The Geologic Framework of Rodinia in the Vicinity of the Eastern Tennessee Seismic Zone

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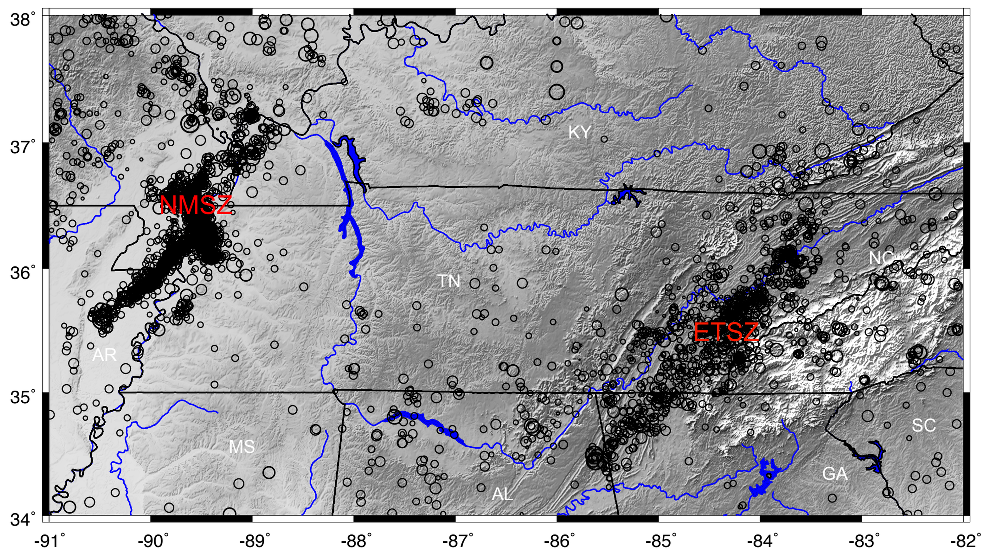
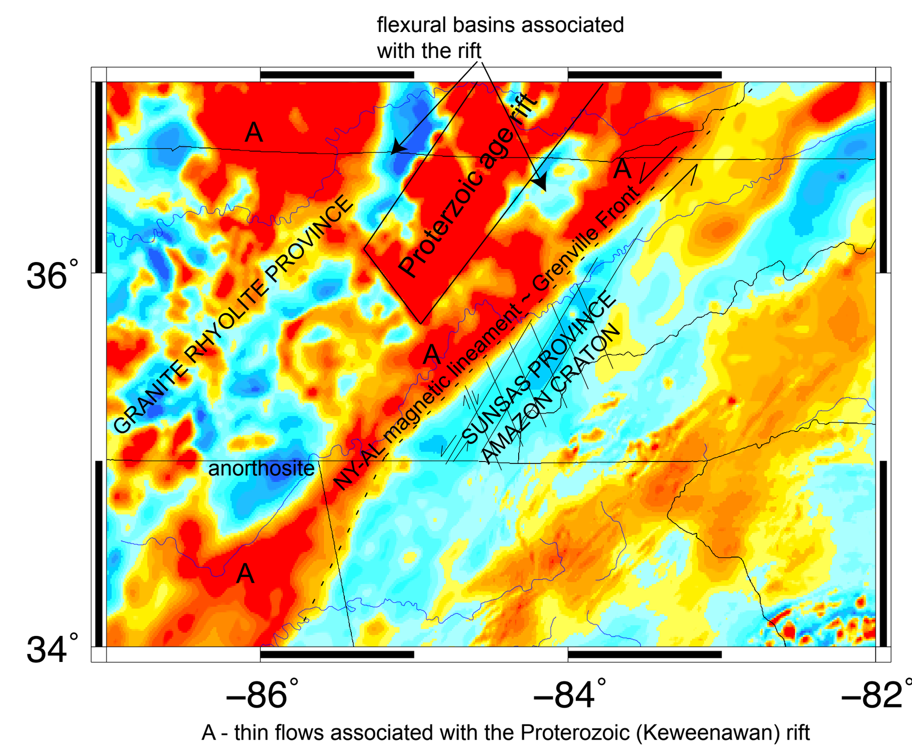


Regional location map showing the New Madrid seismic zone (NMSZ) and the Eastern Tennessee seismic zone (ETSZ). ETSZ epicenters for the years 1984-2009. ETSZ earthquakes occur below the major decollemont separating deformed Valley and Ridge and Blue Ridge rocks from Grenville basement rocks; earthquake locations are strongly influenced by Grenville basement structure.

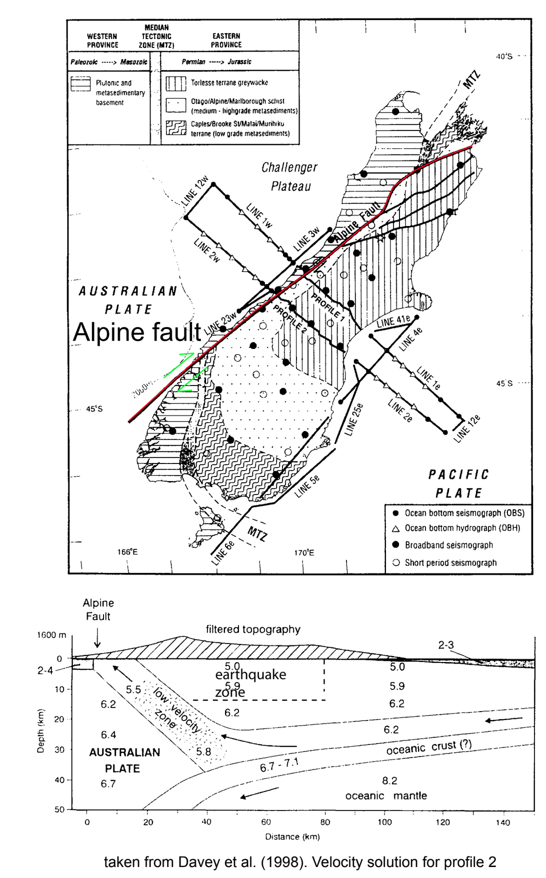
In order to understand why this seismic zone exists we must understand more about the basement. Clues exist in:
- potential field data
- crustal velocity structure
- earthquake locations
- focal mechanisms
- paleomagnetic pole positions
- whole rock Pb and Sm-Nd isotopic data
- the tectonics of the Amazon Craton.

A Model for the Origin of the ETSZ



The major portion of the ETSZ occurs in Grenville basement that was once part of the Sunsas province in the Amazon craton. ETSZ earthquakes represent reactivation of the pervasive set of strike-slip faults developed during the Sunsas orogeny. The NY-AL magnetic lineament represents the major translational boundary that accommodated sinistral motion of Amazonia past Laurentia and, in the vicinity of the ETSZ, represents the Grenville Front. This idea has been proposed previously and is now supported by new data from several sources.

A Modern Analog for the ETSZ Tectonic Framework



A possible present-day analog for the proposed tectonic framework for the ETSZ is givin by the transpressive Alpine fault in New Zealand. Compare the velocity model to ETSZ velocity profiles 2 and 3 in Figure 4 and C and D in Figure 5.

Potential field data delineate major basement features

Evidence supporting the ETSZ basement model

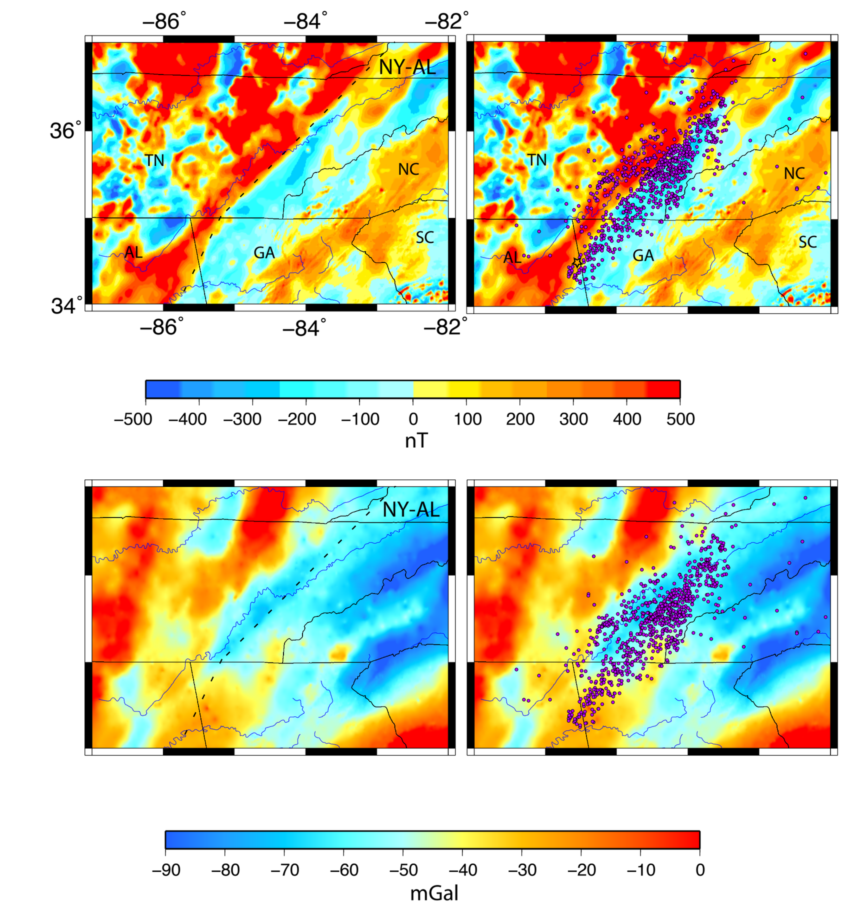


Figure 1. Purple circles are ETSZ epicenters. (Top) Aeromagnetic anomalies. Wide dashed line is the portion of the New York – Alabama magnetic lineament (NY-AL) in the study region. The NY-AL is indicative of Grenville basement features. Most ETSZ earthquakes occur to the southeast of the NY-AL. (Bottom) Bouguer gravity anomalies. High magnetic anomalies northwest of the NY-AL are associated with gravity lows.

Earthquakes and stations used in the inversion for crustal velocity structure

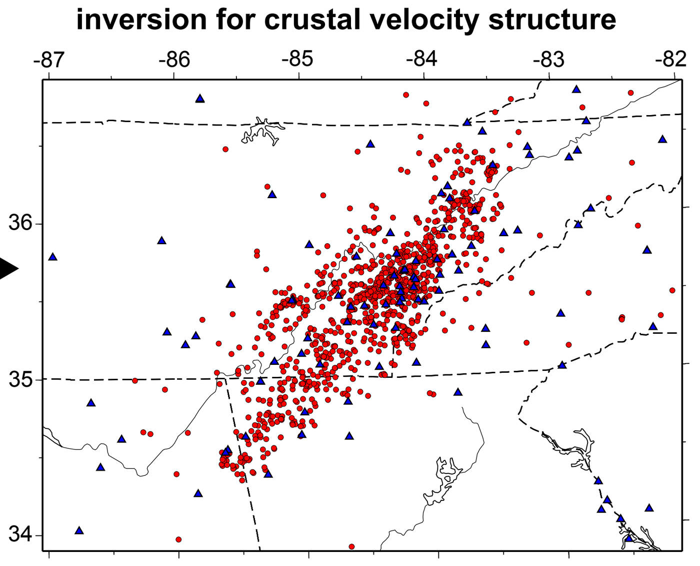


Figure 2. Earthquakes 1993-2009. Benz et al. (1996) inversion algorithm, cell size 12x12 km (horizontal) by 4 km (vertical), finite difference time calculation, LSQR used for velocity parameters. Final data set 1,039 earthquakes with 10,343 P- and 7,220 S-wave arrivals.

Crustal velocity structure indicates a low velocity zone associated with the NY-AL magnetic lineamnet. Velocity changes abruptly across the lineament suggesting the presence of a deep crustal fault.

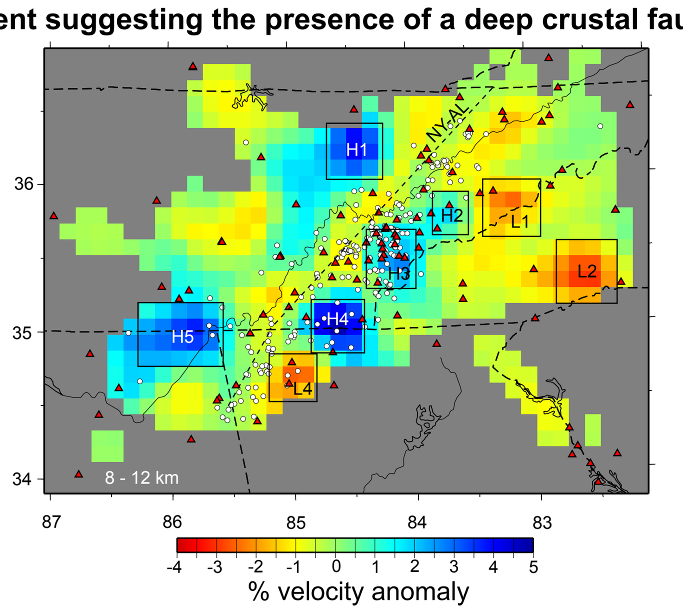


Figure 3. P-wave velocity solution for the depth 8-12 km. Major imaged features indicated. Synthetic modeling is used to determine the actual velocities for several features.

Feature	Vp (km/s)	Vs (km/s)	Sample of Compatible rock types
H1	6.58	3.73	diorite, greenschist facies basalt
H3	6.22-6.34	3.65-3.75	paragranulite, granodiorite
H4	6.53	3.65	felsic granulite, diorite
H5	6.90	3.73	anorthosite, anothositic granulite
L1	5.84-6.11		granite gneiss, metagraywake
L4	5.88-6.00		granite gneiss, metagraywake

Crustal velocity structure and earthquake distribution change abruptly across the NY-AL magnetic lineament

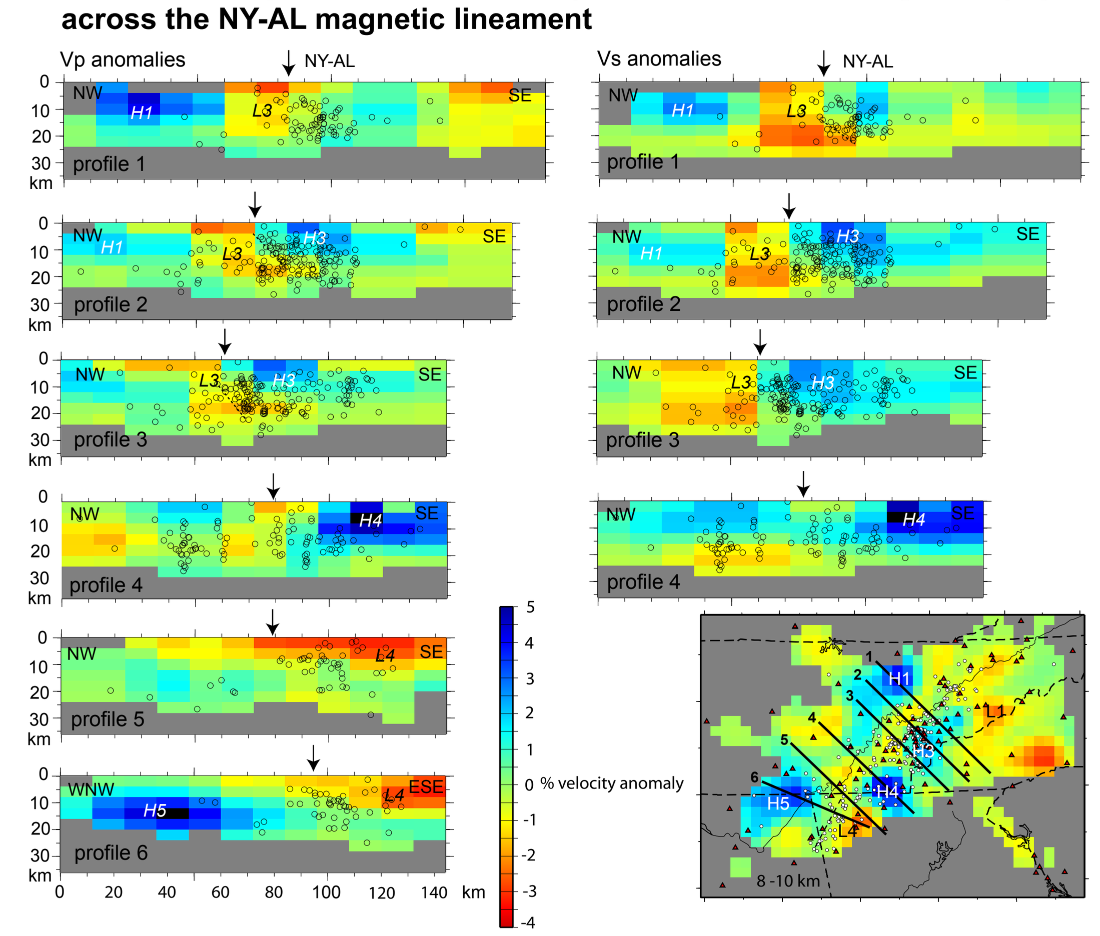


Figure 4. Cross sections trending perpendicular to the NY-AL lineament (arrow). Earthquakes within 12 km from either side of the profile plotted. Earthquake density and crustal velocity changes across the lineament. There is an apparent SE dip in the velocity and hypocenter distributions in profiles 1-3 (dashed lines). Clustering of hypocenters in profiles 4 and 5 suggest the presence of vertical, NE-SW trending faults. Hypocenters in profile delineate a fault plane with an apparent dip to the ESE.

Earthquake locations suggest reactivation of an ancient shear zone

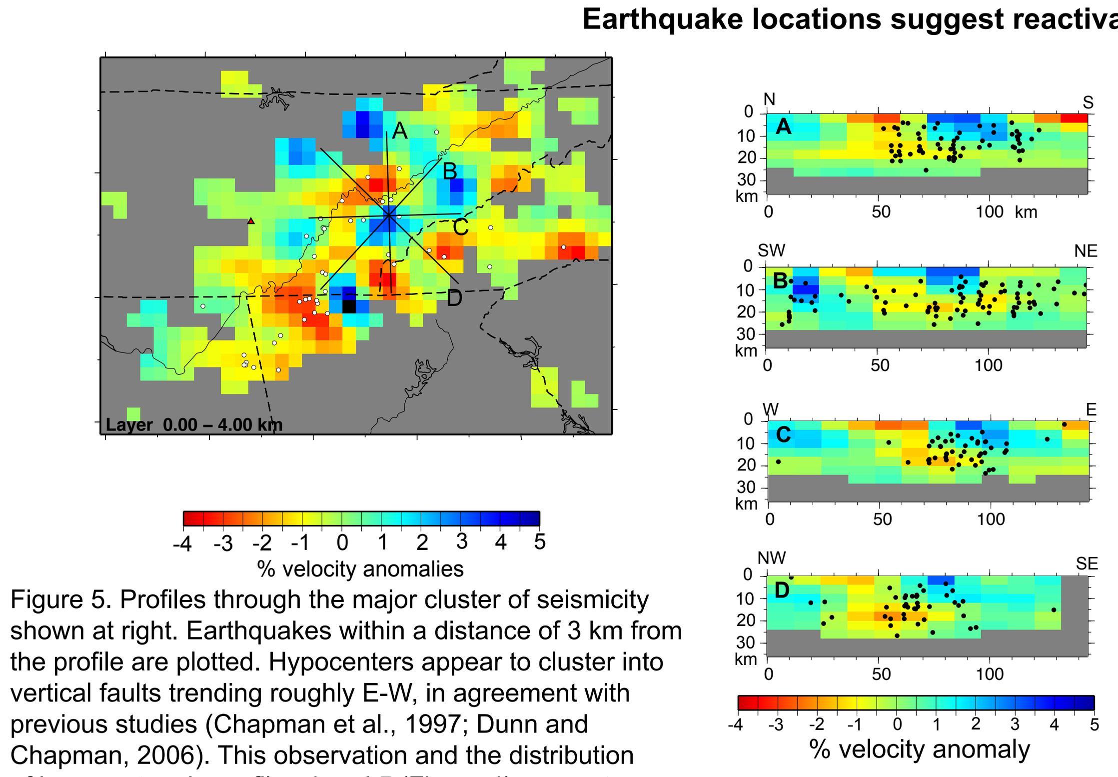


Figure 5. Profiles through the major cluster of seismicity shown at right. Earthquakes within a distance of 3 km from the profile are plotted. Hypocenters appear to cluster into vertical faults trending roughly E-W, in agreement with previous studies (Chapman et al., 1997; Dunn and Chapman, 2006). This observation and the distribution of hypocenters in profiles 4 and 5 (Figure 4) suggests reactivation of an ancient shear zone.

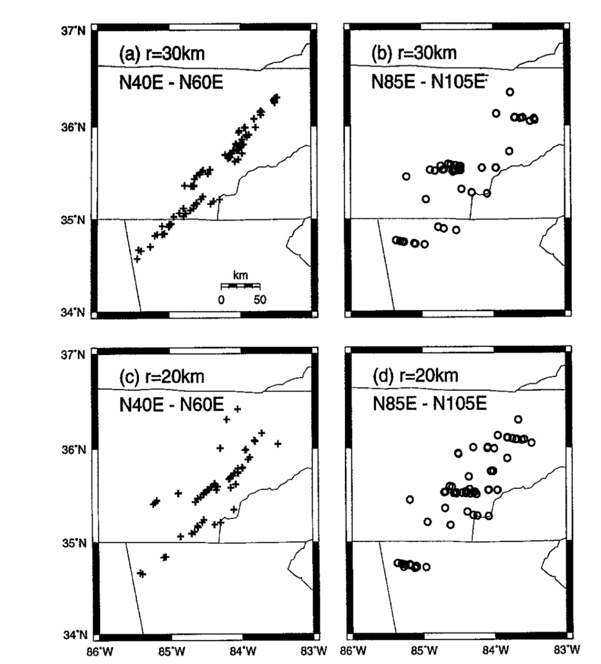


Figure 6. Statistically significant alignment of epicenters. From Chapman et al. (1997).

Consistency of focal mechanism solutions suggest reactivation of an ancient shear zone

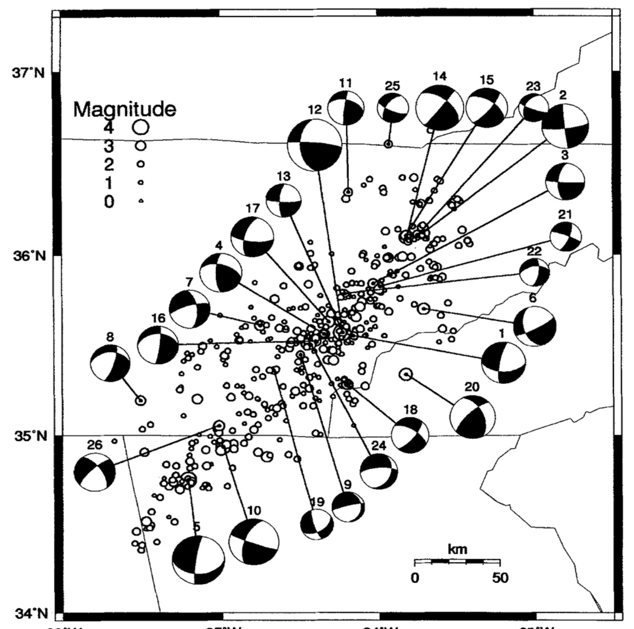


Figure 7. Focal mechanism solutions for earthquakes occurring 1983-1993. Compressional quadrants are shaded. Strike-slip motion on steeply dipping fault planes trending N-S and E-W dominates. Another set of steeply dipping fault planes trends NE-SW and NW-SE. From Chapman et al. (1997).

Whole rock Pb and Sm-Nd isotopic data indicates that basement located east of the NY-AL magnetic lineament is exotic with respect to Laurentia

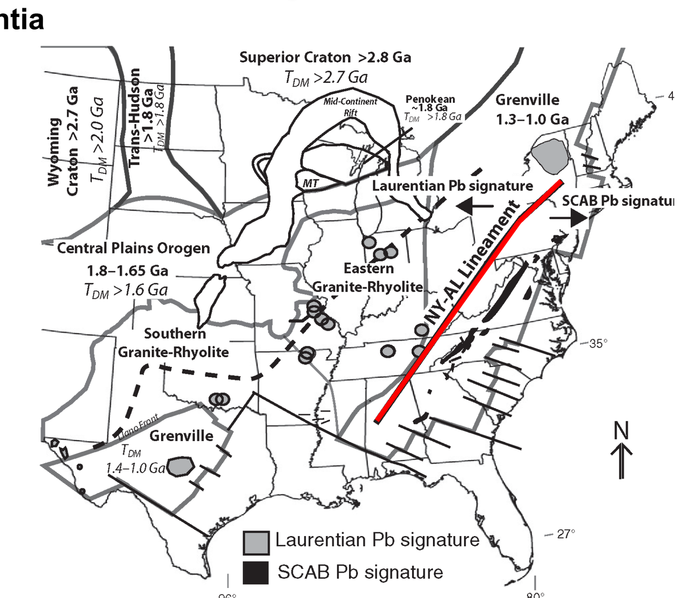


Figure 8. Distribution of Proterozoic Laurentian (Granite Rhyolite) and southern and central Appalachian basement (SCAB) Pb isotope signatures compared with the location of the NY-AL lineament. Granite Rhyolite rocks lie systematically to the west of the lineament while Grenville Appalachian basement lies to the east. This suggests that the NY-AL lineament marks the suture between these provinces. Taken from Fisher et al. (2010).

Paleomagnetic evidence for transpressive motion between Amazonia (Sunsas Province) and Laurentia

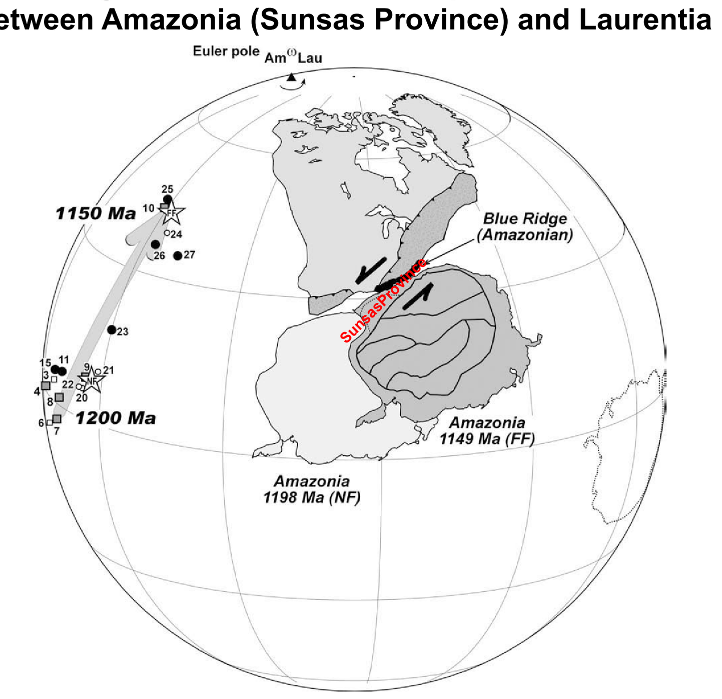


Figure 9. Paleomagnetic evidence for the 2000 km along-strike migration of the Amazon craton relative to Laurentia during the formation of Rodinia. Gray arrow is the apparent polar wander path for proto-North America. Transpressional motion brought the Sunsas Province of the Amazon craton in contact with Laurentia. Taken from D'Agrella-Filho et al. (2008).

Tectonics of the Sunsas Province involves an extensive shear zone developed during the formation of Rodinia

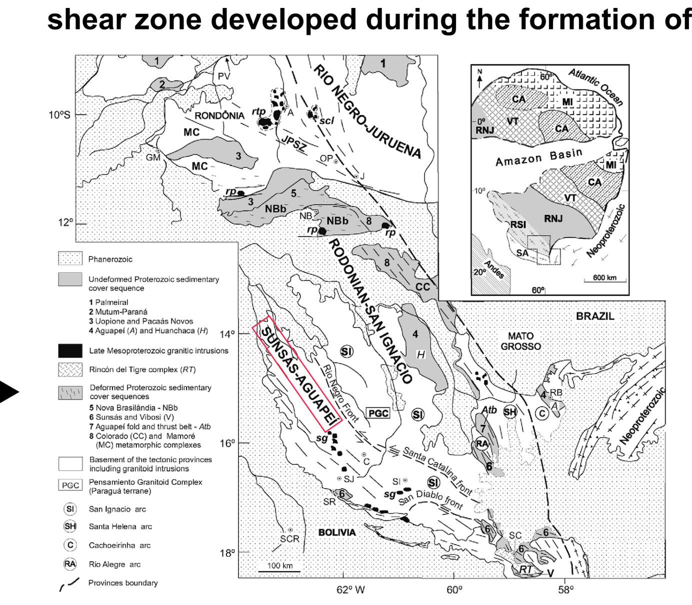


Figure 10. The Sunsas Province in the Amazon craton today. Sunsas orogeny (1100-900 Ma) occurred during the formation of Rodinia. The deformation is marked structurally by extensive, linear mylonitic shear zones that involved sinistral strike-slip motion. Little to no metamorphic overprint is present. Pervasive shear zones controlled emplacement of syn- to late-tectonic granites.Taken from Teixeira et al. (2010).

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