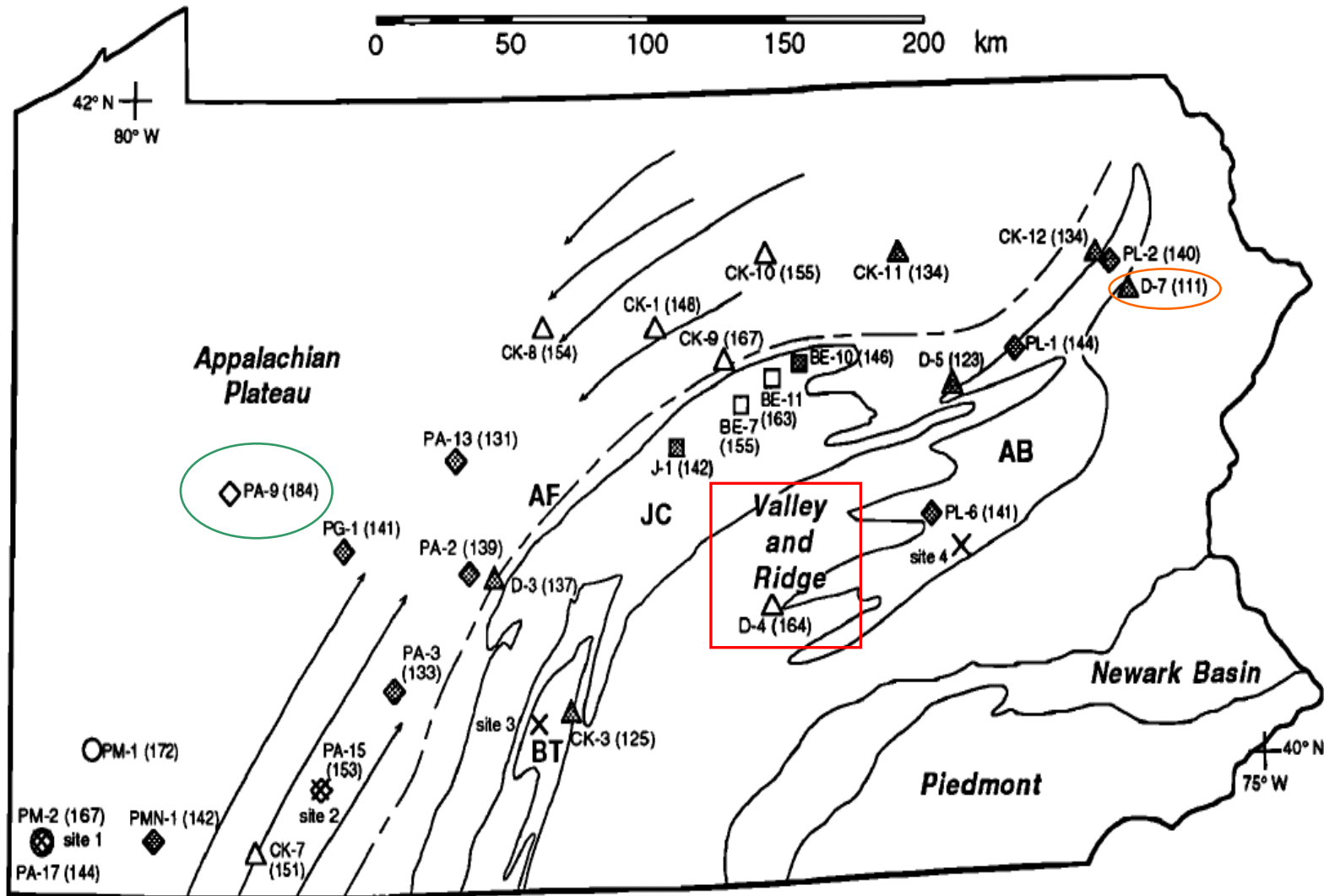
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*from Zobaa, et al., 2011*



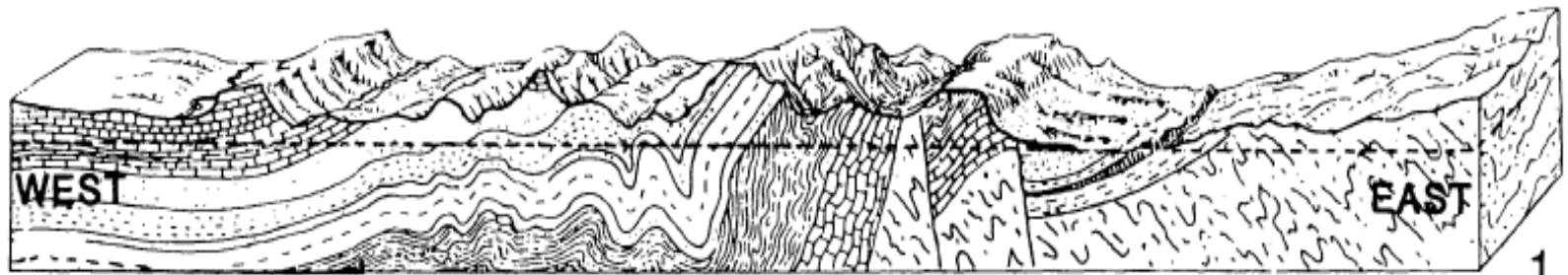
*from Zobaa, et al, 2011*



Stratigraphic Age: ○ Permian ◇ Pennsylvanian △ Devonian □ Ordovician



Eocene  
40 ma



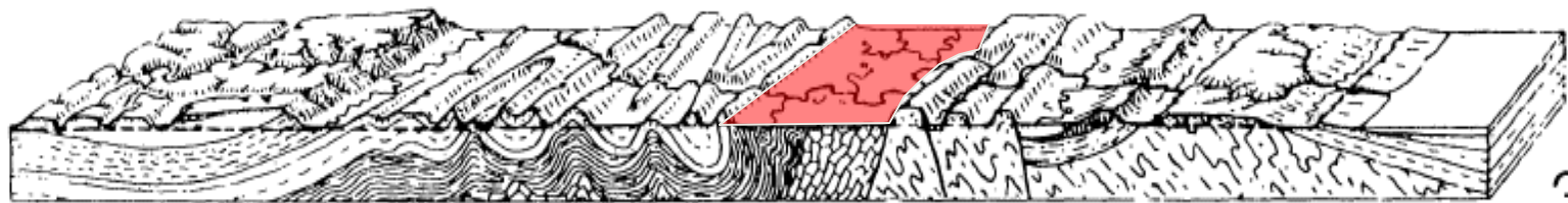
Late Triassic

1



Middle Jurassic - Cretaceous

2



Late Cenozoic

3

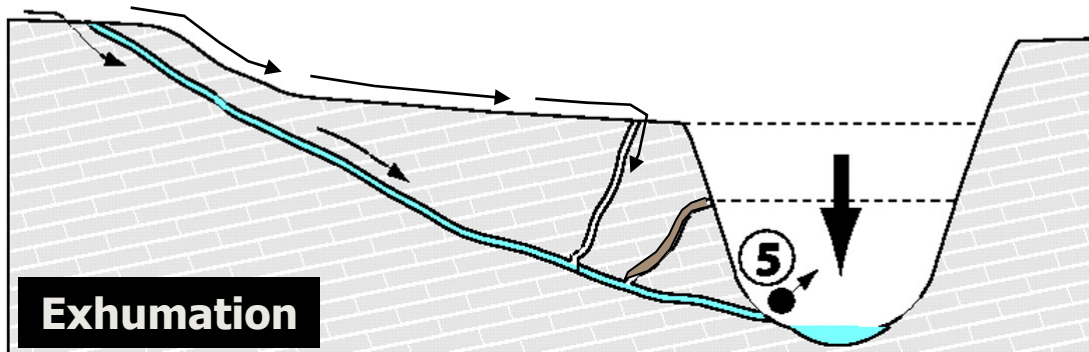
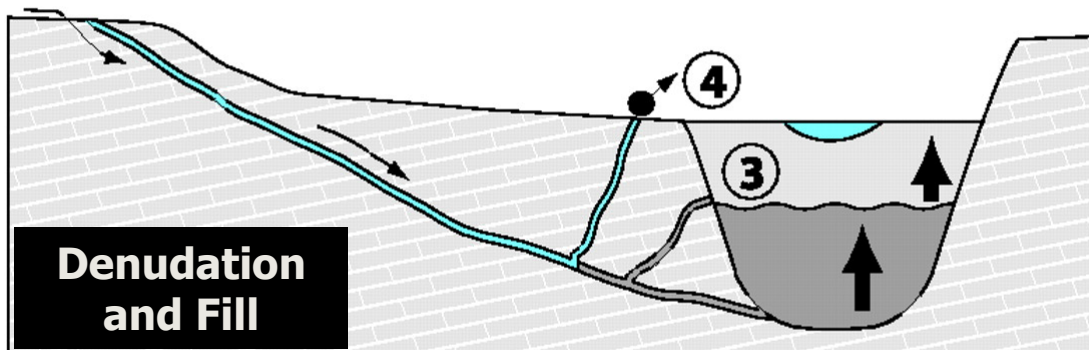
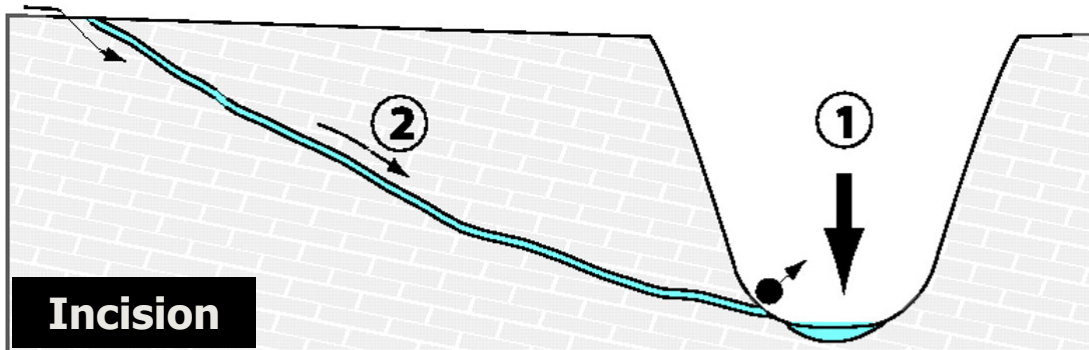
*from Dunbar, 1964*





## The Dolomites – A range in the Alpine foreland

# Vauclusian Spring Cycle





"natural bridge"  
composed of  
Pleistocene varved  
clay, cemented by  
travertine





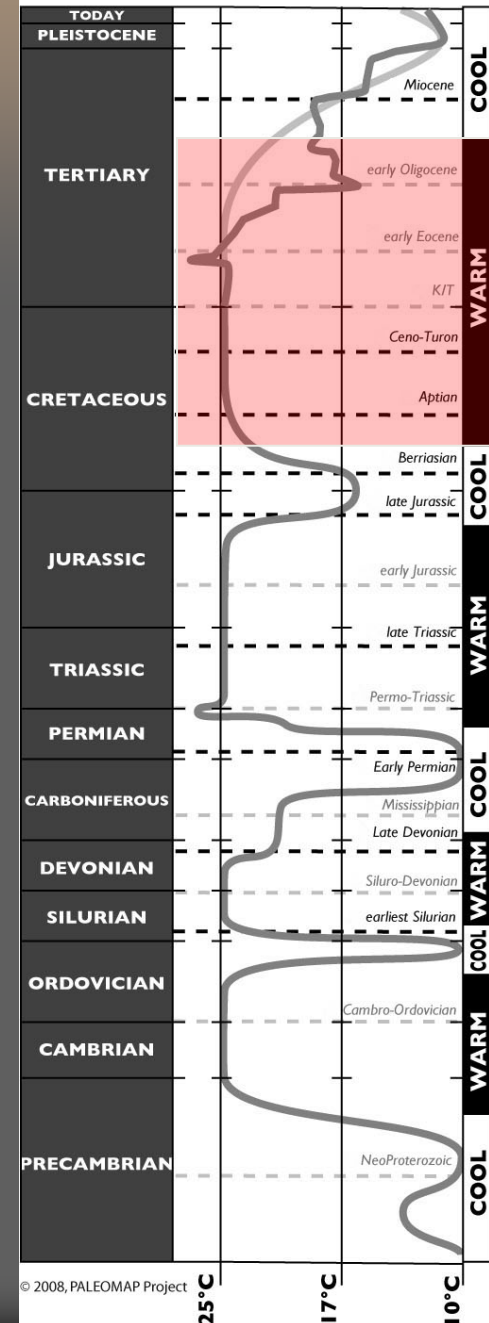


# Paleontological Evidence

- ⇒ Occurrence of Late Cretaceous through Miocene pollen suggest a lengthy exposure of the AGV karst surface.
- ⇒ Paleogene fossils in a sinkhole fill immediately adjacent and at the same elevation with a second sinkhole containing Late Miocene – Early Pliocene fossils suggest the history of the AGV karst is more complex than previously understood.
- ⇒ The stratigraphic sequence and mineralogy at the Chronister Site is oddly similar to many of the AGV bauxite occurrences.

# Paleoclimatic Evidence

- ➔ Climatic conditions necessary for the formation of kaolin and bauxite only existed north of the tropical zone during specific periods in the regions history.
- ➔ Large quantities of kaolin were produced and transported to the coastal plain by intense chemical weathering during the Cretaceous and Paleogene.
- ➔ Bauxitization probably occurred simultaneously with the diagenesis of the kaolins.
- ➔ A change during the Miocene from chemical to mechanical weathering, and a concurrent uplift of the Appalachian foreland via isotactic rebound, may have formed the existing regional topography by downcutting and exhumation.



© 2008, PALEOMAP Project



# So how old is the AGV karst?

- ⇒ Cretaceous through Neogene fossils and sediments are found in relict epikarst sediment traps, that form a continuous network with the existing underlying karst system, the depth of which is still unknown.
- ⇒ Thus, the bedrock conduit network must predate the sediments and fossils it contains, and therefore must pre-date the Late Cretaceous.
- ⇒ It is most likely that the AGV system was formed when the Appalachian foreland was unroofed, between 184 and 125 ma (Jurassic through Early Cretaceous).

**Relict fill in an  
Australian cave, K-Ar  
dated at 340 - 357 ma**



**Relict fill in AGV cave,  
age unknown.**





## **FUTURE INVESTIGATIONS:**

### **Cave Sediment Studies**

- **K-Ar Dating**
- **Cosmogenic Quartz Nuclides**
- **Magnetic Reversals**
- **Palynology**

### **Paleo-current Analysis**

**Mineralogical analysis of indurated sediment**

# Acknowledgments

Thanks to: Wil Orndorf (VA DCR), Joey Fagan, David Hubbard (VA DMME), Art & Betty Palmer, Alexander Klimchouk, Will White, Rob Weems (USGS), George Harlow (USGS), Dave Nelms (USGS), Joel Maynard (VDEQ), Guy Darrow, Mike Fix, Bruce Stinchcomb, and the NJSM Chronister Site Team (David Parris, Barbara Grandstaff and Bob O'Neill).

...and all the people who have tolerated my endless discussions on the topic of the speleogenesis of the AGV karst!