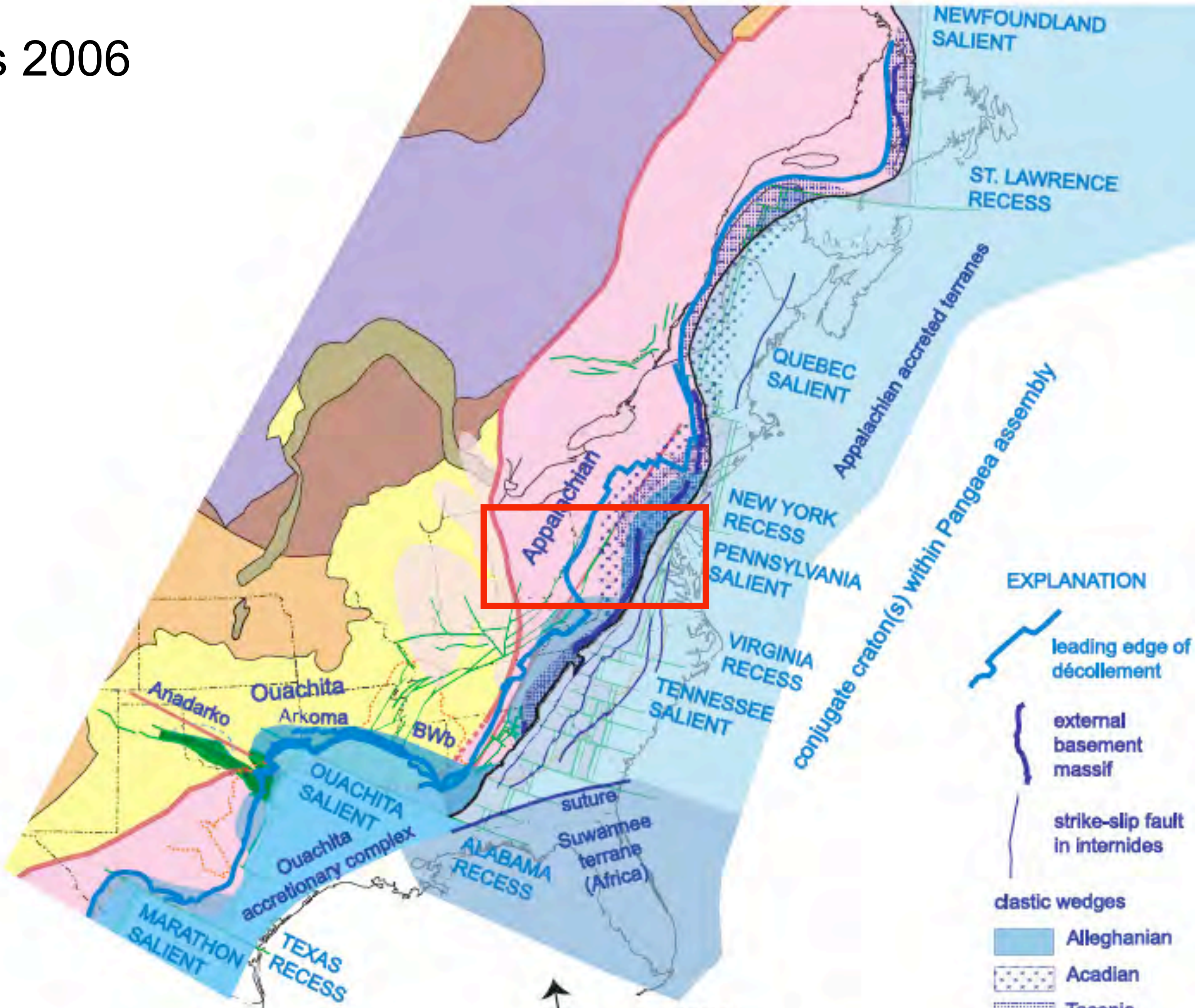
Thomas 2006


NEWFOUNDLAND SALIENT
ST. LAWRENCE RECESS
Appalachian accreted terranes
QUEBEC SALIENT
conjugate craton(s) within Pangaea assembly
NEW YORK RECESS
PENNSYLVANIA SALIENT
VIRGINIA RECESS
TENNESSEE SALIENT
Appalachian
Anadarko
Ouachita
Arkoma
BWb
OUACHITA SALIENT
Ouachita accretionary complex
suture
Suwannee terrane (Africa)
ALABAMA RECESS
MARATHON SALIENT
TEXAS RECESS
N
SCALE
0 200 400 600 km
EXPLANATION
leading edge of décollement
external basement massif
strike-slip fault in internides
clastic wedges
Alleghanian
Acadian
Taconic

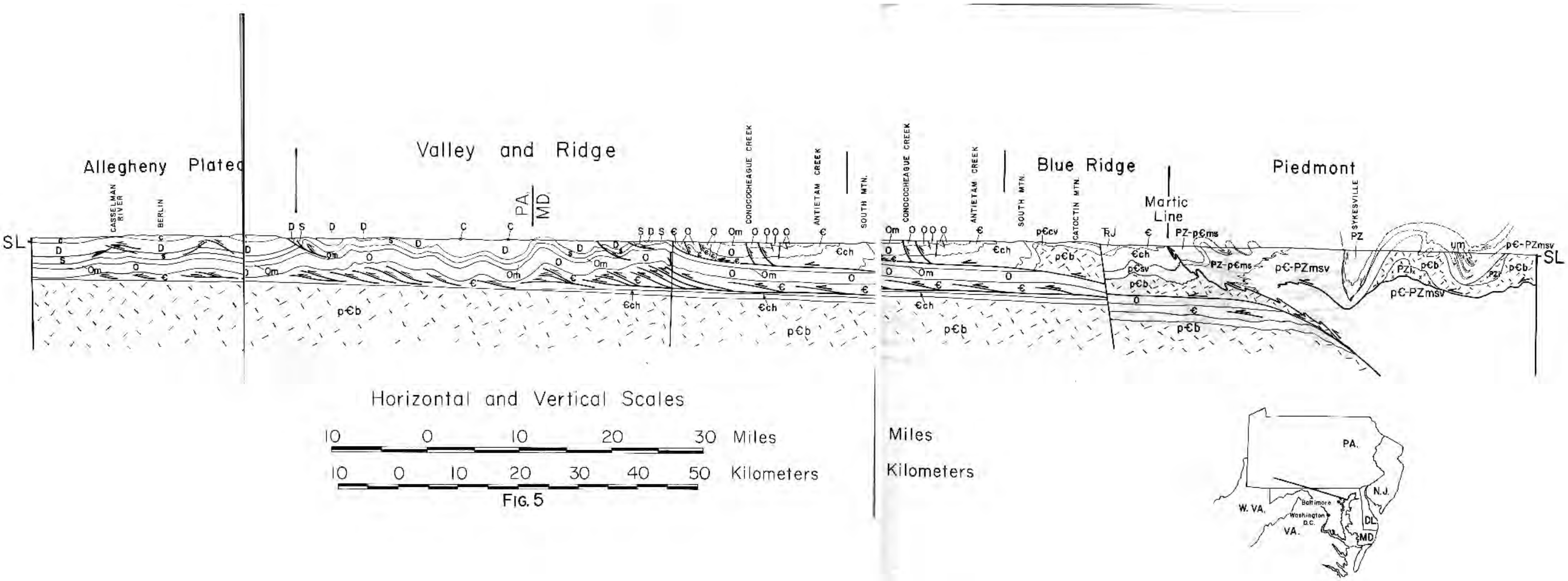
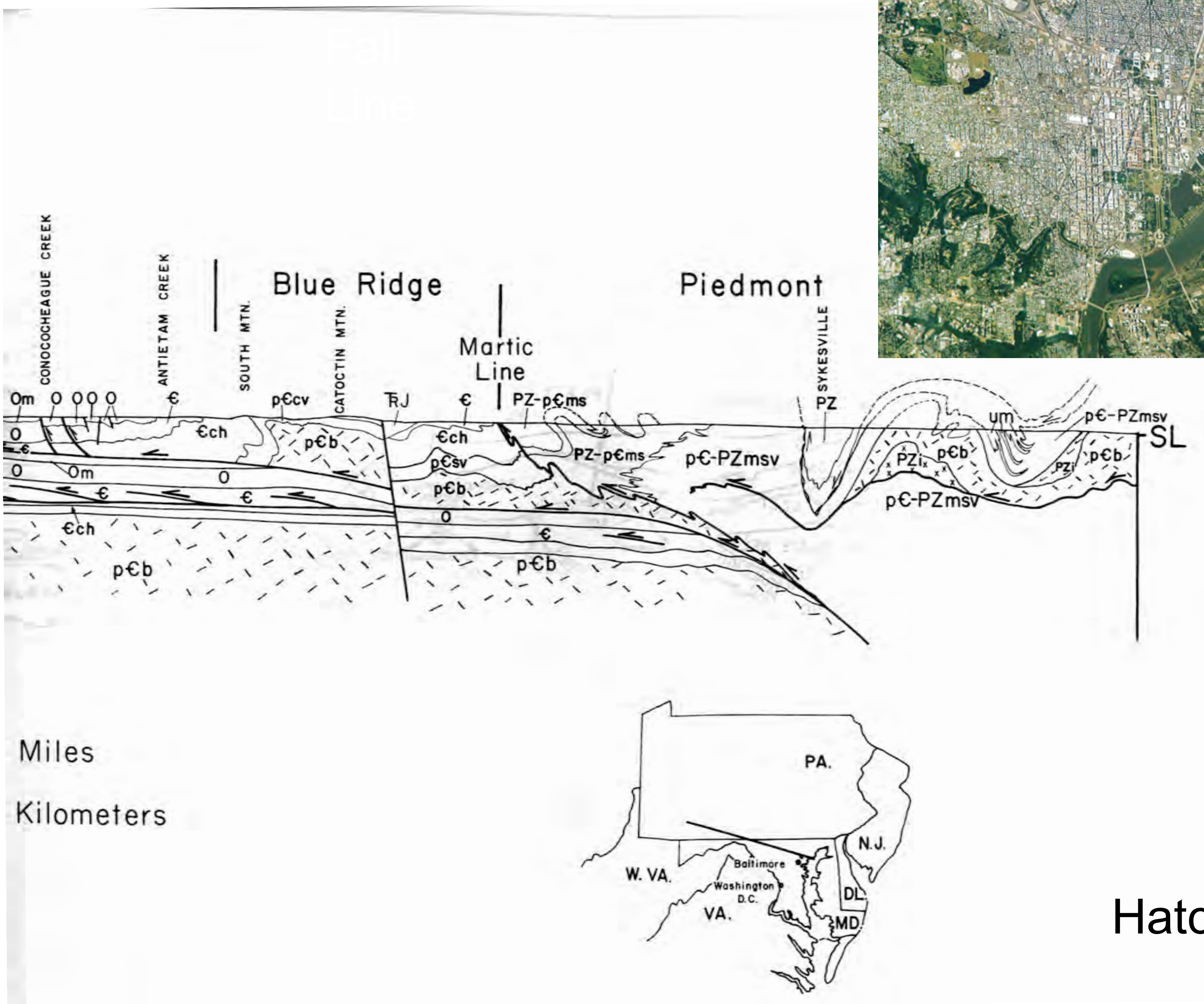


FIG. 5

Hatcher 1981



Hatcher 1981

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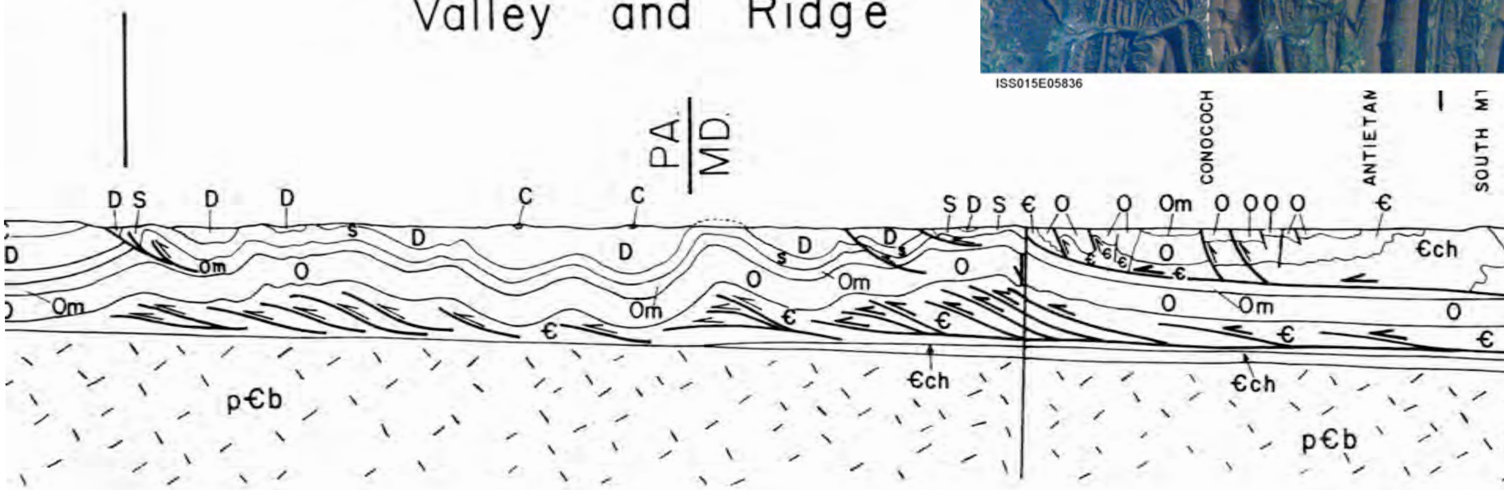
Valley and Ridge

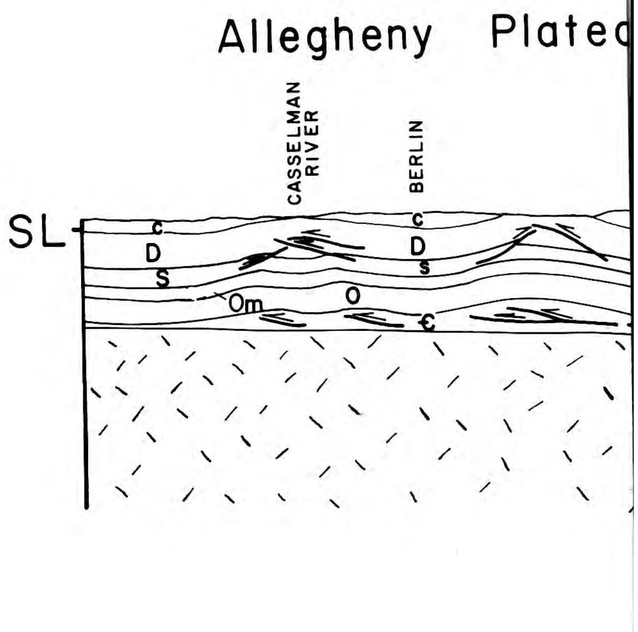


Horizontal and Vertical Scales

10 0 10 20 30 Miles

10 0 10 20 30 40 50 Kilometers

FIG. 5



Allegheny Plateau
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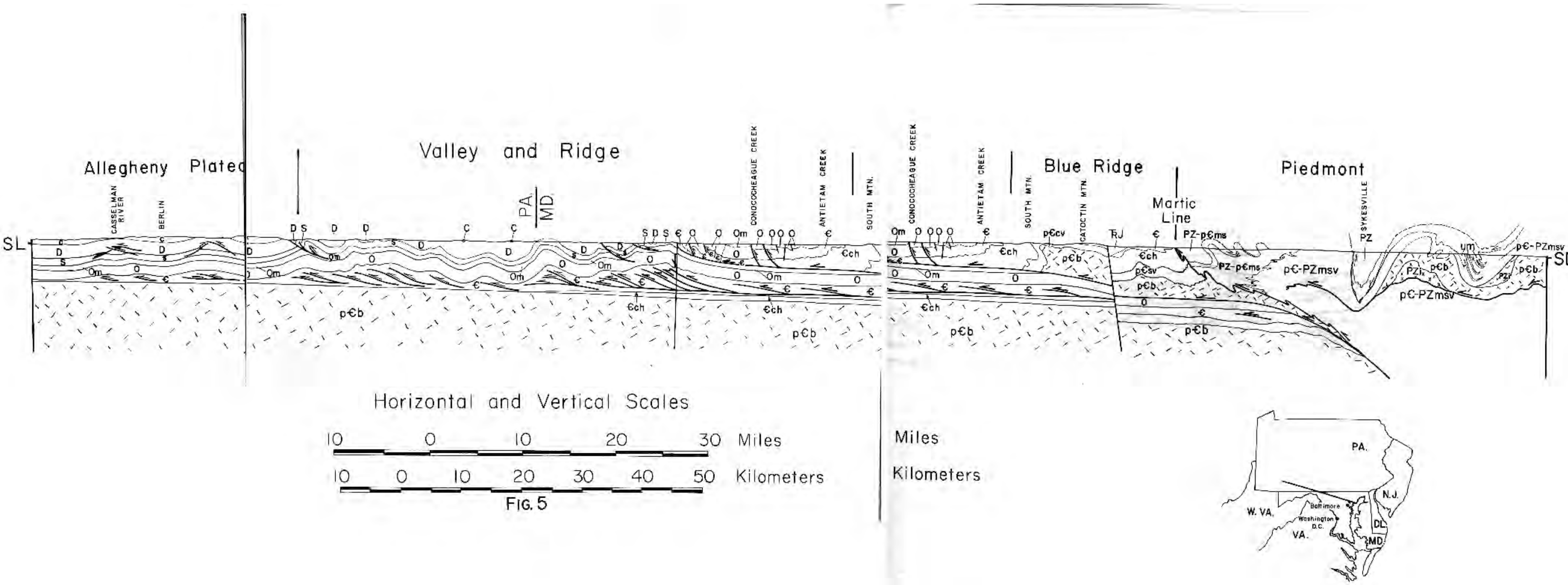
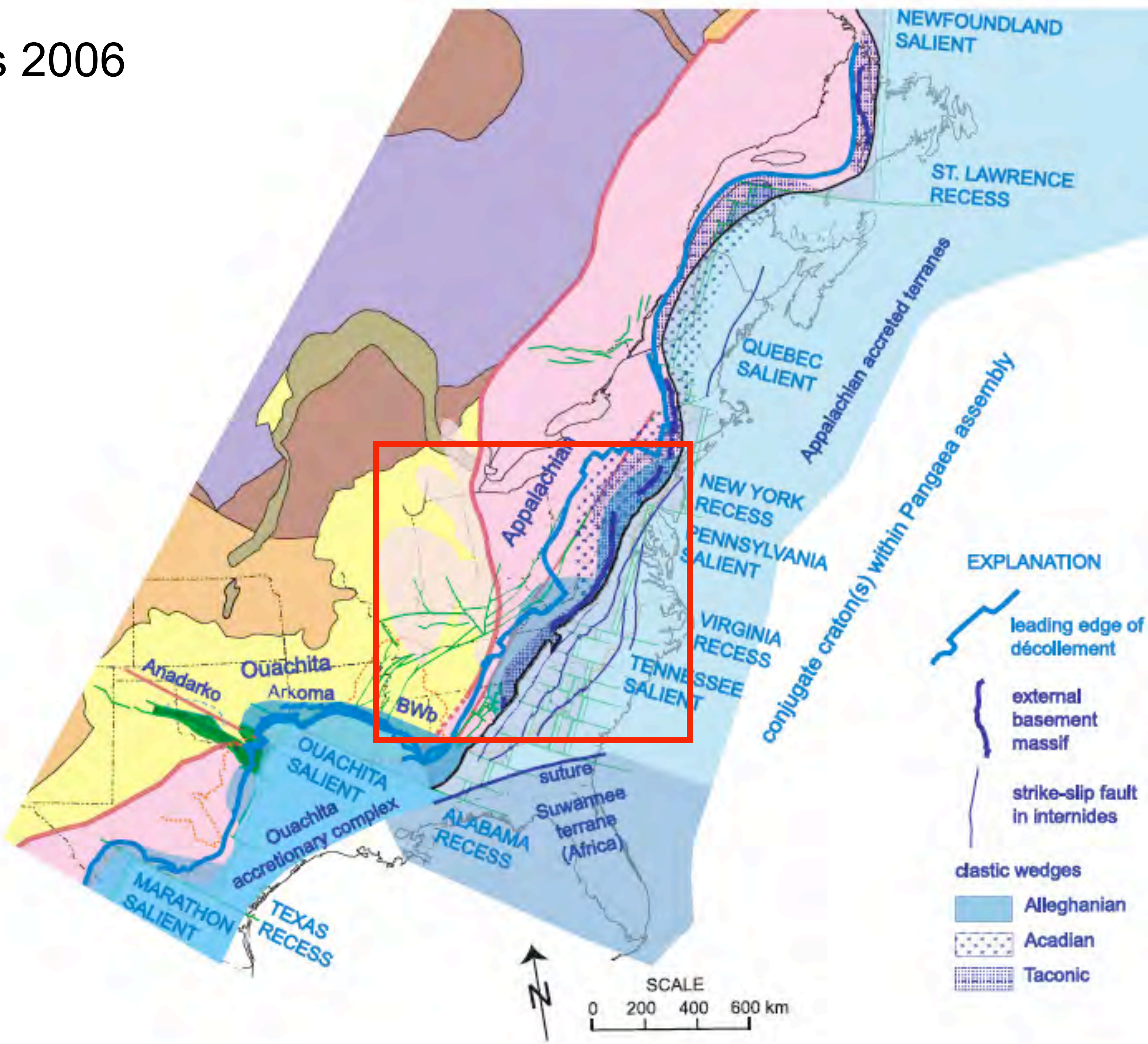


FIG. 5

Hatcher 1891

Thomas 2006



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Engelder & Whitaker 2006

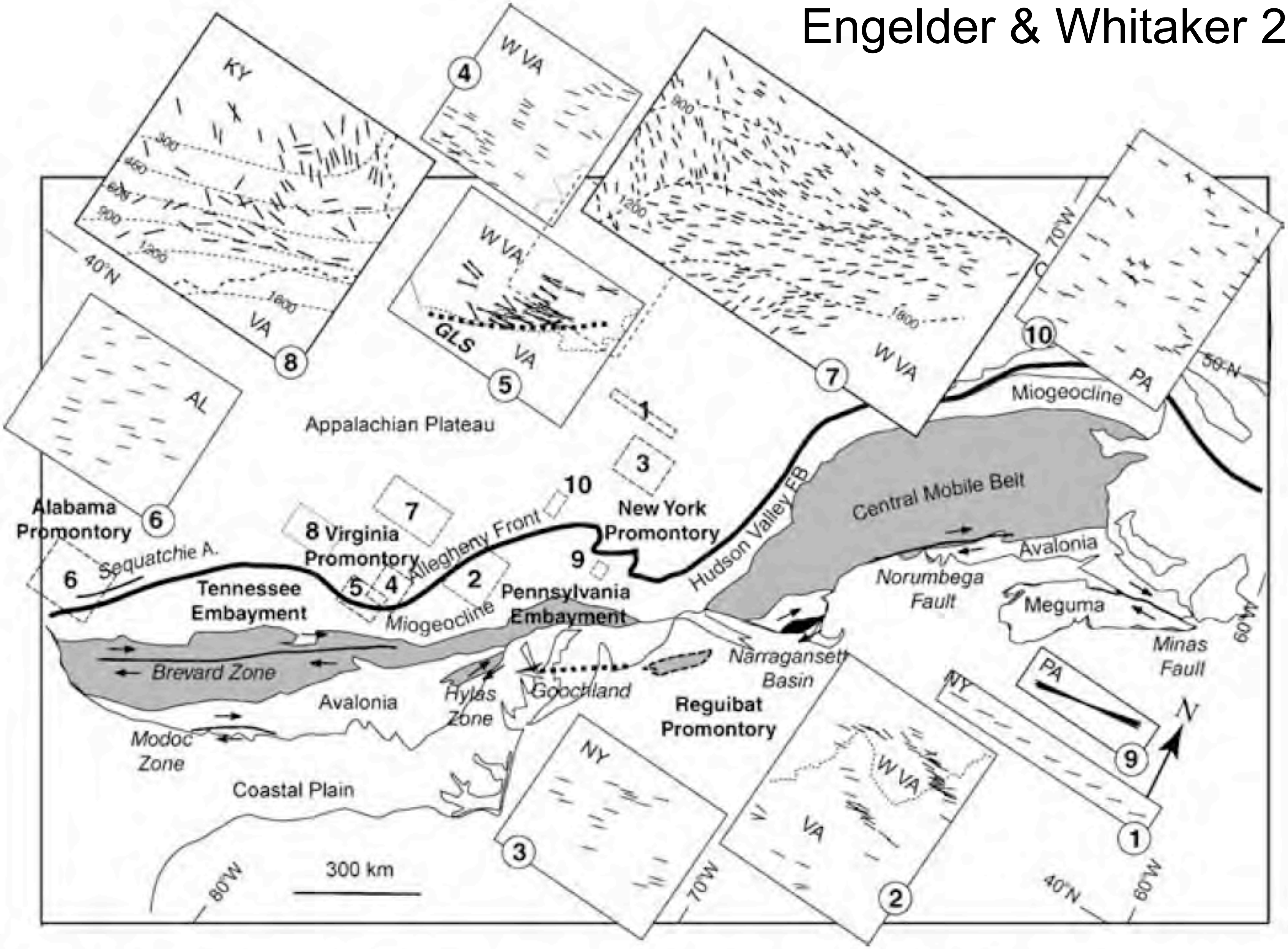


Figure 1. Distribution of ENE joint sets along Appalachian Mountains. References to insets and their map locations (dashed rectangles) are in text. Pennsylvanian isopachs (m) are dashed within insets 7 and 8 (after Colton, 1970).


Photo credit: Alberta Geological Survey

Engelder & Whitaker 2006

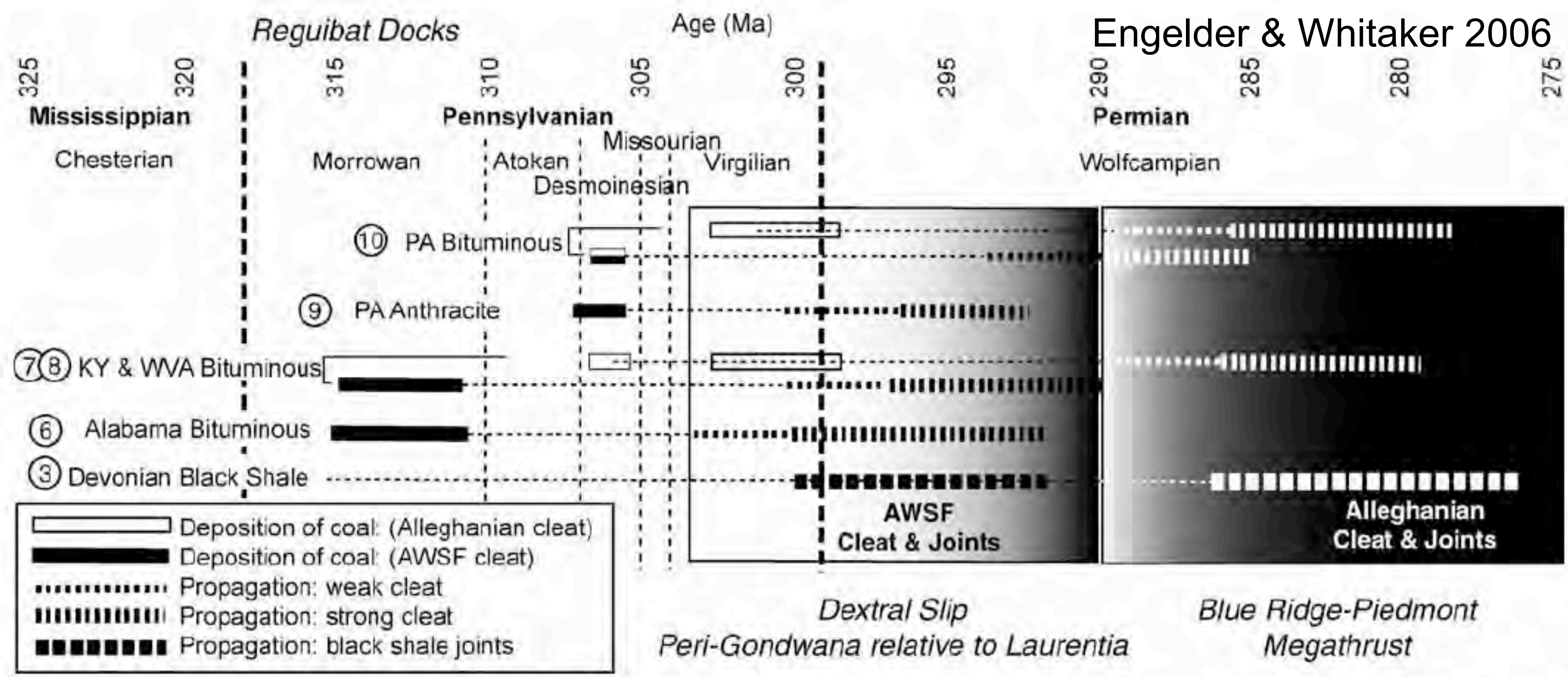


Figure 2. Time line for coal deposition and propagation of Appalachian cleat and joints. Ages are consistent with International Commission on Stratigraphy (www.stratigraphy.org; stage names are North American). AWSF—Appalachian-wide stress field.

Engelder & Whitaker 2006

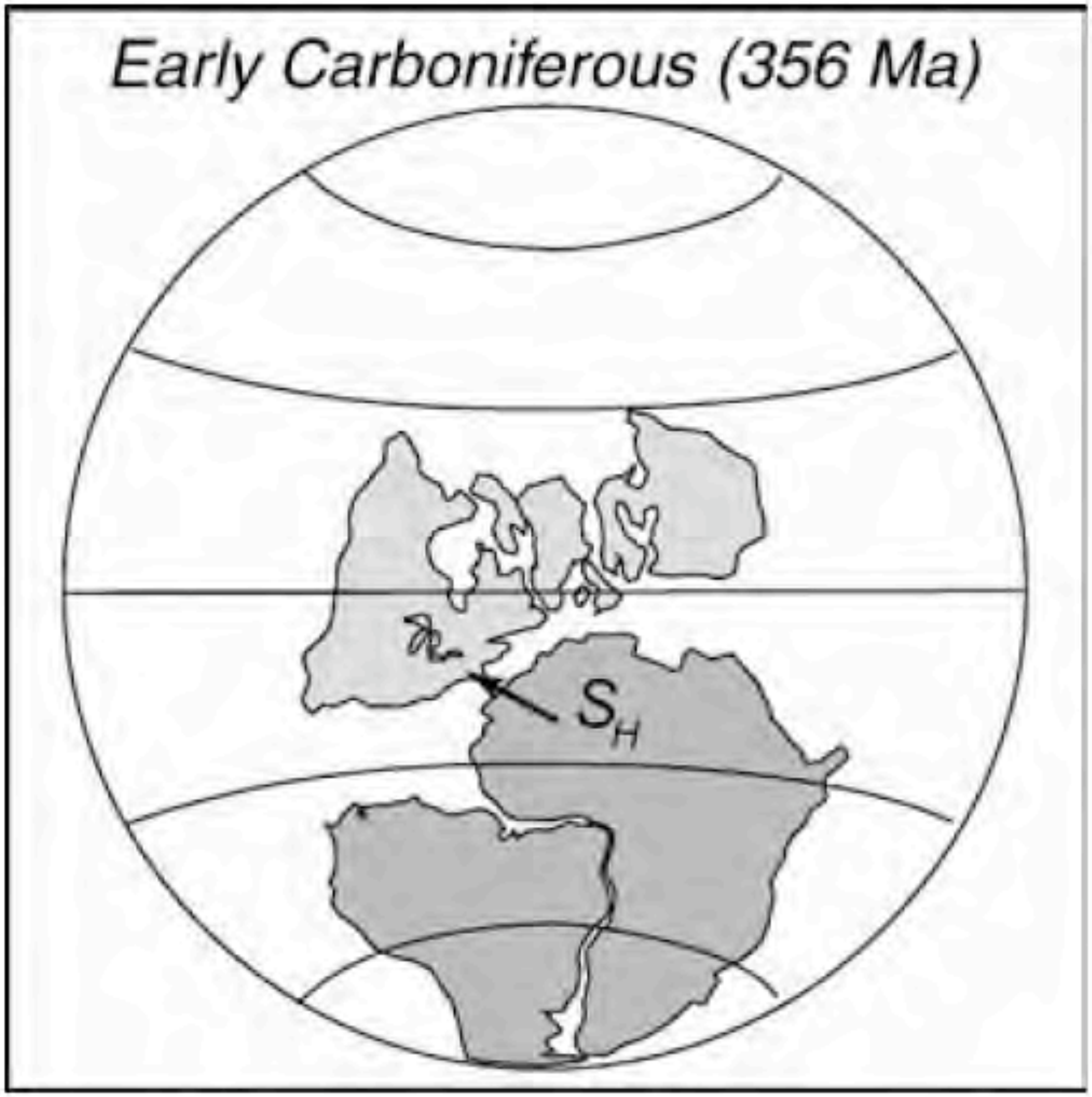


Figure 3. Configuration of continents in early Carboniferous time, when Pangea began to form (Scotese, 2002). S_H—maximum horizontal stress.

Mt Katadhim, Maine: Acadian Granite

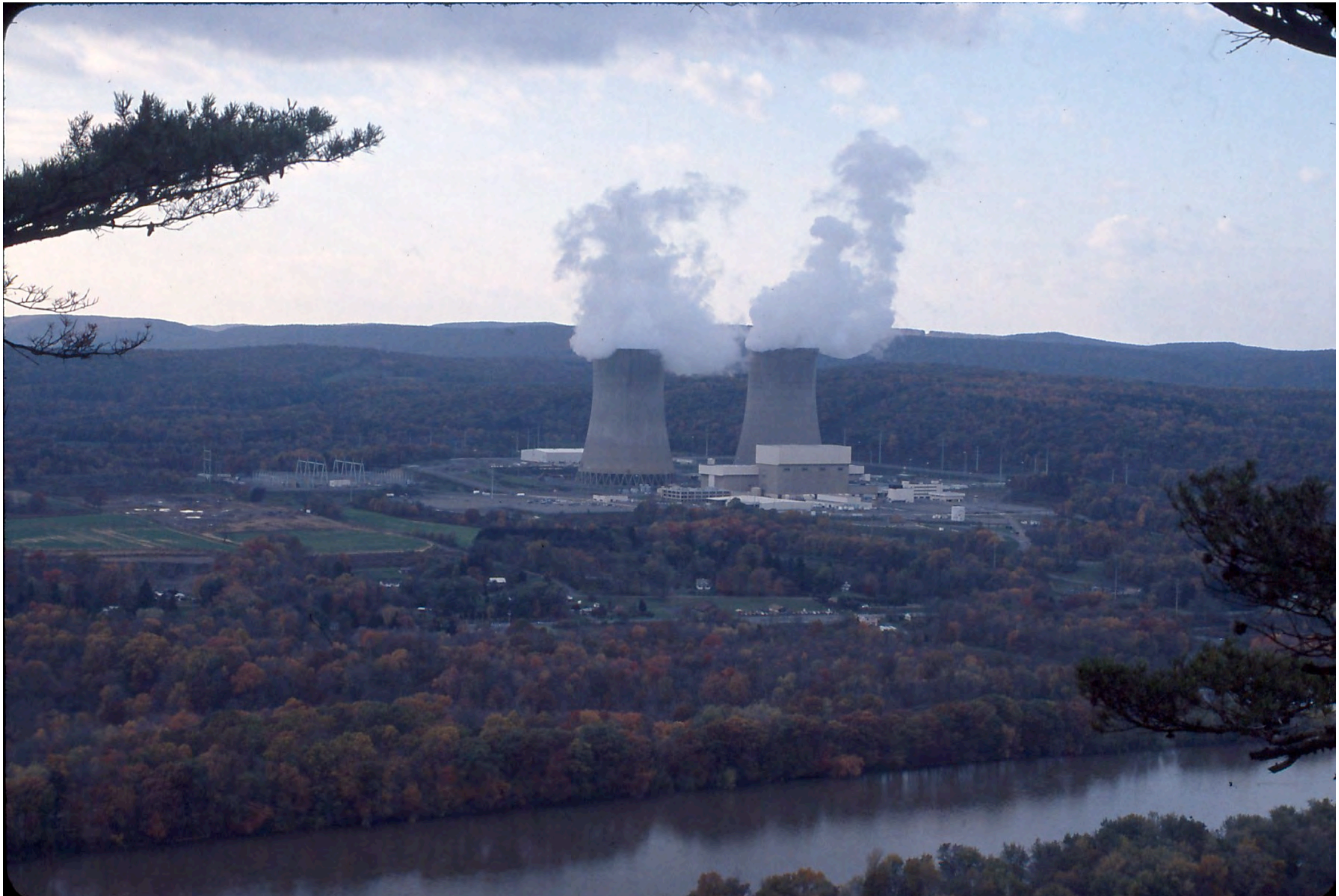
Summit Mt Katadhim, Maine: Acadian Granite

Mt Desert Island & Penobscot Bay, Maine: Acadian Granite

Mt Desert Island & Penobscot Bay, Maine: Acadian Granite

Susquahana River: Valley and Ridge Province, Pennsylvania

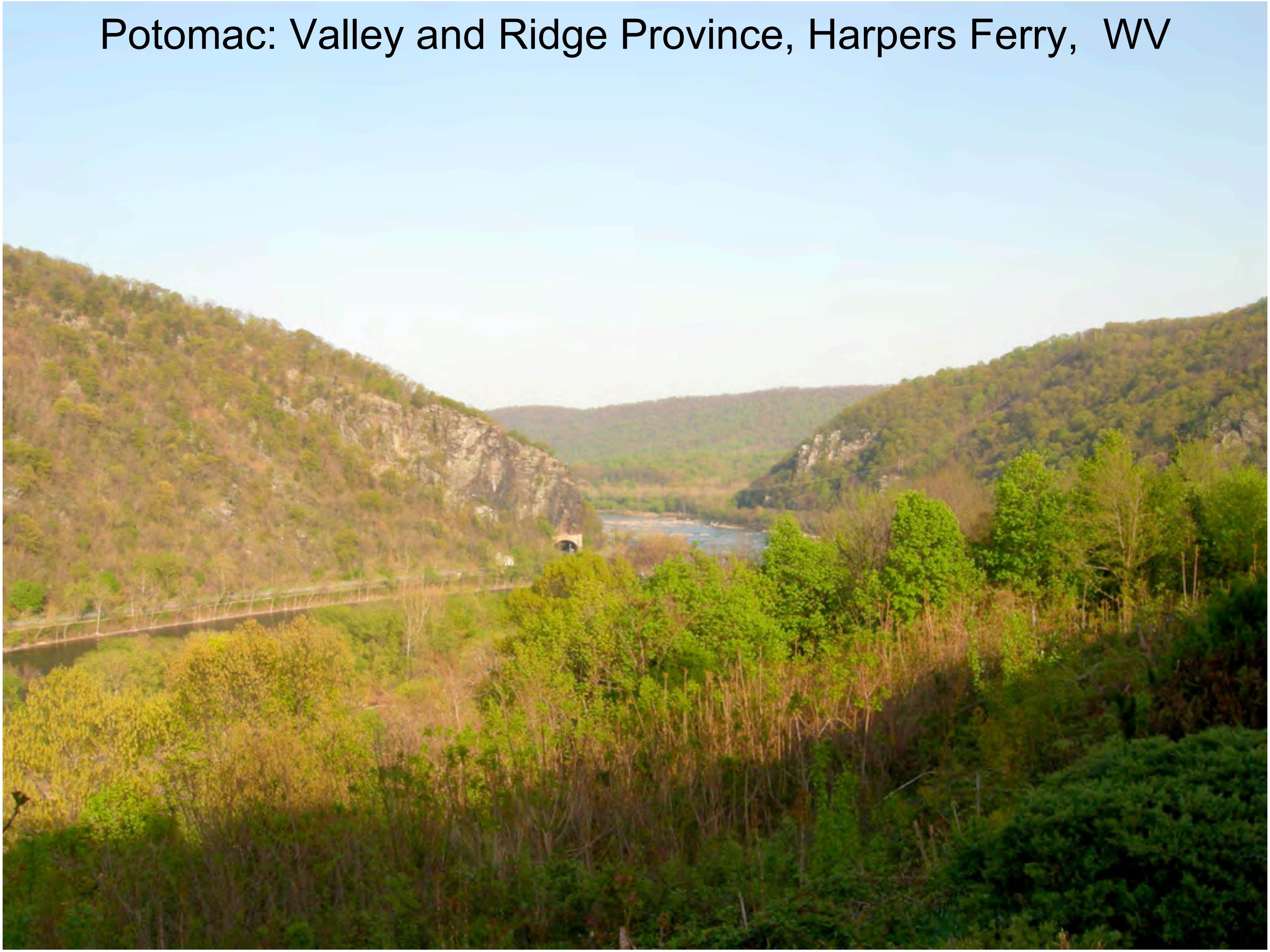
Susquahana River: Valley and Ridge Province, Pennsylvania



Susquahana River: Valley and Ridge Province, Harrisburg, PA

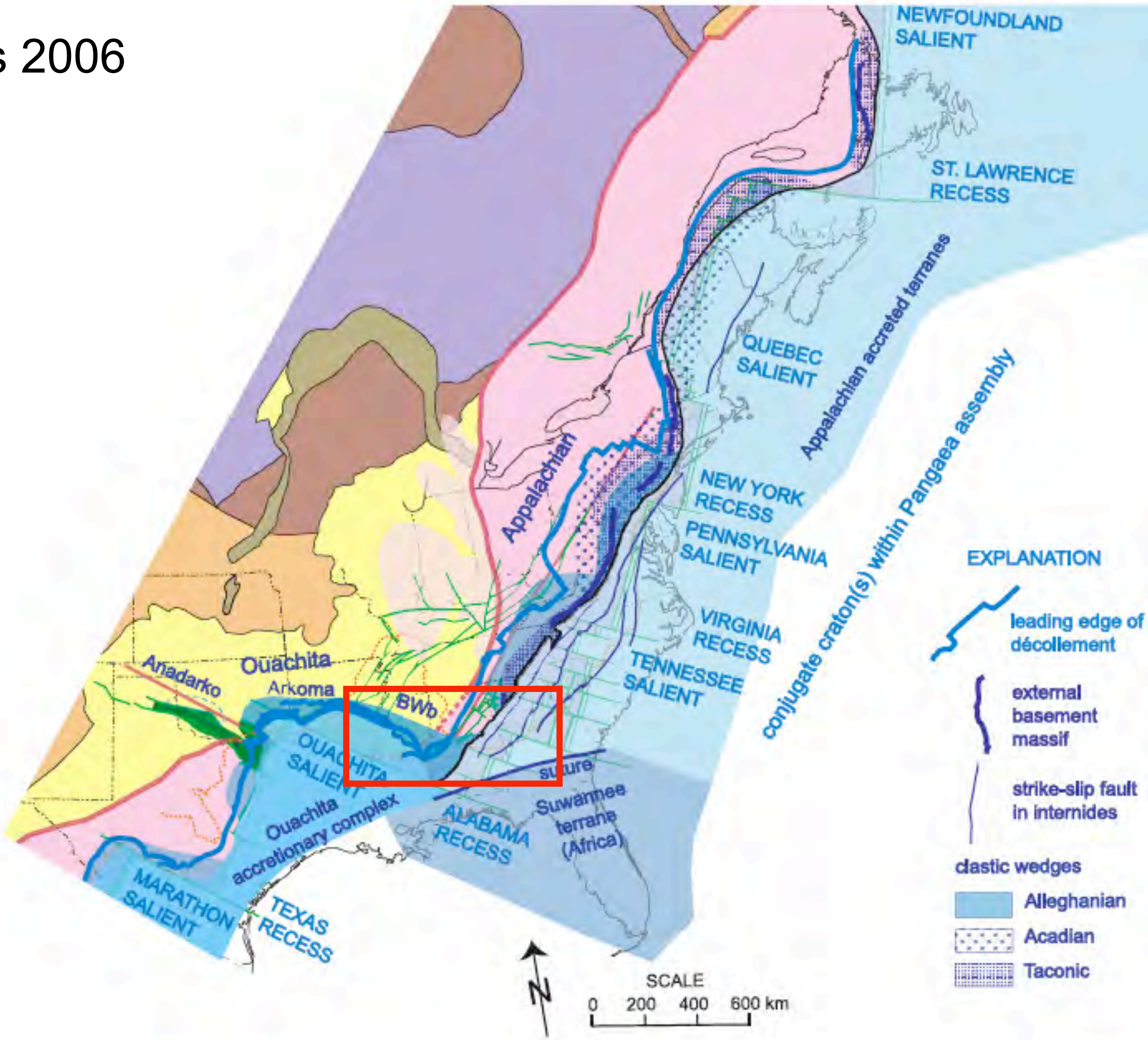
Potomac River: Valley and Ridge Province, Point of Rocks, MD

Potomac: Valley and Ridge Province, Harpers Ferry, WV




Coal Tipple, Appalachian Plateau, PA

Thomas 2006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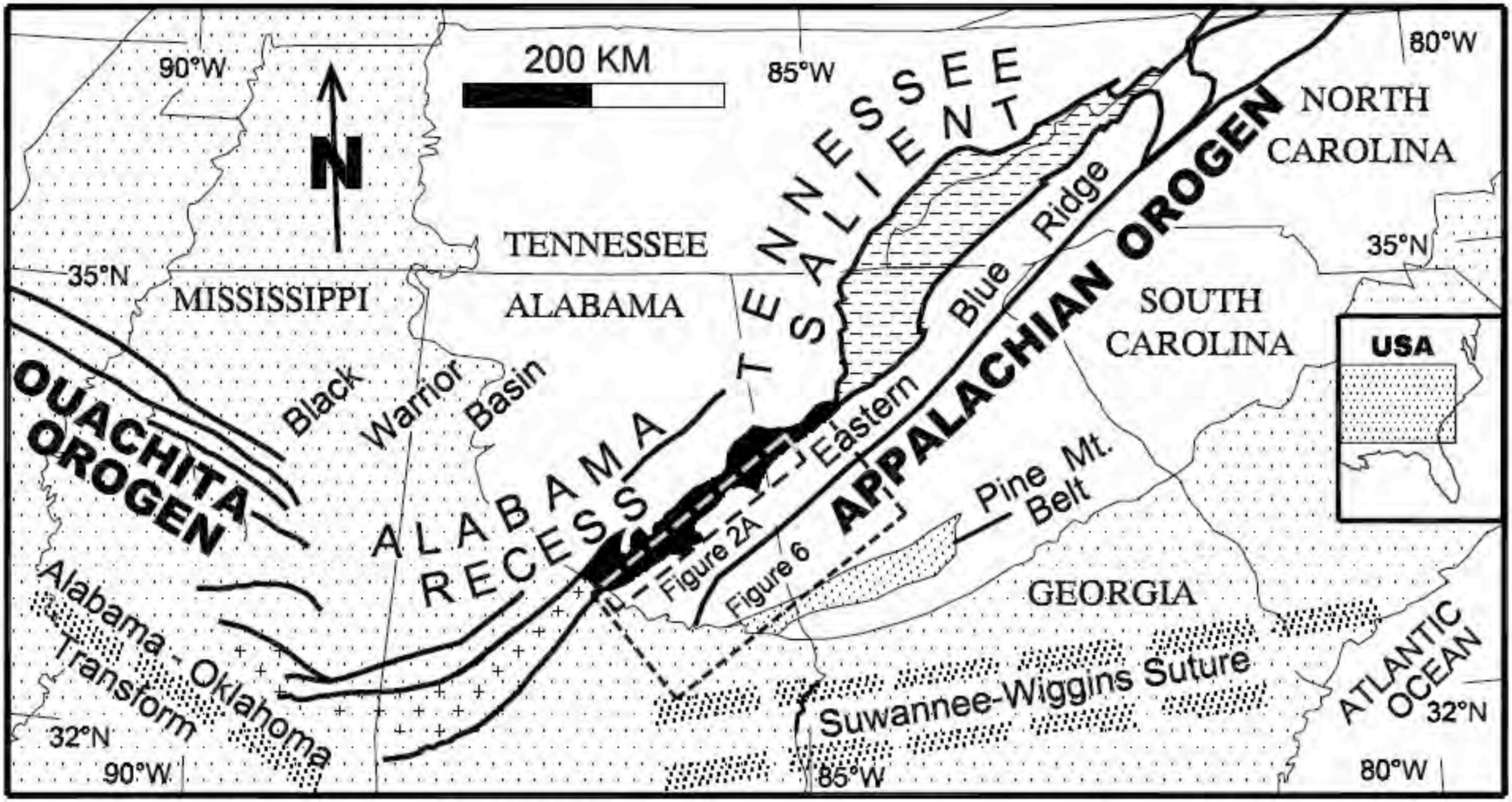
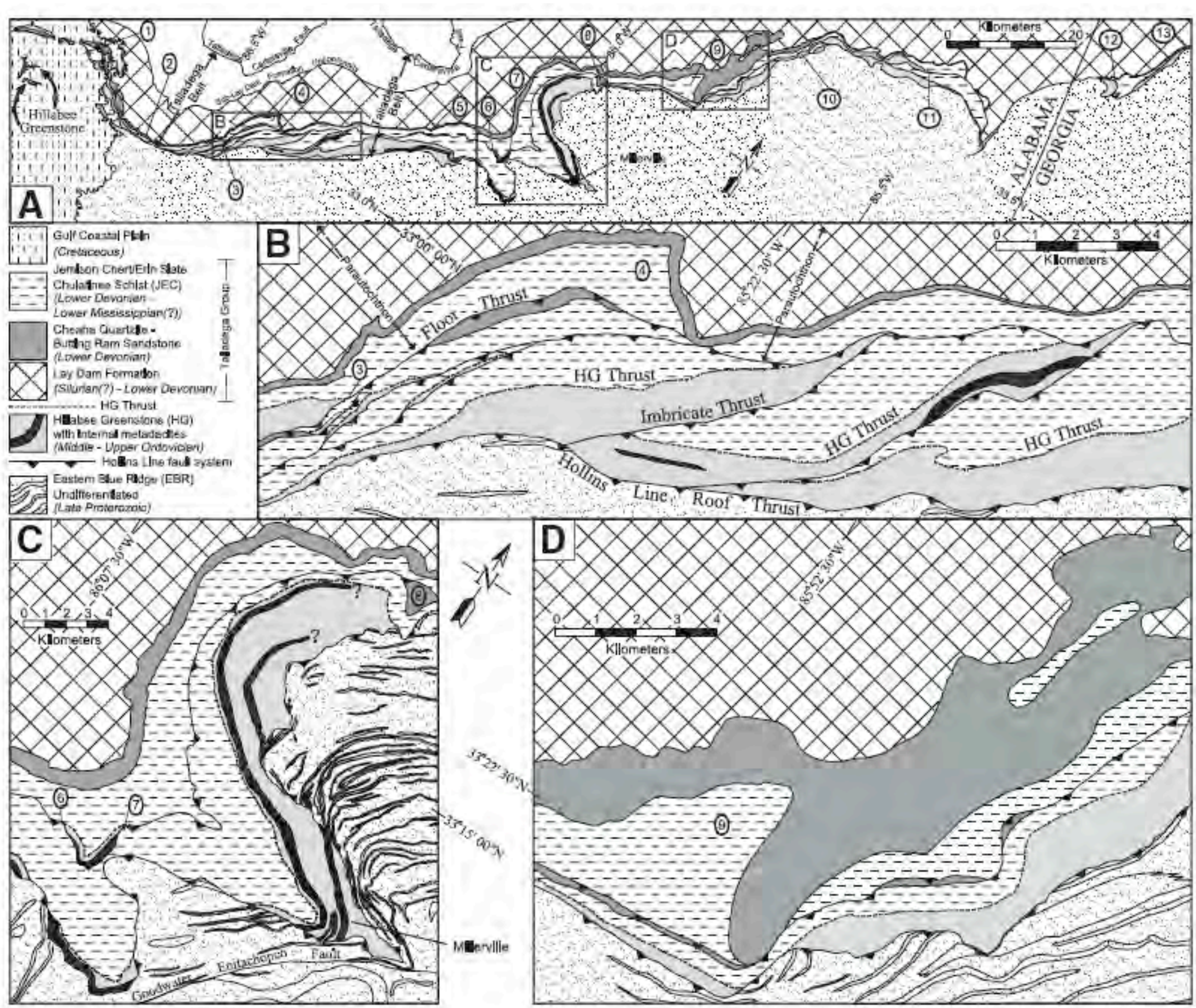
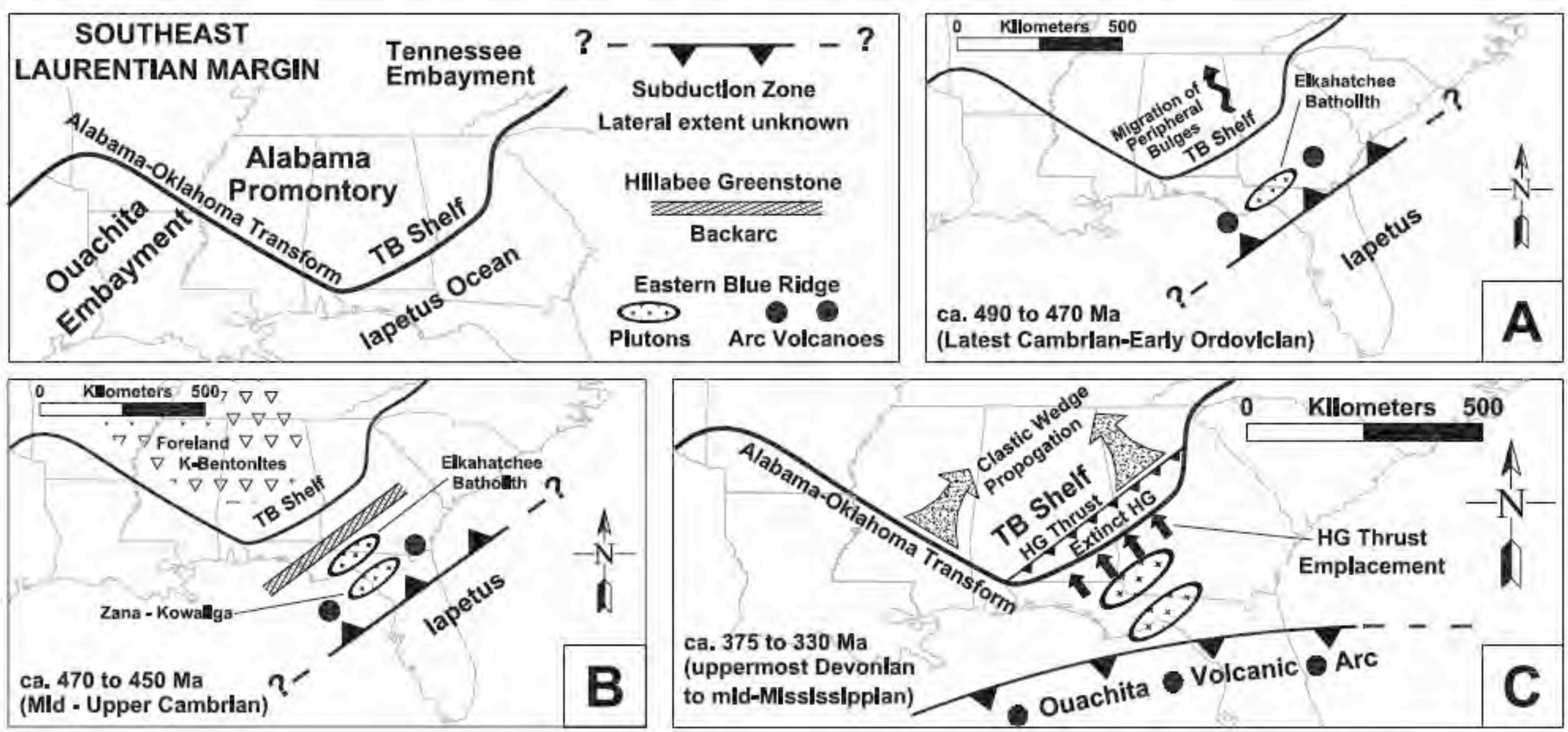


Figure 1. Generalized geologic map of the southern Appalachian and eastern Ouachita orogens. Solid and plus sign patterns are areas of Talladega belt outcrop and subcrop, respectively. Light stipple pattern—Mesozoic and Cenozoic rocks of the Gulf and Atlantic Coastal Plains. Heavy stipple pattern—locations of Alabama-Oklahoma transform fault and Suwannee-Wiggins late Paleozoic suture. Dashed pattern—distribution of late Proterozoic Ocoee Supergroup. Thick solid lines—faults. Location of Figures 2A and 6 are shown. (Modified from plate 9 of Thomas et al., 1989.)

Tull et al 2007

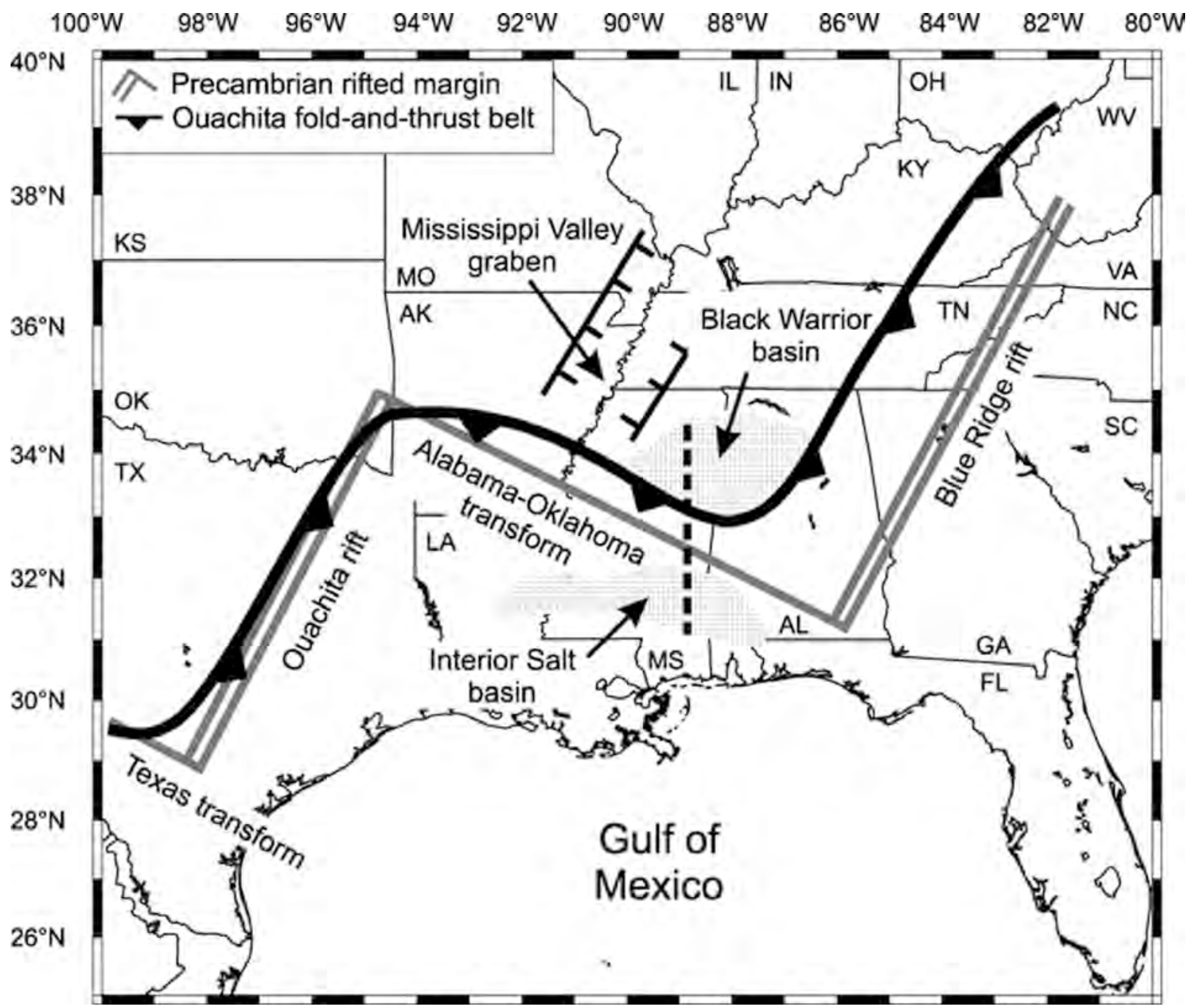


Tull
Et al
2007



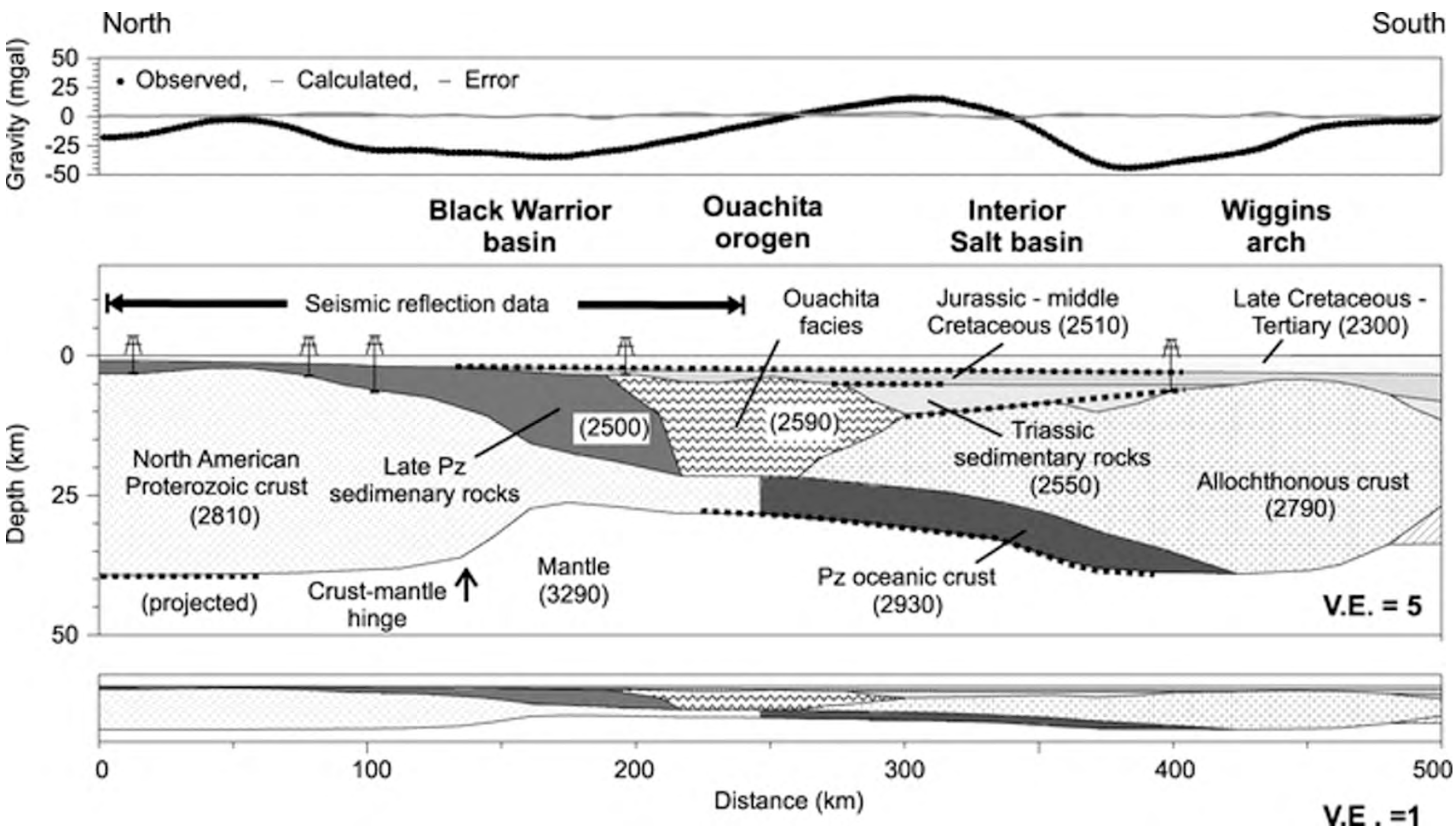
Tull et al 2007

Figure 1. Simplified tectonic map of southeastern North America (after Thomas, 1991).



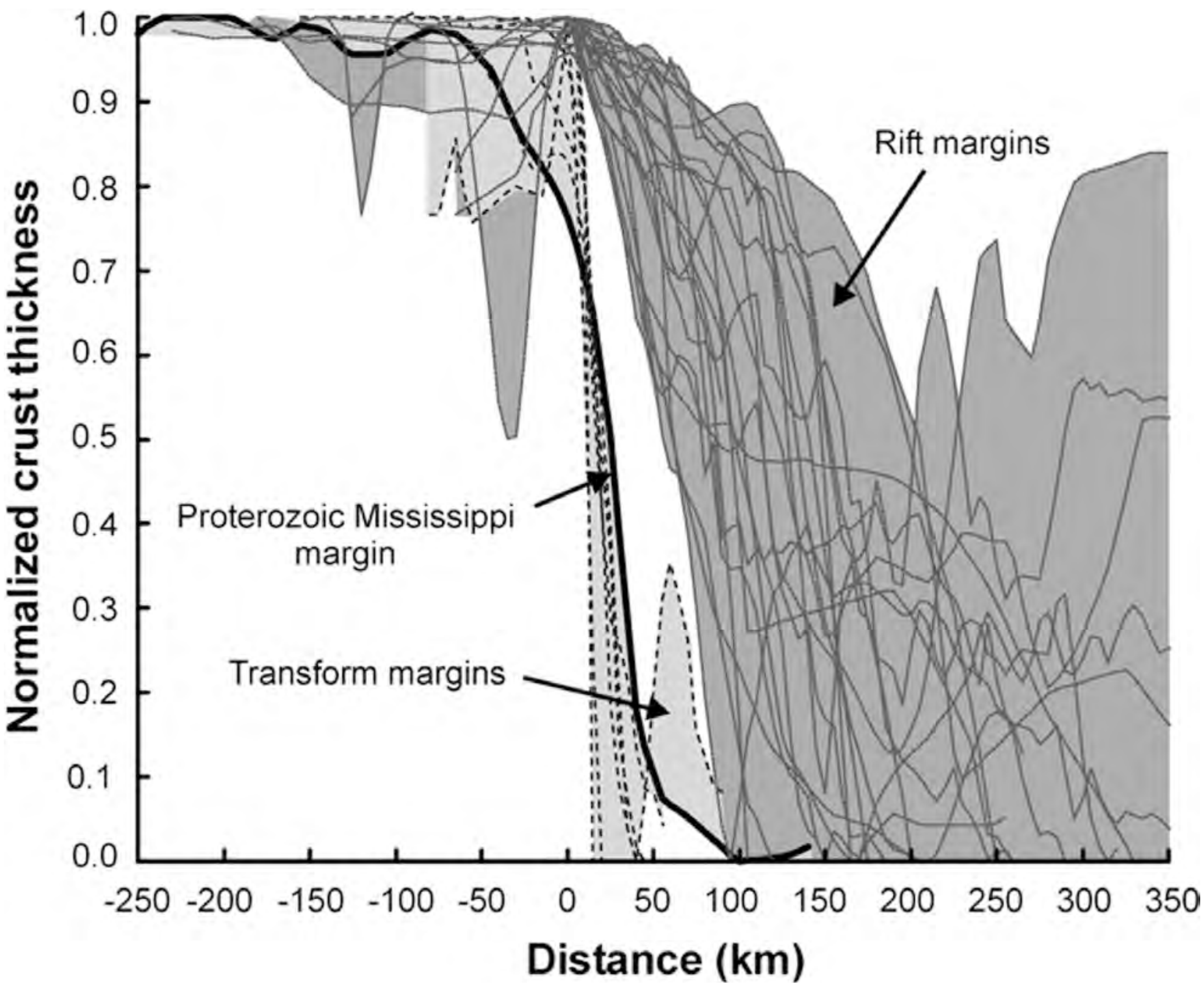
Harry D et al. Geology 2003;31:969-972

Figure 2. Cross section across Paleozoic (Pz) margin and Ouachita suture in central Mississippi (after Harry and Londono, 2004).



Harry D et al. Geology 2003;31:969-972

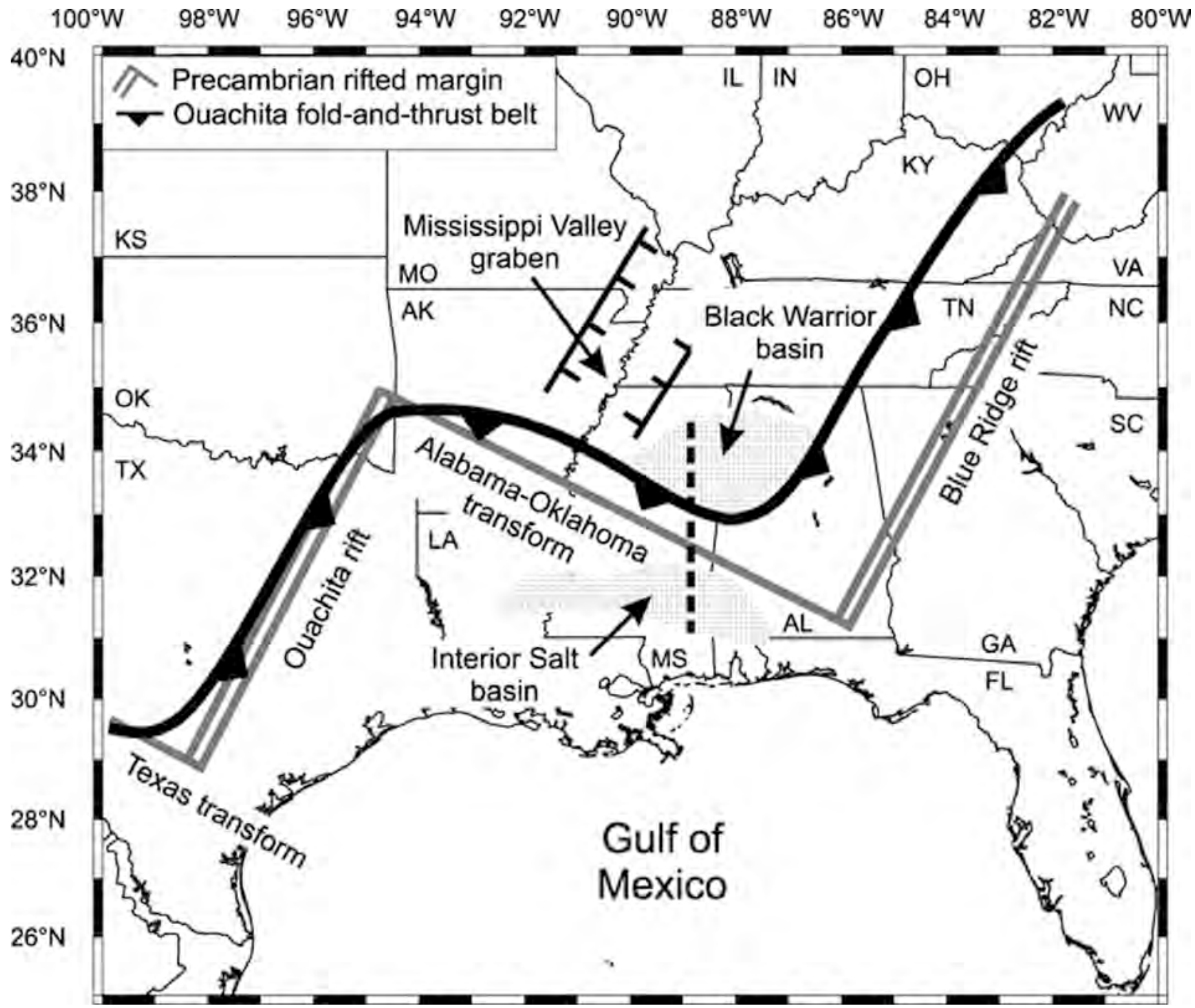
Figure 3. Crustal thickness variations across continental margins.



Harry D et al. Geology 2003;31:969-972

THE GEOLOGICAL SOCIETY OF AMERICA

Figure 1. Simplified tectonic map of southeastern North America (after Thomas, 1991).



Harry D et al. Geology 2003;31:969-972

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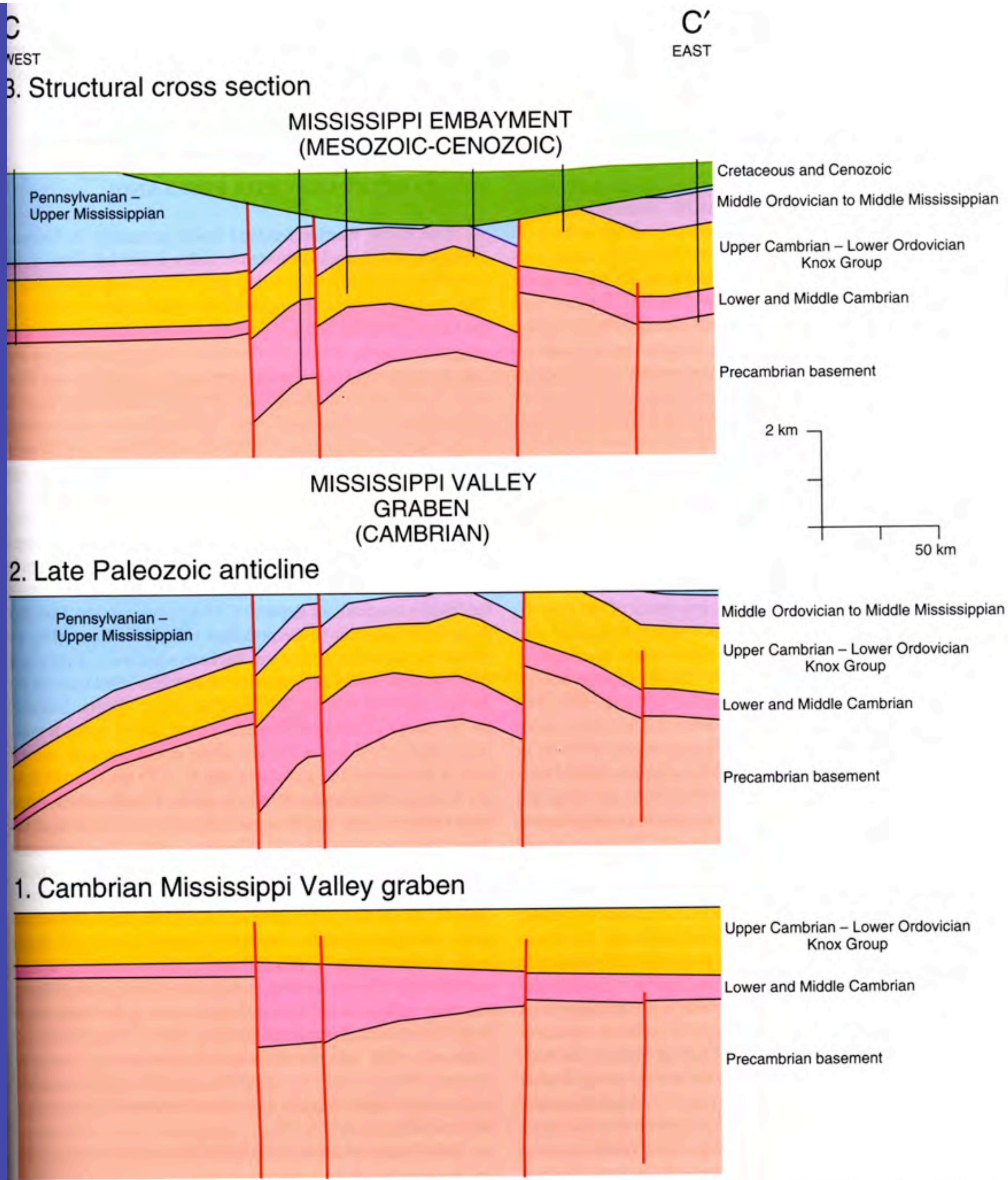


Figure 8. Structural cross section (panel 3) of southern part of Mississippi Valley graben, and palinspastic reconstructions for end of Early Ordovician (panel 1) to show Iapetan synrift faults and for pre-Mesozoic (panel 2) to show late Paleozoic fault reactivation and basement arching. Location of cross section is shown in Figure 3. Vertical black lines in panel 3 show locations of wells used in the structural cross section (well data and identifications in Thomas, 1991).

Thomas 2010

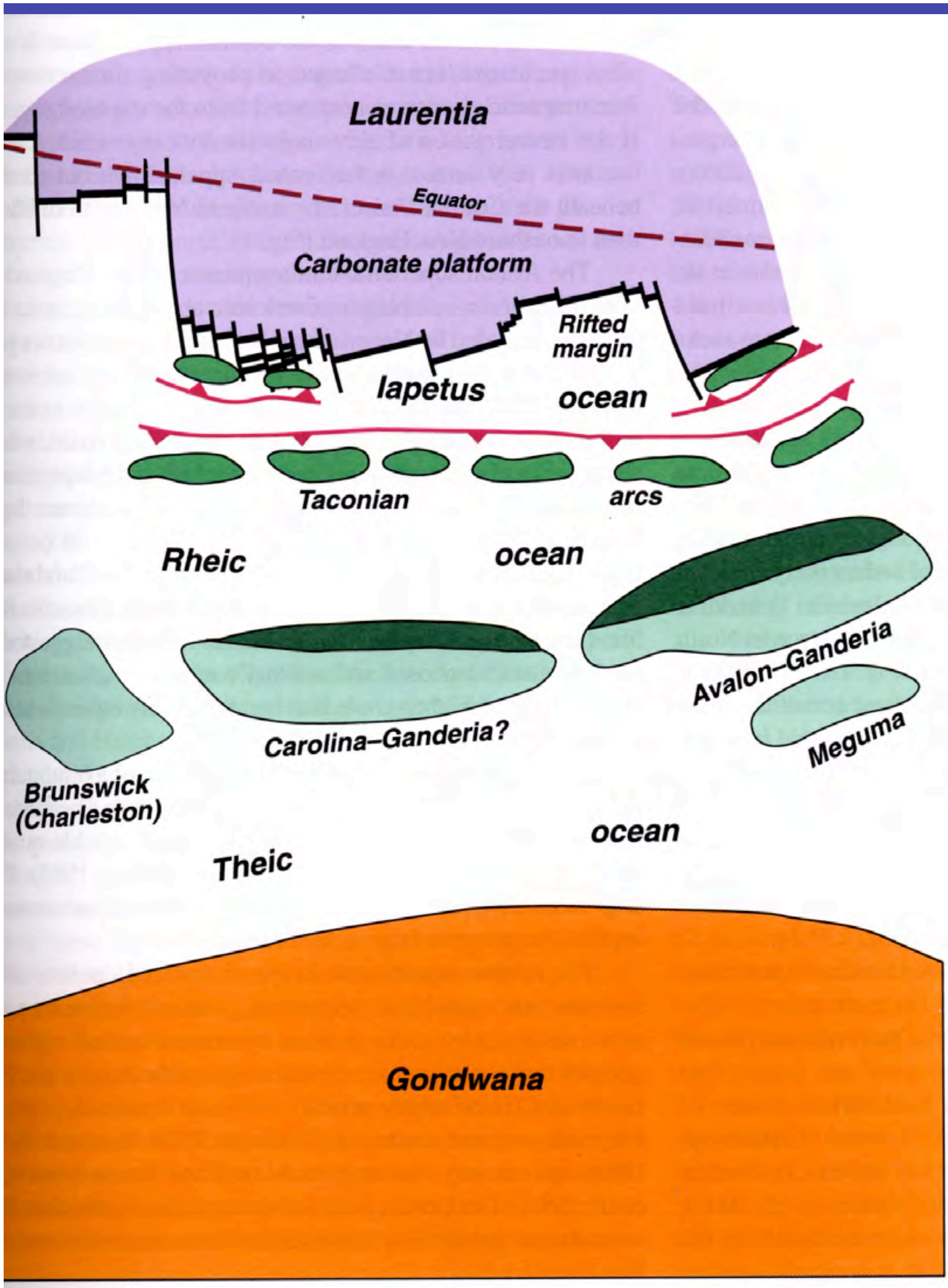


Figure 4. Possible configuration of Laurentia, Gondwana, peri-Gondwanan terranes ("ribbon" microcontinents), Theic and Rheic oceans, and the soon-to-close Iapetus ocean during the early Middle Ordovician (late Arenig). A west-dipping subduction zone may have existed along the entire Laurentian margin that was subducted by the east-dipping subduction during the main-phase Taconic orogeny.

Hatcher 2010

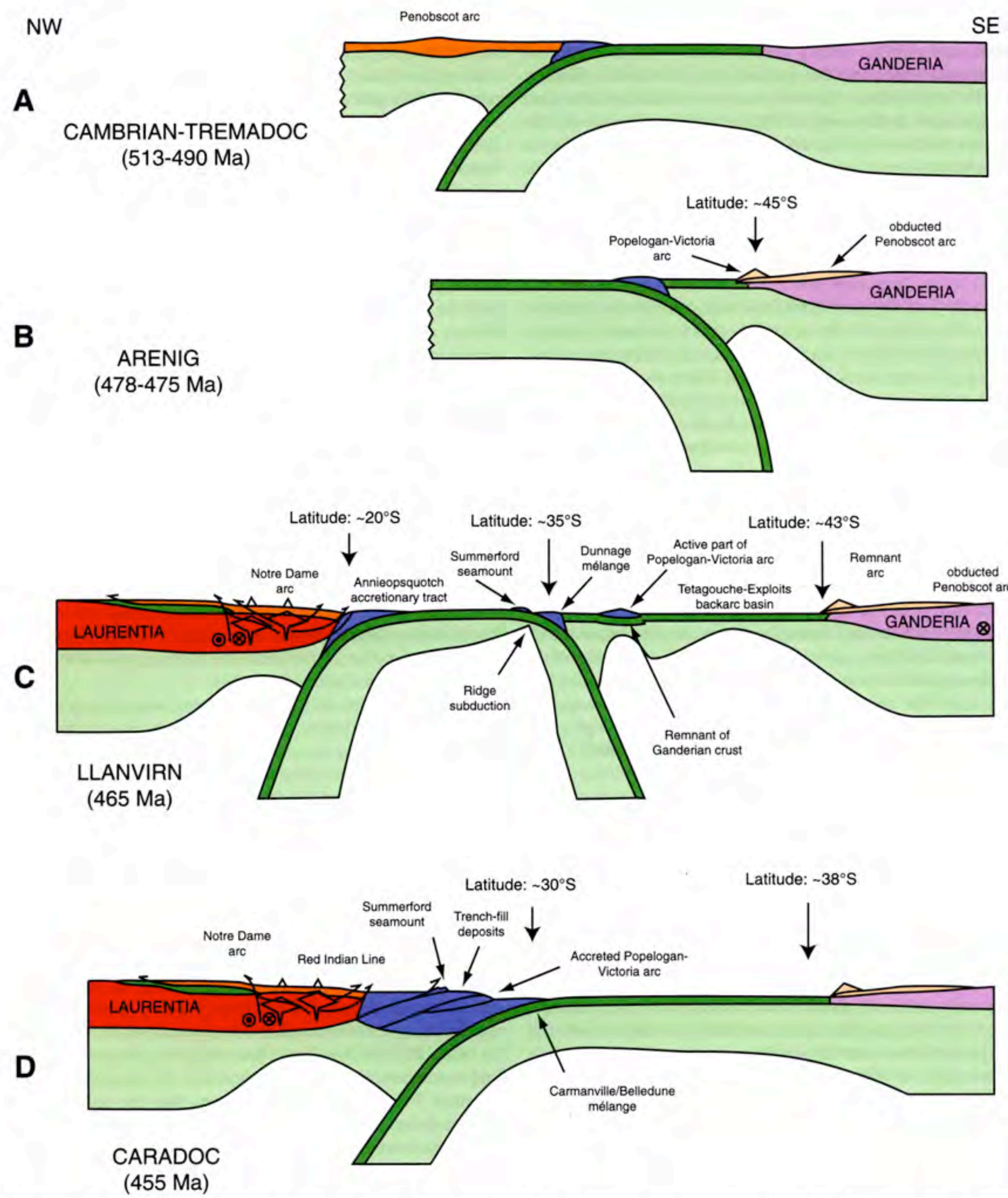
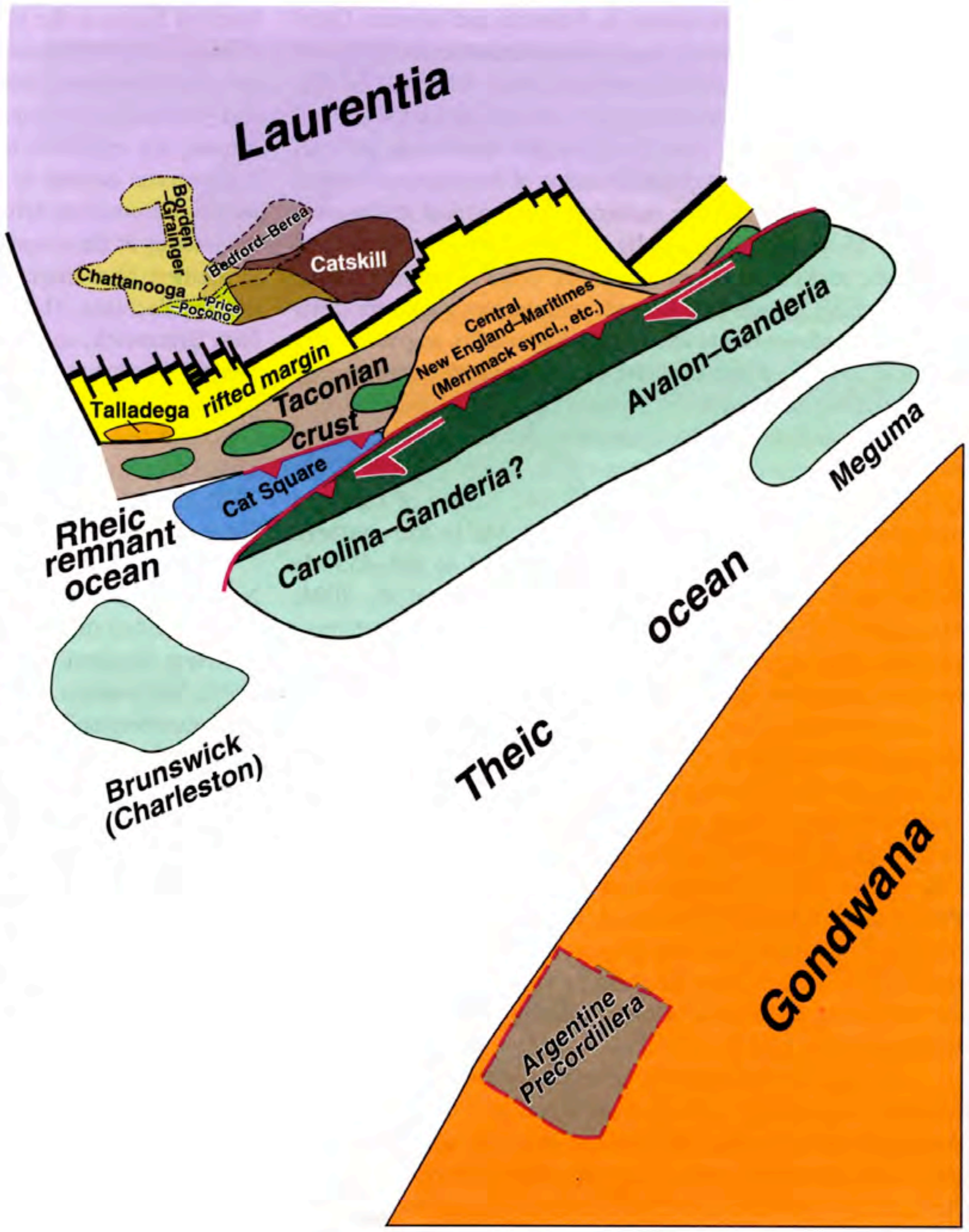


Figure 5. Example of the complexity of Late Cambrian to Late Ordovician arc geometries and convergence in the Newfoundland Appalachians where the orogen is less deformed and metamorphosed than farther south. Compare with McClellan et al. (2007, their Fig. 10). (Figure is from van Staal et al., 1998.)

Hatcher 2010

Figure 6. Possible relationships during Late Devonian to early Mississippian time (~360 Ma) among Laurentia, already formed Taconic crust, and Carolina-Gander superterranes that collided transpressionally (southwest-directed) with the Laurentian–Taconian assemblage and subducted these elements beneath them, producing high-grade metamorphism and uplift in southern New England and progressively subducting more of the Laurentian–Taconian terranes, together with sediments deposited in the remnant Rheic ocean, southwestward reaching burial depths of 18–20 km in a relatively short time (1–4 m.y., depending on dip of the subduction zone). The result was a tectonically forced, southwestward escaping, orogenic channel of partially melted Cat Square sediments and Laurentian Taconian crust (Hatcher and Merschat, 2006). Configuration of diachronously prograding deltas on the platform (from Ettensohn, 2004) correlates directly with the northeast-to-southwest transpressionally zippered closing of the remnant Rheic ocean. (Figure is modified from Merschat and Hatcher [2007].)



Hatcher 2010

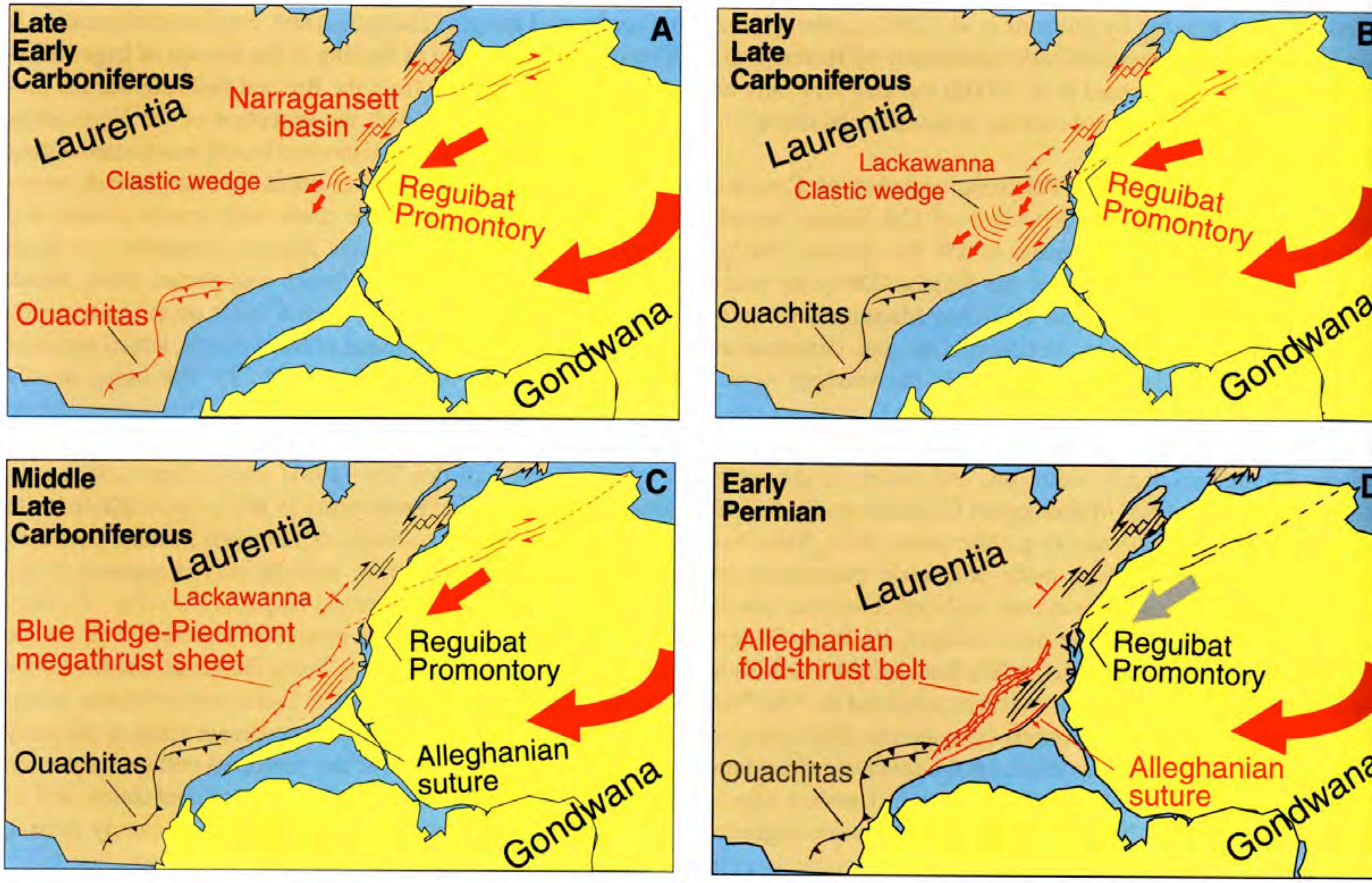
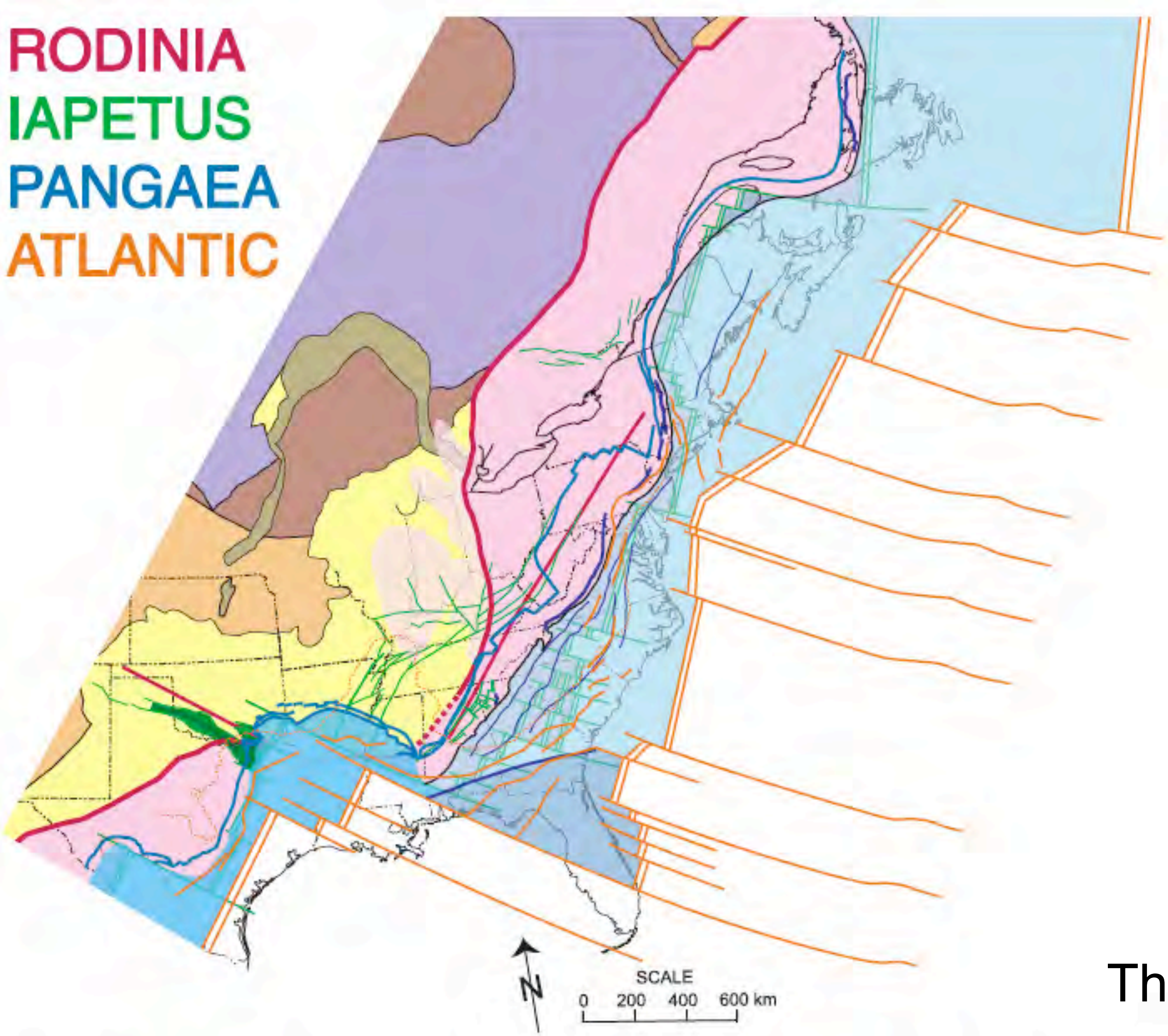


Figure 7. Zipper closing of Theic ocean to form the Alleghanian orogen (continents are shown on Robinson projection; reconstruction modifie from that in Ziegler, 1990). Red lines and symbols indicate feature is active in the time interval shown. (A) Initial contact between Gondwana an Laurentia occurred in late Early Carboniferous (late Mississippian), producing initially sinistral faulting in New England followed immediatel by dextral motion and pull-apart basins, then shedding of clastic sediments onto the continent, and Lackawanna-phase deformation. (B) South ward movement and rotation of Gondwana with respect to Laurentia in early Late Carboniferous (early Pennsylvanian) produced dextral motio throughout orogen, waning of Lackawanna phase deformation, and greater dispersal of sediments onto the Laurentian foreland. (C) Continue clockwise rotation of Gondwana with respect to Laurentia during the Late Carboniferous closed the Theic ocean southward, bringing Gondwan into head-on collision with Laurentia, and producing the first movement on the Blue Ridge–Piedmont megathrust sheet. (D) Early Permia head-on collision of Gondwana with Laurentia produced major transport on Blue Ridge–Piedmont megathrust sheet that drove foreland fold thrust belt deformation (Valley and Ridge and Plateau) ahead of it.

Hatcher 2010



Thomas 2006

Figure 1. Map showing the record of tectonic inheritance through two complete Wilson cycles in eastern North America (compiled from Figs. 2–5). Assembly of Rodinia, opening of the Iapetus Ocean, assembly of Pangaea, and opening of the Atlantic Ocean are color-coded on this map and in Figures 2–5.

Thomas 2006

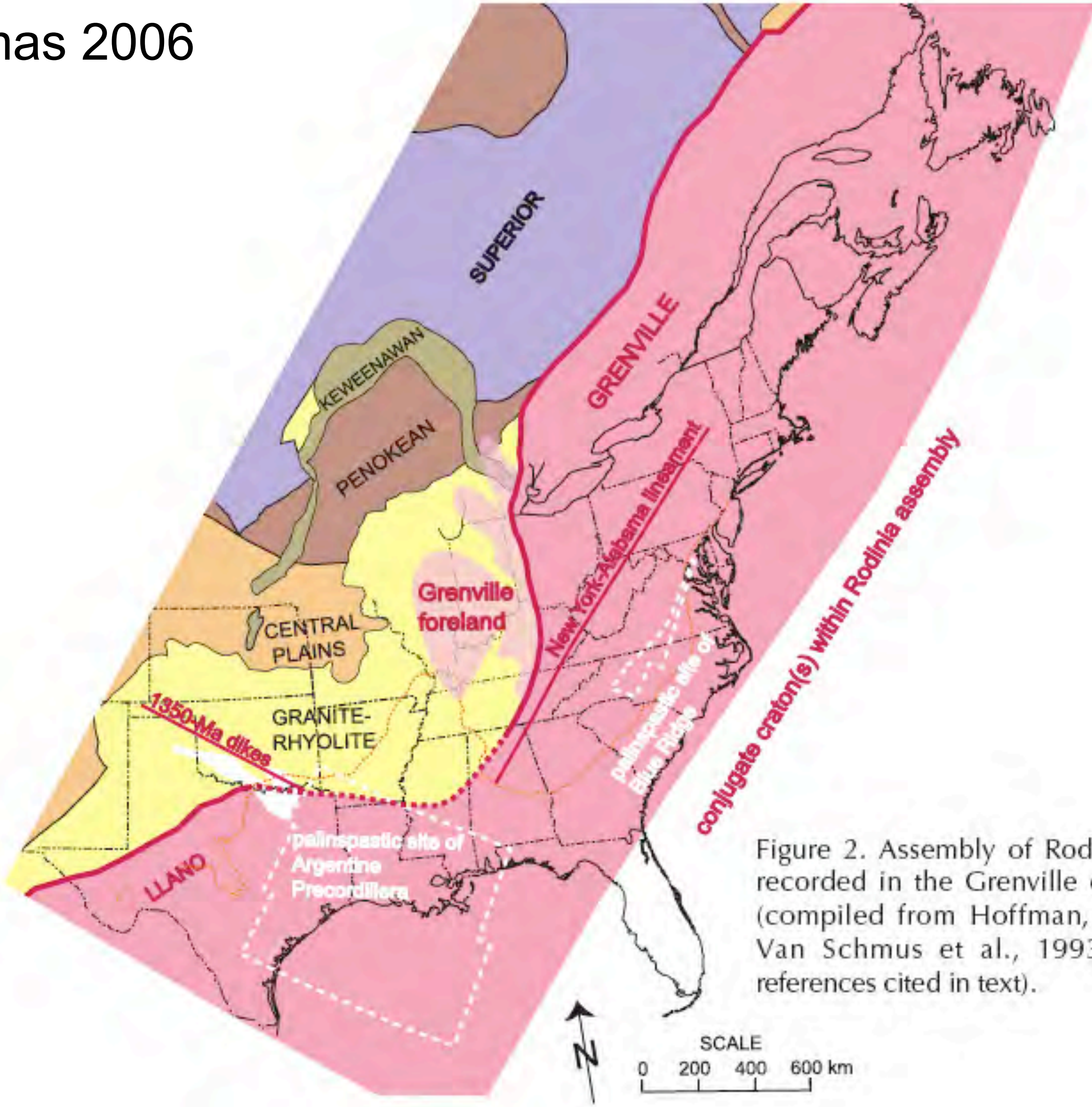


Figure 2. Assembly of Rodinia as recorded in the Grenville orogen (compiled from Hoffman, 1989; Van Schmus et al., 1993; and references cited in text).

Thomas 2006

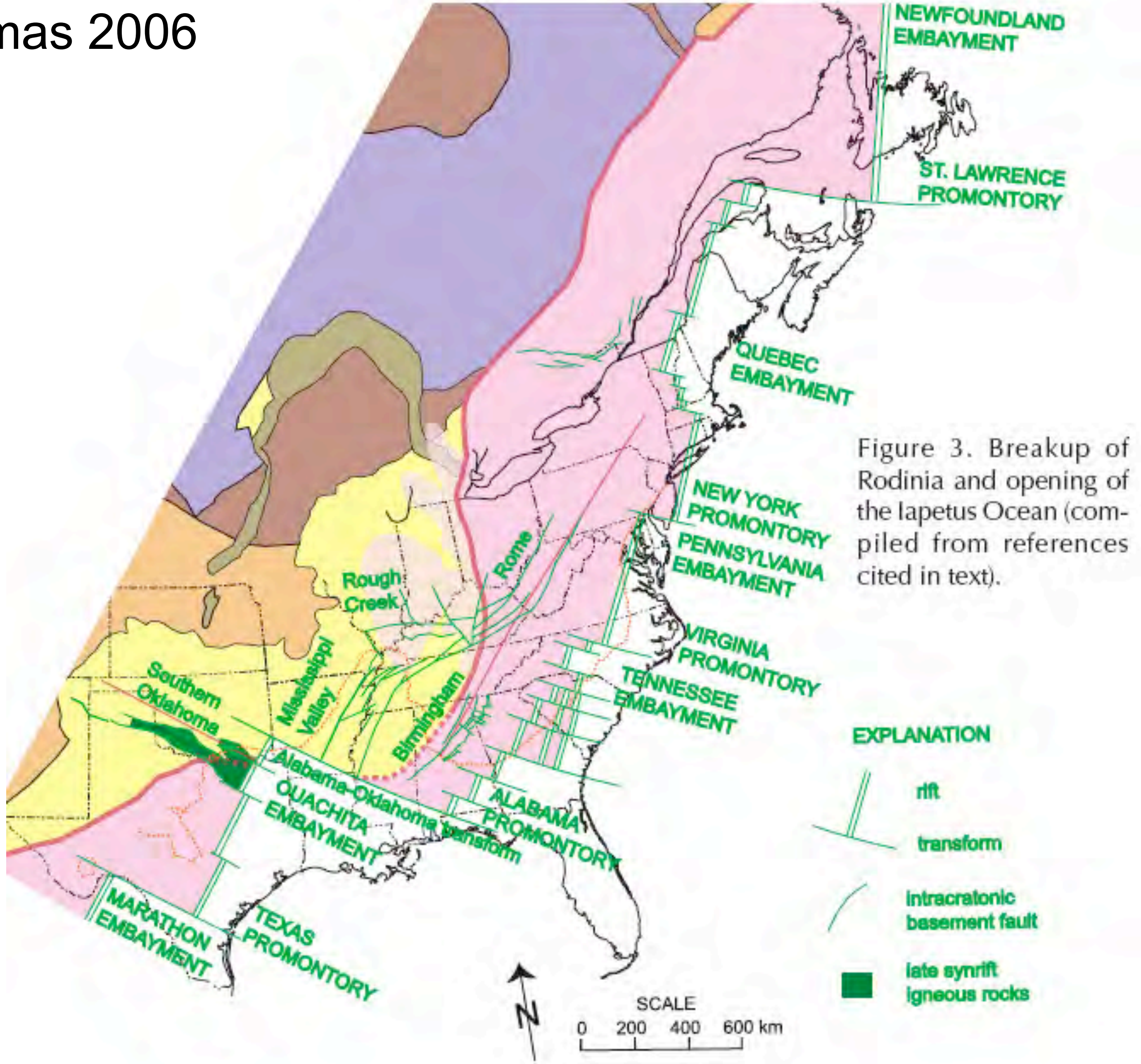
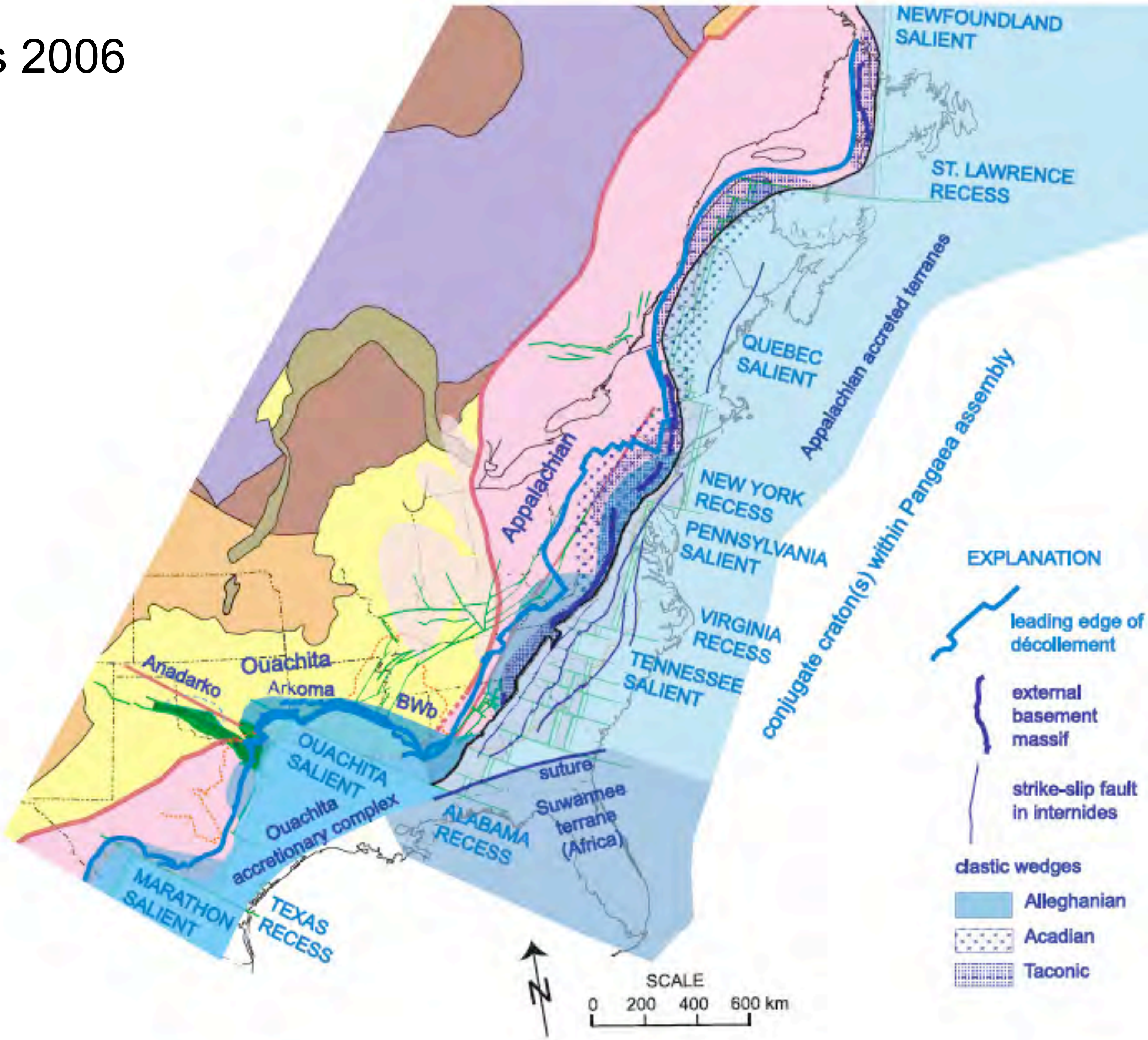


Figure 3. Breakup of Rodinia and opening of the Iapetus Ocean (compiled from references cited in text).

Thomas 2006



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Alleghanian
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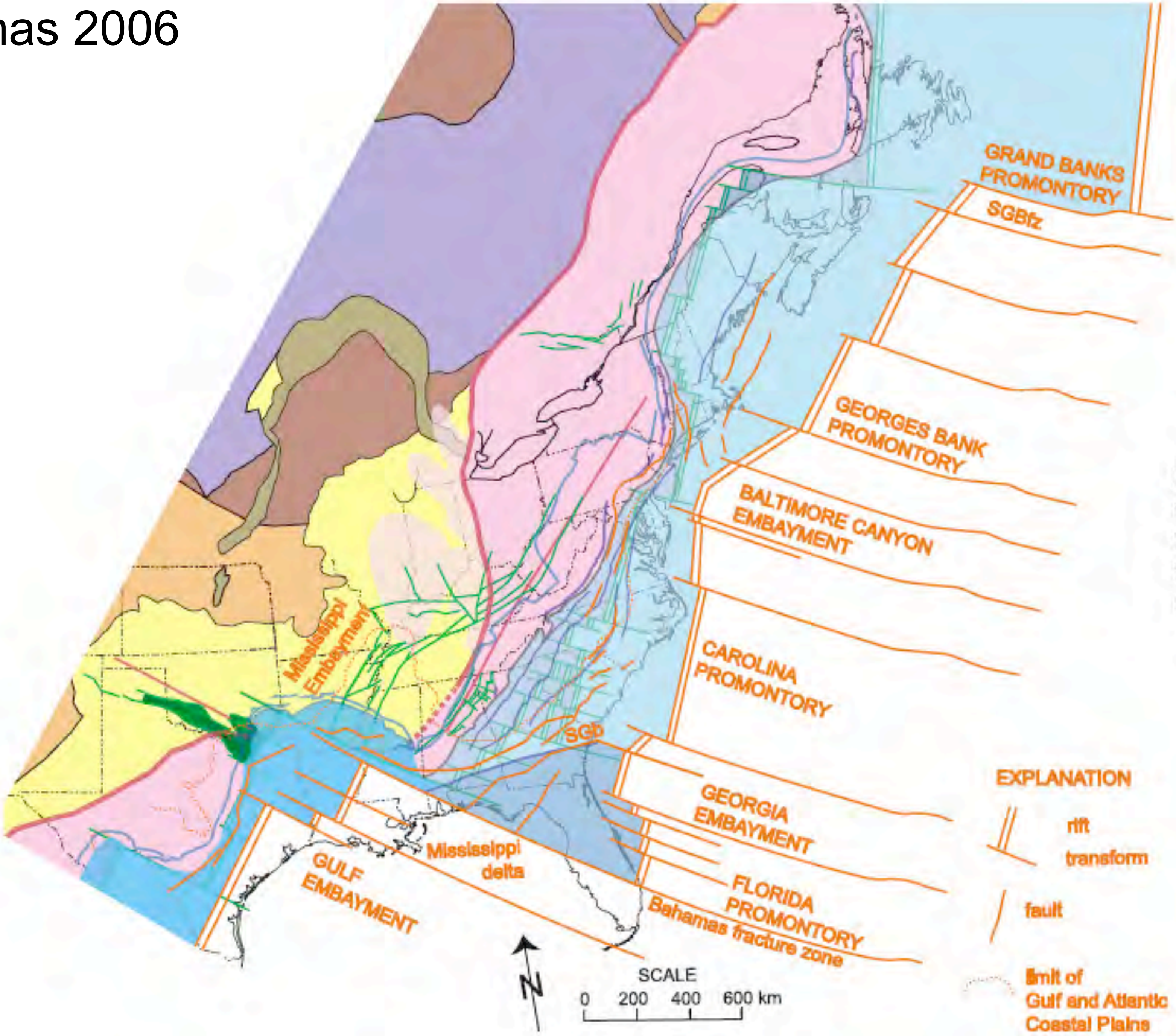
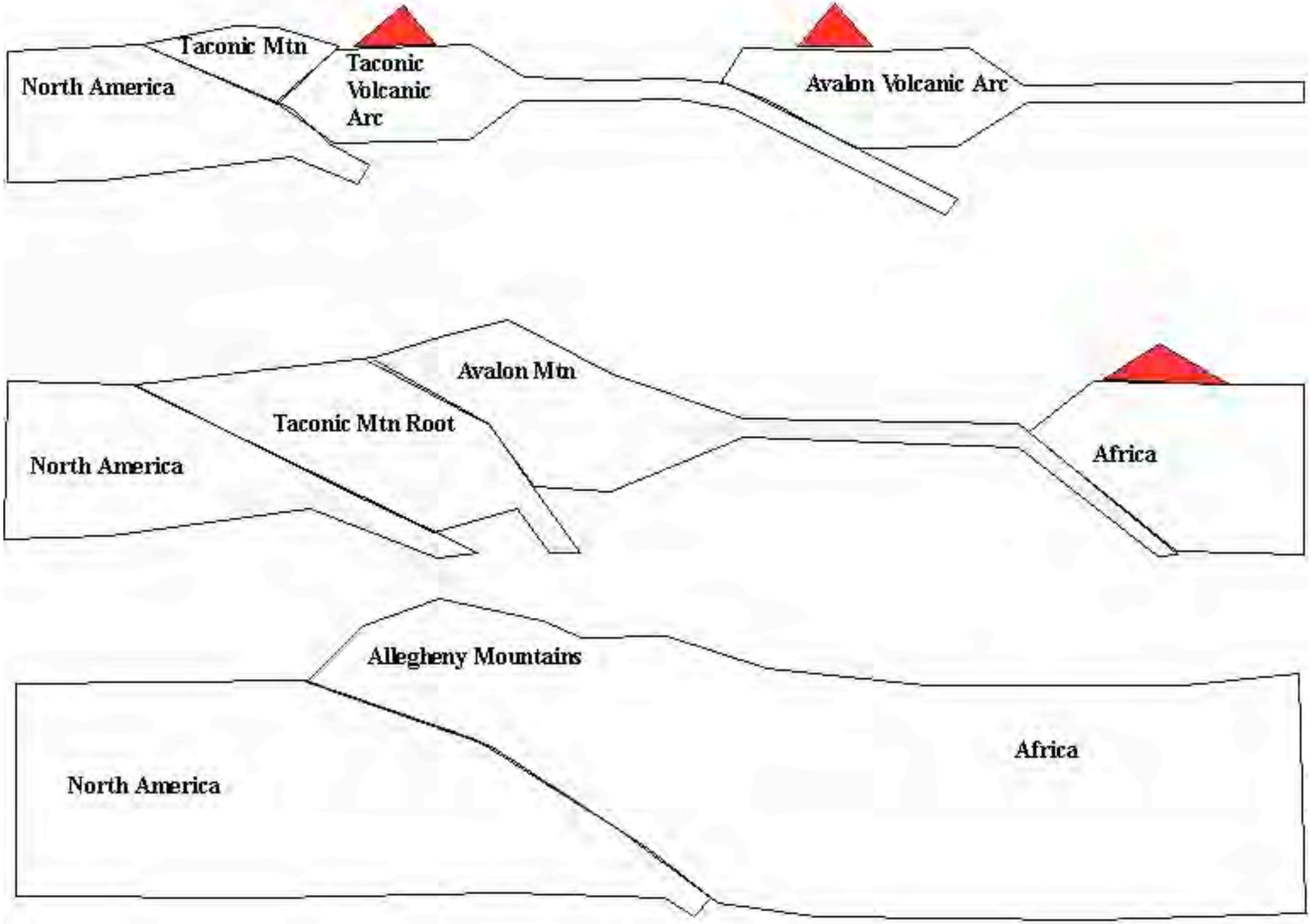
Taconic

Thomas 2006



GRAND BANKS PROMONTORY
SGBfz
GEORGES BANK PROMONTORY
BALTIMORE CANYON EMBAYMENT
CAROLINA PROMONTORY
SGb
GEORGIA EMBAYMENT
FLORIDA PROMONTORY
Bahamas fracture zone
Mississippi Embayment
Mississippi delta
GULF EMBAYMENT
EXPLANATION
rift
transform
fault
limit of Gulf and Atlantic Coastal Plains
SCALE
0 200 400 600 km
N


Taconic Mtn
North America
Taconic
Volcanic
Arc
Avalon Volcanic Arc
Avalon Mtn
Taconic Mtn Root
North America
Africa
Allegheny Mountains
North America
Africa

Beranek et al 2008

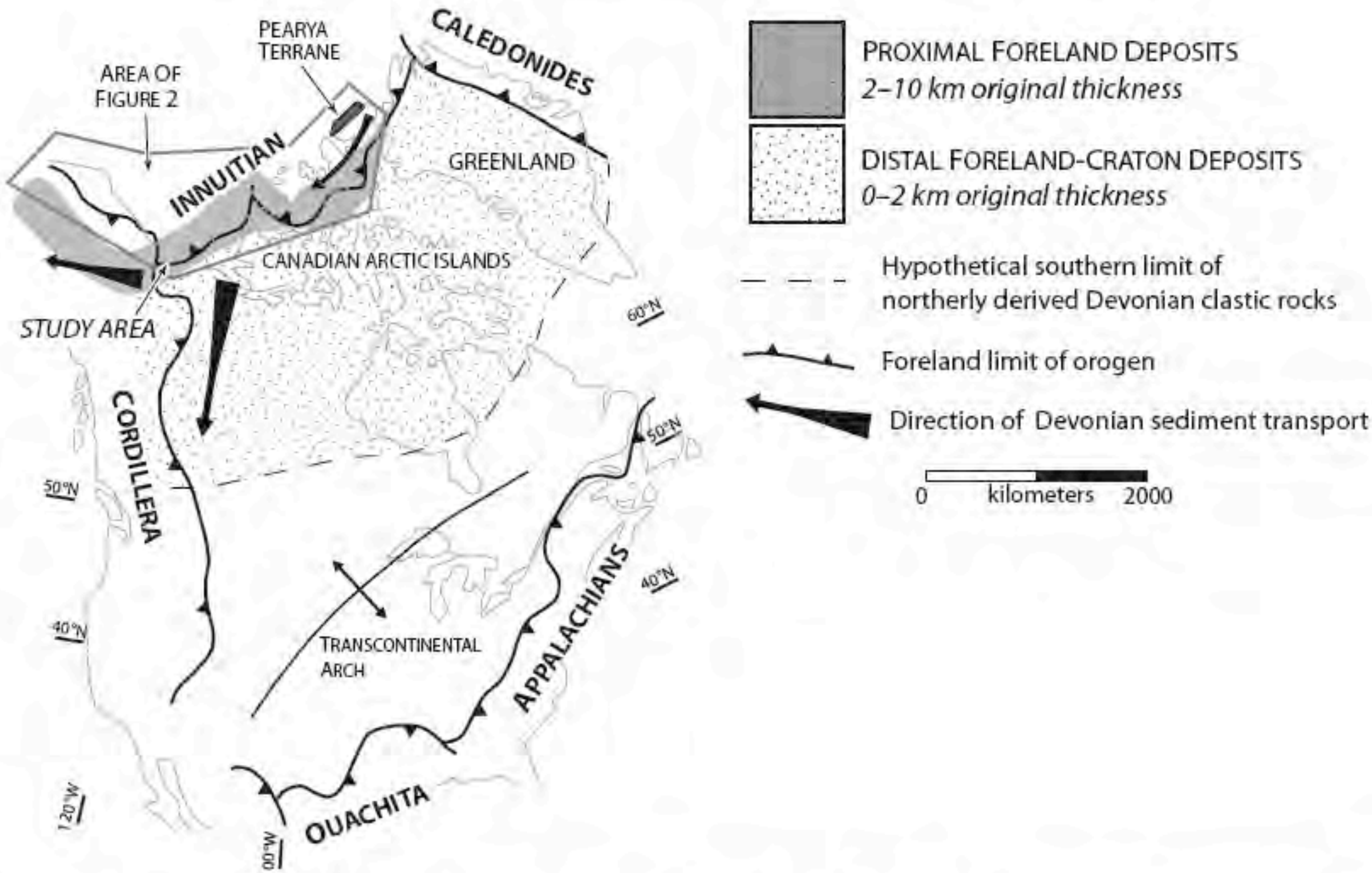


Figure 1. Generalized distribution of Innuitian clastic wedge strata, sedimentary dispersal patterns during the Devonian, and Phanerozoic mountain belts of North America (modified from Patchett et al., 1999, 2004).

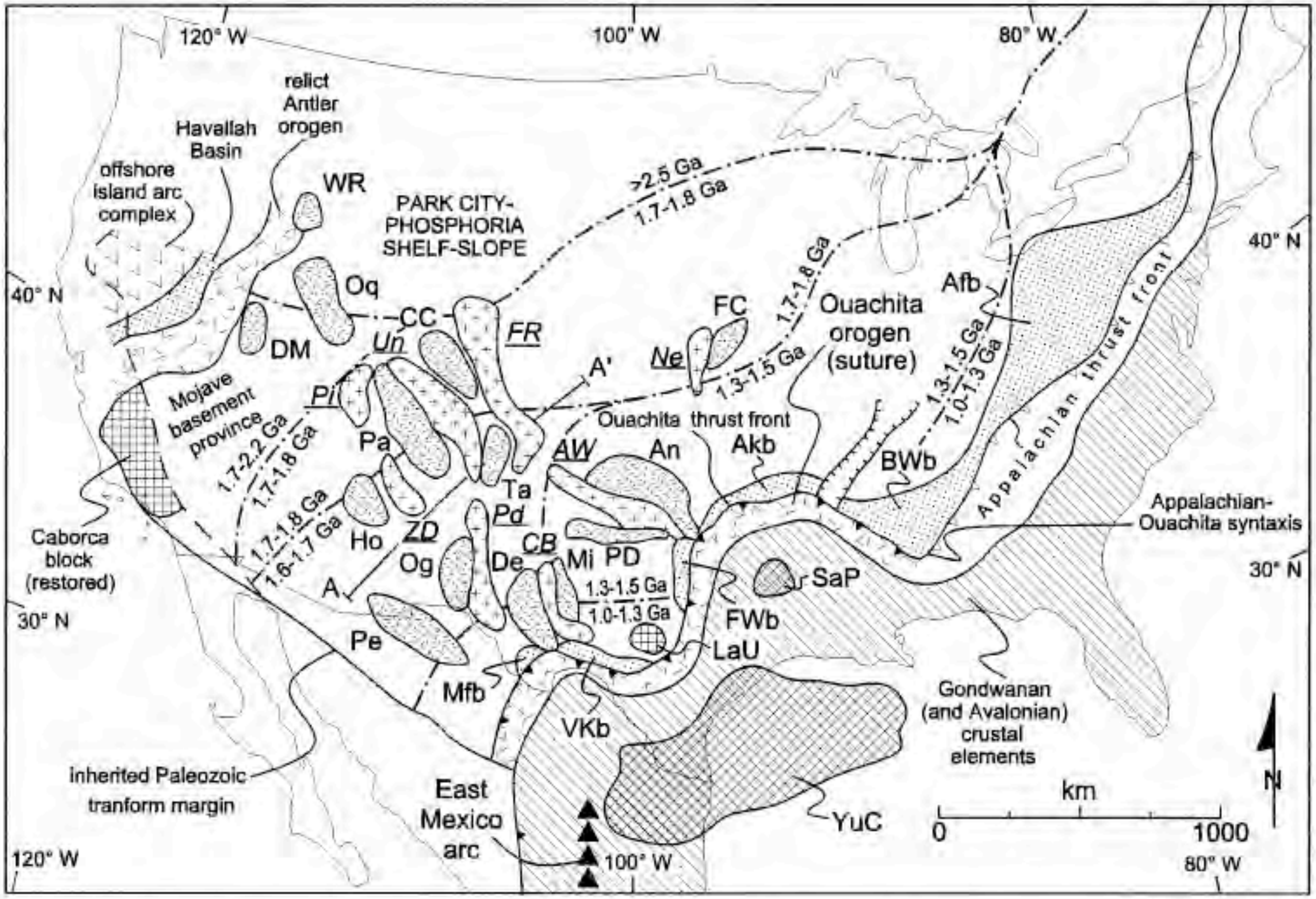
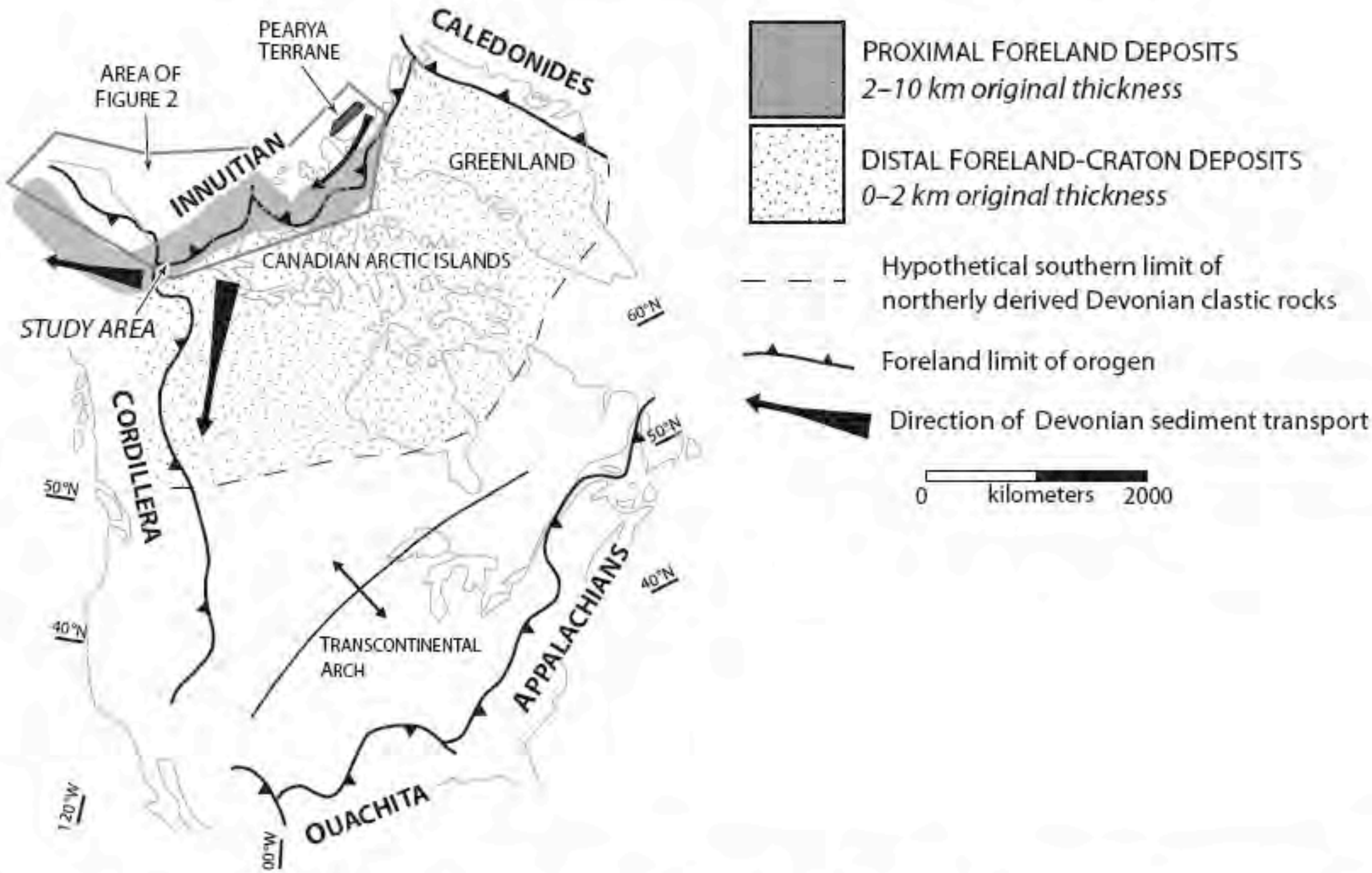


Figure 1. Areal distribution (schematic) of Ancestral Rocky Mountains uplifts (crosses) and basins (heavy stipples) in relation to other Pennsylvanian geotectonic features of Laurentia and its margins, including proforeland basins (light stipples), and to Precambrian belt boundaries within craton. Ancestral Rockies uplifts (underlined italics): AW, Amarillo-Wichita; CB, Central Basin platform; FR, Front Range; Ne, Nemaha Ridge; Pd, Pedernal; Pi, Piute; Un, Uncompahgre; ZD, Zuni-Defiance. Ancestral Rockies basins: An, Anadarko; CC, Central Colorado trough; De, Delaware; DM, Dry Mountain trough; FC, Forest City; Ho, Holbrook; Mi, Midland; Og, Orogrande; Oq, Oquirrh; Pa, Paradox; PD, Palo Duro; Pe, Pedregosa; Ta, Taos trough; WR, Wood River. Proforeland basins: Afb, Appalachian; Akb, Arkoma; BWb, Black Warrior, FWb, Fort Worth, VKb, Valverde-Kerr; Mfb, Marfa. Other geotectonic features: LaU, Llano uplift; SaP, Sabine platform; YuC, Yucatán peninsula and adjoining Campeche Bank (restored prior to opening of Gulf of Mexico after Dickinson and Lawton, 2001). East Mexico arc of middle Wolfcampian (Lower Permian) to Middle Triassic age (Dickinson and Lawton, 2001) postdated Ancestral Rocky Mountains deformation.

Dickinson and Lawton 2003

Beranek et al 2008



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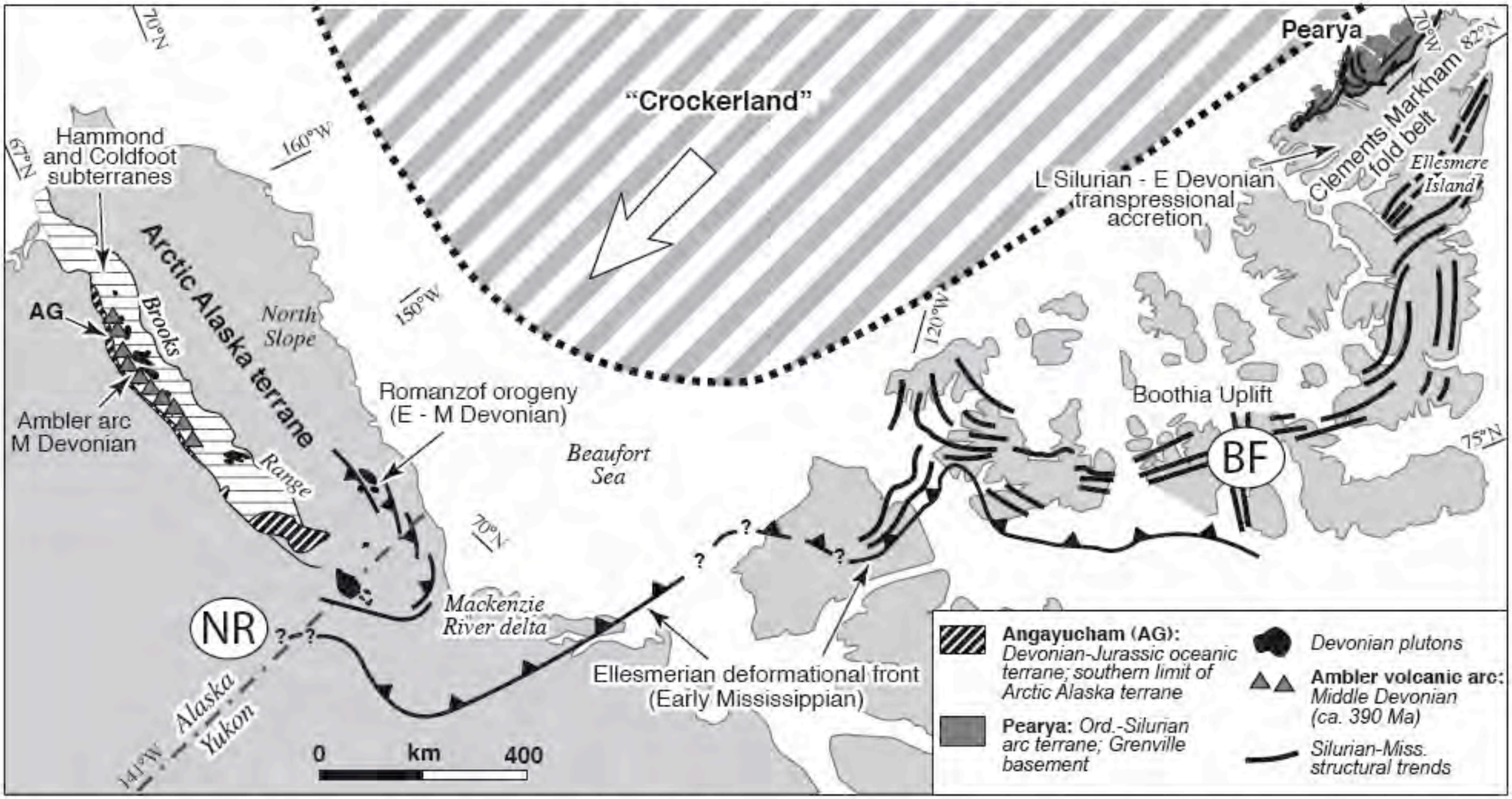

Figure 2. Distribution of tectonic elements and geologic features of northern Alaska and Canada (modified from Colpron and Nelson, 2009). BF indicates the location of the Middle Devonian Bird Fiord detrital zircon sample of McNicoll et al. (1995). NR represents the Late Devonian Nation River Formation detrital zircon sample of Gehrels et al. (1999).

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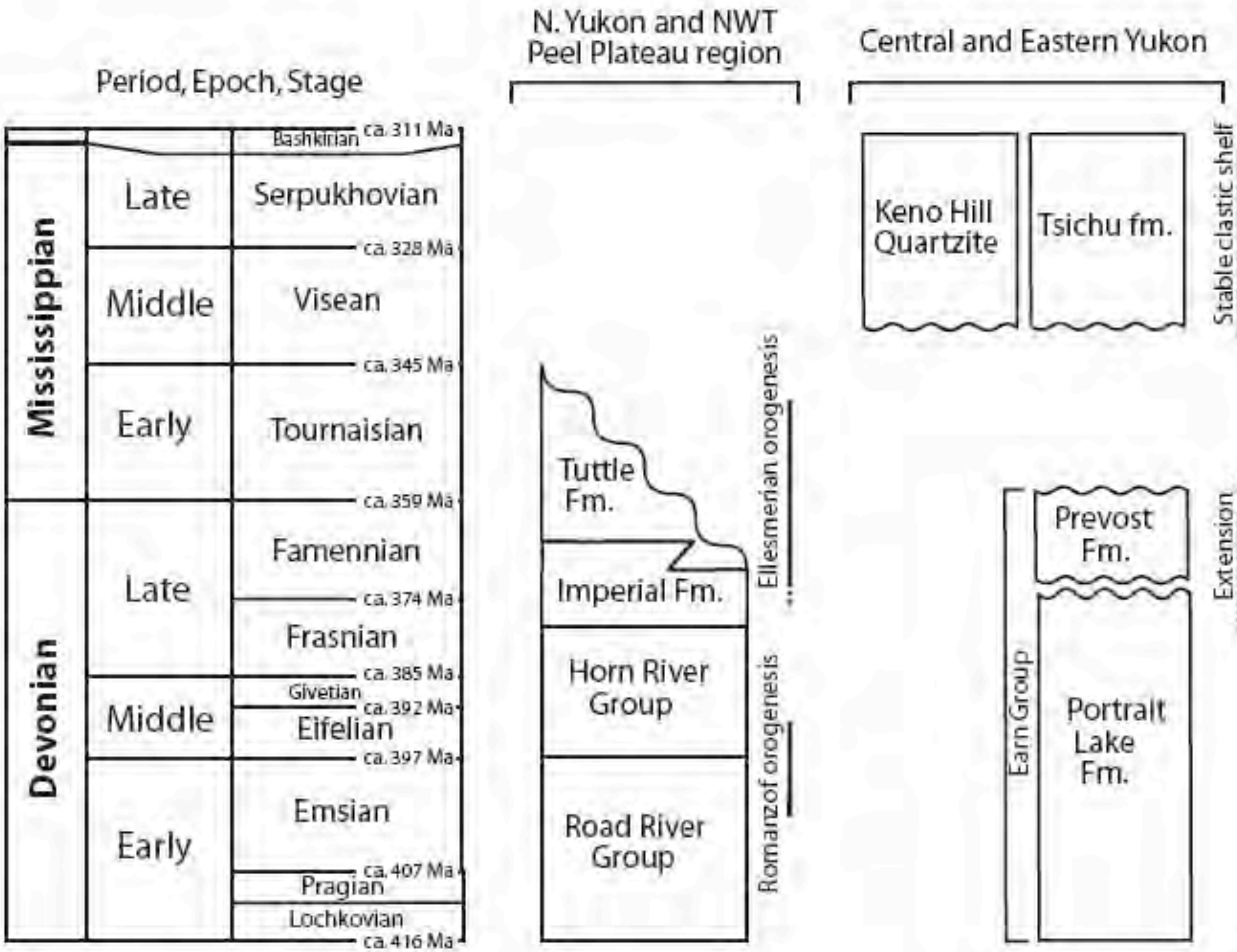

Figure 3. Devonian and Mississippian stratigraphic and tectonic framework in Yukon and Northwest Territories (adapted from Gordey et al. [1991] using the time scale of Gradstein et al. [2004] and fossil determinations in Orchard [2006]). Abbreviations: Fm.—Formation (formal), fm.—formation (informal), N.—northern, NWT—Northwest Territories.

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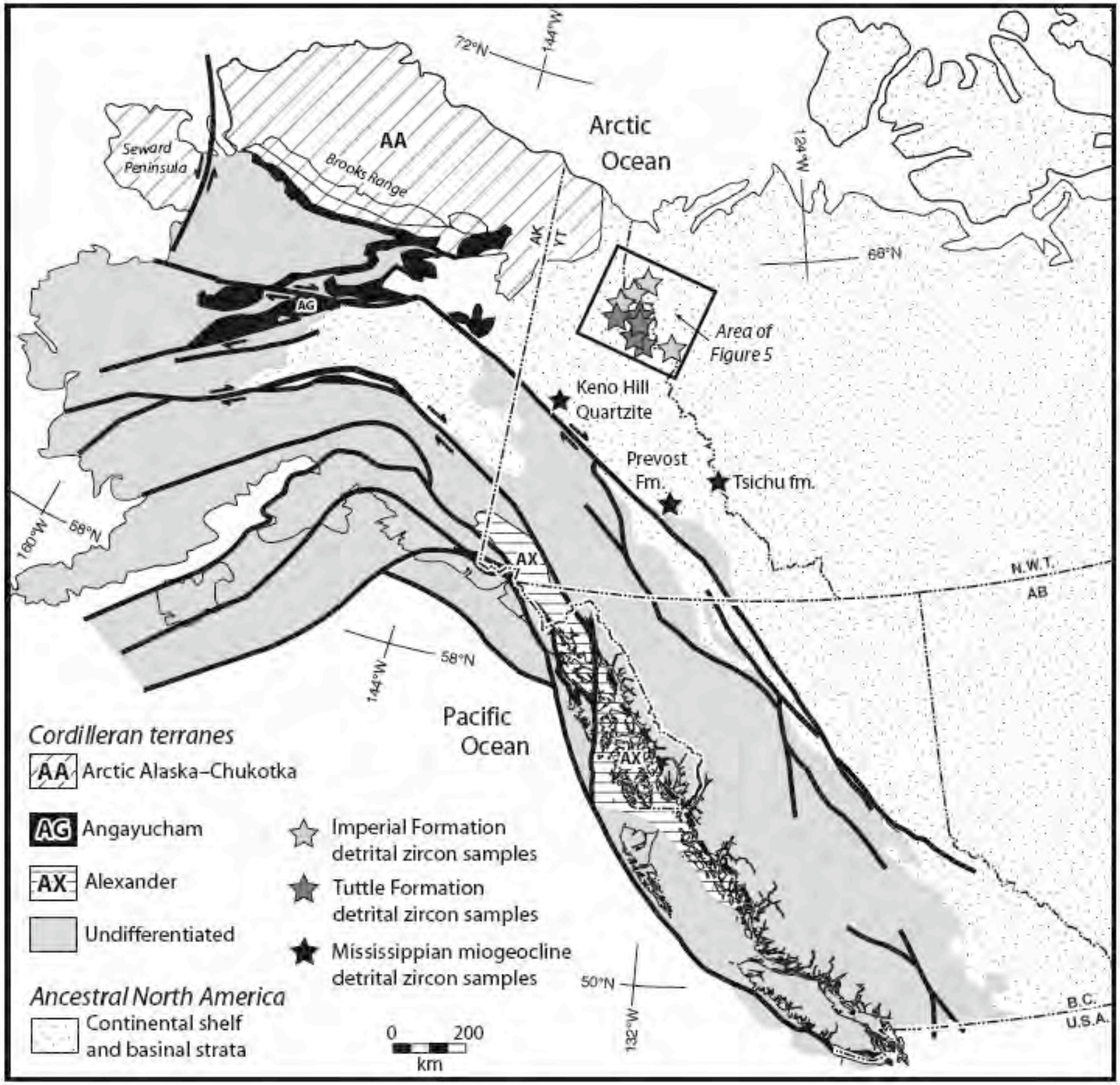
Figure 4. Simplified tectonic element map of the Alaskan and Canadian Cordillera (modified from Colpron et al., 2007) that displays the location and distribution of detrital zircon samples from this study. Abbreviations: AB—Alberta, AK—Alaska, B.C.—British Columbia, Fm.—Formation, fm.—formation (informal), NWT—Northwest Territories, YT—Yukon.



Beranek et al 2010

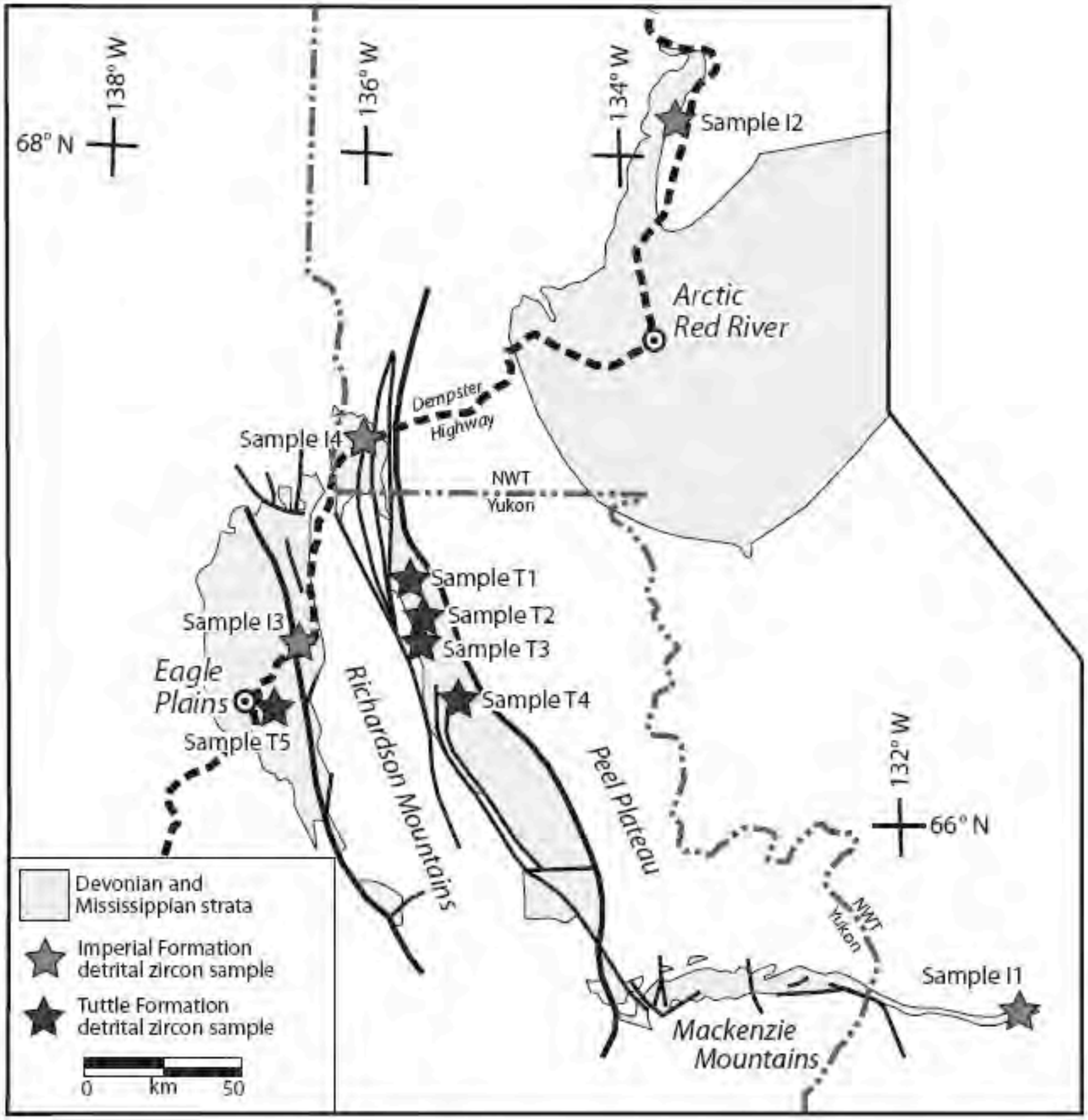


Figure 5. Distribution of Devonian and Mississippian strata and location of detrital zircon samples in the northern Richardson Mountains–Peel Plateau area of northern Yukon and Northwest Territories (NWT).

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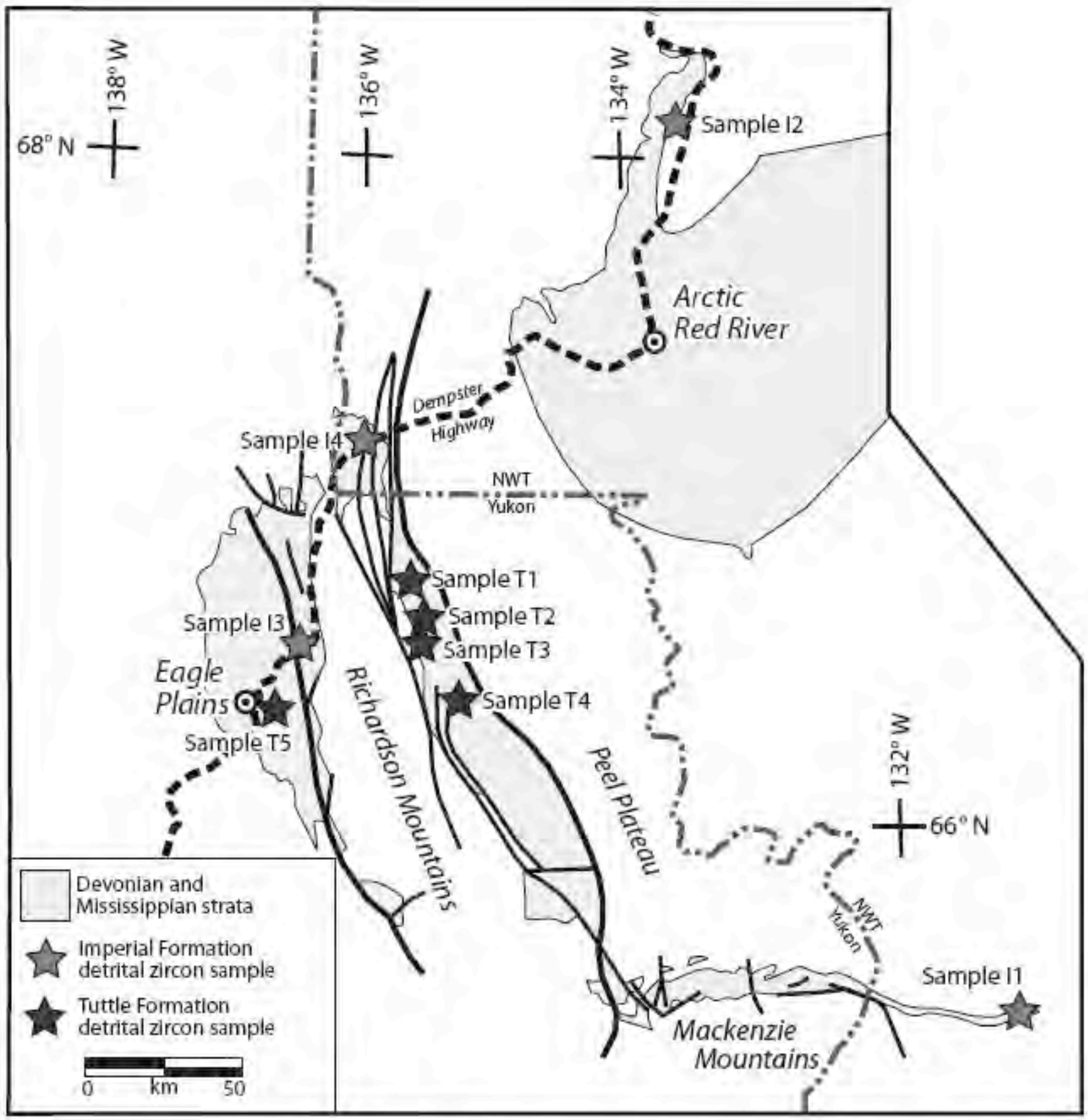

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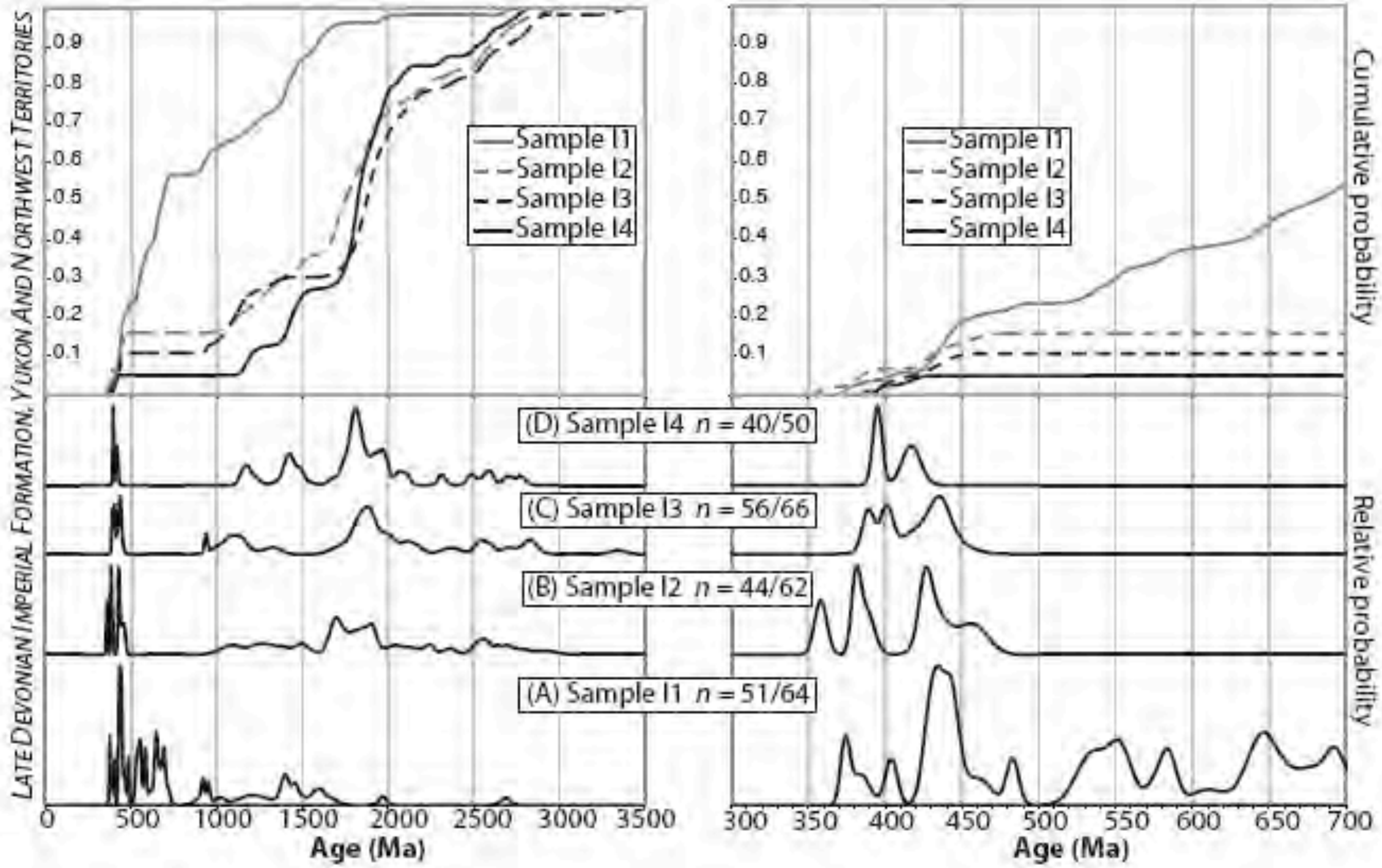

Figure 6. Relative probability and cumulative probability plots (0–3000 Ma and 300–700 Ma) displaying detrital zircon ages from the Imperial Formation: (A) sample I1—lower Imperial Formation feldspathic sandstone; (B) sample I2—middle Imperial Formation feldspathic sandstone; (C) sample I3—middle Imperial Formation chert lithic sandstone; and (D) sample I4—middle Imperial Formation quartz sandstone.

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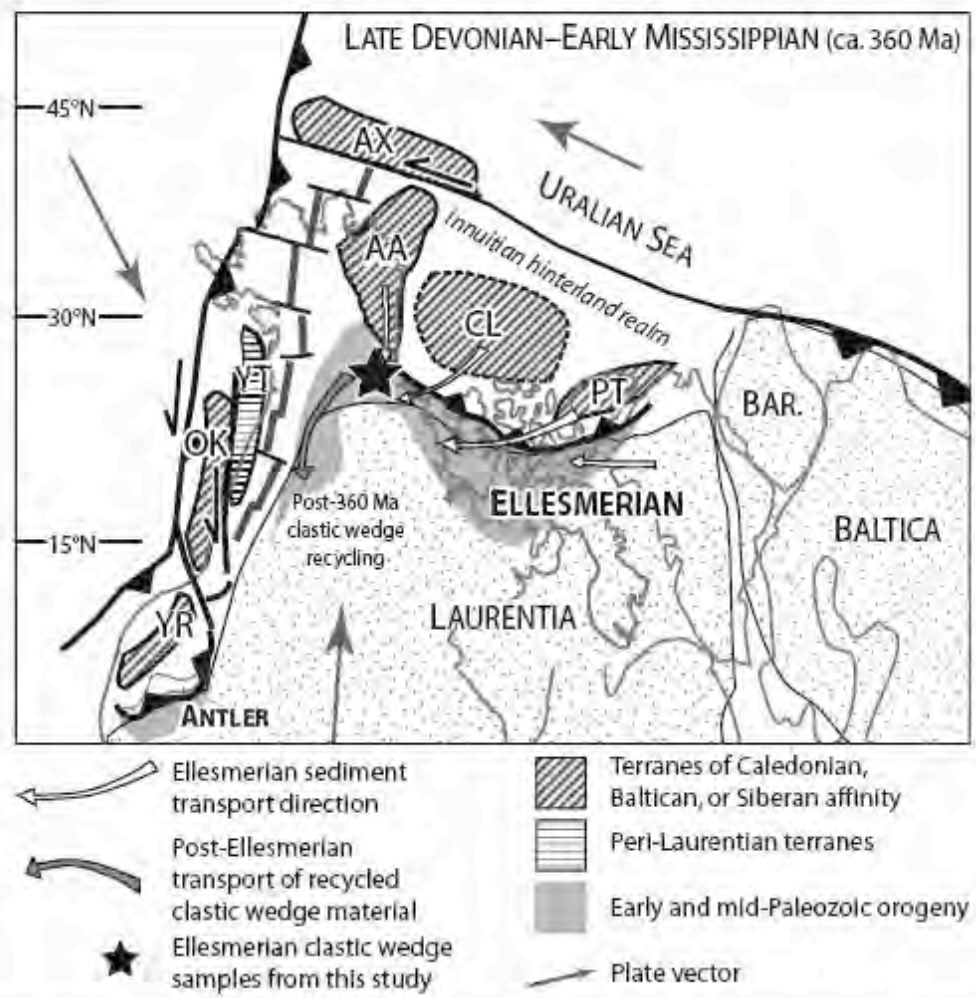

Figure 10. Late Devonian to early Mississippian (ca. 360 Ma) paleogeography (modified from Colpron and Nelson, 2009) highlighting Ellesmerian and Antler orogenic development, inferred sediment dispersal patterns in northern Laurentia, and location of exotic terranes. Abbreviations: AA—Arctic Alaska–Chukotka terrane, AX—Alexander terrane, Bar.—Barentsia, CL—Crockerland, OK—Okanagan subterrane, PT—Pearya terrane, YR—Yreka subterrane (including Trinity subterrane and Shoo Fly complex), YT—Yukon-Tanana terrane.

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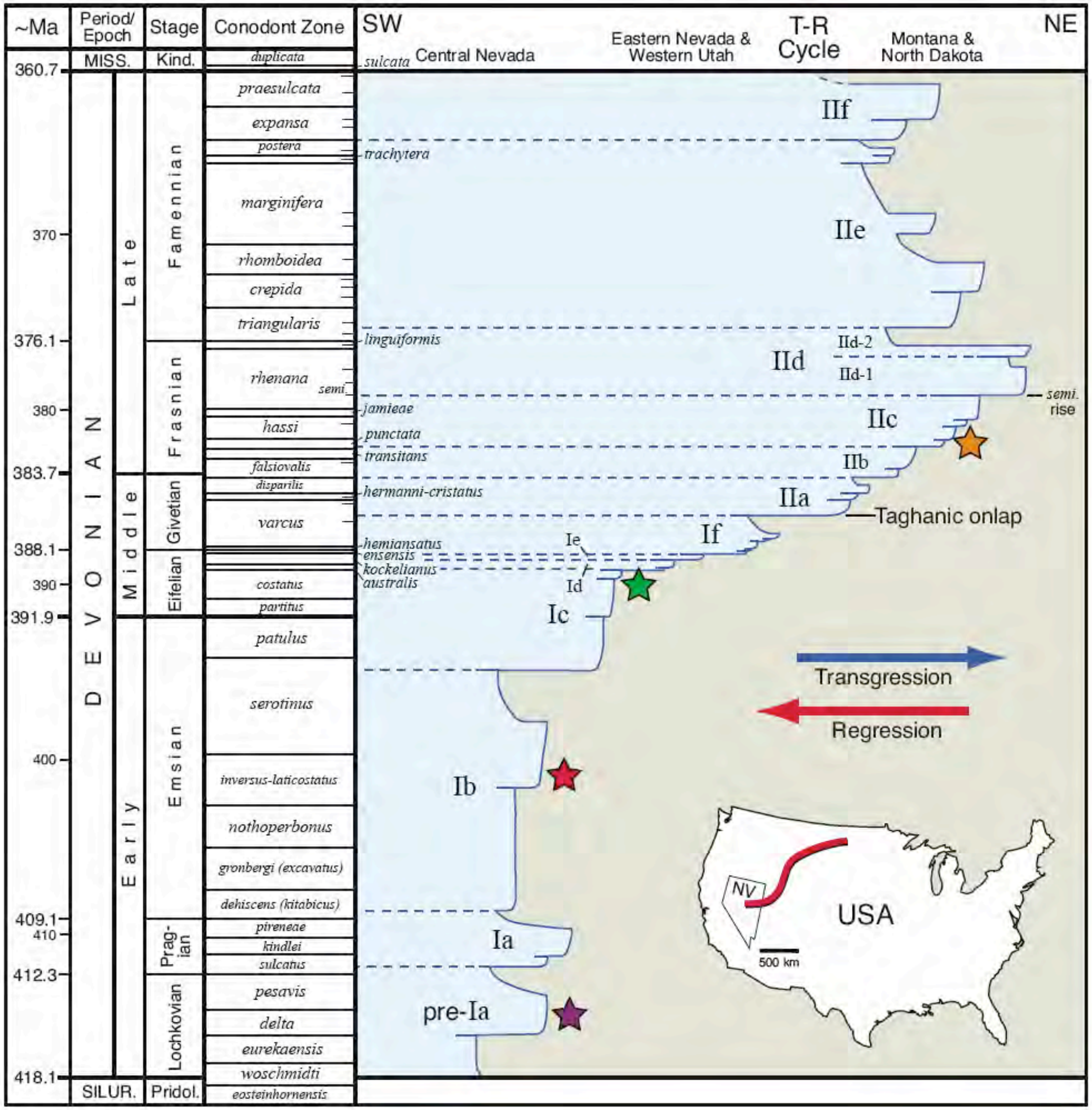

Figure 2. Devonian eustatic sea-level curve, transgressive-regressive (T-R) cycles, and conodont biochronology (Fig. 1) scaled to the numerical time scale of Kaufmann (2006). Additional subdivision of T-R cycle IId into subcycles IId-1 and IId-2 is after Morrow and Sandberg (2003). Colored stars mark carbonate-shelf margin positions shown in Figure 3. Inset shows transect depicted in figure. Abbreviations: MISS.—Mississippian; Kind.—Kinderhookian; NE—northeast; Pridol.—Pridolian; *semi.*—*semichatovae* Subzone interval and *semichatovae* rise; SILUR.—Silurian; SW—southwest. Modified from Johnson et al. (1985, 1991), Johnson and Sandberg (1989), Sandberg et al. (2002), Kaufmann (2006), and our personal observ.

Morrow and Sandberg 2008

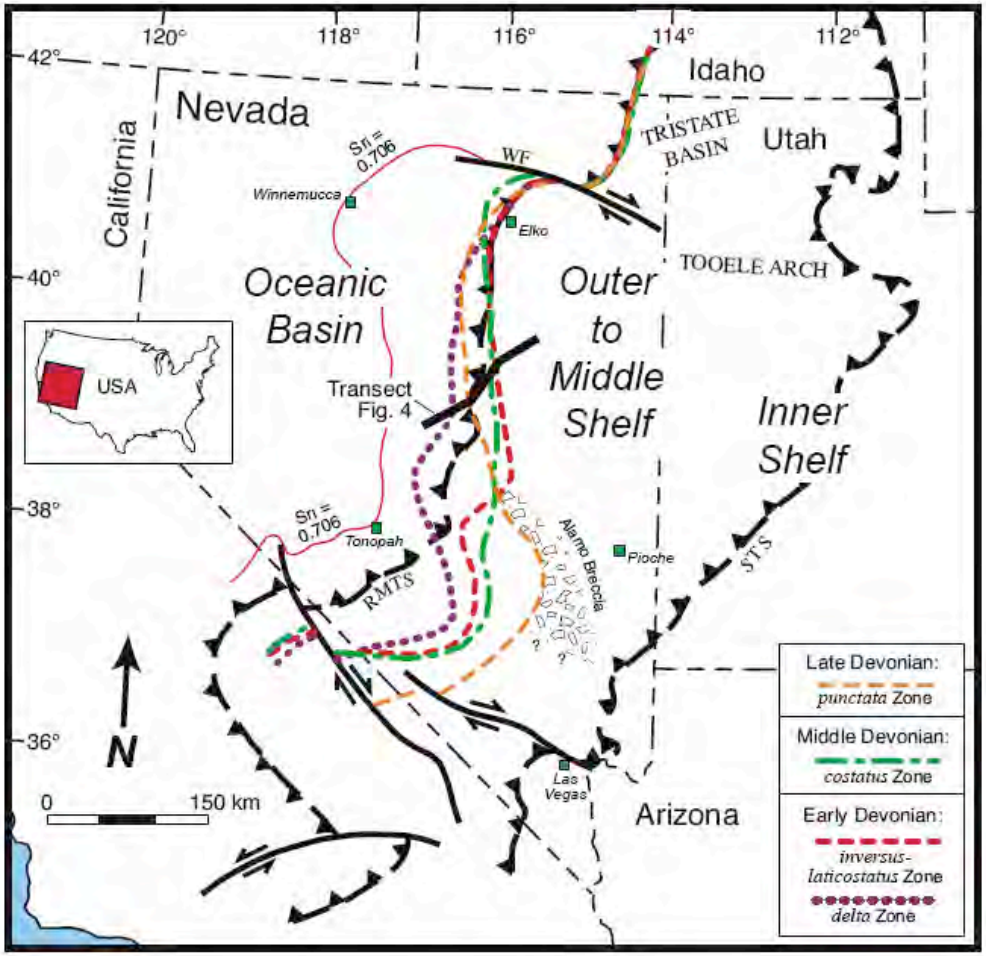

Figure 3. Partly restored paleogeographic map, Nevada and western Utah, showing representative positions of the carbonate-shelf margin through the Devonian; see Figure 1 for conodont biochronology. Position of *punctata* Zone margin is prior to eastward shift (Fig. 6) produced by the Alamo Impact and formation of the Alamo Breccia, indicated in figure. Apparent juxtaposition of carbonate-shelf margin positions in northern Nevada is largely due to Antler orogenic compression and overthrusting. Approximate position of western edge of continental crust is indicated by Sr_i ($^{87}Sr/^{86}Sr$) = 0.706. Tristate basin and Tooele arch are broad, persistent Devonian structural features (Sandberg et al., 1989; Poole et al., 1992). Positions of other Devonian intrashelf basins, including depositional sites of Middle Devonian Woodpecker Limestone (Elrick, 1996) and Upper Devonian–Mississippian Pilot Shale (Sandberg et al., 1989, 2003), are omitted for simplicity. Abbreviations: RMTS—Roberts Mountains thrust system; STS—Sevier thrust system; WF—Wells fault. Major Cenozoic strike-slip faults and time-rock transect line (Fig. 4) are also shown. Data from Johnson et al. (1989) and Sandberg et al. (1989, 2002).

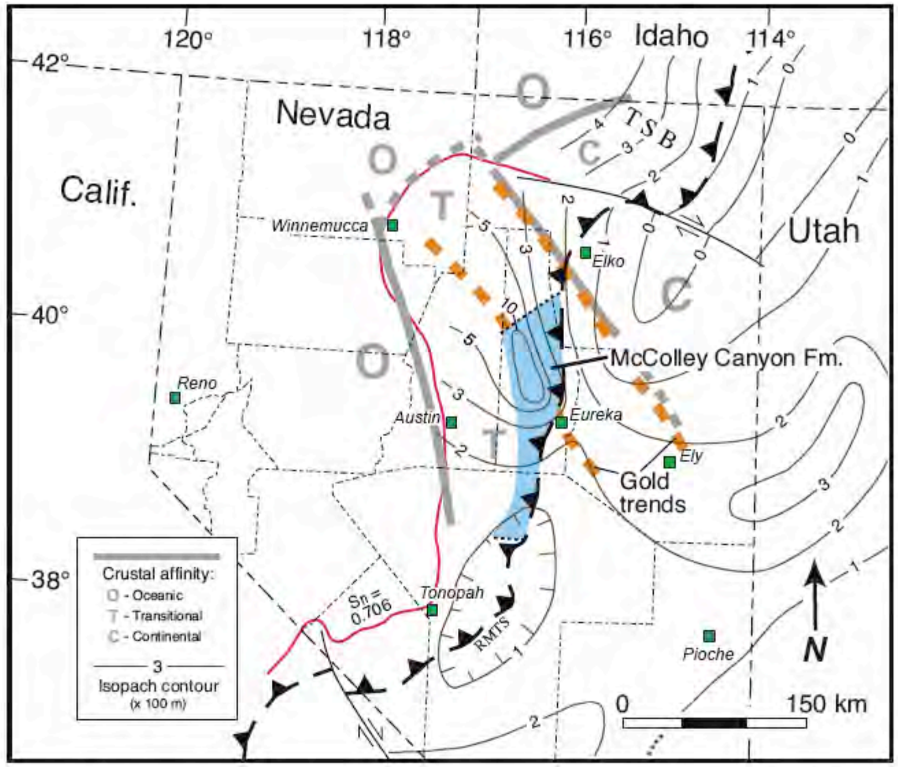

Figure 5. Partly restored base map of northern and central Nevada, showing plot of Lower Devonian isopachs (thin brown lines, contour interval is 100 m), Sr_i ($^{87}Sr/^{86}Sr$) = 0.706 isopleth, crustal affinity (fields defined by bold gray lines), trends of Carlin-type gold deposits (bold dashed gold lines; Battle Mountain–Eureka trend is southwestern line, Carlin trend is northeastern line), and approximate present outcrop extent of Pragian–lower Eifelian McColley Canyon Formation. The thick McColley Canyon Formation is interpreted to record an Early–Middle Devonian shelf-margin basin flanked by syndepositional, deep-seated faults within underlying basement of inferred transitional continental to oceanic composition. The McColley Canyon depocenter also appears as an anomalous, eastward-projecting embayment of slope facies on the Lower Silurian–Middle Devonian lithofacies map of Poole et al. (1992, plate 3–2). Tristate basin (TSB), Nevada county boundaries, and major towns are shown. Abbreviations: RMTS—Roberts Mountains thrust system. Data compiled from Kendall (1975), Poole et al. (1977, 1992), Crafford and Grauch (2002), Emsbo et al. (2006), and M.A. Murphy (14 September 2007, personal commun.).

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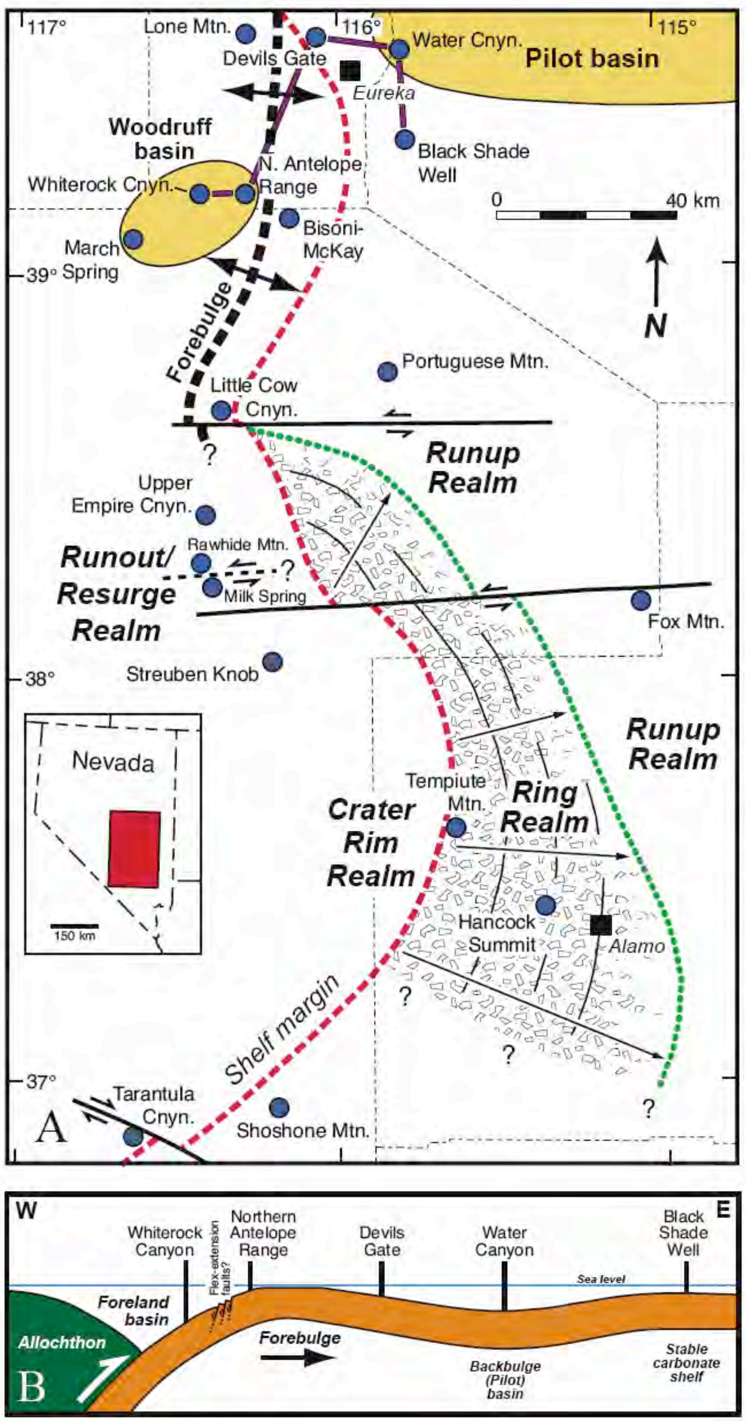
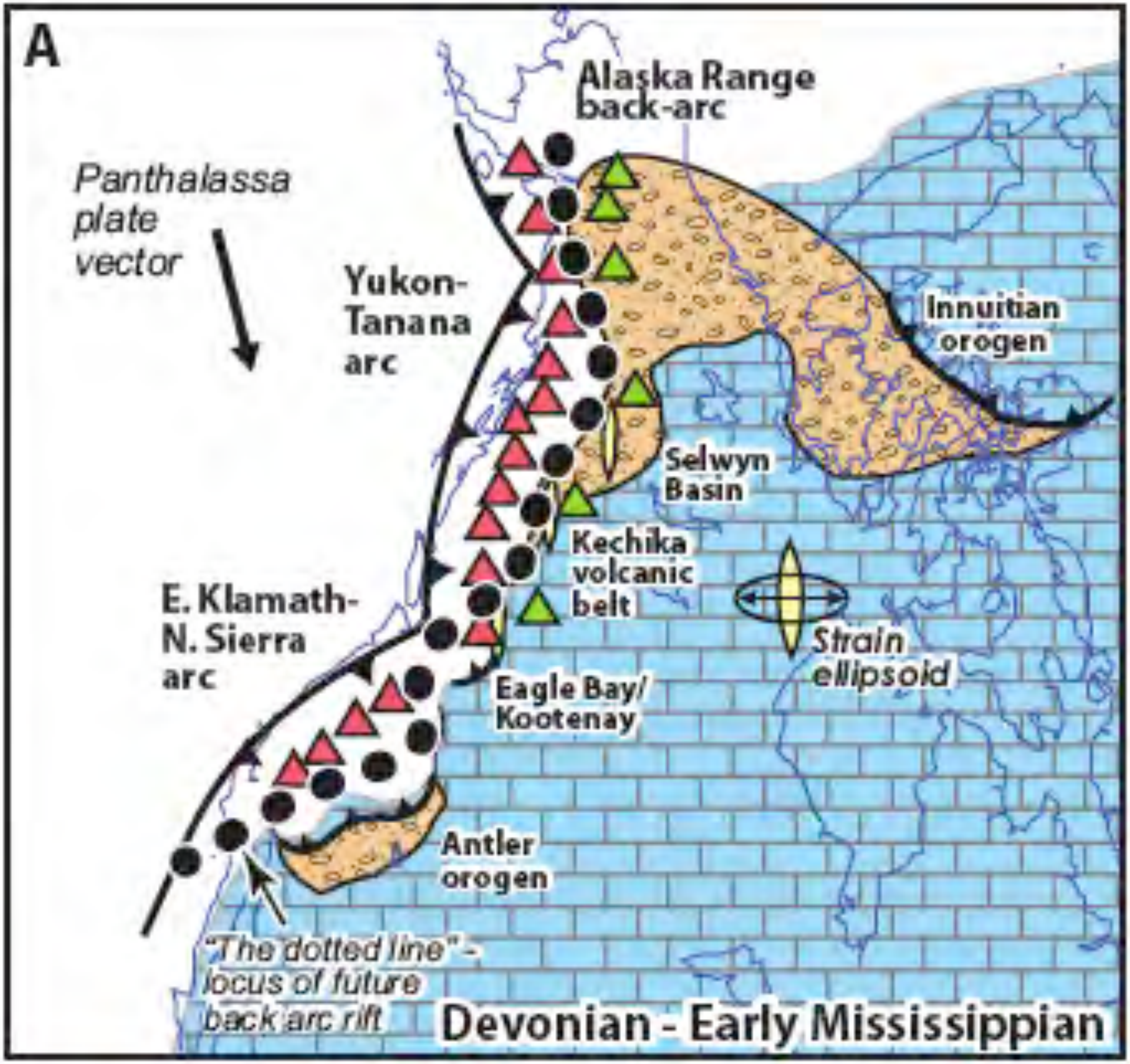


Figure 6. Partly restored, early Late Devonian paleogeographic map and tectonic cross section, southeastern Nevada. (A) Map showing inferred position of *punctata* Zone shelf margin (dashed red line) prior to Alamo Impact Event and diagrammatic eastward shift in margin (arrows and breccia fill pattern) as a result of shattering and downslope and craterward transport of shelf-margin rocks following the event. Genetic Alamo Event realms (Warme and Pinto, 2006; Pinto and Warme, 2008) are indicated. Black concentric curved lines within Ring Realm depict inferred annular ring faults, which are related to the Alamo Event, discussed by Warme and Kuehner (1998) and Pinto and Warme (2008). Maximum possible post-impact eastward shift in shelf margin (green dotted line) corresponds to onshore limit of Ring Realm (or Alamo Breccia Zone 2 of Warme and Sandberg, 1995; Warme and Kuehner, 1998; Morrow et al., 2005). Also shown are positions of initial Pilot and Woodruff basins that formed adjacent to the proto-Antler forebulge (bold dashed black line) during the succeeding Early *hassi* Zone. Closed blue circles denote selected important localities used to constrain map. Purple line connecting Whiterock Canyon and Black Shade Well localities marks cross section in Figure 6B. Fine dashed lines delineate Nevada county boundaries. Abbreviations: Cnyn.—Canyon; Mtn.—Mountain; N.—Northern. Modified from Sandberg et al. (2003) and Warme and Pinto (2006). (B) Schematic west to east tectonic cross section during Early *hassi* Zone, showing positions of Antler allochthon, foreland basin, eastward-migrating proto-Antler forebulge, initial backbulge (Pilot) basin, and carbonate shelf. Inferred flexural loading extensional faults west of the forebulge are after Silberling et al. (1997), who proposed such features for the Mississippian foreland system. A similar tectonic model was proposed for the Late Devonian and Mississippian by Poole (1974). By the Early *rhenana* Zone, Black Shade Well was within the expanding Pilot basin (Sandberg et al., 1989; Morrow and Sandberg, 2003). Not to scale; actual west to east distance from toe of allochthon to forebulge axis may have been as much as 200–250 km. Modified from Goebel (1991), Giles (1994), and Giles and Dickinson (1995).

Morrow and Sandberg 2008



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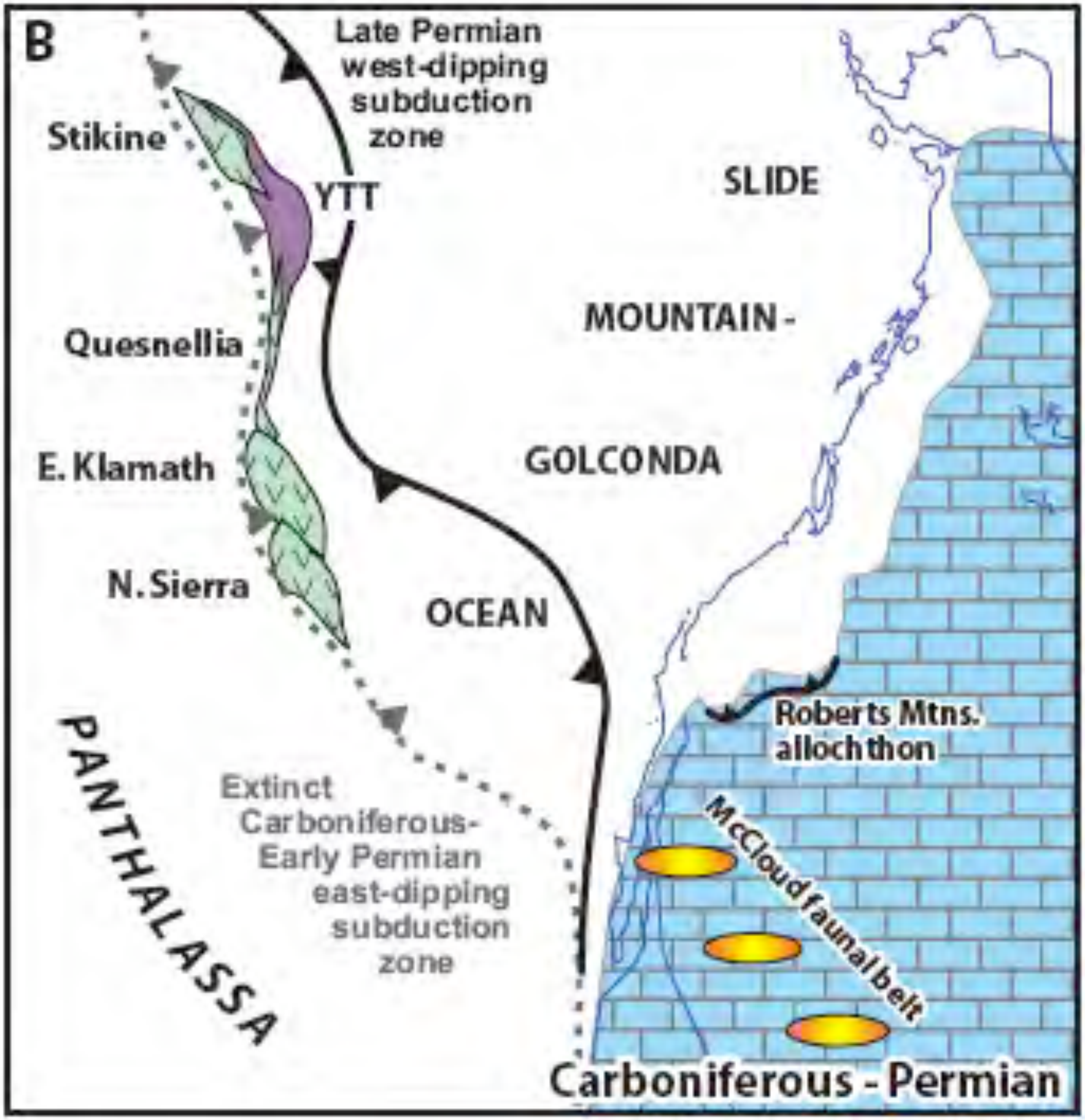

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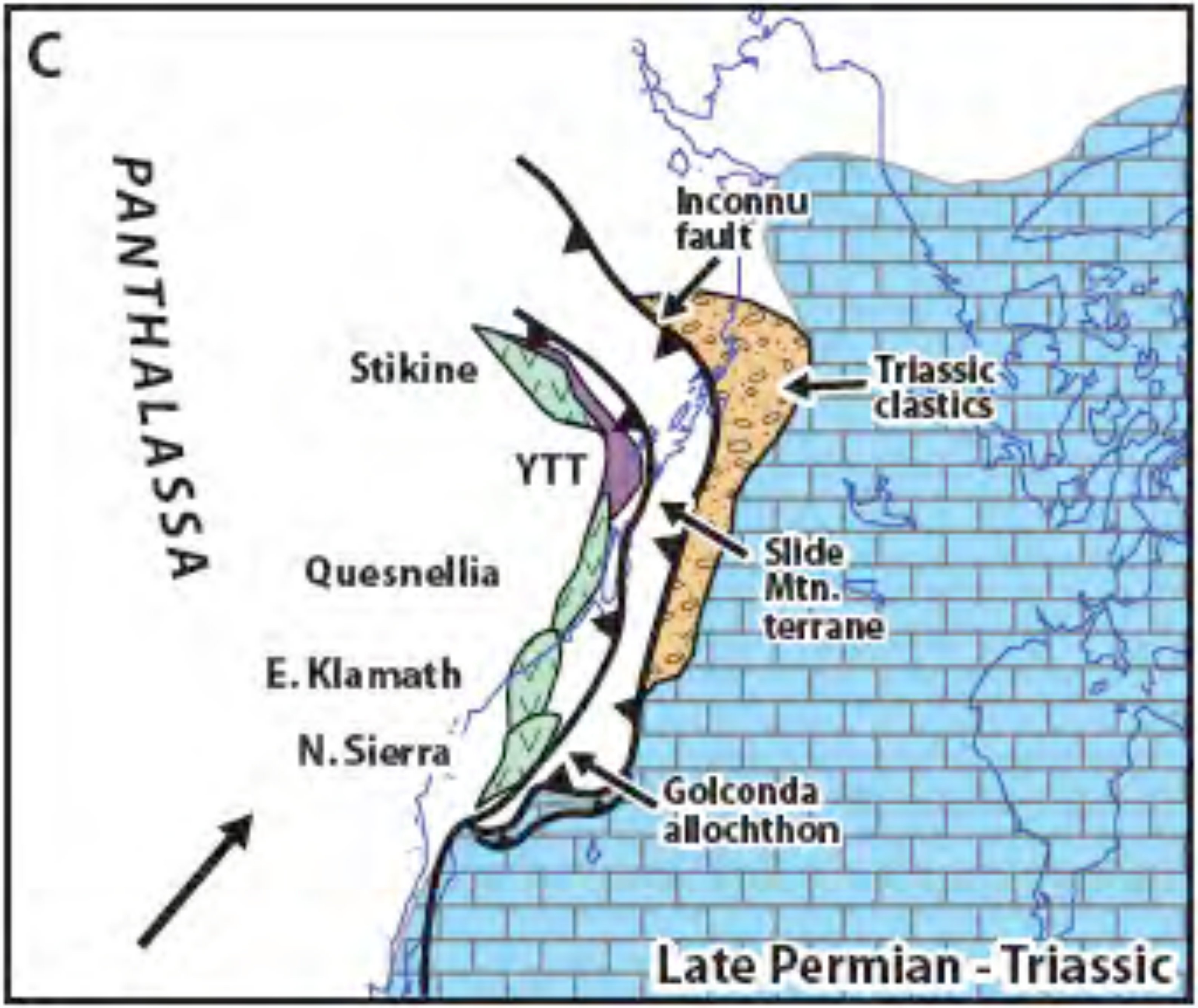

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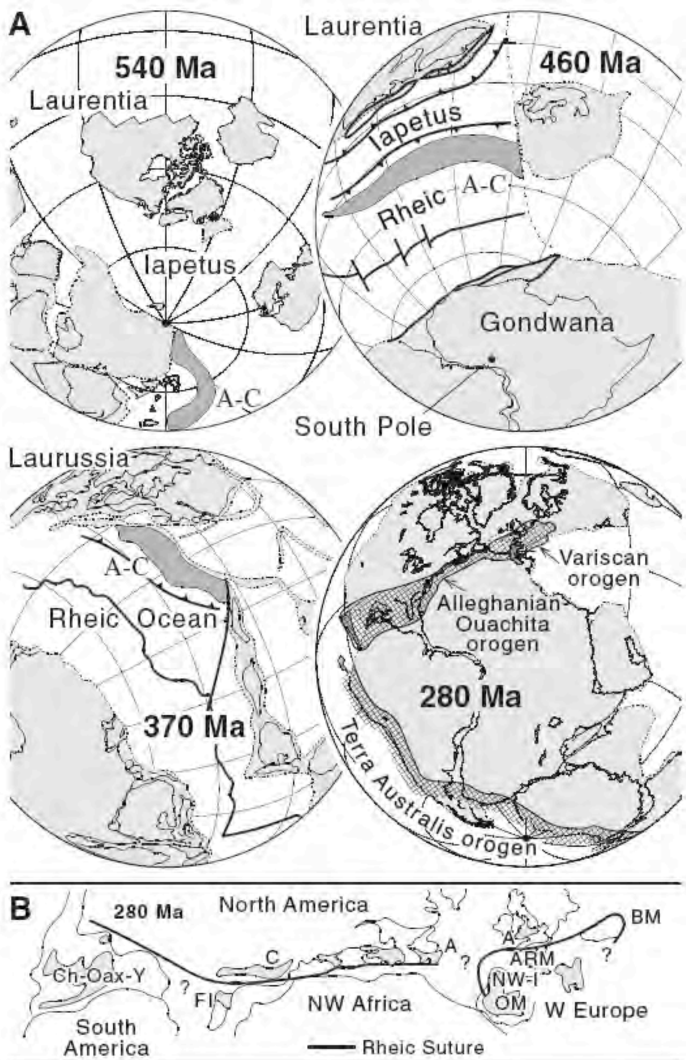
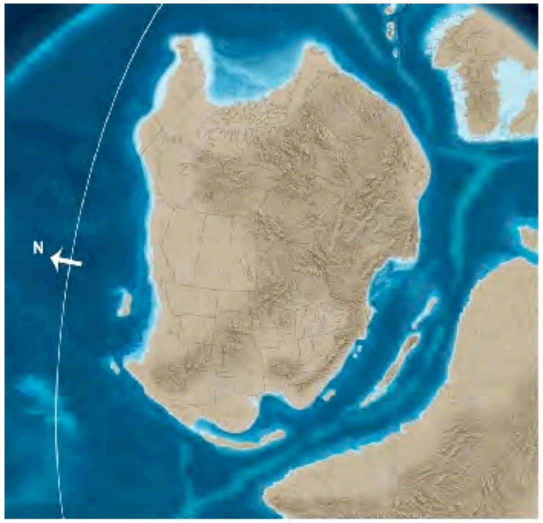
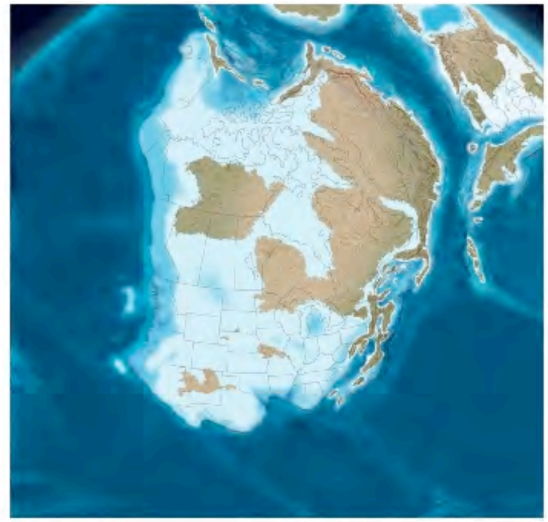


Figure 1. Paleozoic reconstructions (modified from Scotese, 1997; Cocks and Torsvik, 2002; Stampfli and Borel, 2002; Murphy et al., 2006; Cawood and Buchan, 2007). A: By 540 Ma, Iapetus Ocean had formed between Laurentia and Gondwana. By 460 Ma, Avalonia-Carolinia (A–C) had separated from Gondwana, creating the Rheic Ocean. By 370 Ma, Laurentia, Baltica, and A–C had collided to form Laurussia, and Rheic Ocean began to contract, closing by 280 Ma, to form Pangea. Terra Australis orogen at 280 Ma was located along periphery of Pangea, representing vestige of tectonic activity within paleo–Pacific Ocean. B: Location of Rheic Ocean suture within Alleghanian-Ouachita and Variscan orogens and early Mesozoic position of peri-Gondwanan terranes mentioned in text (see Keppie et al., 2003). Ch-Oax-Y—Chortis, Oaxaquia-Yucatan; F—Florida; C—Carolina; A—Avalonia; O-M—Ossa Morena; NW-I—Northwest Iberia, ARM—Armorica; BM—Bohemian massif.

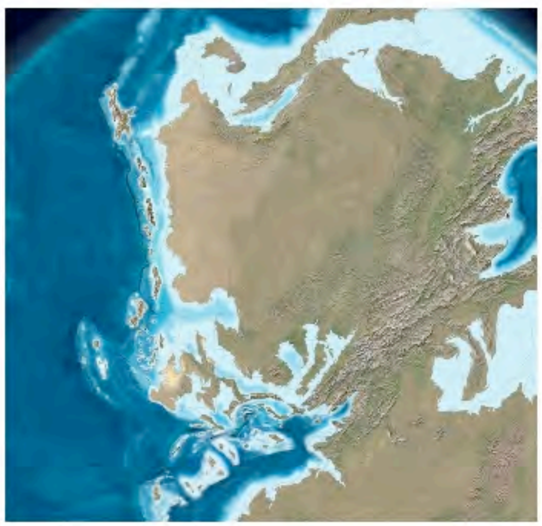
Murphy and Nance 2008



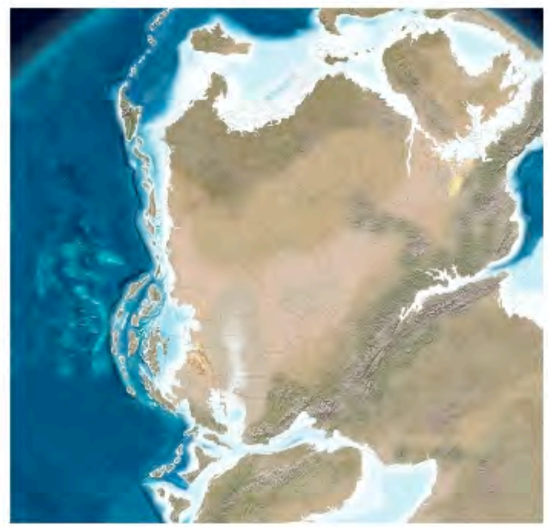
Late Precambrian 550 MY



Ordovician Taconic Orogeny
450 MY



Pennsylvanian
Acadian Orogeny 315 MY



Late Permian Alleghenian Orogeny
260 MY

Modified from Blakely http://jan.ucc.nau.edu/~rcb7/nam.html