Middle Ordovician clastic wedges in East Tennessee: A new look at an old basin

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Acknowledgements

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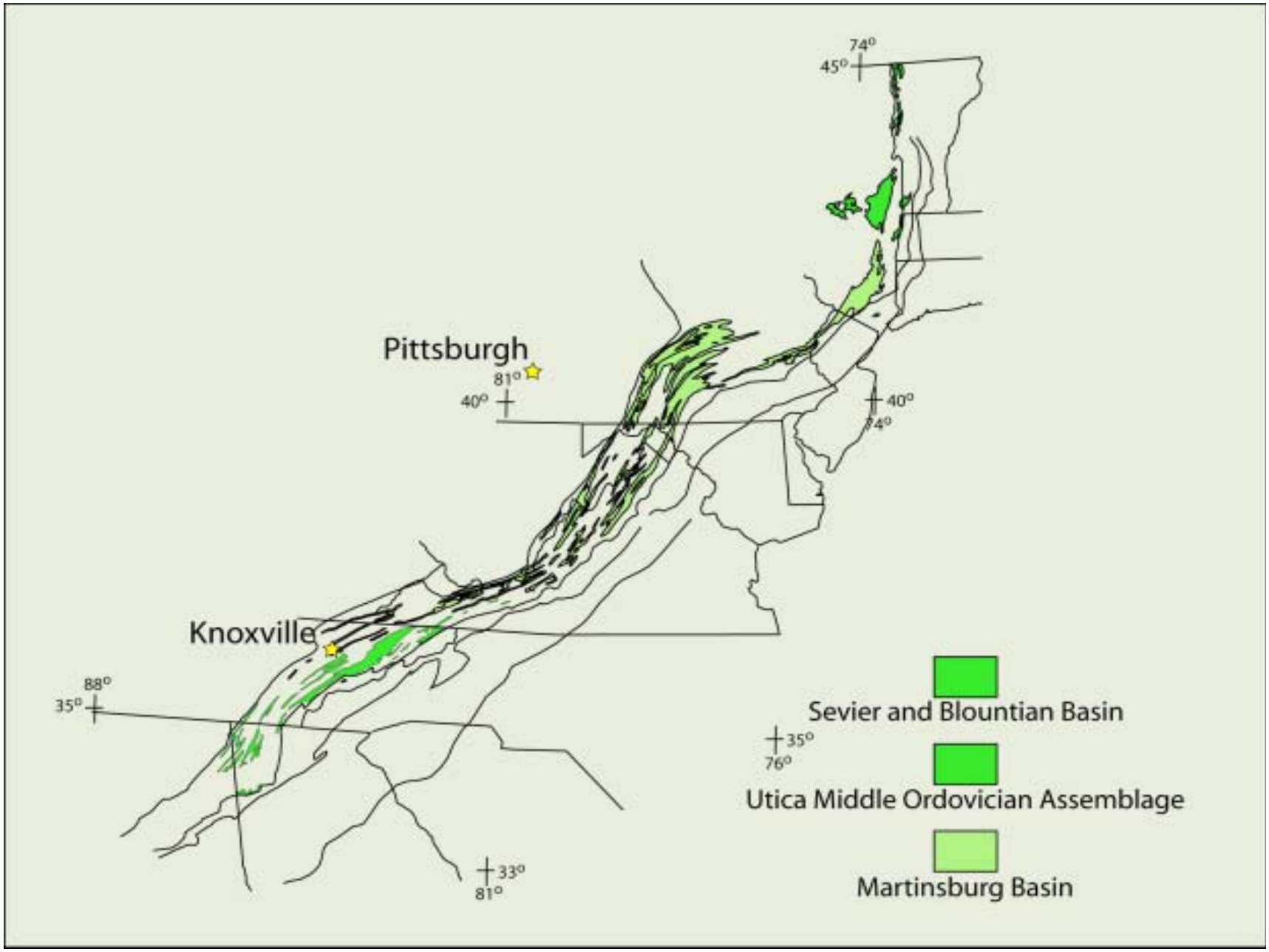
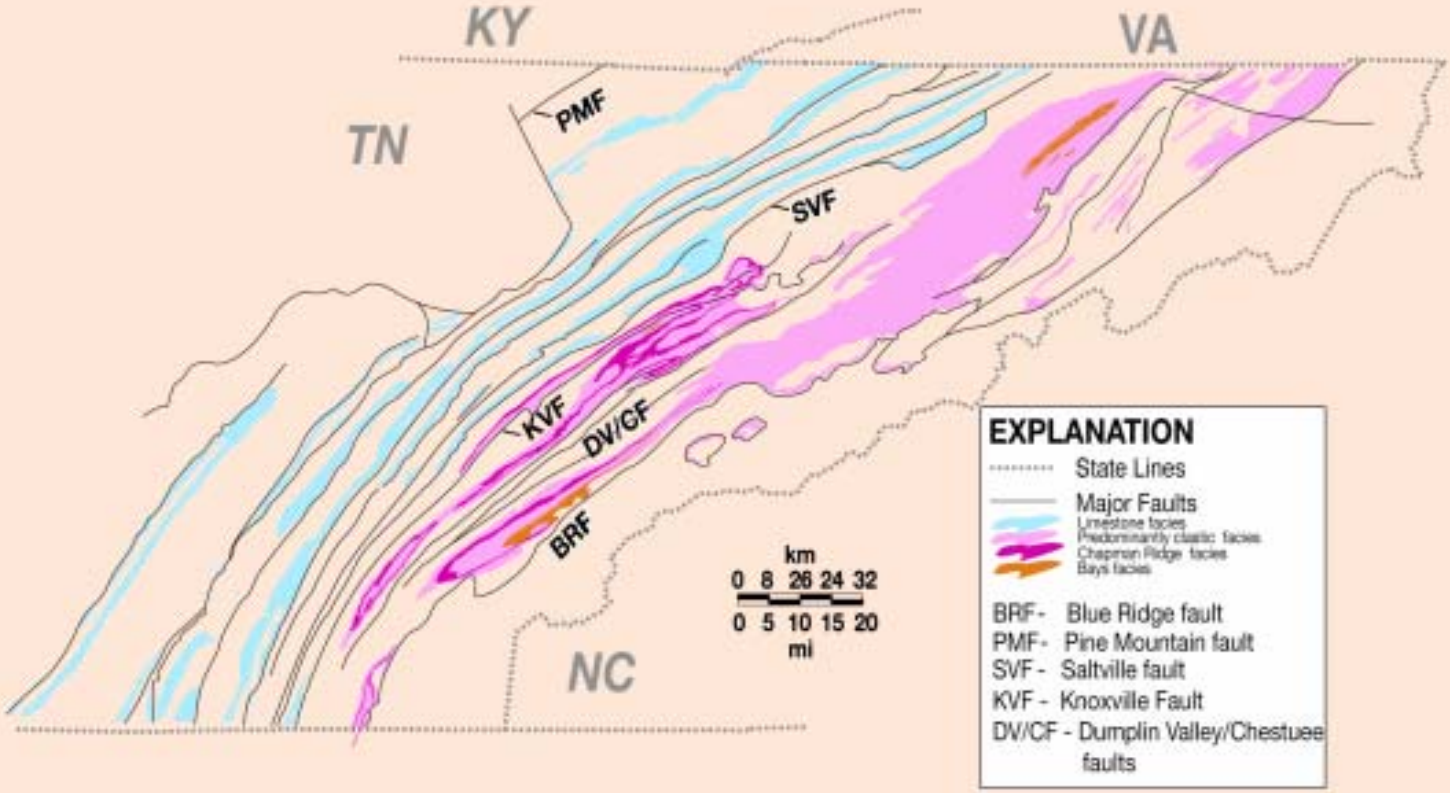
USGS EDMAP Program

University of Tennessee
Science Alliance Center of Excellence

Tectonic Map of the U.S. Appalachians


74°
45°
Pittsburgh
81°
40°
40°
74°
Knoxville
88°
35°
35°
76°
33°
81°
Sevier and Blountian Basin
Utica Middle Ordovician Assemblage
Martinsburg Basin


KY
VA
TN
NC
PMF
SVF
KVF
DV/CF
BRF
km
0 8 26 24 32
0 5 10 15 20
mi
EXPLANATION
State Lines
Major Faults
Limestone facies
Predominantly clastic facies
Chapman Ridge facies
Bays facies
BRF - Blue Ridge fault
PMF - Pine Mountain fault
SVF - Saltville fault
KVF - Knoxville Fault
DV/CF - Dumplin Valley/Chestuee faults

Ages

Upper Ordovician	Martinsburg basin
Middle Ordovician	Sevier-Blountian basin
Middle Ordovician Unconformity	
Lower Ordovician to Upper Cambrian	Knox Group carbonate bank

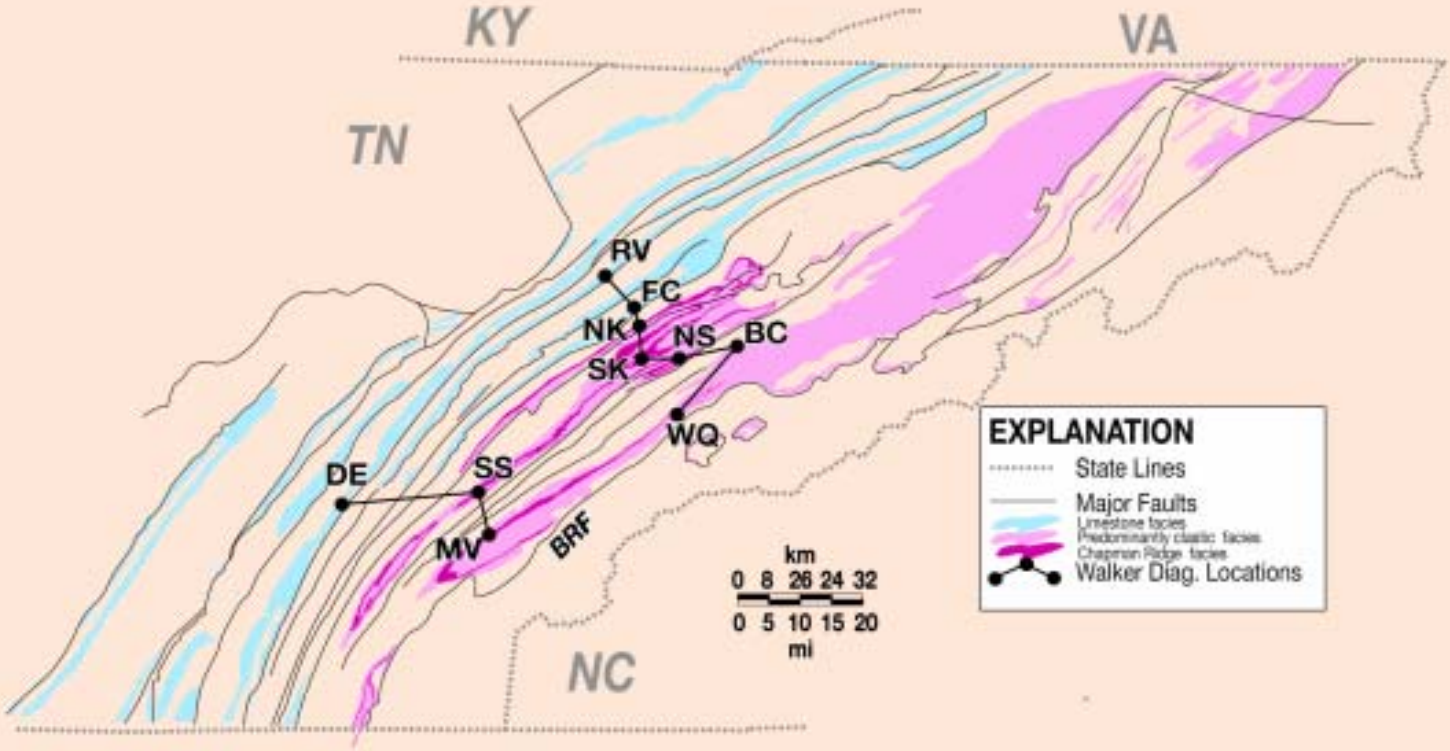
Sevier Basin

Up to 3,000 meters of sediment (Rodgers, 1953; Shanmugam and Walker, 1978)

Taconic foredeep (Shanmugam and Walker, 1978)

Contact of Middle Ordovician with Knox Group is Middle Ordovician unconformity

Carbonates become drowned out by clastics prograding to the west


KY
VA
TN
NC
RV
FC
NK
NS
BC
SK
WQ
DE
SS
MV
BRF
km
0 8 26 24 32
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mi
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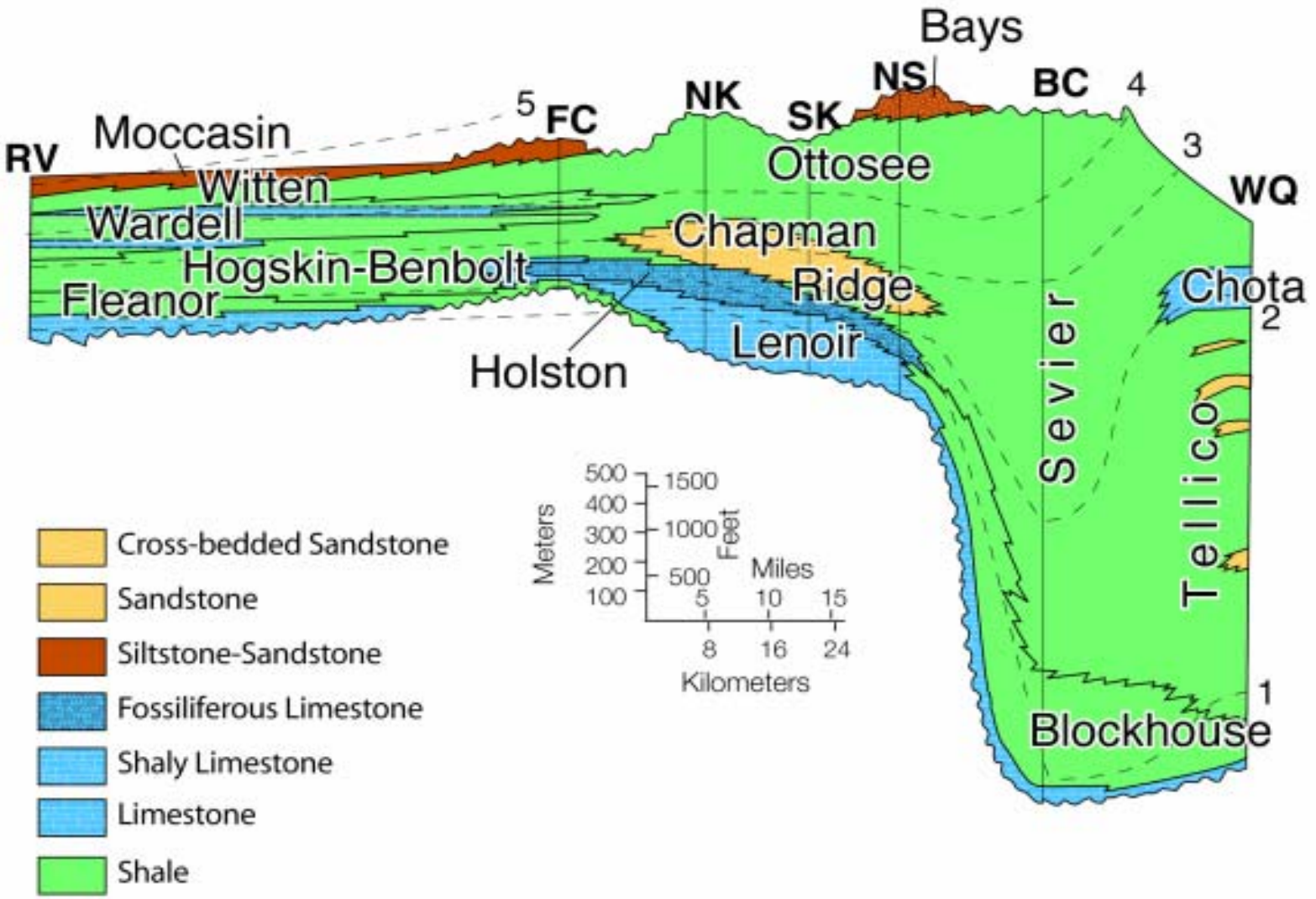
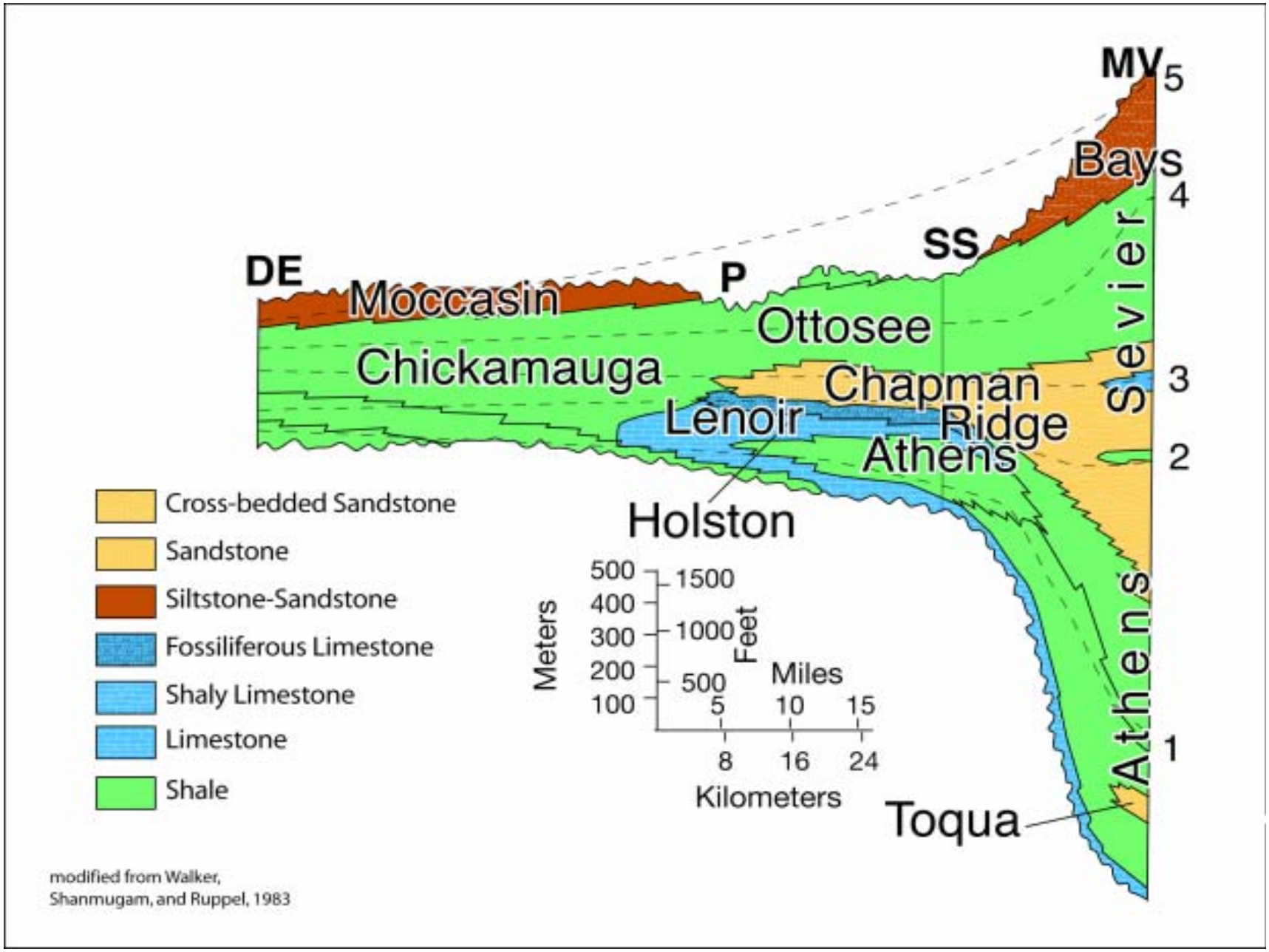
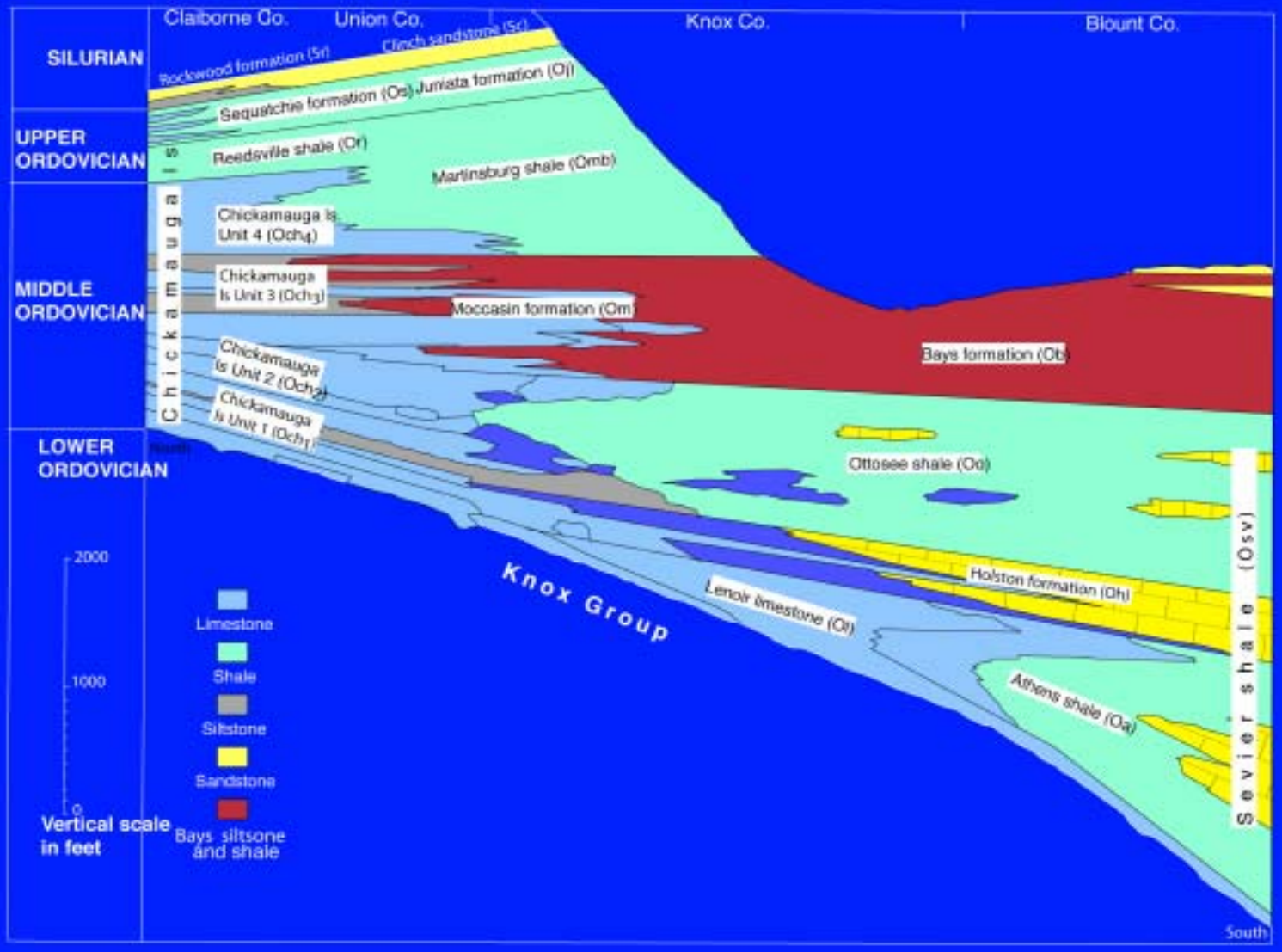
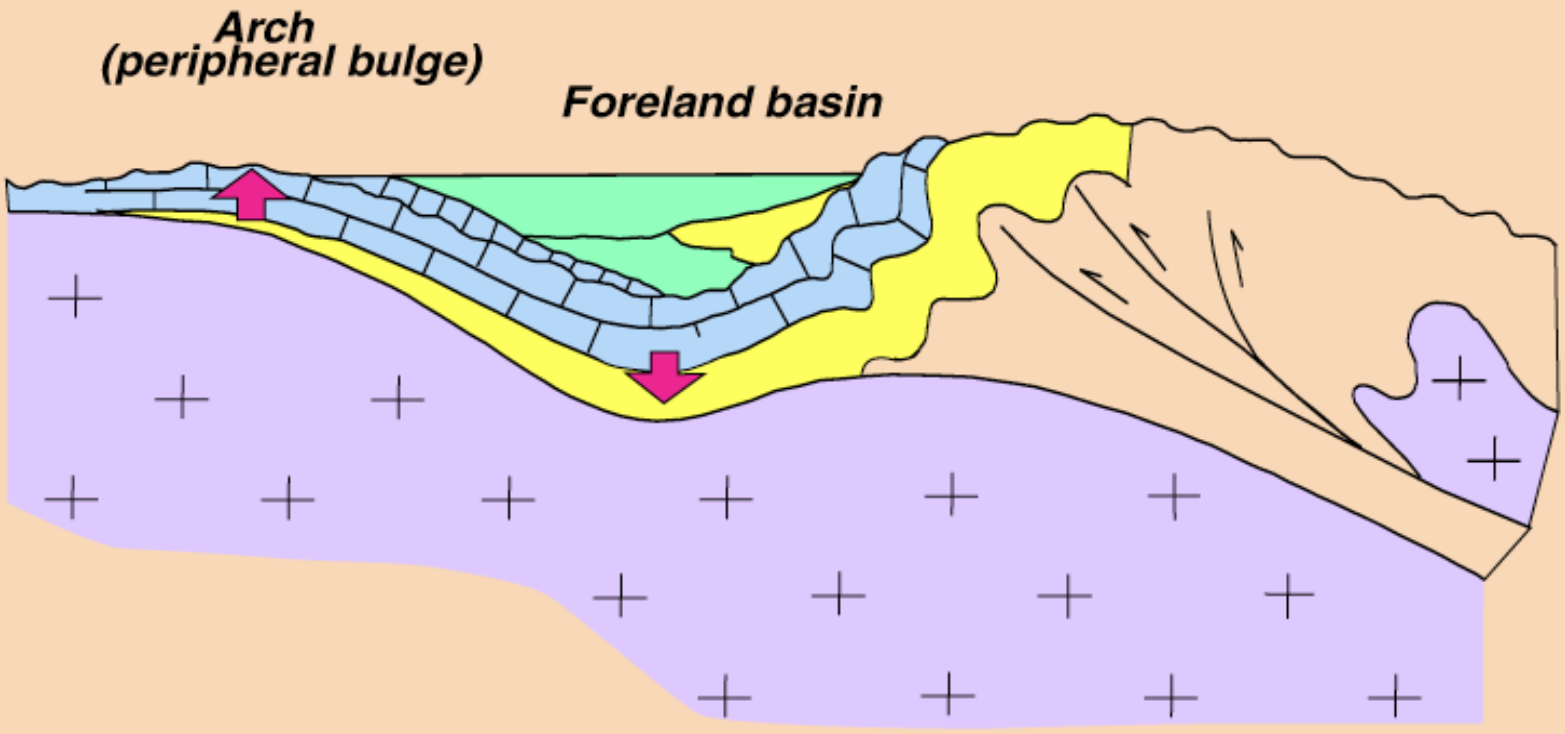
Walker Diag. Locations



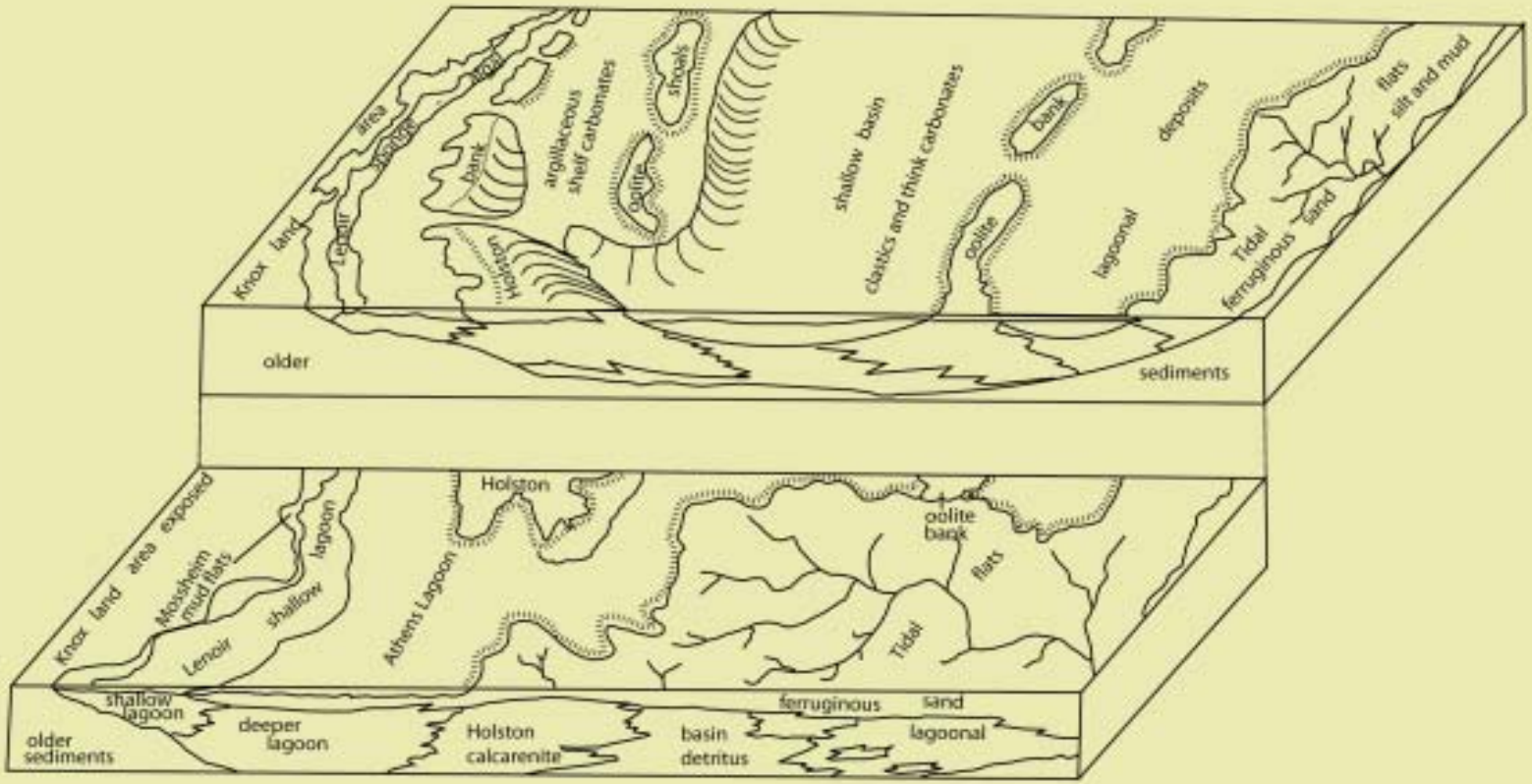
modified from Walker, Shanmugam, and Ruppel, 1983


MV
5
Bays
4
SS
DE
P
Moccasin
Ottosee
Chickamauga
Chapman
Ridge
Lenoir
Athens
3
2
Sevier
Holston
Athens
1
Toqua
Cross-bedded Sandstone
Sandstone
Siltstone-Sandstone
Fossiliferous Limestone
Shaly Limestone
Limestone
Shale
Meters
500
400
300
200
100
Feet
1500
1000
500
Miles
5
10
15
8
16
24
Kilometers
modified from Walker,
Shanmugam, and Ruppel, 1983

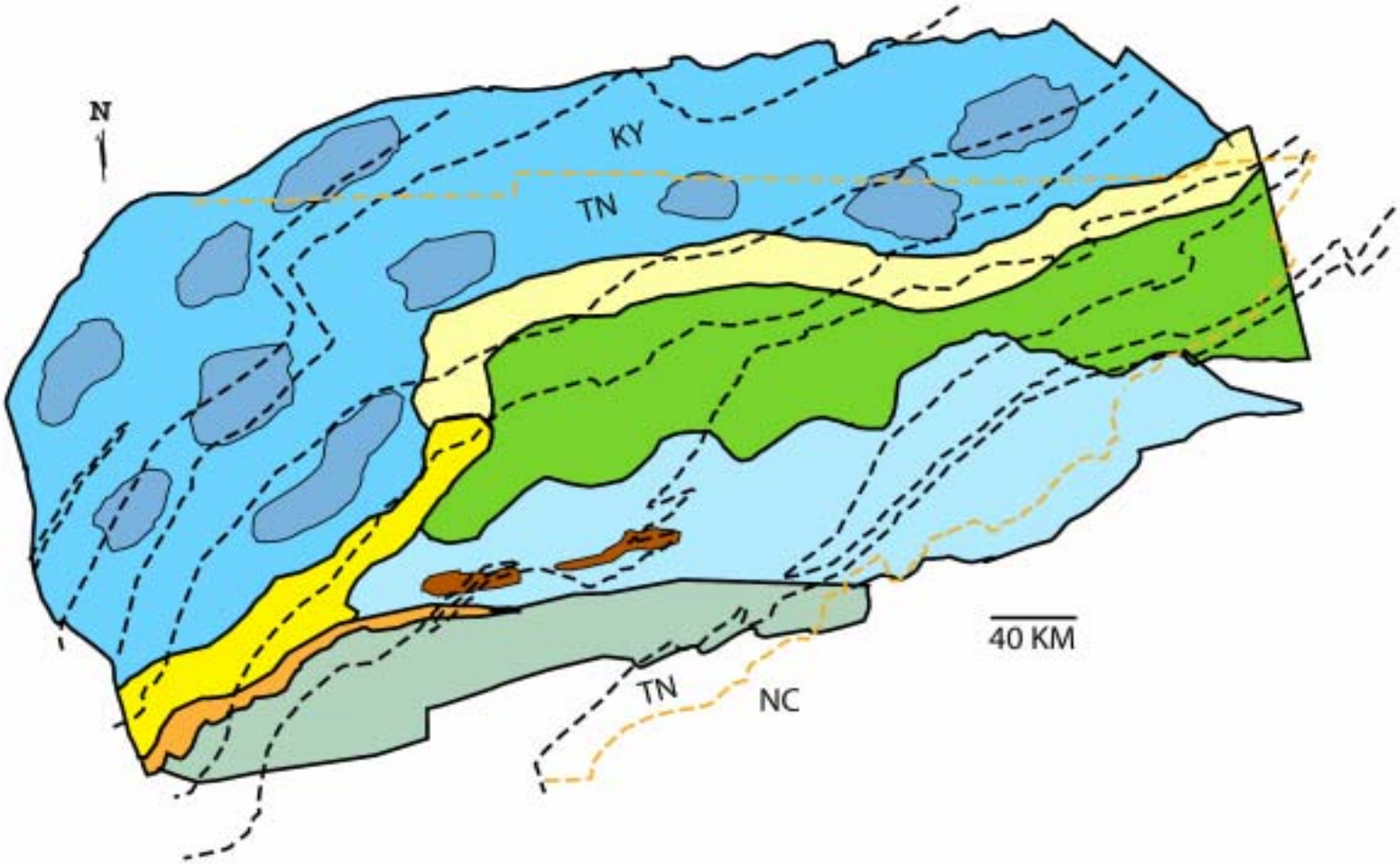

Claiborne Co.
Union Co.
Knox Co.
Blount Co.
SILURIAN
UPPER ORDOVICIAN
MIDDLE ORDOVICIAN
LOWER ORDOVICIAN
Clinch sandstone (Sc)
Rockwood formation (Sr)
Juniata formation (Oj)
Sequatchie formation (Os)
Reedsville shale (Or)
Martinsburg shale (Omb)
Chickamauga ls
Chickamauga ls Unit 4 (Och4)
Chickamauga ls Unit 3 (Och3)
Moccasin formation (Om)
Bays formation (Ob)
Chickamauga ls Unit 2 (Och2)
Chickamauga ls Unit 1 (Och1)
Ottosee shale (Oo)
Knox Group
Holston formation (Oh)
Lenoir limestone (Ol)
Athens shale (Oa)
Sevier shale (Osv)
South
2000
1000
0
Vertical scale in feet
Limestone
Shale
Siltstone
Sandstone
Bays siltsone and shale



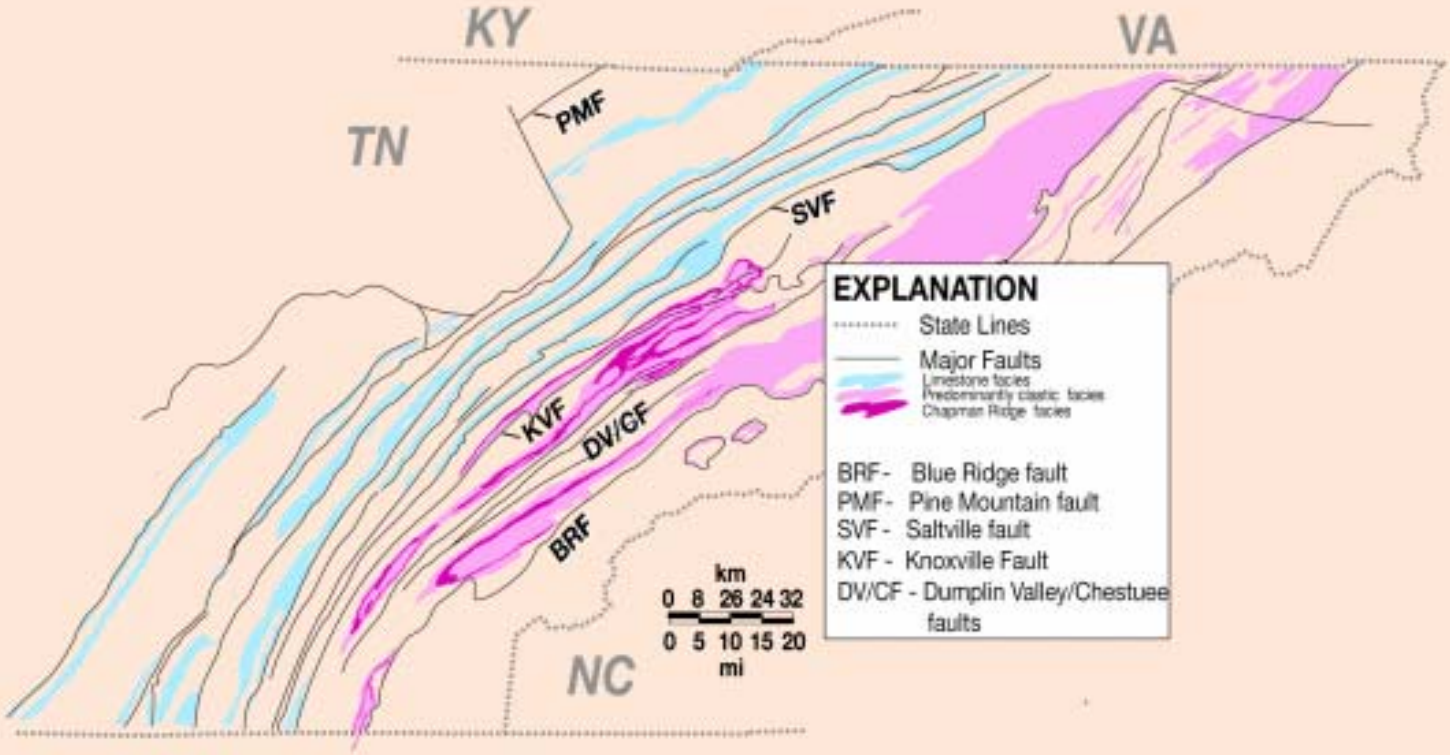
after Mussman and Read (1986)

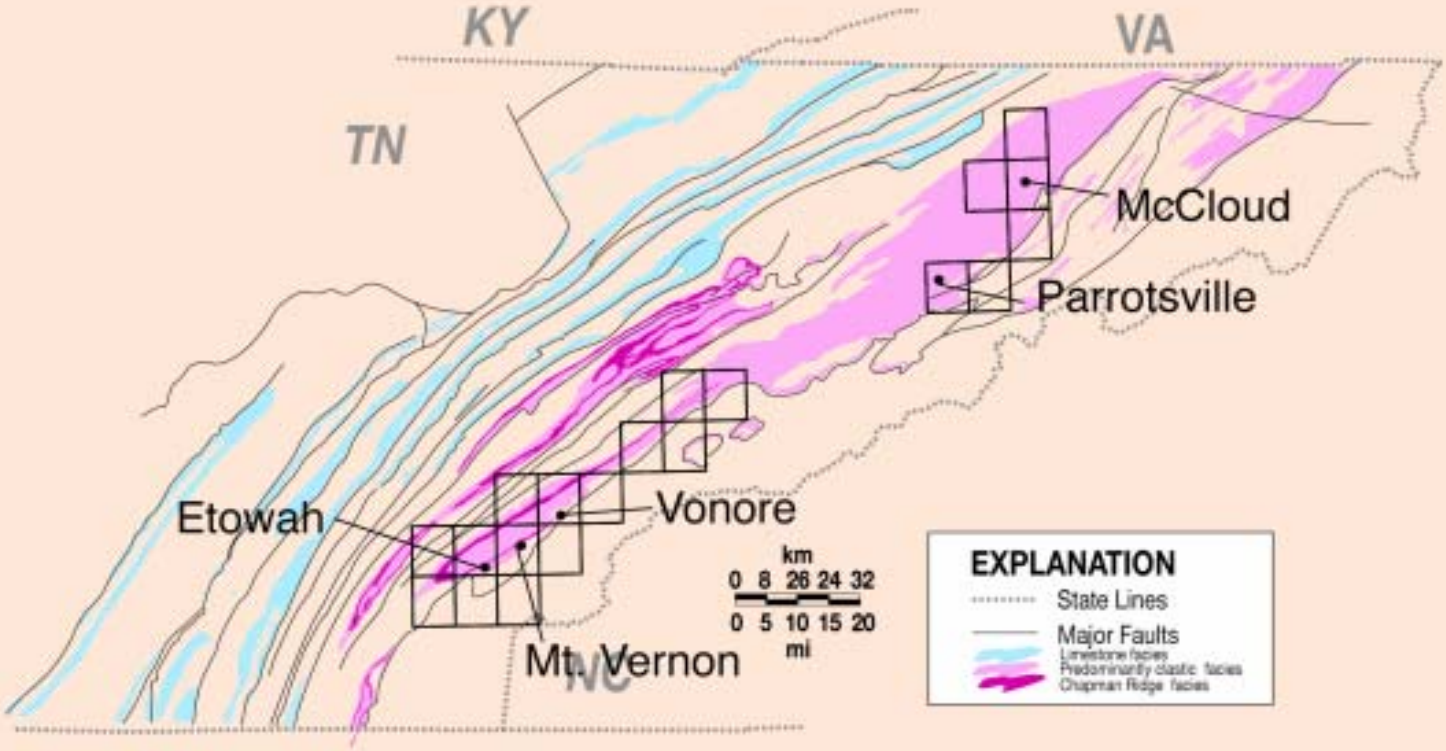


modified from Smith, 1976



modified from Ruppel and Walker, 1984


KY
VA
TN
NC
PMF
SVF
KVF
DV/CF
BRF
EXPLANATION
State Lines
Major Faults
Limestone facies
Predominantly clastic facies
Chapman Ridge facies
BRF - Blue Ridge fault
PMF - Pine Mountain fault
SVF - Saltville fault
KVF - Knoxville Fault
DV/CF - Dumplin Valley/Chestuee faults
km
0 8 26 24 32
0 5 10 15 20
mi


KY
VA
TN
NC
McCloud
Parrotsville
Vonore
Etowah
Mt. Vernon
km
0 8 26 24 32
0 5 10 15 20
mi
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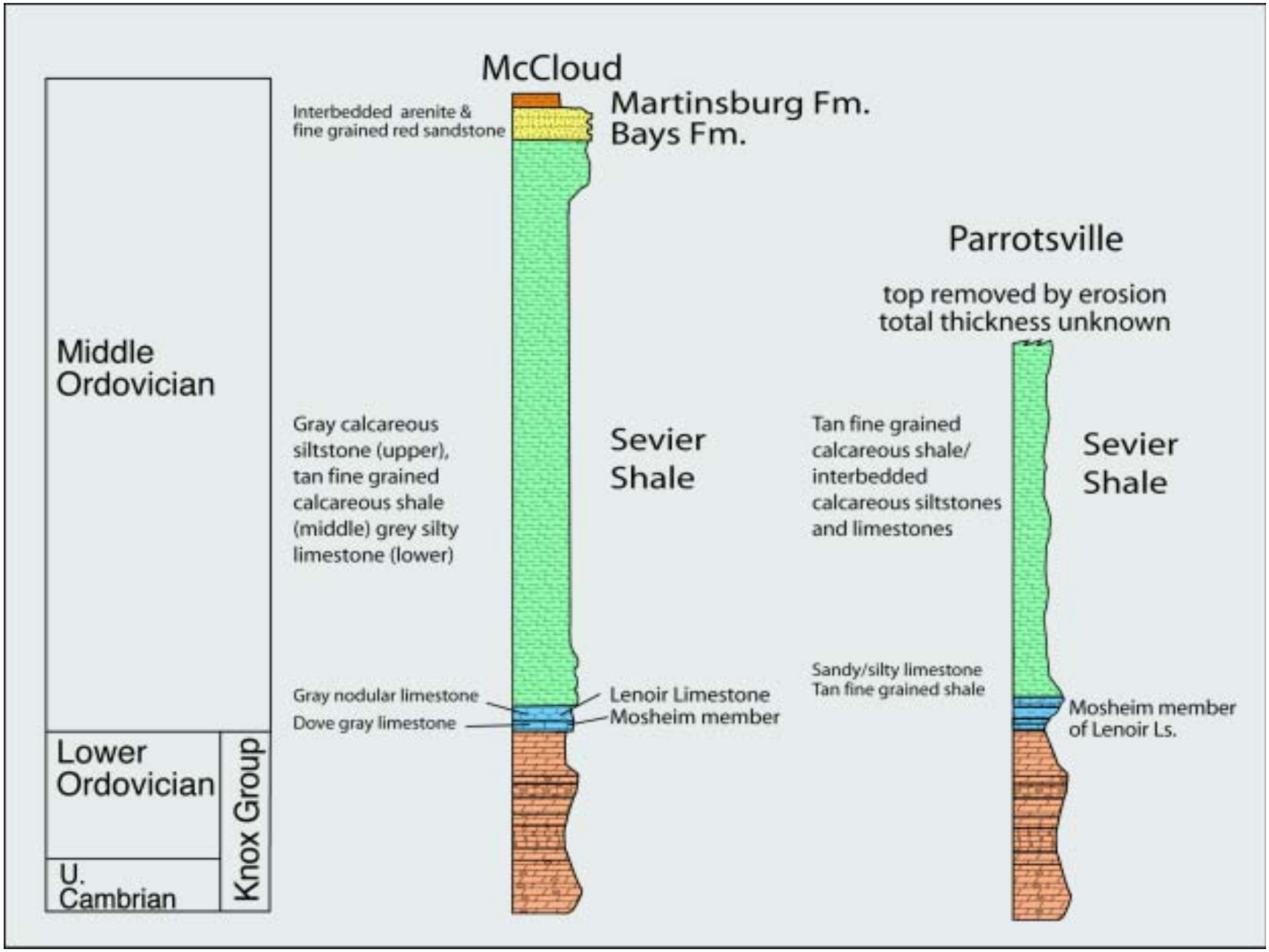
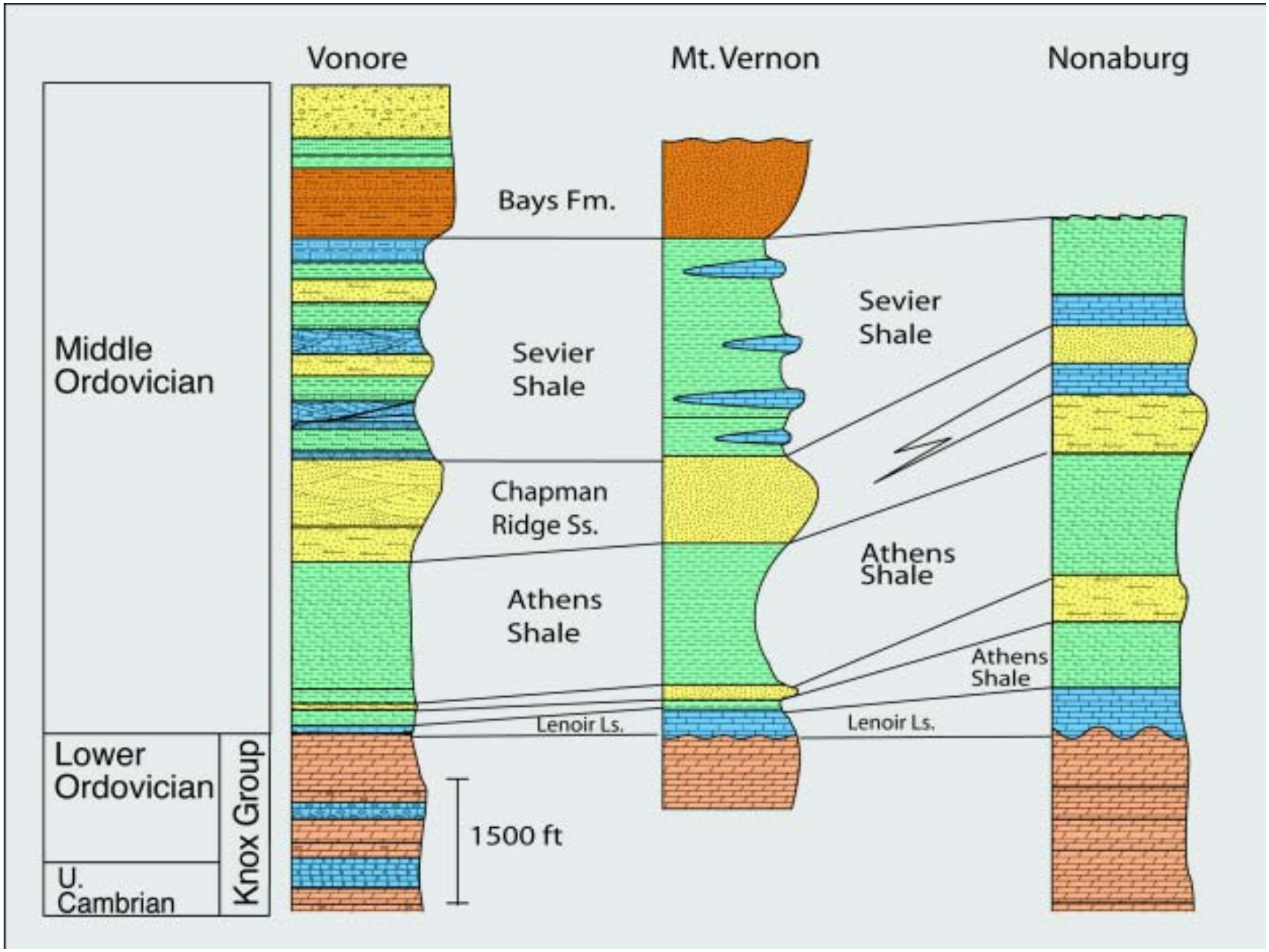
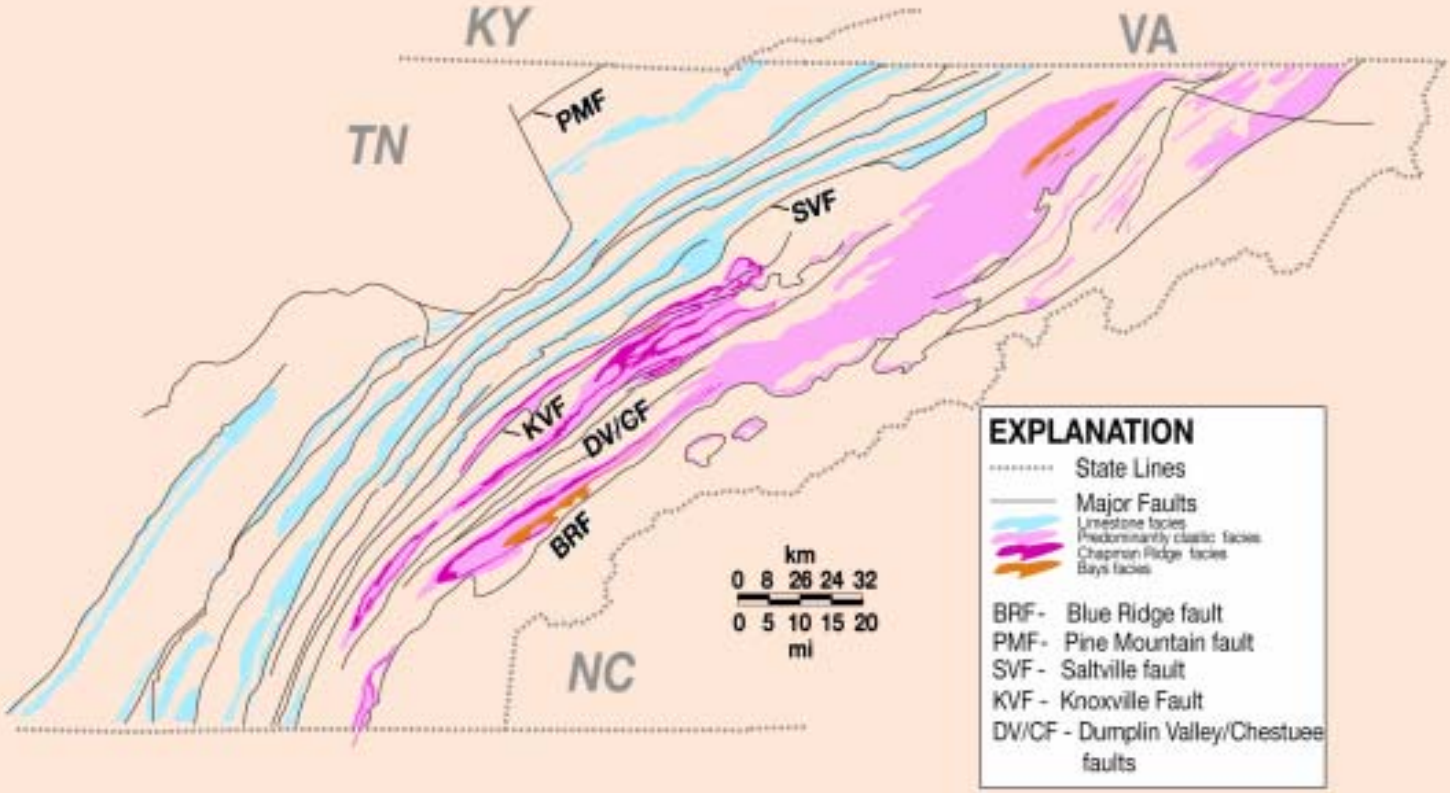

McCloud
Martinsburg Fm.
Bays Fm.
Interbedded arenite & fine grained red sandstone
Middle Ordovician
Gray calcareous siltstone (upper), tan fine grained calcareous shale (middle) grey silty limestone (lower)
Sevier Shale
Gray nodular limestone
Dove gray limestone
Lenoir Limestone
Mosheim member
Lower Ordovician
U. Cambrian
Knox Group
Parrotsville
top removed by erosion
total thickness unknown
Tan fine grained calcareous shale/ interbedded calcareous siltstones and limestones
Sevier Shale
Sandy/silty limestone
Tan fine grained shale
Mosheim member of Lenoir Ls.


Vonore
Mt. Vernon
Nonaburg
Middle Ordovician
Lower Ordovician
U. Cambrian
Knox Group
Bays Fm.
Sevier Shale
Chapman Ridge Ss.
Athens Shale
Lenoir Ls.
1500 ft
Sevier Shale
Athens Shale
Lenoir Ls.
Athens Shale


KY
VA
TN
NC
PMF
SVF
KVF
DV/CF
BRF
km
0 8 26 24 32
0 5 10 15 20
mi
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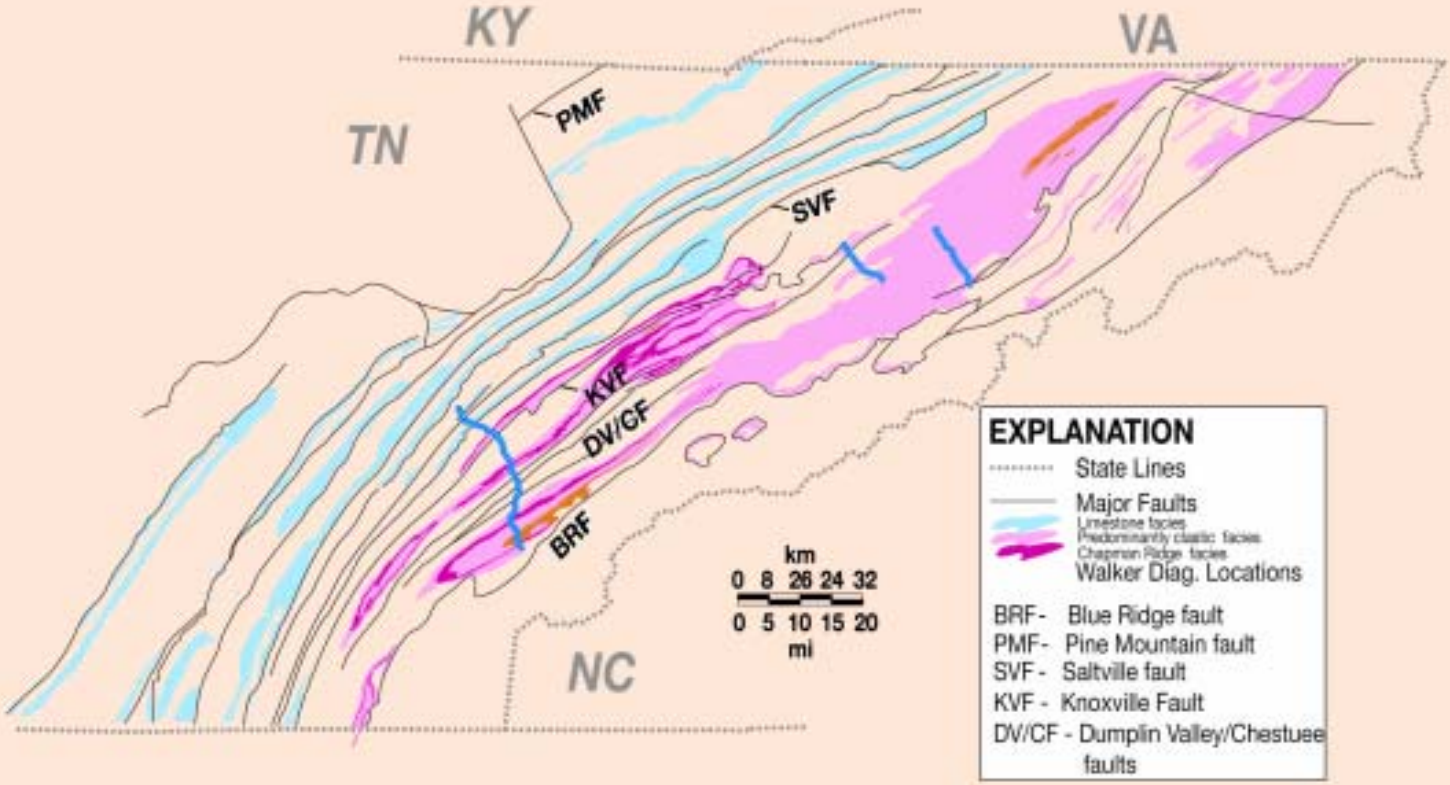
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VA
TN
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PMF
SVF
KVF
DV/CF
BRF
km
0 8 26 24 32
0 5 10 15 20
mi
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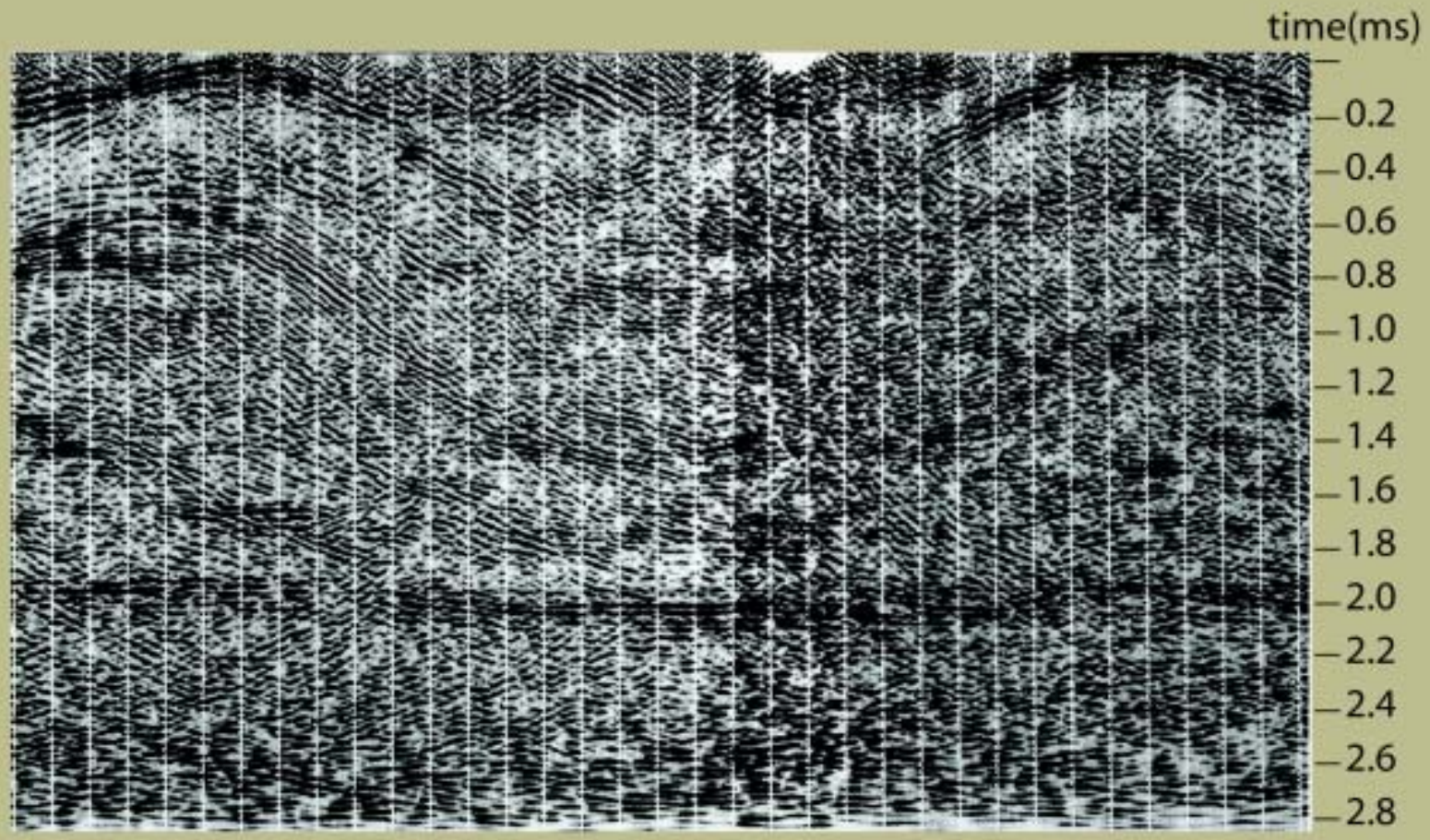
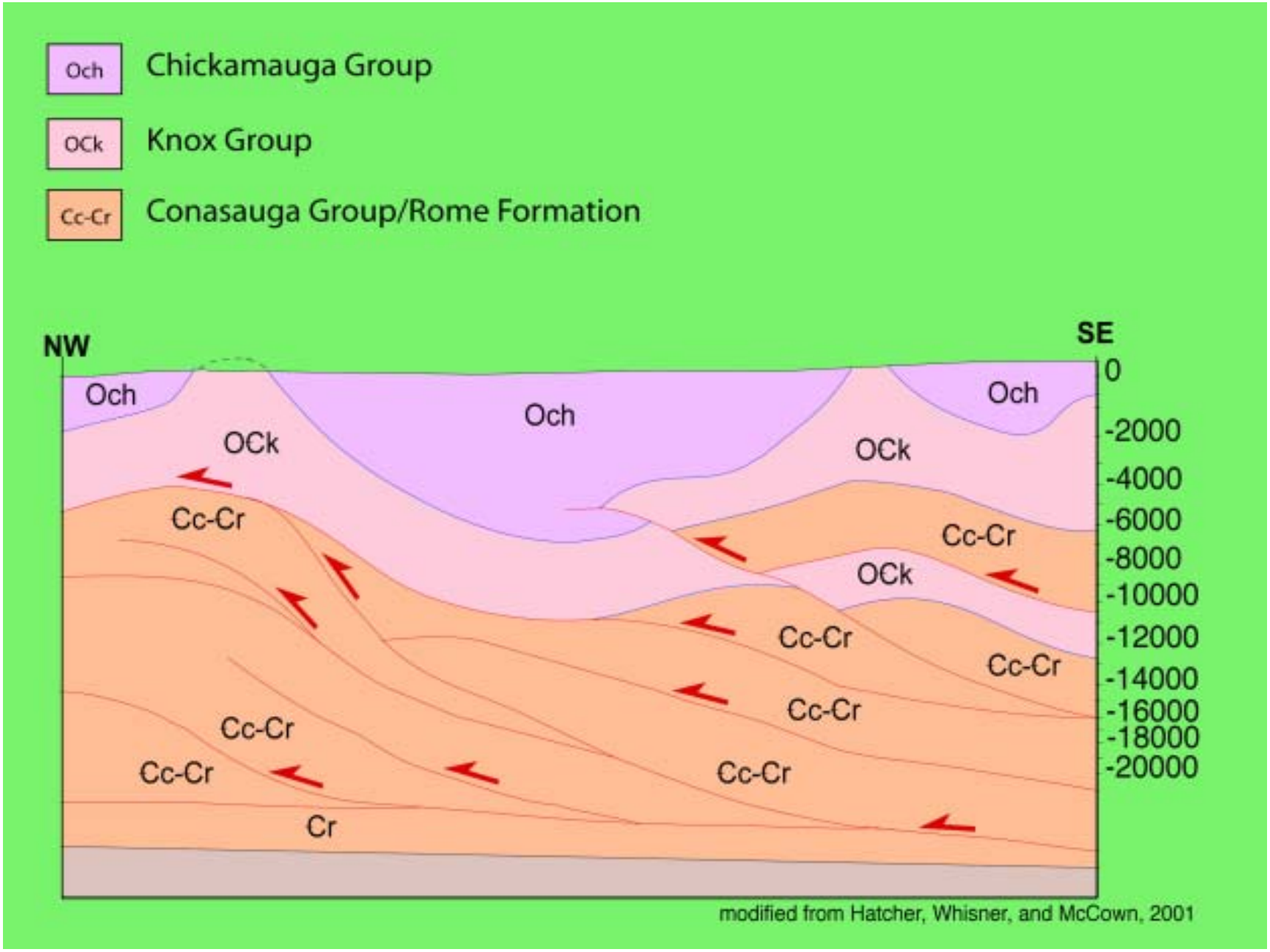
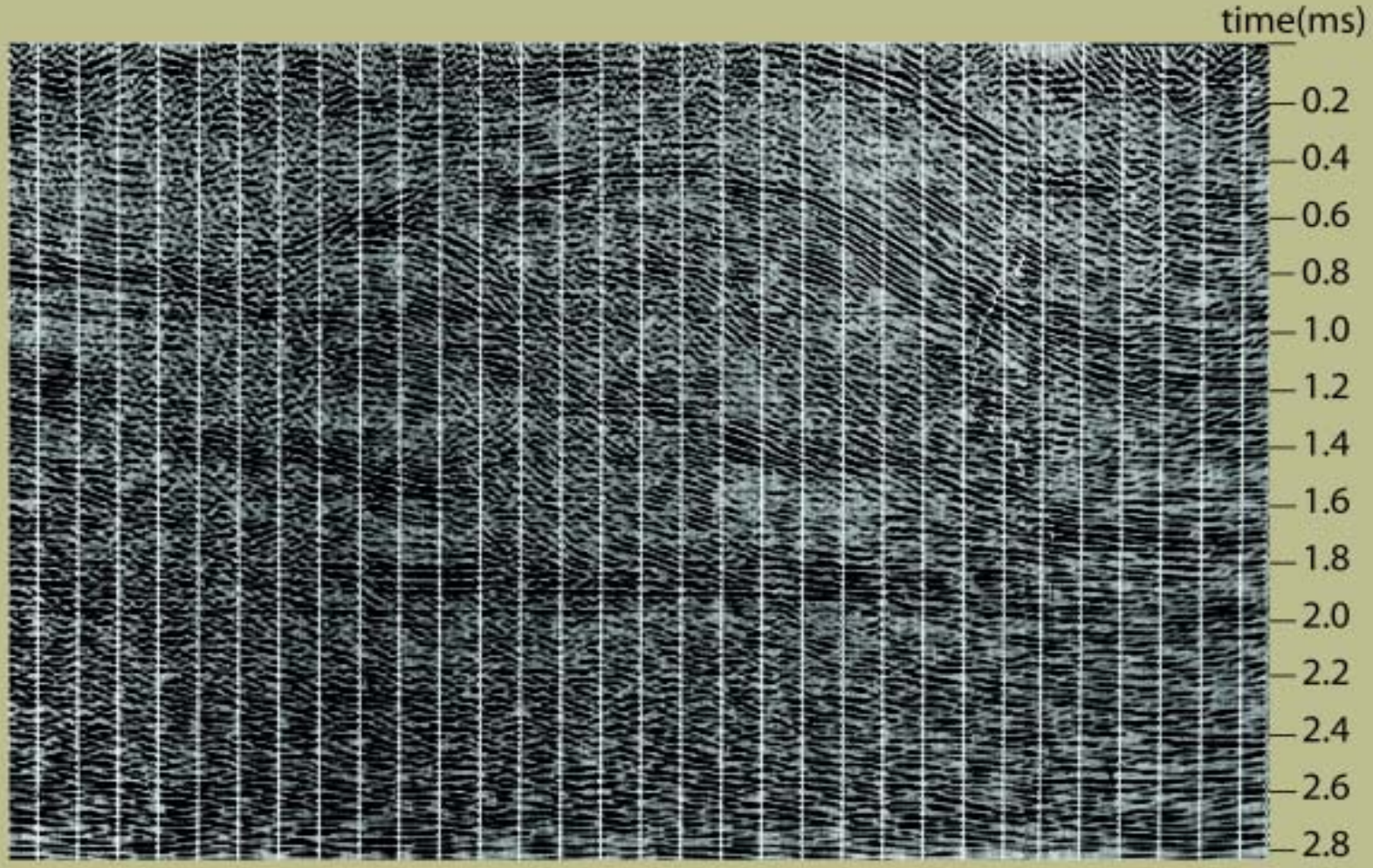
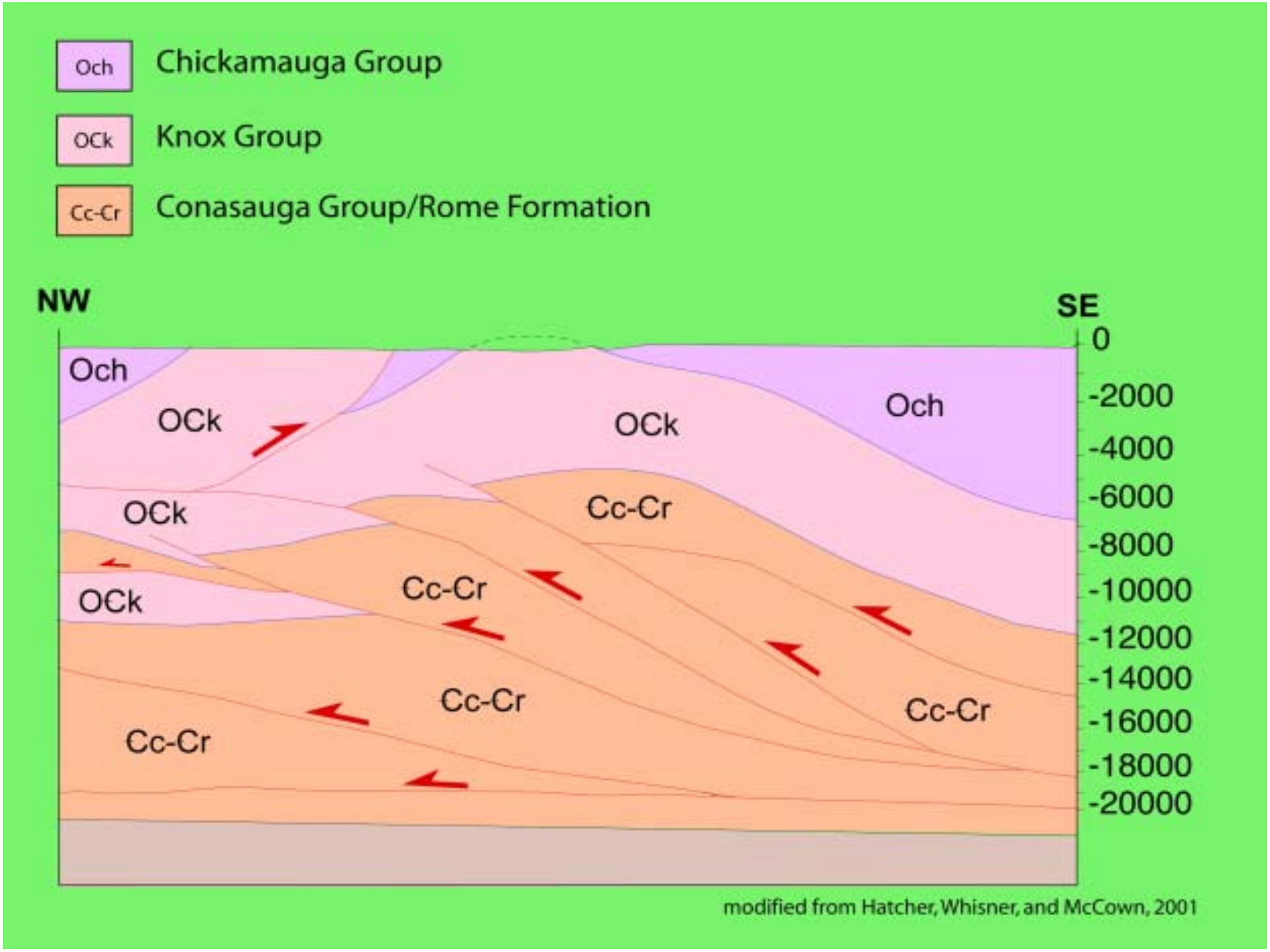


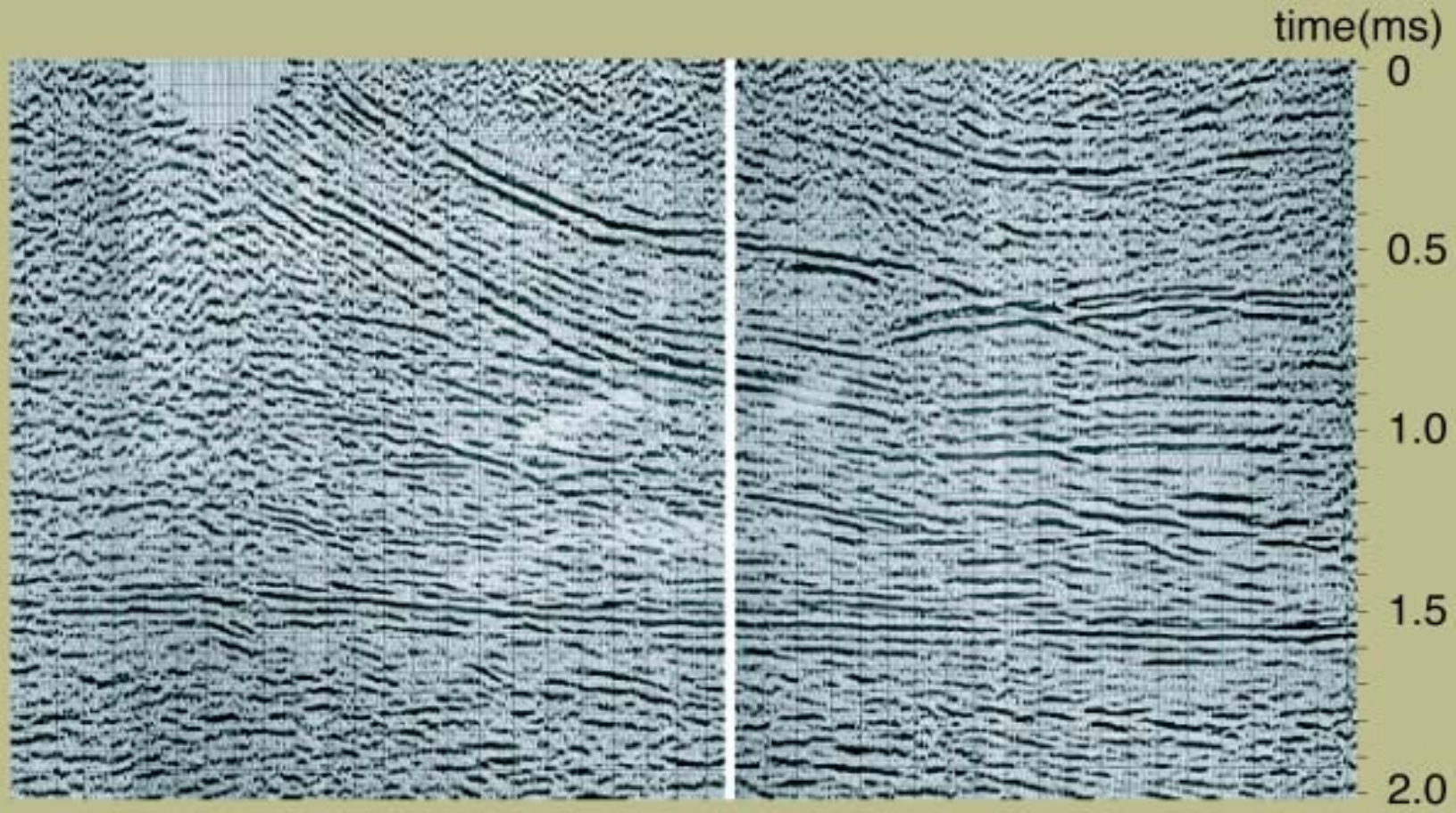
Industry seismic


Och
Chickamauga Group
OCk
Knox Group
Cc-Cr
Conasauga Group/Rome Formation
NW
SE
0
-2000
-4000
-6000
-8000
-10000
-12000
-14000
-16000
-18000
-20000
Och
Och
Och
OCk
OCk
OCk
Cc-Cr
Cc-Cr
Cc-Cr
Cc-Cr
Cc-Cr
Cc-Cr
Cc-Cr
Cc-Cr
Cr
modified from Hatcher, Whisner, and McCown, 2001

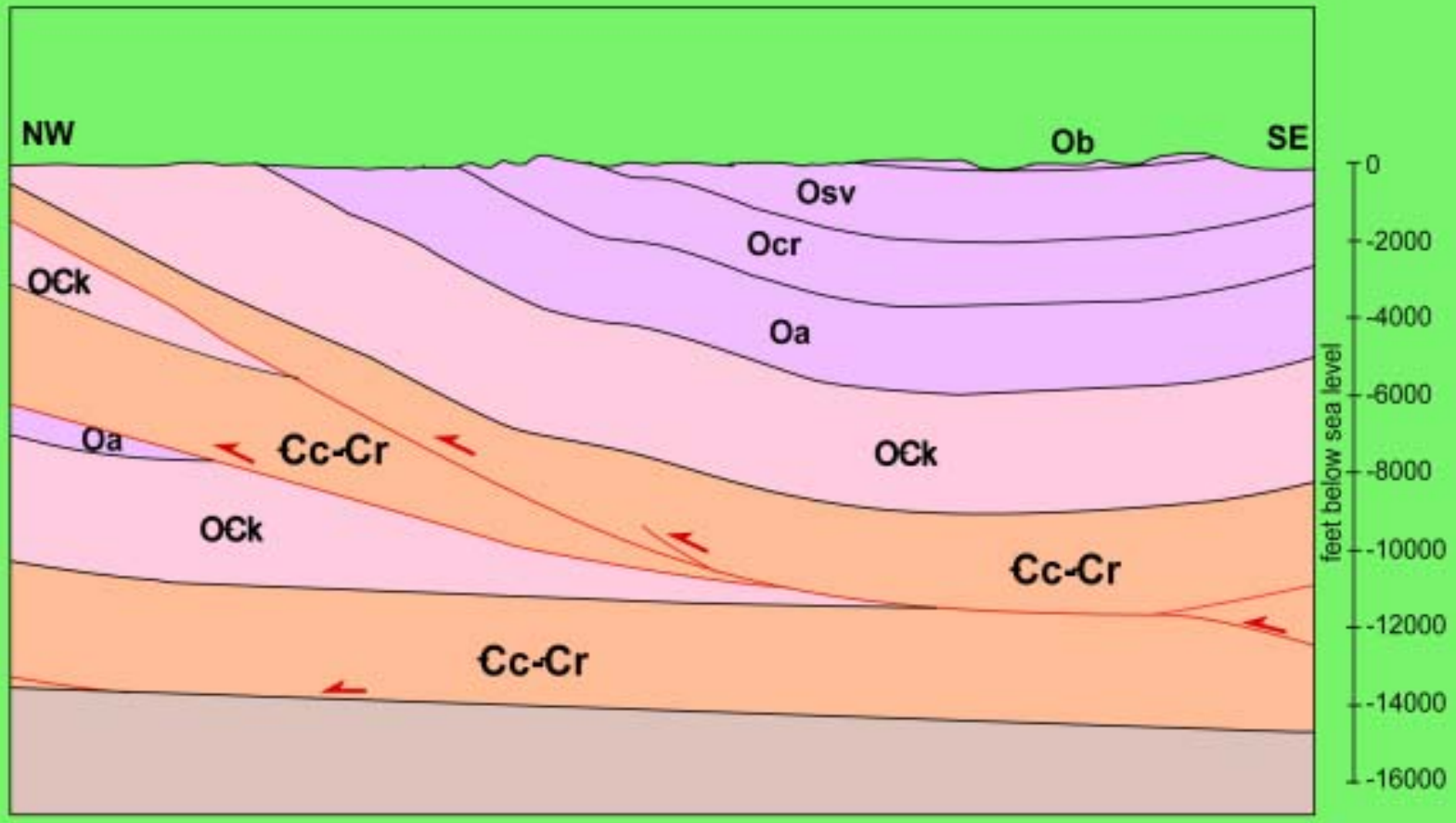


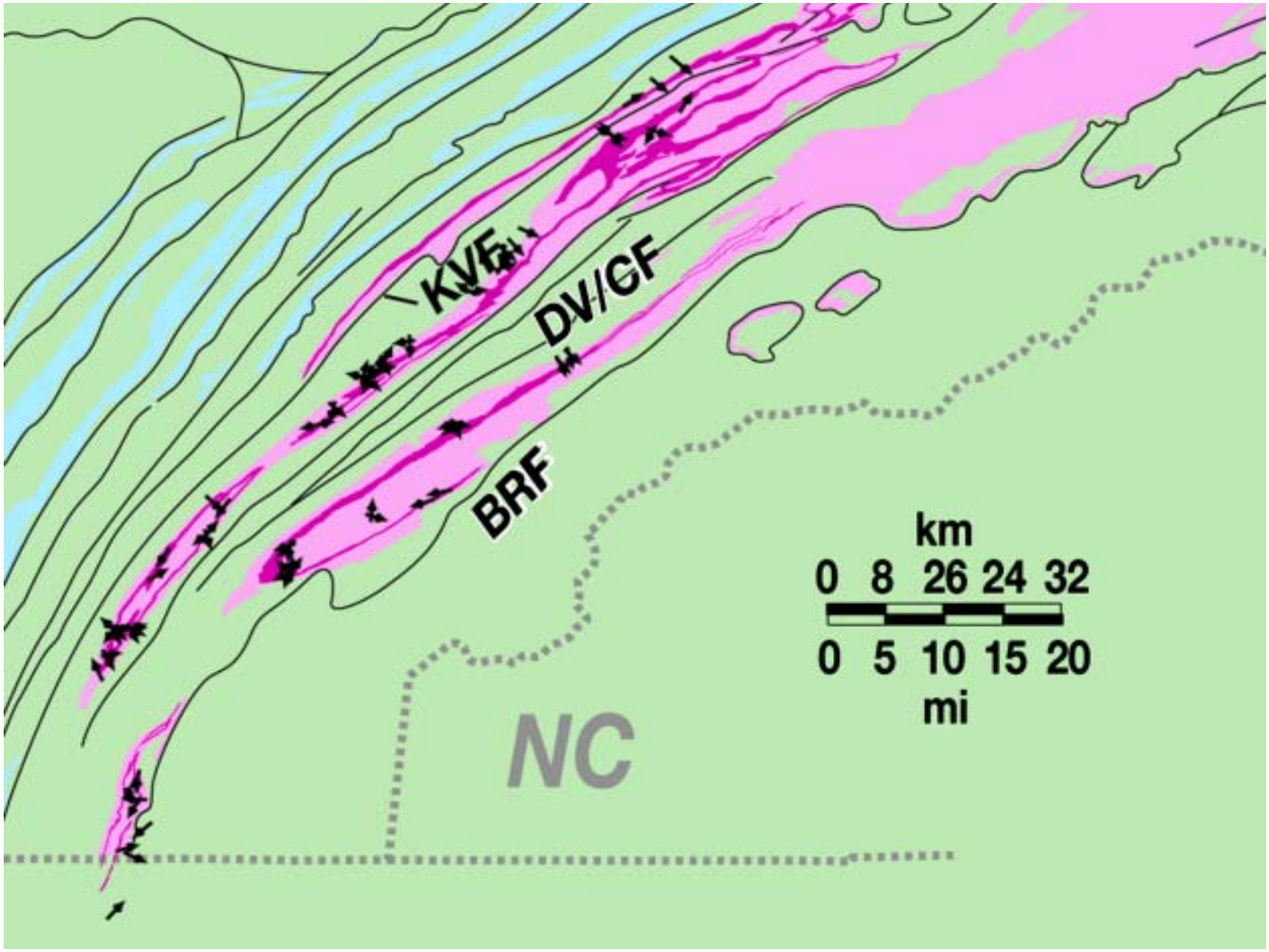
Industry seismic


Och
Chickamauga Group
OCk
Knox Group
Cc-Cr
Conasauga Group/Rome Formation
NW
SE
0
-2000
-4000
-6000
-8000
-10000
-12000
-14000
-16000
-18000
-20000
Och
OCk
OCk
Och
OCk
Cc-Cr
OCk
Cc-Cr
Cc-Cr
Cc-Cr
Cc-Cr
modified from Hatcher, Whisner, and McCown, 2001



industry seismic


NW
SE
Ob
Osv
Ocr
Oa
OCk
Oa
Cc-Cr
OCk
OCk
Cc-Cr
Cc-Cr
0
-2000
-4000
-6000
-8000
-10000
-12000
-14000
-16000
feet below sea level


KVF
DV/CF
BRF
NC
km
0 8 26 24 32
0 5 10 15 20
mi

East of Kite, TN

Cleaved Bays, South of Mt. Zion

Walland, TN

Heath, 2003

Nonaburg, TN

Sediment Sources

Tectonic land to the southeast (Shanmugam and Walker, 1982)?

Middle Ordovician conglomerate clasts are primarily carbonates (Kellberg and Grant, 1956).

Taconic highland with longshore currents?

Current indicators show random transport directions.

Did a barrier exist between the Taconic highlands and the foredeep basin?

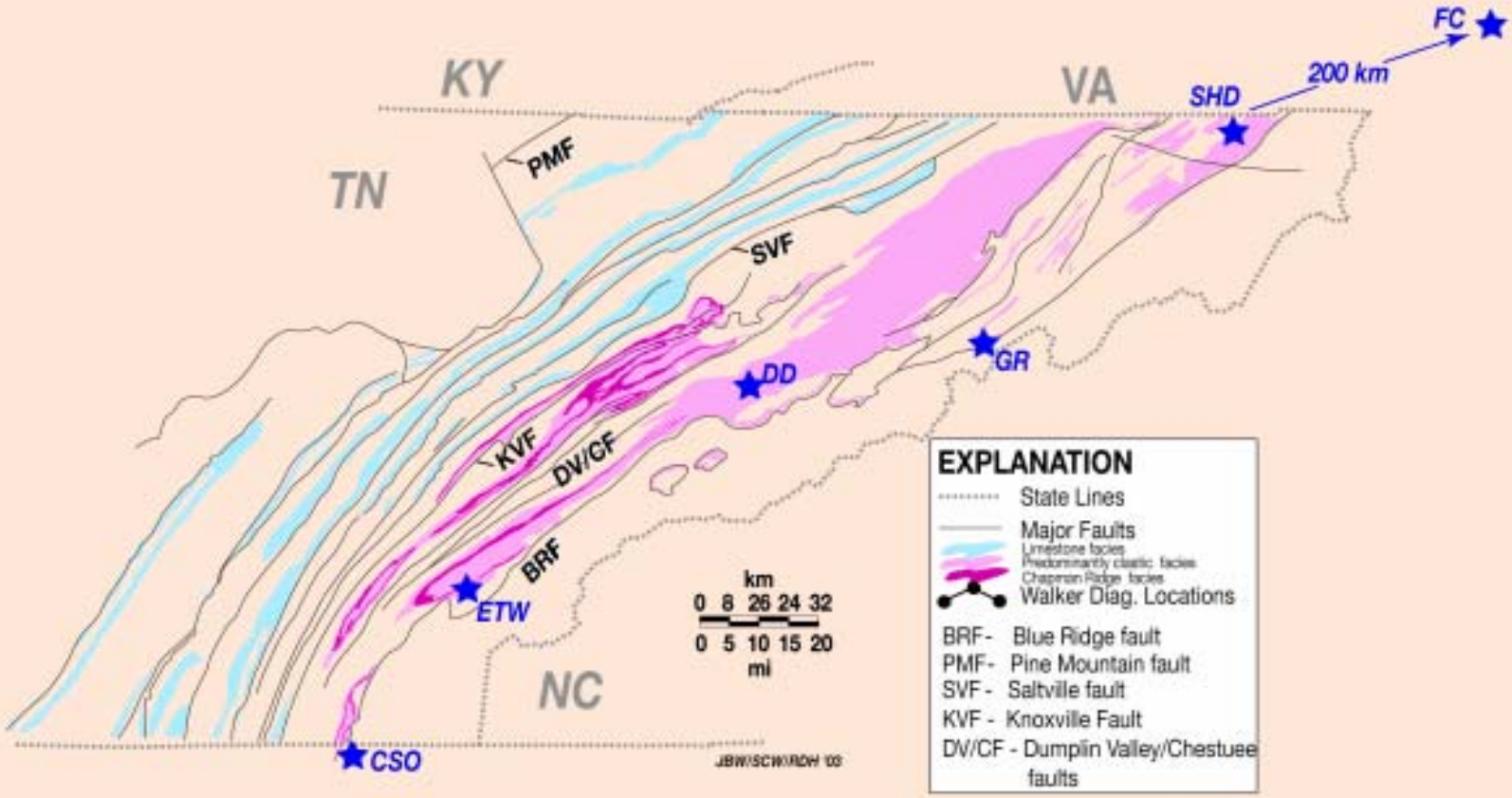
Oil Sources

Self-sourced Middle Ordovician Plateau rocks?

Out of basin migration of organic Sevier Shale?

From older Cambrian and Ordovician rocks (Copper Ridge)?

Black shales in the Chattanooga?


KY
VA
TN
NC
FC
200 km
SHD
PMF
SVF
DD
GR
KVF
DV/CF
BRF
ETW
CSO
km
0 8 26 24 32
0 5 10 15 20
mi
JBW/SCW/RDH '00
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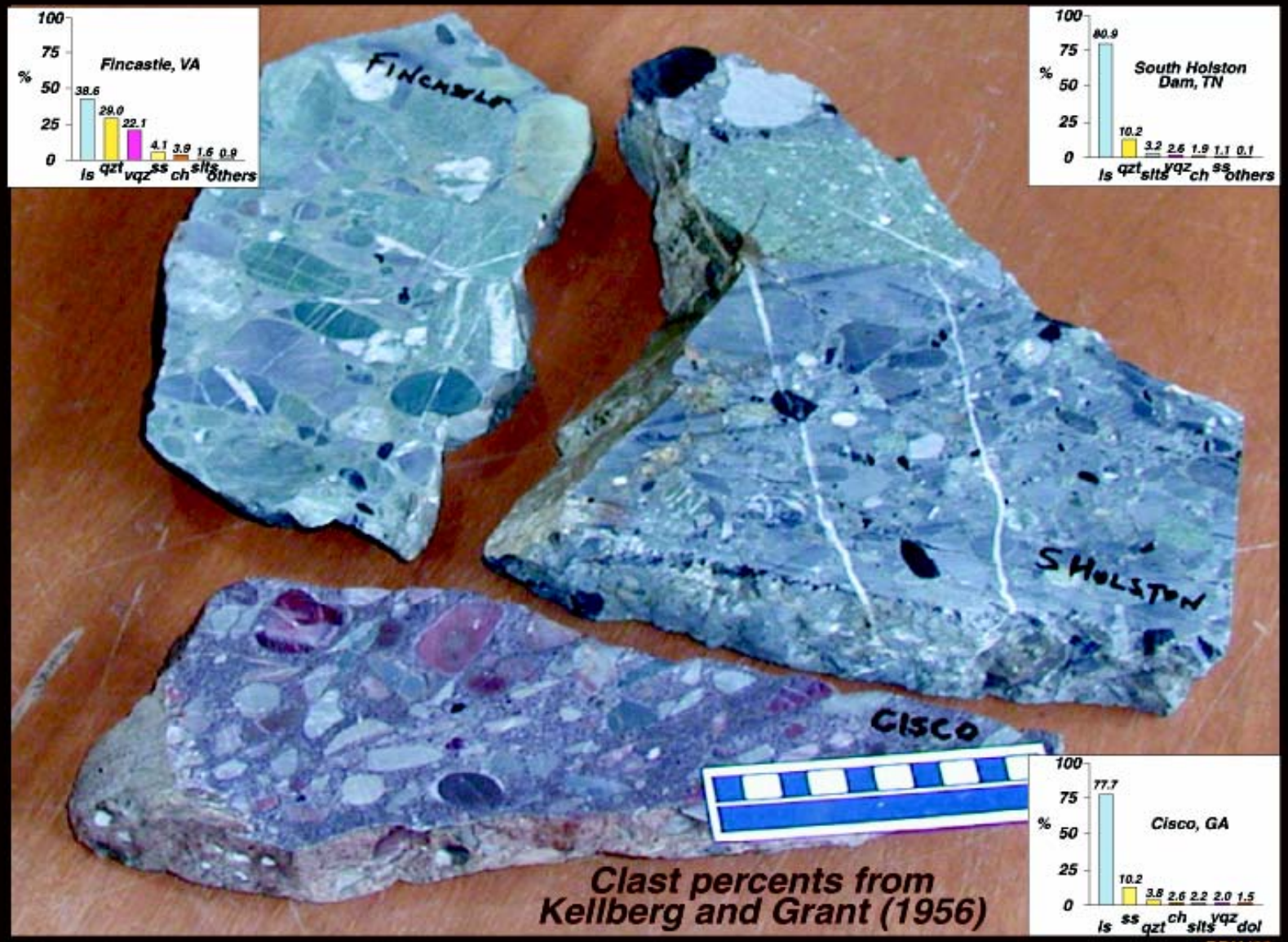

Fincastle, VA
%
100
75
50
25
0
38.6
29.0
22.1
4.1
3.8
1.6
0.9
ls
qzt
vqz
ss
ch
slts
others
South Holston Dam, TN
80.9
10.2
3.2
2.6
1.9
1.1
0.1
ls
qzt
slts
vqz
ch
ss
others
Cisco, GA
77.7
10.2
3.8
2.6
2.2
2.0
1.5
ls
ss
qzt
ch
slts
vqz
dol
FINCASTLE
S HOLSTON
CISCO
Clast percents from
Kellberg and Grant (1956)

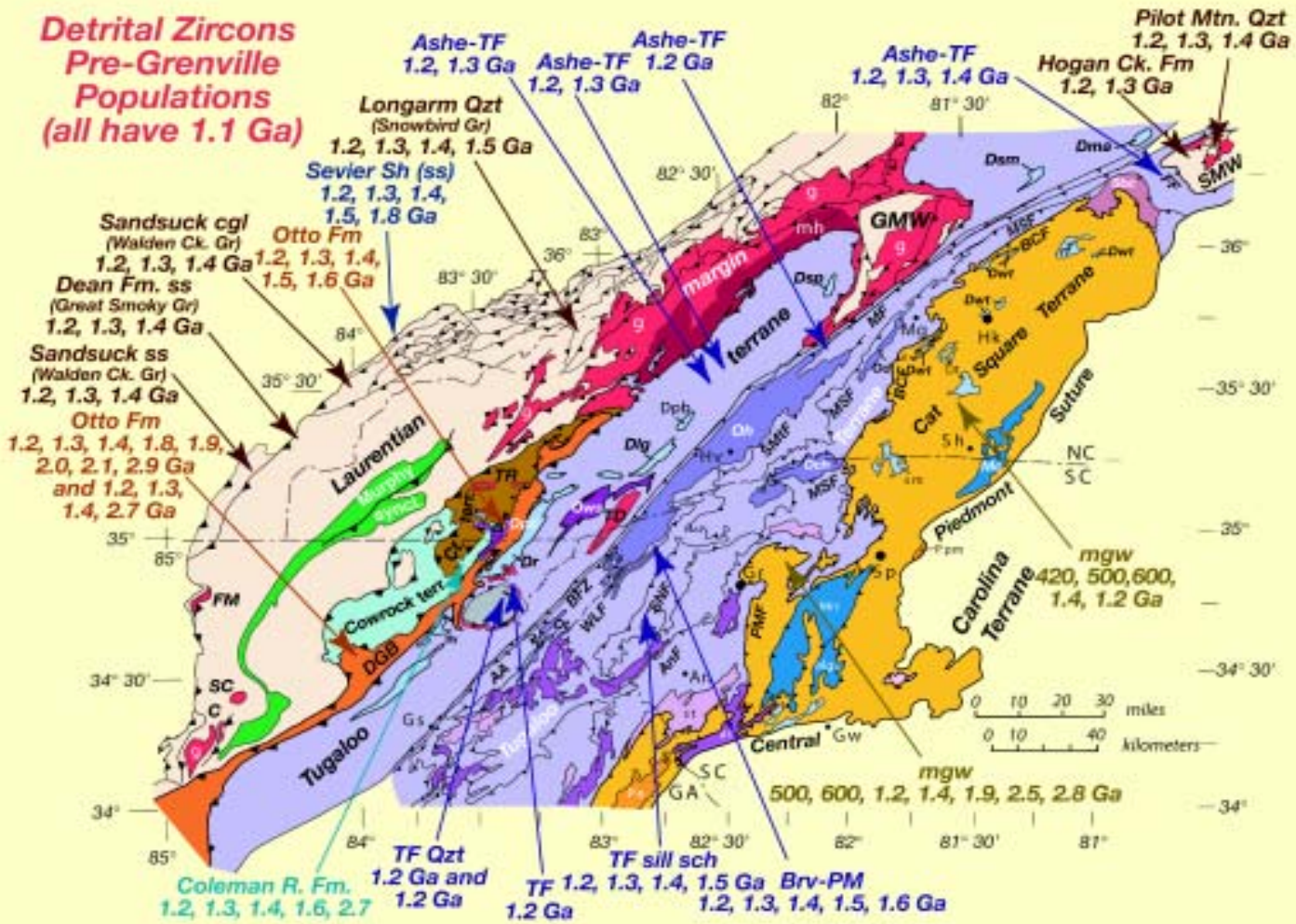
RDH '03

Conglomerate Source

Chilhowee sediments

Cambrian carbonate shelf

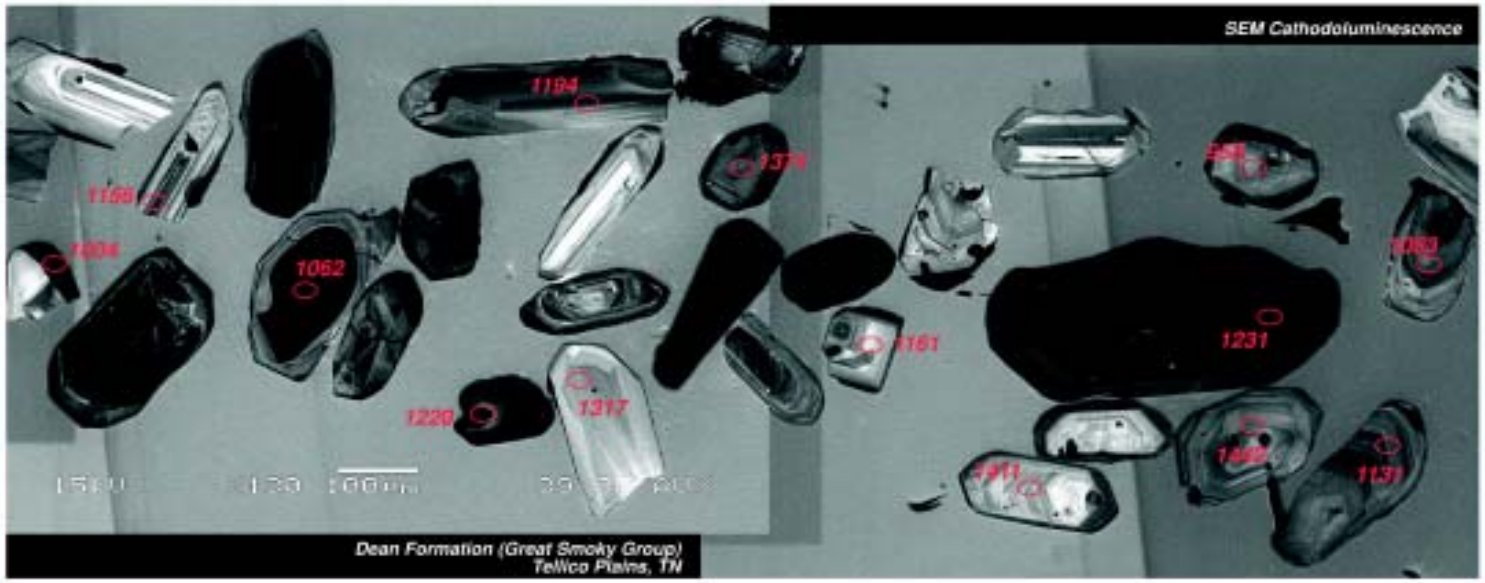
Middle Ordovician carbonates



Detrital Zircons
Pre-Grenville
Populations
(all have 1.1 Ga)
Ashe-TF
1.2, 1.3 Ga
Ashe-TF
1.2, 1.3 Ga
Ashe-TF
1.2 Ga
Ashe-TF
1.2, 1.3, 1.4 Ga
Pilot Mtn. Qzt
1.2, 1.3, 1.4 Ga
Hogan Ck. Fm
1.2, 1.3 Ga
Longarm Qzt
(Snowbird Gr)
1.2, 1.3, 1.4, 1.5 Ga
Sevier Sh (ss)
1.2, 1.3, 1.4,
1.5, 1.8 Ga
Sandsuck cgl
(Walden Ck. Gr)
1.2, 1.3, 1.4 Ga
Otto Fm
1.2, 1.3, 1.4,
1.5, 1.6 Ga
Dean Fm. ss
(Great Smoky Gr)
1.2, 1.3, 1.4 Ga
Sandsuck ss
(Walden Ck. Gr)
1.2, 1.3, 1.4 Ga
Otto Fm
1.2, 1.3, 1.4, 1.8, 1.9,
2.0, 2.1, 2.9 Ga
and 1.2, 1.3,
1.4, 2.7 Ga
Laurentian
Murphy synct
Cowrock terr
DGB
Tugaloo
Tugaloo
margin
terrane
GMW
SMW
Cat Square Terrane
Suture
Piedmont
Carolina Terrane
Central
mgw
420, 500,600,
1.4, 1.2 Ga
mgw
500, 600, 1.2, 1.4, 1.9, 2.5, 2.8 Ga
Coleman R. Fm.
1.2, 1.3, 1.4, 1.6, 2.7
TF Qzt
1.2 Ga and
1.2 Ga
TF
1.2 Ga
TF sill sch
1.2, 1.3, 1.4, 1.5 Ga
Brv-PM
1.2, 1.3, 1.4, 1.5, 1.6 Ga
miles
kilometers
NC
SC
GA

Example detrital zircons

Age in Ma

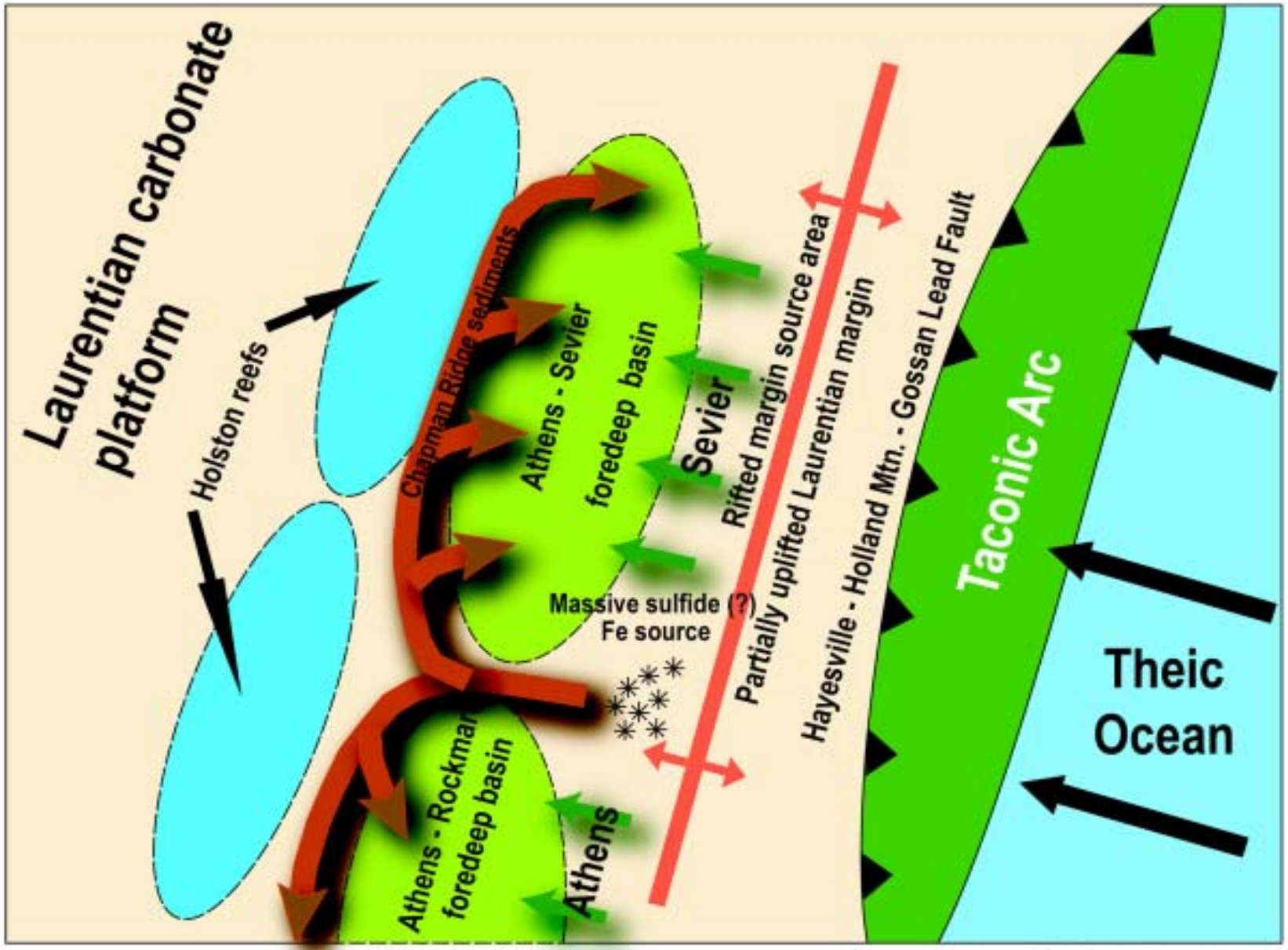


Zircon Data

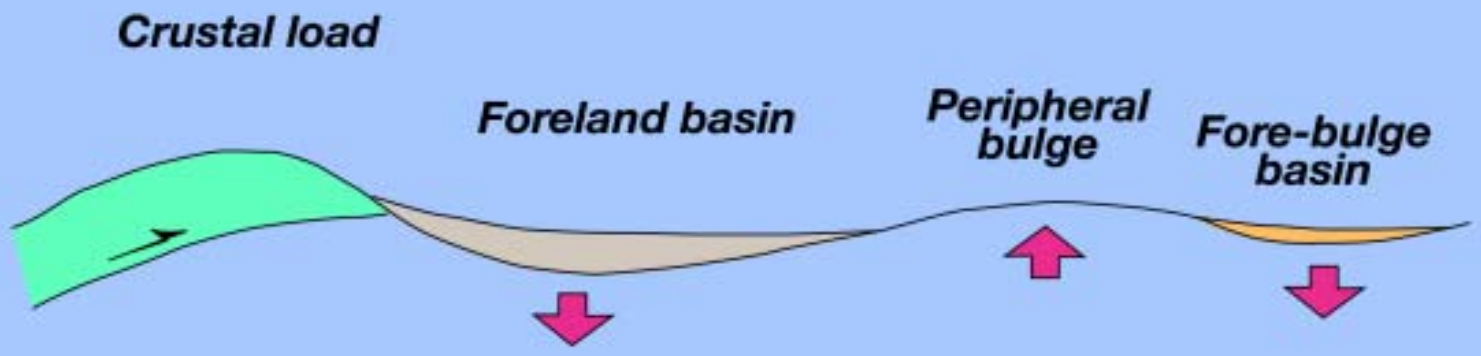
24 Middle Ordovician Sevier shale detrital zircon analyses show only pre-Paleozoic cores (Bream, 2003)

Other zircon analyses from the Ordovician through Pennsylvanian sediments in the Central and Southern Appalachians show few Paleozoic cores until the Carboniferous (Gray and Zeitler, 1997; Eriksson et al, 2002)

Unroofing of the southern and central Appalachians did not occur until the late Paleozoic



modified from Thigpen, 2002


Crustal load
Foreland basin
Peripheral bulge
Fore-bulge basin

Conclusions

The Sevier basin could be either a foredeep or backbulge

Transport directions in the Chapman Ridge do not identify the source clearly

Thicknesses obtained via detailed structural mapping are similiar to thicknesses of Shanmugam and Walker (1978).