

THE STRUCTURAL EVOLUTION OF THE PENNSYLVANIA SALIENT: A NEW MODEL

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ABSTRACT:
The origin of the Pennsylvania salient has been a matter of debate for over 150 years. A new, comprehensive deformation model is proposed here that integrates regional cross-sections in a 3D structural reconstruction, a structural retrodeformation, regional finite strain, paleomagnetic, and fracture orientation and fault slip data, radiometric dates, and syntectonic overburden reconstructed from fluid inclusion microthermometry.

The Blue Ridge and Reading Prong massifs serve as indenters that control the deformation in the salient, and initially restore to ~130 km hinterlandward of their present positions with the Blue Ridge striking ~030° and the Reading Prong striking ~045°, making a foreland-facing 'elbow'. In the Early Pennsylvanian, the Blue Ridge advances along the Blue Ridge thrust and the Reading Prong along the Yellow Breeches thrust. Motion of the massifs is driven by the impingement of the Reguibat indentor and the regional dextral transpressional fault system in the Piedmont. The structurally rising massifs shed sediments into the foreland in two broad depocenters in the areas of the future Anthracite Belt and western Valley & Ridge. In the area of the future Juniata culmination, at the juncture of the two massifs, there is minimal sedimentation. During the Late Pennsylvanian – Early Permian, the massifs advance toward the foreland along a detachment in the Cambrian. NW-directed shortening forms a ~320° striking joint set in the foreland. The earliest Valley & Ridge folds form at the 'elbow' by imbrication of the Cambro-Ordovician carbonate lithotectonic unit. The depocenters continue to receive sediments, and the thickness controls the future thrust imbrication style in the Valley & Ridge. Between the Mid- to Late Permian, the Valley & Ridge folds grow and advance, extending from the impinging 'elbow.' Continued carbonate imbrication occurs as the Blue Ridge advances toward ~300° then to ~280°, and the advancing Reading Prong rotates clockwise toward ~350°. Corresponding joint sets form in the foreland. In the Late Permian, the Valley & Ridge structures are complete and folding continues into the Plateau province. The Blue Ridge advances toward ~280° then ~290° resulting in joint sets and tear faults in the Plateau. The advancing Reading Prong results in ~360° striking joint sets in the foreland.

DATA USED
This model takes into consideration data from numerous sources:

- Maximum syntectonic burial from fluid inclusion microthermometry
- Regional fracture patterns from published reports and field measurements
- Fracture timing from cross-cutting relationships and vein mineral history
- Meso-scale structural relationships (faults, slip lineations, cleavage, etc.)
- The construction of 33 regional balanced cross-sections and 15 smaller cross-sections based on bedrock geologic maps, depth to basement, available seismic data, available deep well data
- A three-dimensional model of the region constructed in Move
- A volume balanced retrodeformation of the 3D model
- Regional finite strain data used in the retrodeformation
- Deformational age data where available
- Paleomagnetic data

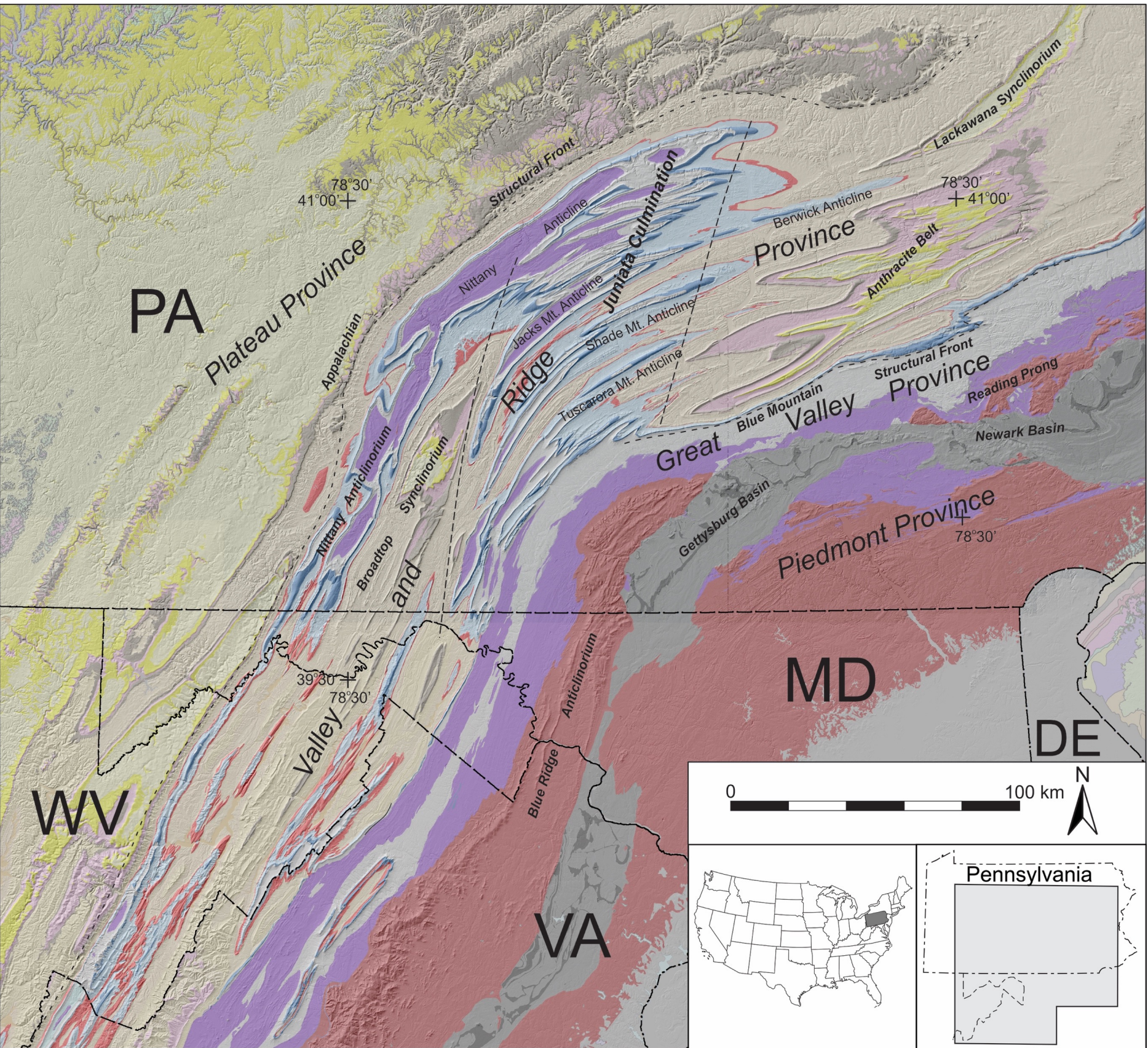
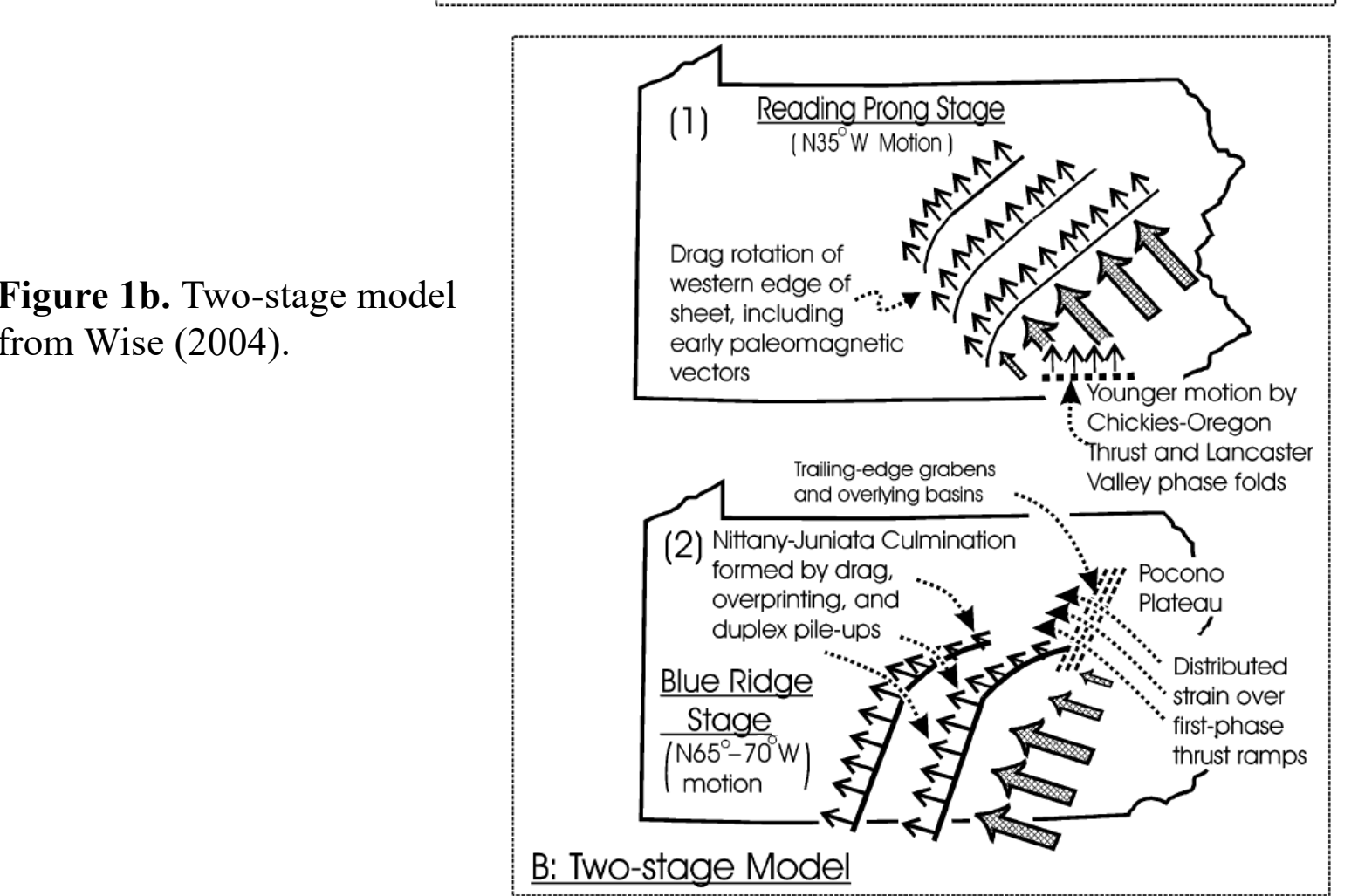
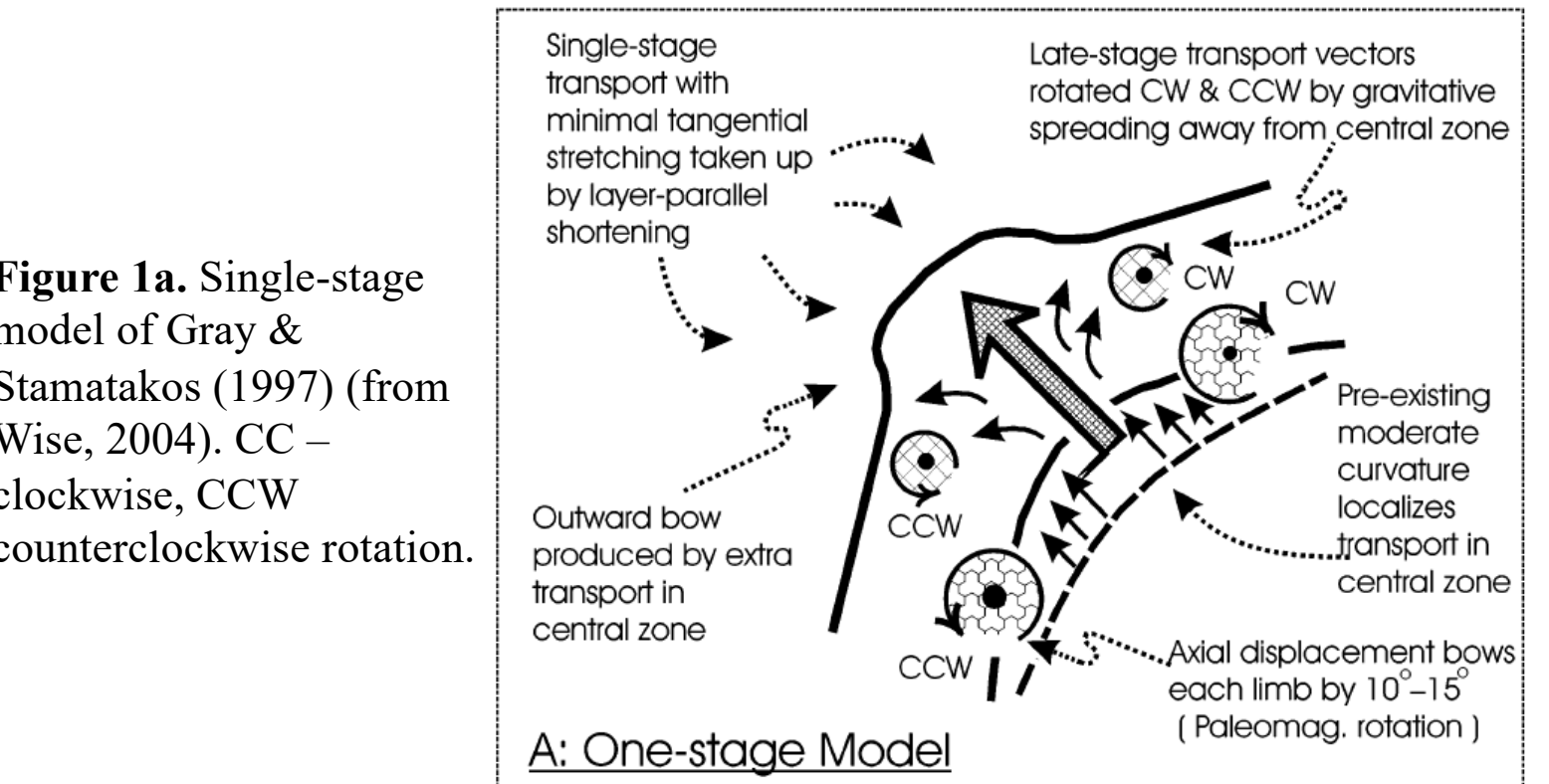


Figure 2. Regional Geologic Map.

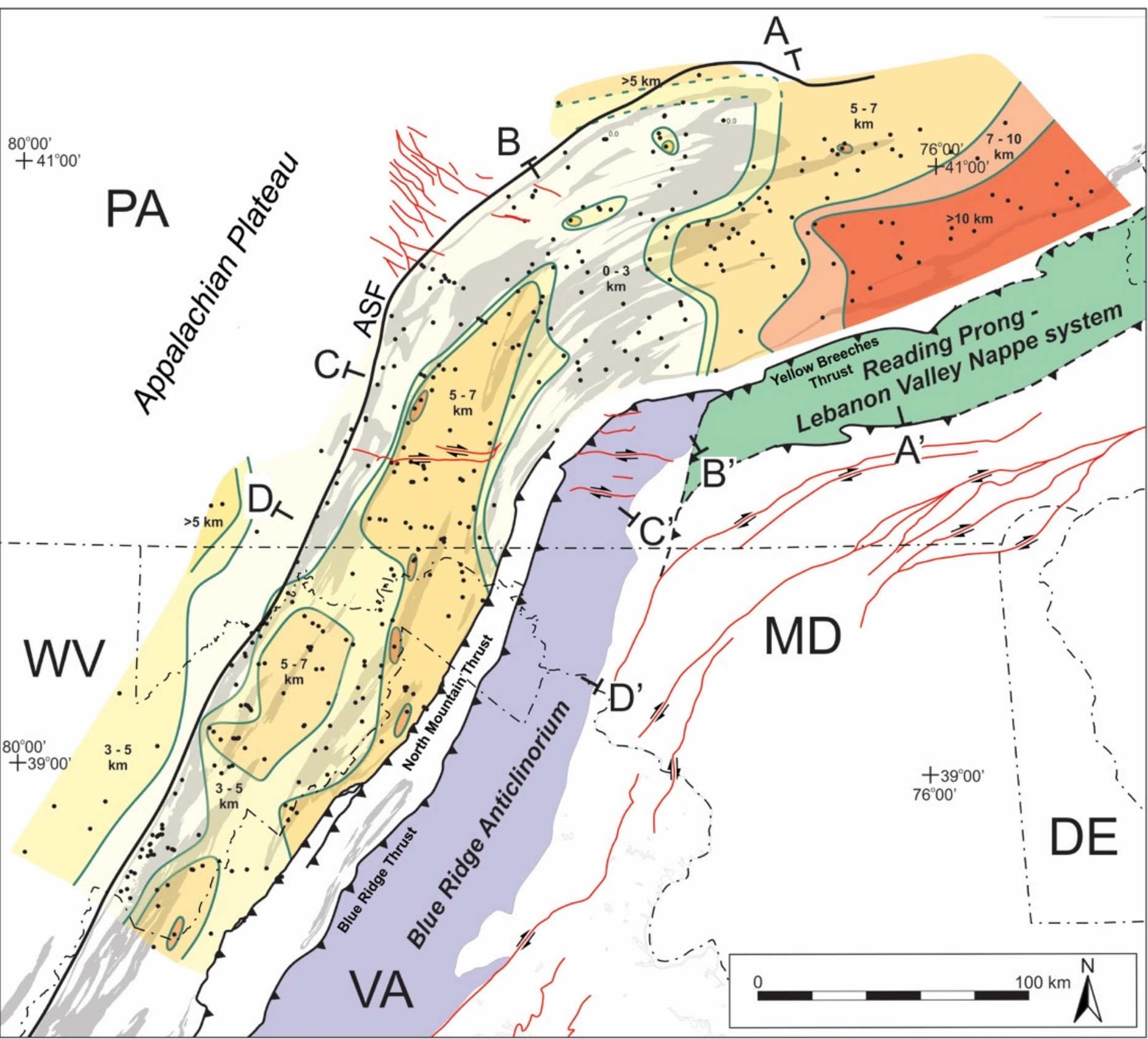


Figure 3. Regional map showing major structural features and the syntectonic (Penn-Perm) overburden thickness as determined from fluid inclusion microthermometry.

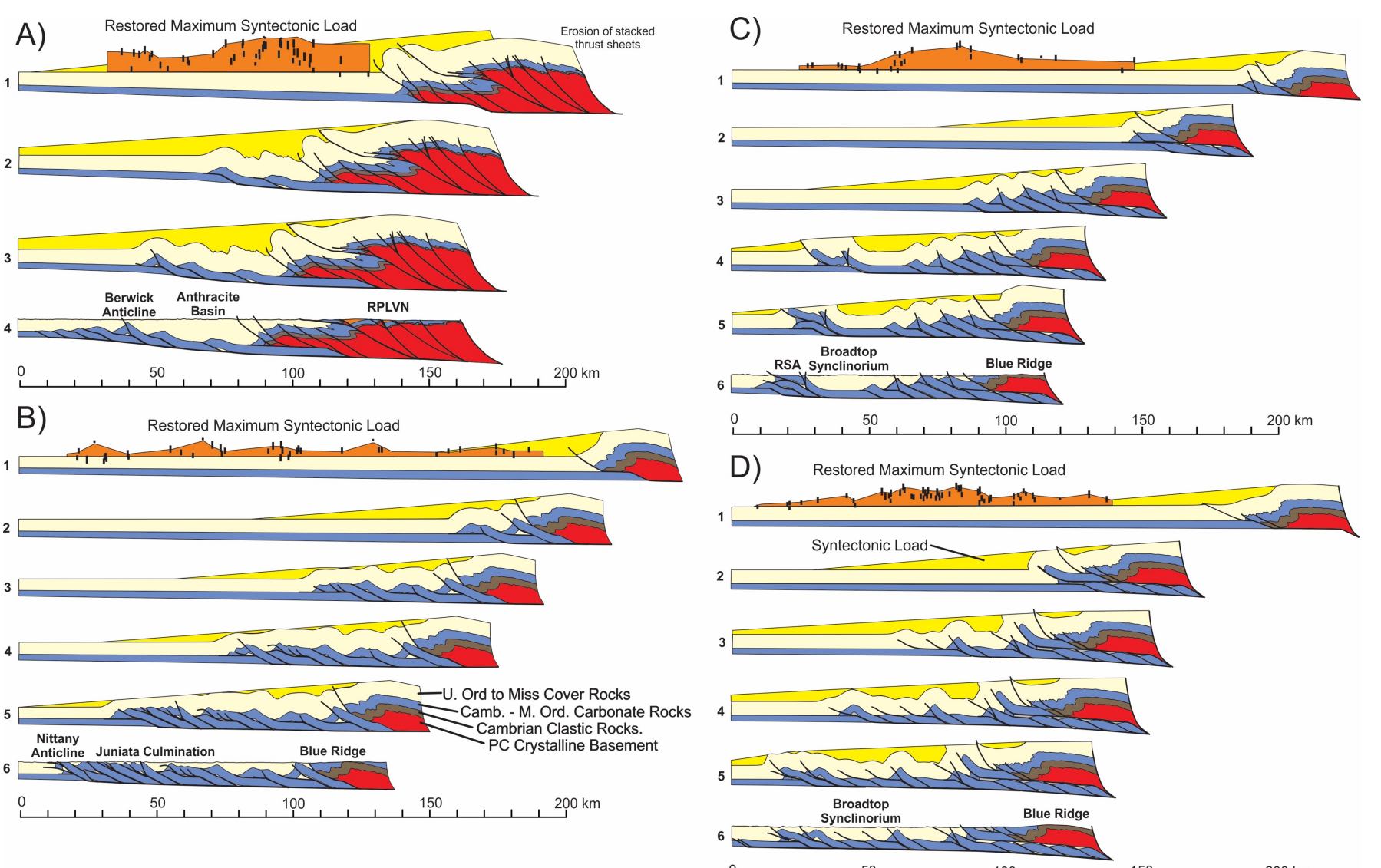
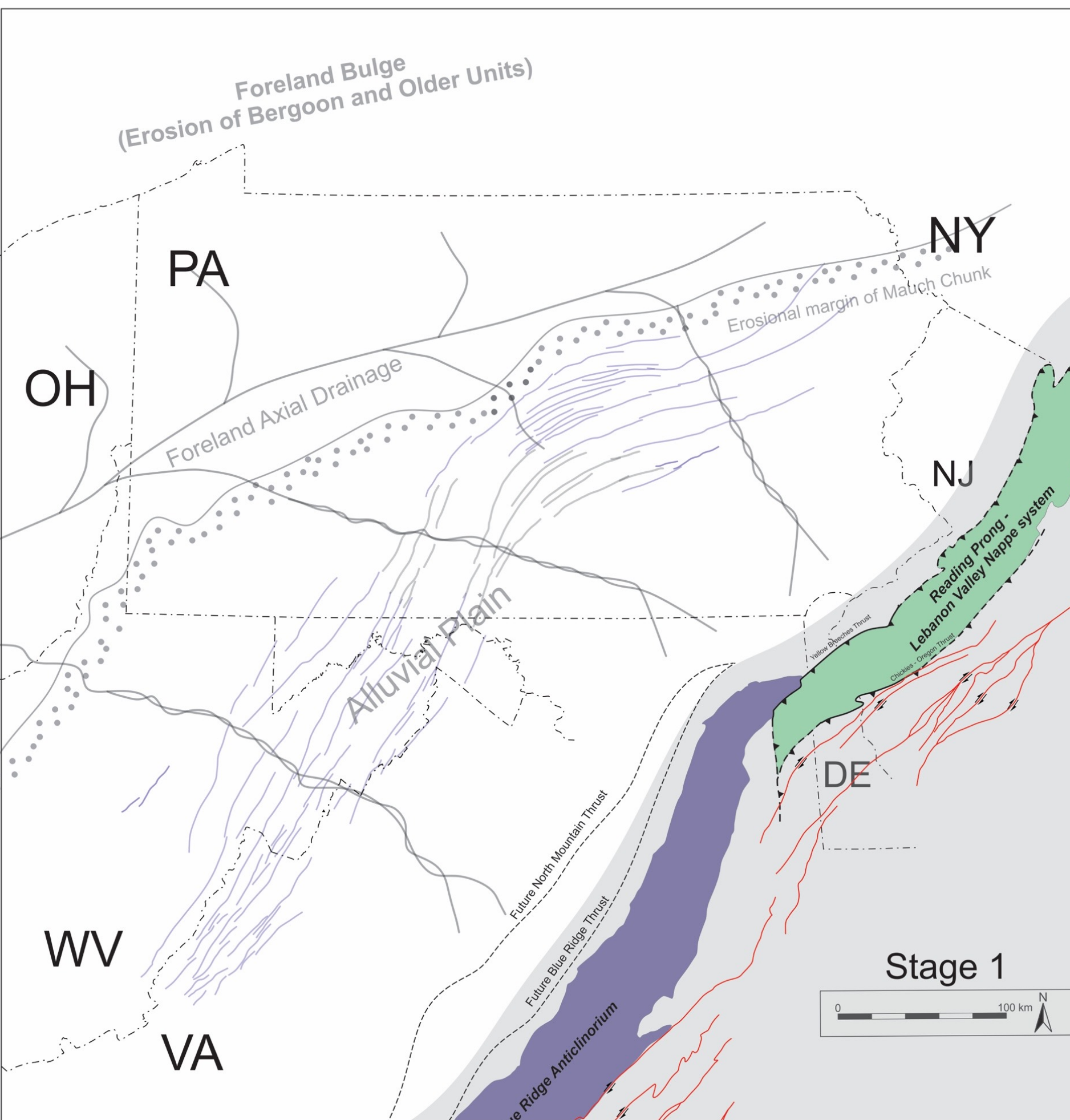
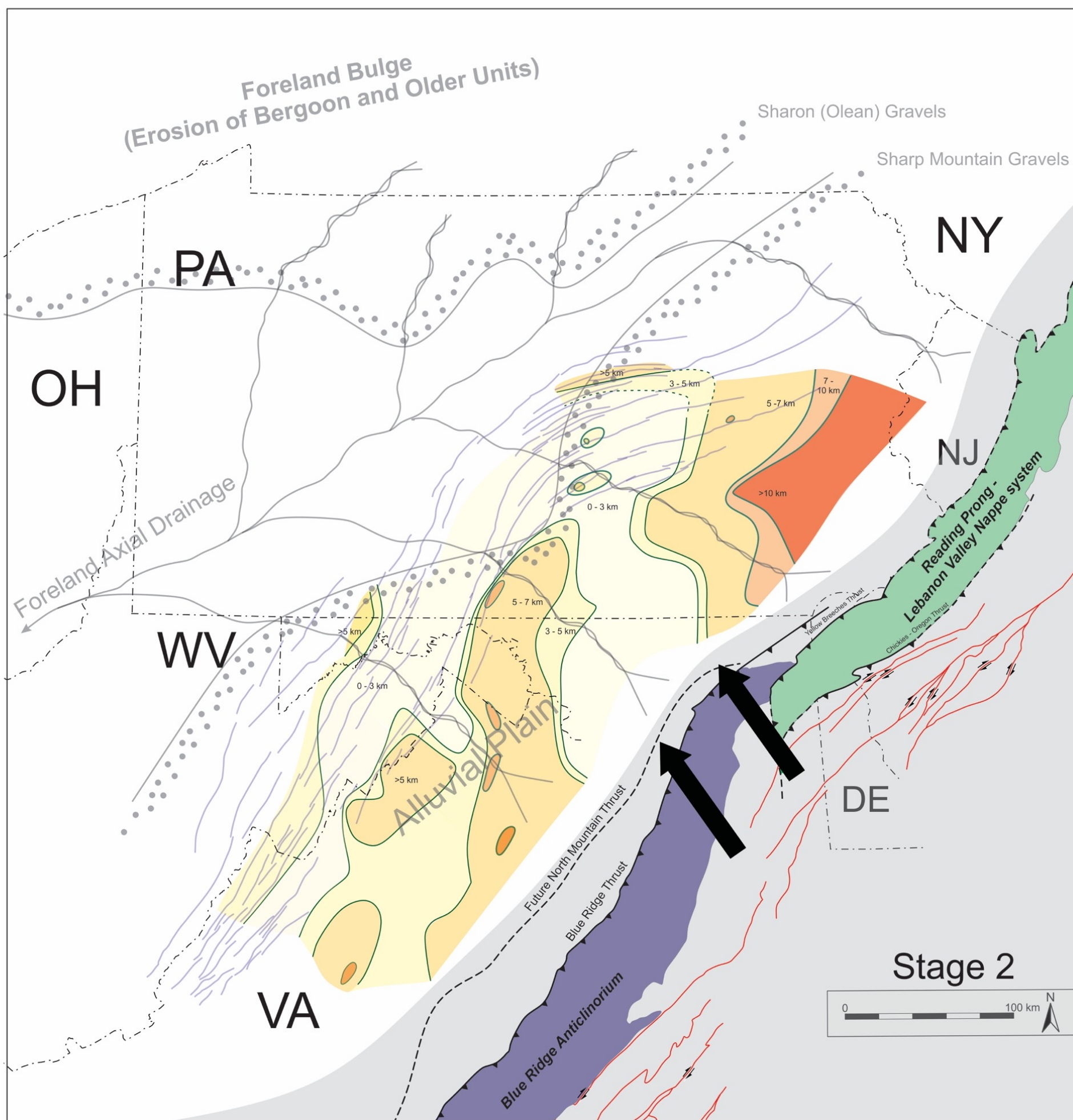


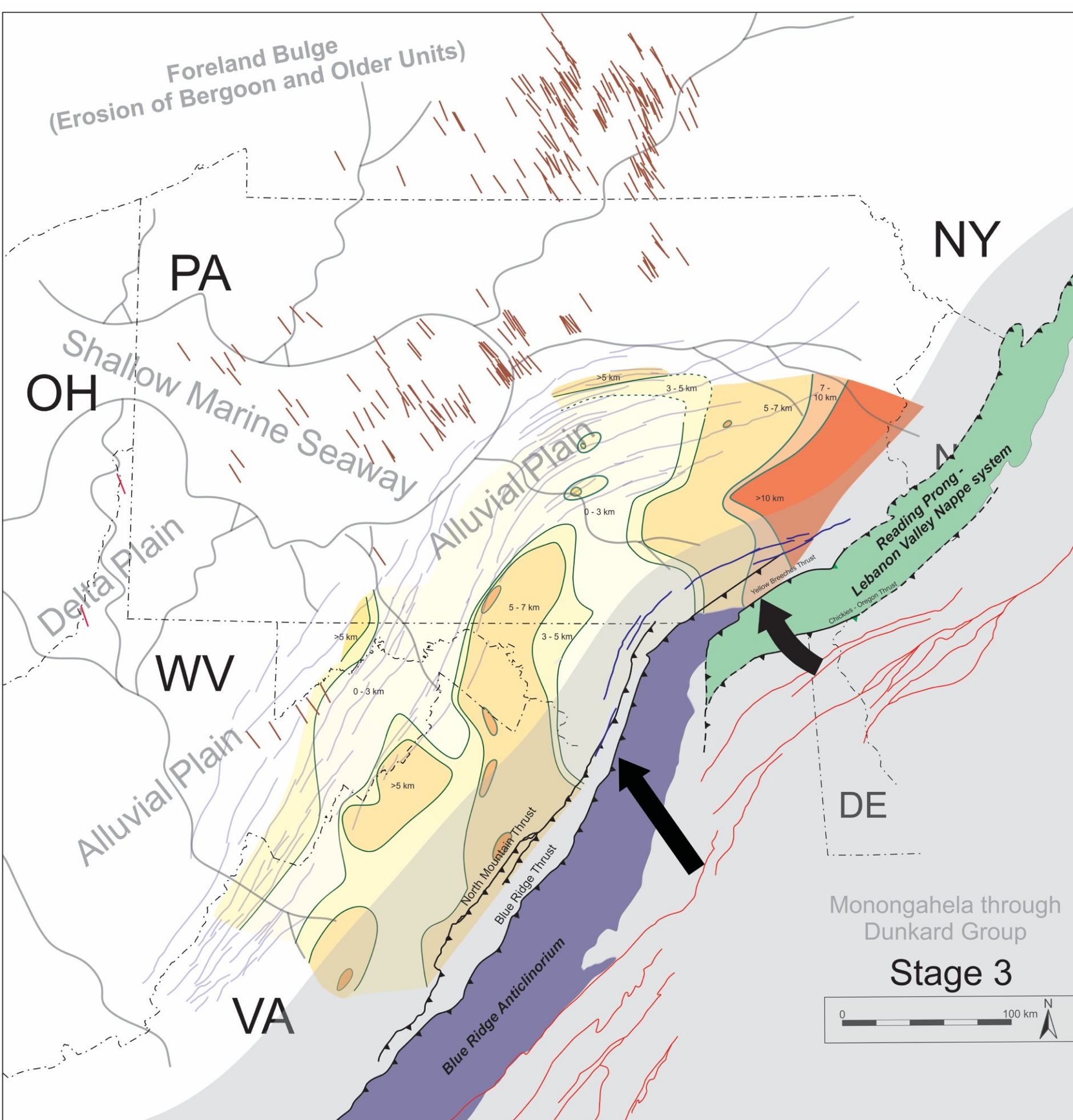
Figure 4. Sequential deformation cross sections for each of the four regional cross sections shown in Figure 3. Section 1 in each case shows the restored maximum syntectonic load (black bars, and orange shading) as determined from fluid inclusion microthermometry. Yellow shading in each case is interpreted syntectonic sediment wedge.



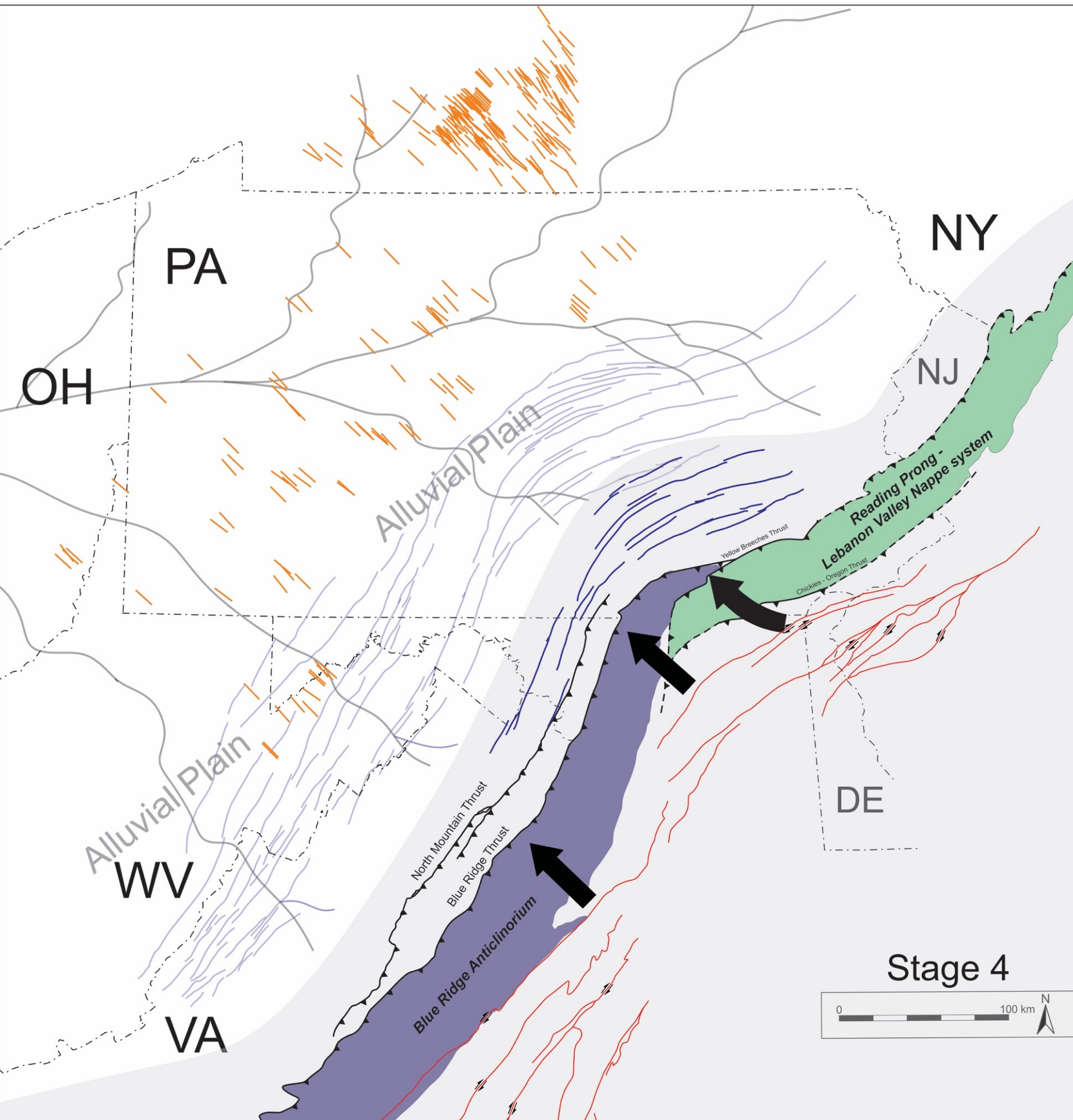
Stage 1: Middle to Late Mississippian



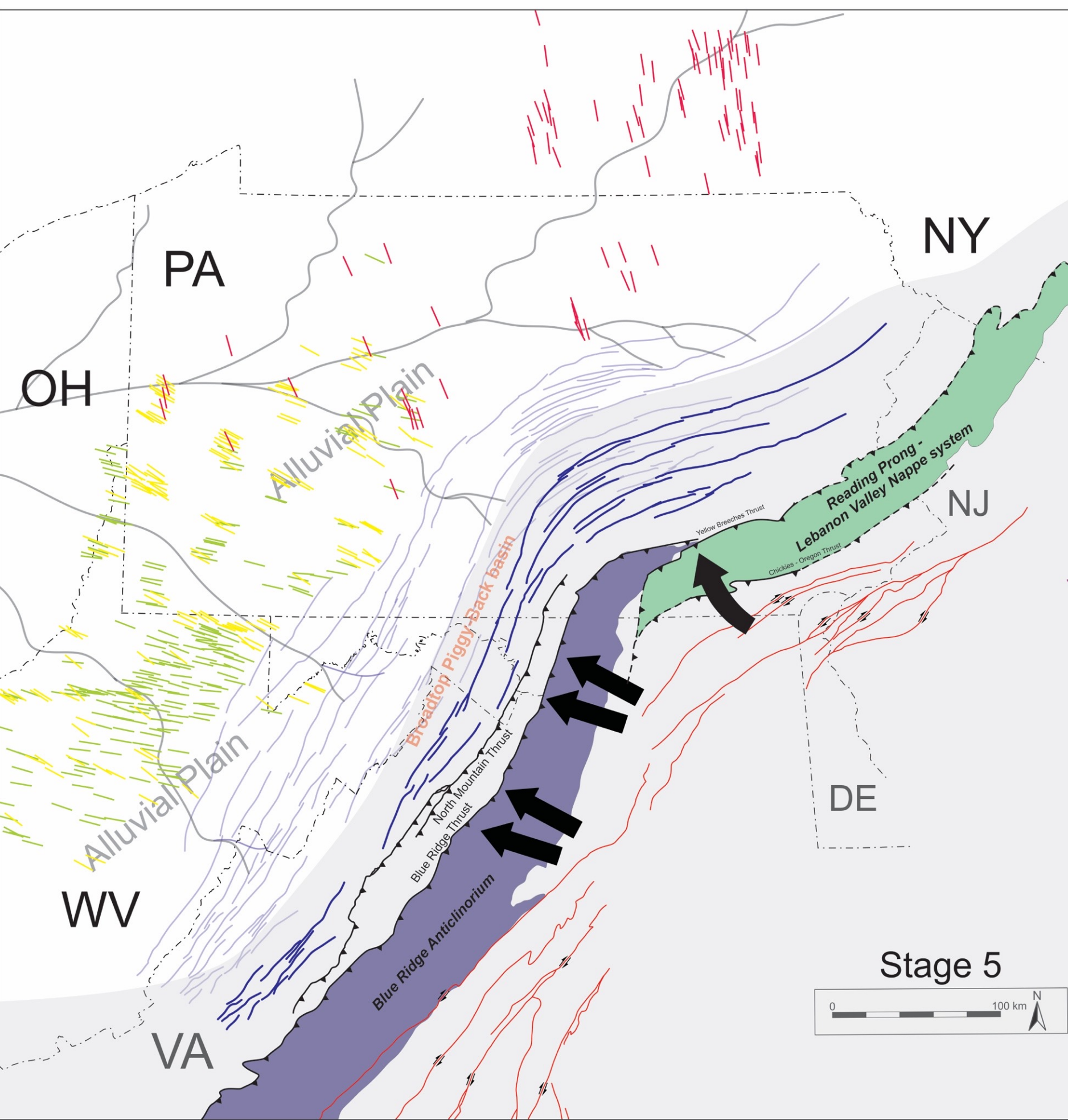
Stage 2: Early to Middle Pennsylvanian



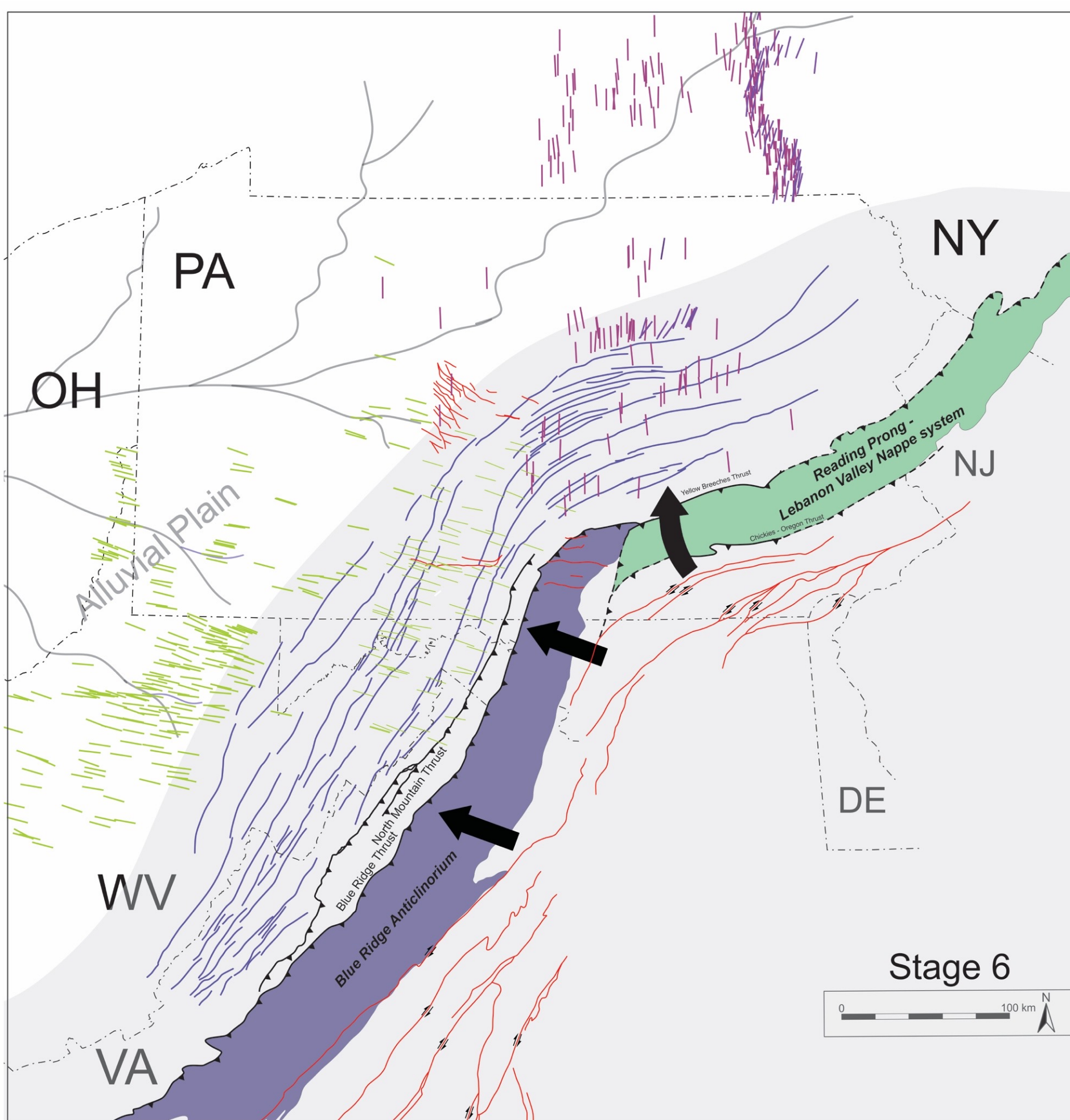
Stage 3: Late Penn. to Middle Permian



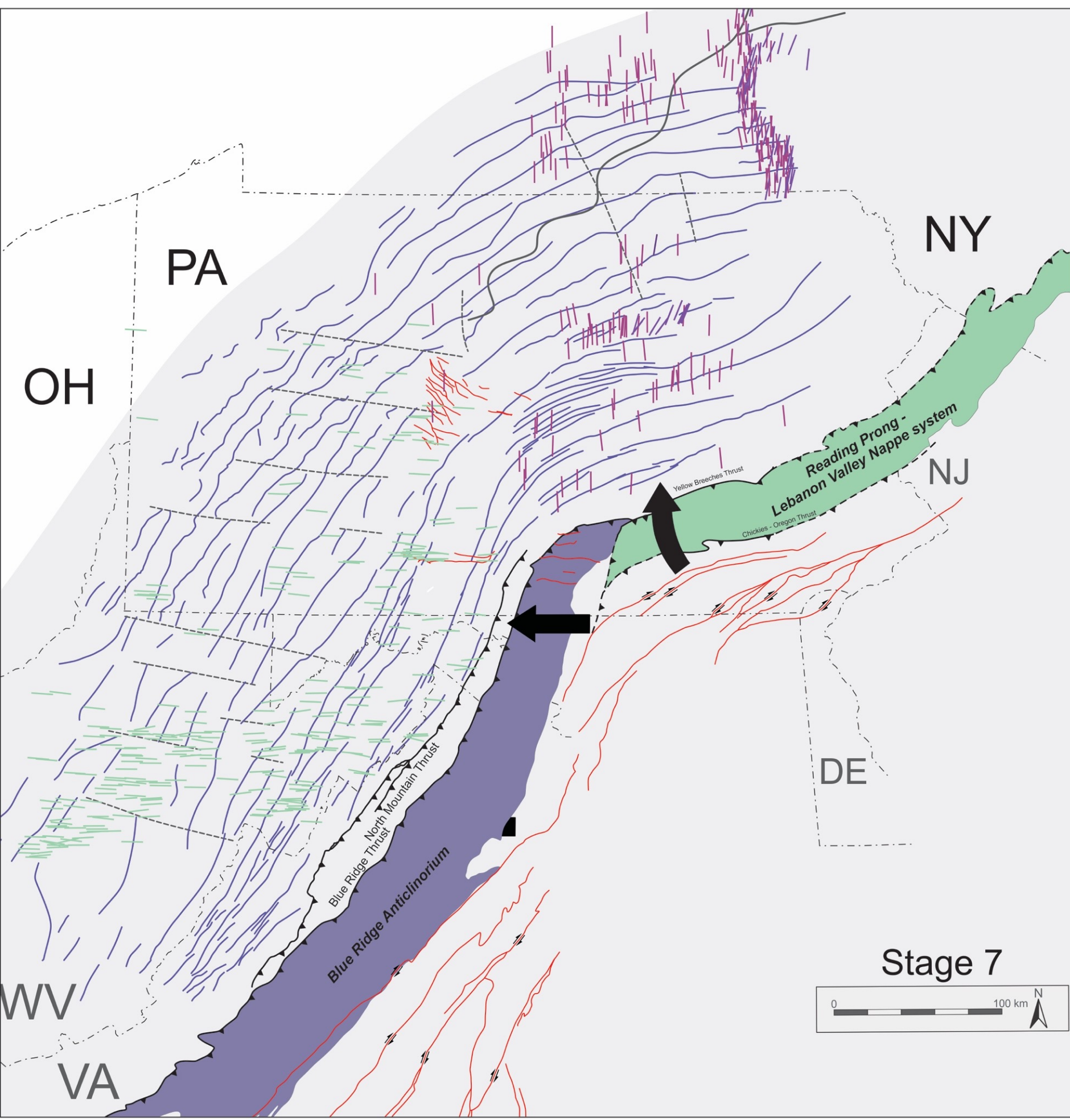
Stage 4: Middle Permian



Stage 5: Early Late Permian



Stage 6: Late Permian



Stage 7: Latest Permian

Figure 5. Seven stages in the structural development of the Pennsylvania Salient. Fracture orientations from Nickelsen and Hough (1967), Engelder and Geiser (1980), Kulander and Dean (1993), and unpublished mapping. Shaded region is interpreted to be in uplift and erosion.

SUMMARY

- The Blue Ridge and Reading Prong massifs are interpreted to move toward the foreland in about the same direction until Stage 3.
- Fold structure axes in the Valley and Ridge retrodeform to nearly straight lines.
- The impingement of the northern Blue Ridge and southwest Reading Prong massif develops the fold curvature in the salient.
- With continued translation, the direction of the Blue Ridge shifts more toward the west, and the Reading Prong rotates toward the north.

SUMMARY (Cont.)

- The rotation of the Reading Prong is interpreted to be related to transpression in the Pennsylvania/Maryland Piedmont area.
- Final emplacement of the Blue Ridge is interpreted to be nearly due west, resulting in cross-strike discontinuities in the Plateau, common outcrop-scale strike-slip faults in the Valley & Ridge, and brittle fault structures in the western Blue Ridge of Virginia.
- The present fracture pattern in the region is a summation of the fractures developed in each stage.

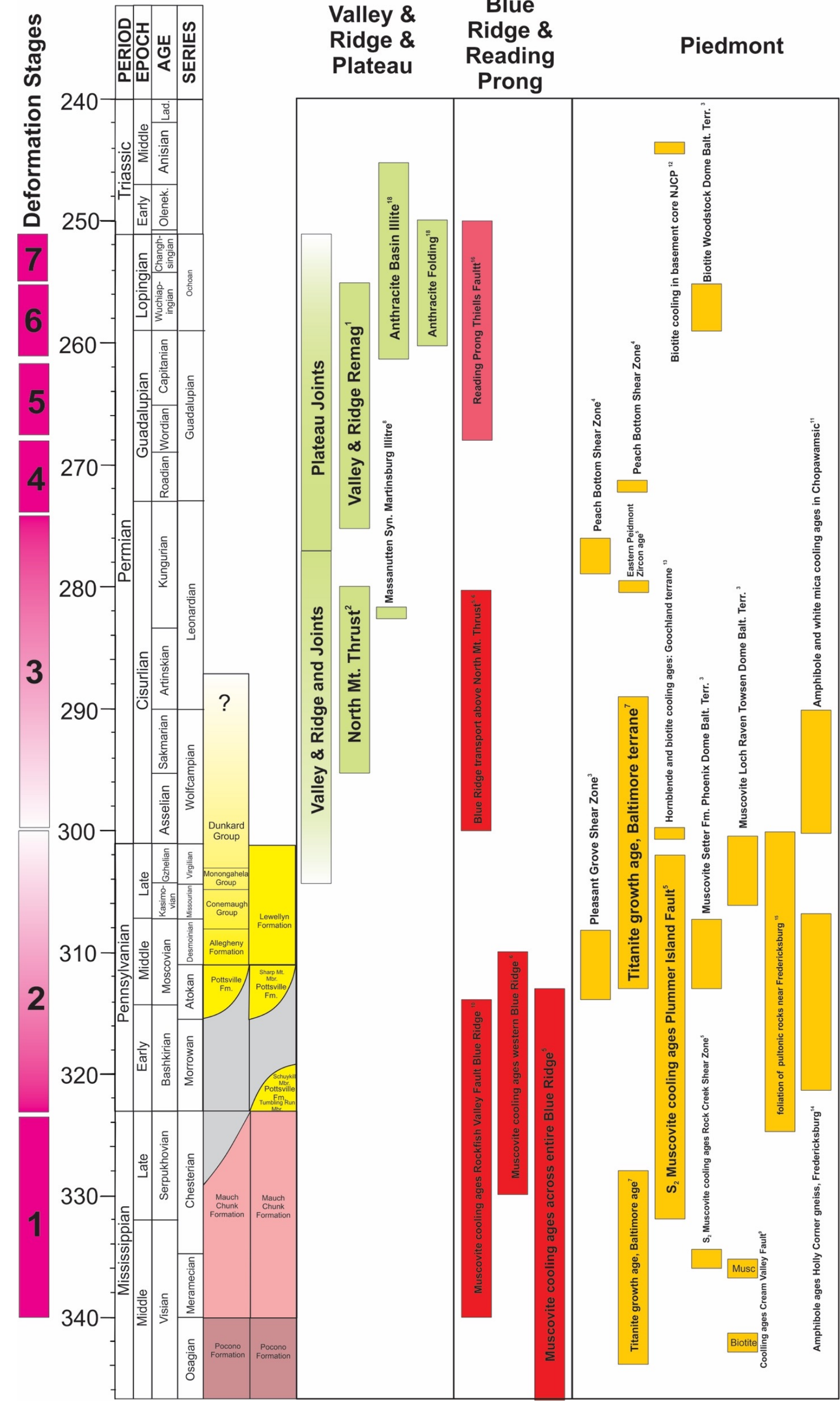


Figure 6. Alleghenian Events with interpreted Stage durations.