

Relict Paleozoic faults in the epicentral area of the August 23, 2011 Virginia earthquake:



Assessing potential sources of reactivation with field observations

November 6th, 2012
2012 GSA Annual Meeting
Charlotte, NC
Session #154: Virginia Earthquakes of 2011

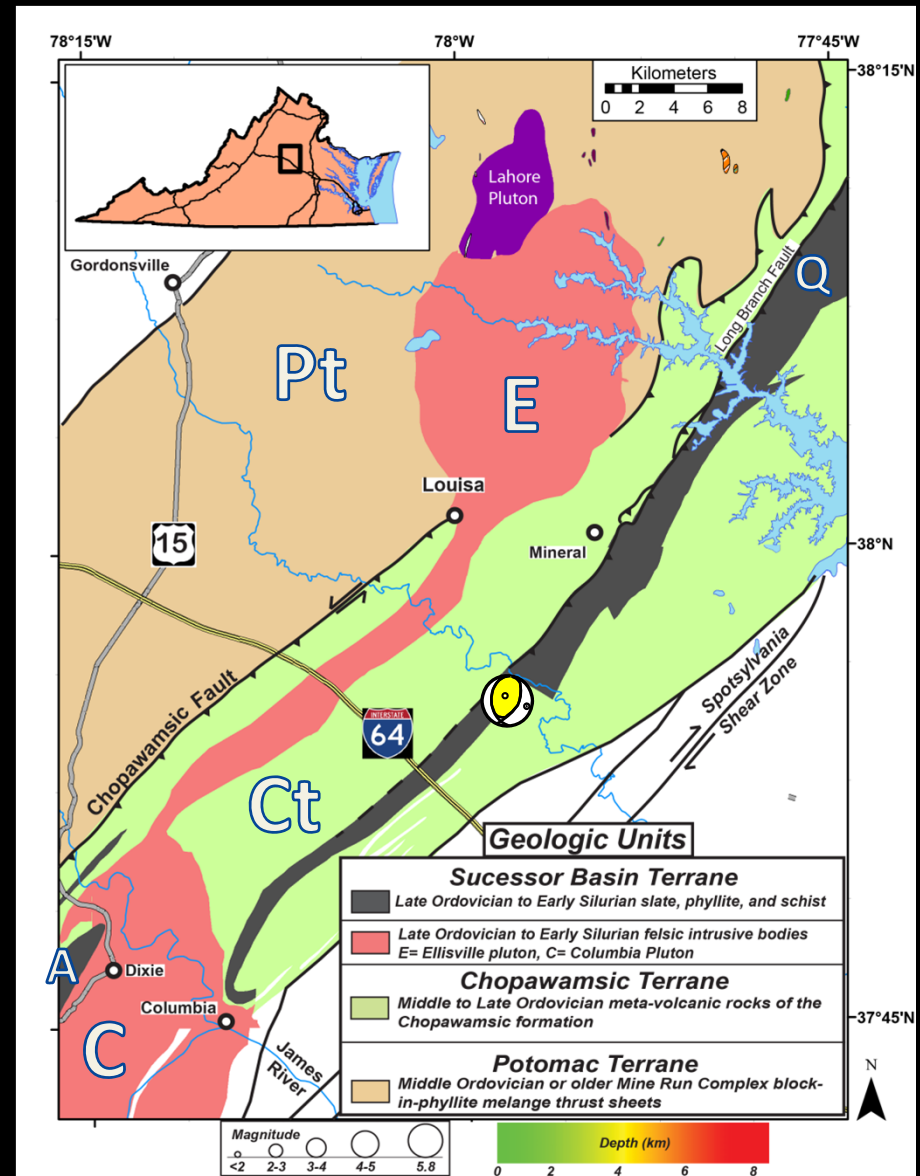
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North Carolina State University
Raleigh, NC



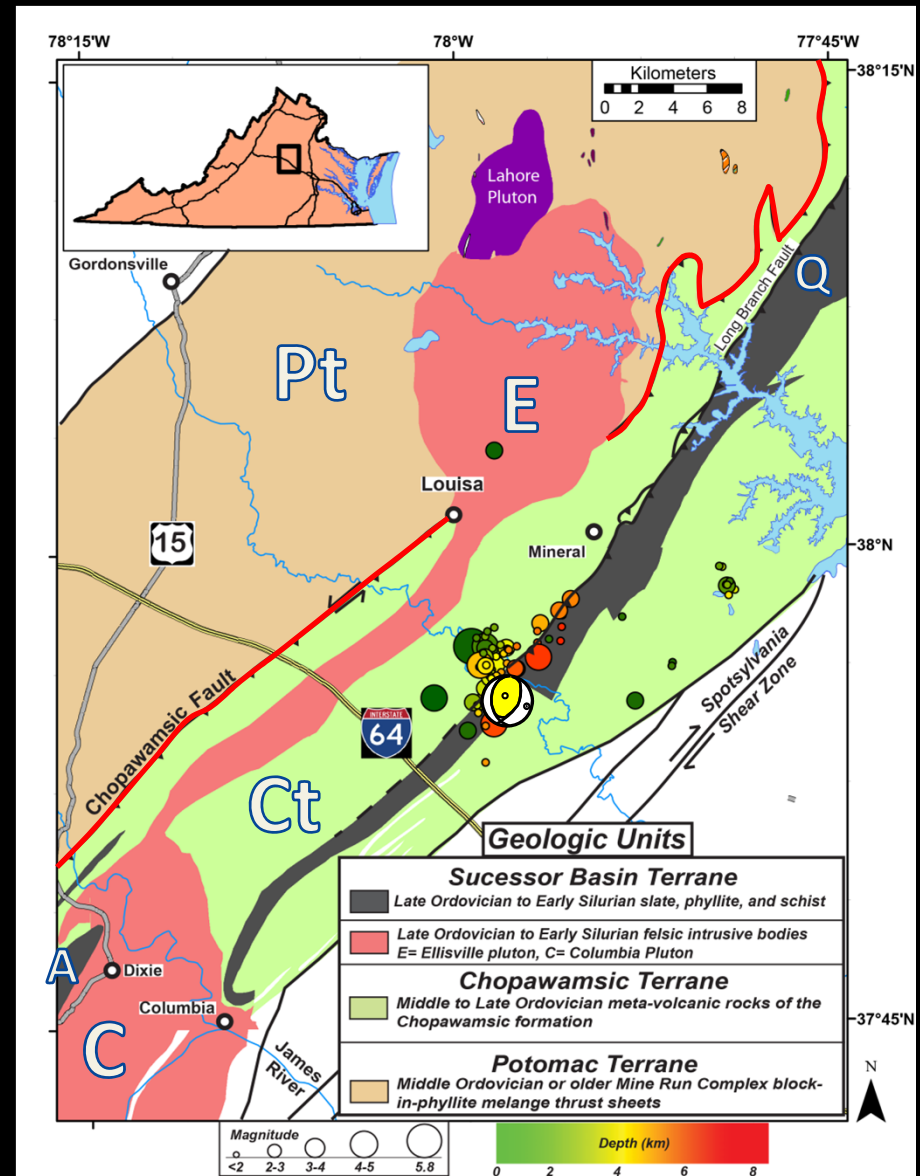
Western Piedmont of VA

- Potomac terrane (Pt)
 - Mine Run Complex
(Older than Mid Ordovician)
- Chopawamsic terrane (Ct)
 - Chopawamsic Fm
(Mid-Late Ordovician, 470 – 453 Ma)
- Plutons
 - Ellisville pluton (E)
(Earliest Silurian— 444 Ma)
 - Columbia composite pluton (C)
(Late Ordovician— 457 Ma)
- Successor Basins (Late Ord – Early Sil)
 - Quantico Fm (Q)
 - Arvonias Fm (A)



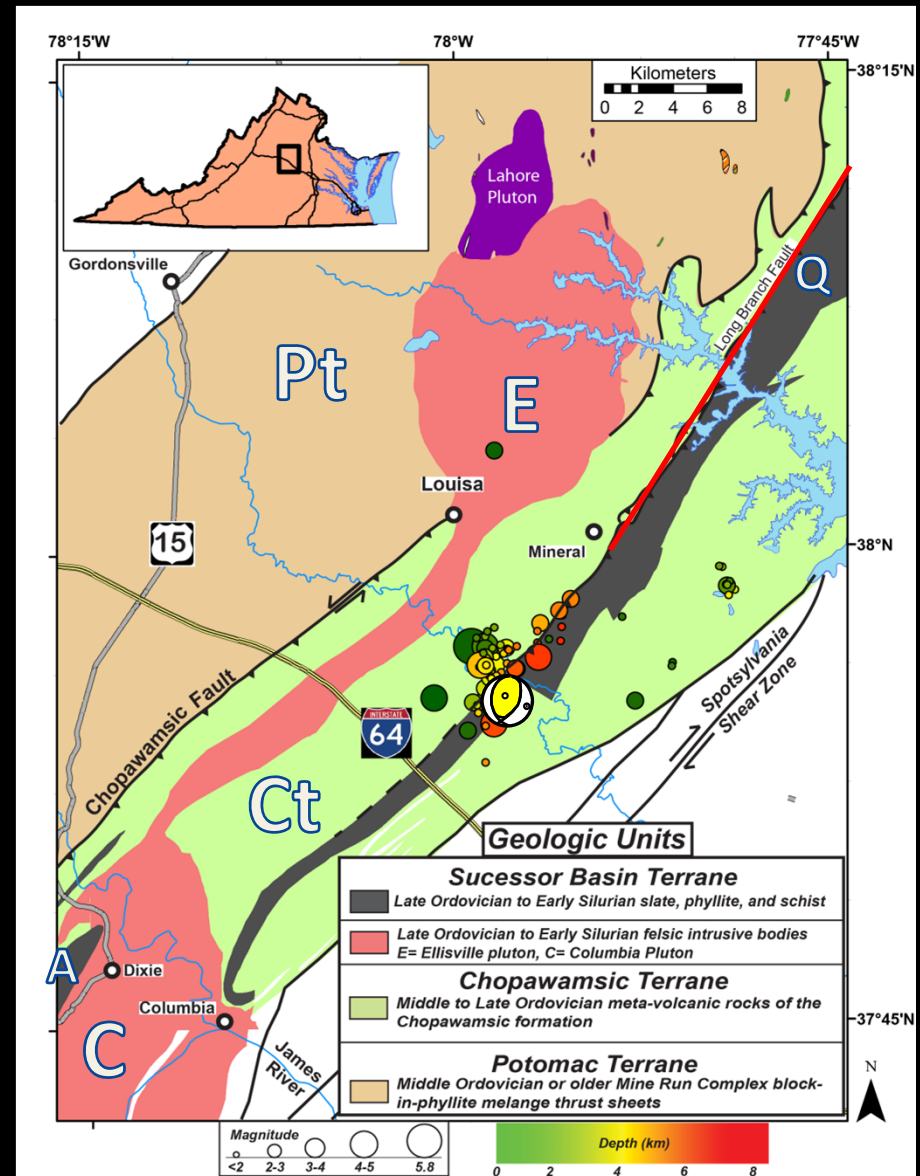
Western Piedmont of VA

- **Chopawamsic fault**
 - Separates Chopawamsic and Potomac terranes
 - Re-mapped in epicentral area (2010)
 - Age = 453 – 444 Ma (Hughes et al., ms, submitted)
- **Long Branch fault**
 - Separates Chopawamsic and Quantico fms.
 - Extends farther south than previously mapped (38°N)
 - Age = best estimate is late Paleozoic (Alleghanian)
 - Kinematically dissimilar to the Chopawamsic fault
 - Previously interpreted to record 2 episodes of motion (Pavlidis, 1976, 2000)
- Both dip to the Southeast

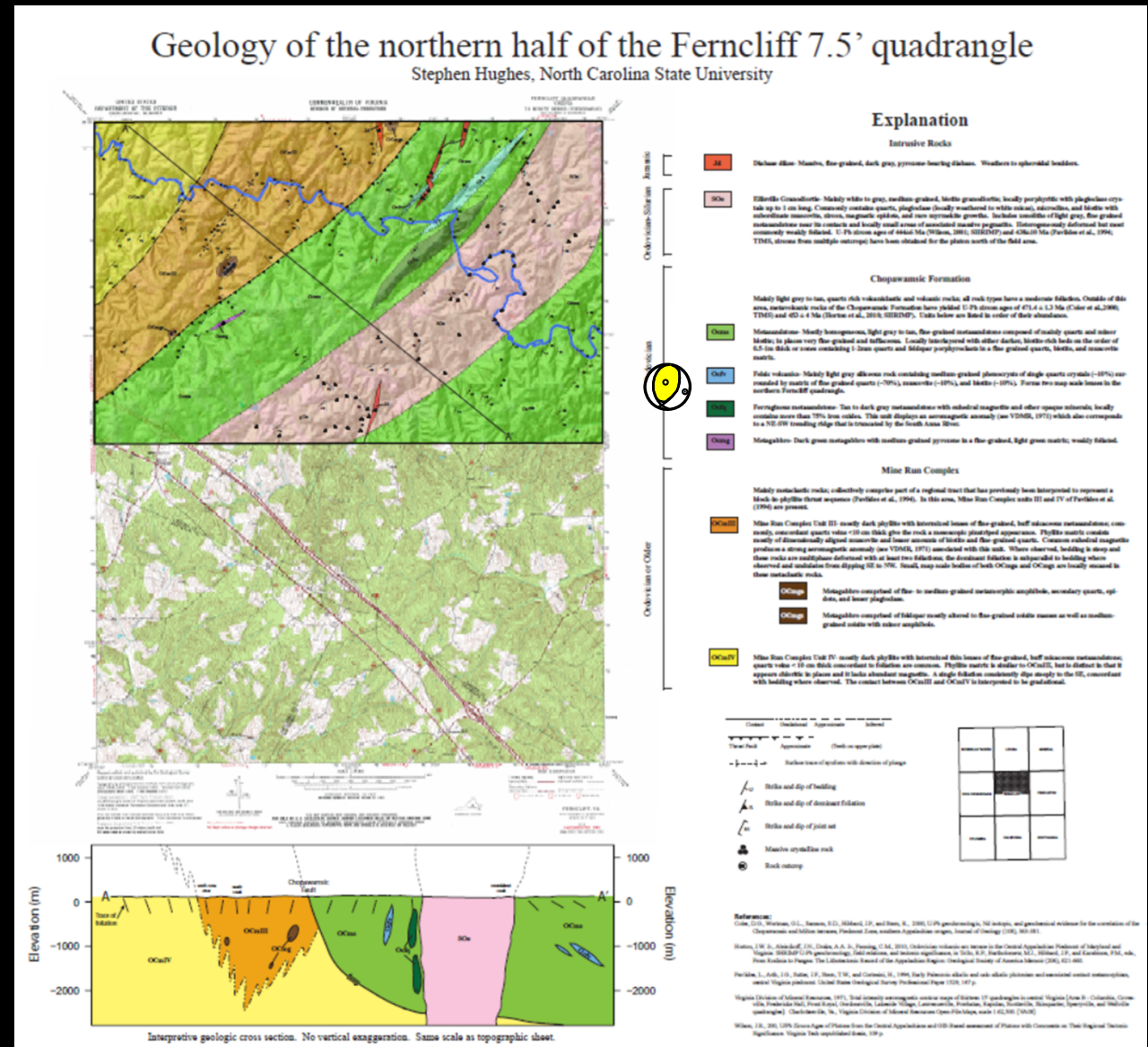


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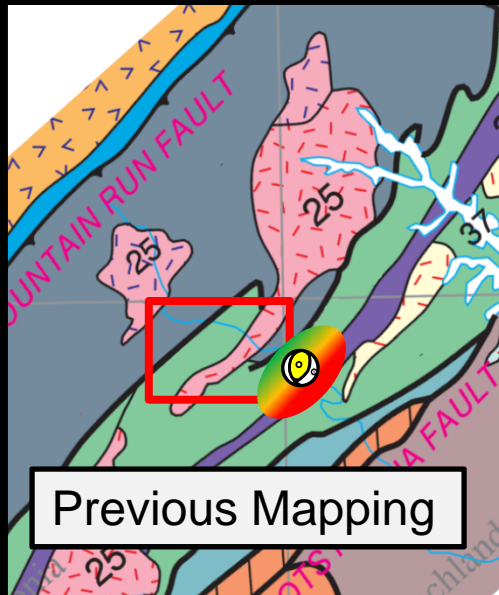


Geology of the northern half of the Ferncliff 7.5' quadrangle

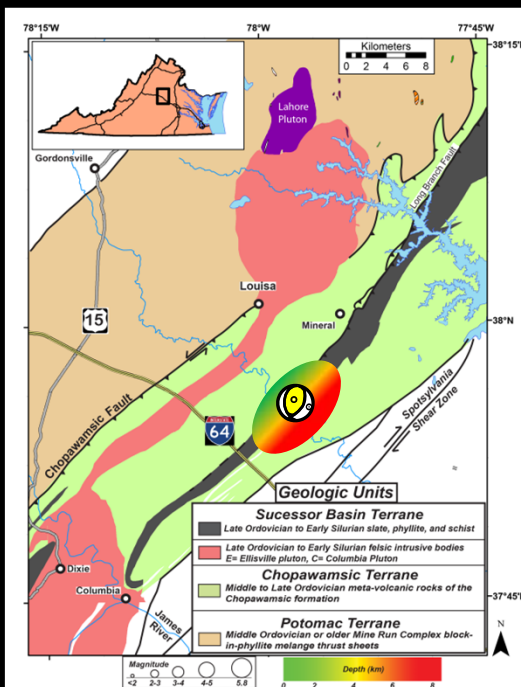
Previous Mapping



Chopawamsic fault



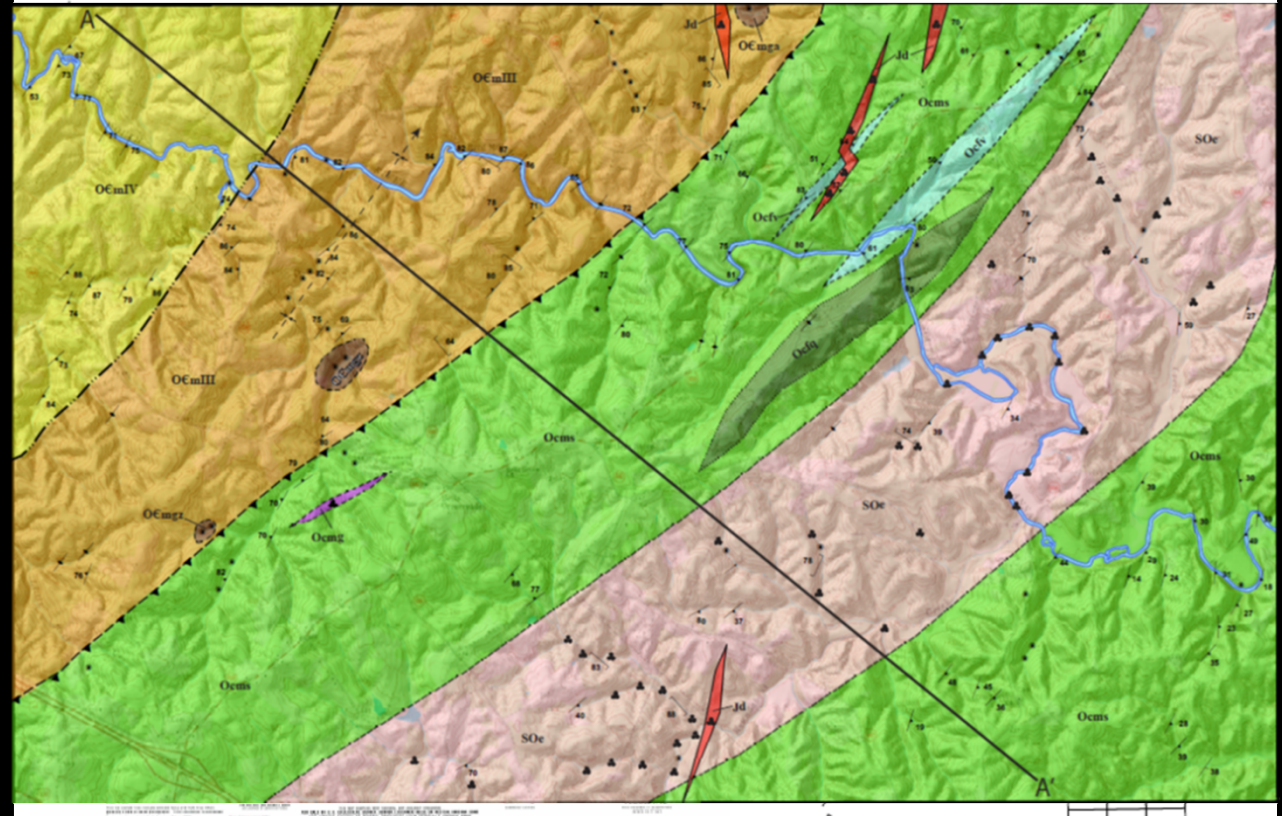
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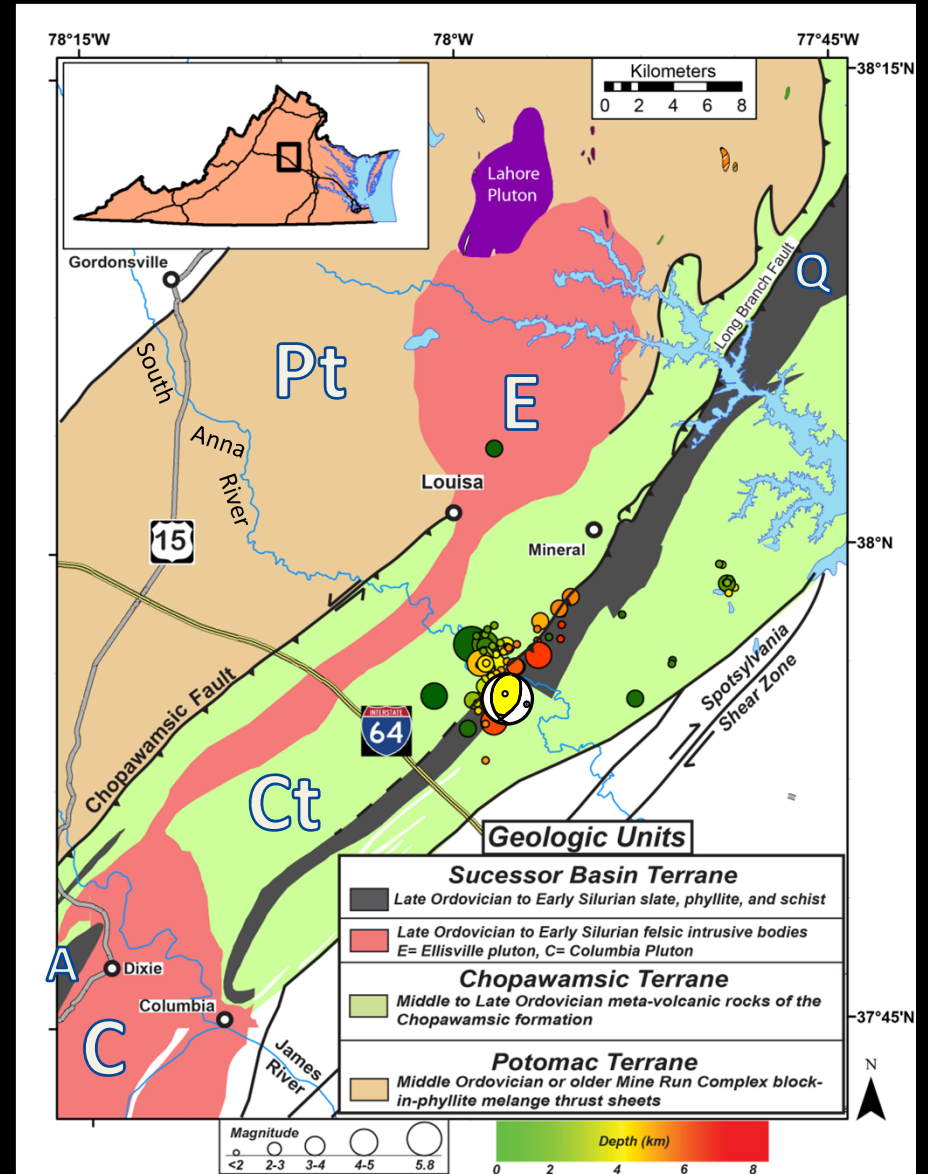
Stephen Hughes, North Carolina State University



Our detailed mapping of the Chopawamsic fault shows that it is an unlikely candidate for reactivation in the zone active in 2011.

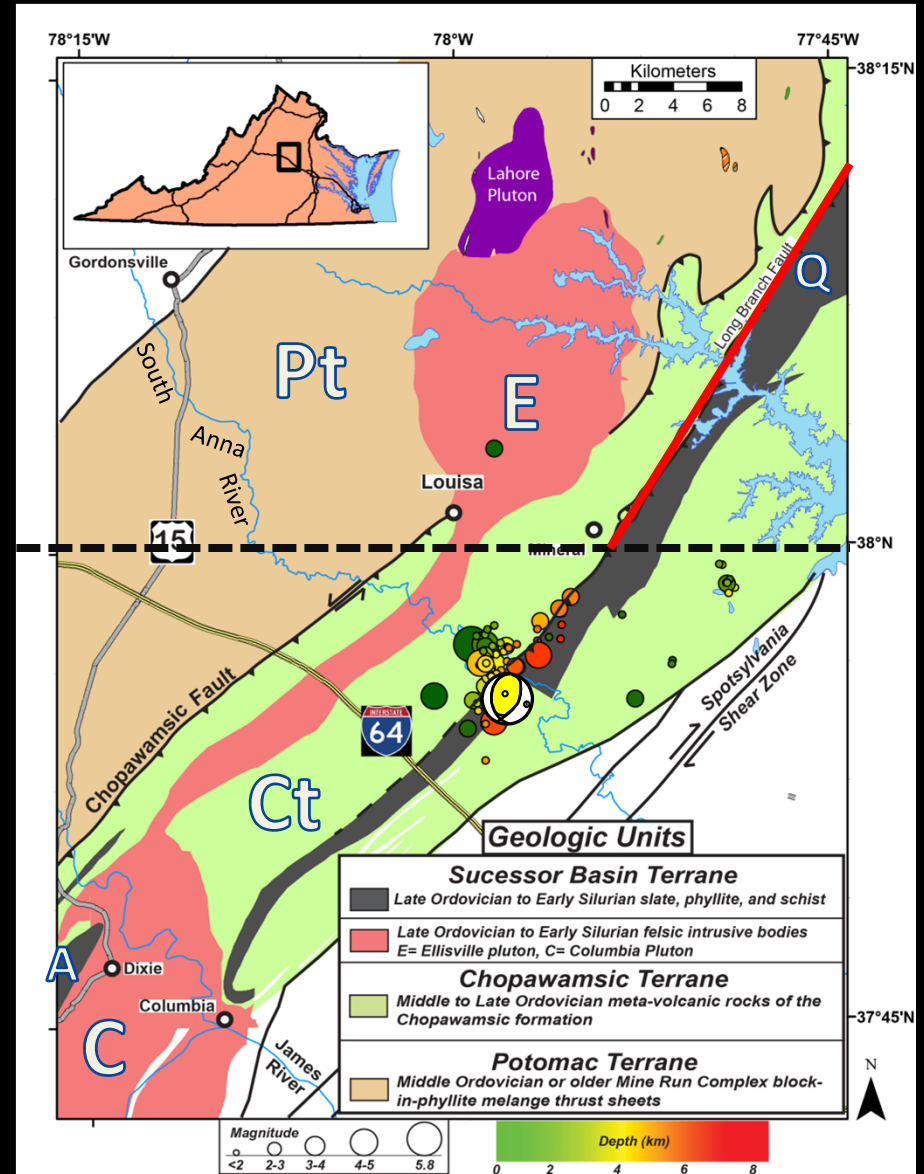
Long Branch fault (LBf)

- Previously only mapped as far south as 38°N.



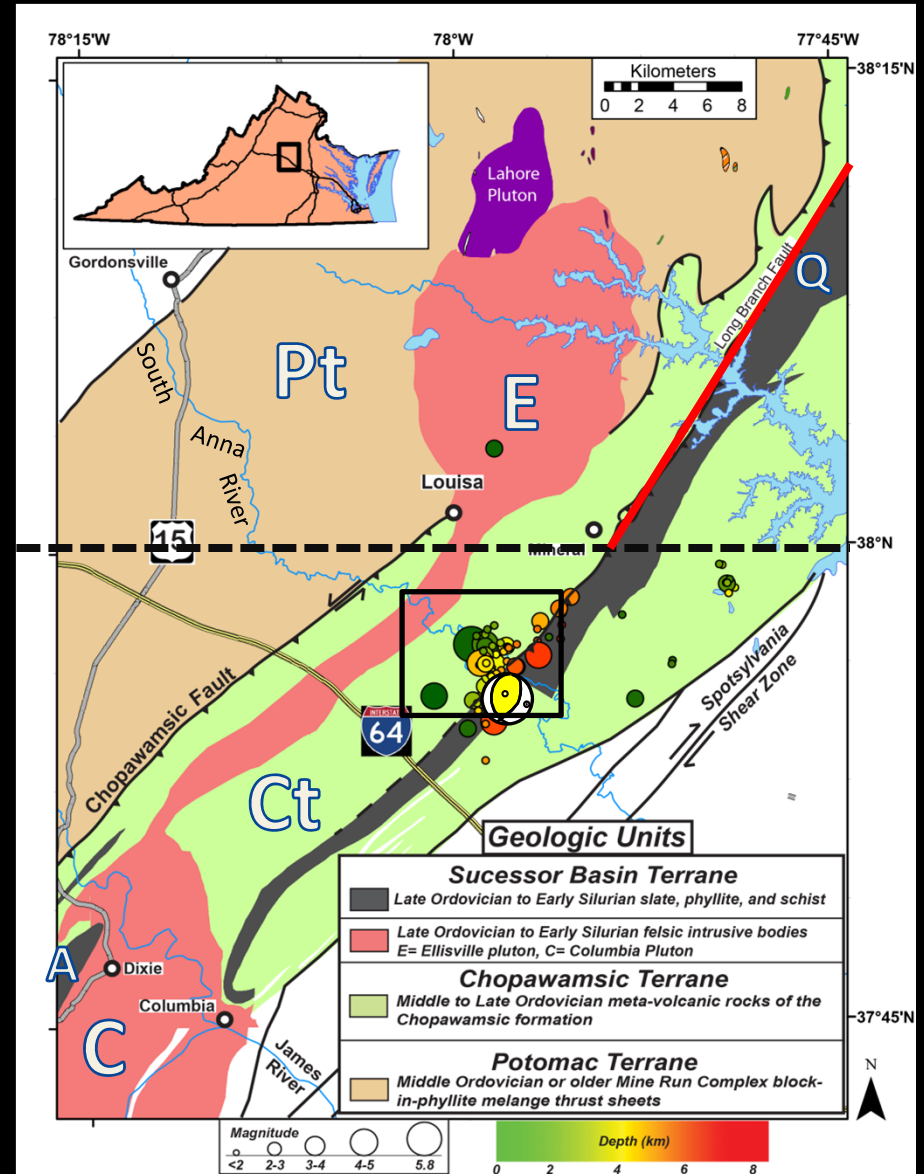
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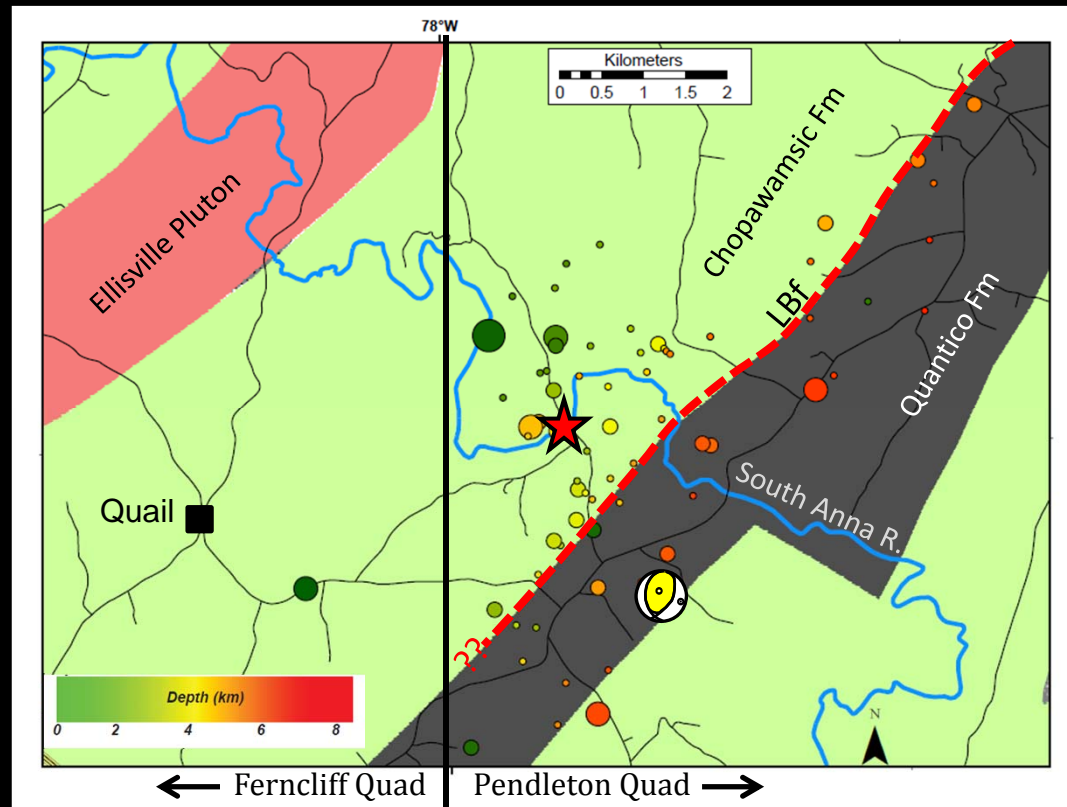
Long Branch fault (LBf)

- Previously only mapped as far south as 38°N.
- However, we see evidence for it as far south as the South Anna River.



Long Branch fault (LBf)

Yanceyville Linear Fabric: $T = 70^\circ$ $P = 35^\circ$



★ = Yanceyville outcrop (<750 m from the LBf surface trace)

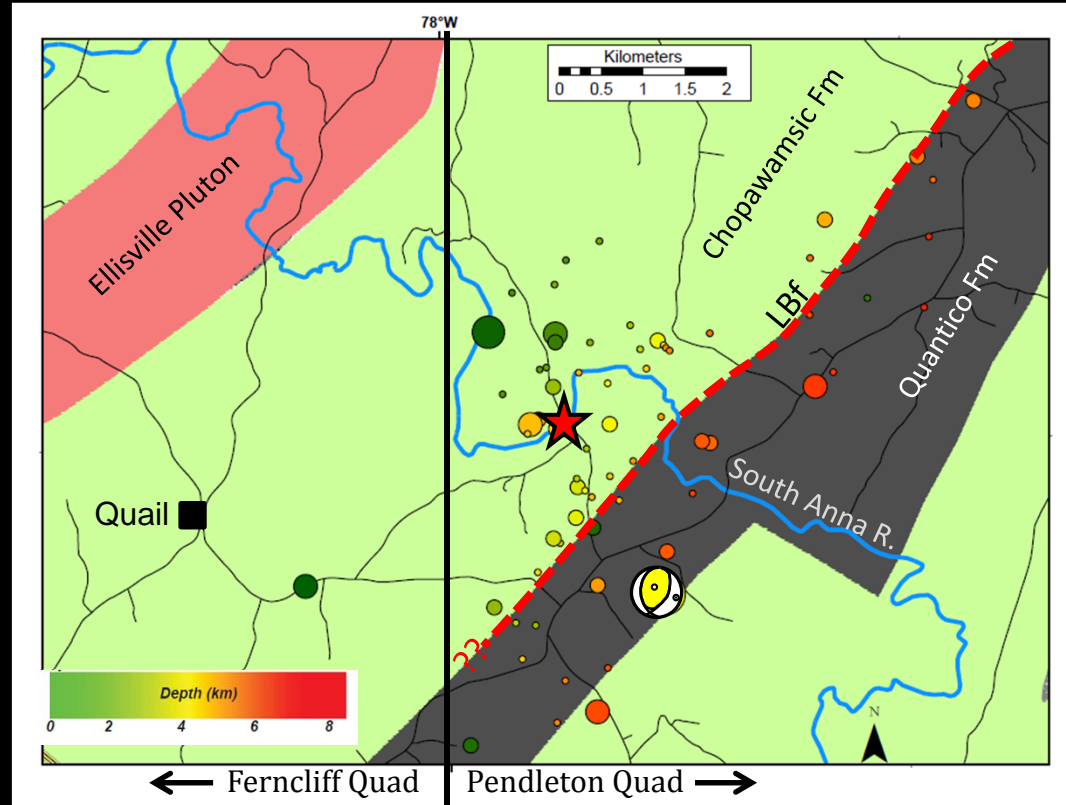
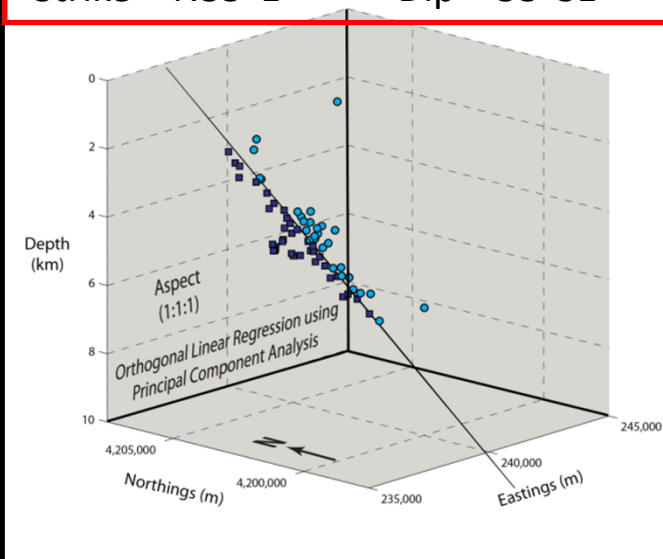
We interpret the Yanceyville L-tectonite to represent deformation in the footwall of the LBf.

Simple Earthquake Analysis

- Aftershocks recorded by VTSO between Aug. 23rd and September 1st
- Looking for primary fault plane related to mainshock and most aftershocks. n=67

Strike = N35°E

Dip = 53°SE

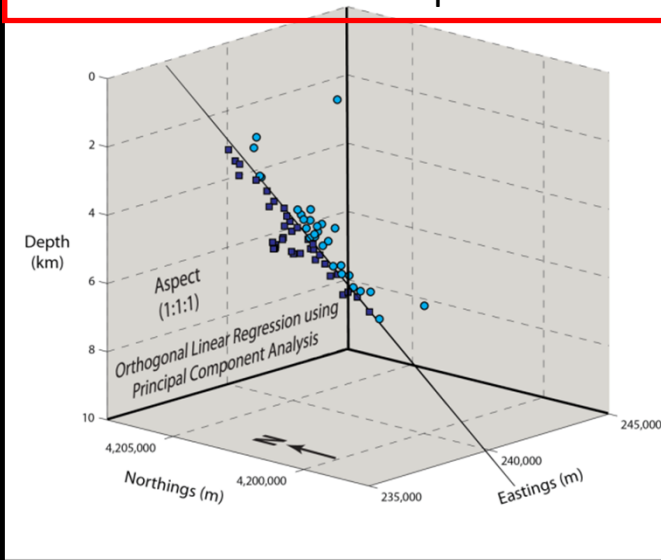


Simple Earthquake Analysis

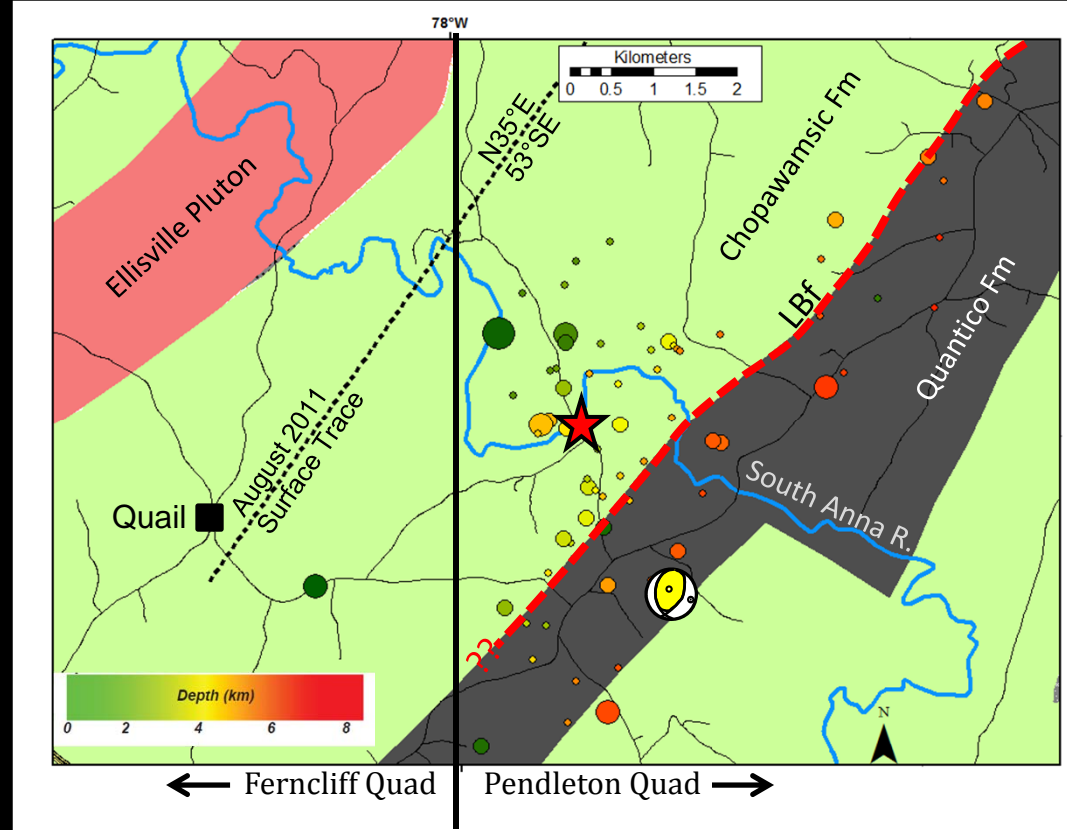
- Assuming aftershocks occur on and around main fault surface; *not* preferentially in hangingwall or footwall.
- The plane projects to the surface between the LBf and Ellisville pluton.

Strike = N35°E

Dip = 53°SE

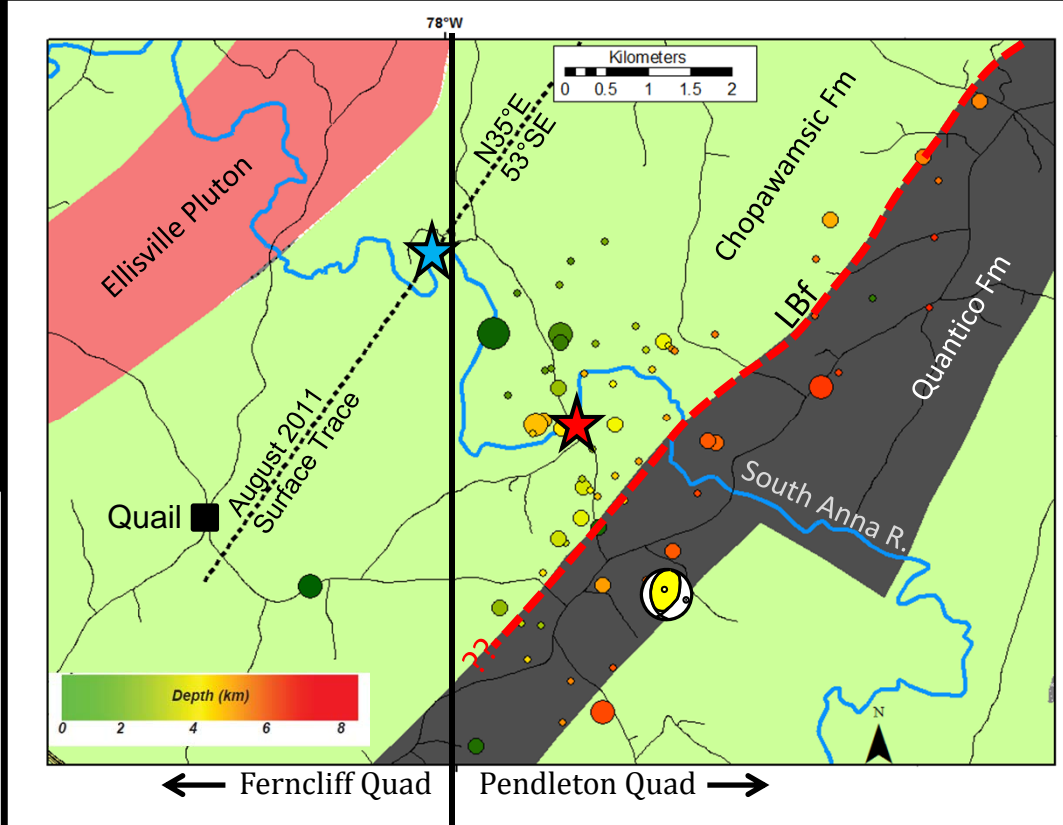


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Statistic	n=64		
	Depth	Eastings	Northings
R ²	0.75	0.96	0.98
Standard Error	±258 m		

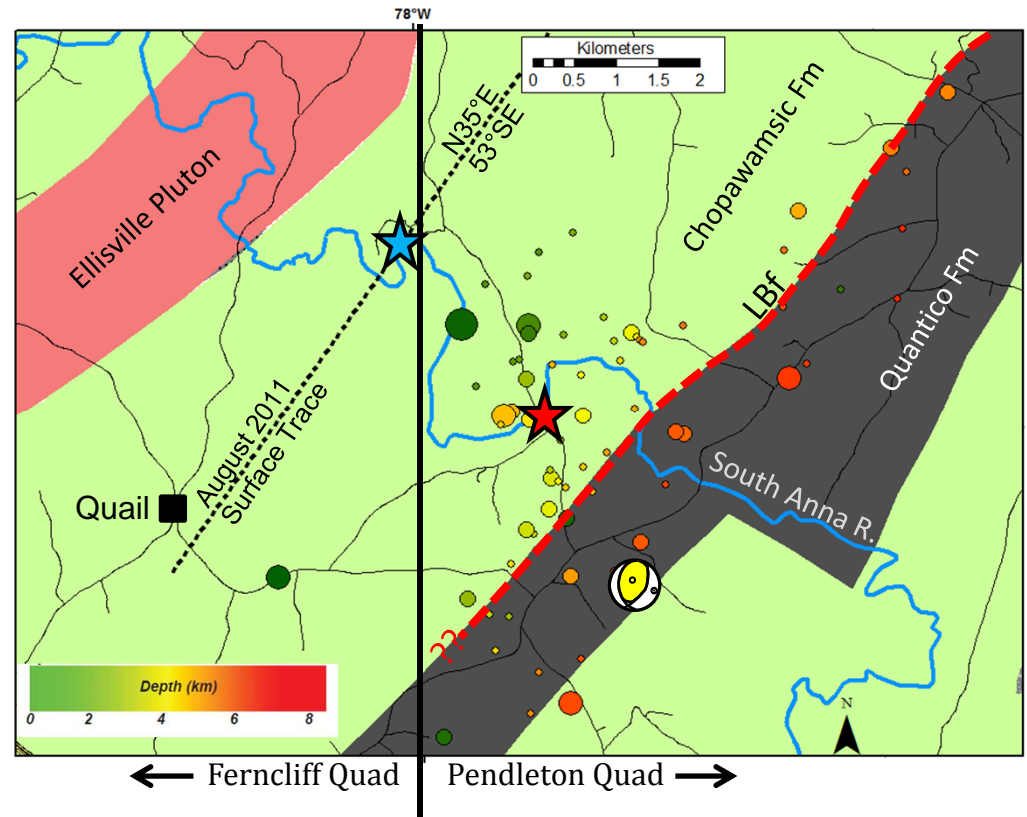
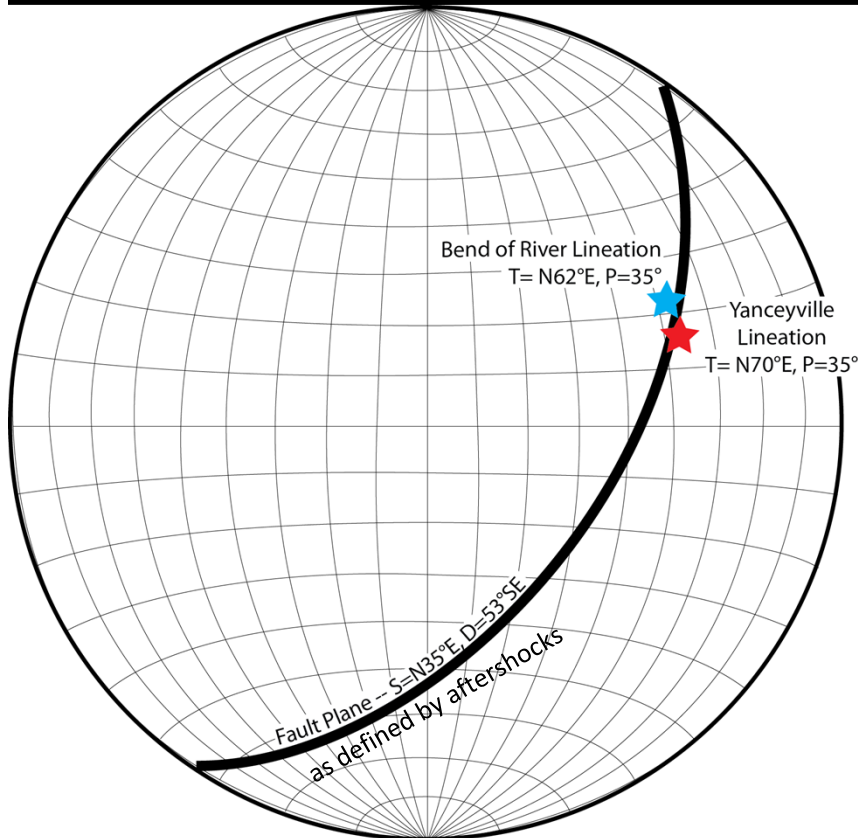
Bend of River lineation



- ★ = Yanceyville lineation: $T=70^\circ$, $P=35^\circ$
- ★ = Bend of River lineation: $T=62^\circ$, $P=35^\circ$

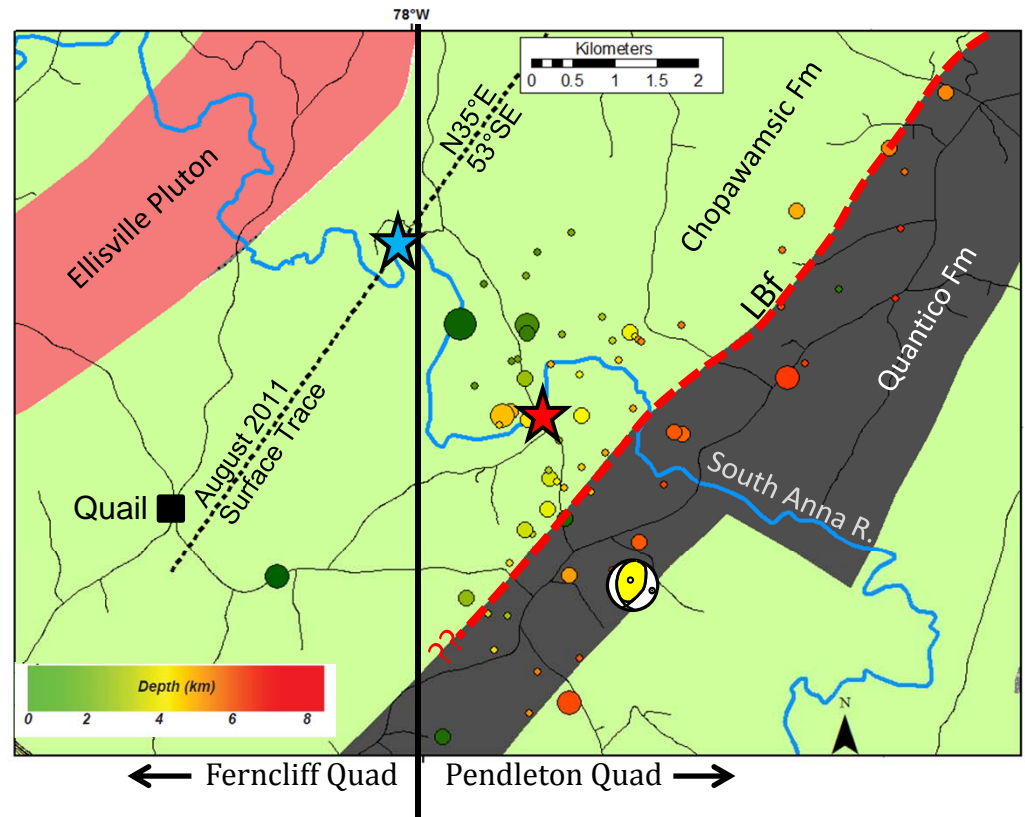
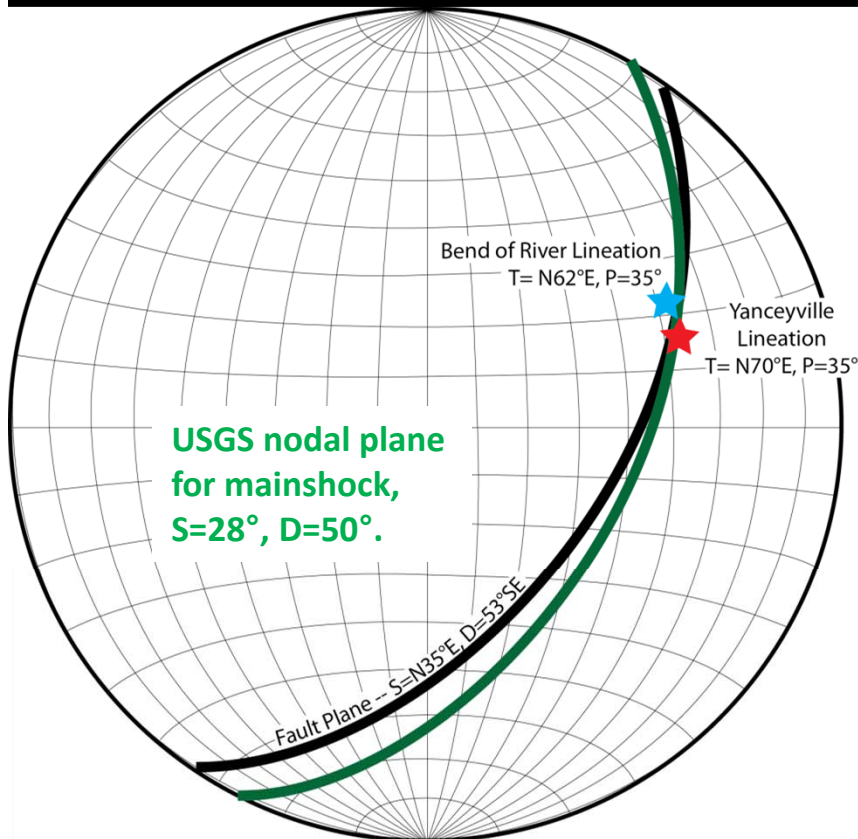
Similar linear fabrics at both sites suggest a kinematic link between deformation seen along the LBf and the surface trace of the recently active fault.

Summary



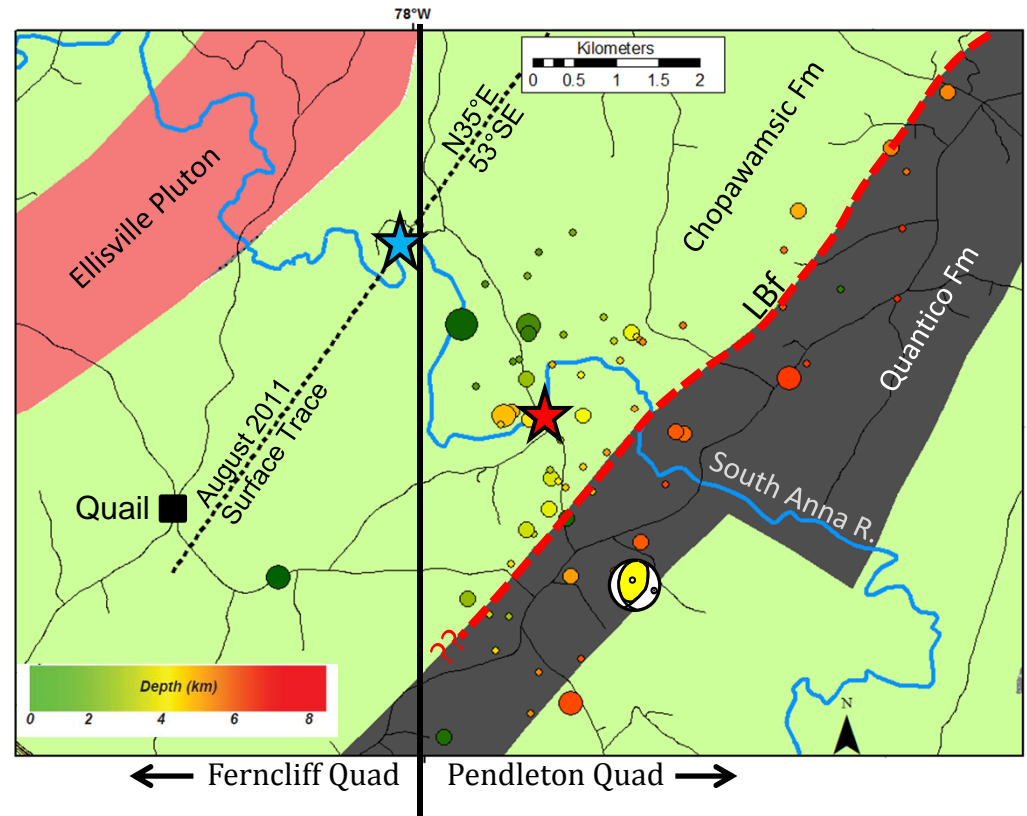
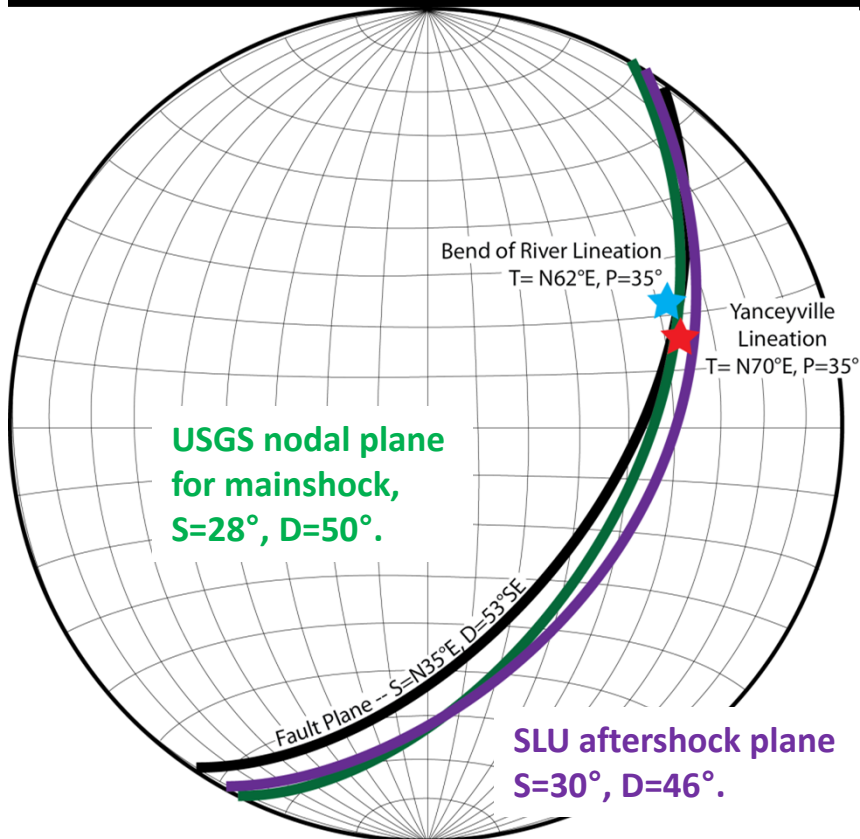
These observed ductile linear fabrics are not only spatially coincident. Their orientations lie within the fault plane of the main cluster of August 2011 EQs.

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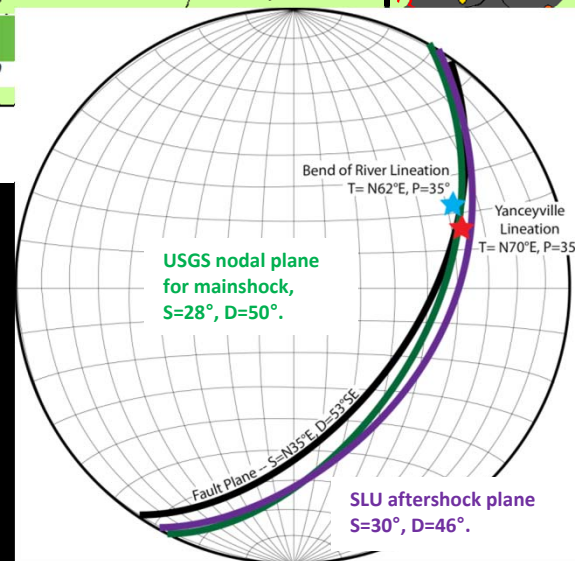
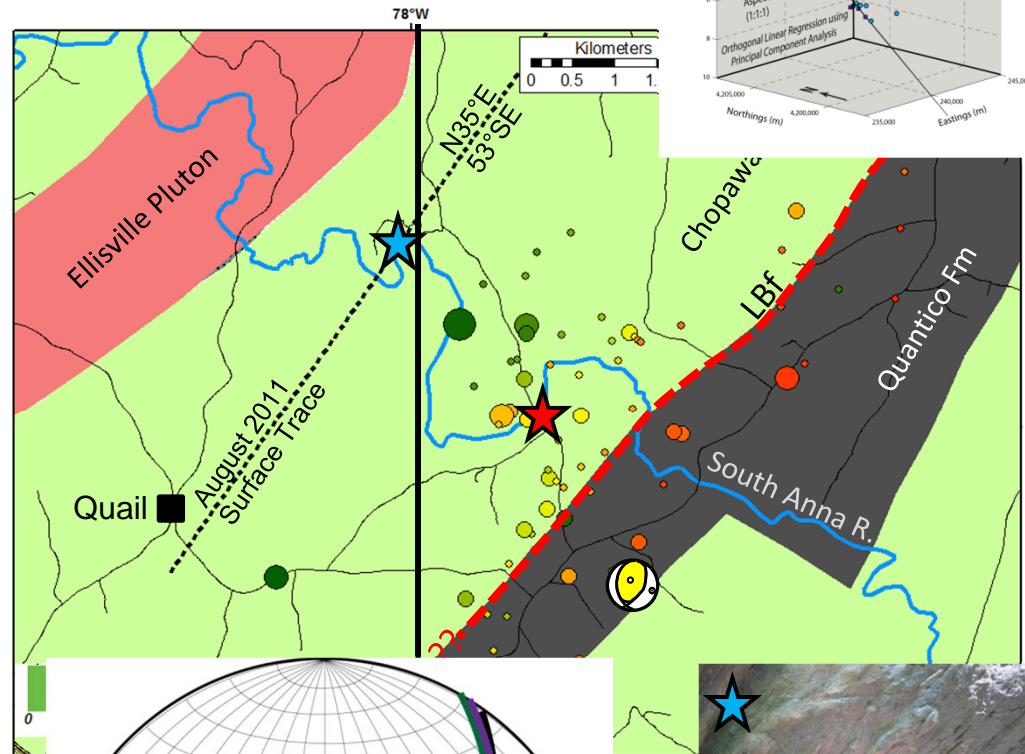
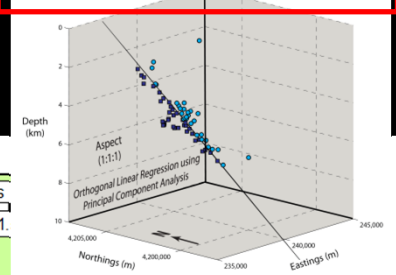
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This evidence suggests that the weakened footwall zone of the LBf is the most likely source of reactivation in the 2011 event.

Conclusions

- The Chopawamsic fault doesn't coincide with aftershock zone. Not a candidate for reactivation.
- The surface trace of the 2011 active fault lies east of the margin of the Ellisville pluton.
- The August 23, 2011 earthquakes occurred in a zone that shares deformational characteristics with products of the LBf.
- We interpret the August 23, 2011 event to be a result of reactivation within a footwall splay system or termination zone of the LBf.

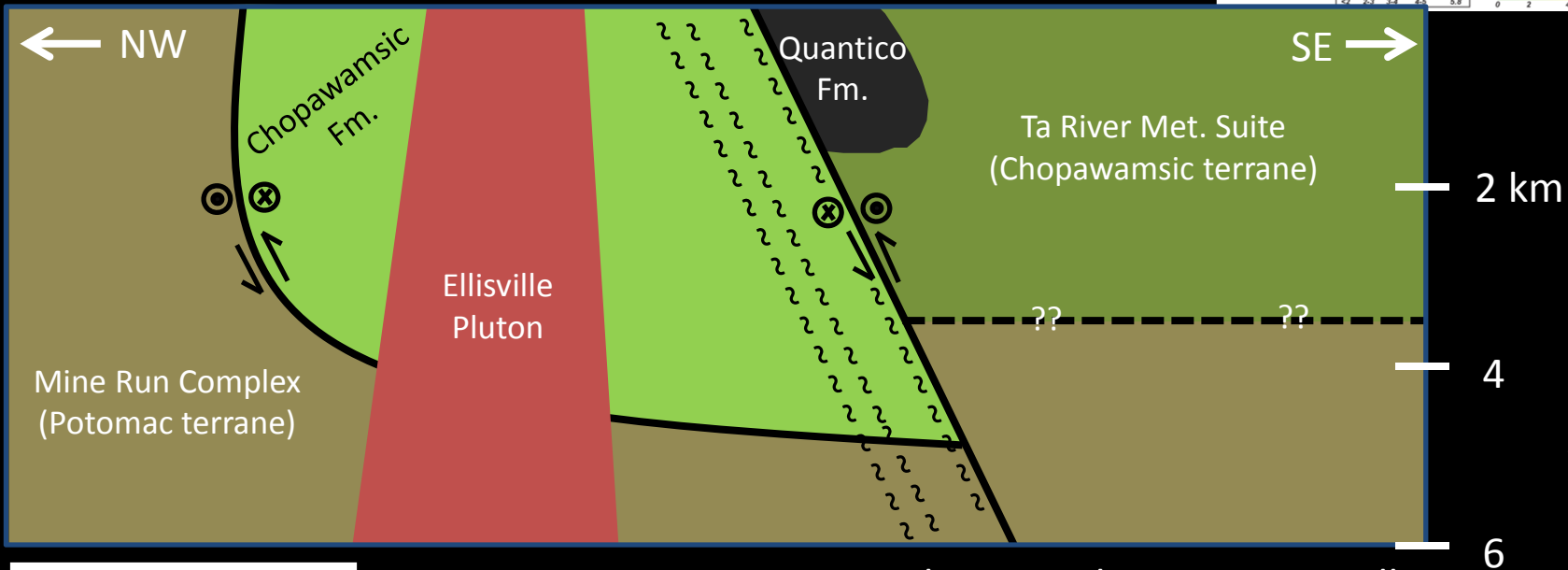
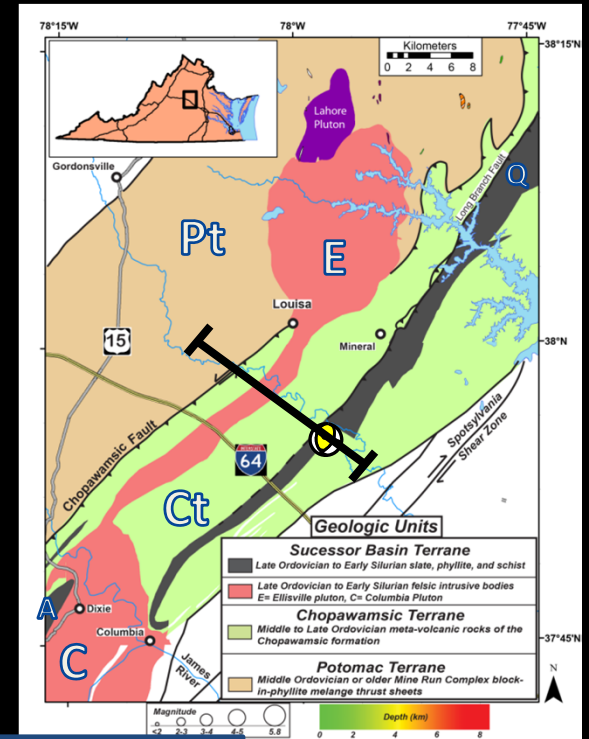
Strike = N35°E Dip = 53°SE



Conclusions

Chopawamsic fault
(Late Ordovician)

Long Branch fault
(late Paleozoic)



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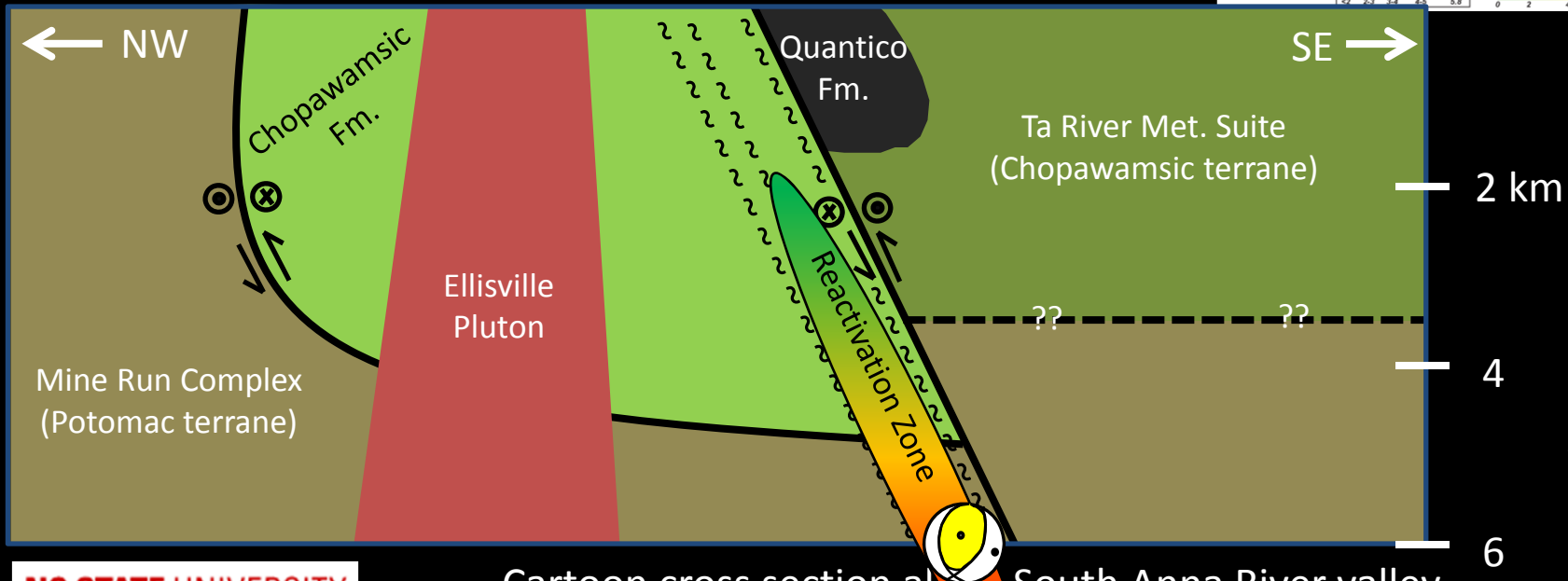
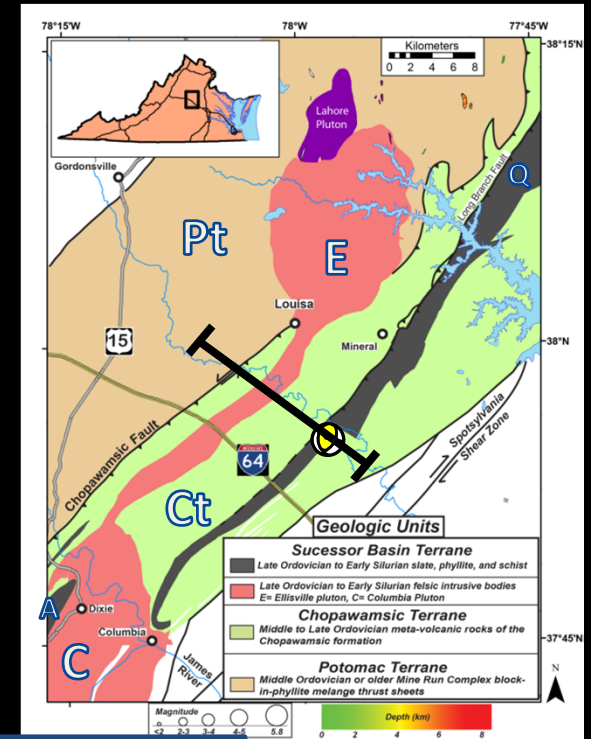
Cartoon cross section along South Anna River valley

Modified from Hughes 2011 Ferncliff quad map, I-64 seismic profile (see: Harris et al., 1986; Pratt et al., 1988), and reconnaissance work.

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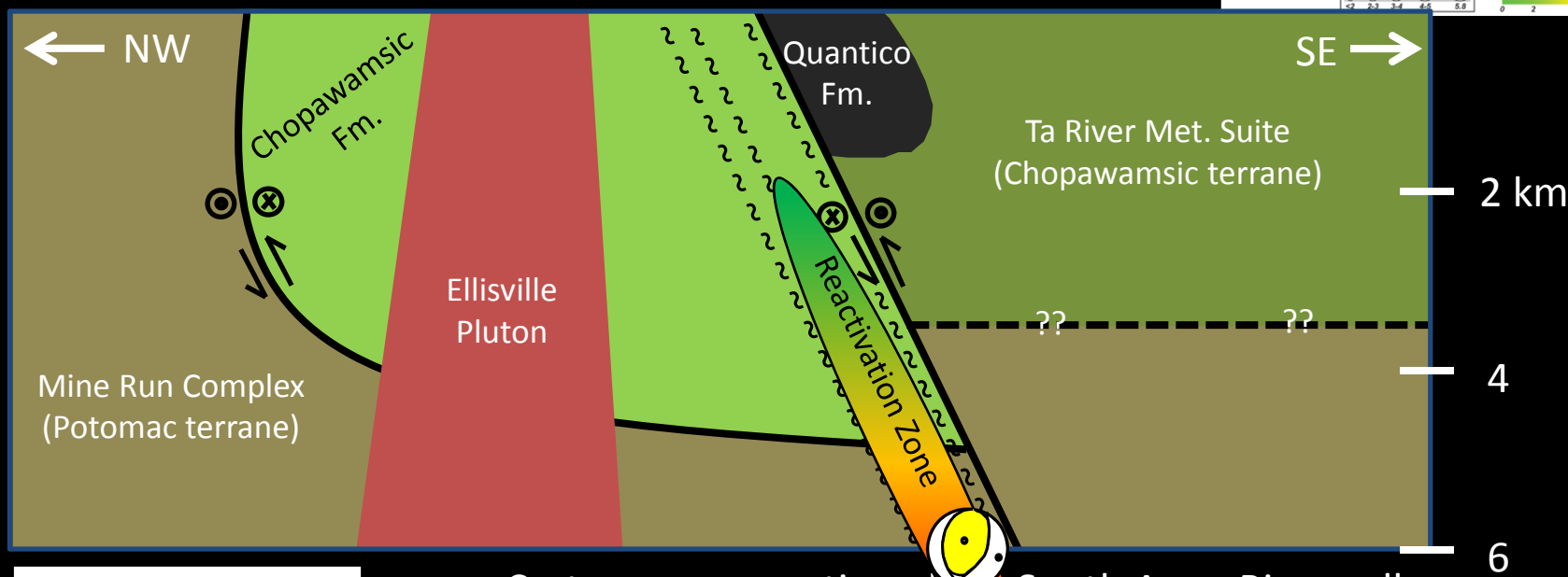
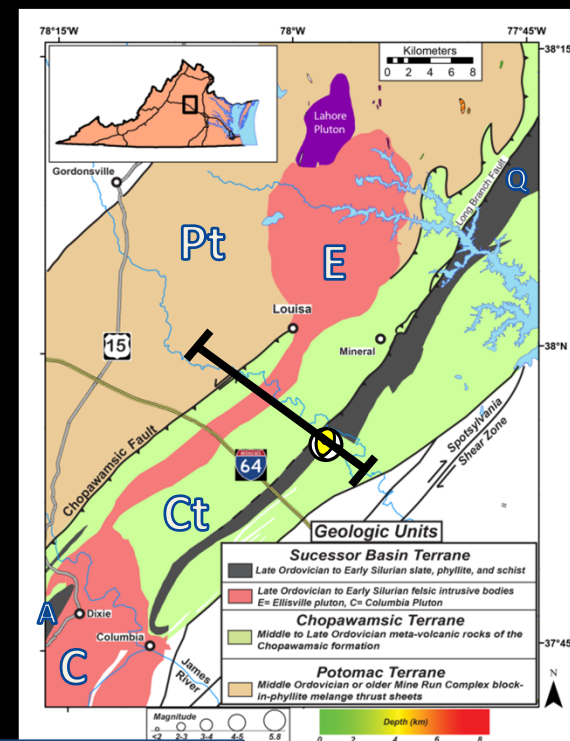
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Questions/Comments?

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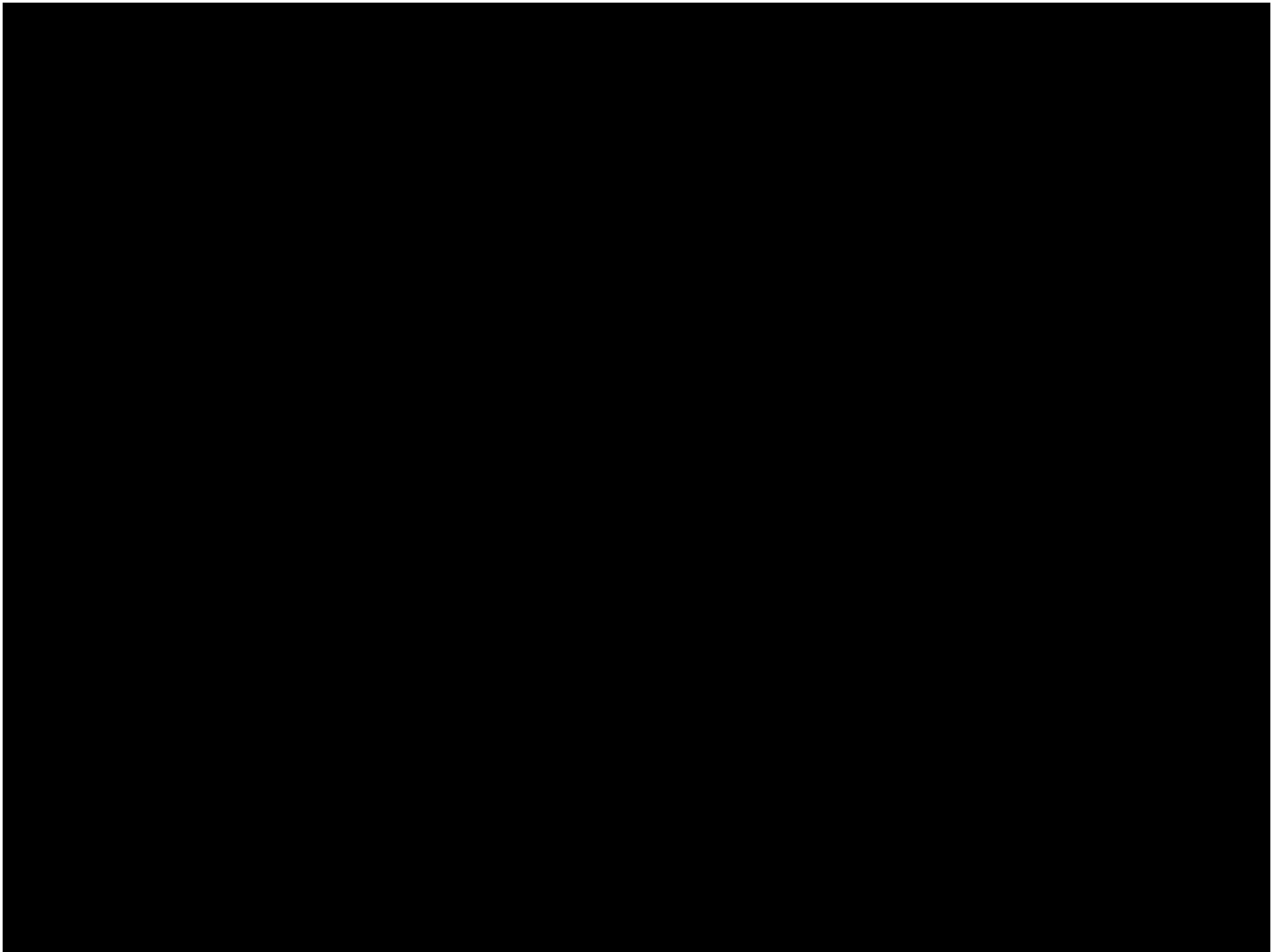
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Earthquake Analysis

- N35°E, 53°SE
- This plane projects to the surface between the LBf and Ellisville pluton. This line represents the westernmost potential trace of the fault.
- If fault surface isn't totally planar (common in region), surface trace likely lies further to southeast.

