Compiling Crustal Velocity Structures of the Central and Eastern US

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US Geological Survey

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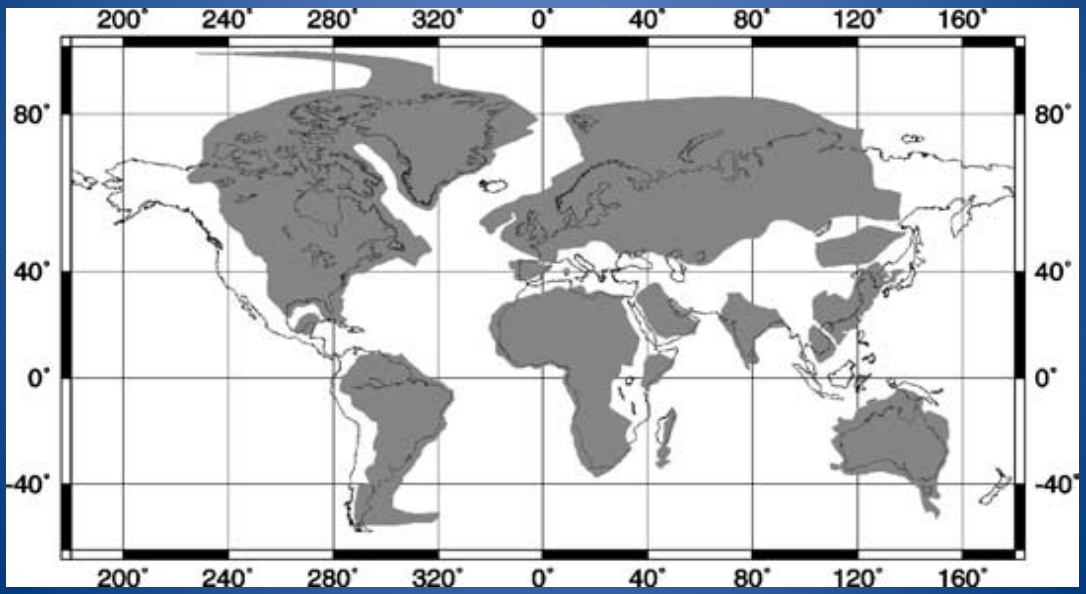
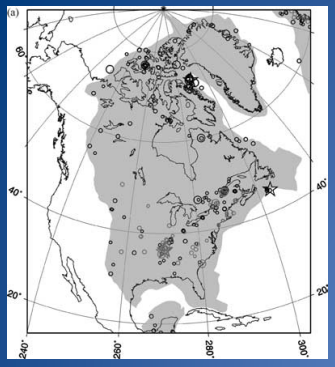
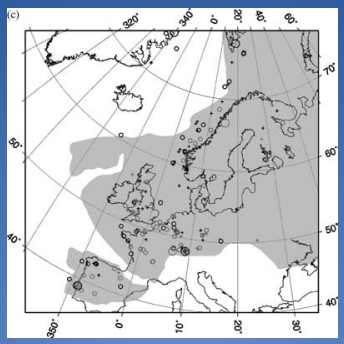
Crustal Velocity Structure Regions and Correlation with Tectonic Domains

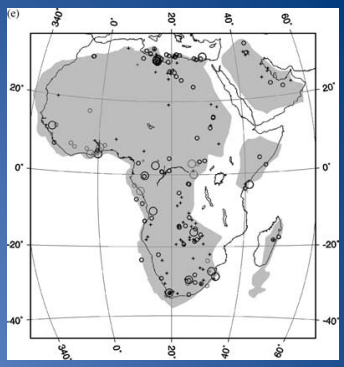
Crustal Velocity Structure Regionalization		Tectonic Domains (Genetic Regionalization)	
No.	**Name**	**No.**	**Name**
1.	Offshore New England	218	Margin
2.	Northern Appalachians	221	Magdalen
3.	Atlantic Coastal Plain	218	Margin
4.	Gulf Coast Plain	216	Gulf Coast
		225	Ouachita
5.	Southern Appalachians	223	Piedmont
		224	Valley & Ridge
6.	Central Tennessee	223	Piedmont
		224	Valley & Ridge
		226	Grenville
7.	Western Tennessee	230	Granite-Rhyolite—East
8.	New Madrid Rift	228	Reelfoot Rift
		229	Cottage Grove—Rough Ck.
9.	Ozarks	230	Granite-Rhyolite—East
10.	Northern Grenville - Superior	236	Superior
		226	Grenville
		227	St. Lawrence—Ottawa
		222	Acadia
11.	Lake Superior Basin	235	Keweenawan
12.	Mid-continent	230	Granite-Rhyolite—East
		233	Panokean
13.	Northern Great Plains	237	Trans Hudson
14.	Central Plains	255	Central Plains
15.	Southern Great Plains	231	Granite-Rhyolite—West
		232	Oklahoma Aulacogen
16.	Williston Basin	238	Wyoming

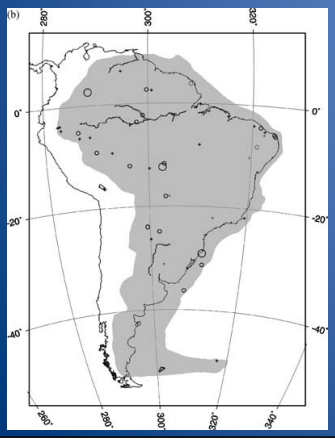
EPRI Stable Continent

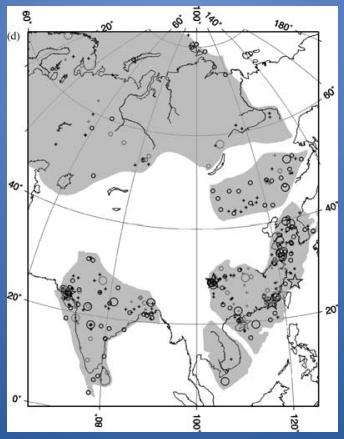


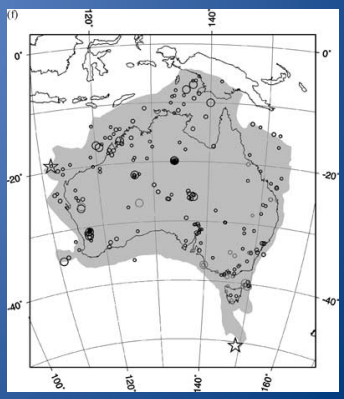




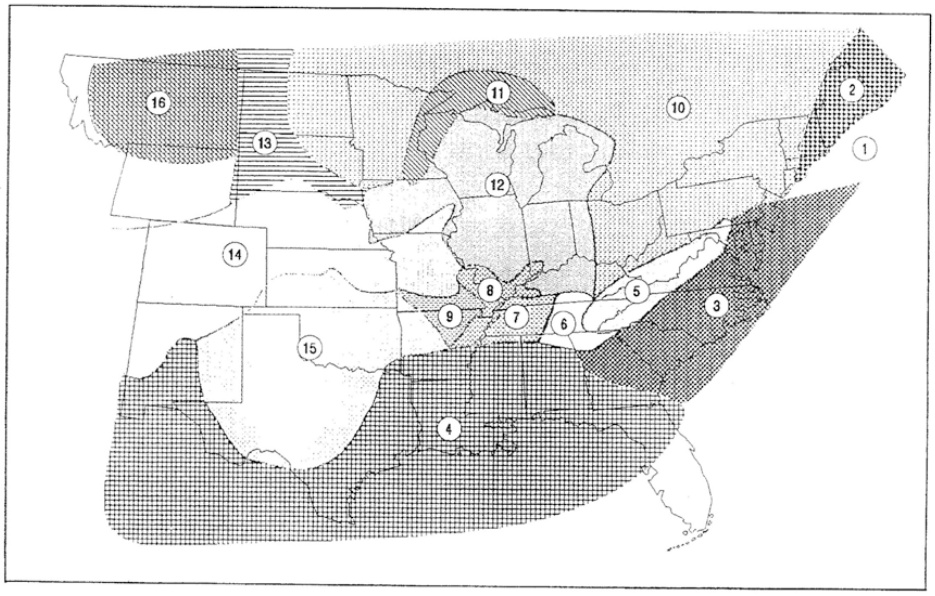




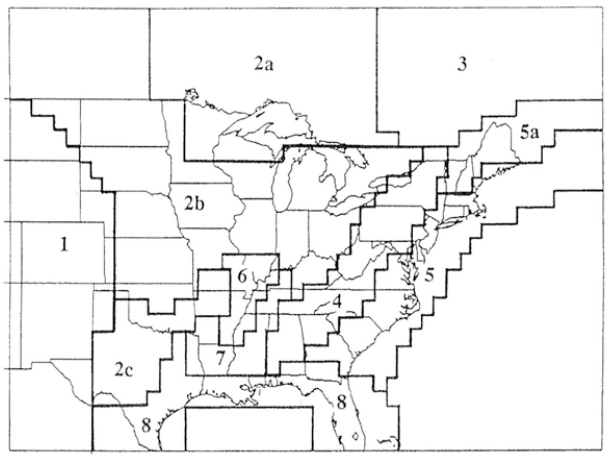




16 crustal structure regions defined by EPRI (1993)



Five Q models were developed by EPRI (1993), based largely data recorded by LRSM network stations operational in the 1960's (Gupta et al., 1989).



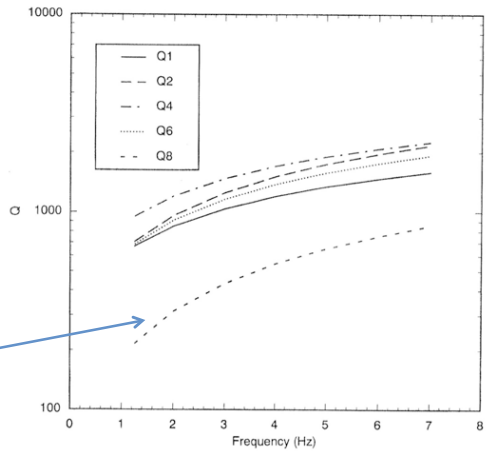
Q regionalization by Gupta et al., (1989)

The Five Q models developed by EPRI (1993) to represent attenuation in the 16 Crustal Structure Regions

Table 5-6

Q Models

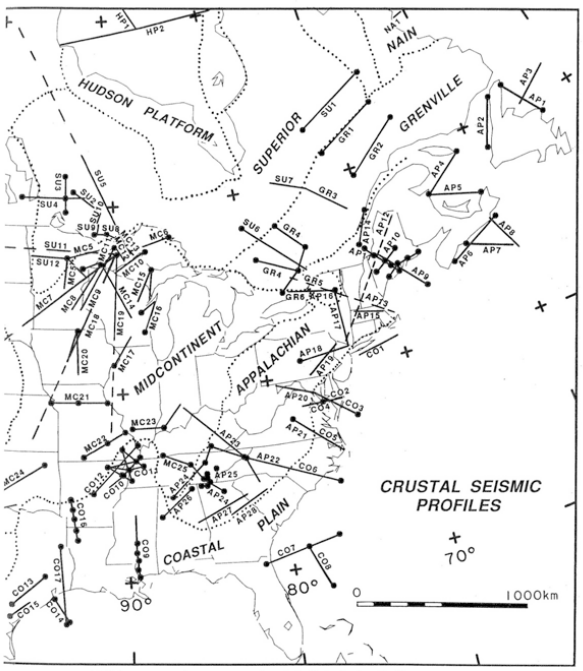
Q Region	Model
1	$600\ f^{0.50}$
2	$610\ f^{0.65}$
4	$850\ f^{0.50}$
6	$600\ f^{0.60}$
8	$180\ f^{0.80}$



Gulf Coast

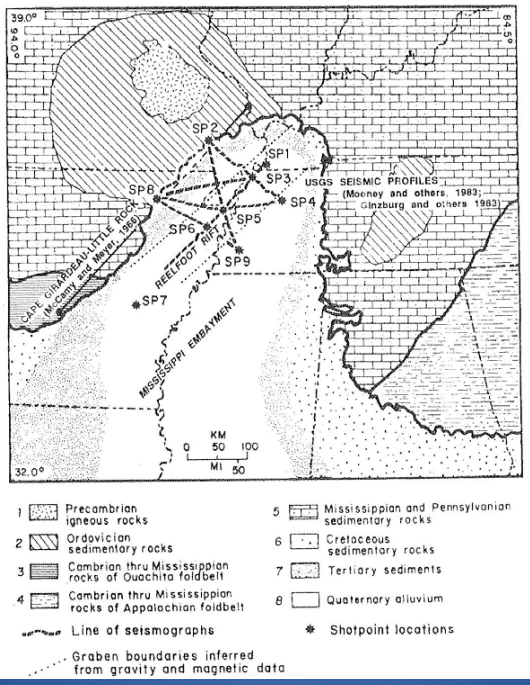
Figure 5-19. Comparison of the five Q models used to represent the Q for the 16 velocity regions.

Locations of deep crustal seismic refraction profiles

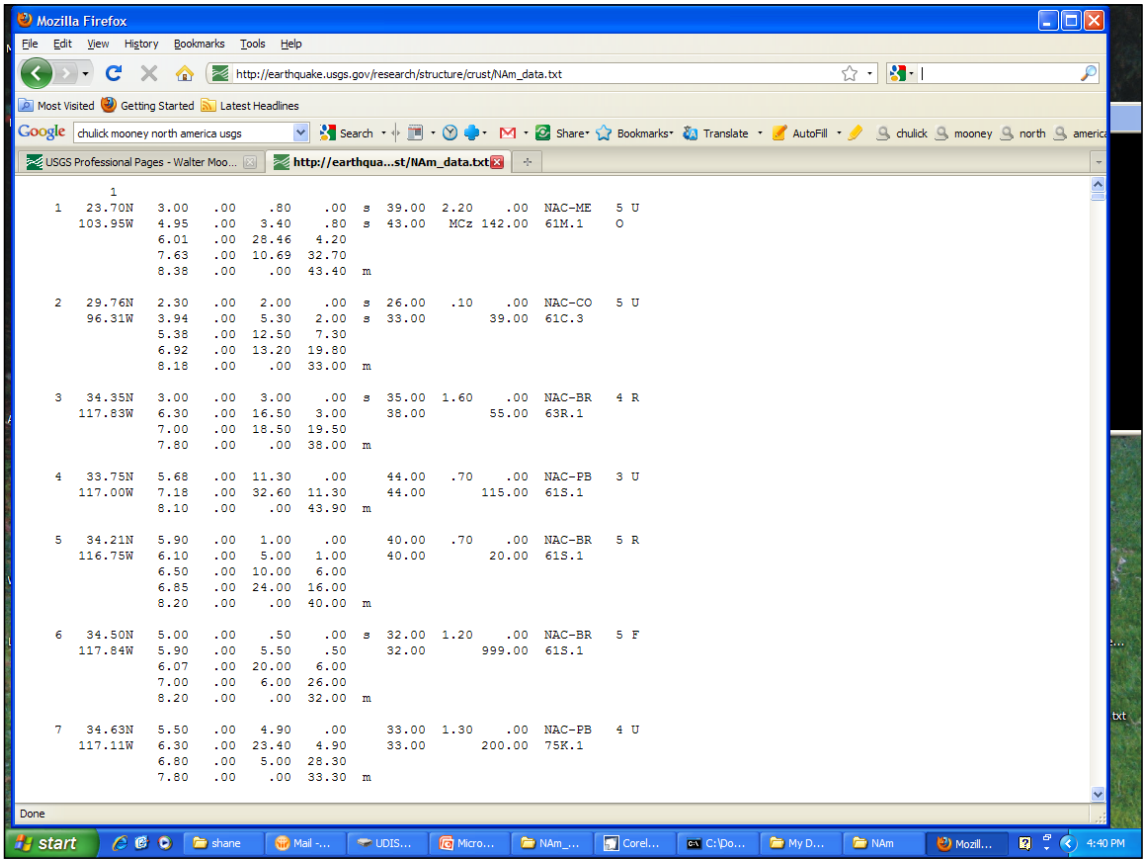


from: Braile et al., (1989).

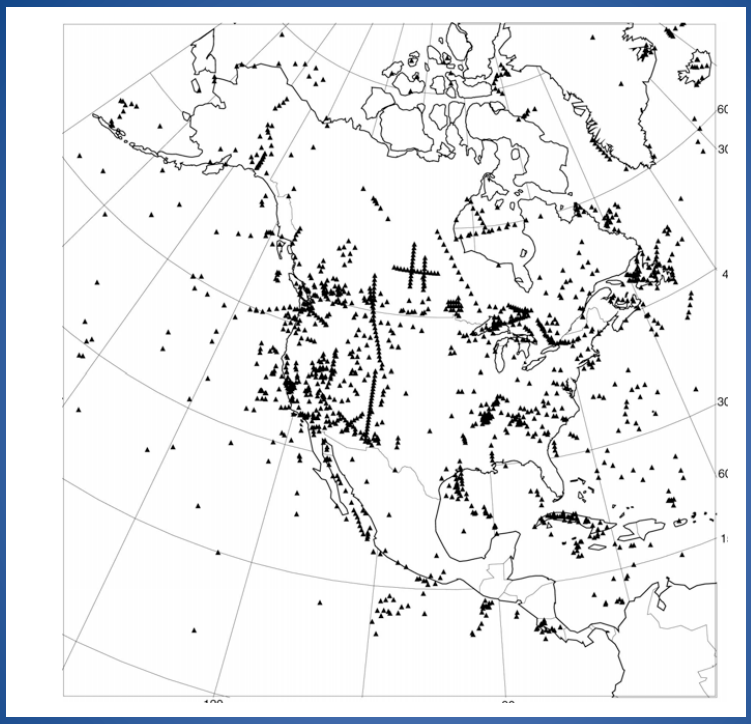
Locations of recording profiles in the Upper Mississippi Embayment



from: Braile (1989)

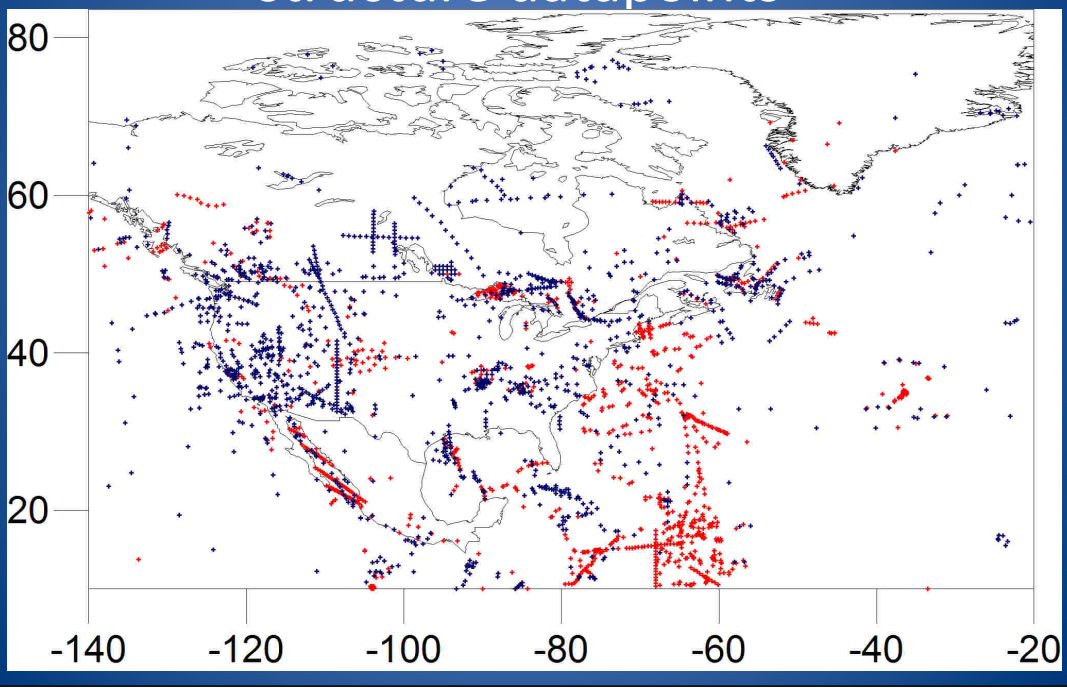



```
      1
1   23.70N   3.00   .00   .80   .00  s  39.00  2.20   .00  NAC-ME   5 U
   103.95W   4.95   .00  3.40   .80  s  43.00   MCz 142.00  61M.1    O
             6.01   .00 28.46  4.20
             7.63   .00 10.69 32.70
             8.38   .00   .00 43.40  m

2   29.76N   2.30   .00  2.00   .00  s  26.00   .10   .00  NAC-CO   5 U
    96.31W   3.94   .00  5.30  2.00  s  33.00        39.00  61C.3
             5.38   .00 12.50  7.30
             6.92   .00 13.20 19.80
             8.18   .00   .00 33.00  m

3   34.35N   3.00   .00  3.00   .00  s  35.00  1.60   .00  NAC-BR   4 R
   117.83W   6.30   .00 16.50  3.00     38.00        55.00  63R.1
             7.00   .00 18.50 19.50
             7.80   .00   .00 38.00  m

4   33.75N   5.68   .00 11.30   .00     44.00   .70   .00  NAC-PB   3 U
   117.00W   7.18   .00 32.60 11.30     44.00       115.00  61S.1
             8.10   .00   .00 43.90  m

5   34.21N   5.90   .00  1.00   .00     40.00   .70   .00  NAC-BR   5 R
   116.75W   6.10   .00  5.00  1.00     40.00        20.00  61S.1
             6.50   .00 10.00  6.00
             6.85   .00 24.00 16.00
             8.20   .00   .00 40.00  m

6   34.50N   5.00   .00   .50   .00  s  32.00  1.20   .00  NAC-BR   5 F
   117.84W   5.90   .00  5.50   .50     32.00       999.00  61S.1
             6.07   .00 20.00  6.00
             7.00   .00  6.00 26.00
             8.20   .00   .00 32.00  m

7   34.63N   5.50   .00  4.90   .00     33.00  1.30   .00  NAC-PB   4 U
   117.11W   6.30   .00 23.40  4.90     33.00       200.00  75K.1
             6.80   .00  5.00 28.30
             7.80   .00   .00 33.30  m
```

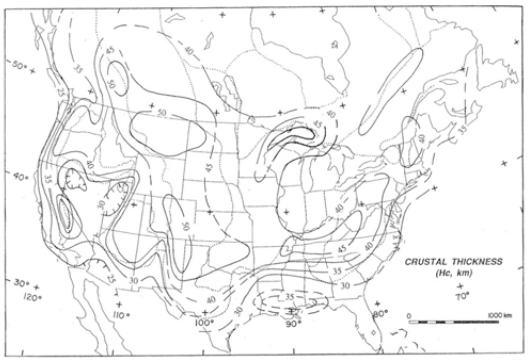


From: Chulick, G.S. and W. D. Mooney (2002), Seismic structure of the Crust and uppermost Mantle of North America and Adjacent Ocean Basins: A synthesis, Bull. Seism. Soc. Am, 92, 2478-2492

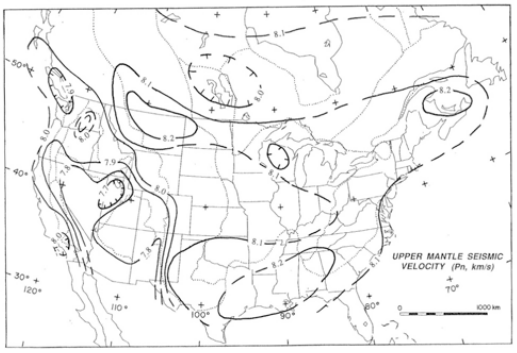
Existing North American crustal structure datapoints



Contour Map of Crustal Thickness

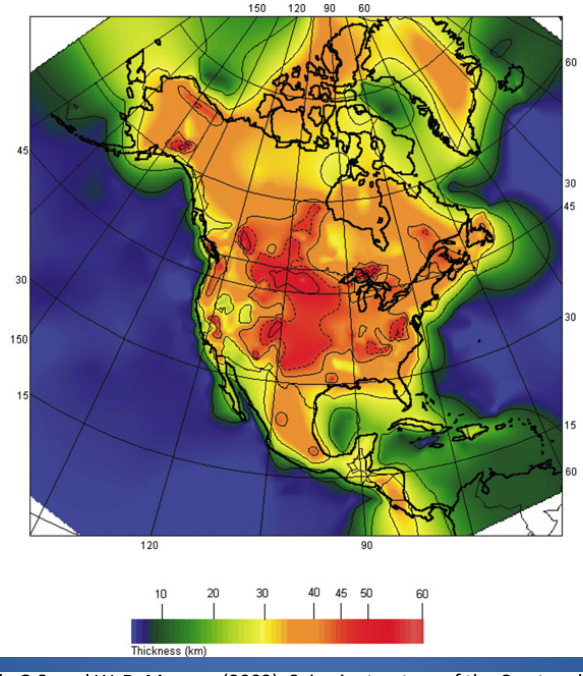


Contour Map of Pn velocity



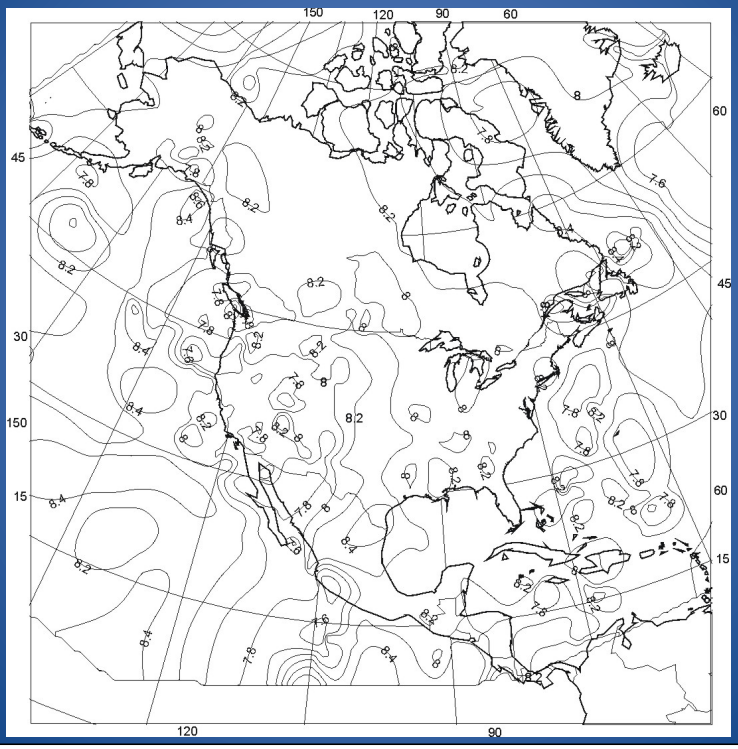
from: Braile et al., (1989)

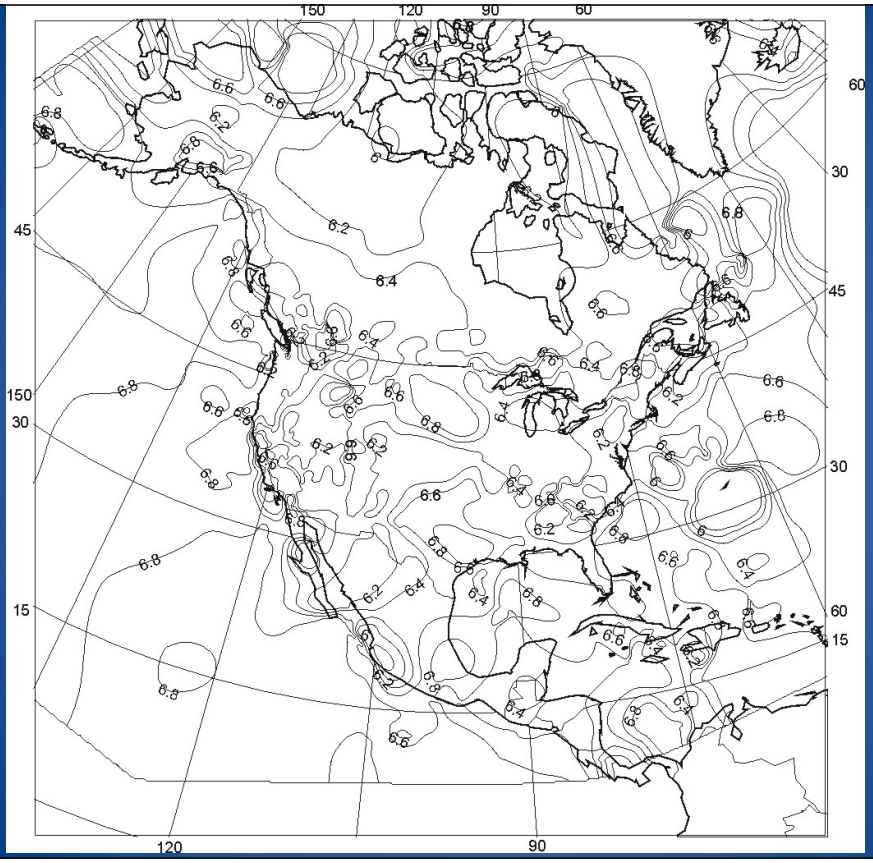
Crustal Thickness



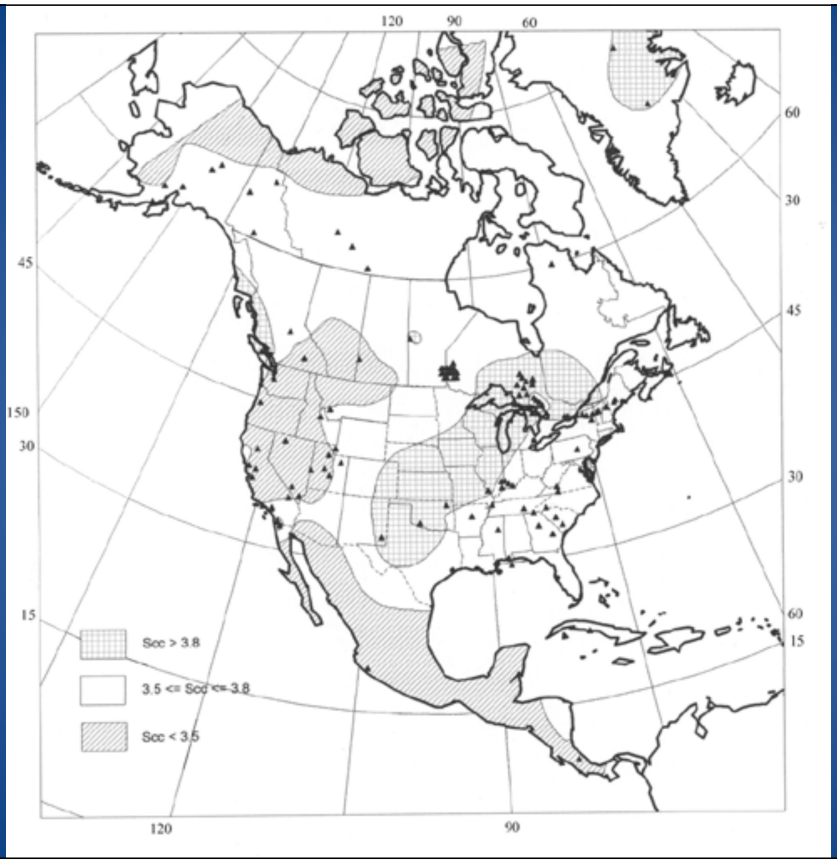
From: Chulick, G.S. and W. D. Mooney (2002), Seismic structure of the Crust and uppermost Mantle of North America and Adjacent Ocean Basins: A synthesis, Bull. Seism. Soc. Am, 92, 2478-2492

Chulick and Mooney Pn velocity (2002)





Pcc



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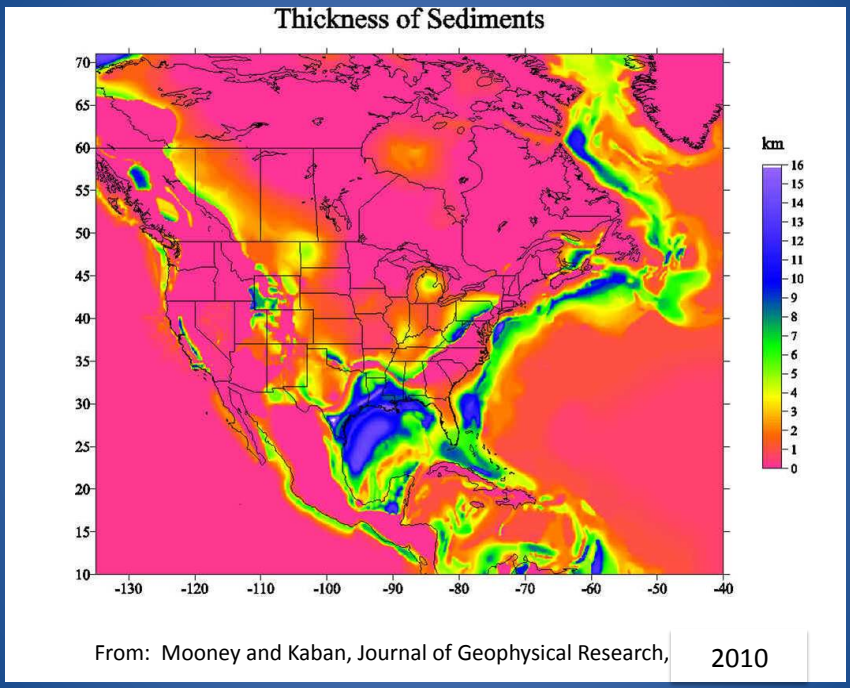


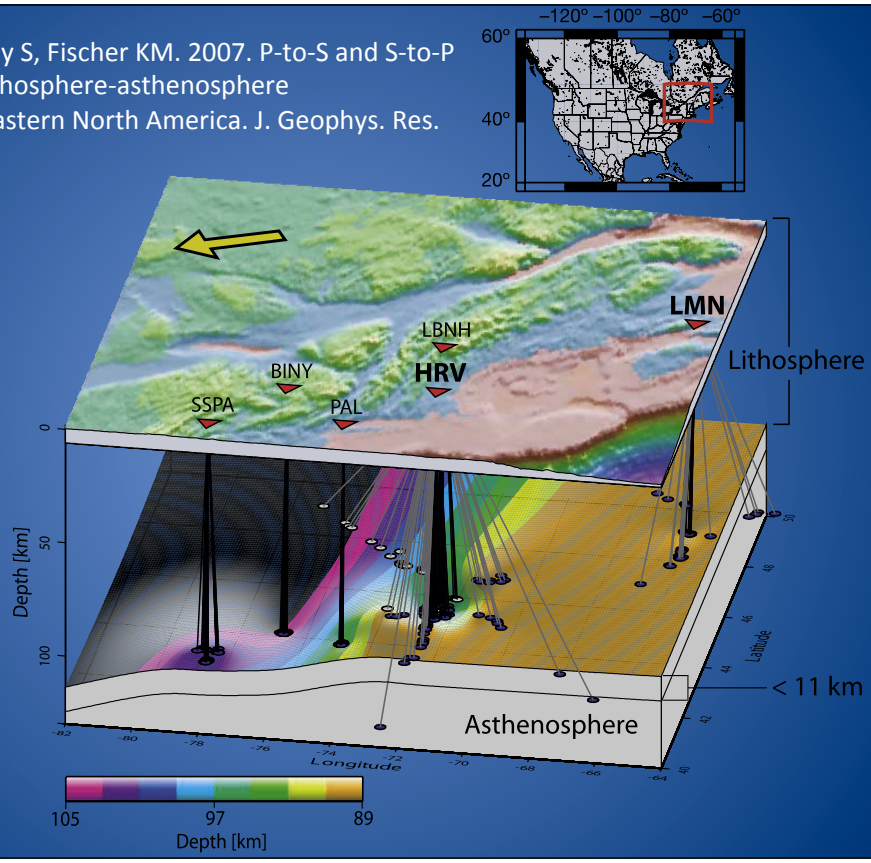
From: Mooney and Kaban, Journal of Geophysical Research, 2010

What new information remains to be found?

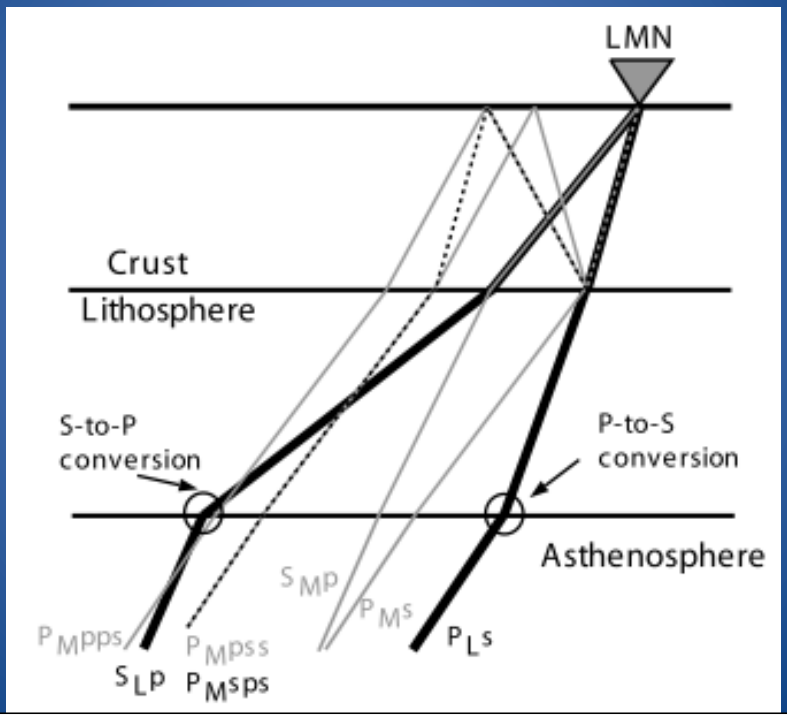
- Our catalog will be updated to include the most recent data available concerning both the shallow and deep seismic structure for Vp, Vs, Qp and Qs
- Of particular importance is the issue of the seismic properties of the upper 1 km of the crust. The 1993 EPRI report adopted a 1 km thick surface layer with Vp 5.0-6.0 km/s. This project will reassess the appropriateness of this assumption.

Rychert CA, Rondenay S, Fischer KM. 2007. P-to-S and S-to-P imaging of a sharp lithosphere-asthenosphere boundary beneath eastern North America. J. Geophys. Res. 112:B08314

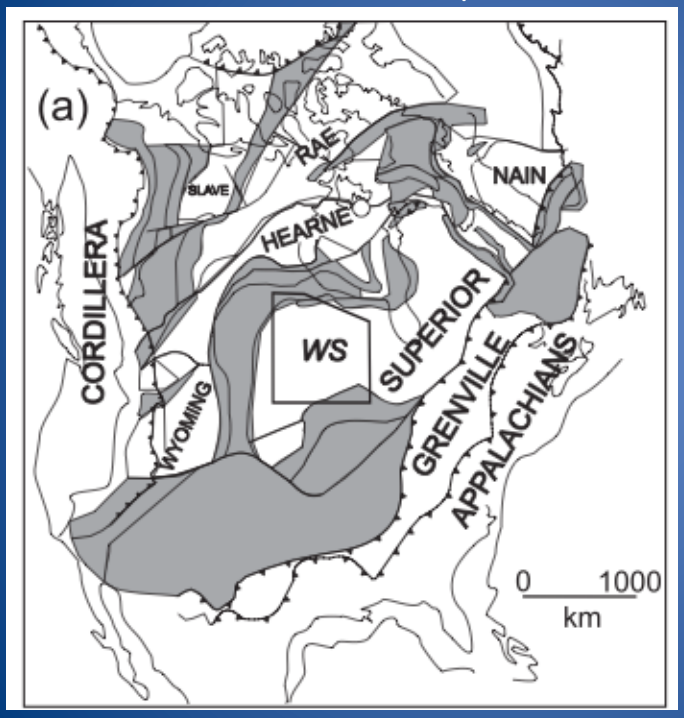
NE North America



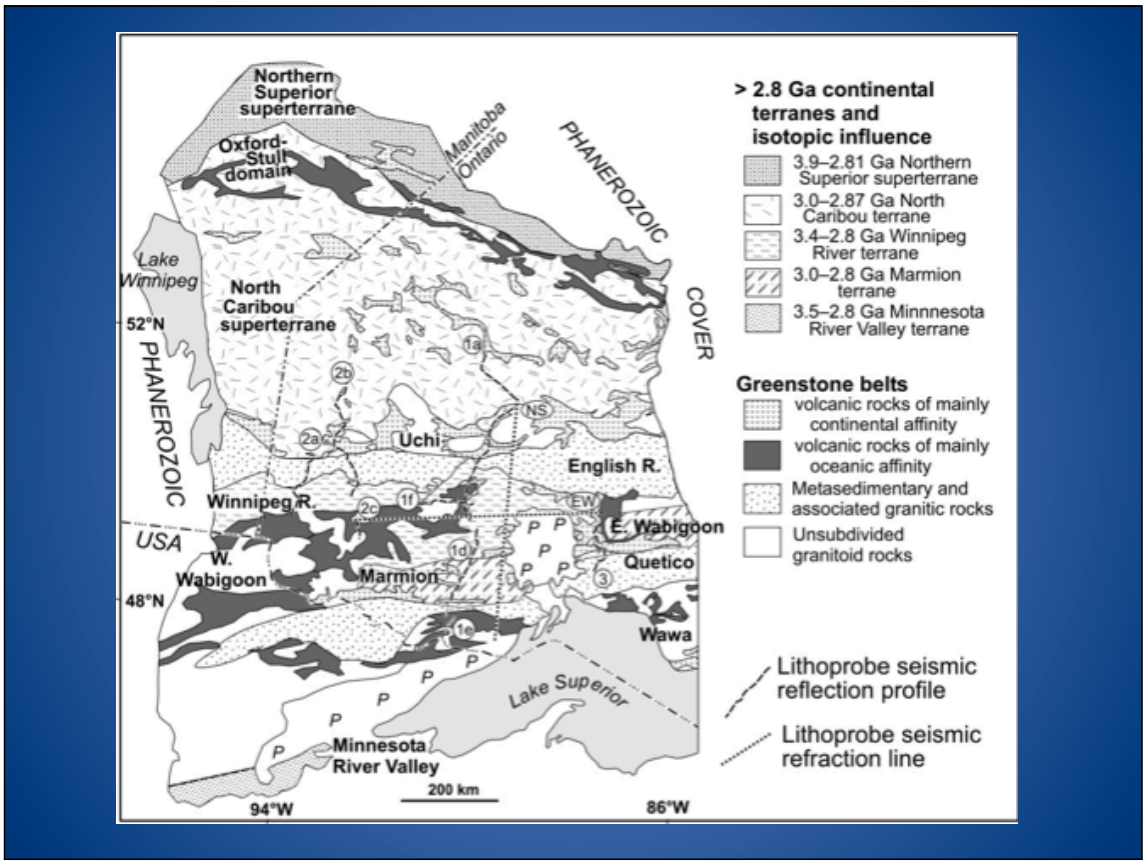
Example seismic waves and phases

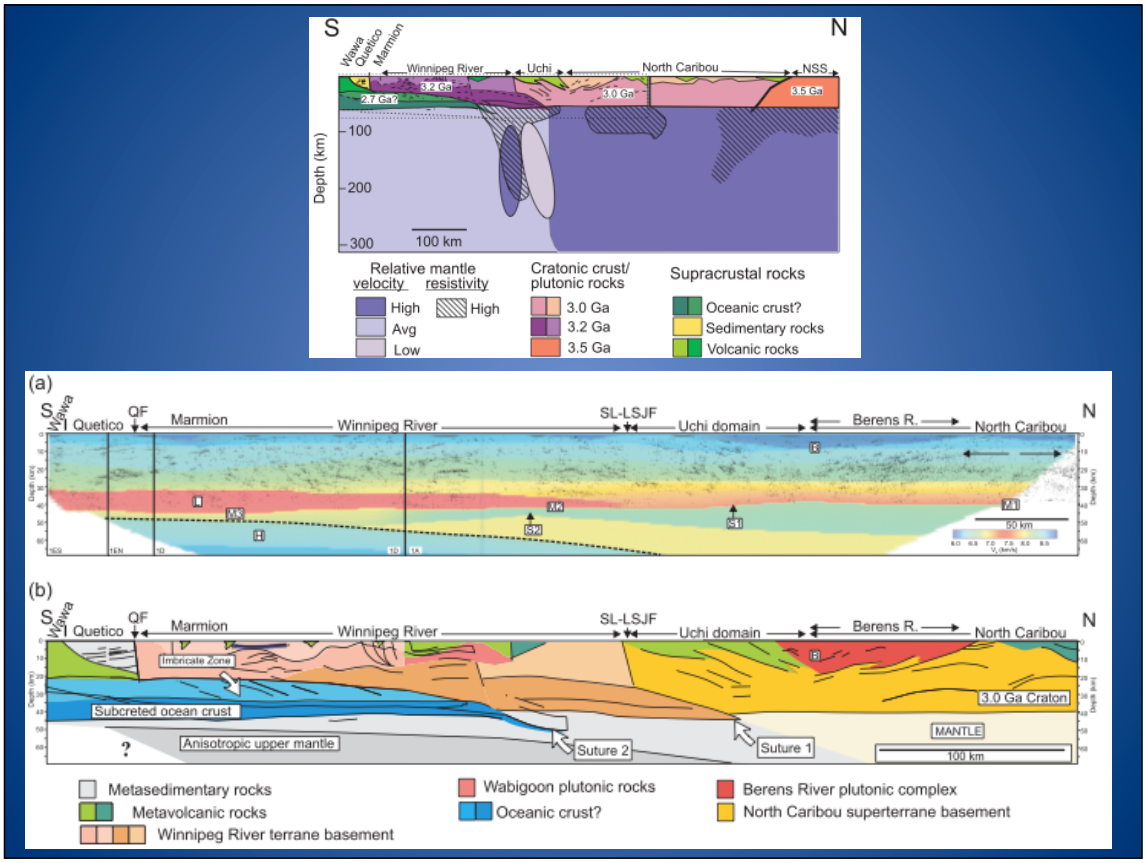


Western Superior Province

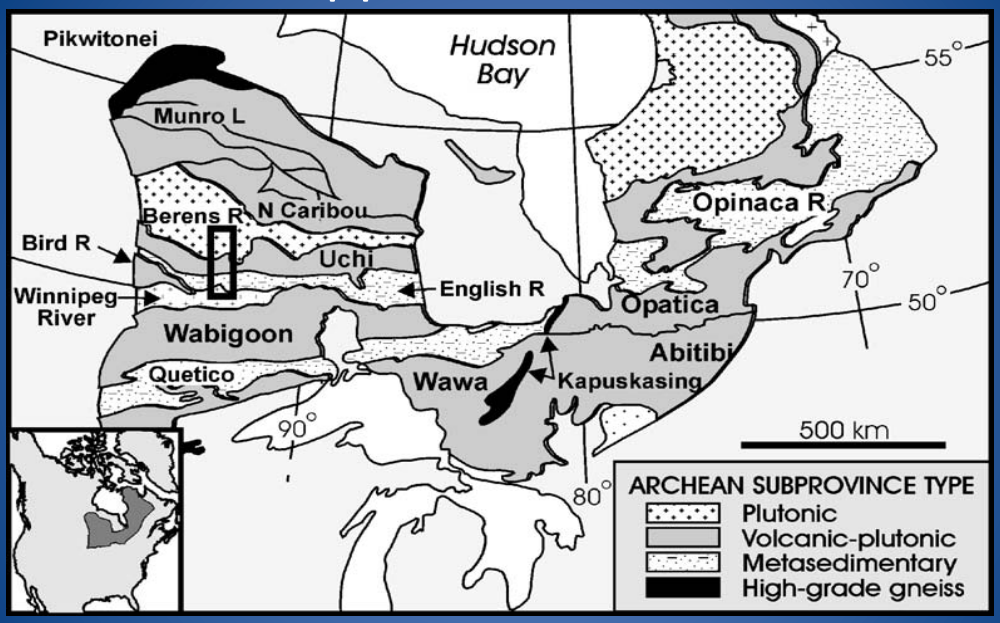


Percival, J.A., Sanborn-Barrie, M., Skulski, T., Stott, G.M., Helmstaedt, H., and White, D.J., 2006b, Tectonic evolution of the western Superior Province from NATMAP and Lithoprobe studies: Canadian Journal of Earth Sciences, v. 43 p. 1085-1117 doi: 10.1139/E06-062.

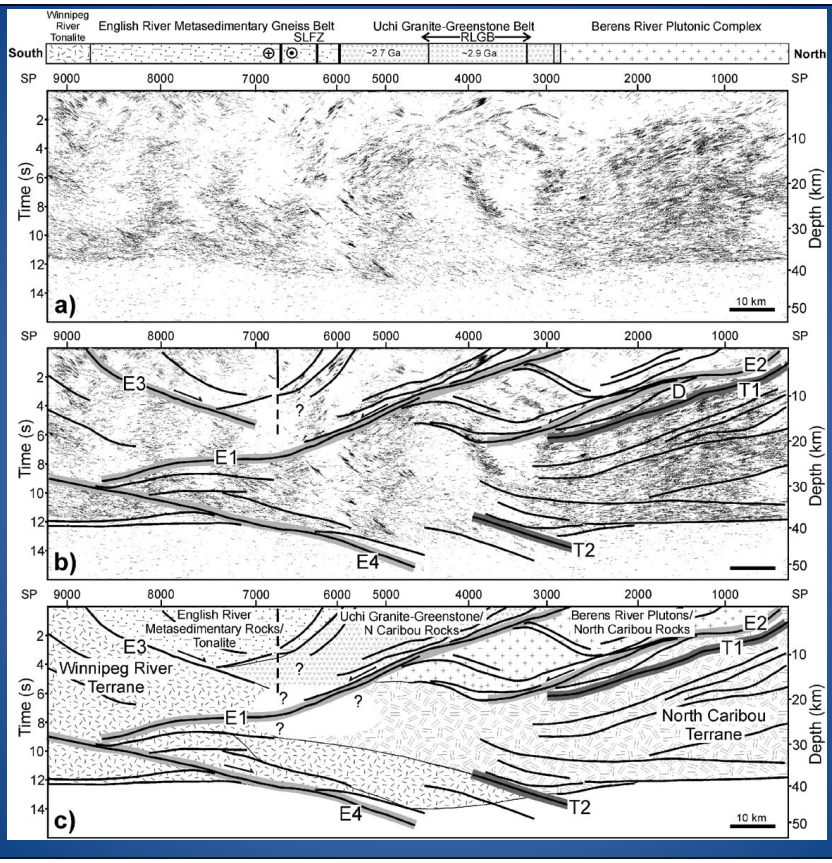

Northern Superior superterrane
Oxford-Stull domain
Manitoba
Ontario
PHANEROZOIC
COVER
Lake Winnipeg
North Caribou superterrane
52°N
PHANEROZOIC
Uchi
English R.
Winnipeg R.
E. Wabigoon
USA
W. Wabigoon
Marmion
Quetico
48°N
Wawa
Lake Superior
Minnesota River Valley
200 km
94°W
86°W
> 2.8 Ga continental terranes and isotopic influence
3.9–2.81 Ga Northern Superior superterrane
3.0–2.87 Ga North Caribou terrane
3.4–2.8 Ga Winnipeg River terrane
3.0–2.8 Ga Marmion terrane
3.5–2.8 Ga Minnnesota River Valley terrane
Greenstone belts
volcanic rocks of mainly continental affinity
volcanic rocks of mainly oceanic affinity
Metasedimentary and associated granitic rocks
Unsubdivided granitoid rocks
Lithoprobe seismic reflection profile
Lithoprobe seismic refraction line

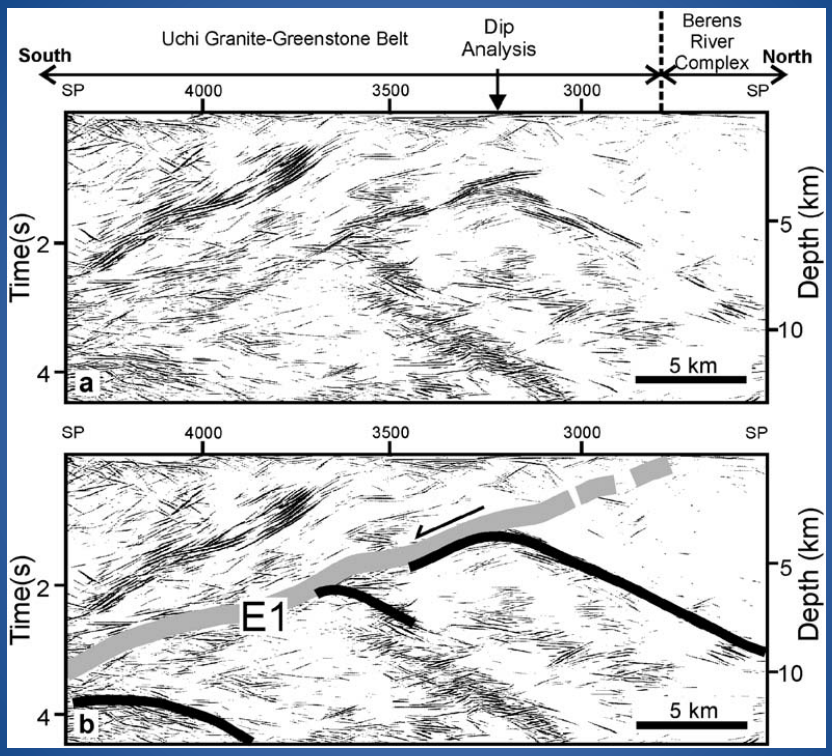

S
N
Wawa
Quetico
Marmion
Winnipeg River
Uchi
North Caribou
NSS
3.2 Ga
2.7 Ga?
3.0 Ga
3.5 Ga
Depth (km)
100
200
300
100 km
Relative mantle velocity
resistivity
High
Avg
Low
High
Cratonic crust/ plutonic rocks
3.0 Ga
3.2 Ga
3.5 Ga
Supracrustal rocks
Oceanic crust?
Sedimentary rocks
Volcanic rocks
(a)
QF
SL-LSJF
Uchi domain
Berens R.
50 km
(b)
Imbricate Zone
Subcreted ocean crust
Anisotropic upper mantle
Suture 2
Suture 1
3.0 Ga Craton
MANTLE
100 km
Metasedimentary rocks
Metavolcanic rocks
Winnipeg River terrane basement
Wabigoon plutonic rocks
Oceanic crust?
Berens River plutonic complex
North Caribou superterrane basement

Upper Great Lakes

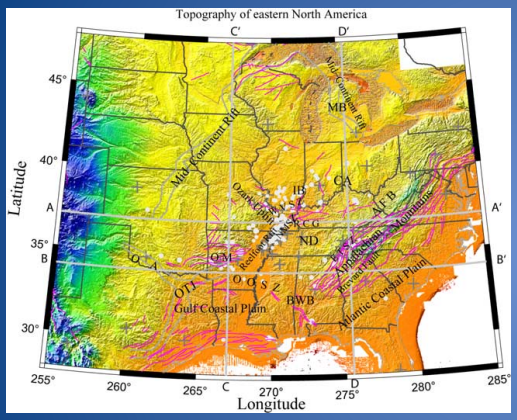


Calvert et al., 2004 A.J. Calvert, A.R. Cruden and A. Hynes, Seismic evidence for preservation of the Archean Uchi granite–greenstone belt by crustal-scale extension. Tectonophysics, 388 (2004), pp. 135–143.

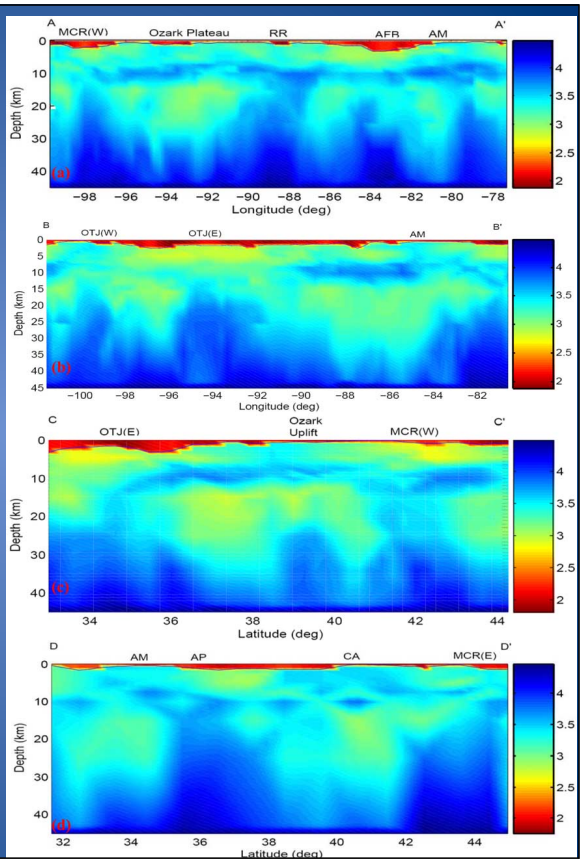


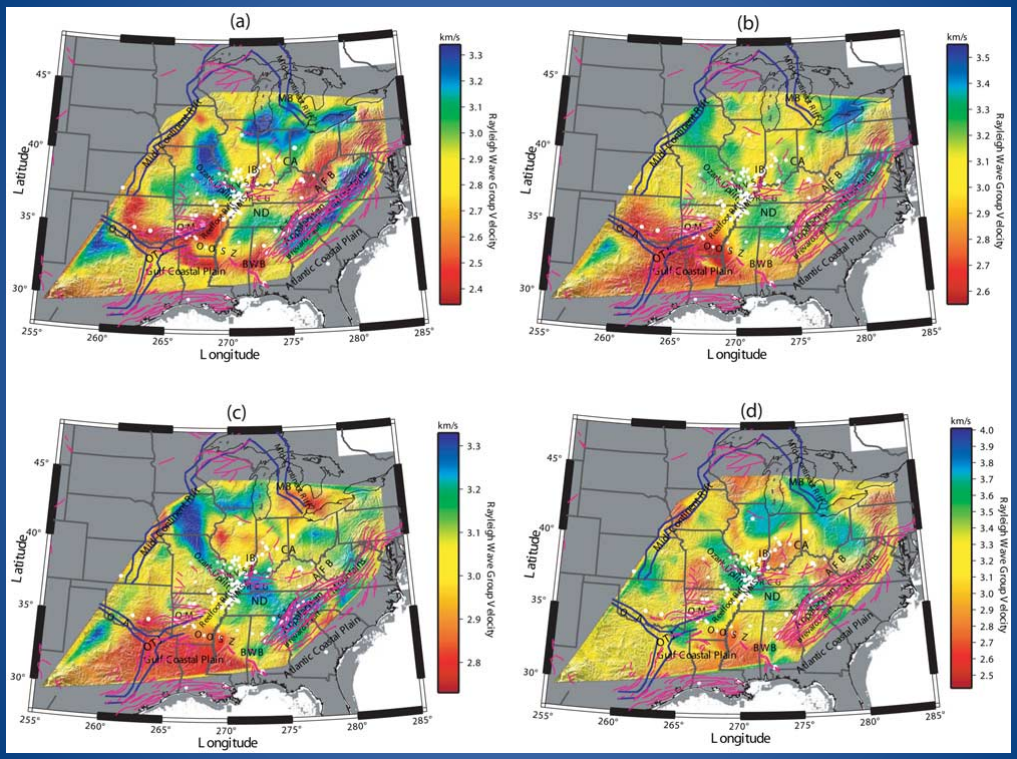


Central US

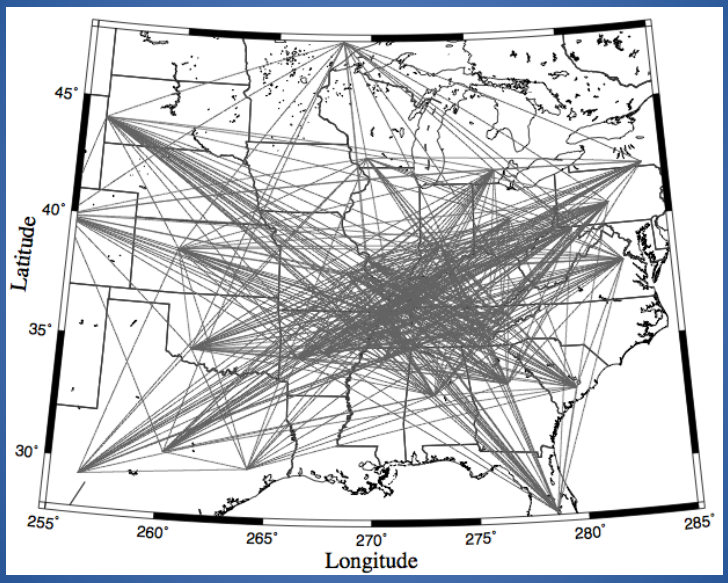


Liang, C., and C. A. Langston (2009), Three-dimensional crustal structure of eastern North America extracted from ambient noise, J. Geophys. Res., 114, B03310, doi: 10.1029/2008JB005919.

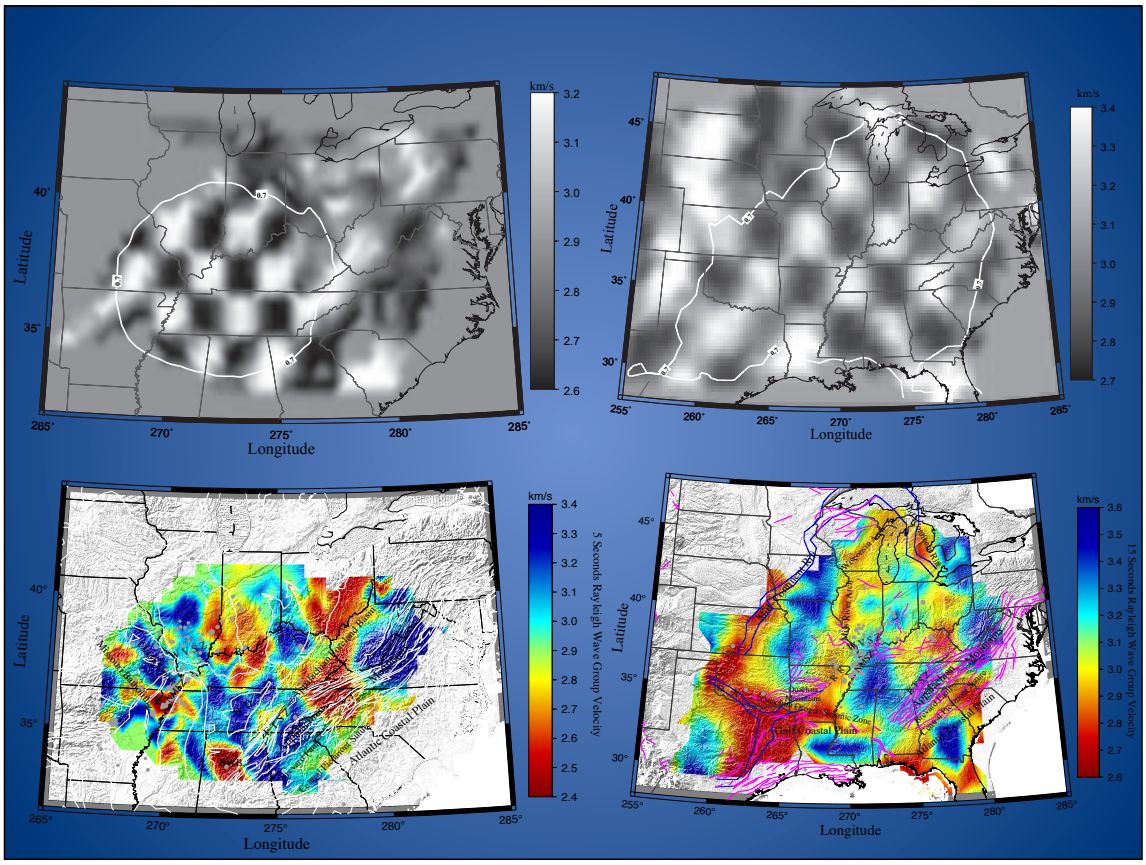




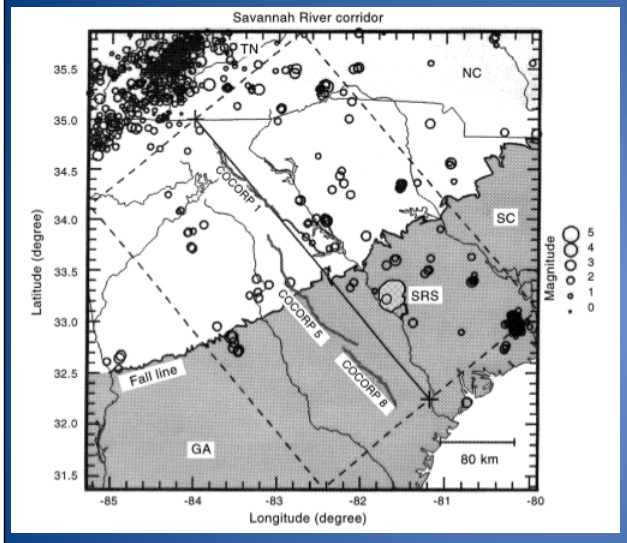
Central US Structure

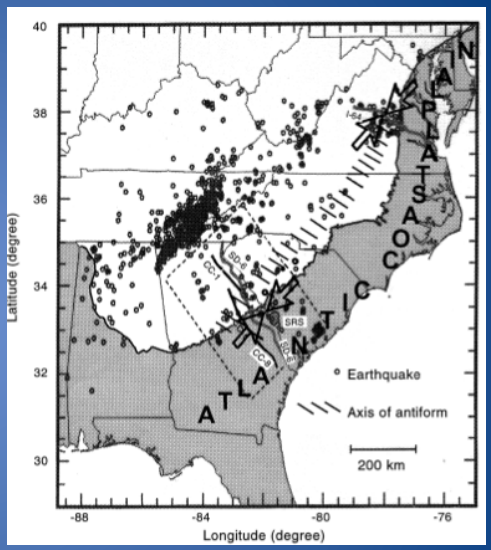


Liang, C., and C. A. Langston (2008), Ambient seismic noise tomography and structure of eastern North America, J. Geo- phys. Res., 113, B03309, doi:10.1029/2007JB005350.



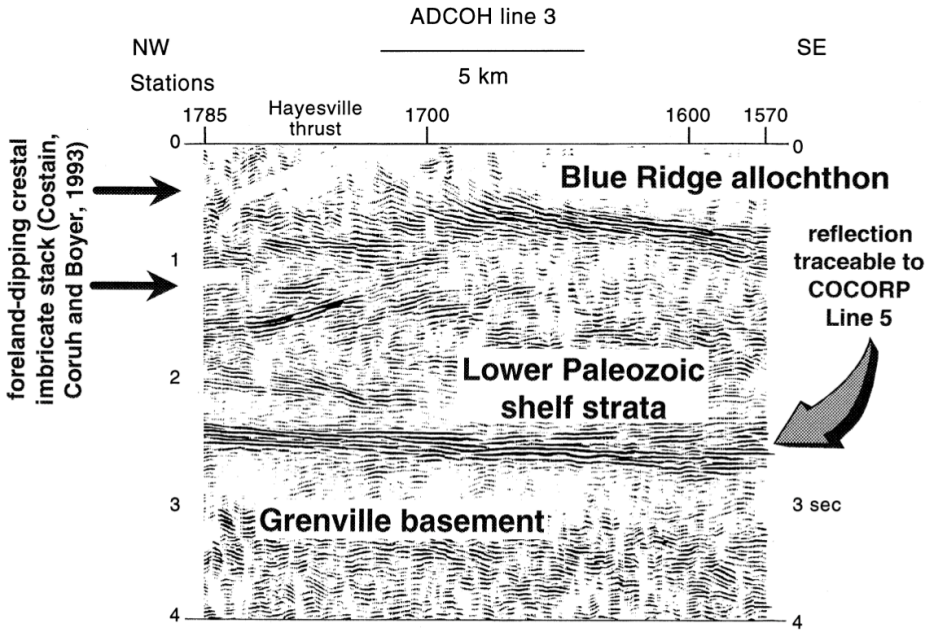
SE Appalachians



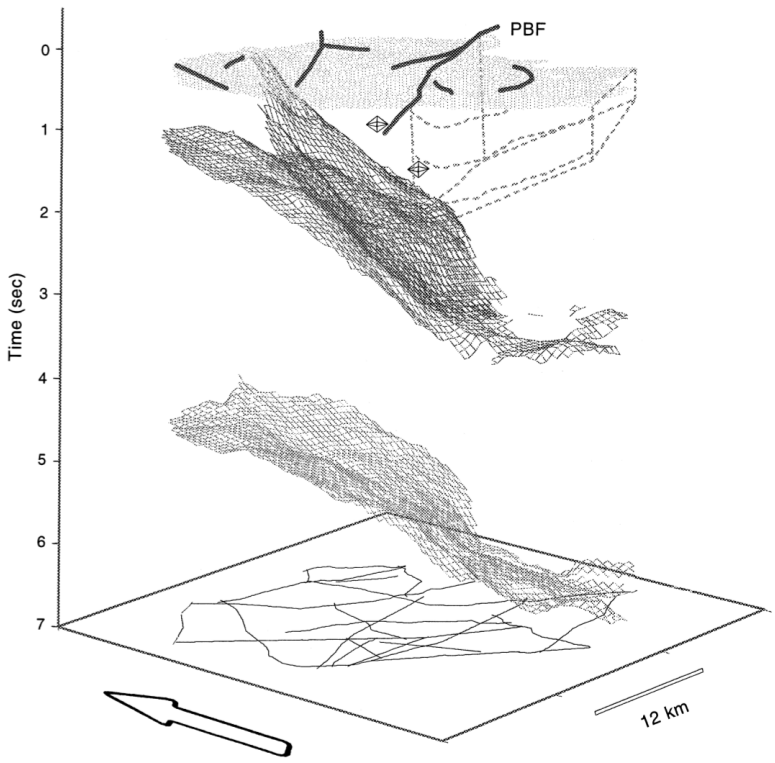


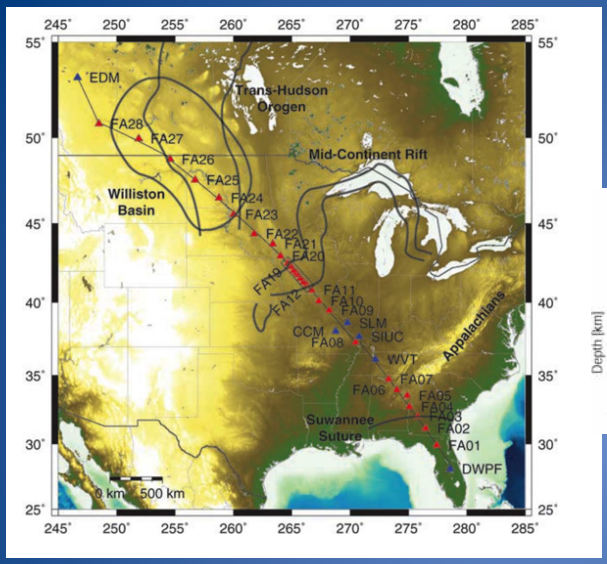
Domoracki et al., 1999 W.J. Domoracki, D.E. Stevenson, C. Çoruh and J.K. Costain, Seismotectonic structures along the Savannah River Corridor, South Carolina, U.S.A. *J. of Geodynamics*, **27** (1999), pp. 97–108.

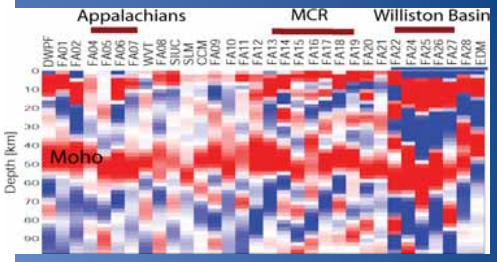
W.J. Domoracki et al./*Geodynamics 27 (1999) 97–118*



W.J. Domoracki et al./*Geodynamics 27 (1999) 97–118*







Florida-Edmonton broadband seismometer array (FLED) station locations from: French, S.W., K.M. Fischer, E.M. Syracuse and W.E. Wysession, Geoph. Res. Lett., 36, L08309, (2009).

USGS Work 2011-12*

- Task 1- data compilation (already begun)
- Task 2- data extraction
- Task 3- data validation, QC and entry
- Task 4- Respond to queries from NGA-East participants regarding completeness, use and format of the database, and the facilitation of its efficient use by participants (amend as needed)
  - Task 4a- deliver new maps showing datapoints and crustal structure information

* Our subtask