Extension of Appalachian Black-Shale Source Rocks into Adjacent Intracratonic Basins through Basin Yoking*

Frank R. Ettensohn[1]

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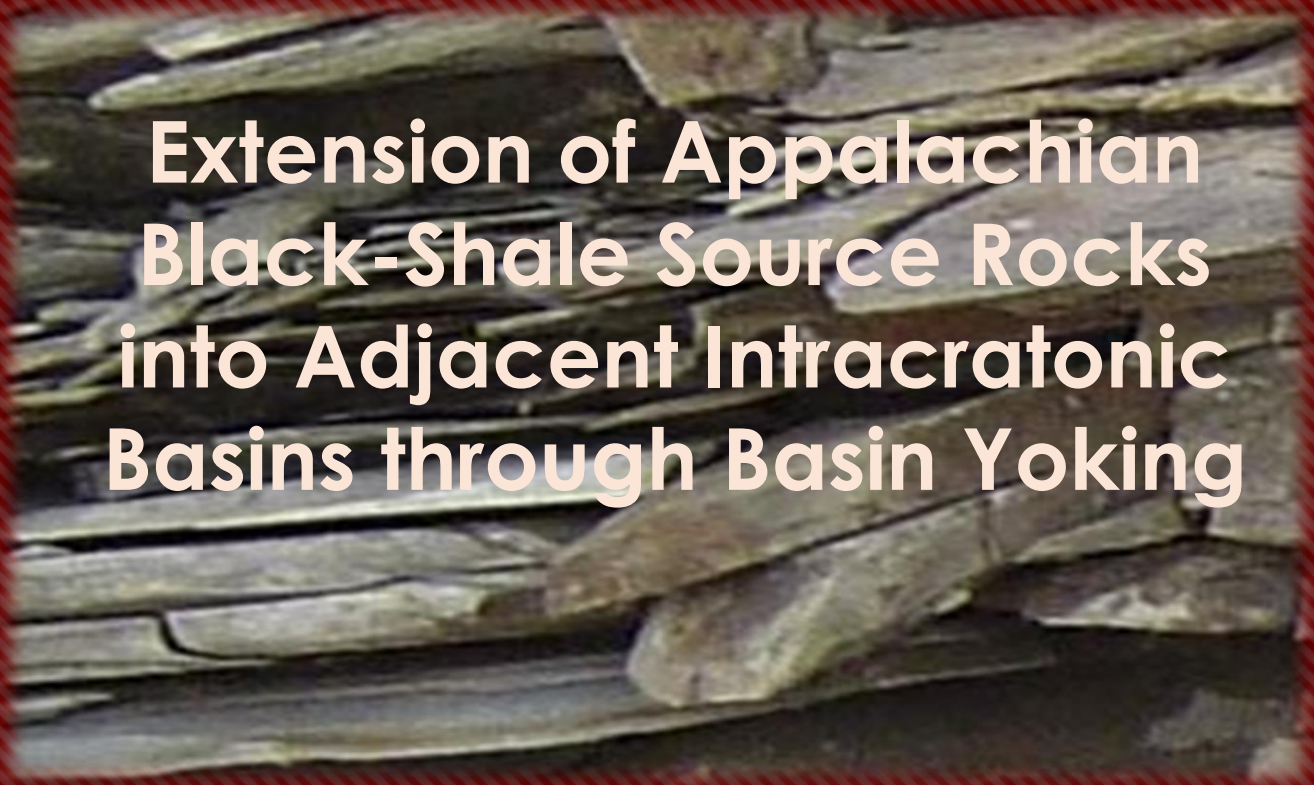
[1]University of Kentucky, Lexington, Kentucky (fettens@uky.edu)

Abstract

Foreland basins are typically major repositories for dark, organic-rich gas shales in epicontinental settings, and mapping the distribution of these dark-shale basins shows that they are related to the migration of deformational orogenic loads in space and time. However, mapping also shows that at certain times and places, these same dark shales, along with their respective depositional regimes, migrated beyond the normal limits of the foreland basin into adjacent intracratonic basins. Such a flexural interaction between a foreland basin and an intracratonic basin has been called basin yoking. Considering that basins and intervening arches or bulges reflect long wave-length fluctuations of the crust, yoking represents the craton-ward movement of a foreland deformational load to the point that loading-related subsidence effectively "submerges" any inter-basinal arch due to destructive interference between basins and bulges, thereby allowing the depositional conditions from one basin to migrate into another. Moreover, much of the subsidence involved in basin yoking occurred along old basement fault zones that were reactivated in ways that apparently facilitated flexural movement in upper viscous parts of the crust. Some of the yoking, like that during the Blountian tectophase of the Taconian Orogeny, involved a rather tortuous path of subsiding basement structures with accompanying dark shales, whereas in the Late Ordovician Taconic tectophase, northwestern parts of the Utica dark-shale basin merely joined the Michigan Basin between two simple structures during the Late Ordovician Eden-Mayville transition.

Other basins, like the Devonian Illinois Basin, started with their own distinctive Middle-Late Devonian dark-shale sequences, which were abruptly replaced with later Devonian (Acadian), Appalachian-Basin-type sequences due to yoking. Although

foreland basins may provide ideal circumstances for dark-shale deposition, basin yoking is a widespread, and largely unrecognized, way of extending that deposition to adjacent basins. Although foreland and yoking-related subsidence are mainly controlled by large-scale kinematic processes during convergence, much of the subsidence clearly occurred along basement structures that probably controlled the local timing, nature and distribution of the related dark shales. Such basin yoking is in part responsible for the presence of black-shale source rocks and unconventional resources found in both the intracratonic Michigan and Illinois basins.



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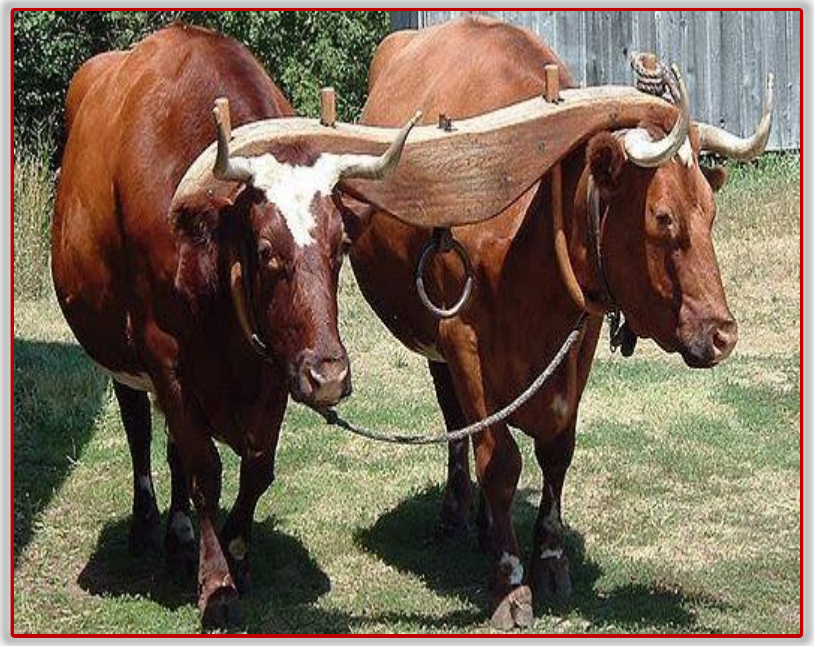
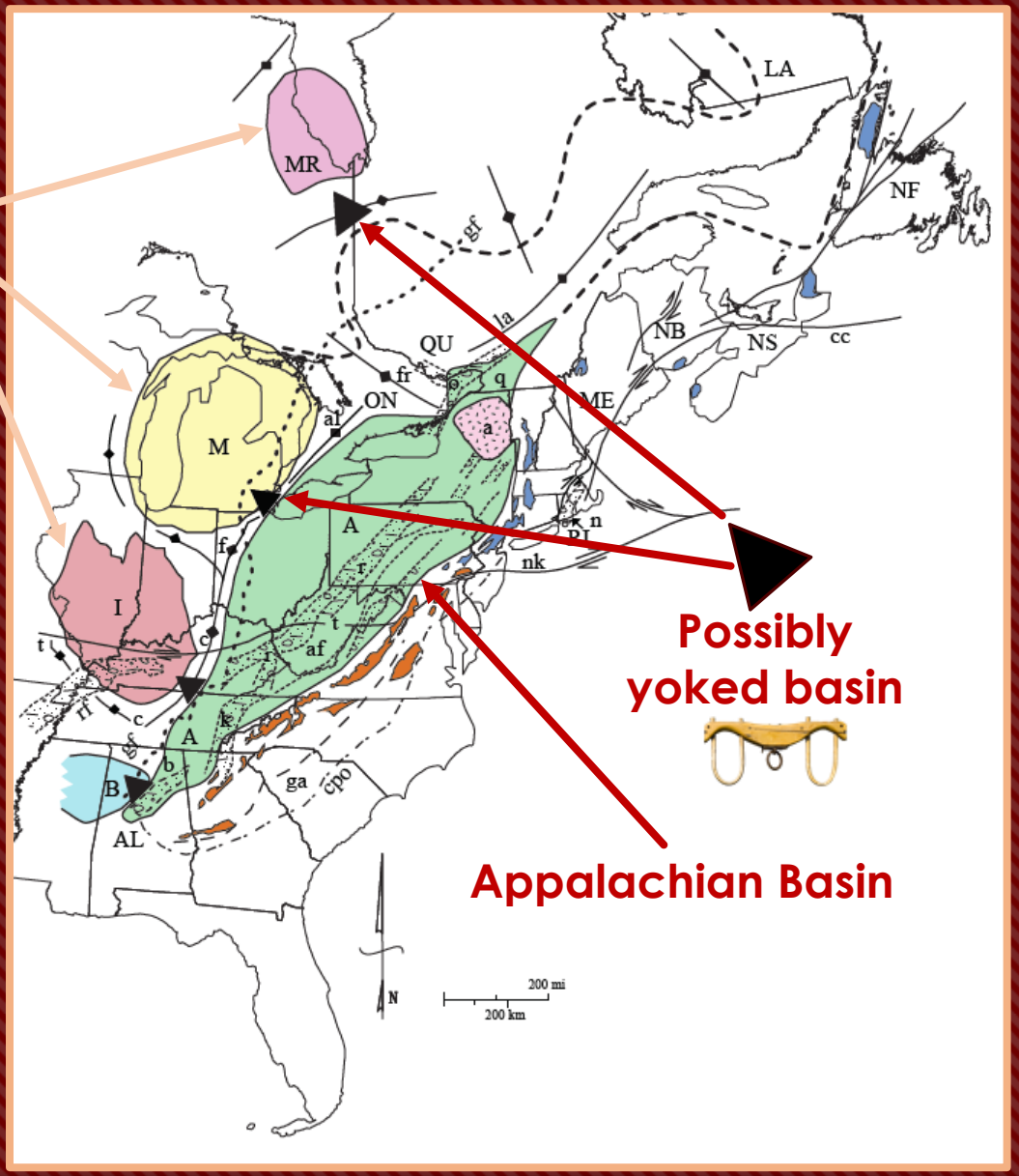
Frank R. Ettensohn
Department of Earth & Environmental Sciences
University of Kentucky
Lexington, KY 40506

Talk Outline

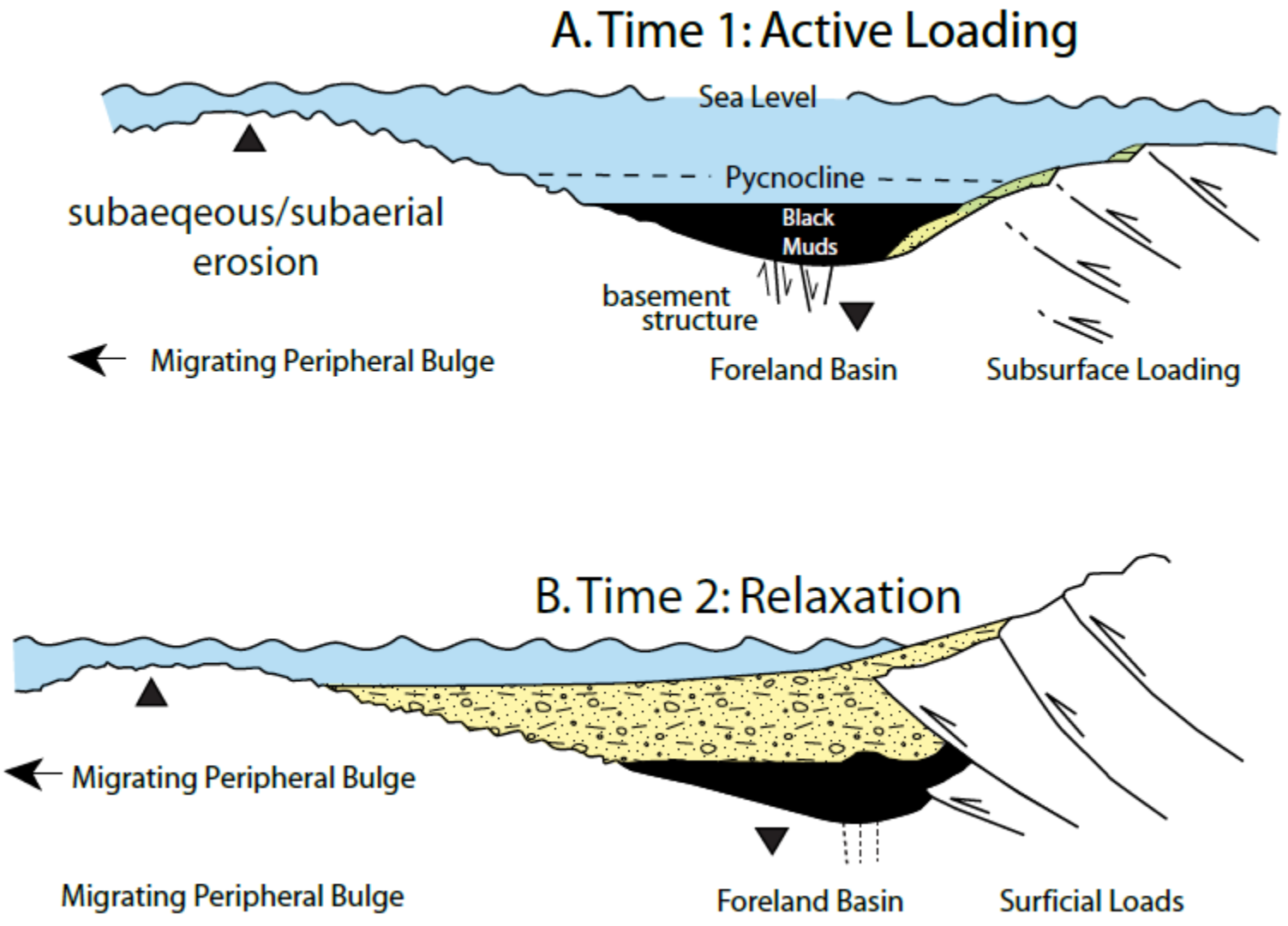
- 1.) Central thesis
- 2.) Yoking mechanism
- 3.) Ordovician example
- 4.) Devonian examples
- 5.) Mississippian example
- 6.) Summary



Intracratonic basins

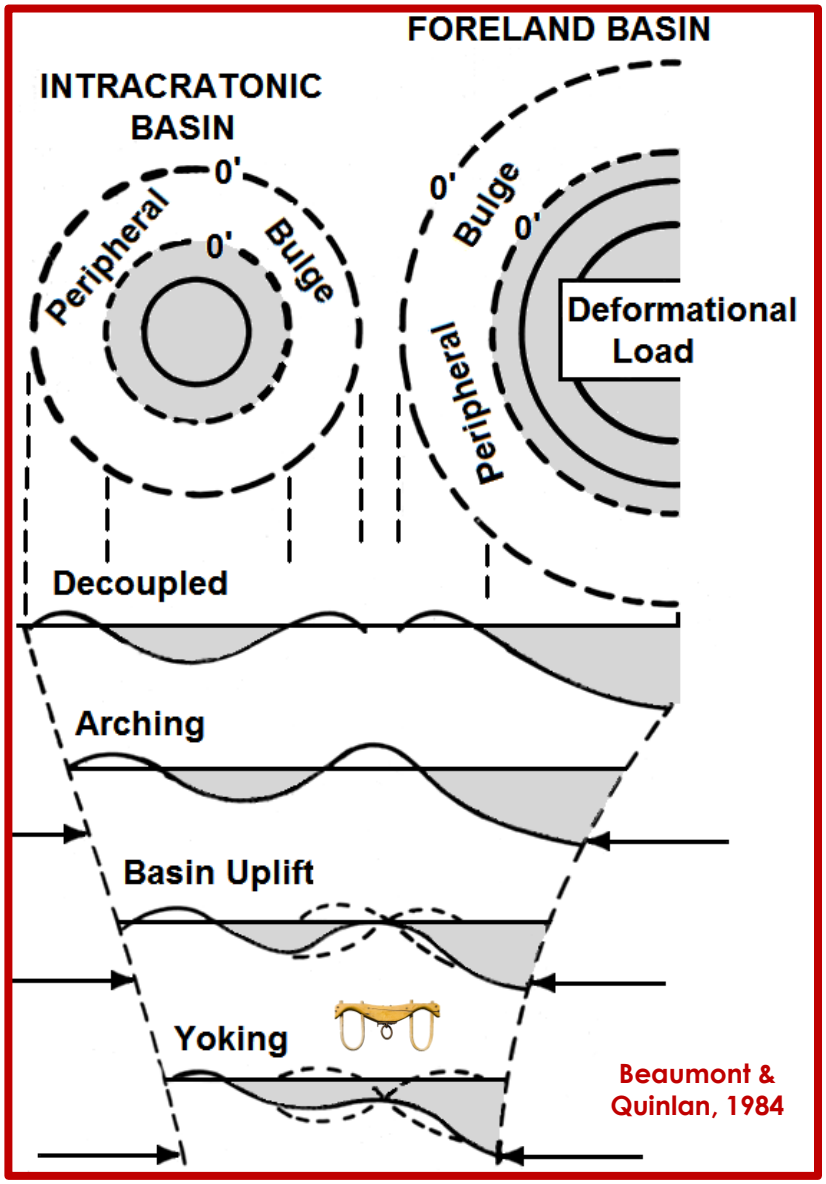


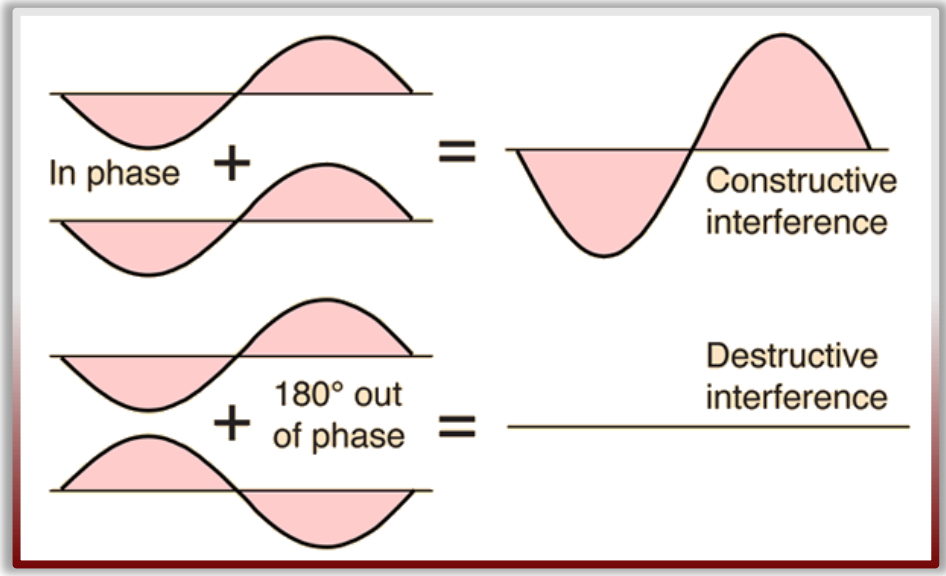
1.) Central thesis: The Appalachian Basin was periodically yoked to intracratonic basins during orogenic events.



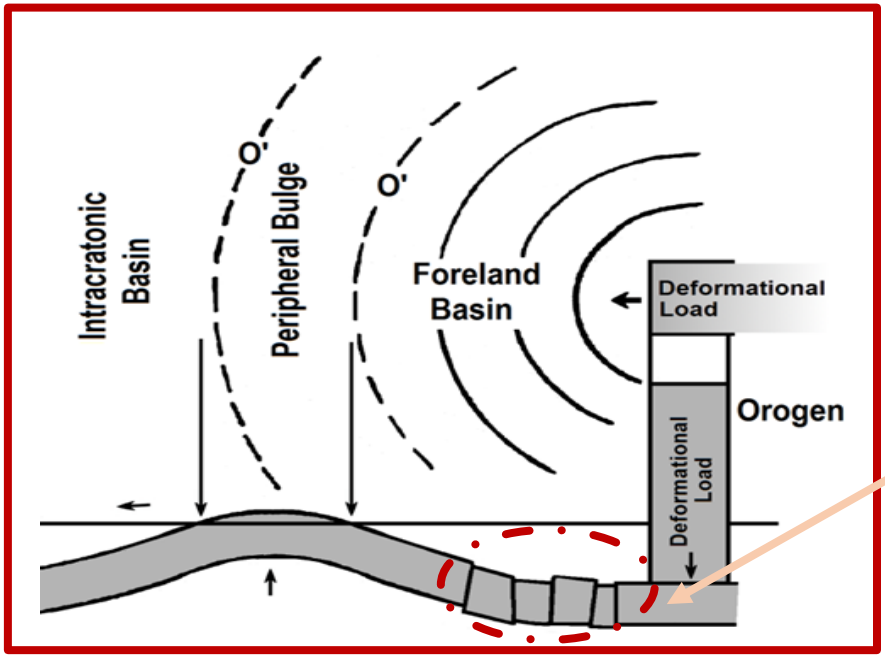
2.) <u>Yoking mechanism</u>: Loading-related subsidence as long-wavelength deflections of Earth's crust generated by far-field stresses during orogeny.

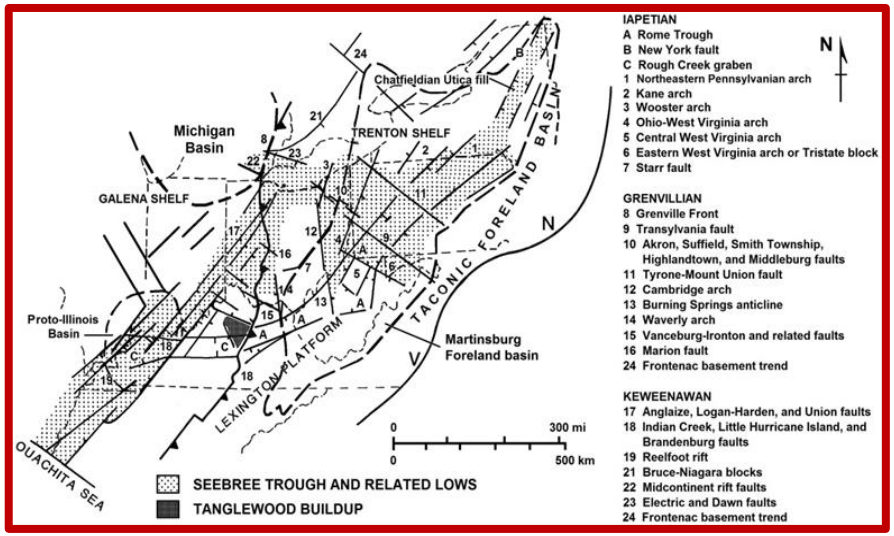
Basin Yoking





2.) Yoking mechanism: Constructive and destructive interference of long wave-length deflections in Earth's crust during orogeny.



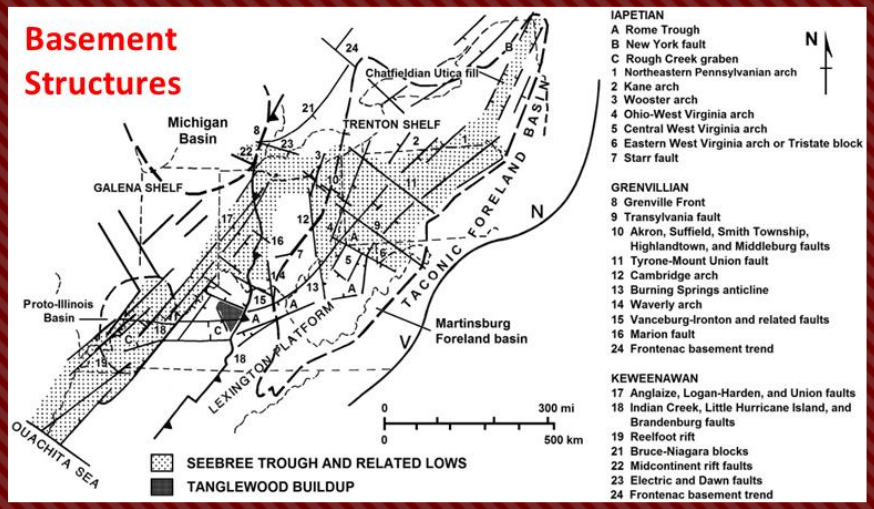


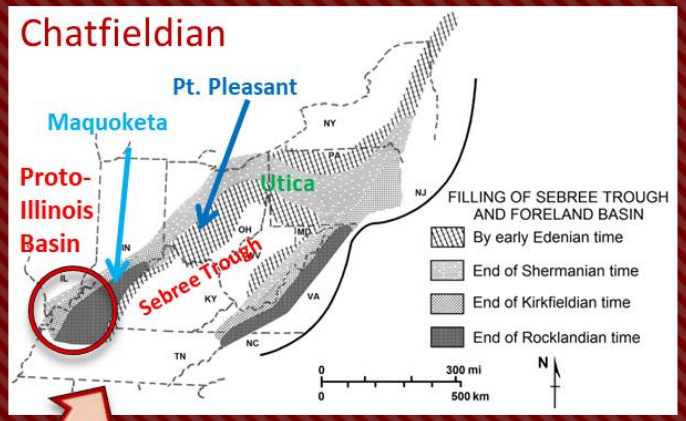
2.) <u>Yoking mechanism</u>: Basement structures.

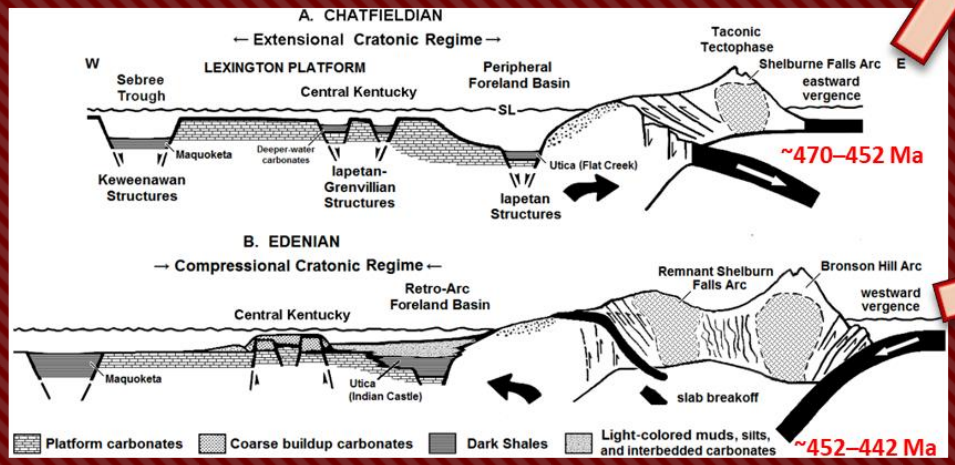
Movement of long-wavelength crustal deflections may reactivate basement structures, facilitating the yoking process.

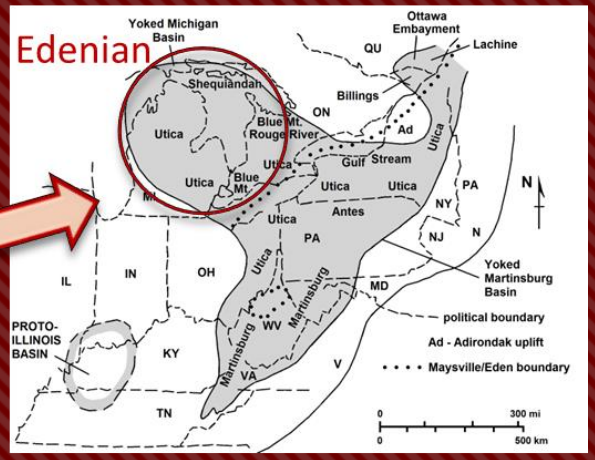
Basement structures of many ages that weaken the surficial crust are prevalent.

Ordovician (Taconian) examples of yoking related to tectonic regime





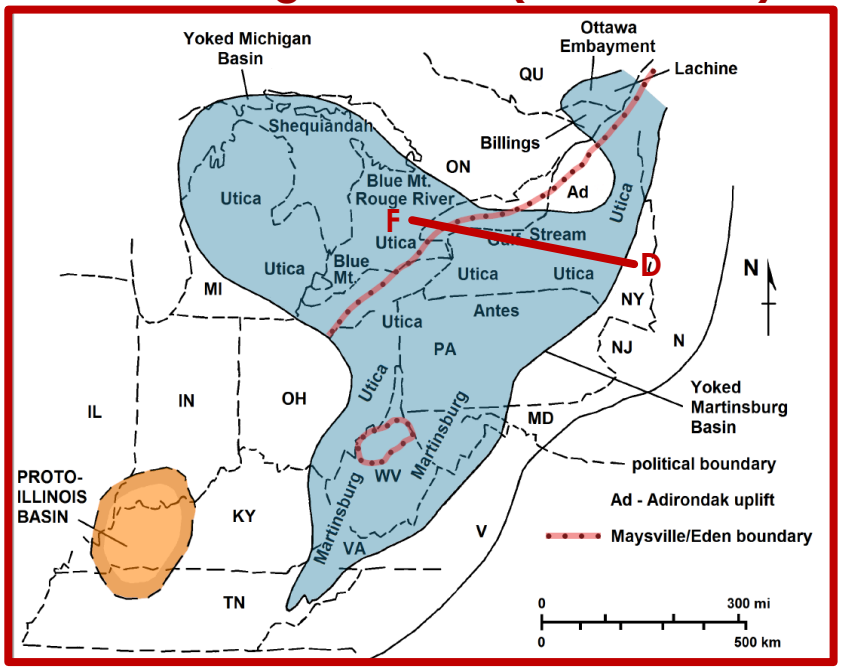




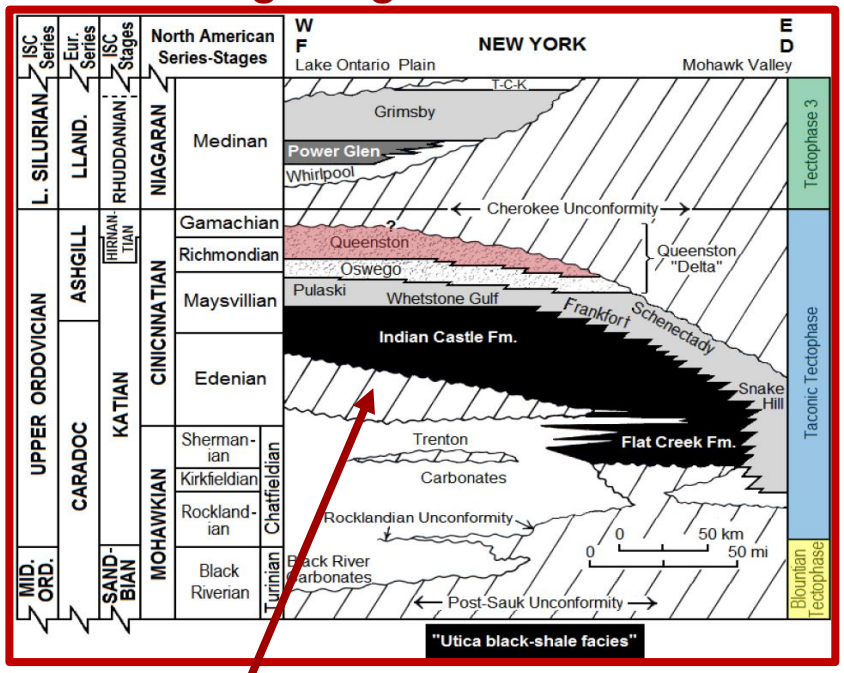
2.) <u>Yoking mechanism</u>: The crustal yoking response is related to the tectonic stress regime, either tensional or compressional.

3.) Ordovician (Taconian) Example: Yoking during Utica black-shale deposition

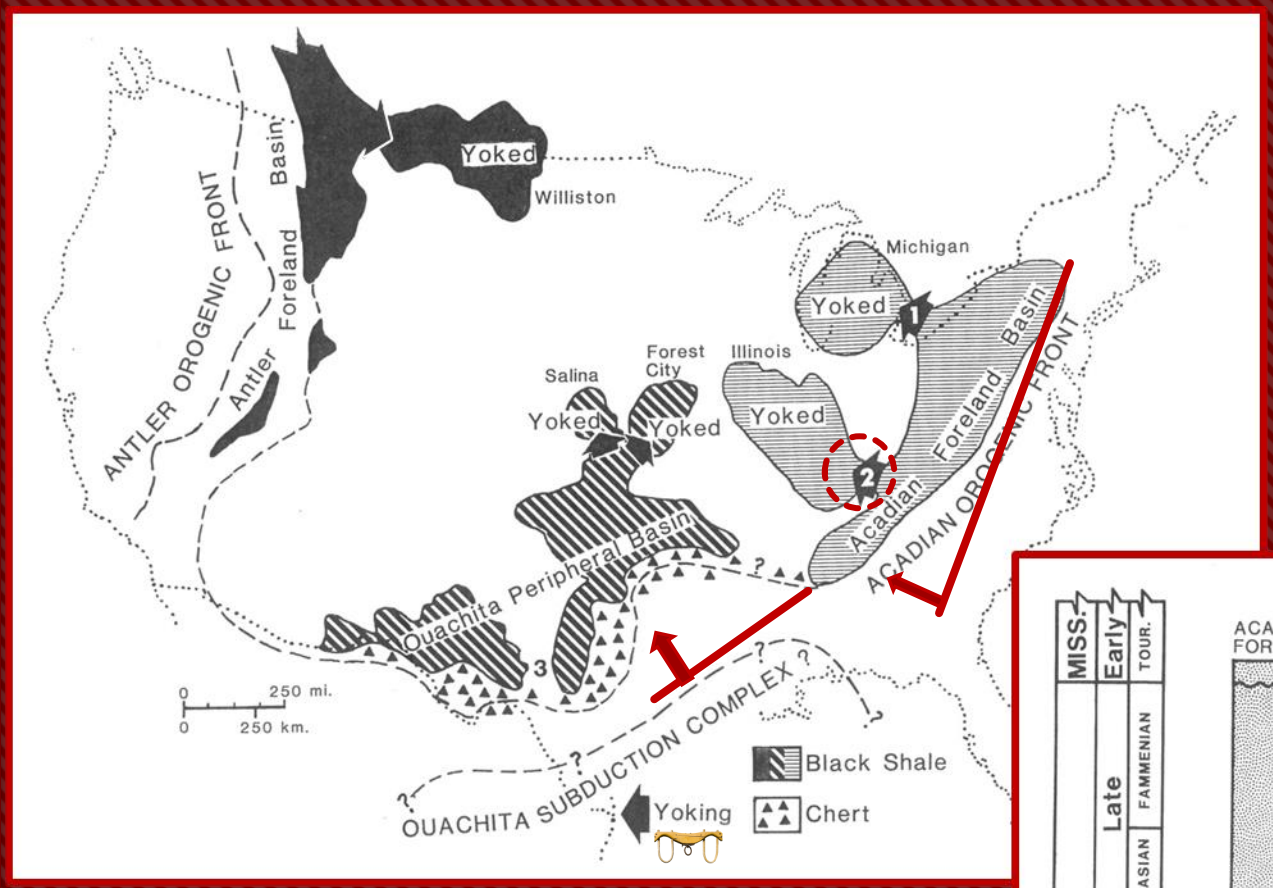
Late Ordovician yoked Appalachian and Michigan basins (Utica Shale)

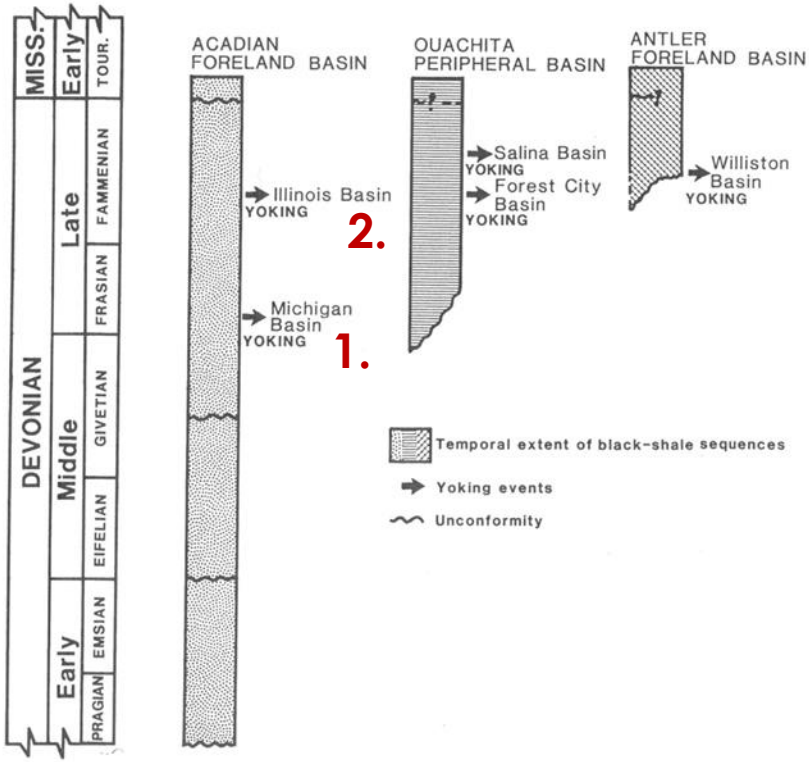


Sectional view showing westwardly "migrating" Utica Shale



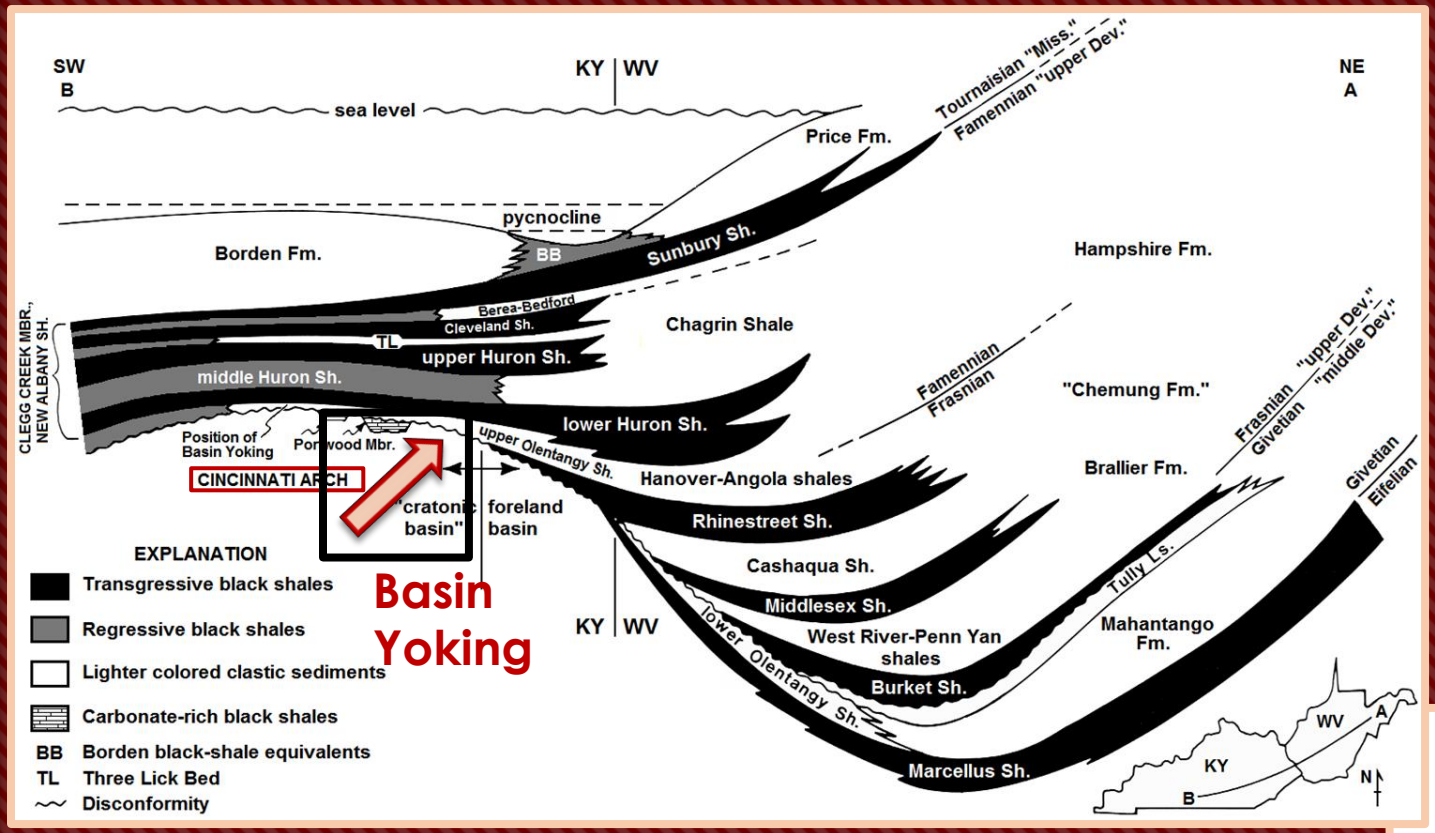
Migrating bulge-related unconformity



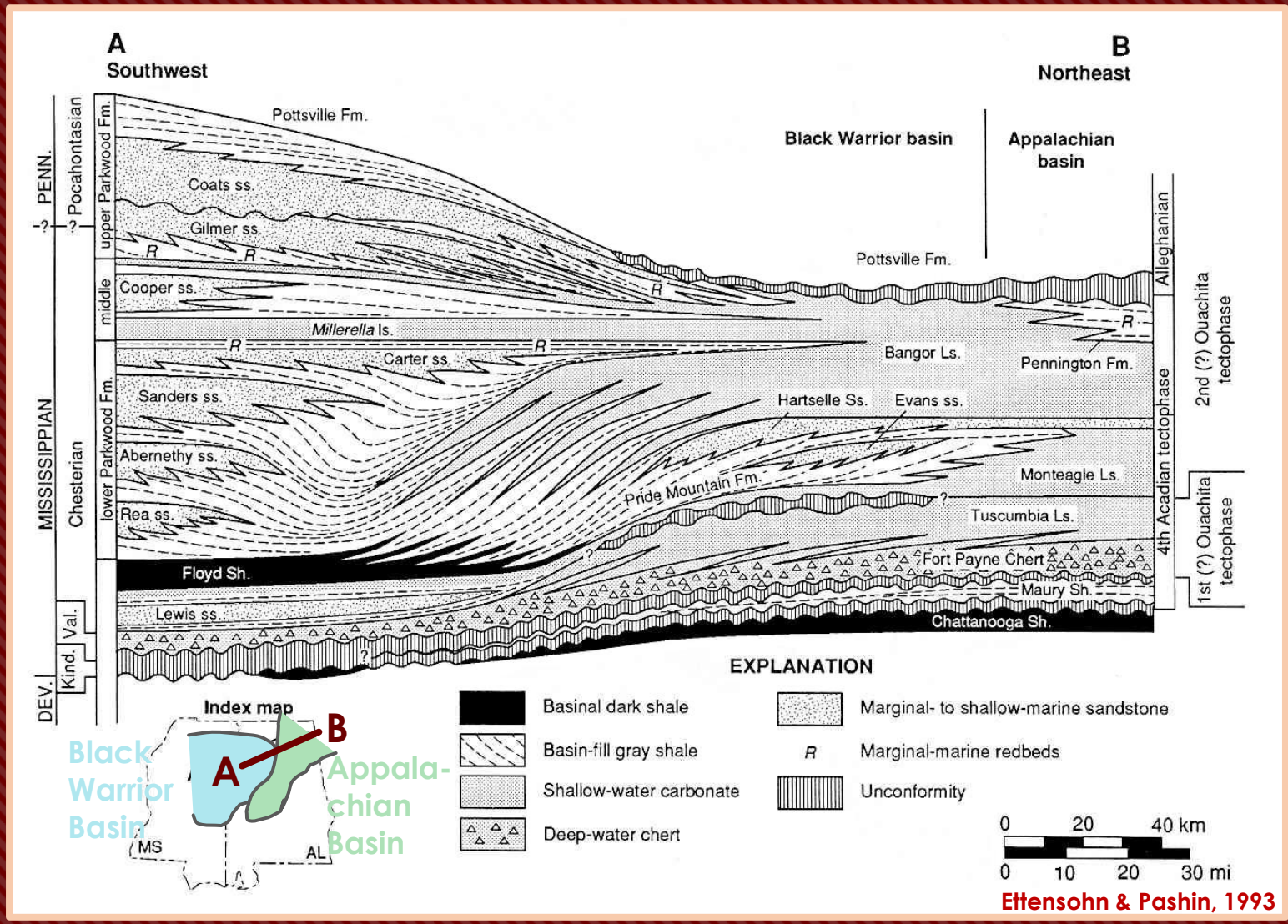


Late Devonian Basin Yoking and Timing : Basin yoking tracks the progress of Acadian orogeny (diachronous scissors-like closings).

4.) Late Devonian (Acadian, Ouachita and Antler) examples of yoking



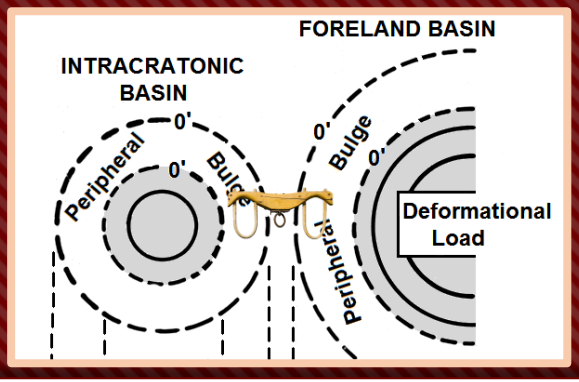
4.) Late Devonian (Acadian) examples of yoking.



Ettensohn & Pashin, 1993

5.) Mississippian example of yoking: Appalachian and Black Warrior foreland basins

6.) Summary



- Yoking between foreland and intracratonic basins is a flexural, tectonic response to the further cratonward movement of a deformational load during orogeny.
- Much of the subsidence involved in yoking occurs along old basement fault zones that are reactivated by far-field stress during orogeny.
- The sequence of yoking events across any one foreland basin parallels the process of orogeny in the adjacent orogen.
- Basin yoking is a widespread — and largely unrecognized — way of extending unconventional black-shale resources into adjacent basins.