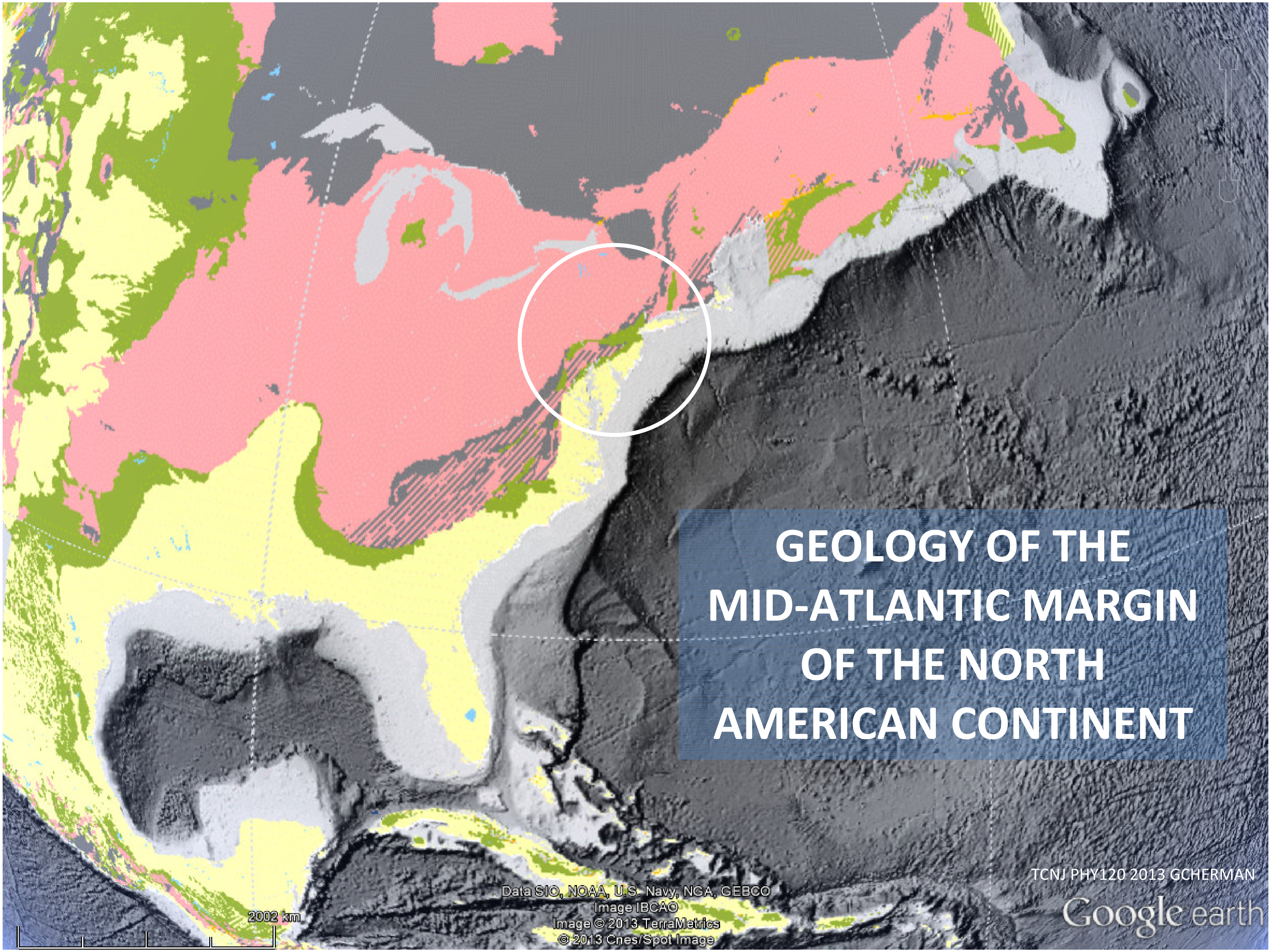
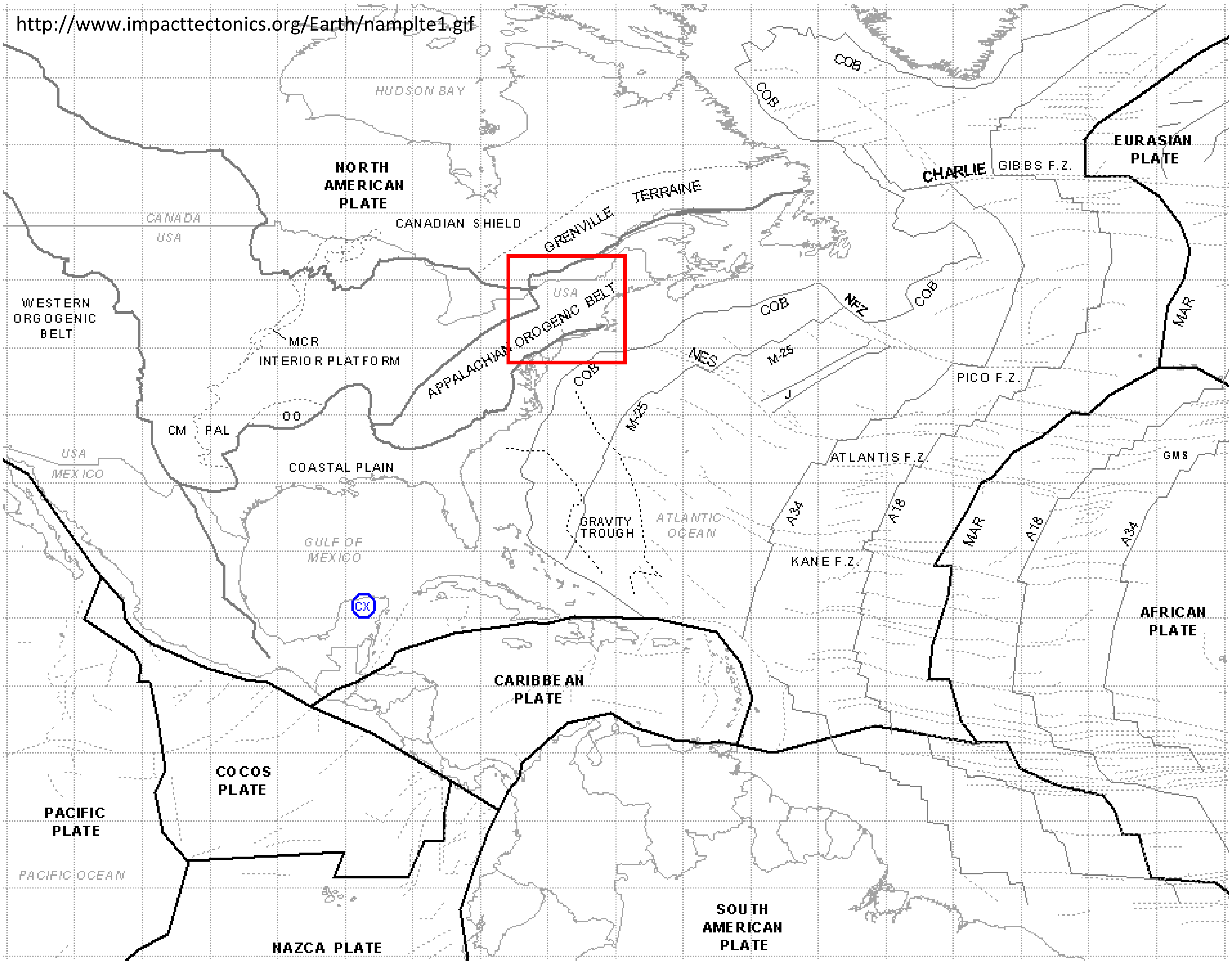
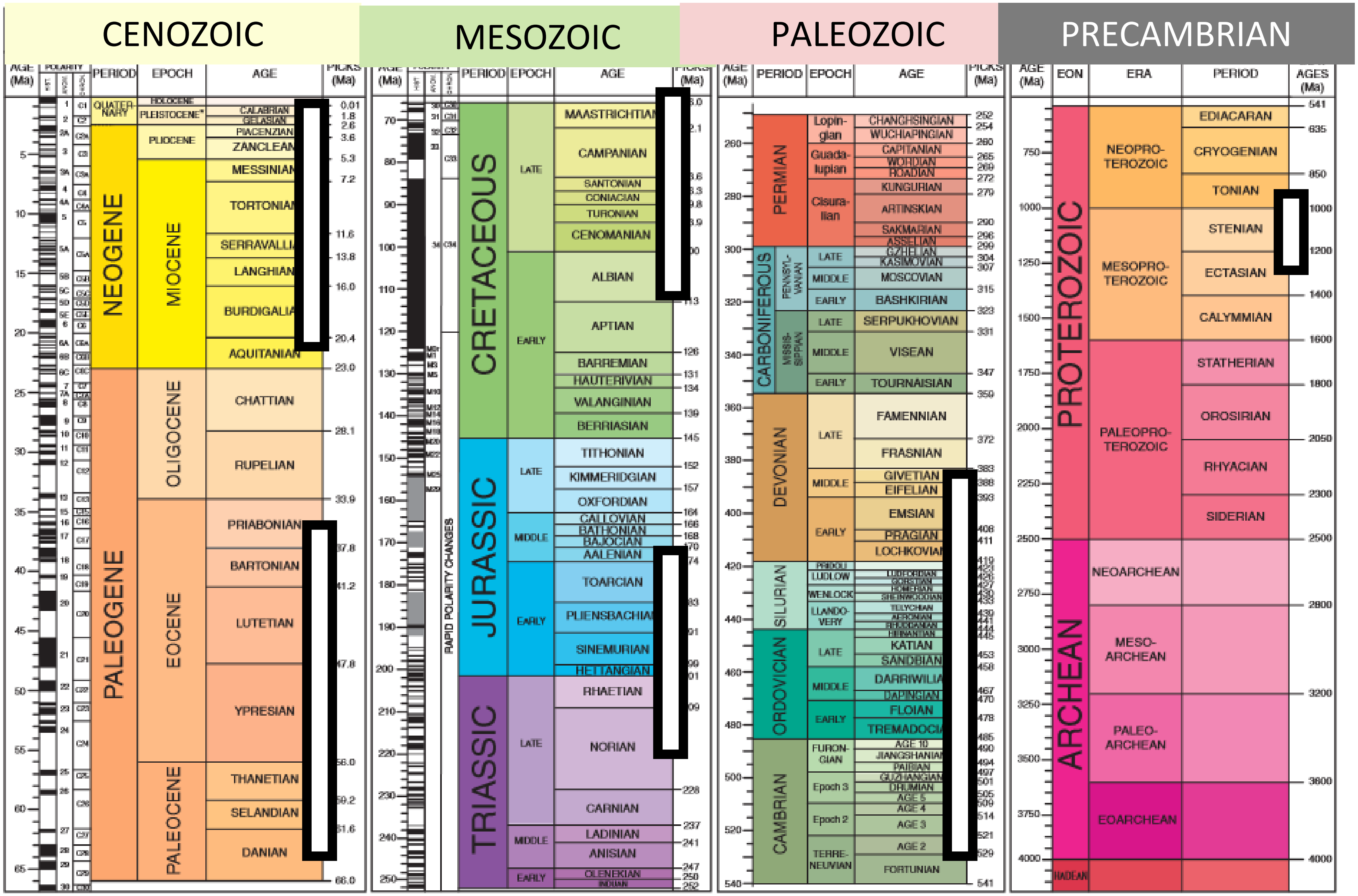

GEOLOGY OF THE
MID-ATLANTIC MARGIN
OF THE NORTH
AMERICAN CONTINENT
TCNJ PHY120 2013 GCHERMAN
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image IBCAO
Image © 2013 TerraMetrics
© 2013 Cnes/Spot Image
2002 km
Google earth

http://www.impacttectonics.org/Earth/namplte1.gif



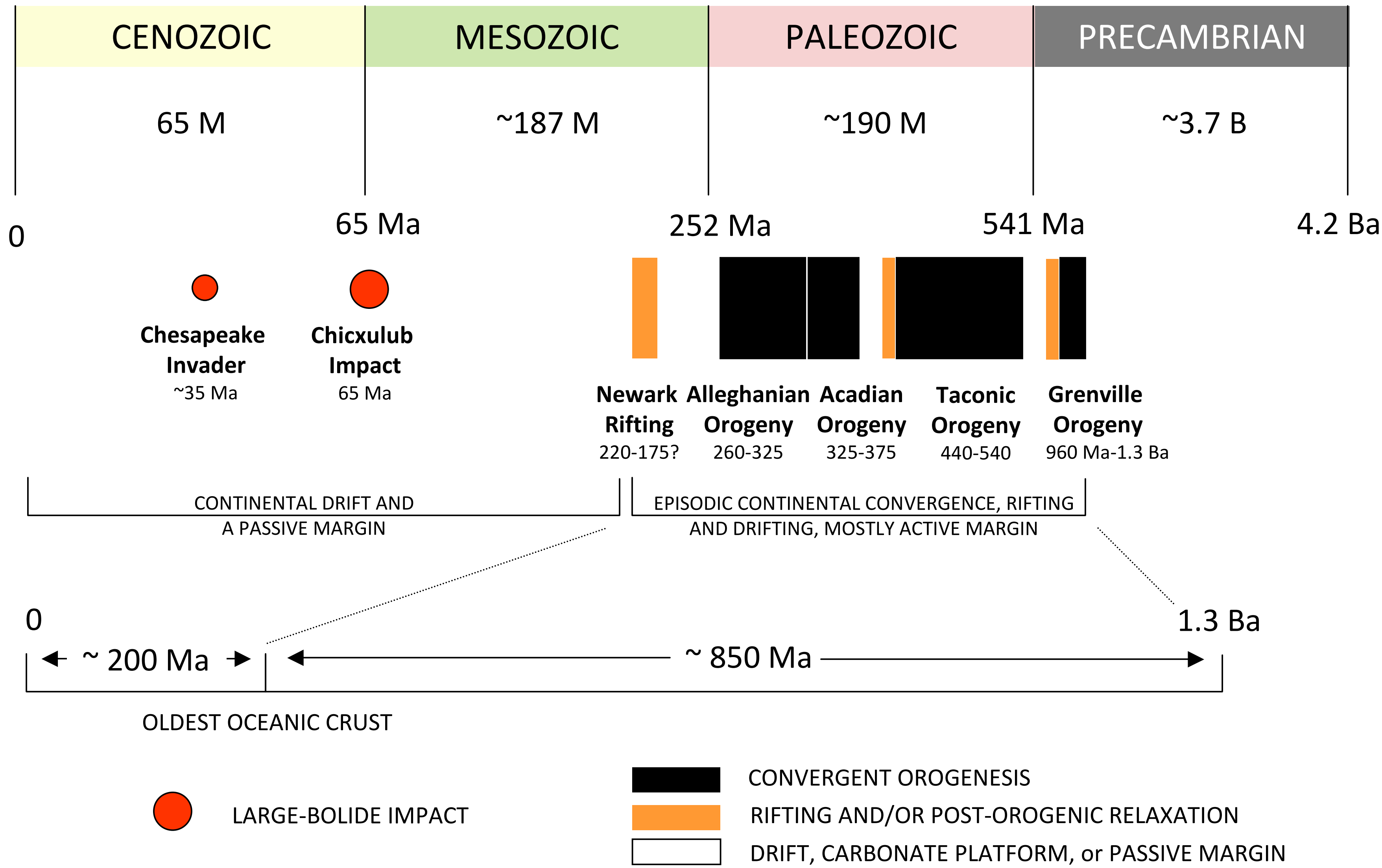
GSA GEOLOGIC TIME SCALE v. 4.0



ROCKS AND SEDIMENTS OF A WIDE RANGE OF AGES

THE GEOLOGICAL SOCIETY OF AMERICA®

MID-ATLANTIC MARGIN TECTONICS



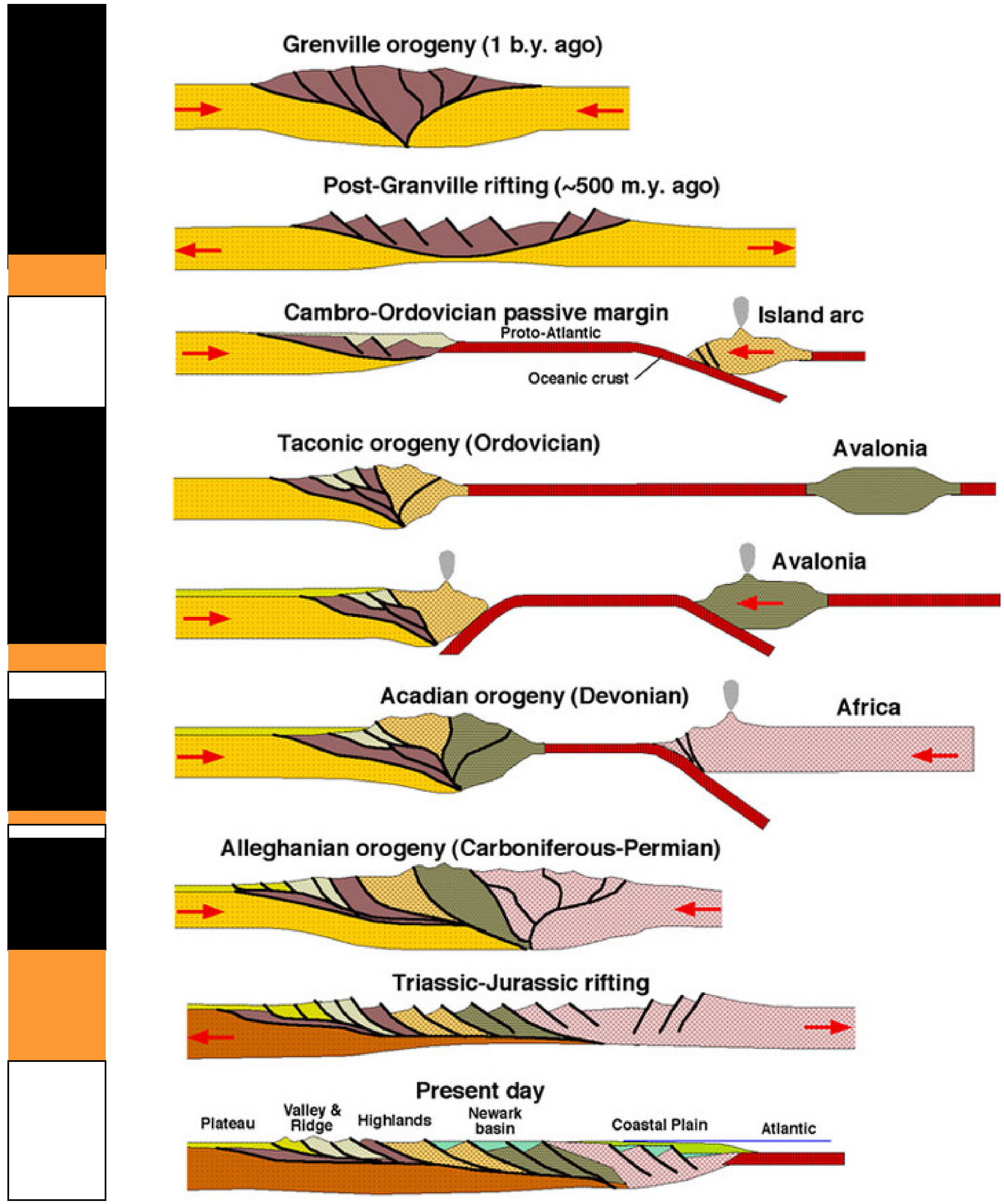
Grenville Orogeny
960 Ma-1.3 Ba

Taconic Orogeny
440-540

Acadian Orogeny
325-375

Alleghanian Orogeny
260-325

Newark Rifting
220-190?



GRENVILLE OROGENY

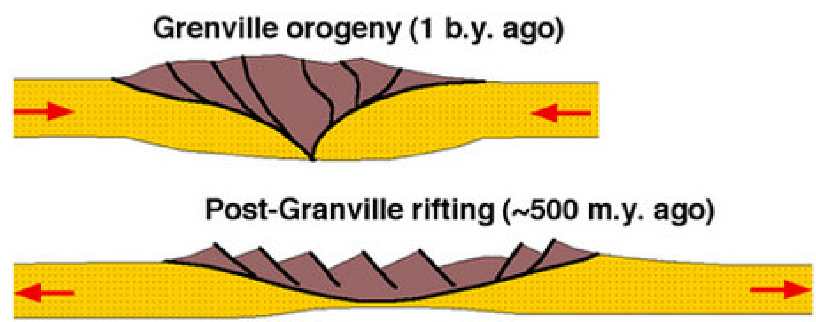
1.3 Ba - 960 Ma

- *The Grenville Orogeny was a long-lived, very old mountain-building event associated with the assembly of the supercontinent Rodinia.*

- Its record is a prominent orogenic belt which spans a significant portion of the North American continent, from Labrador to Mexico, as well as to Scotland.

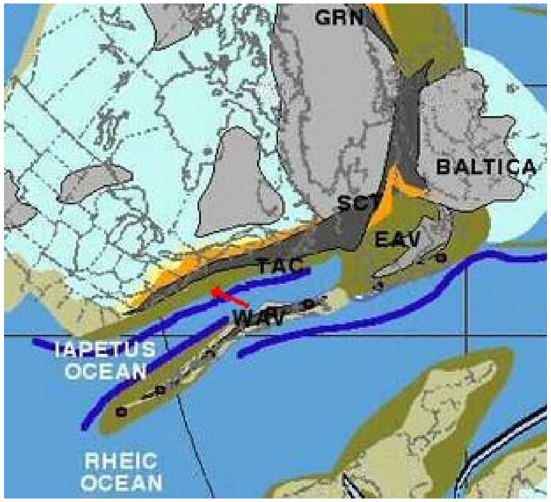
- Orogenic crust of mid-late Proterozoic age is found worldwide, but generally, only events which occurred on the southern and eastern margins of Laurentia are recognized under the “Grenville” name (Kibaran orogeny in Africa,and the Dalslandian orogeny in western Europe).

No higher resolution available.
Grenville-Extent.png (555 × 445 pixels, file size: 26 KB, MIME type: image/png)



TACONIC AND ACADIAN OROGENIES 540-325 Ma

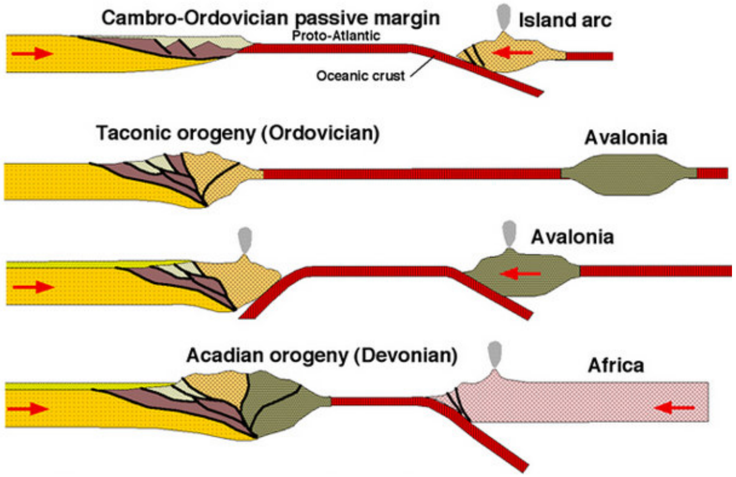
Dr. Ron Blakely, Northern Arizona University



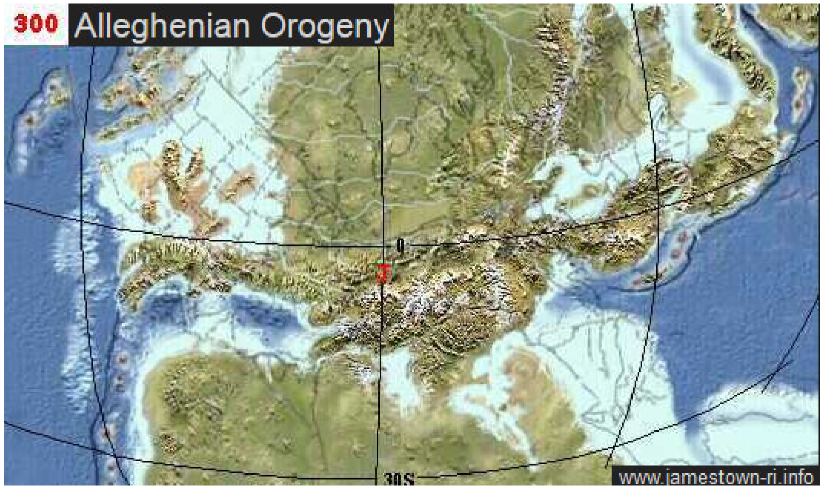
http://www.jamestown-ri.info/acadian.htm

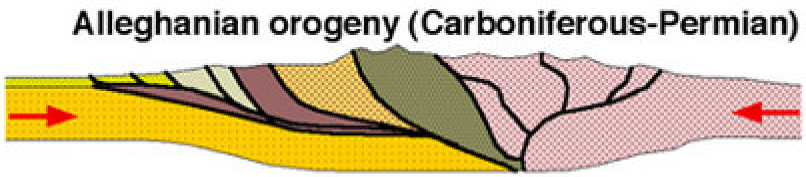
- Proto North America (PNA) about 430 million years ago, with Greenland nestled against northern Canada.
- PNA is straddling the equator, the present "east coast" is closer to being a "south coast", and much of the US and Canada was covered by shallow seas.

- Baltica, the core of western Europe, moving westward, made impact against Greenland, and raised mountains on both continents.
- The Taconic island chain (TAC) began to collide with Proto North America about 40 million years earlier (470 to 450 million years ago).
- The Iapetus Ocean, which had been the shoreline for Proto North America, is closing as Western and Eastern Avalonia (WAV and EAV), following behind the Taconic arc, are heading for collision with the recently-extended coast of Proto North America.
- A wide swath of Iapetus Ocean seabed material will be pushed onto Proto North America as the Avalonian islands push against and onto Proto North America.



ALLEGHANIAN OROGENY 325-260 Ma

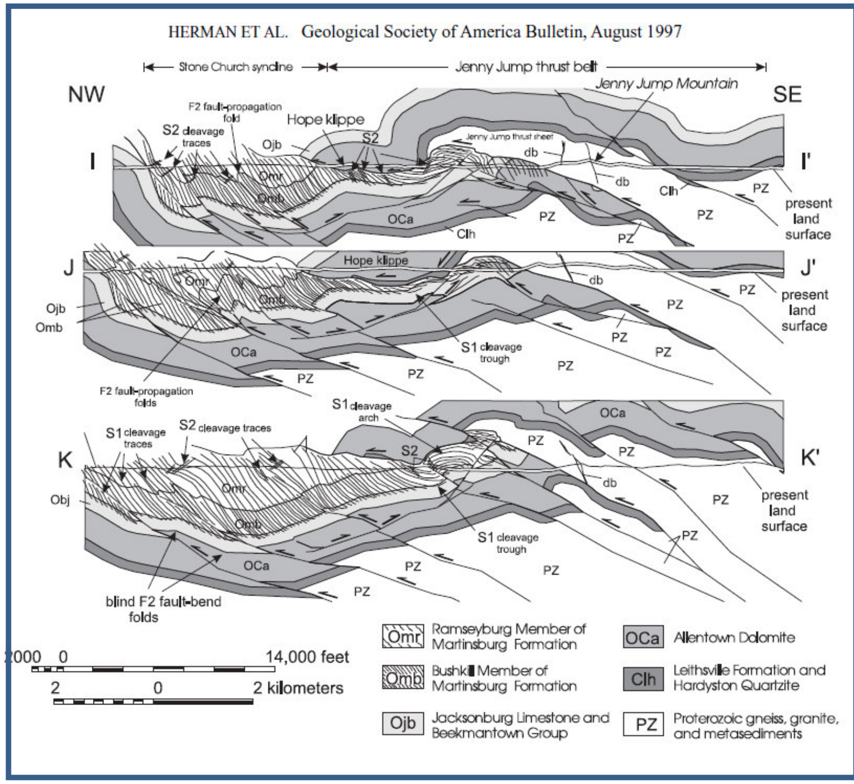


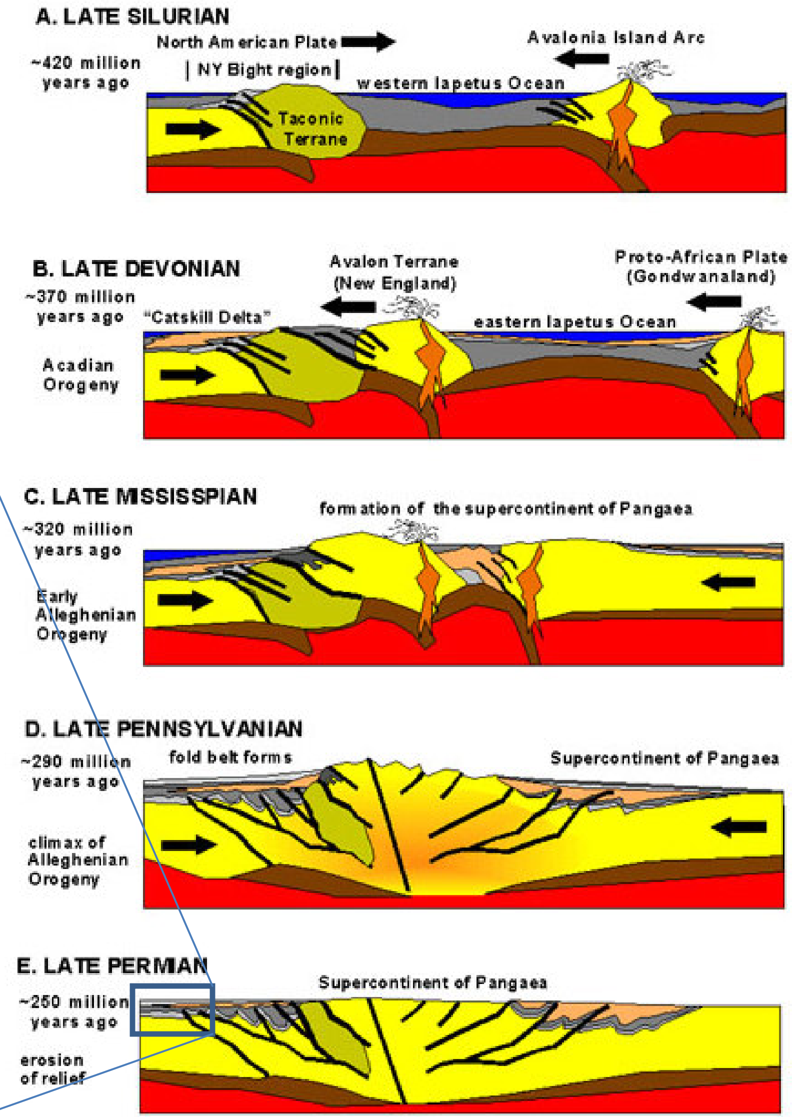


- *The Alleghanian orogeny is the suturing of two continents into the supercontinent Pangaea.*

ALLEGHANIAN OROGENY

- Orogenesis occurred approximately 325 million to 260 million years ago over at least five deformation events in the Carboniferous to Permian period.





NEWARK RIFTING

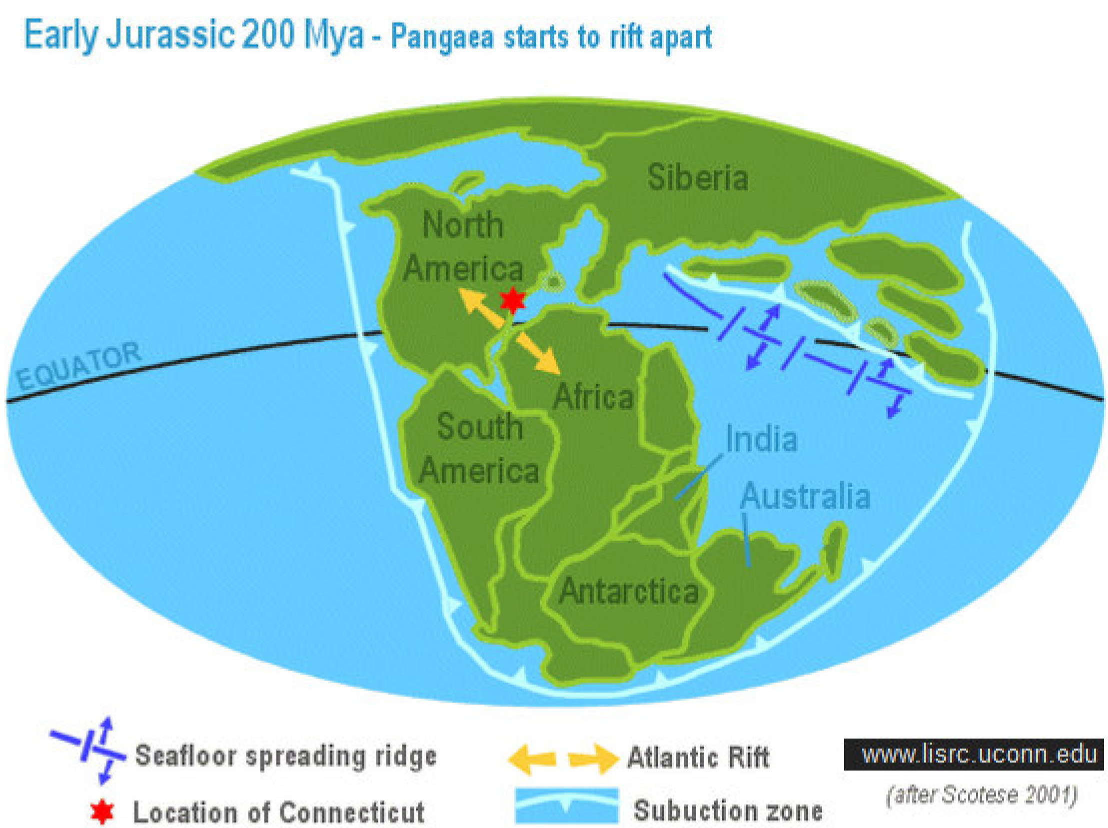
220-175 (?) Ma

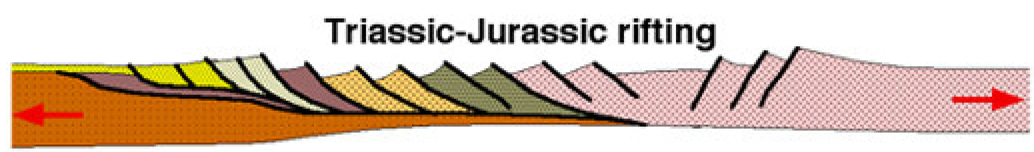
- *Approximately 220 million years ago, during the late Triassic Period, the supercontinent Pangaea began to break apart.*

- *The focus of the rifting began somewhere between where present-day eastern North America and north-western Africa were joined.*

- The rifted margins subsided, forming basins in which continental and marine sediments accumulated with evaporites forming in restricted basins.

- Sills, dikes and lava flows were injected into predominantly non-marine sediments during the early (Triassic) history.





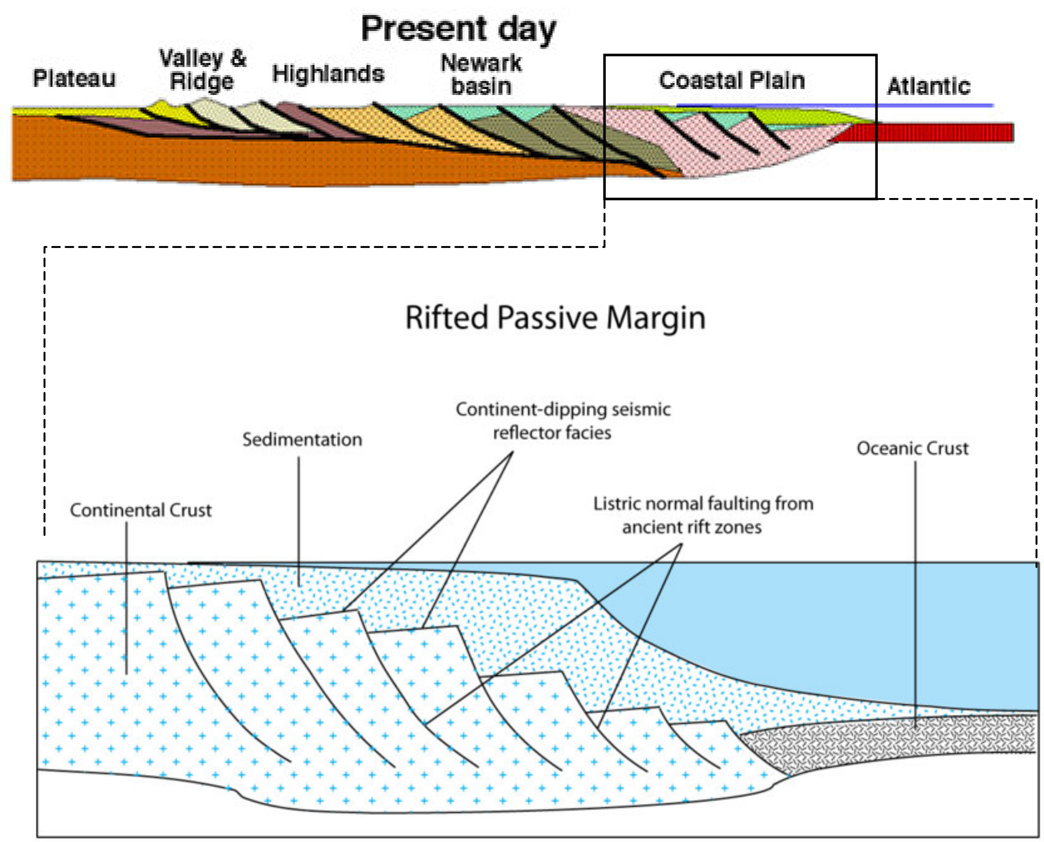
PASSIVE (?) DRIFT

175 (?) Ma - 0

•The rate of subsidence slowed with time as the margin cooled, but the accumulating sediment contributed to the sink rate.

•Following the rifting and initial accretion of oceanic crust, the Atlantic grew to over 1,000 kilometers wide during the Jurassic, but this early ocean was shallow because it was over the spreading center.

•During the late Cretaceous and Cenozoic, the controls on shelf sedimentation were regional warping and faulting and eustatic sea level changes.



•Subsidence with sediment influx and accumulation of sediments continued on the shelf and a continental rise was developed by turbidity current deposits from the shelf and slope.

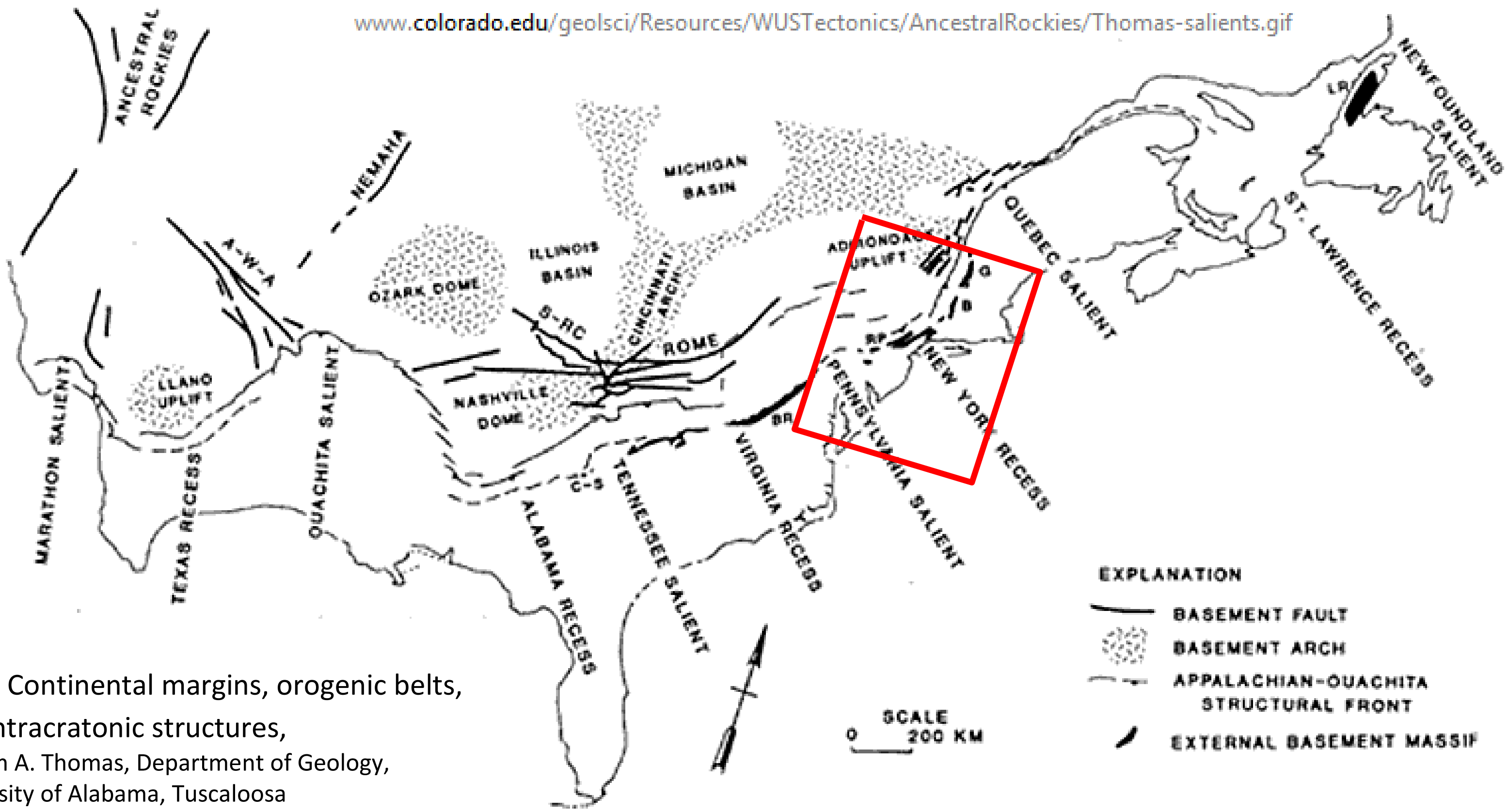
• The North American continent is growing along the Atlantic slope and the shelf break advances seaward as sediments accumulate over older strata. The sequence in the growth of the Atlantic margin is a model for divergent margin development.

•No mention of impact tectonic effects in the current geological tectonic framework.

ARCHITECTURE OF THE EASTERN MARGIN OF THE NORTH AMERICAN PLATE

- The eastern seaboard of the North American continent is scalloped with a series of concave and convex regions stemming from overlapping, orogenic (and impact) events.

- Angular bends (promontories and embayments) in rifted and passive continental margins are interpreted to be the precursors of curves (*recesses and salients*, respectively) in orogenic belts.

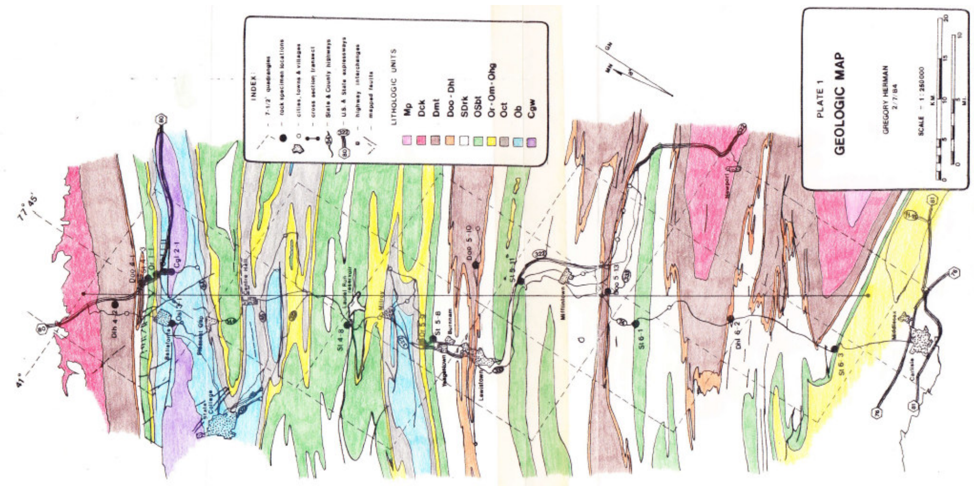


1983, Continental margins, orogenic belts, and intracratonic structures,
William A. Thomas, Department of Geology, University of Alabama, Tuscaloosa

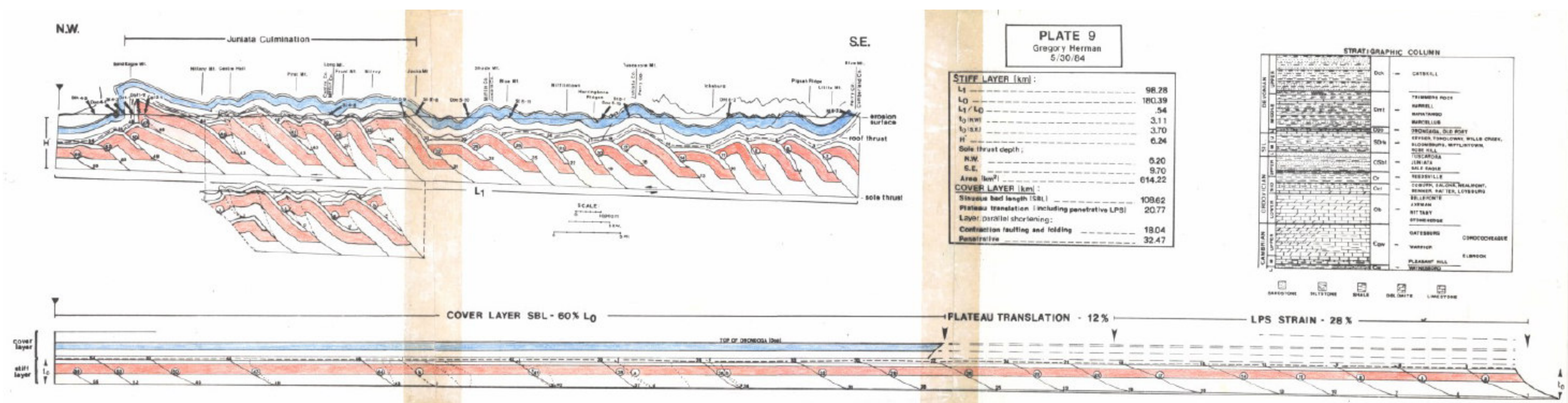
PENNSYLVANIA SALIENT AND THE NEW YORK RECESS

- Plate convergence at an irregularly shaped continental margin results in along-strike diachroneity of closing (and thus of orogeny) and in a variable trajectory of stress into continental crust.

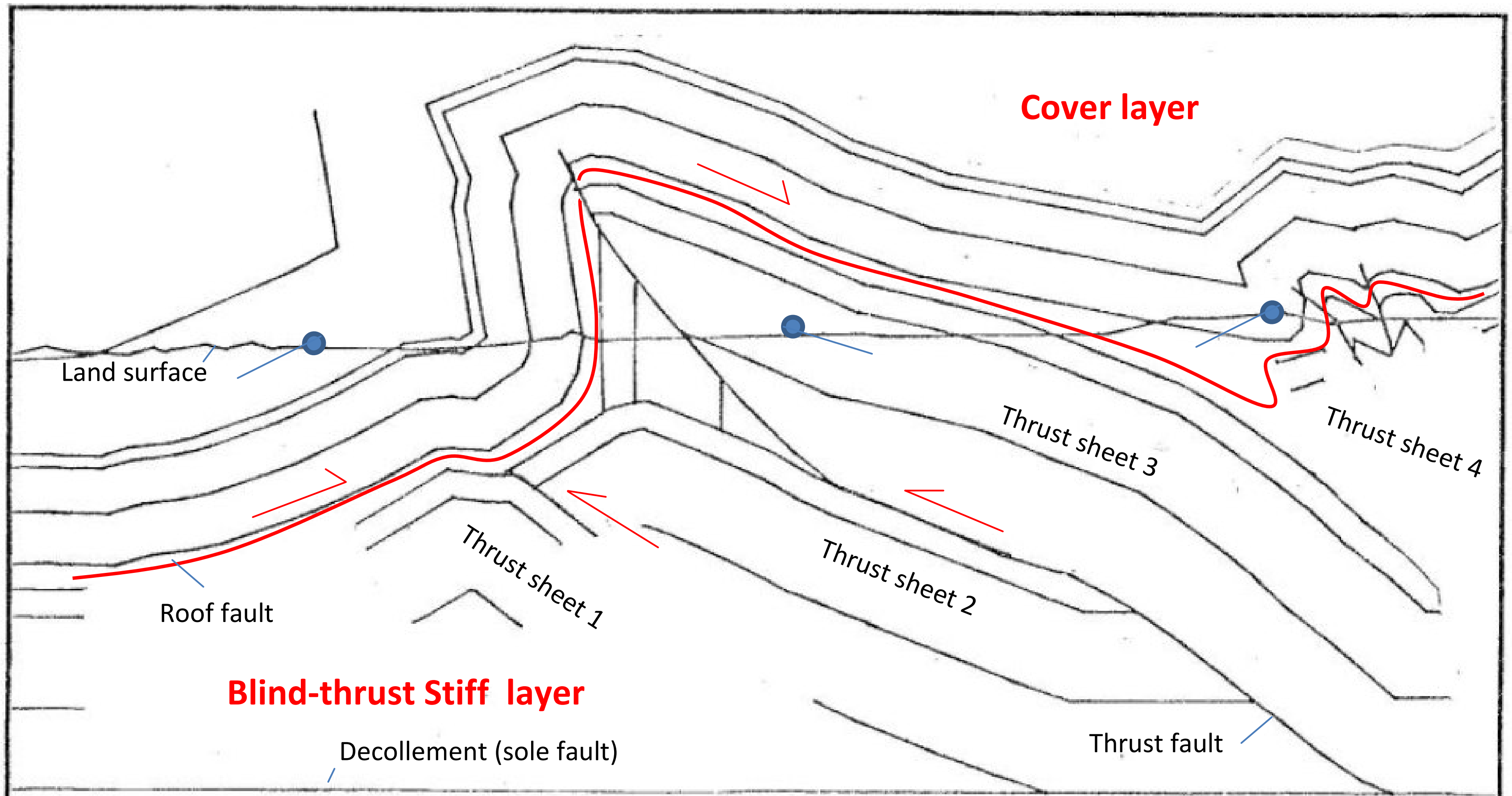
PALINSPASTIC INTERPRETATION OF THE PENNSYLVANIA SALIENT



- Blind-thrust, foreland fold-and-thrust belt of Alleghanian age.



COMPUTER-AIDED CROSS-SECTION INTERPRETATION



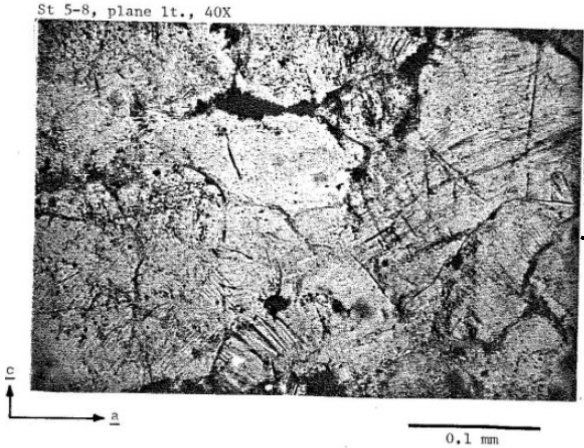
(C) EEO-LOSIC SYSTEMS, Inc. (83/02/12) Scale: 1 cent. = 998.248 klm. PARTA

Figure 8. - Developement of the stiff layer
The configuration of the outcropping stiff layer slices and the cover layer combine to help position other thrust slices. Refer to text for further explanation.

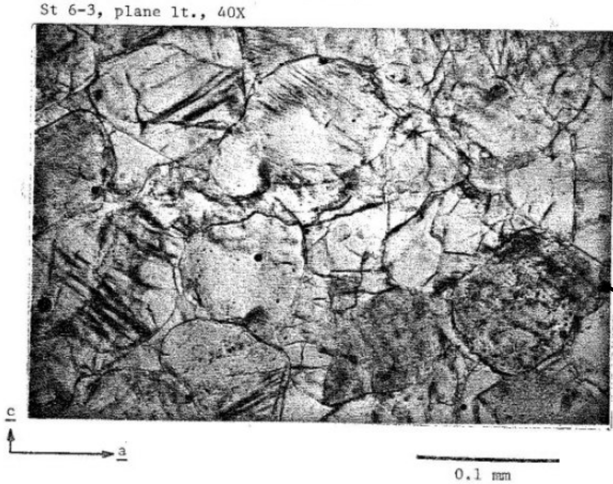
77

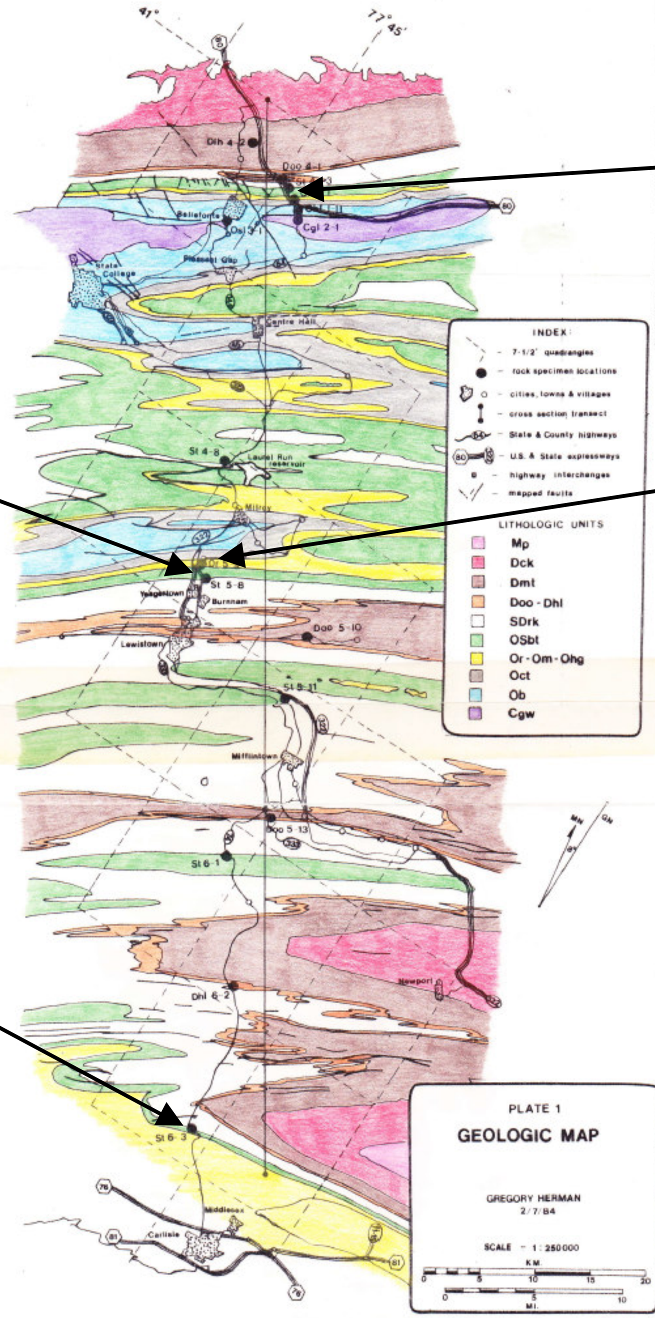
PENETRATIVE COVER STRAINS

St 5-8, plane lt., 40X



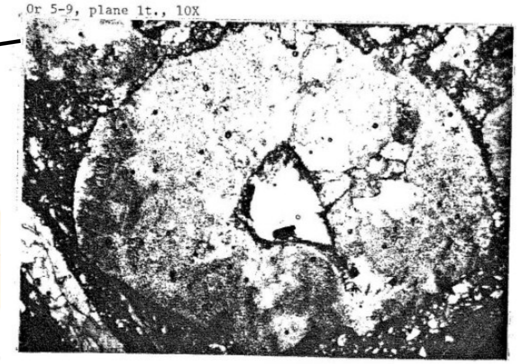
St 6-3, plane lt., 40X





St 4-3, plane lt., 40X

Or 5-9, plane lt., 10X

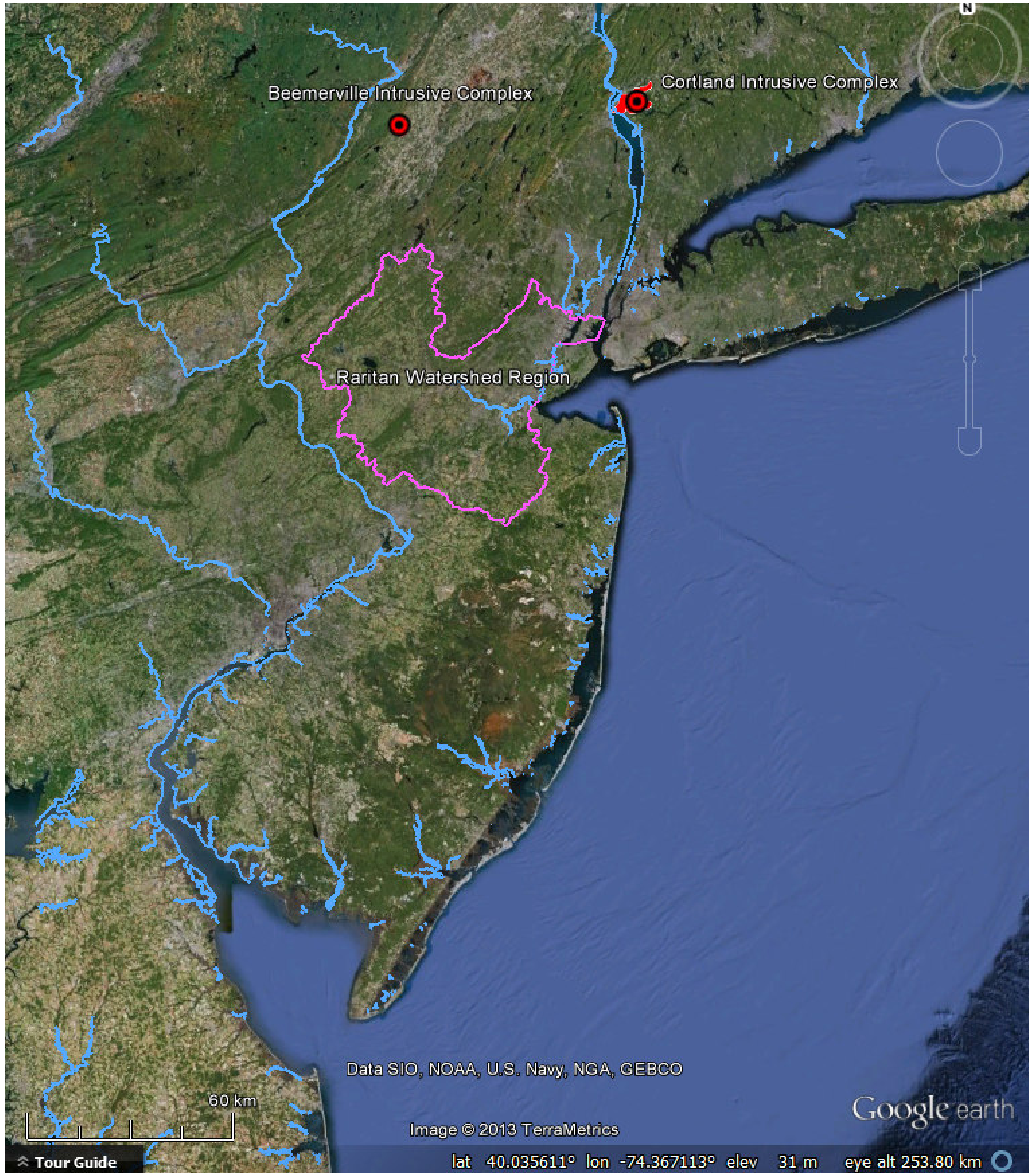


NEW YORK RECESS

Mid-Atlantic margin of the North American Plate, The York Recess

Default view for

L10_Mid-Atlantic_Geology.kmz



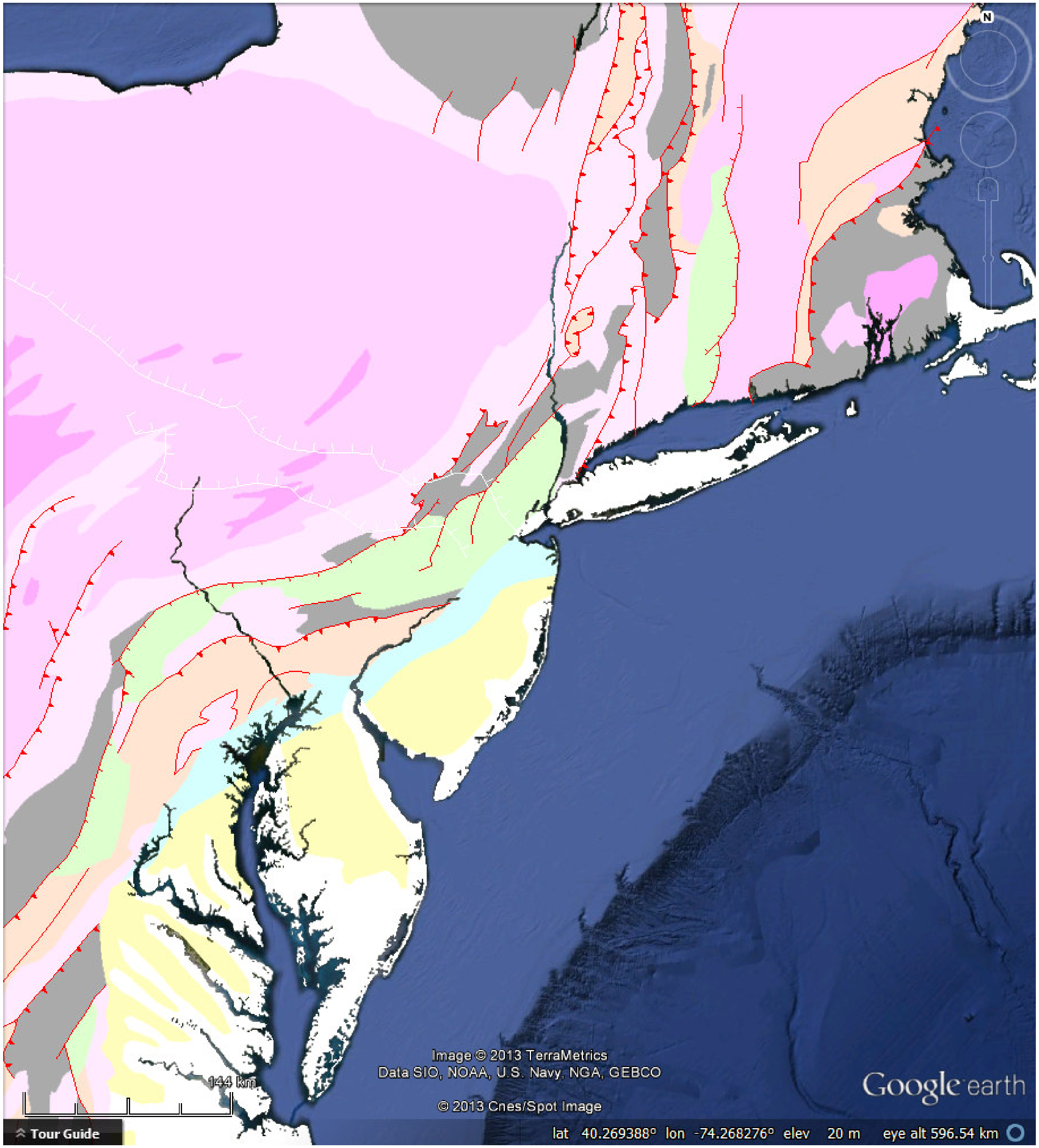
NEW YORK RECESS

Mid-Atlantic margin of the North American Plate, The York Recess

•Two regional bedrock geological studies between 1984 and 1997.

NEW YORK RECESS

Mid-Atlantic margin of the North American Plate, The York Recess

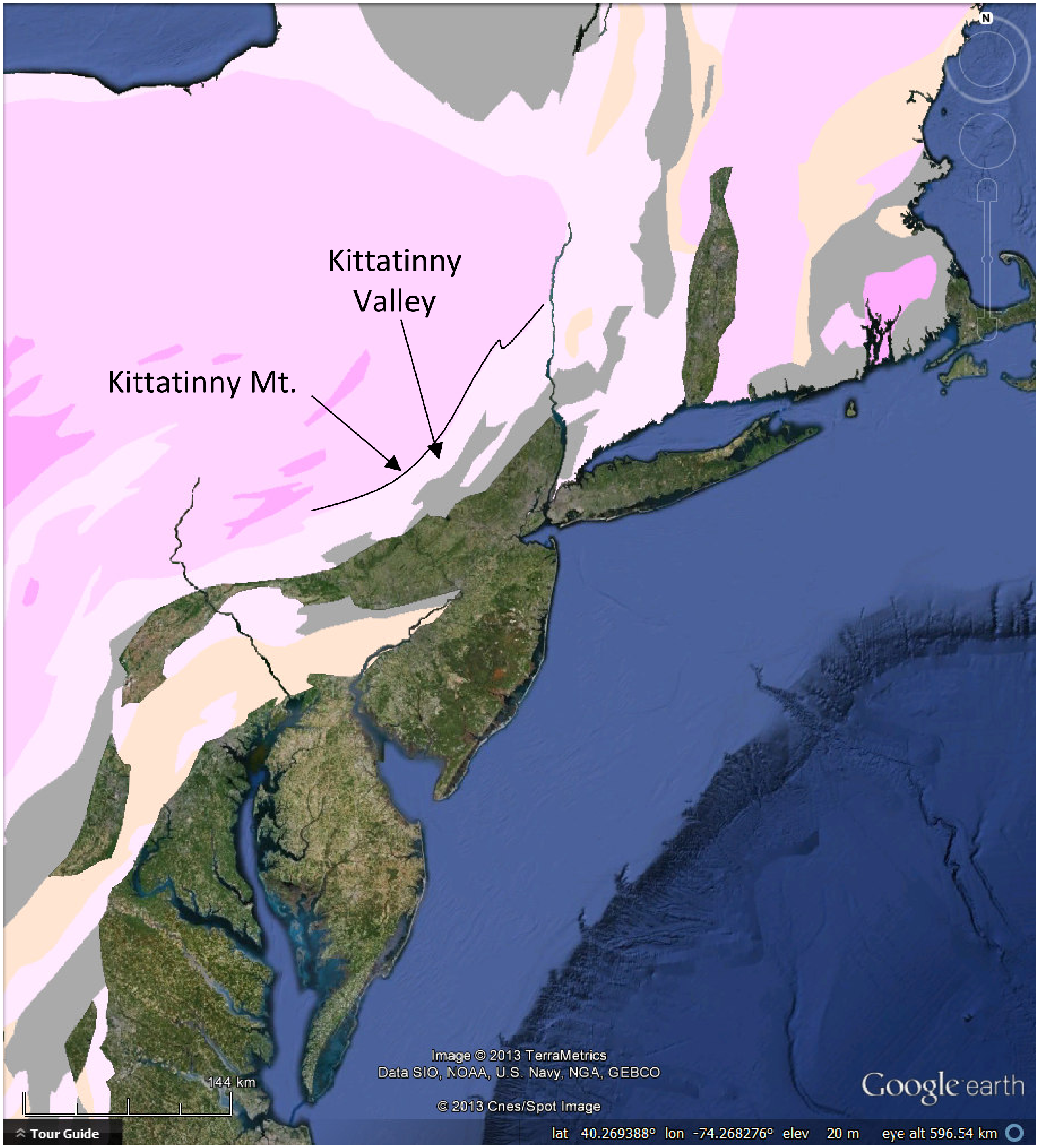


PRECAMBRIAN IGNEOUS AND GRANULITE FACIES BASEMENT MASSIFS

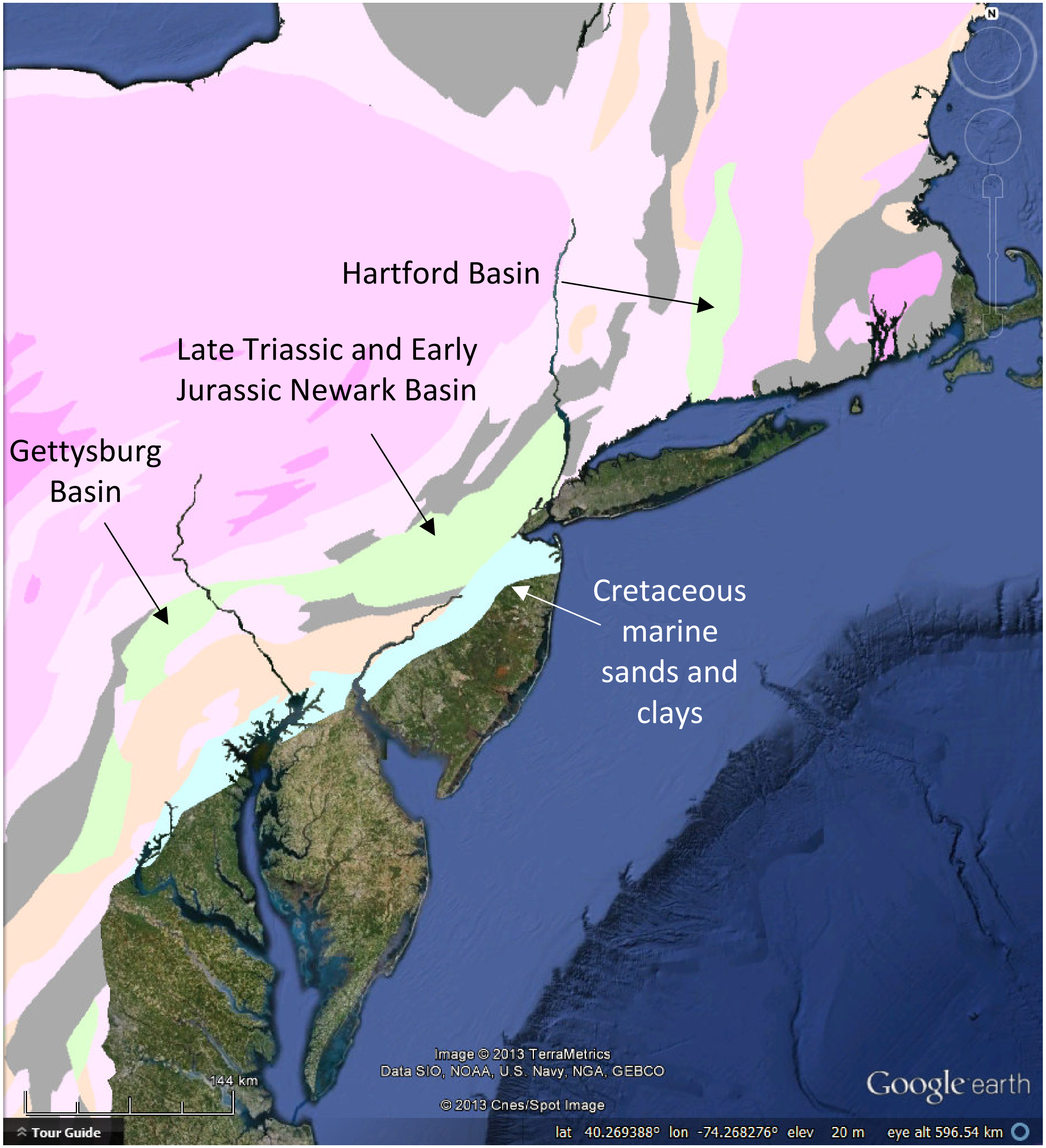
MIXED EARLY PALEOZOIC AND PRECAMBRIAN SCHIST AND METAMORPHIC ROCKS

PALEOZOIC ROCKS

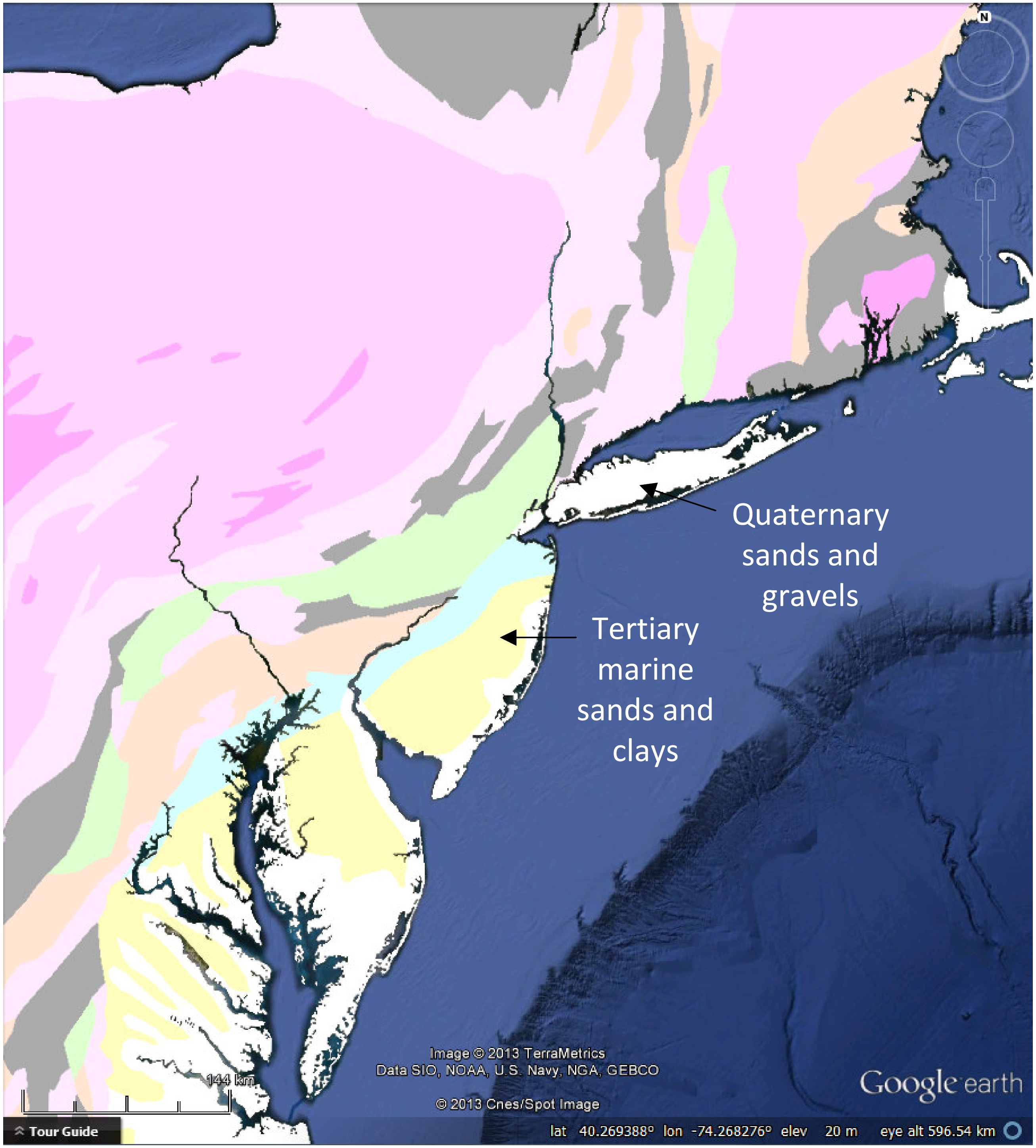
- LOWER, MIDDLE, AND UPPER



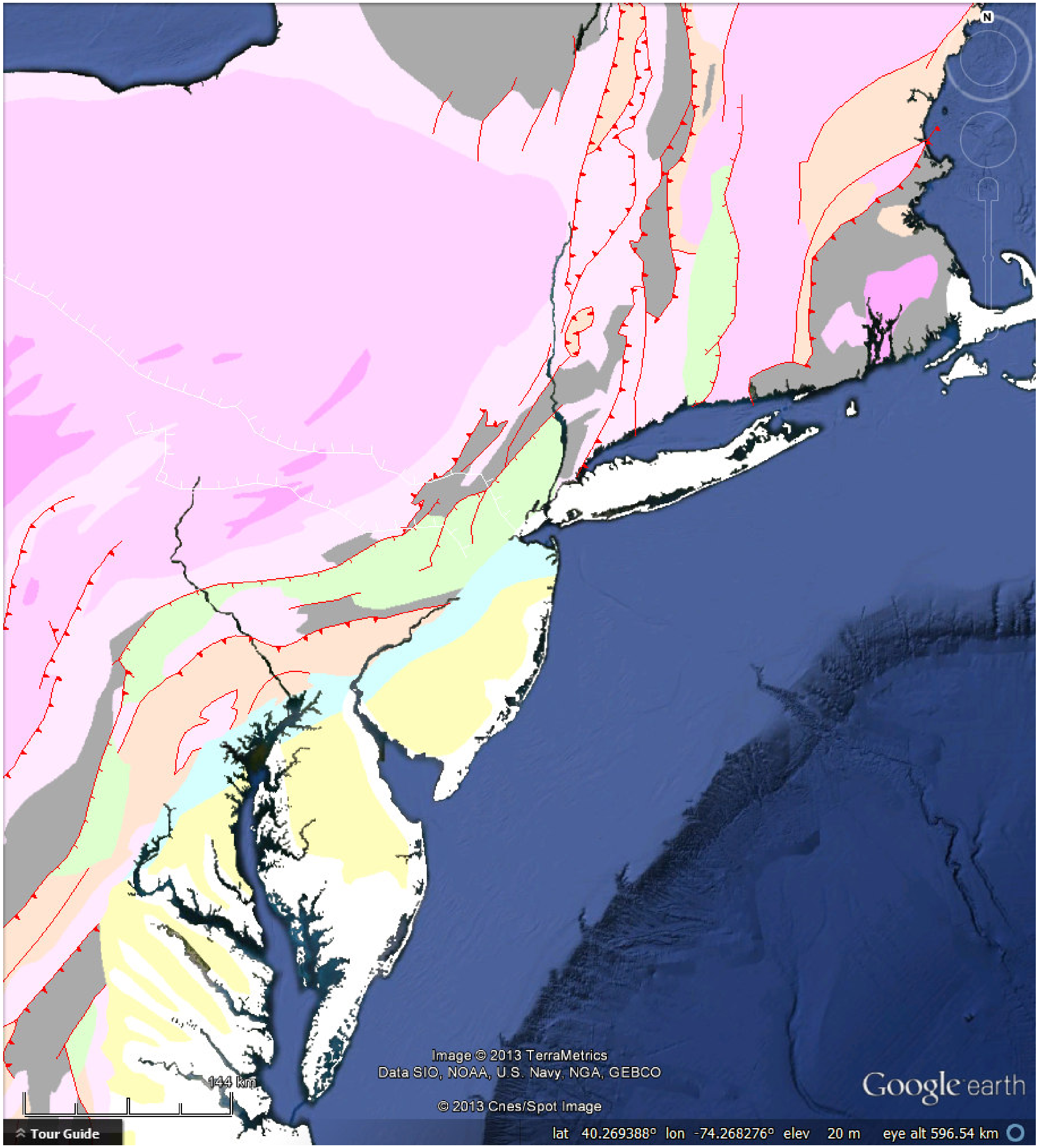
MESOZOIC ROCKS



CENOZOIC ROCKS

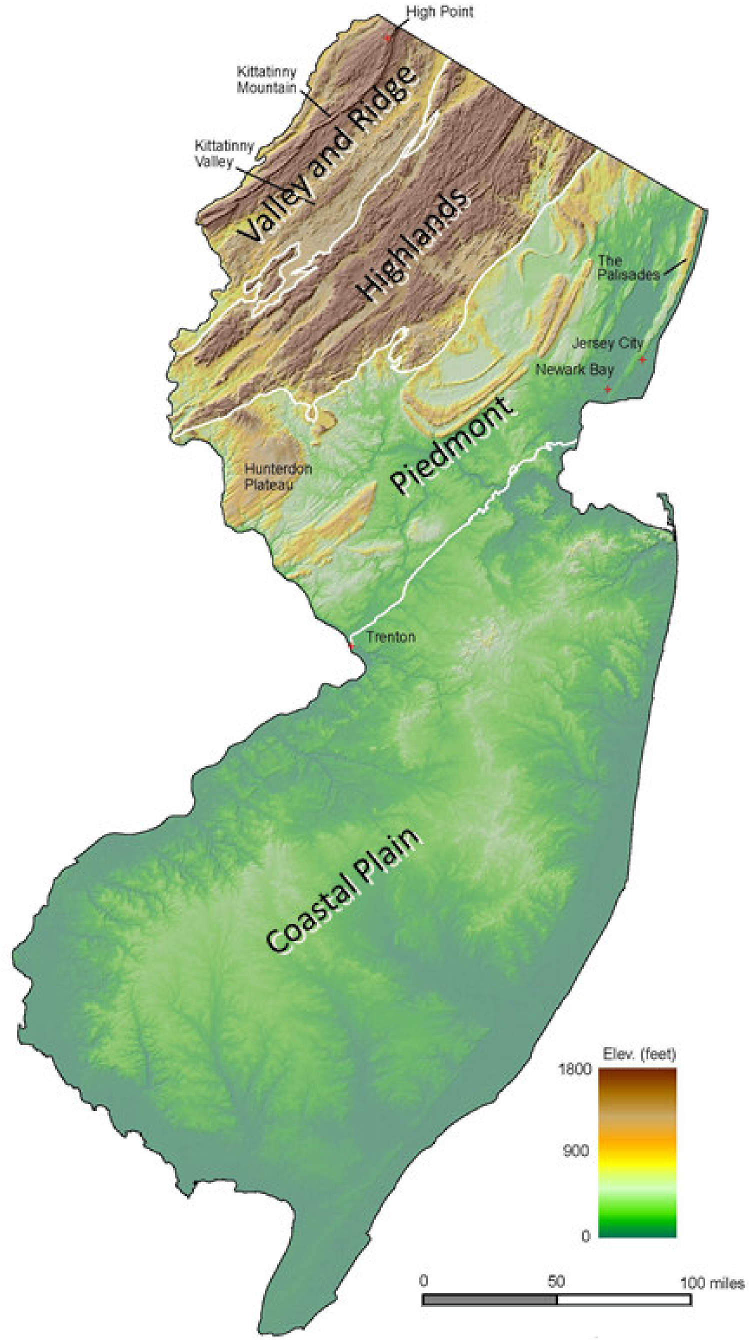


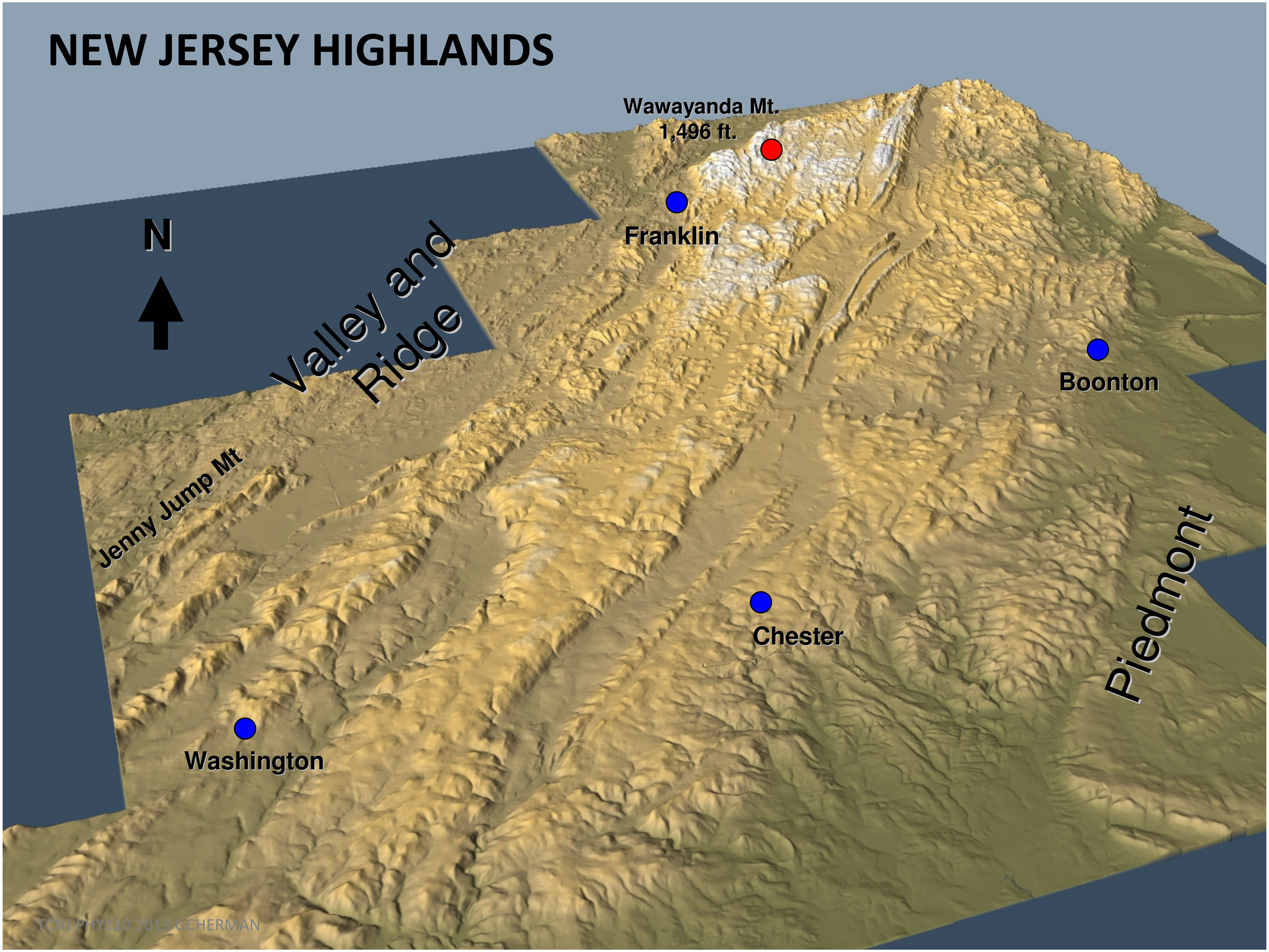
ALL ROCKS SHOWING MAJOR FAULTS AND GLACIAL MORAINES



NEW JERSEY HIGHLANDS

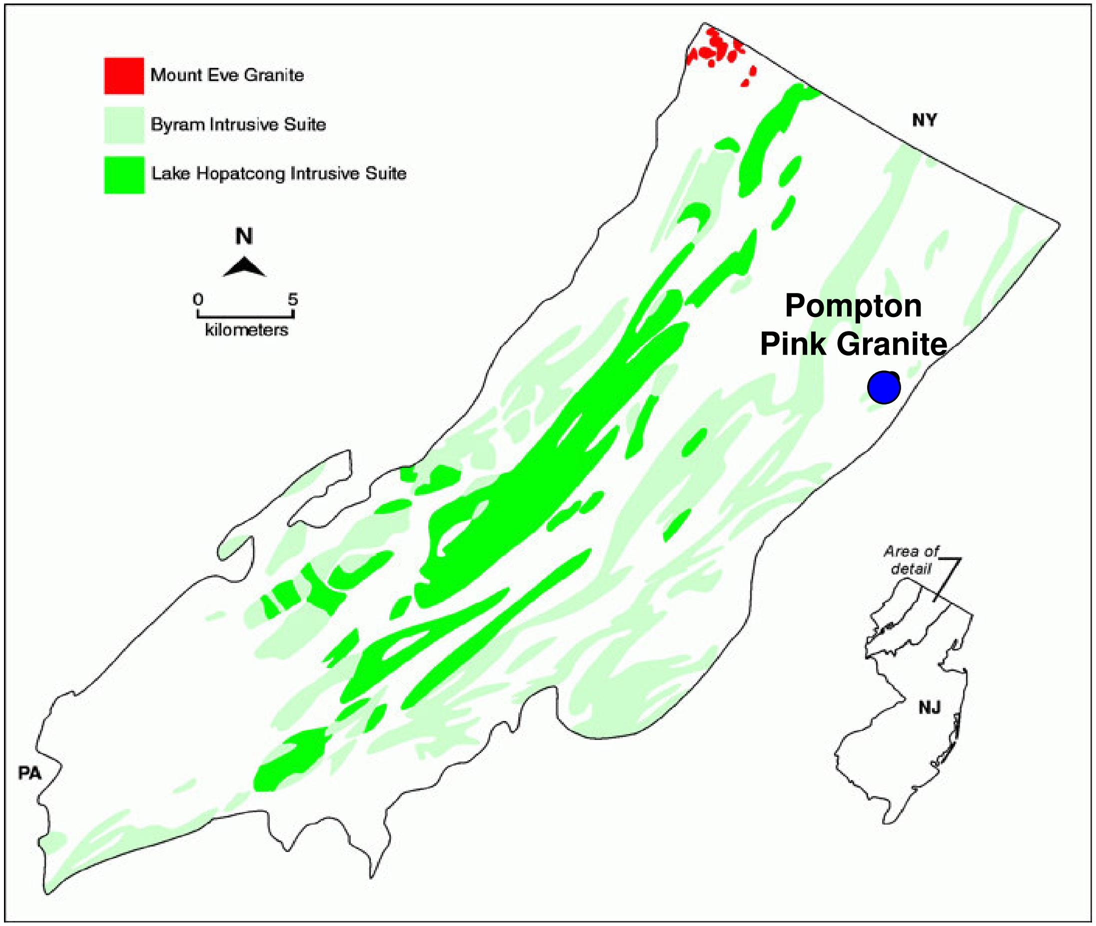
- Scenic and rugged terrain
- Mountainous uplands
- Northeast-trending ridges
- Rocks resistant to erosion
- Broad, flat valleys underlain by less resistant Proterozoic rocks and/or younger shale and limestone/dolomite




NEW JERSEY HIGHLANDS
Wawayanda Mt.
1,496 ft.
N
Franklin
Valley and
Ridge
Boonton
Jenny Jump Mt
Chester
Piedmont
Washington
TCNJ PHY120 2013 GCHERMAN

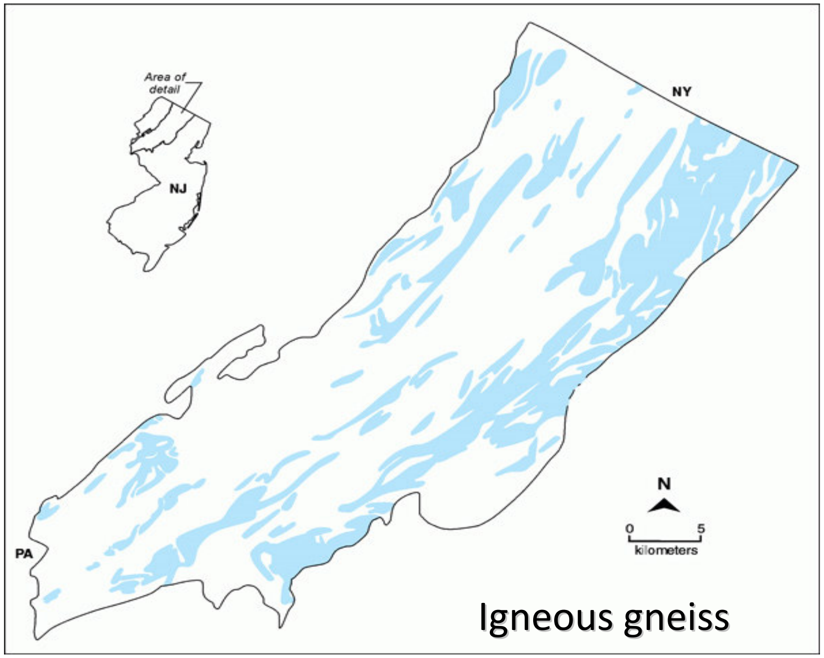
HIGHLANDS GRANITE

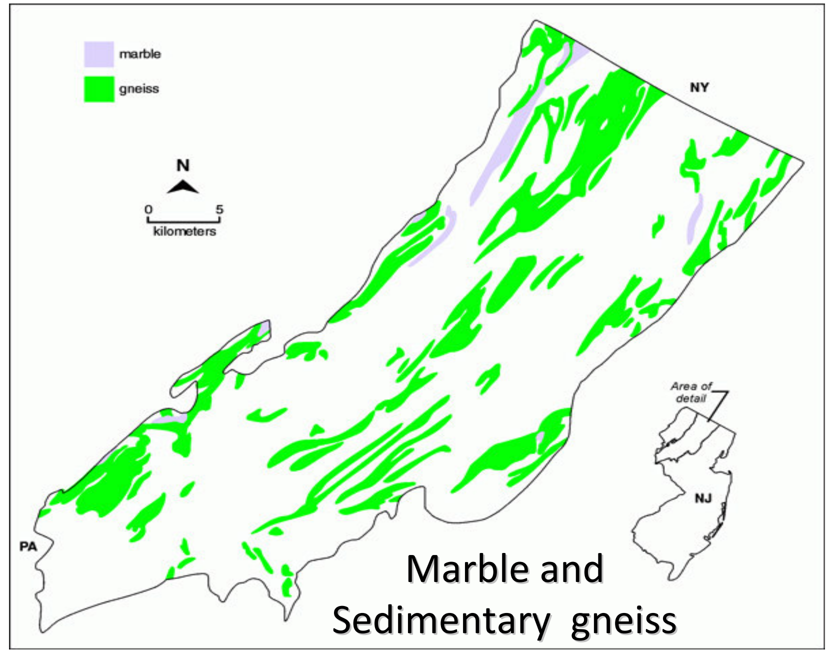
50% of outcrop area

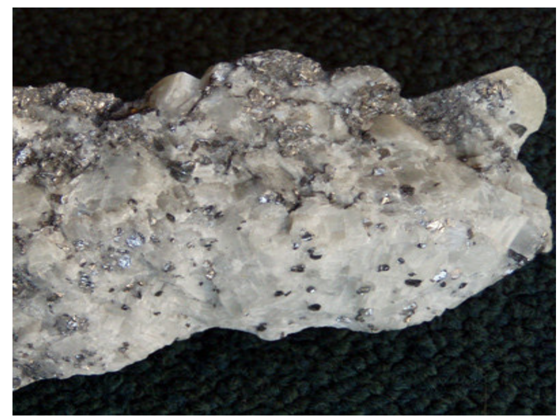


HIGHLANDS GNEISS AND MARBLE

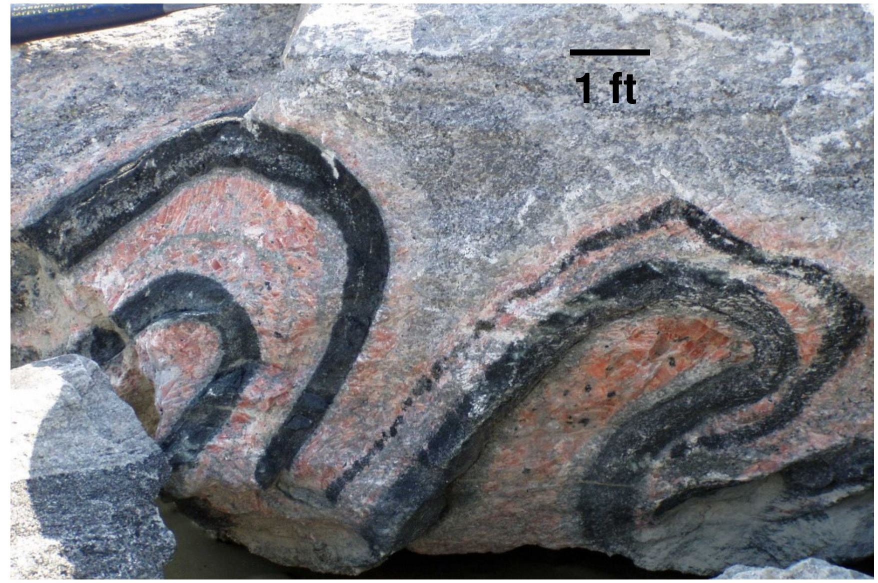
50% of outcrop area

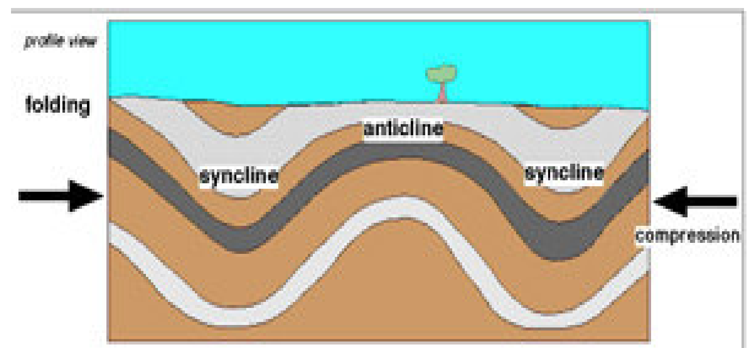






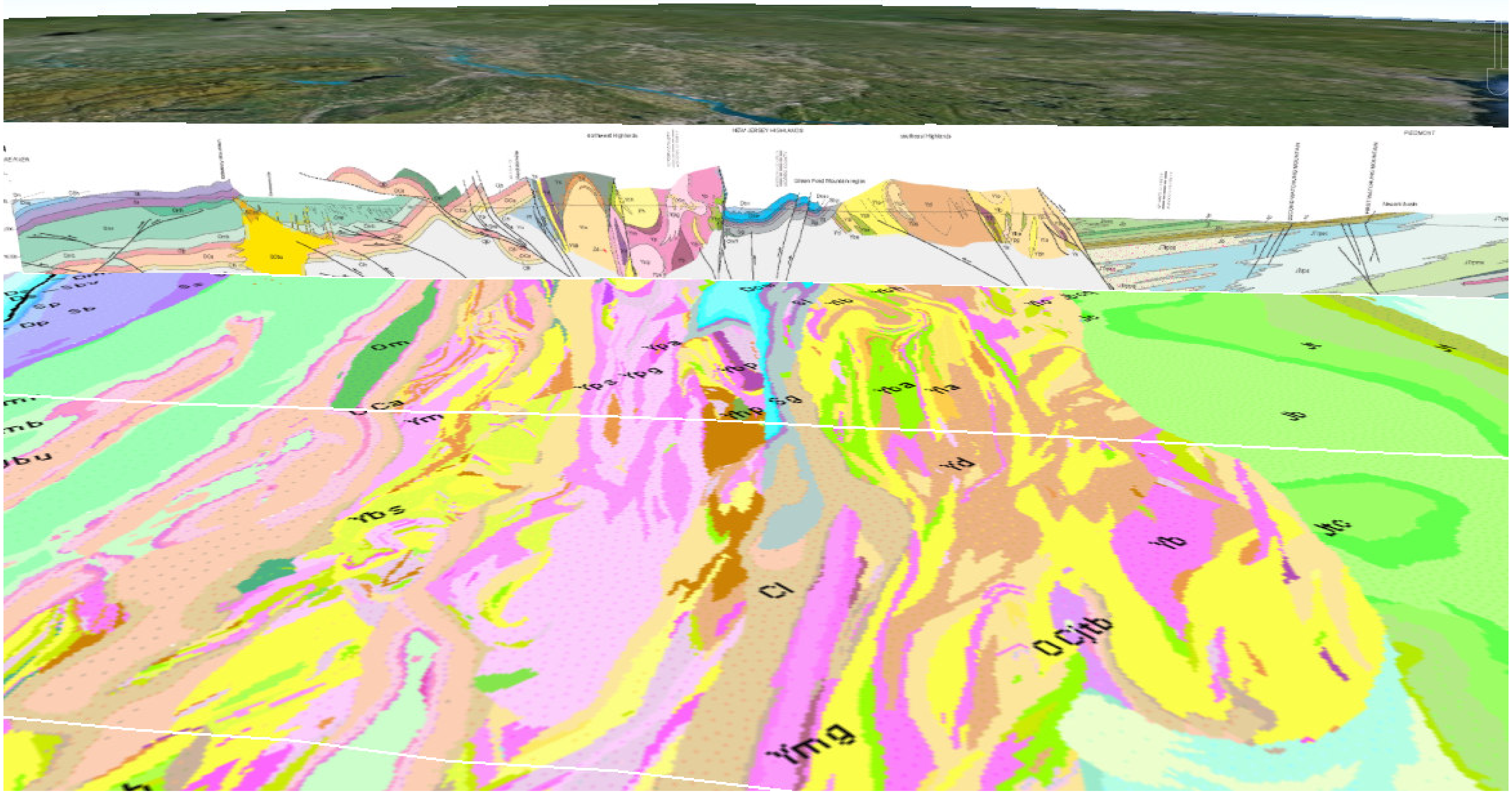
HIGHLANDS FOLDS





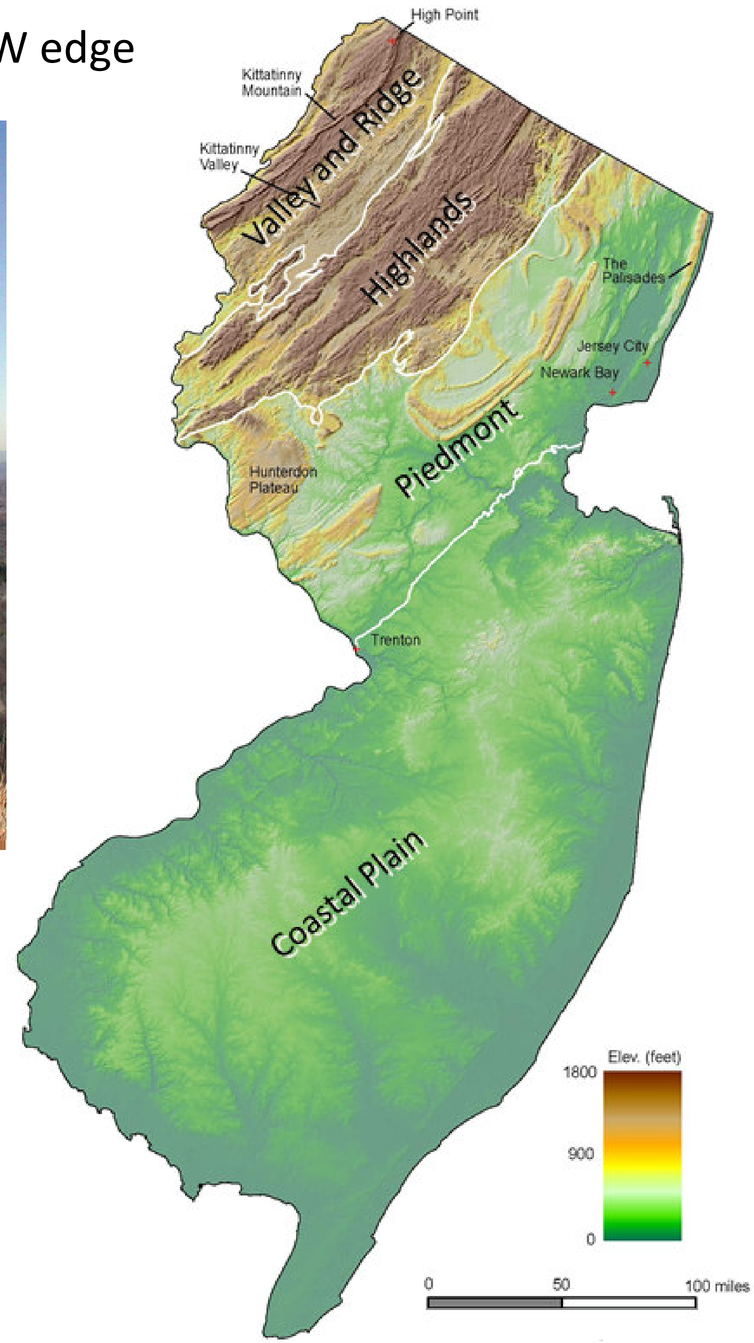
HIGHLANDS STRUCTURE 3D Google Earth View of NJ Bedrock Section A-A'

- http://www.impacttectonics.org/gcherman/downloads/GEO310/GCH_GESymbols/NJ_Bedrock_cross_section_A.kmz



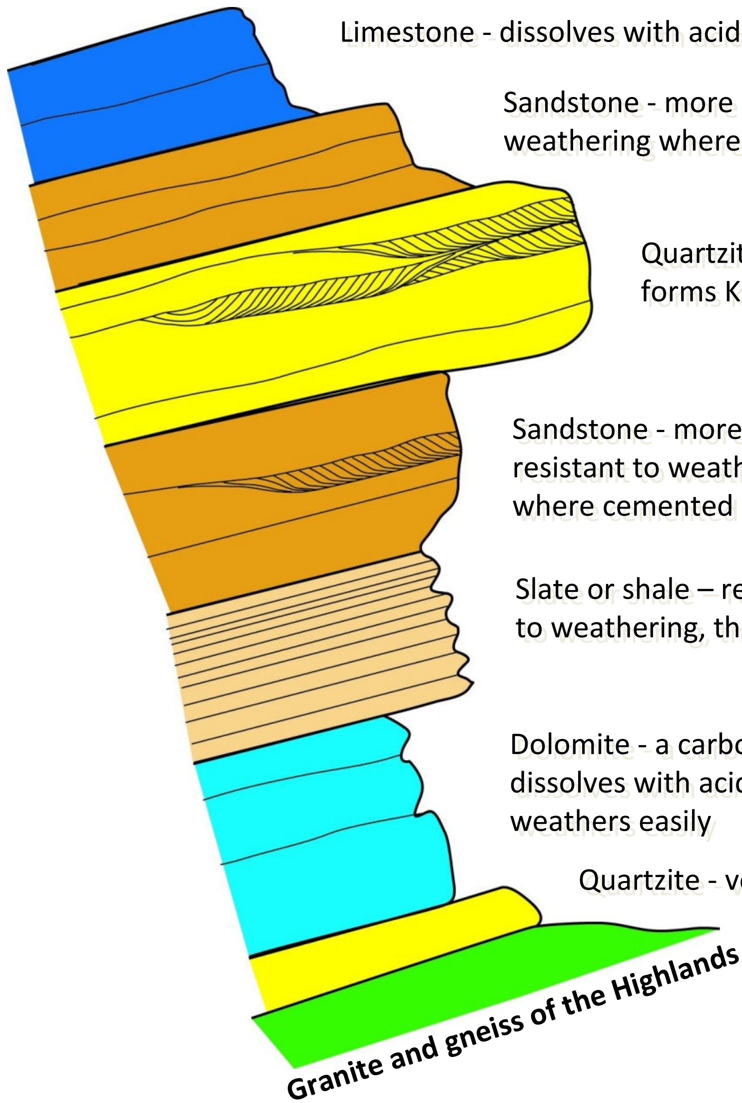
- NJ_Bedrock_cross_section_A.kmz (253 KB)

VALLEY & RIDGE About 1/15th of NJ on its NW edge



- Steep sided ridges and broad valleys composed of folded and faulted Paleozoic sedimentary and igneous rock (Cambrian-Middle Devonian 540-374 Ma)

VALLEY & RIDGE ROCKS



Limestone - dissolves with acid, weathers easily

Sandstone - more resistant to weathering where cemented

Quartzite - very resistant, forms Kittatinny Mountain

Sandstone - more resistant to weathering where cemented

Slate or shale – resistant to weathering, thin soils,

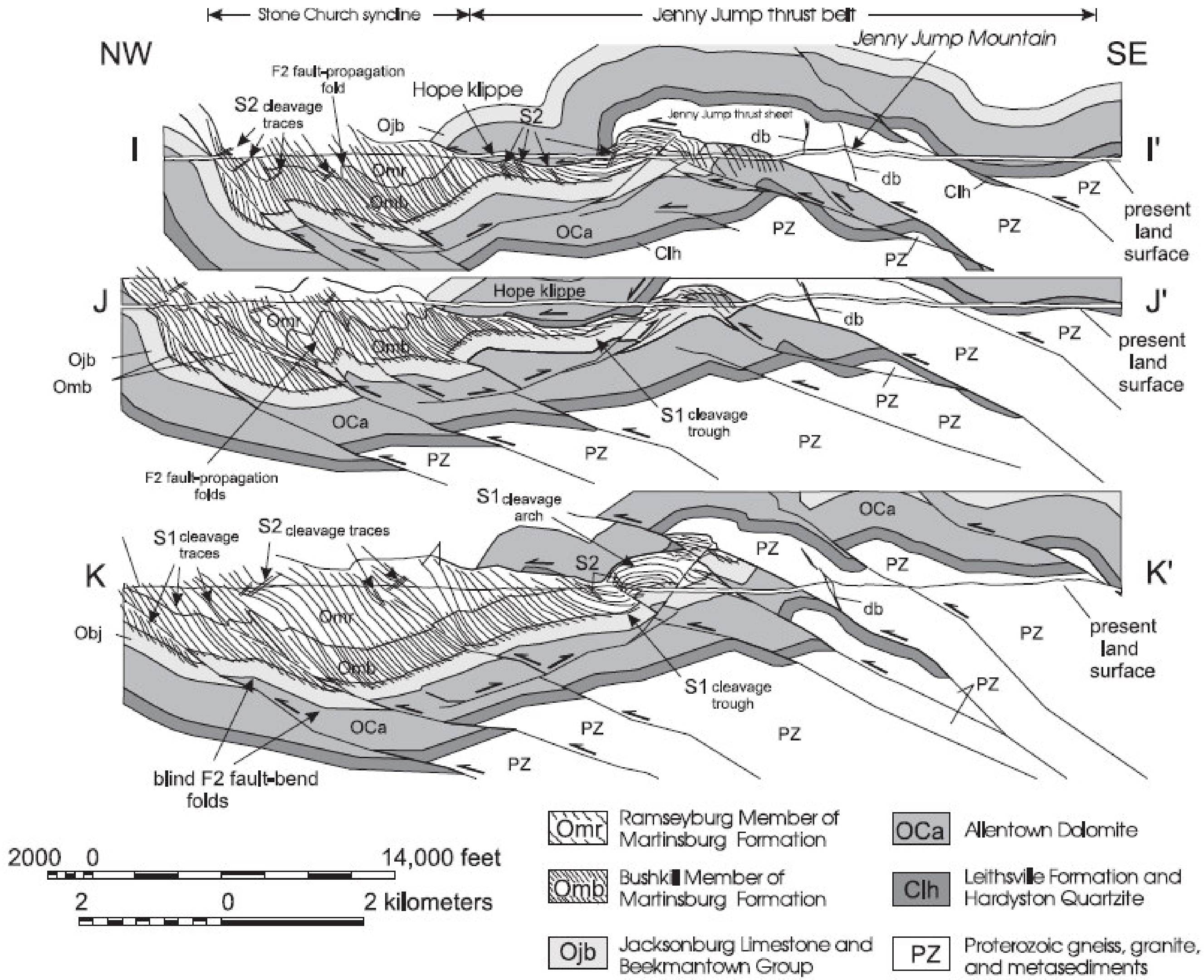
Dolomite - a carbonate, dissolves with acid, weathers easily

Quartzite - very resistant, forms ridges

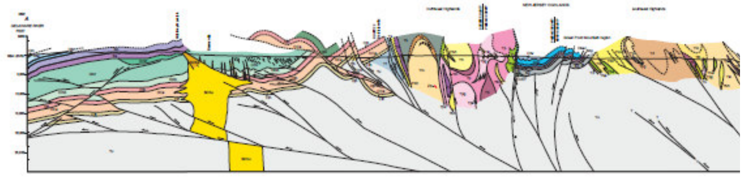
VALLEY & RIDGE STRUCTURES

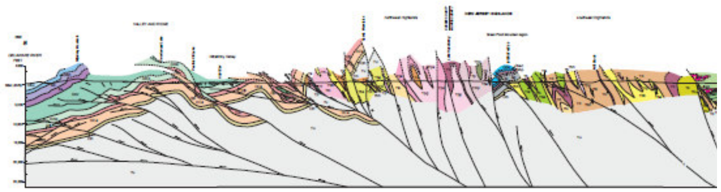
- Folds
- Cleavage
- Fractures
- Faults

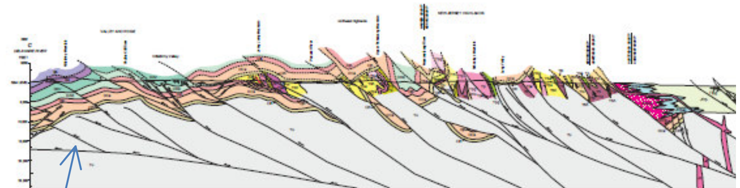
Kittatinny Valley and Jenny Jump Mt. Overthrust, Warren and Sussex Counties, New Jersey

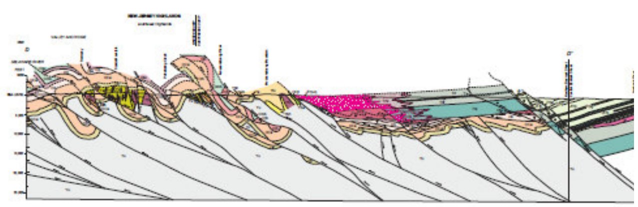


NJ RIDGE AND VALLEY THRUST SYSTEM



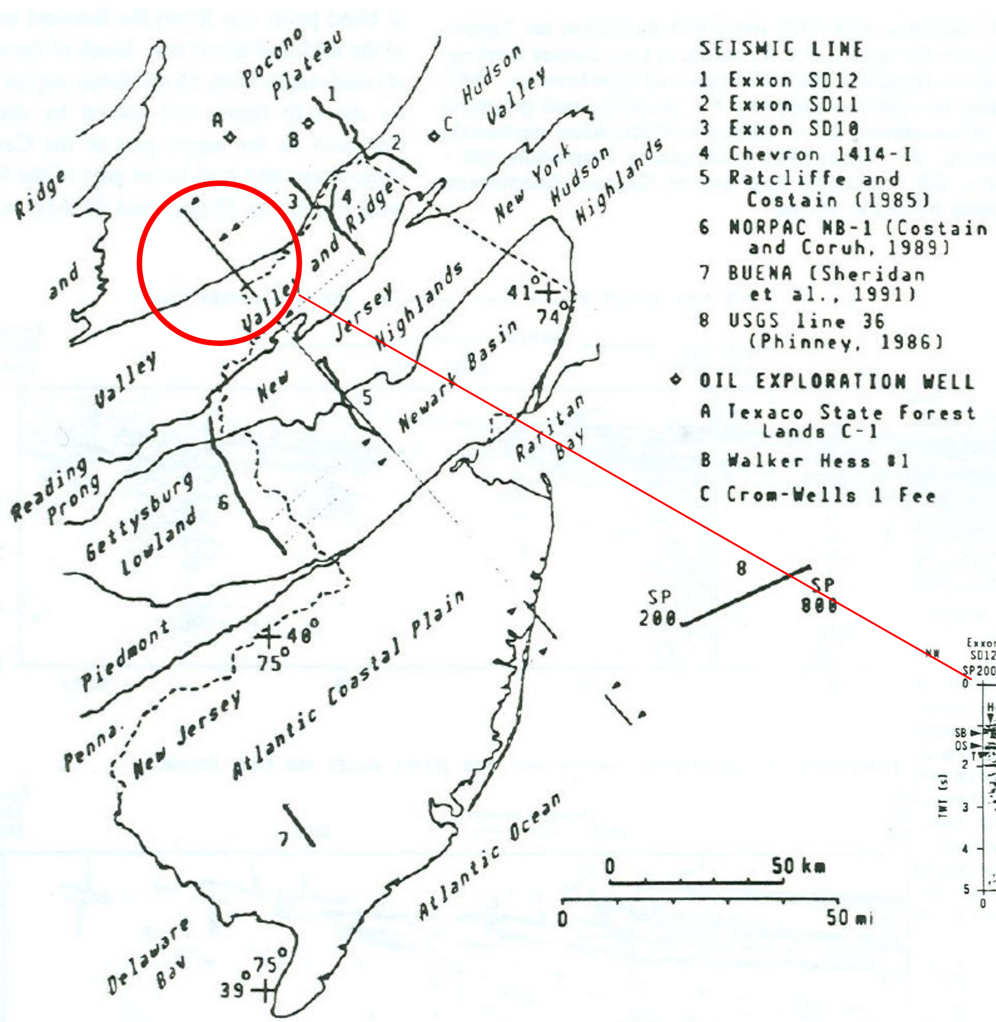






- **Multiply-tectonized foreland riding northwestward on a hypothetical decollement**
- **Cleavage**
- **Fractures**
- **Faults**

POCONO PLATEAU



Age	Seismic units, rock types, and primary seismic reflectors	Formations and groups (thickness in meters): Texaco C-1 State Forest Land well		Formations and groups (thickness in meters): New Jersey Valley and Ridge province	
DEVONIAN	Sandstone, siltstone, shale, quartzite	Catskill Fm., Trimmers Rock Fm., Hamilton Gp.	2362*	Marcellus Fm.	274
	H				
SILURIAN-DEVONIAN	Limestone, dolomite, calcareous clastics	Onondaga Fm., Oriskany Gp., Heiderberg Gp., Keyser Fm., Tonoloway Fm., Wills Creek Fm.	833	Buttermilk Falls Ls., Schoharie Fm., Esopus Fm., Oriskany Gp., Helderberg Gp., Rondout Fm., Decker Fm., Bossardville Fm., Poxono Island Fm.	616
	SB				
SILURIAN	Sandstone, siltstone, shale, quartzite	Bloomsburg Fm., Clinton Gp., Tuscarora Fm.	692	Bloomsburg Red Beds, Shawangunk Fm.	884
	OS				
ORDOVICIAN	O - Siltstone, shale, sandstone	Martinsburg Fm.	259	Martinsburg Fm.	1372
	T				
CAMBRIAN-ORDOVICIAN	CO - Dolomite, limestone	Trenton Group, Black River Gp., Beekmantown Gp.	59*	Jacksonburg Ls., Beekmantown Gp., Allentown Dolomite, Leithsville Fm., Hardyston Quartzite	1220
	B				
PROTEROZOIC	P - Gneissic and granitoid Grenville basement				

*total thickness penetrated in well

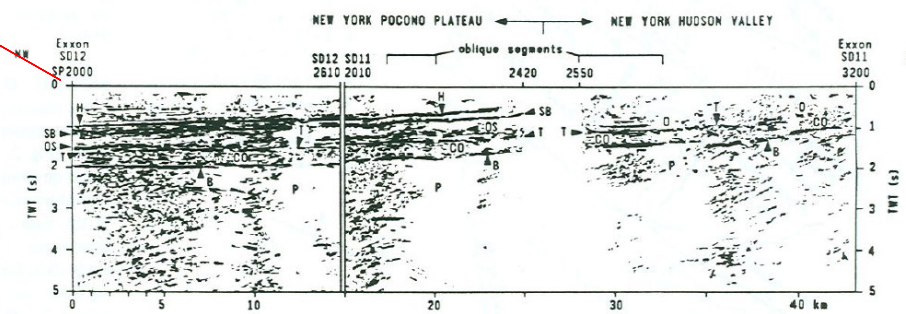
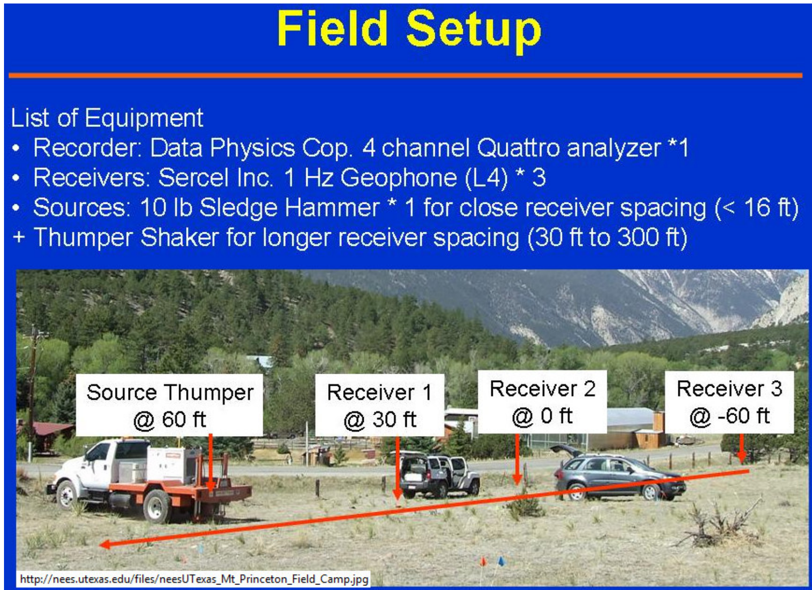
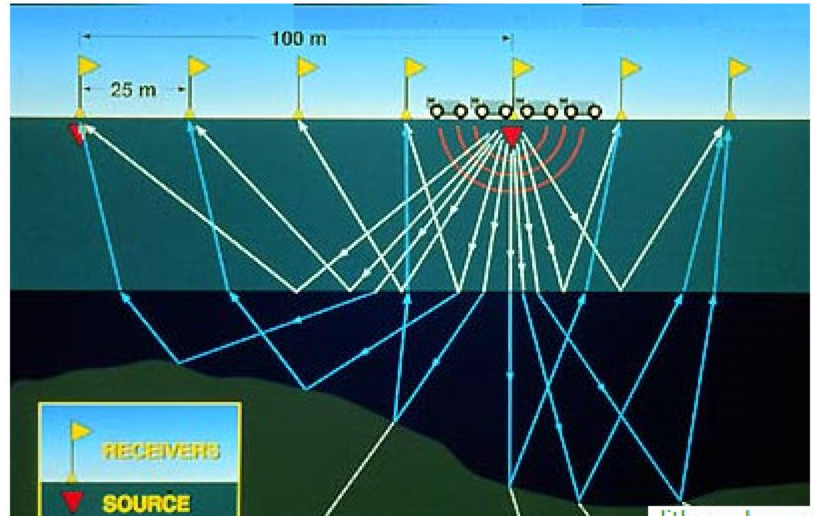


Figure 1. Map showing study area, physiographic provinces, deep seismic reflection lines, wells, and trace of schematic cross section. Dotted-line arrows illustrate projection of seismic line data into corresponding cross-section interval.

SEISMIC-REFLECTION SURVEYS





lithoprobe.ca

Seismic reflection method. Vibroseis sound source with geophone spread.

CONTROLS ON THE SEISMIC-REFLECTION PROFILE

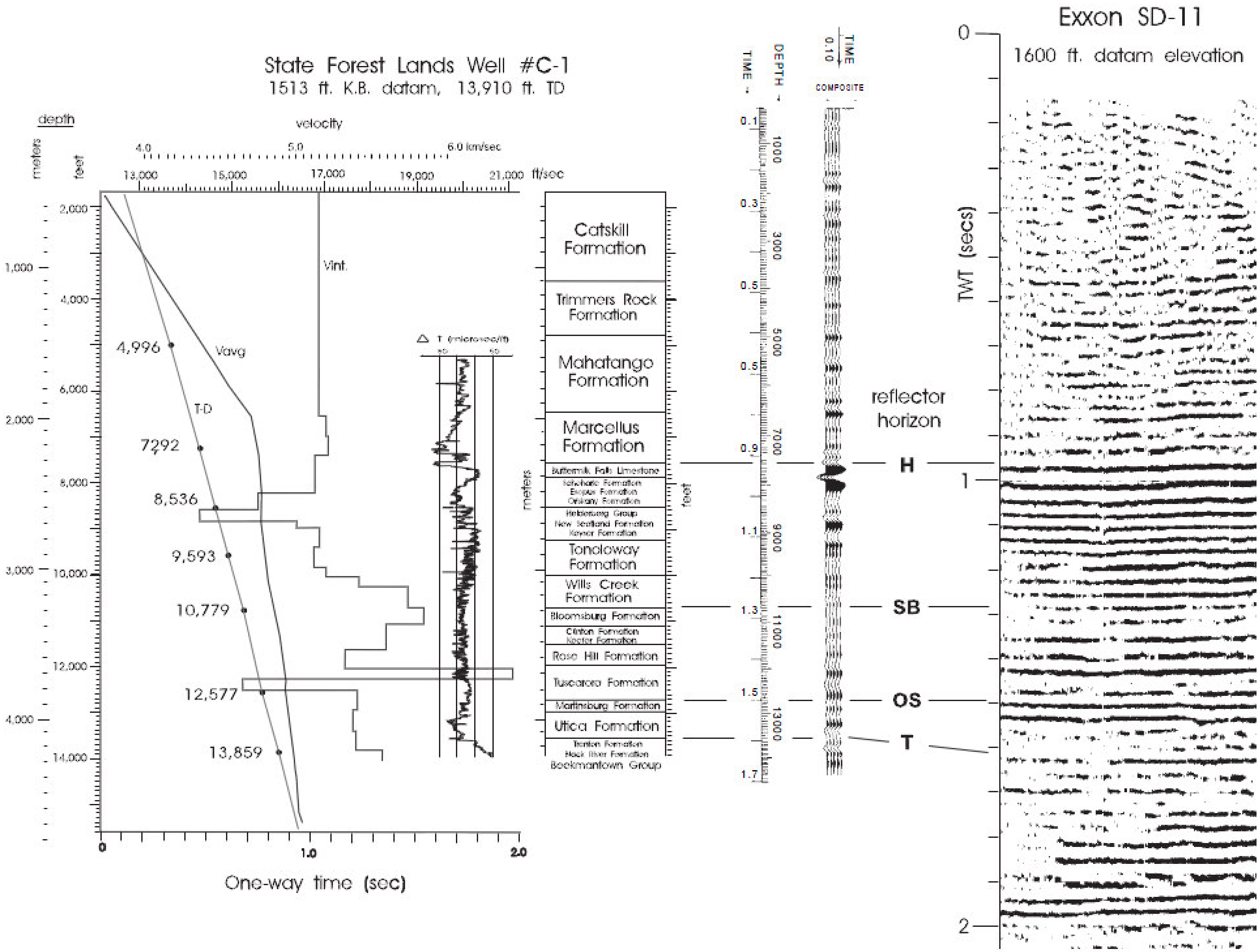
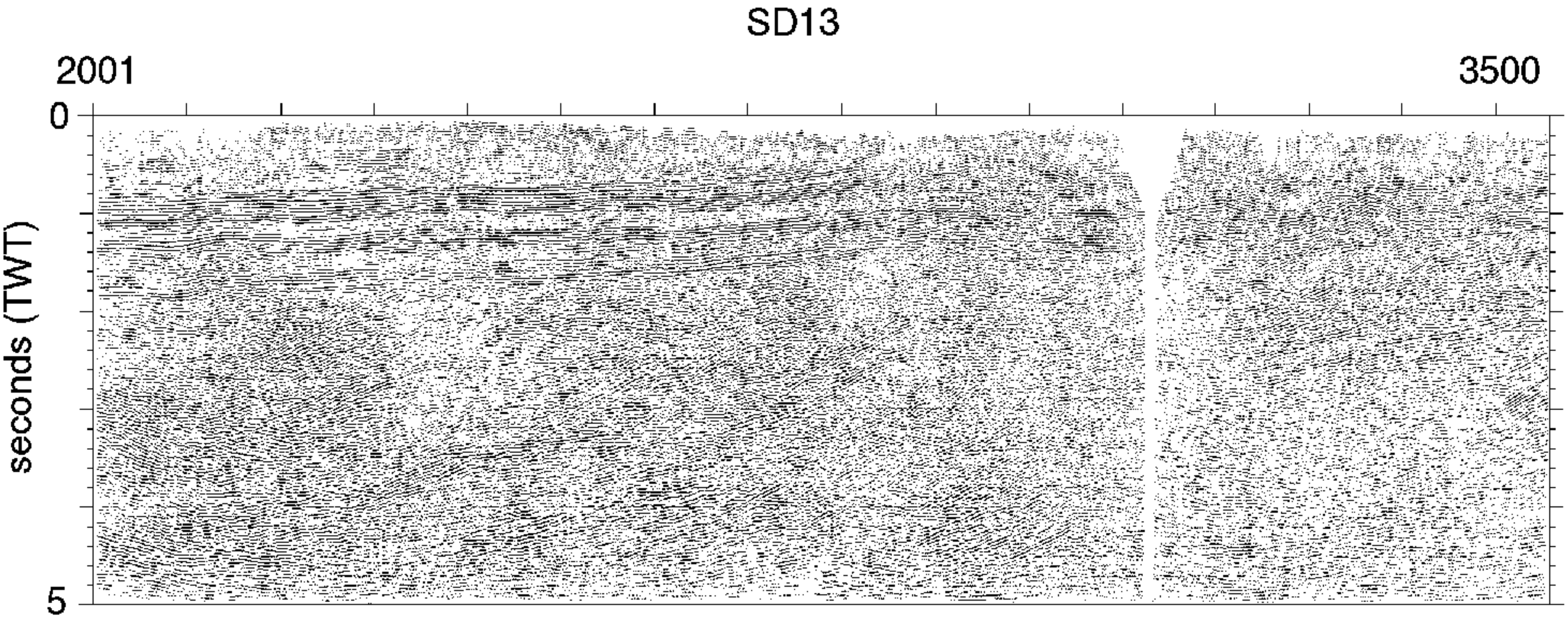


Figure 6. Borehole data for the Texaco well C-1 showing a stratigraphic correlation to the northwest end of Exxon profile SD-11. The bore-hole compensated sonic log and conventional velocity analysis are by Texaco. The synthetic seismogram was generated by Exxon. See text for further discussion.

UNINTERPRETED SEISMIC-REFLECTION PROFILE



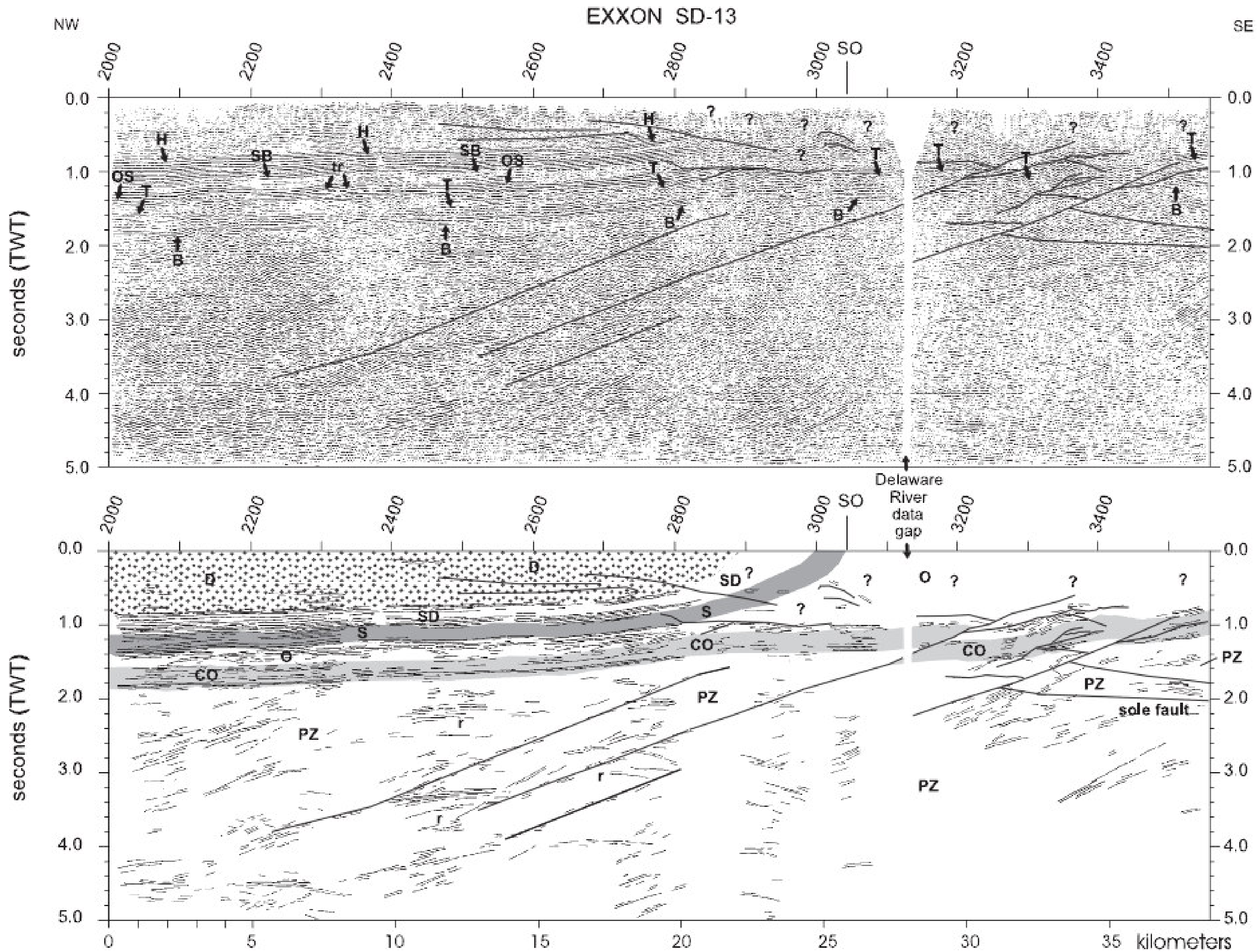
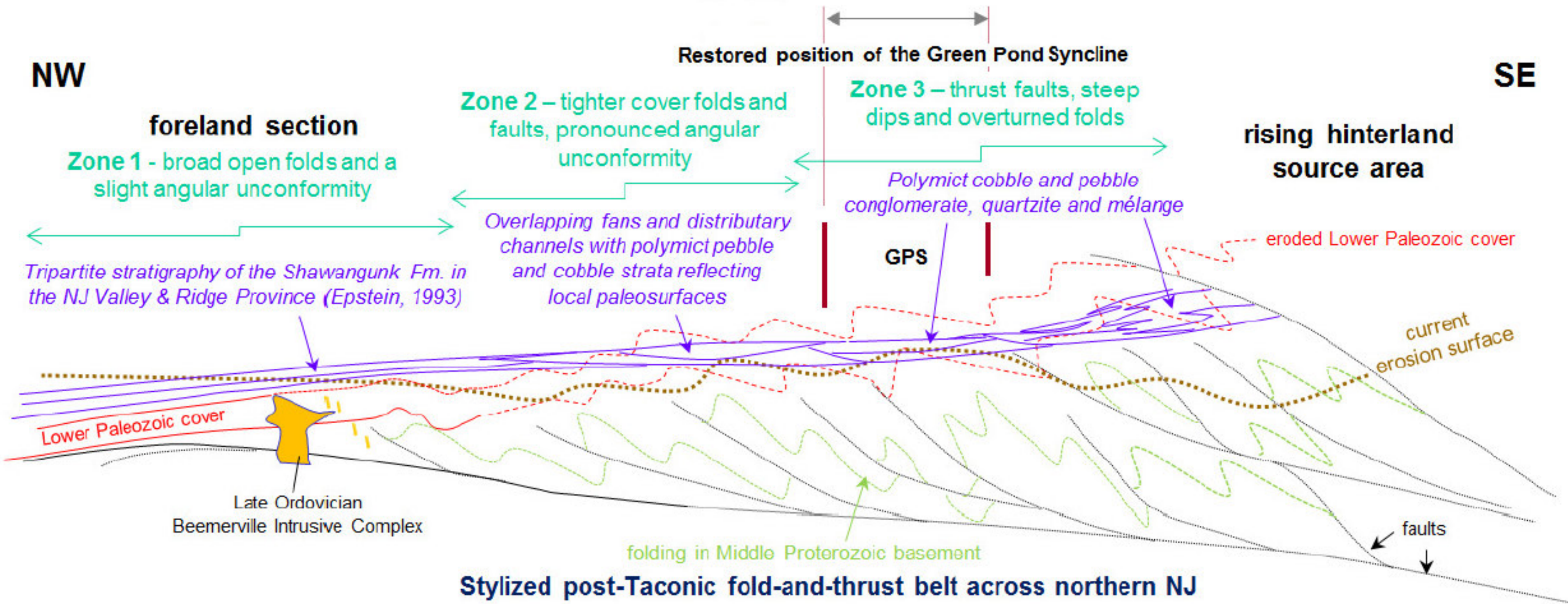


Figure 9. Exxon seismic-reflection profile SD-13. TWT—two-way traveltime. Geologic interpretations are shown for both the migrated, full display (top) and the conventional line drawing of the unmigrated profile (bottom). Abbreviations and symbols as in Figures 7 and 8.

PALINSPASTIC CROSS-SECTION INTERPRETATIONS



CARBONATE PLATFORM WITH FORELAND FOLDS

POST-TACONIC

PASSIVE MARGIN CARBONATE PLATFORM

PRE-TACONIC

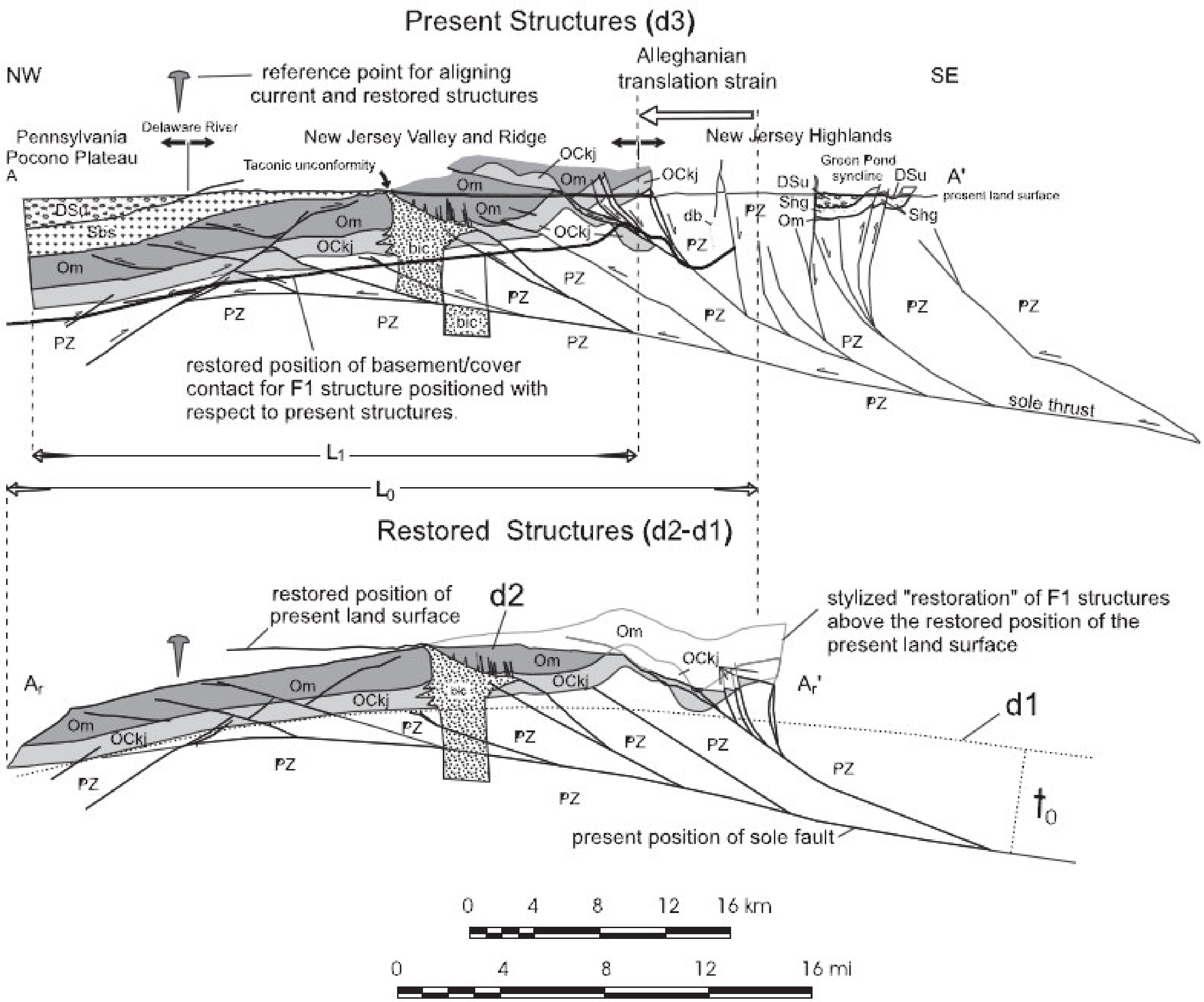
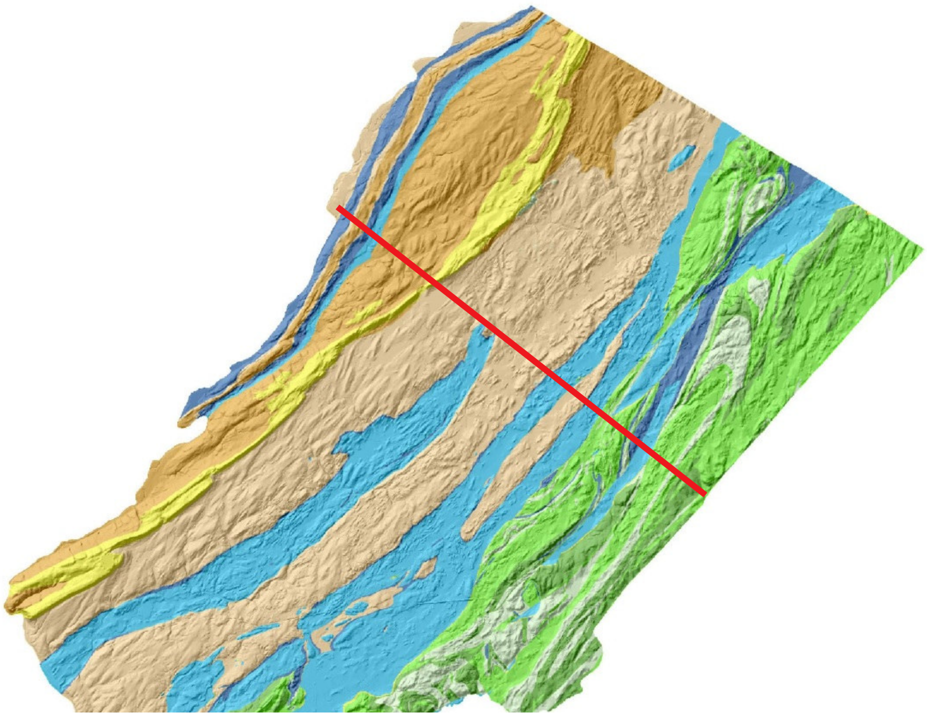
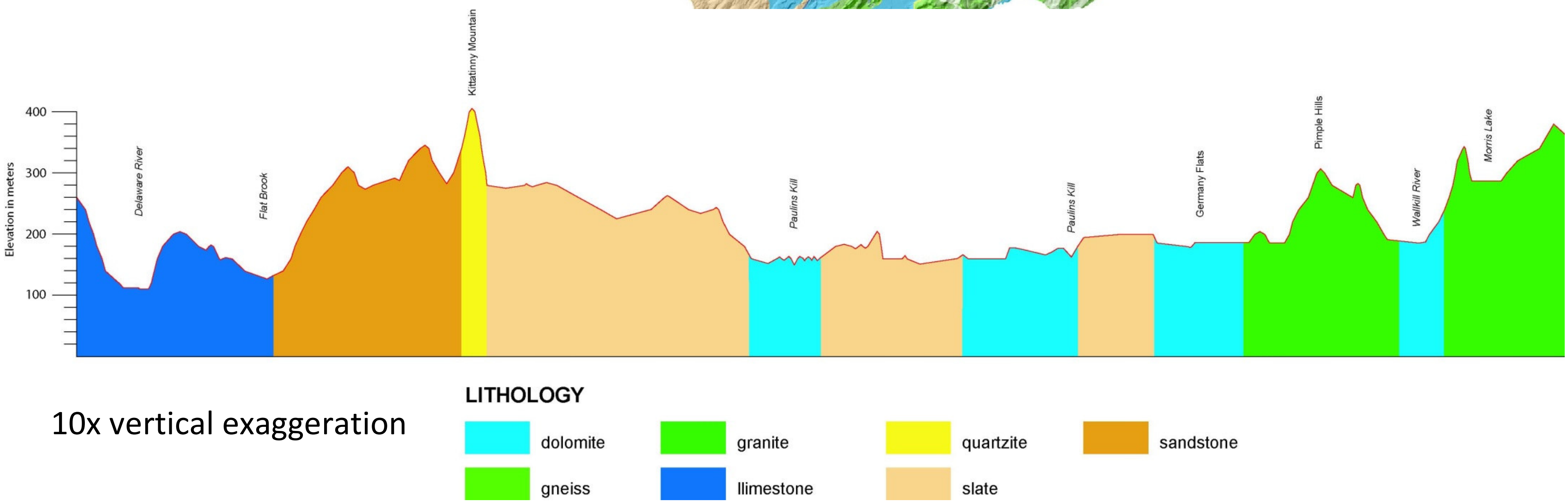


Figure 16. Cross section A–A′ showing present-day and retrodeformed structures and the methods for deriving tectonic dimensions (see Table 2). The d2 position of the basement cover is shown superimposed on d3 (upper figure) to illustrate the structural-relief modeling assumption explained in the text. Rock-unit abbreviations are as in Figure 7.

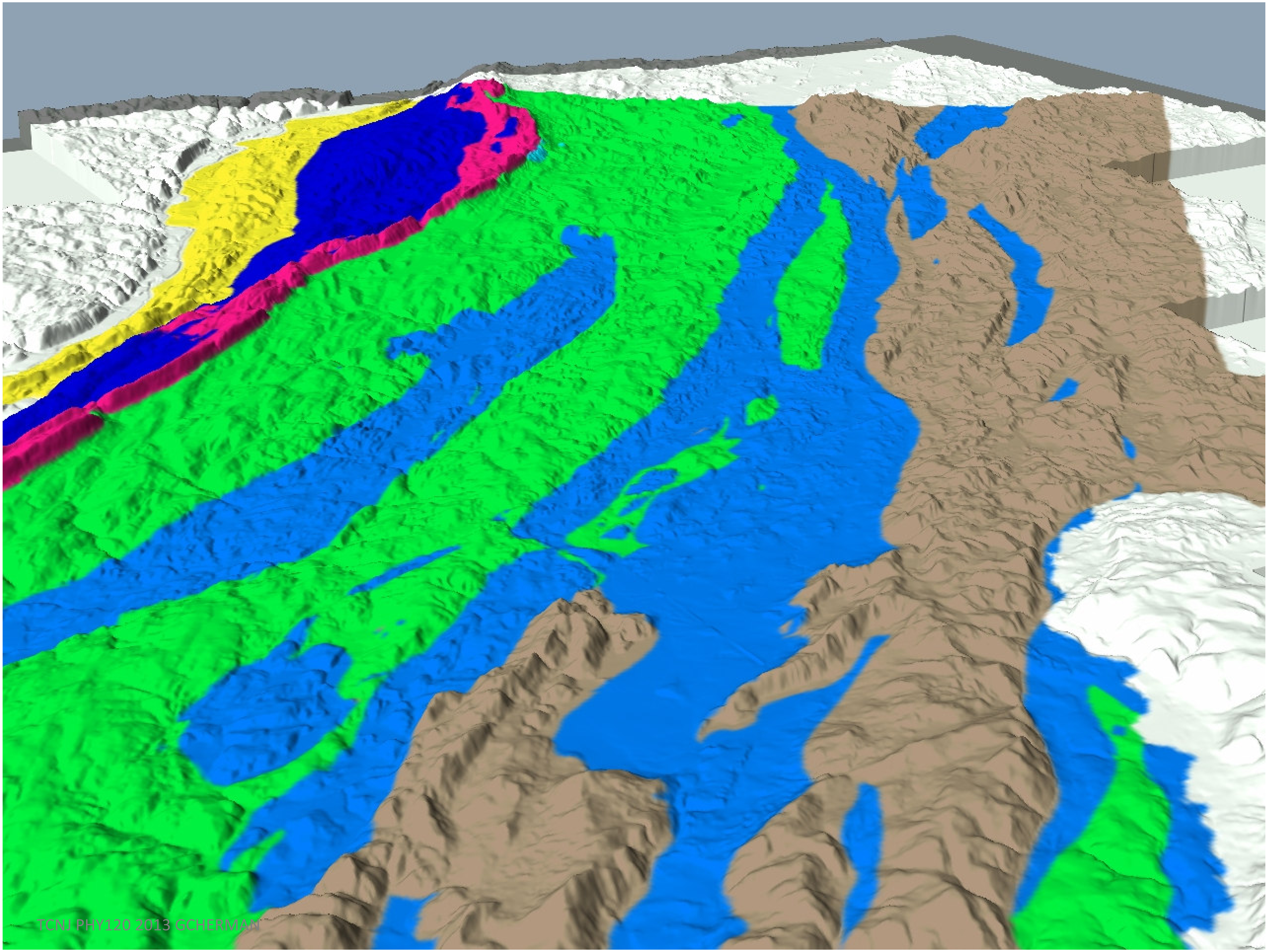
NJ RIDGE AND VALLEY THRUST TOPOGRAPHIC RELIEF



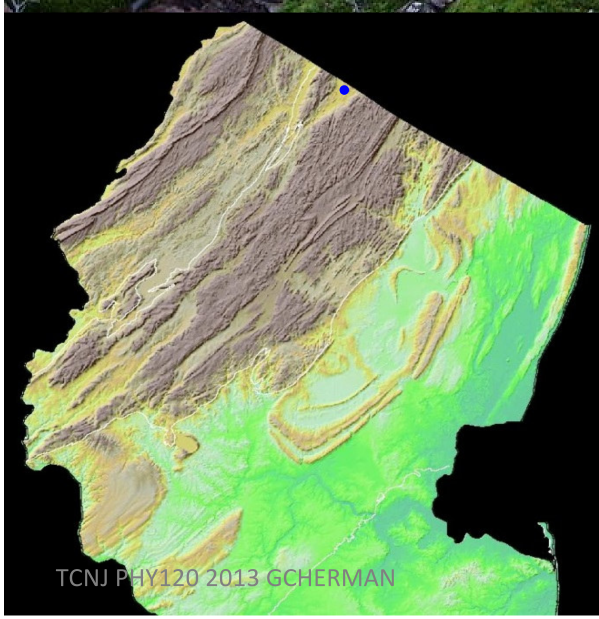


10x vertical exaggeration


TCNJ PHY120 2013 GCHERMAN


TCNJ PHY120 2013 GCHERMAN

Flat lying outcrop of Allentown Dolomite showing widening of joints through solution



Sinkholes are most often the result of the collapse of soil and loose weathered rock into underlying cavities and solution joints.

KITATTINNY VALLEY STRUCTURES

SPACED,
SLATY,
AND
CRENULATION
CLEAVAGE

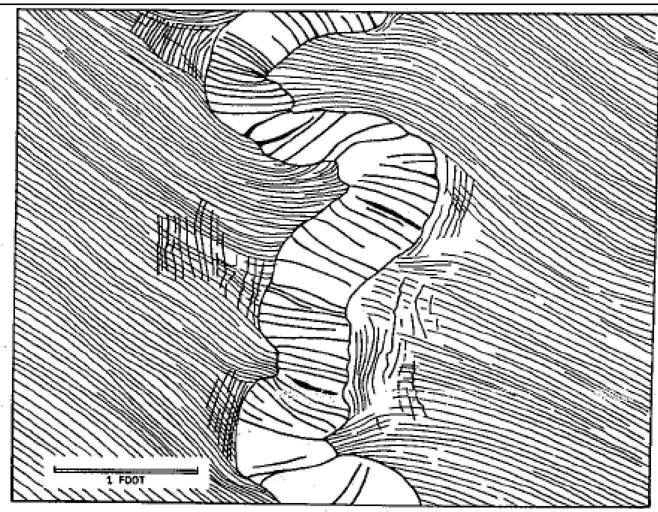


Figure 6. Folding of calcareous silt bed in Martinsburg slate, 1½ miles northwest of Belvidere on U. S. 46

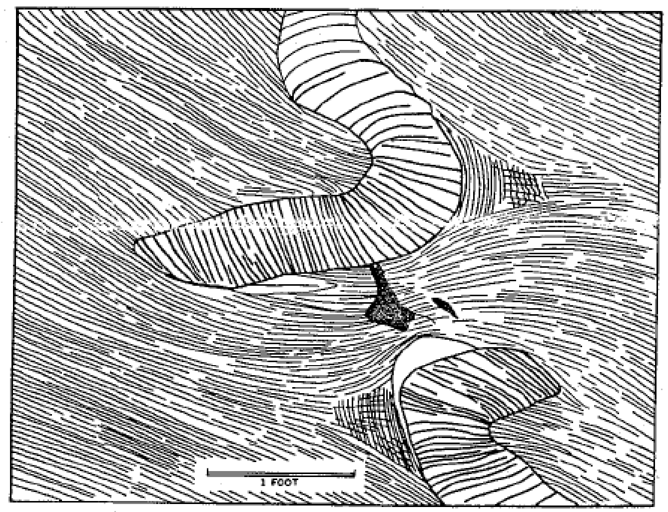
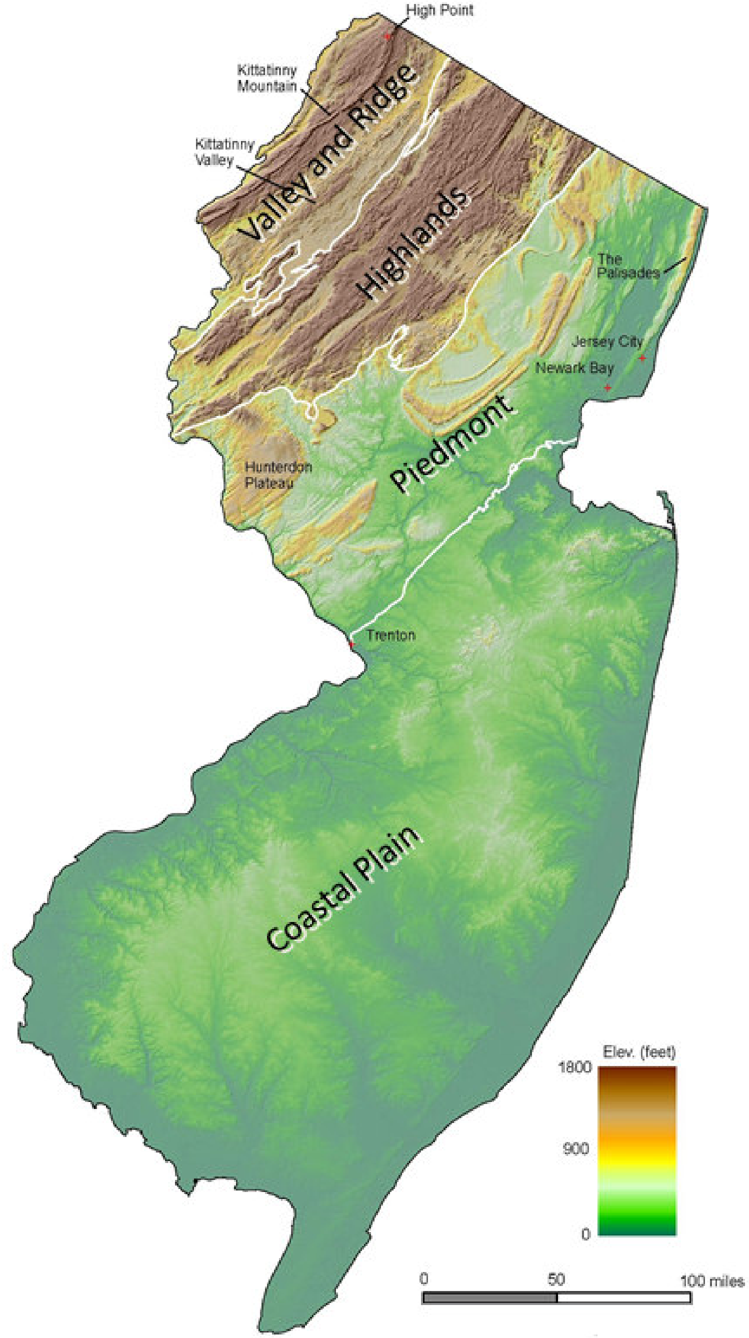


Figure 7. Shearing and transport parallel to slaty cleavage, offsetting calcareous siltstone bed. Same location as Figure 6. Solid black area is quartz-carbonate vein.

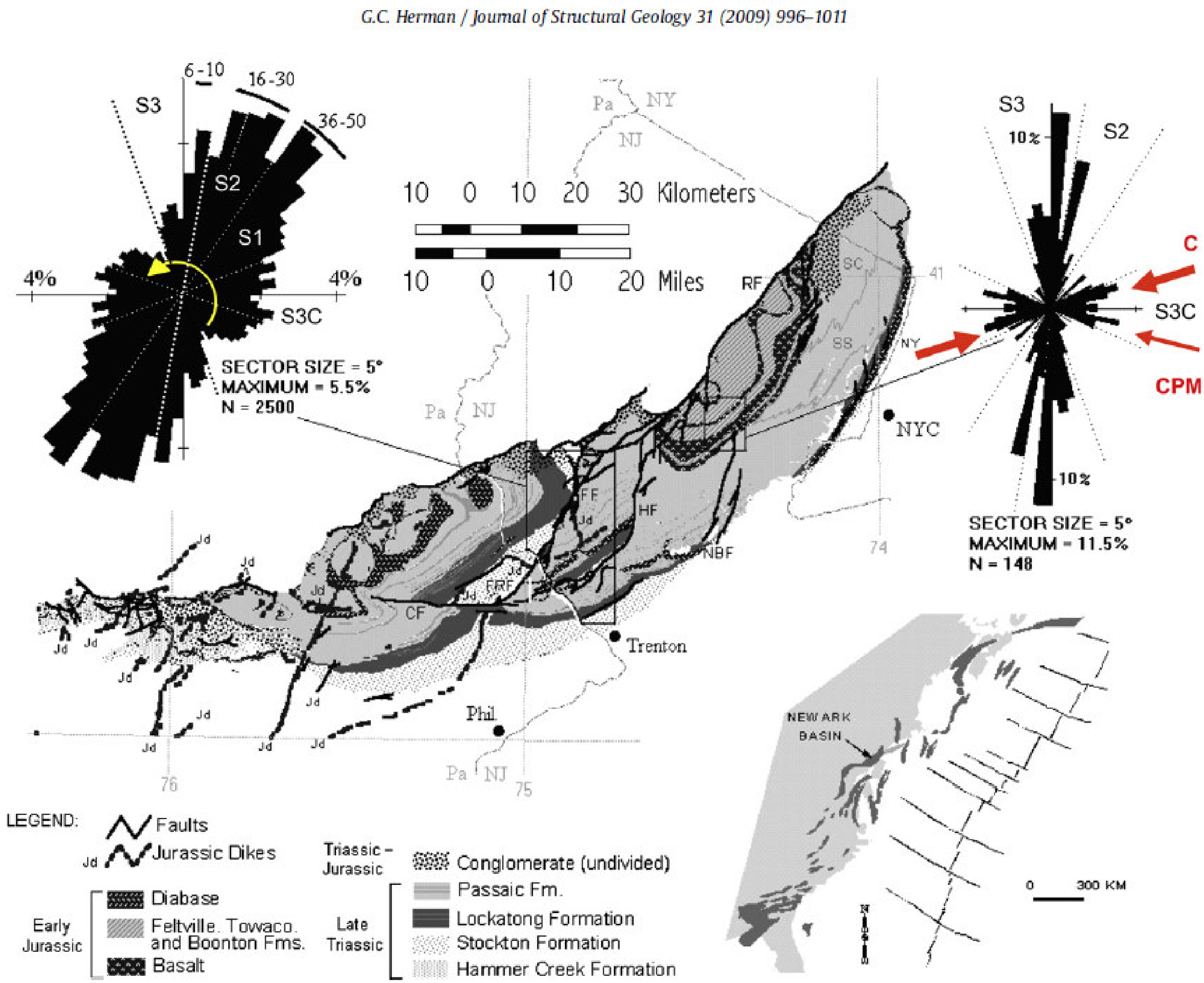
290

PIEDMONT PROVINCE

- Underlies most urban part of state ~ 1/5 NJ
- Low rolling plain divided by series of higher ridges
- Mostly underlain by slightly folded and faulted Mesozoic sedimentary and igneous rocks e

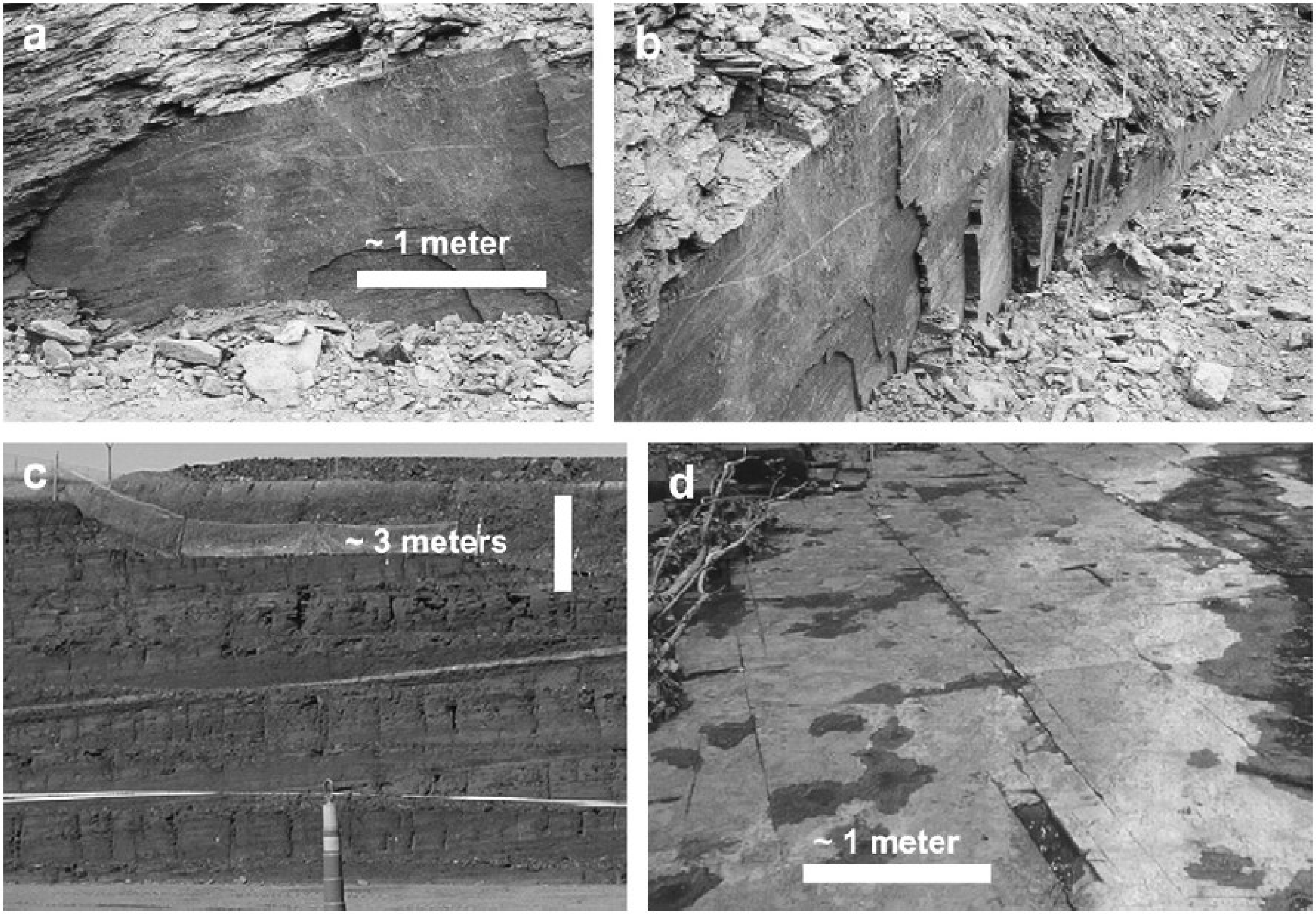


NEWARK BASIN PART OF THE PIEDMONT PROVINCE

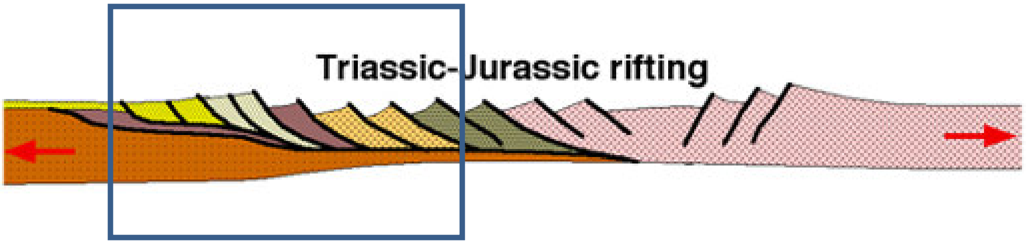


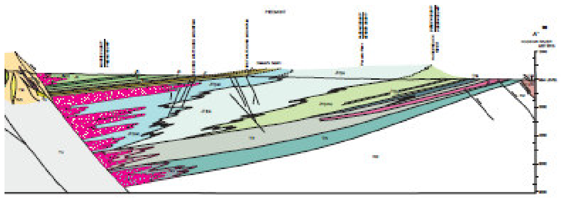
BRITTLE ROCK FRACTURES IN THE NEWARK BASIN

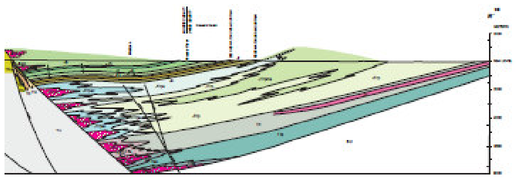
G.C. Herman / Journal of Structural Geology 31 (2009) 996–1011



MESOZOIC HALF-GRABEN RIFT BASIN

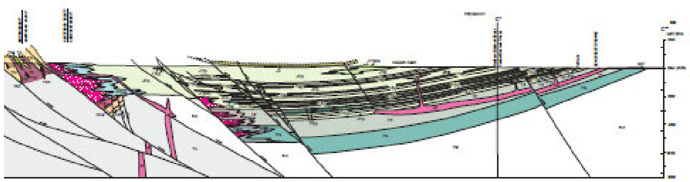




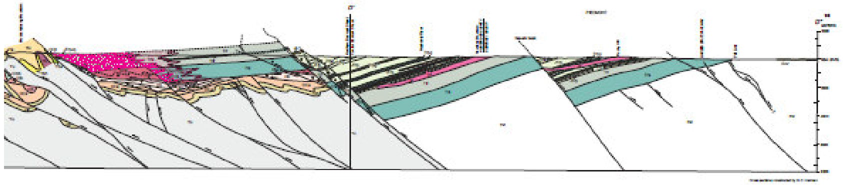


- **Tilted gently NW, faulted on the NW, and hinge on the SE**

- **Intruded by diabase and flooded by basalts ~ 200 Ma.**

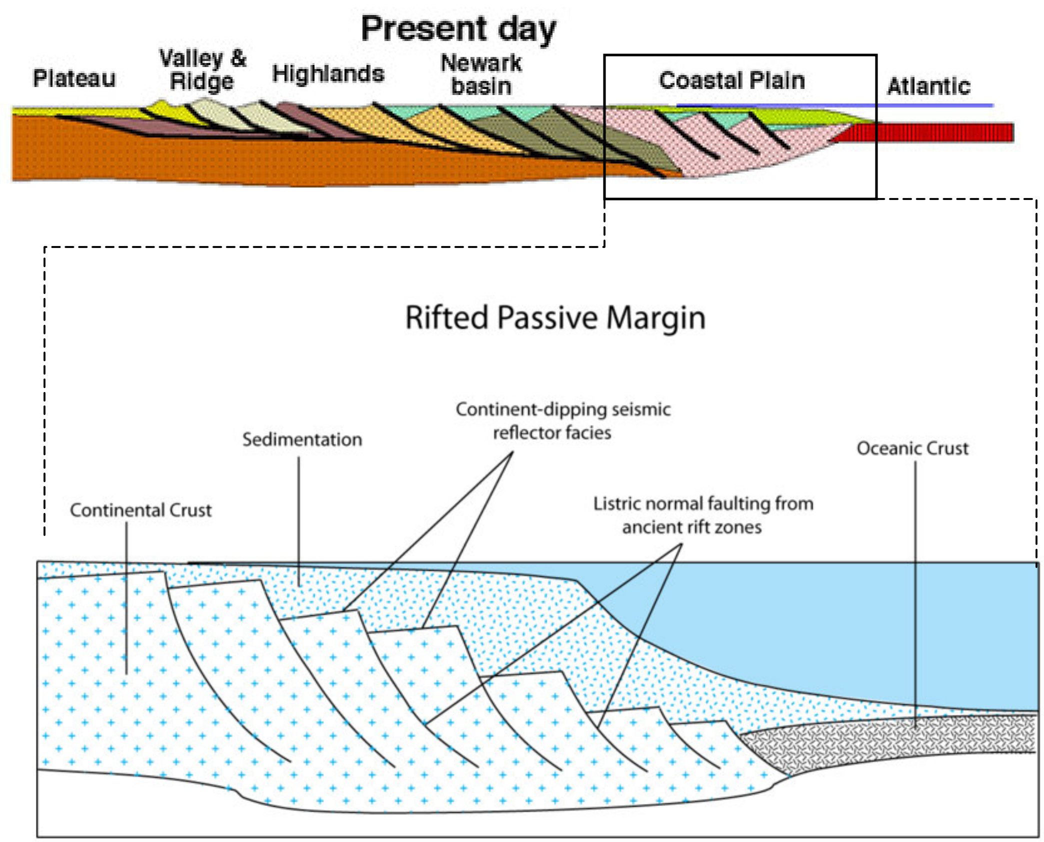


- **Major intrabasinal faults**

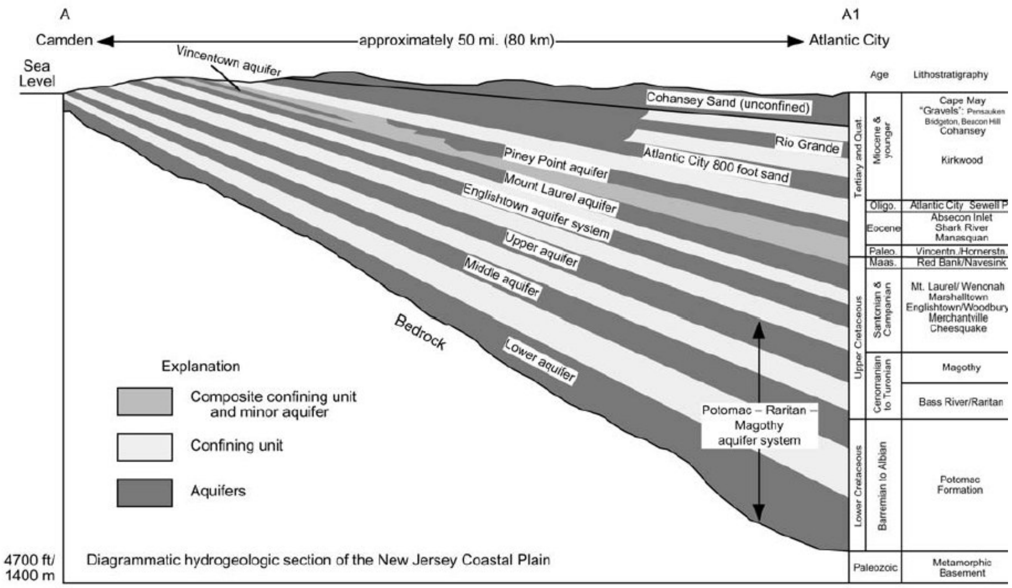


UPPER MESOZOIC (CRETACEOUS) to CENOZOIC PASSIVE MARGIN

- Subsidence with sediment influx and accumulation, turbidity currents depositing sediment onto and outward off the shelf, down the continental slope, and onto the continental rise.
- The North American continent is growing along the Atlantic slope and the shelf break advances seaward as sediments accumulate over older strata.



COASTAL PLAIN STRUCTURE

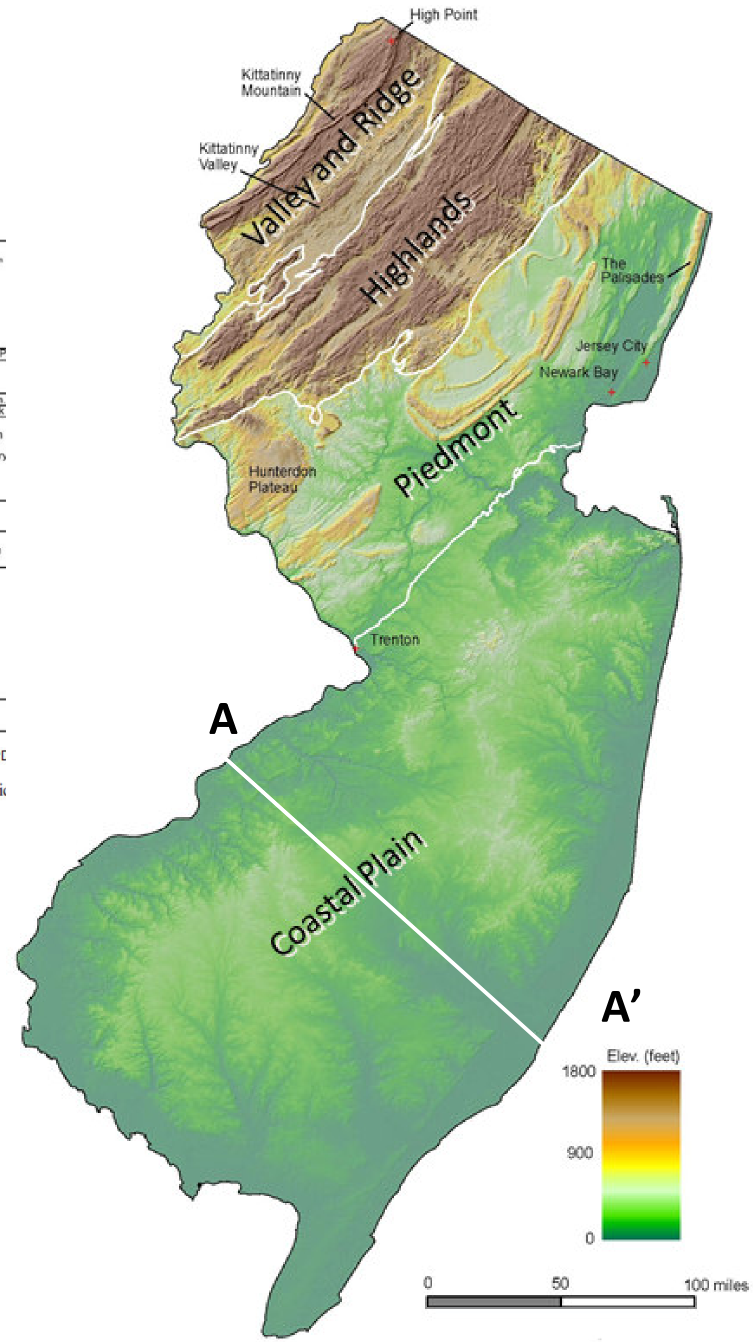


TEXT-FIGURE 2 *Stratigraphy, vol. 2, no. 3, 2005* http://rockbox.rutgers.edu/kgmpdf/05-Sugarman.Strat.PD

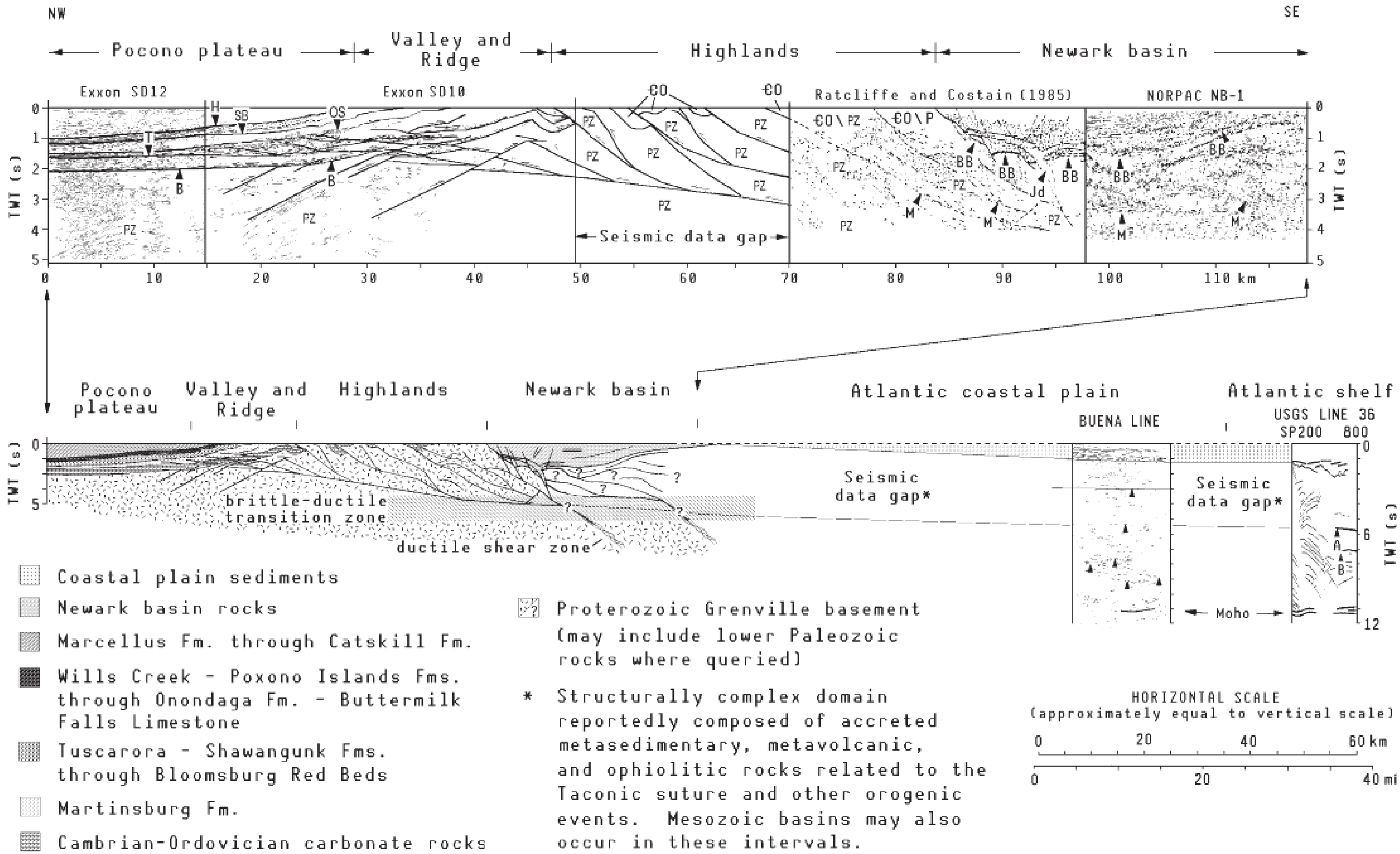
Generalized hydrostratigraphic dip section (modified after Martin 1998) and corresponding lithostratigraphic units from Camden to Atlanti

- **Tilted gently SE**

- **No recognized faults at the surface**

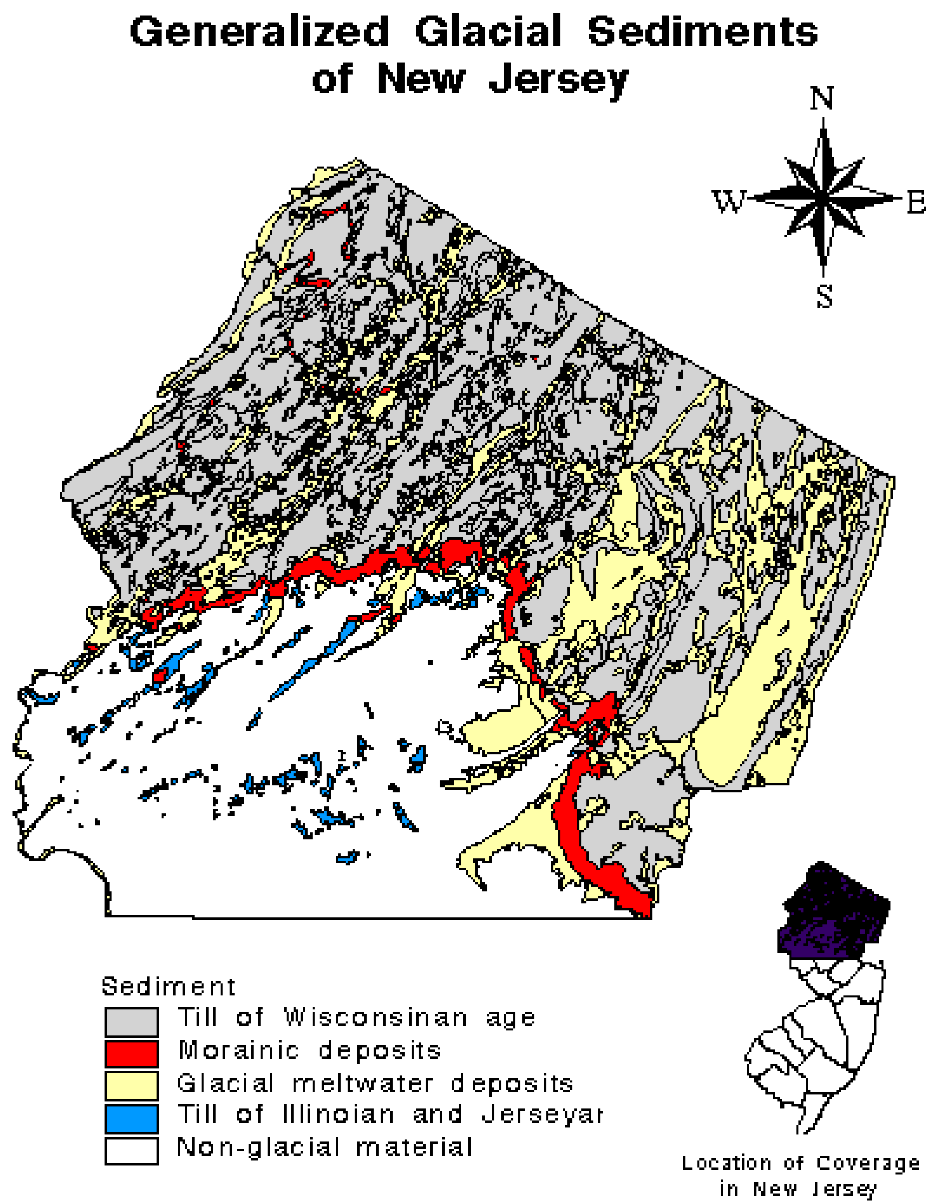


COMPOSITE STRUCTURAL PROFILE ACROSS THE NEW YORK RECESS



QUATERNARY GLACIAL COVER

- Limited in extent to the northern 1/3 of New Jersey
- Generally very good aquifer where greater than 100’ thick in buried valleys.



This map shows some of the data included in DGS 96-1.

NEOTECTONICS AND FRACTURE DIP

New Jersey – New York USA historical seismicity (Sykes, 2006), vertical crustal motion (mm/yr) based on continuously-operated receiving stations in 2010 (CORS), and predicted neotectonic fracture strike and dip directions