



**Early Post-Depositional Bedding-Plane-Parallel  
Melanges Created by Shear and Liquefaction: A  
Common but Largely Misinterpreted Organic-  
Rich Mudrock Facies**

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Sean T. Kinney

September 26, 2016

How they were first found

Summary of conclusions

Examples

Summary of key observations and patterns

Possible processes

Conclusions



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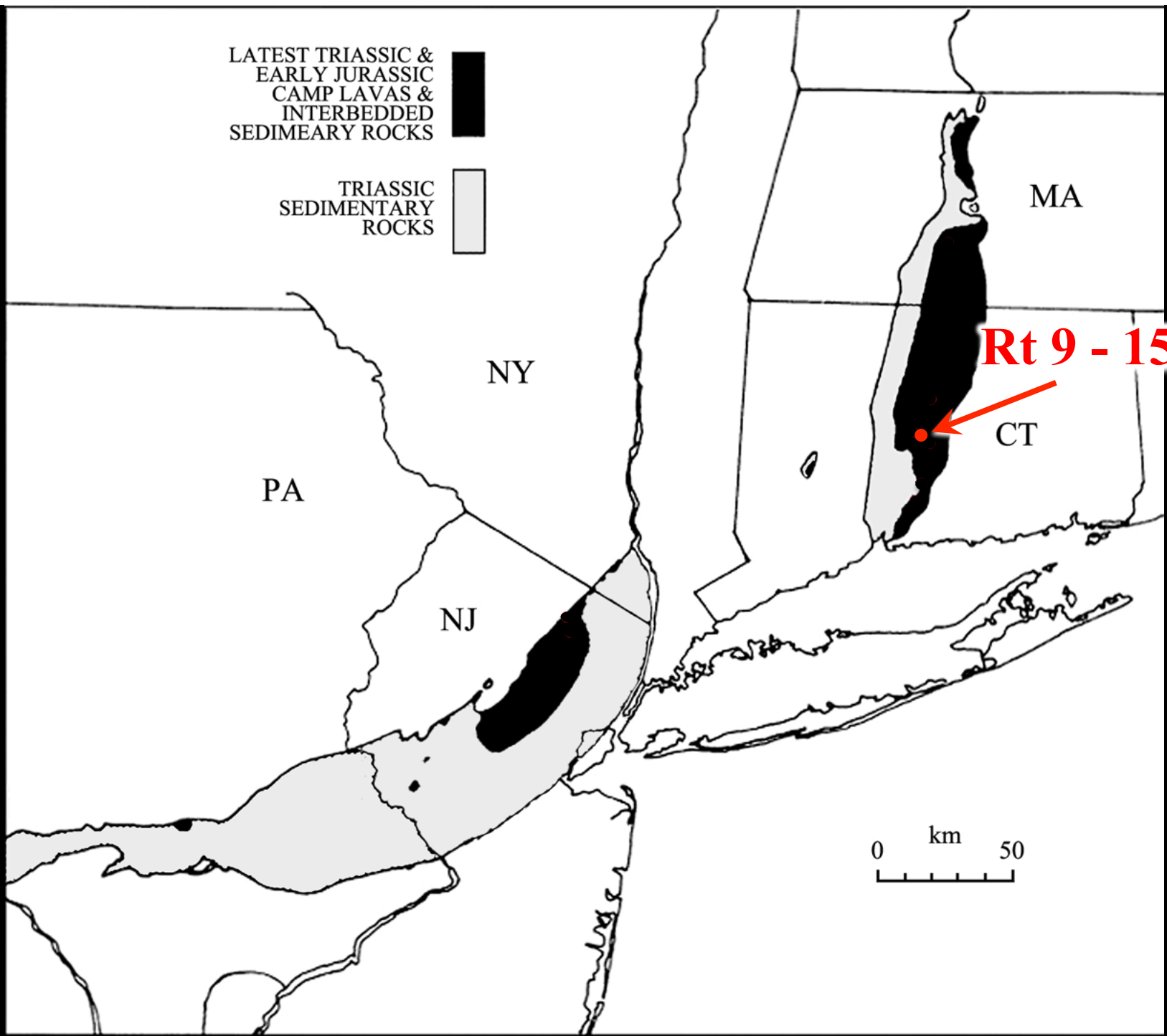
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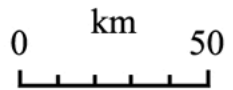
LATEST TRIASSIC &  
EARLY JURASSIC  
CAMP LAVAS &  
INTERBEDDED  
SEDIMENTARY ROCKS



TRIASSIC  
SEDIMENTARY  
ROCKS



**Rt 9 - 15**





# Hartford Basin



Early Jurassic, East Berlin Formation







*Semionotus* sp.



N.G. McDonald collection

Westfield Bed, East Berlin, CT



1 cm





Olsen et al., 1989

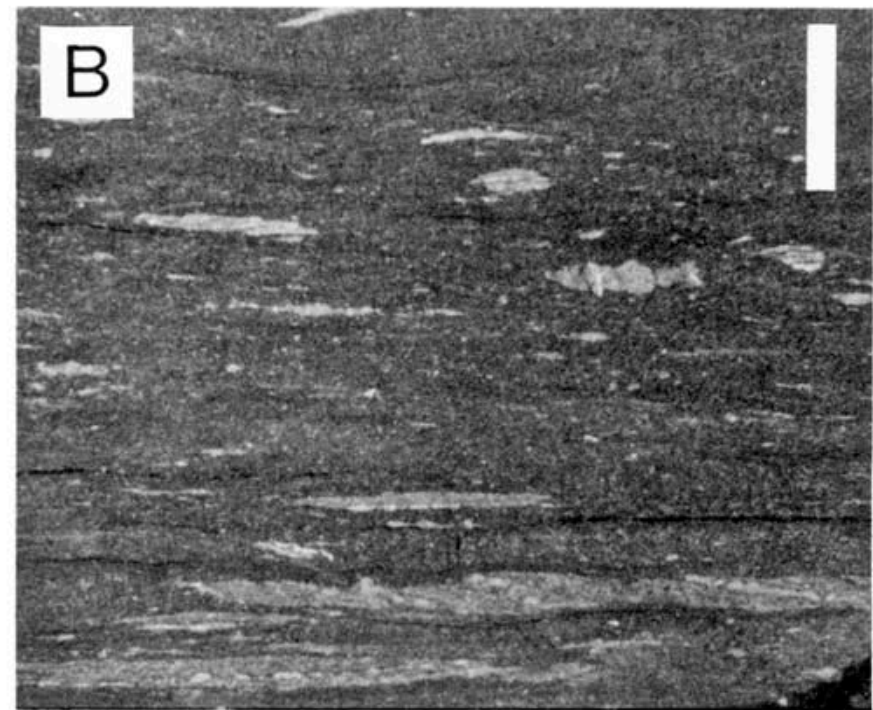
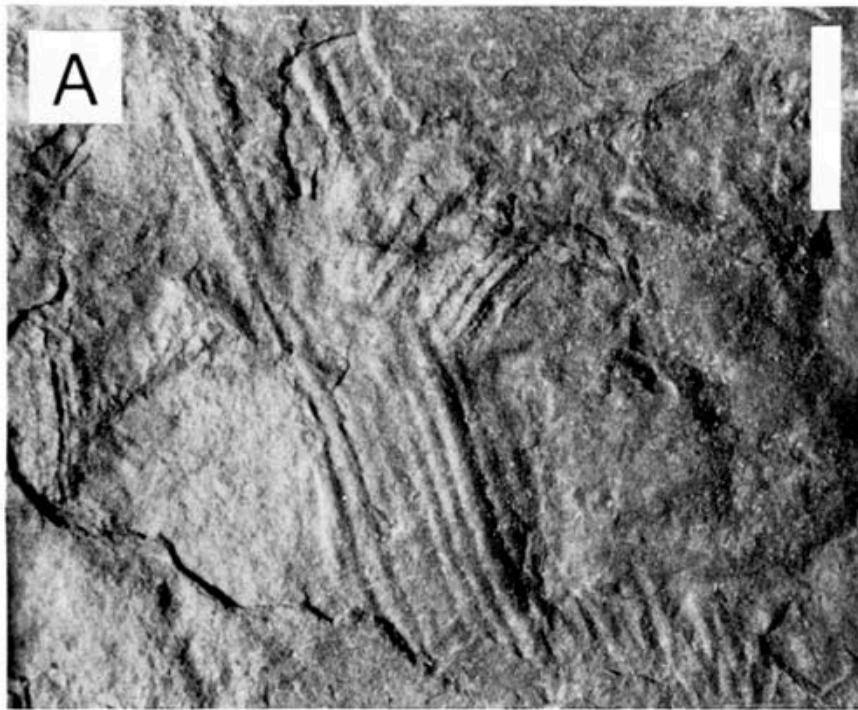


Figure 7.6: "Dead horses" from laminated siltstones at Stop 7.2: A) plan view (scale bar is 2 cm); B) cross-section in which the carbonate-rich "dead horses" show up as the lighter patches with oblique lamination (scale bar is 1 cm). Photo by P.E. Olsen.

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Organic-rich massive mudstone matrix suggests partial liquefaction accompanied by bedding-parallel shear that produced largely rhombic clasts of more competent lithologies from the base and roof exhibiting both brittle and ductile features.

Process occurred early in compaction and presumably early in the sediment history.

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1) Jurassic East Berlin Formation

2) Jurassic Towaco Formation

3) Triassic Feltville Formation

4) Triassic Lockatong Formation

5) Eocene Green River Formation

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2) Jurassic Towaco Formation

3) Triassic Feltville Formation

4) Triassic Lockatong Formation

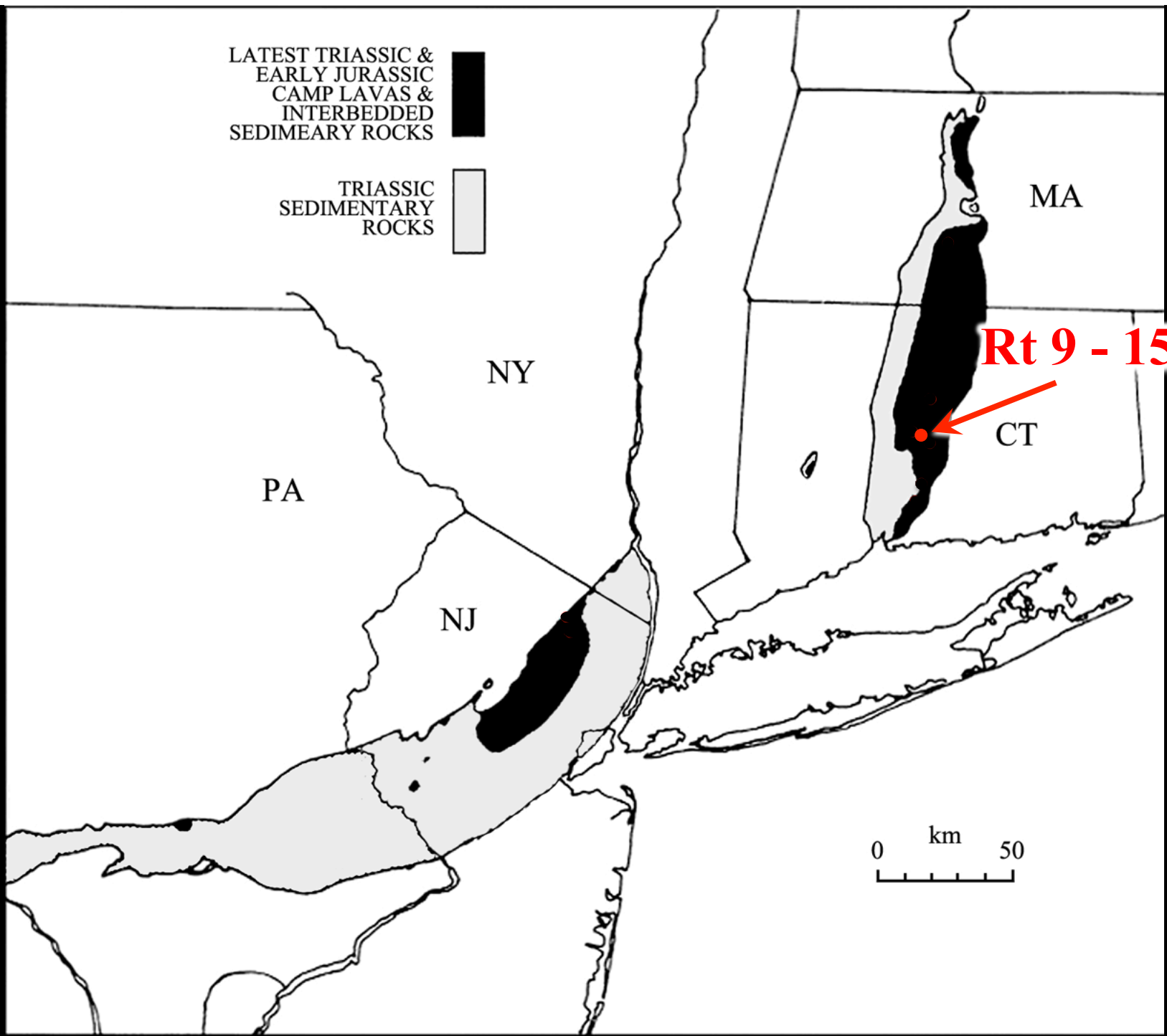
5) Eocene Green River Formation



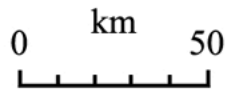
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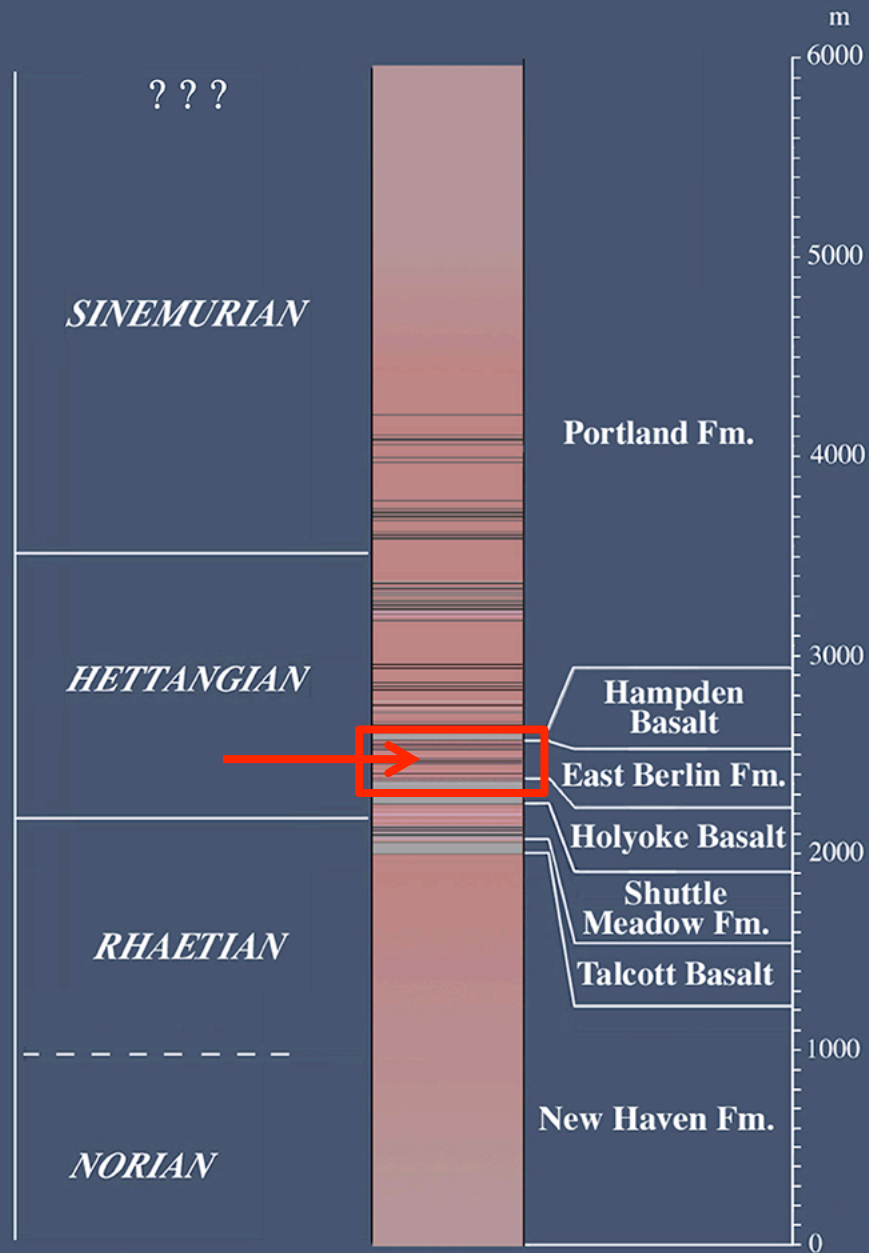
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**Rt 9 - 15**

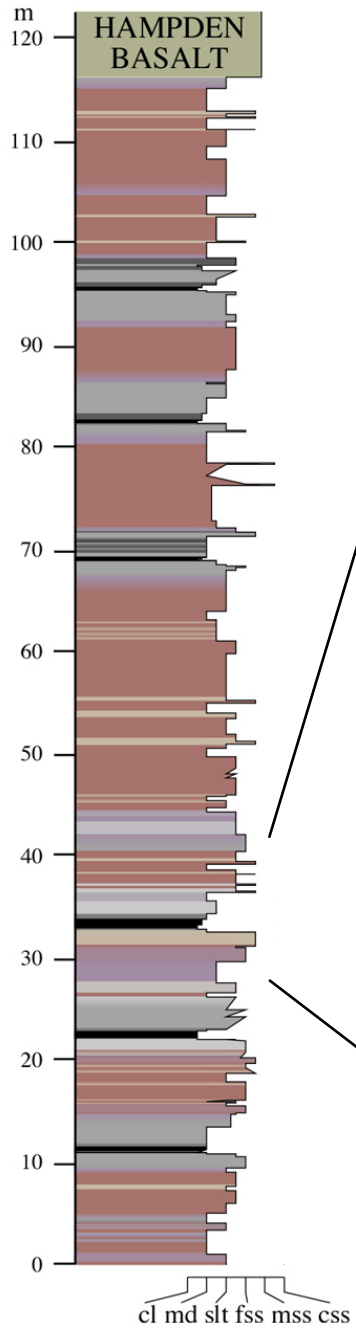


# Hartford Basin





East Berlin Formation



Westfield Bed



TOC

0.7%

1.7%

2.5%

0.4%

0.2%



↑ melange

↑ fish

↑ ash

ash

Emma Leonard,  
2013



*Redfieldius* sp.



Westfield Bed, East Berlin, CT

N.G. McDonald collection



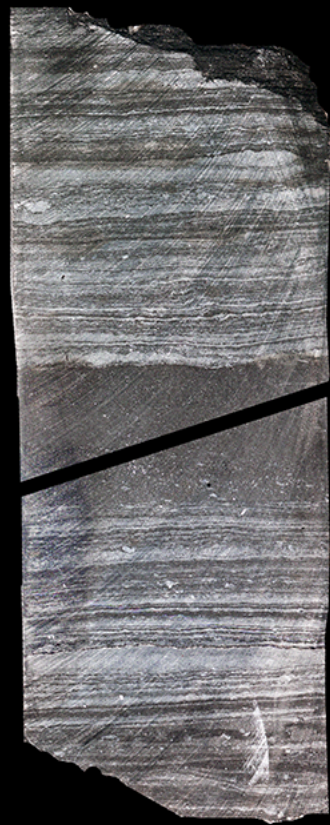
Rt 9, East Berlin Formation



Pompton Tuff, Westfield Fish Bed



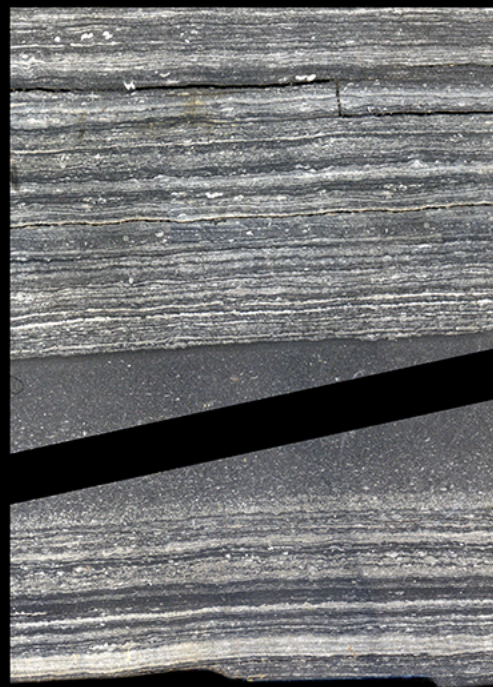
← 0.2 km → 16.1 km → 16.2 km →



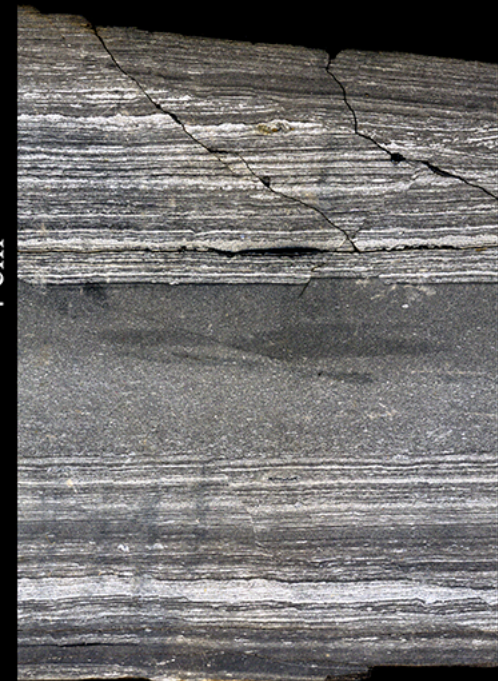
**BD-226**



**BD-225**



**Miner Brook**



**Stevens**

4 cm

4 cm







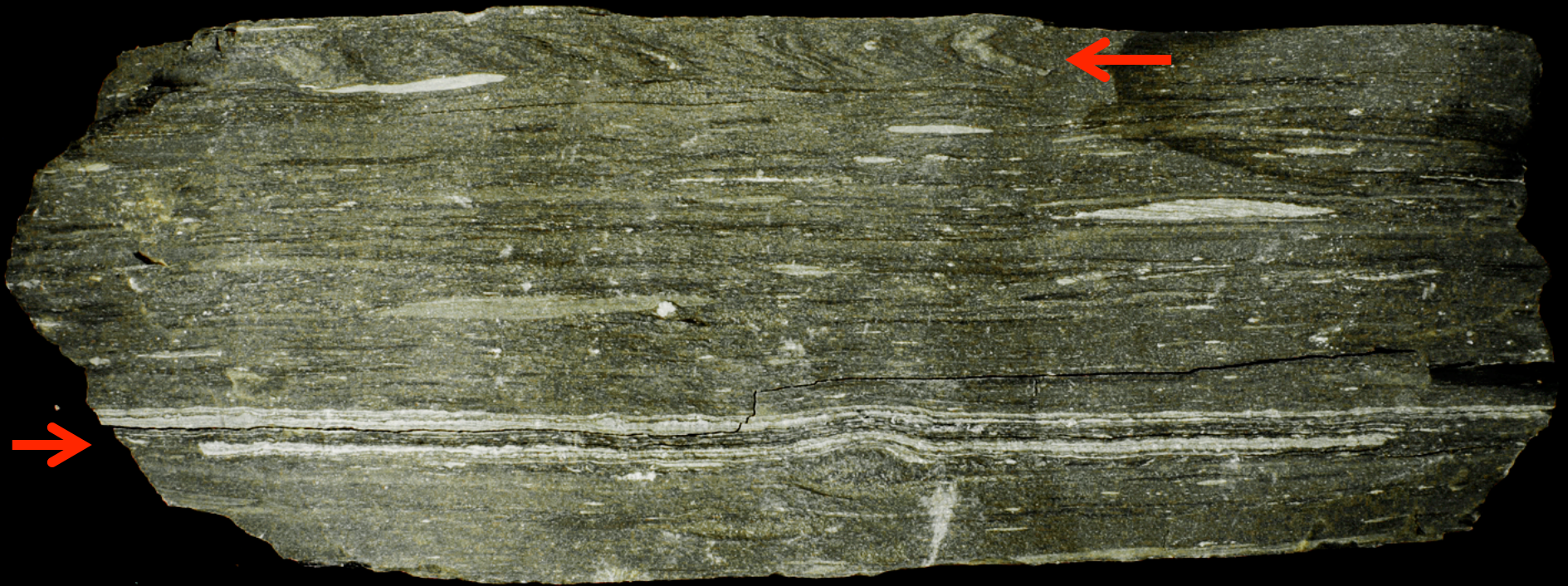
East Berlin Fm., East Berlin, CT



Plan view (bedding plane)



Slab cut perpendicular to bedding



East Berlin Fm., East Berlin, CT



Large clasts



East Berlin Fm., East Berlin, CT



outcrop uppermost cycle

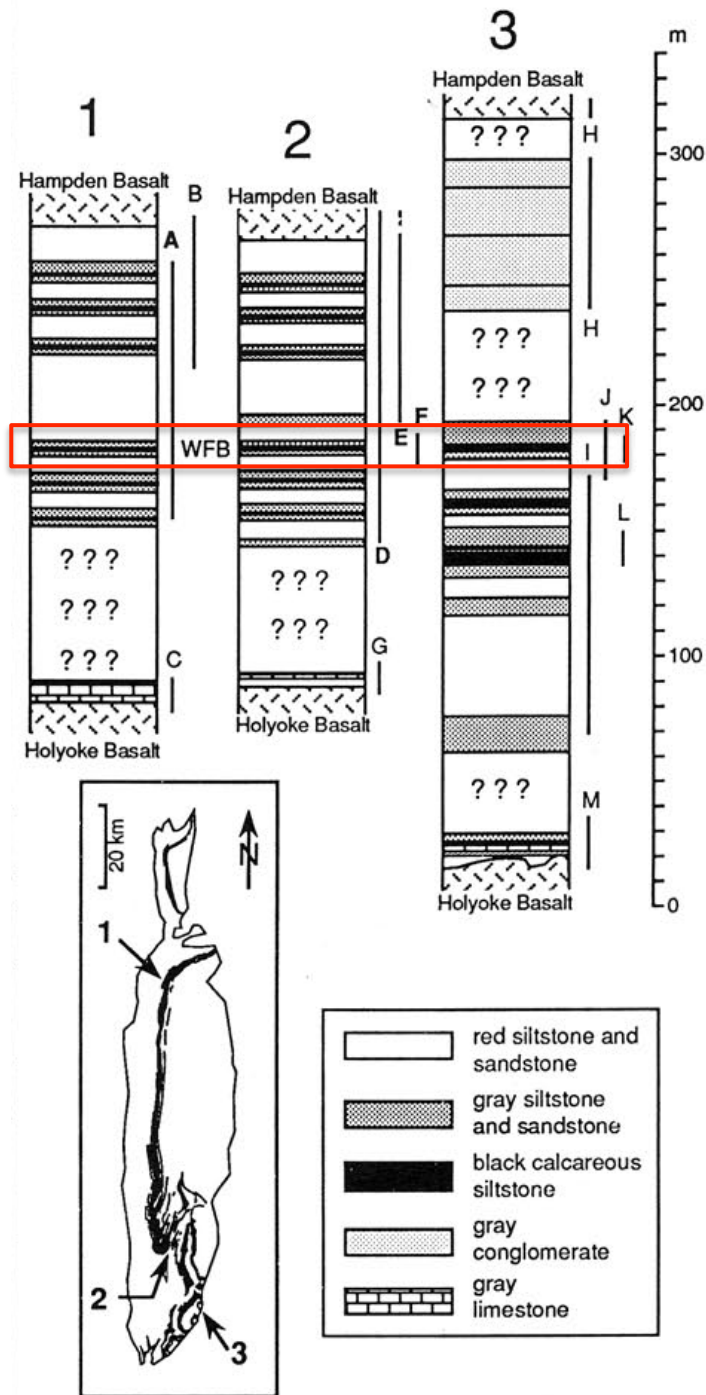


East Berlin Fm., East Berlin, CT



Olsen et al., 1989

**Westfield Bed** →





# Recumbent Fold



**Westfield Bed, East Berlin Fm., North Branford, CT**



*Semionotus* sp.



Westfield Bed, North Branford, CT

N.G. McDonald collection



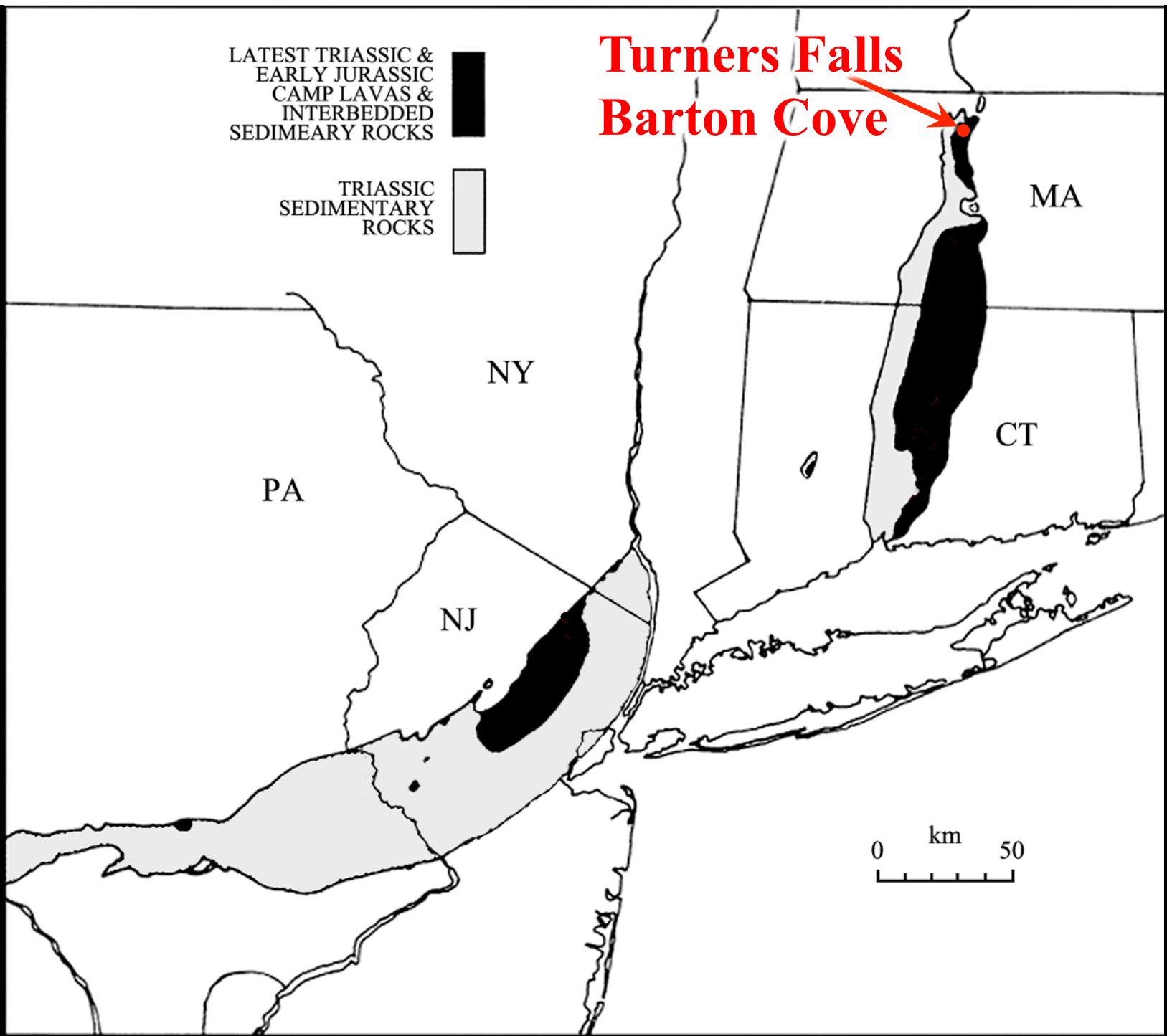
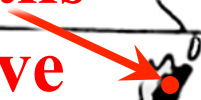
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**Turners Falls**  
**Barton Cove**





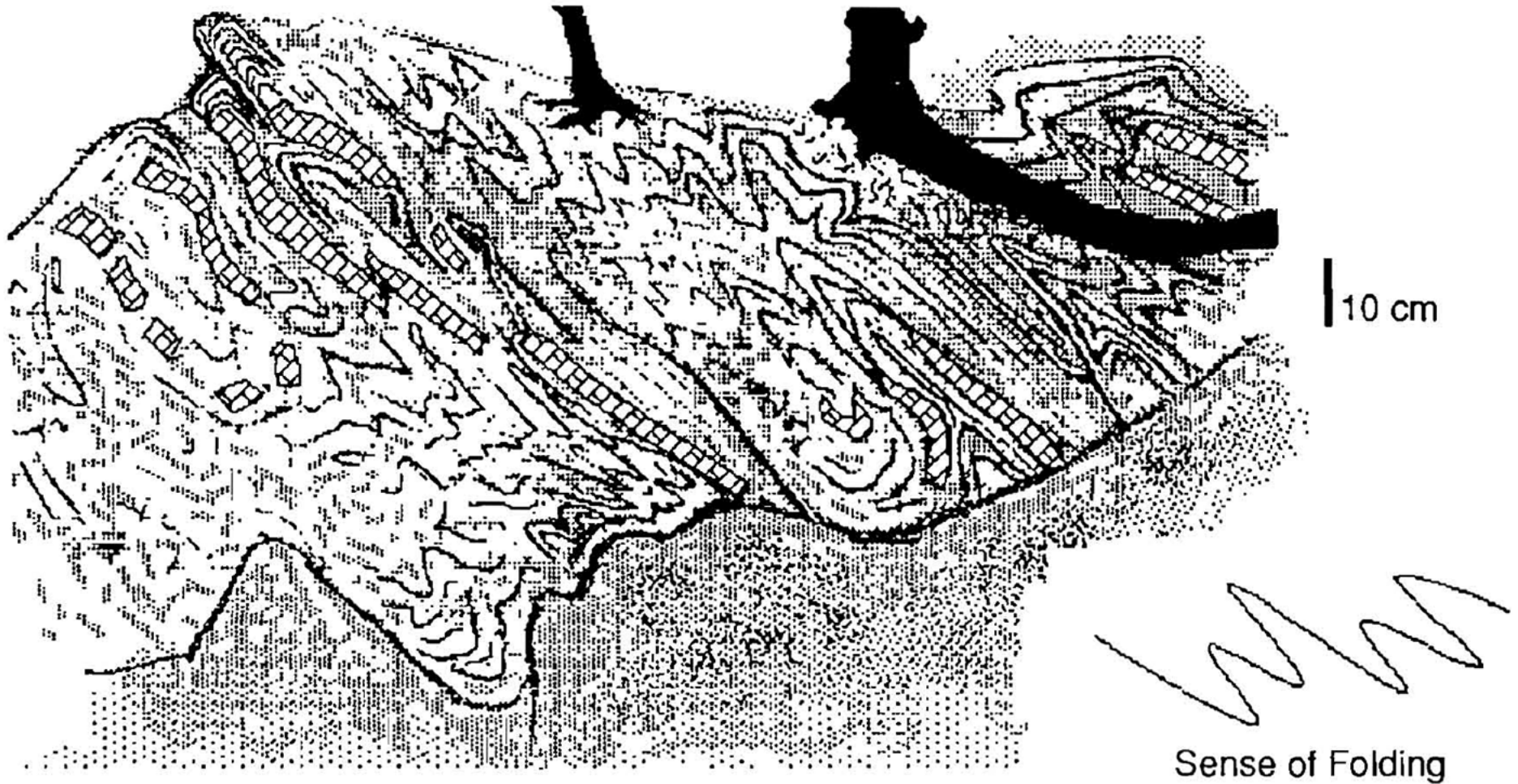


Transposed folds, Turners Falls Fish Bed, Turners Falls, MA



# Fold Breccia Barton Cove, Gill, MA

Transposed Folds



Olsen et al., 1992



# Examples

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2) Jurassic Towaco Formation




3) Triassic Feltville Formation


4) Triassic Lockatong Formation

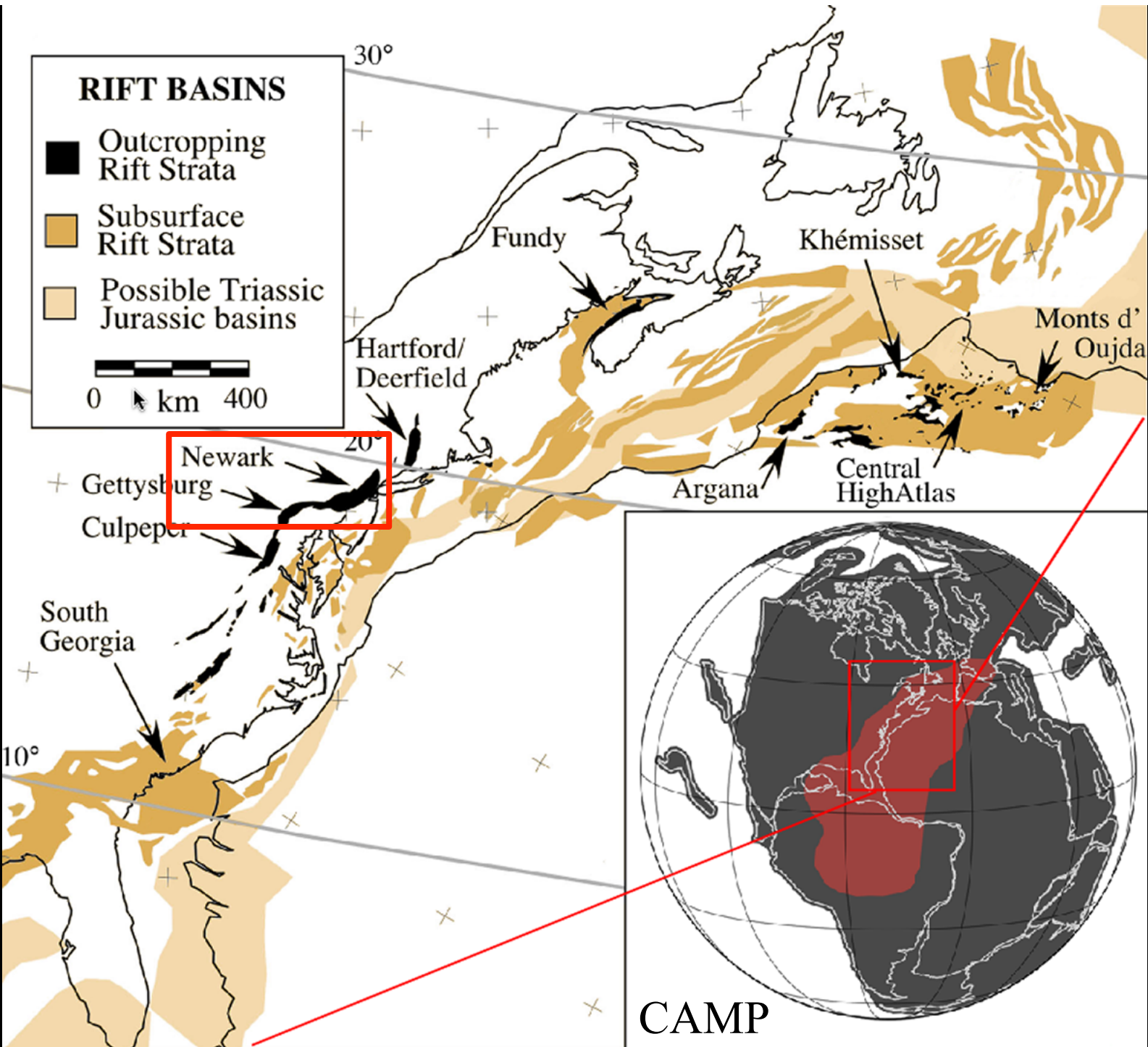
5) Eocene Green River Formation



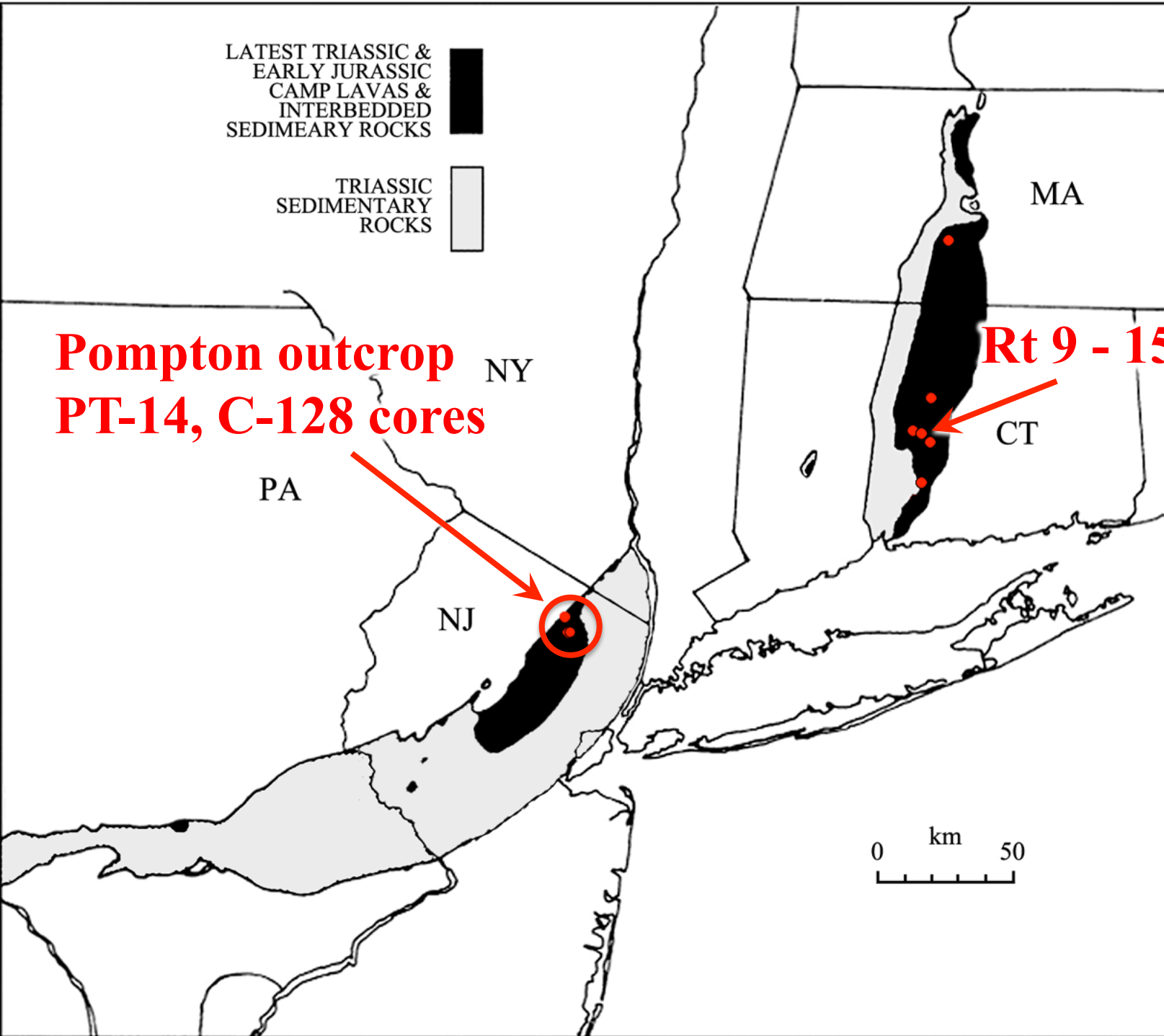
**RIFT BASINS**

-  Outcropping Rift Strata
-  Subsurface Rift Strata
-  Possible Triassic Jurassic basins

0  km 400







LATEST TRIASSIC &  
EARLY JURASSIC  
CAMP LAVAS &  
INTERBEDDED  
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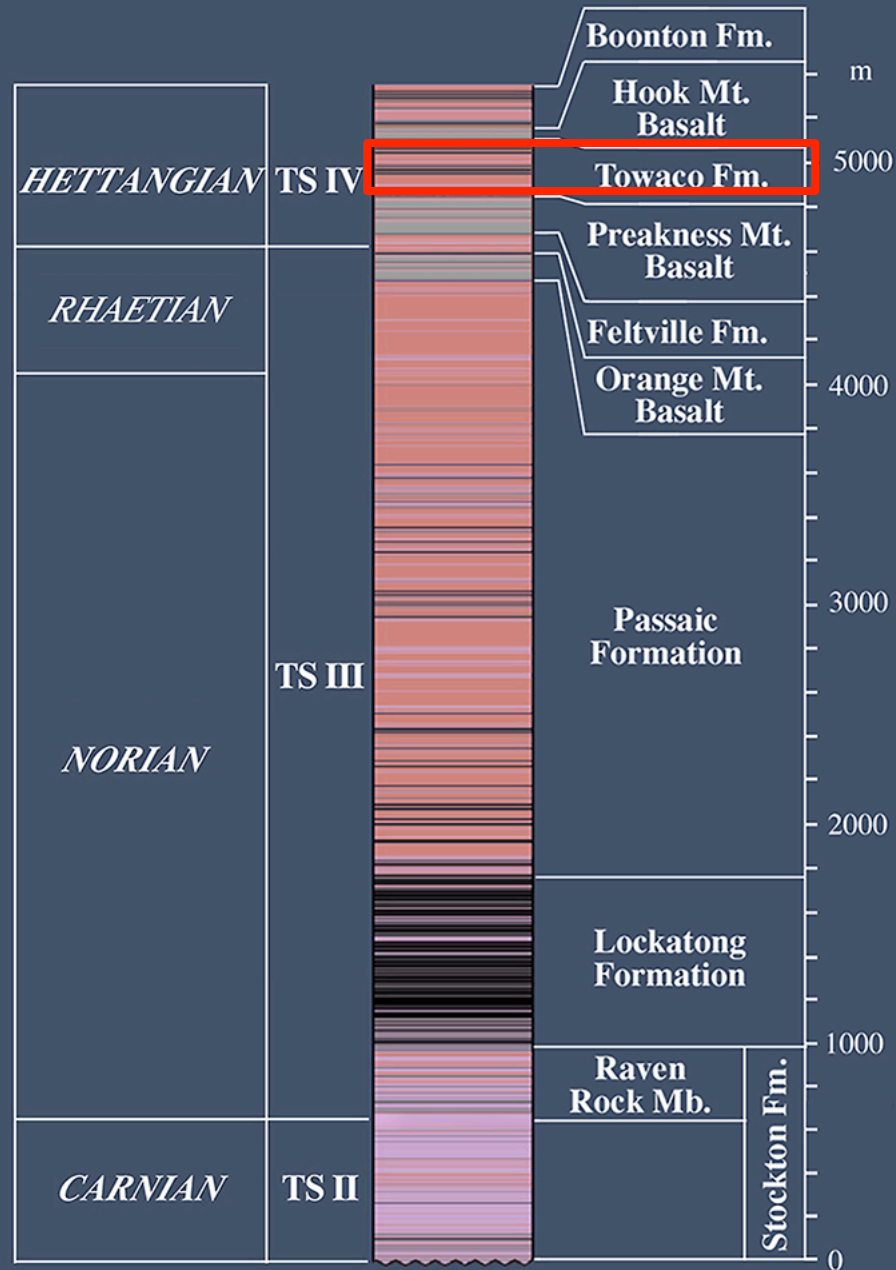
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**Pompton outcrop**  
**PT-14, C-128 cores**

**Rt 9 - 15**

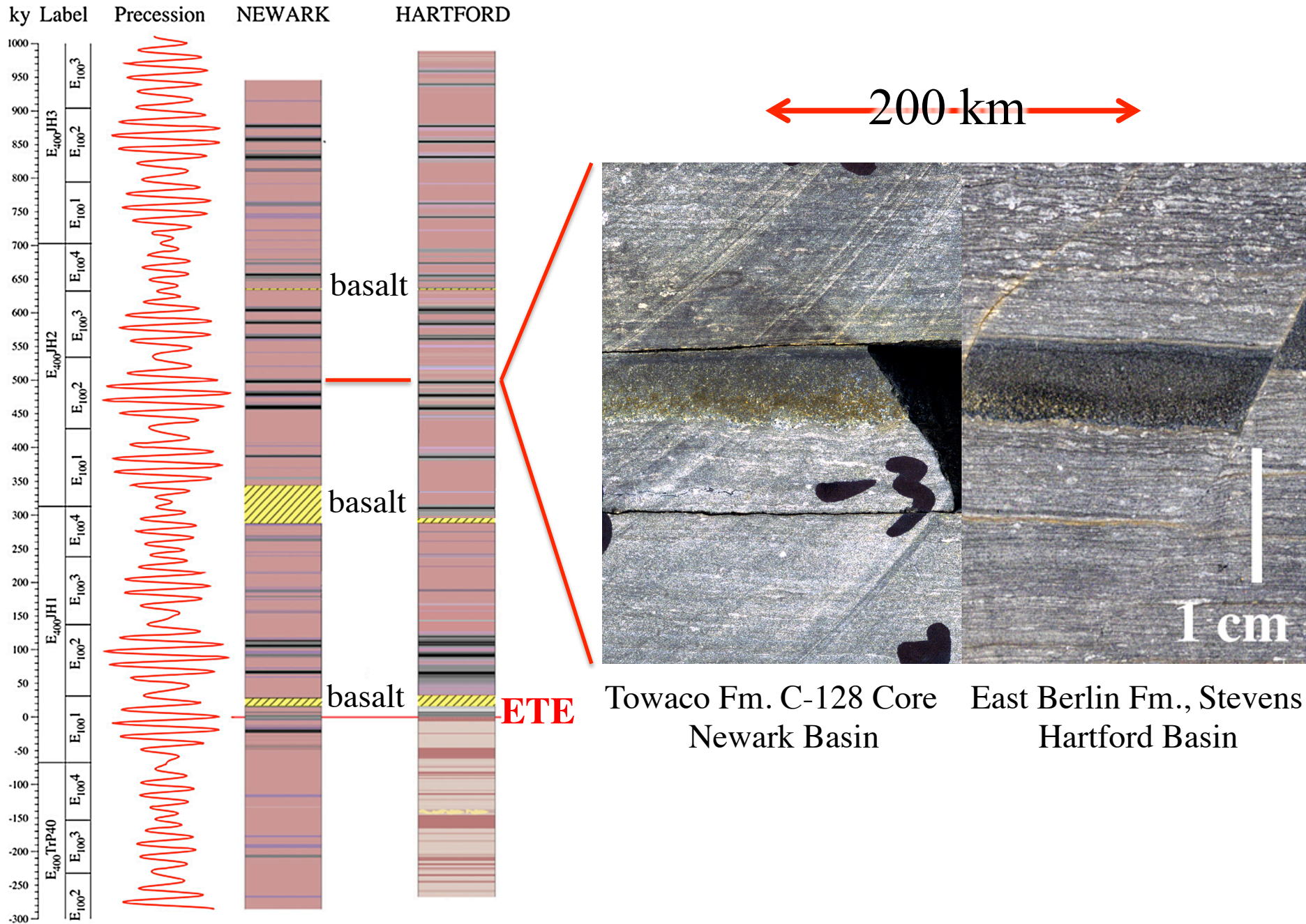
0 km 50

# Newark Basin





# 20°-21° N: Newark and Hartford Basins, Eastern US



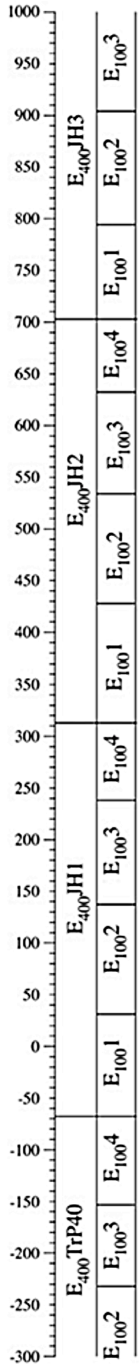


ky Label

Precession

NEWARK

PT-14

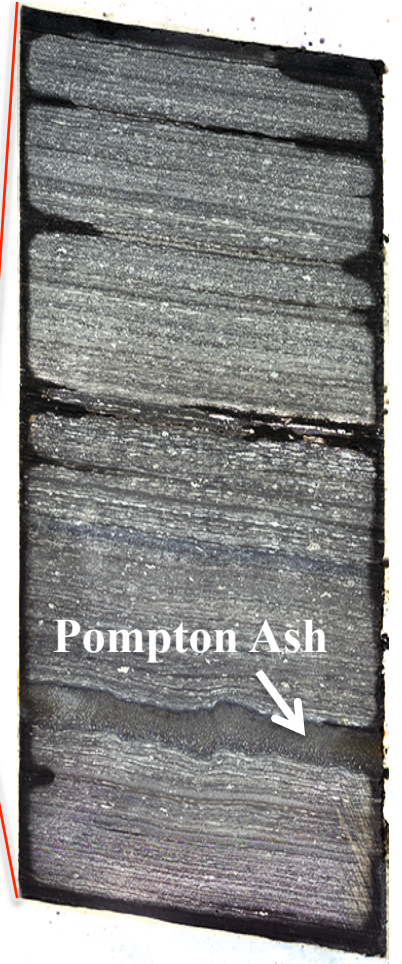
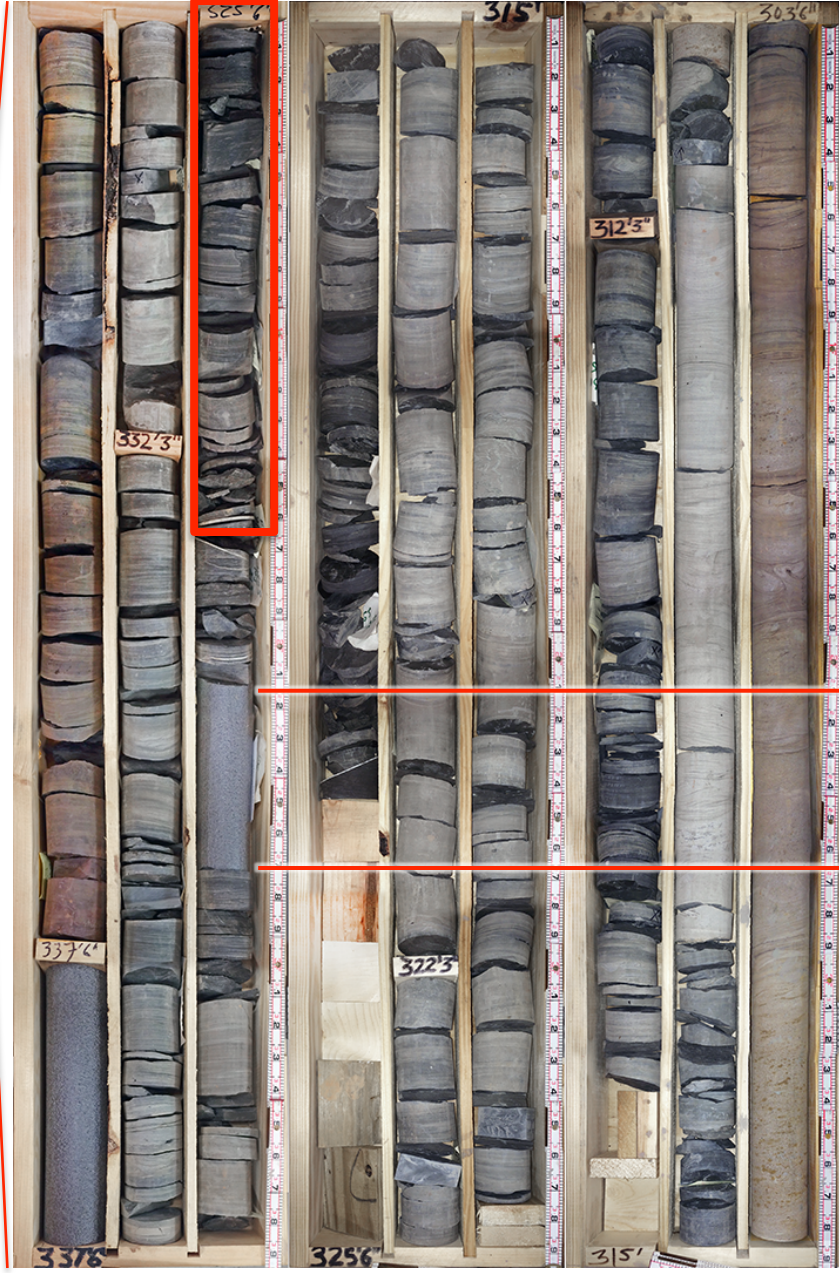


basalt

basalt

basalt

ETE

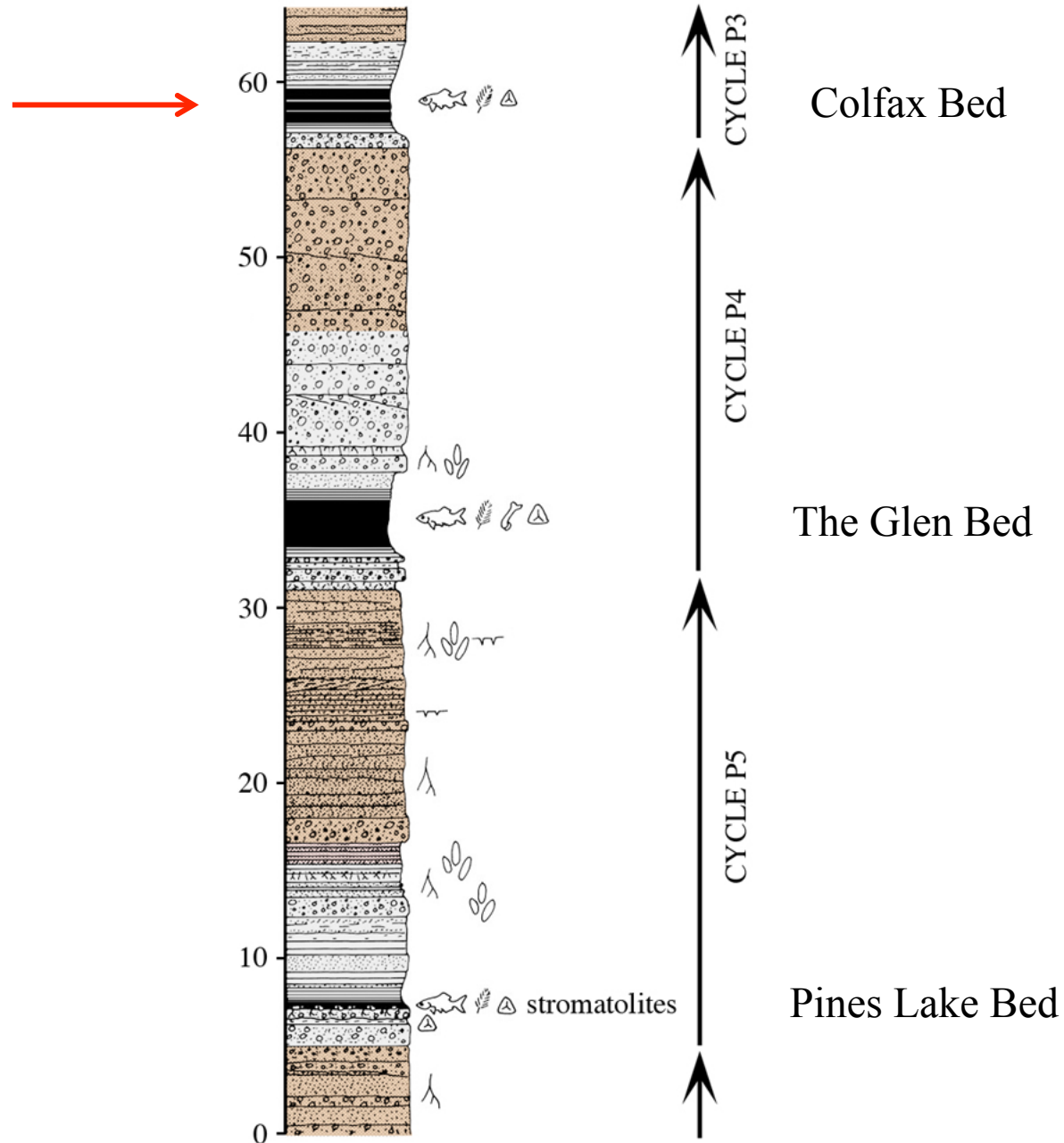


Pompton Ash





# Section at Pompton, Middle Towaco Formation











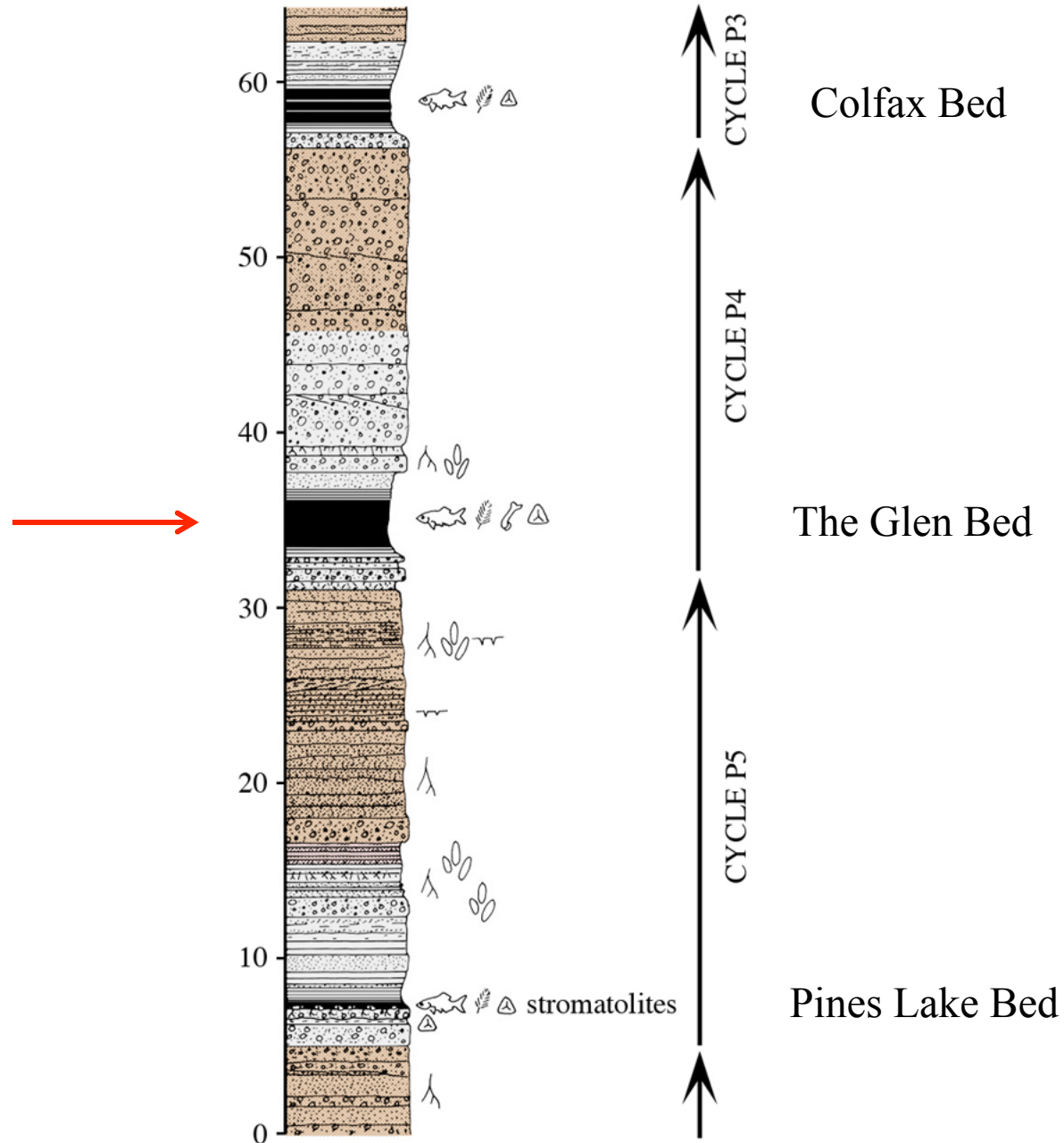


# Pompton Tuff at Pompton, NJ





# Section at Pompton, Middle Towaco Formation













# Examples

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2) Jurassic Towaco Formation

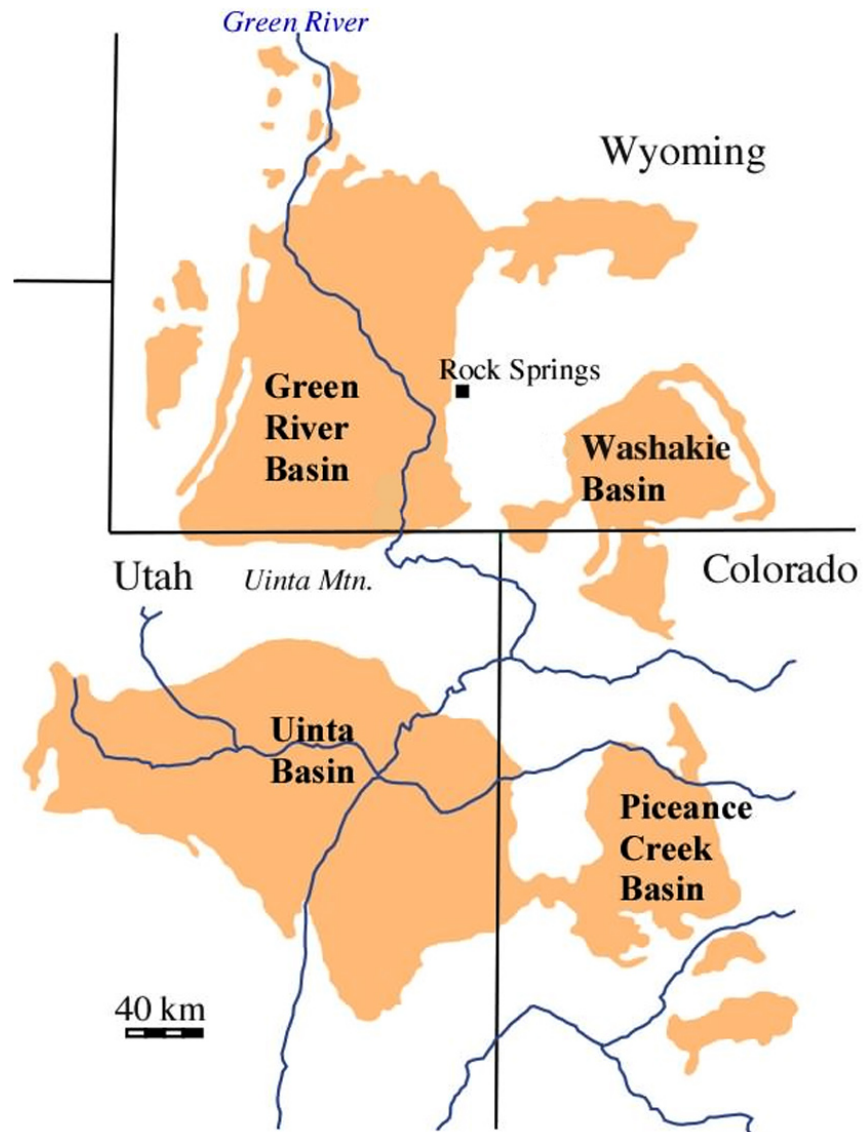
3) Triassic Feltville Formation


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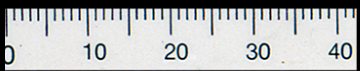
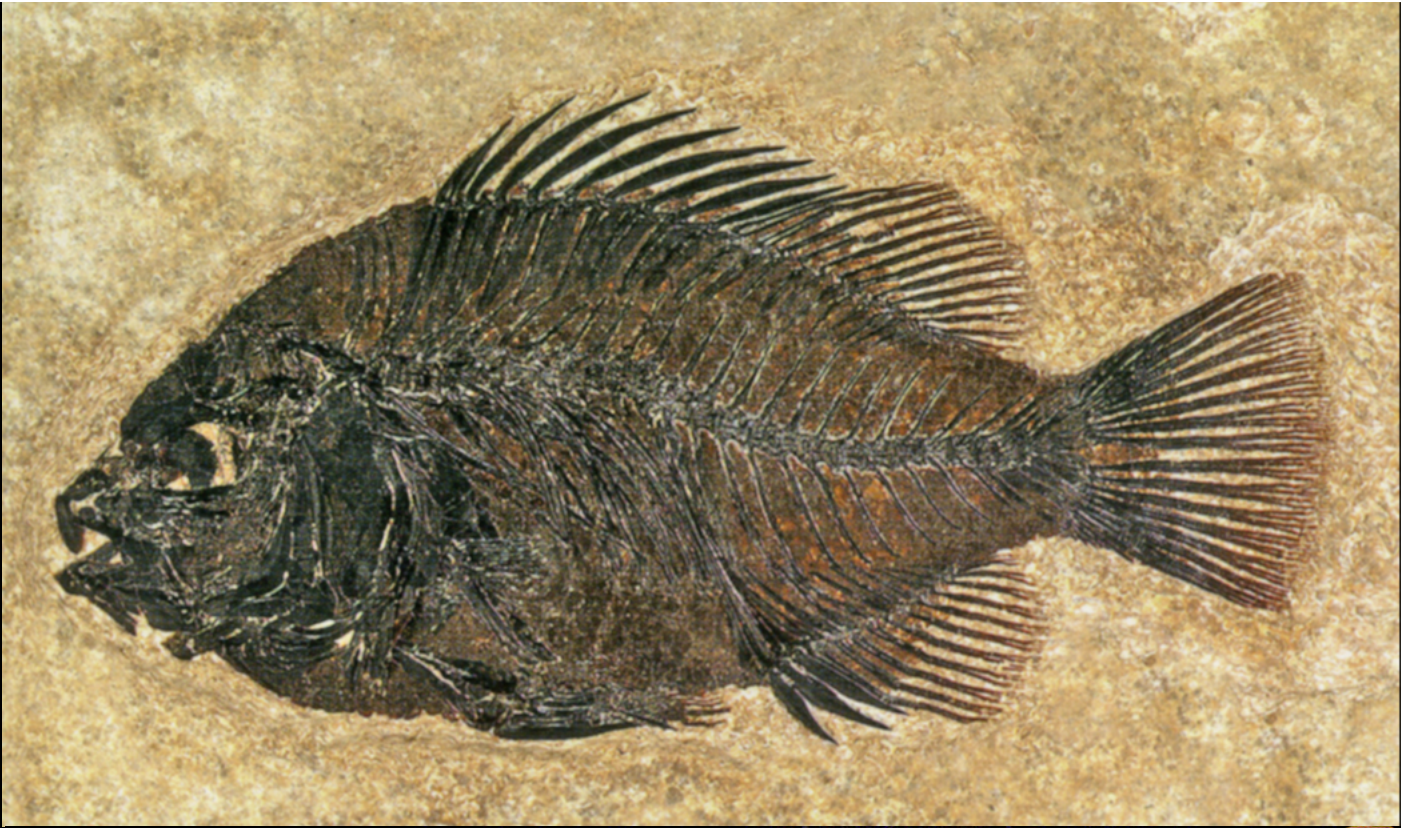


# Eocene Green River Formation

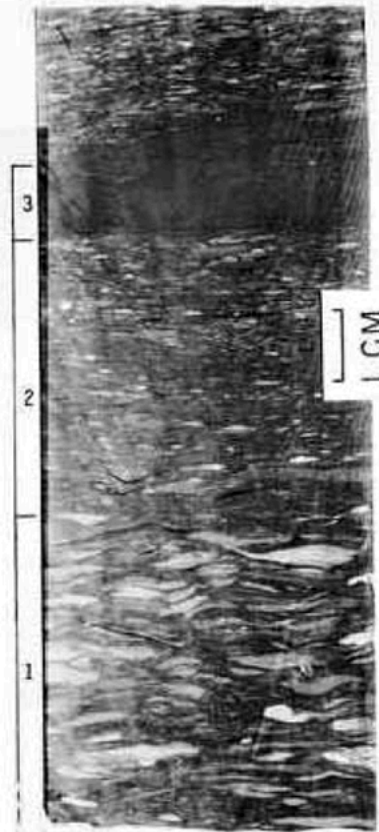
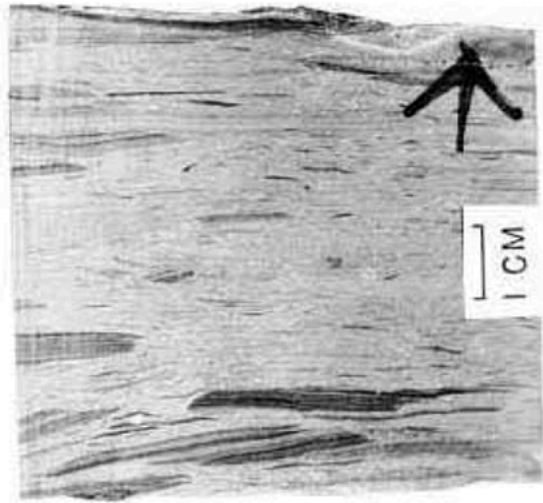


 Surface exposures of the Green River Formation  
(after Grande, 1984)









from Dyni,  
1981





Johnson et al., 2014

Mahogany zone, Parachute Creek Mb., Green River Fm.





Johnson et al., 2014

Mahogany zone, Parachute Creek Mb., Green River Fm.



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Matrix generally without clear bedding

Clasts can match lithologies below and ABOVE melange

Clasts or often but not always rhombic

Clasts can be folded or with laminae at high angles to bedding

Clasts with near vertical laminae show effects of strong compaction AFTER rotation

Clasts may be in boudins or adjacent “fitted” pieces.

There may be roof pendants or basal “flames”

There is no sign of a depositional or erosional upper contact

Can be discordant to bedding

Can have high angle boundaries with bedding



Melange present usually in higher organic, fine grained units

In same beds in siltier facies towards the border faults (in the same cycle) melange is replaced by folded and thrust faulted beds border faults

Intermediate condition may be brecciated folds

*Clasts in melange in higher organic, fine grained units resemble adjacent lithologies and NOT marginal siltier facies and often represent adjacent stratigraphy where melange is locally less vertically extensive.*



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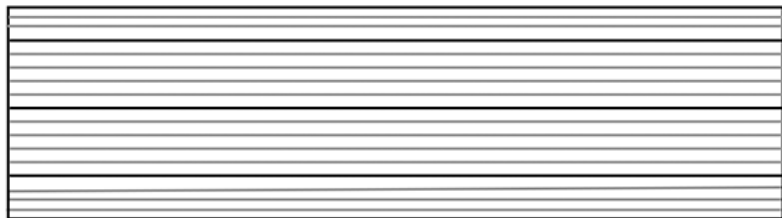
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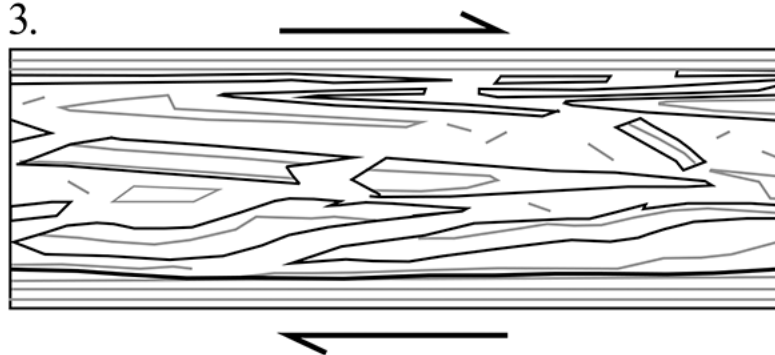
Conclusions



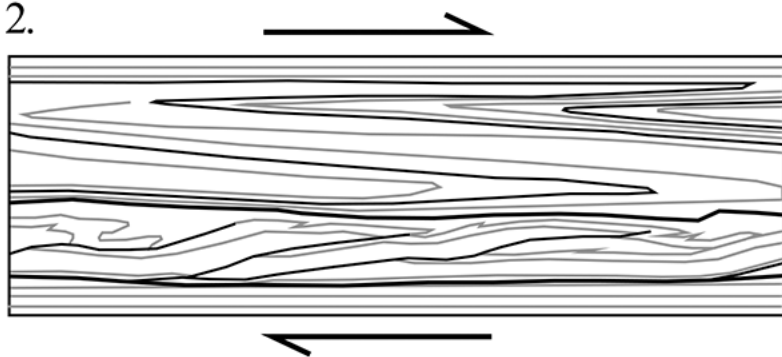
1.



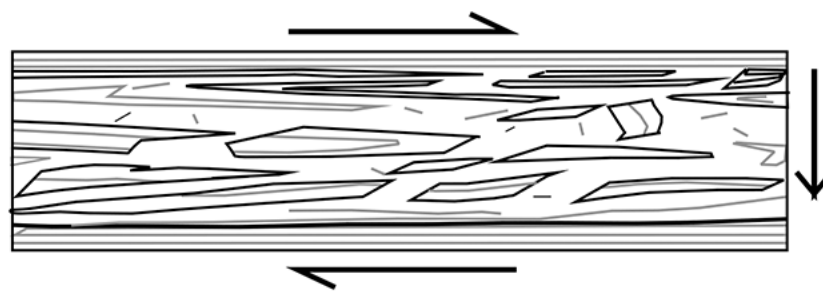
3.



2.



4.



## Can be confused with:

*Mass movement units*: but should have indications of a free upper surface with indications of sedimentation on an irregular surface or erosion.

*Seismites*: should have some influence or relation to surface (sand pipes, intrusions); a sequence of these melanges need have no relationship to sequence of events.

*Evaporite dissolution breccias*: need not show a sense of shear; should show a pattern of replacement consistent with dissolution. Pseudomorphs should be present.

*Late bedding-plane fault*: should have mineralized fractures and faults planes; no mud matrix; but faults can cut melage later.



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- 1) Melanges originate as bedding parallel shear.
- 2) In siltier facies beds remain largely intact with thrust fault duplexes and recumbent folds with duplications of beds in vertical succession common.
- 3) In finer grained facies folds and duplexes re-sheared with some mud liquefaction matrix between clasts in a melange.
- 4) Clasts that are oriented vertical show strong compaction indication early formation of melange.



- 5) In finest grained, often organic rich facies, clasts are derived from immediately local stratigraphy and are not far transported.
- 6) They are not slumps, mass-transported beds, surface erosion rip up clasts, seismites in the usual sense, evaporite dissolution breccias, or brittle faults. *Clear criteria are needed!*
- 7) Their sense of shear does NOT indicate downhill - could be uphill.
- 8) They do record a rheological history, but not a history of depositional or seismic events.