NGA-East Path Working Group Goals/ Objectives

C.1 Identify regions with significant differences in Q, geometrical spreading and duration.

C.2 Estimate Q, geometrical spreading and duration for each region

C.3 Select representative 1D crustal structure for each region

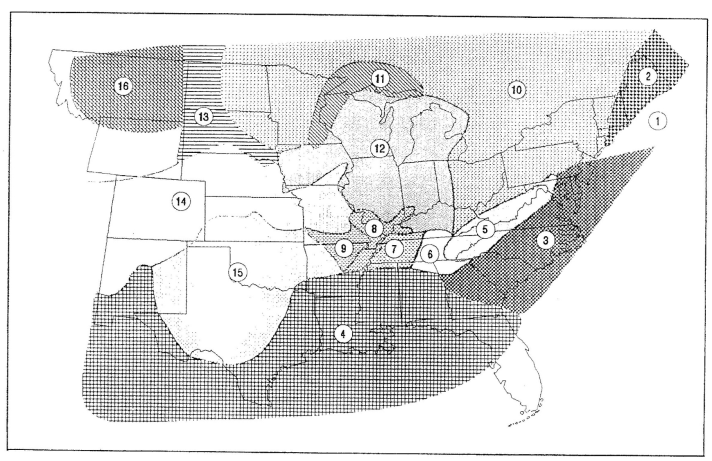
C.4 Evaluate the need for different regions, define different regions

C.5 Develop rules for treatment of region boundary crossing

D.1 Estimate regional source and path parameters for CENA earthquakes

D.2 Develop models for source and path parameters

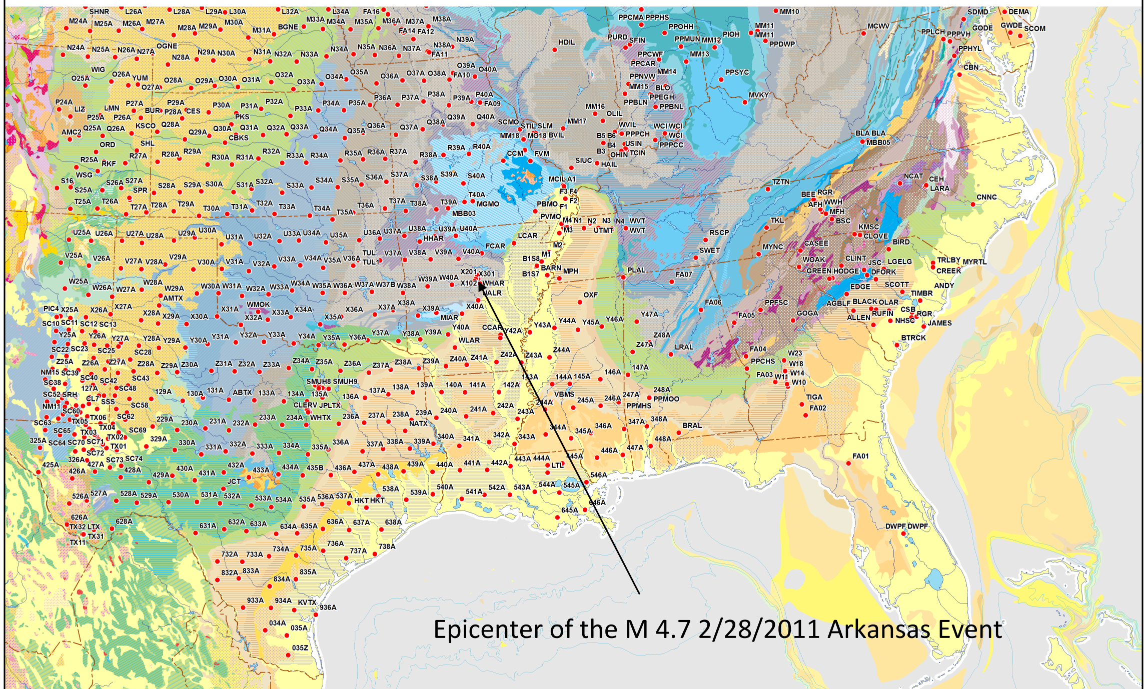
16 crustal structure regions defined by EPRI (1993)



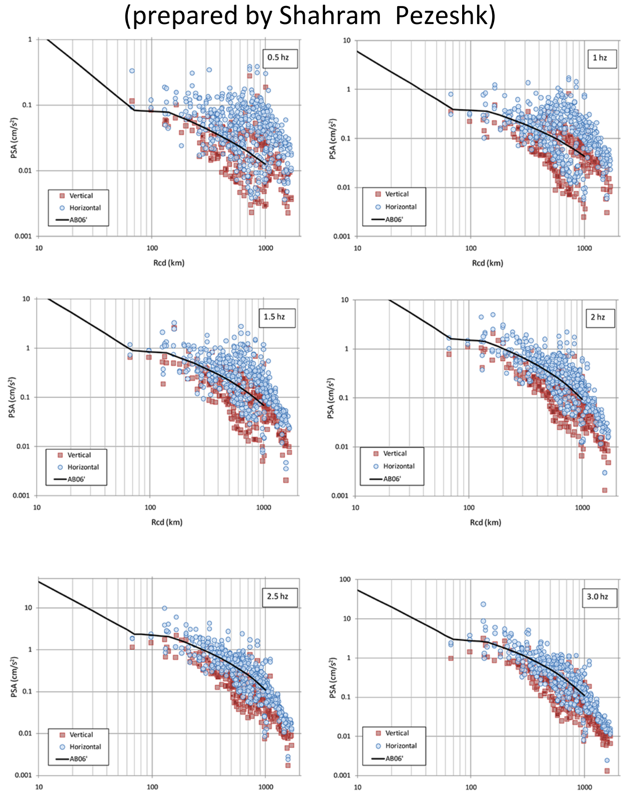
The EPRI study concluded that only the gulf coastal region differed significantly from the rest of the central and eastern parts of the continent, in terms of ground motion propagation.

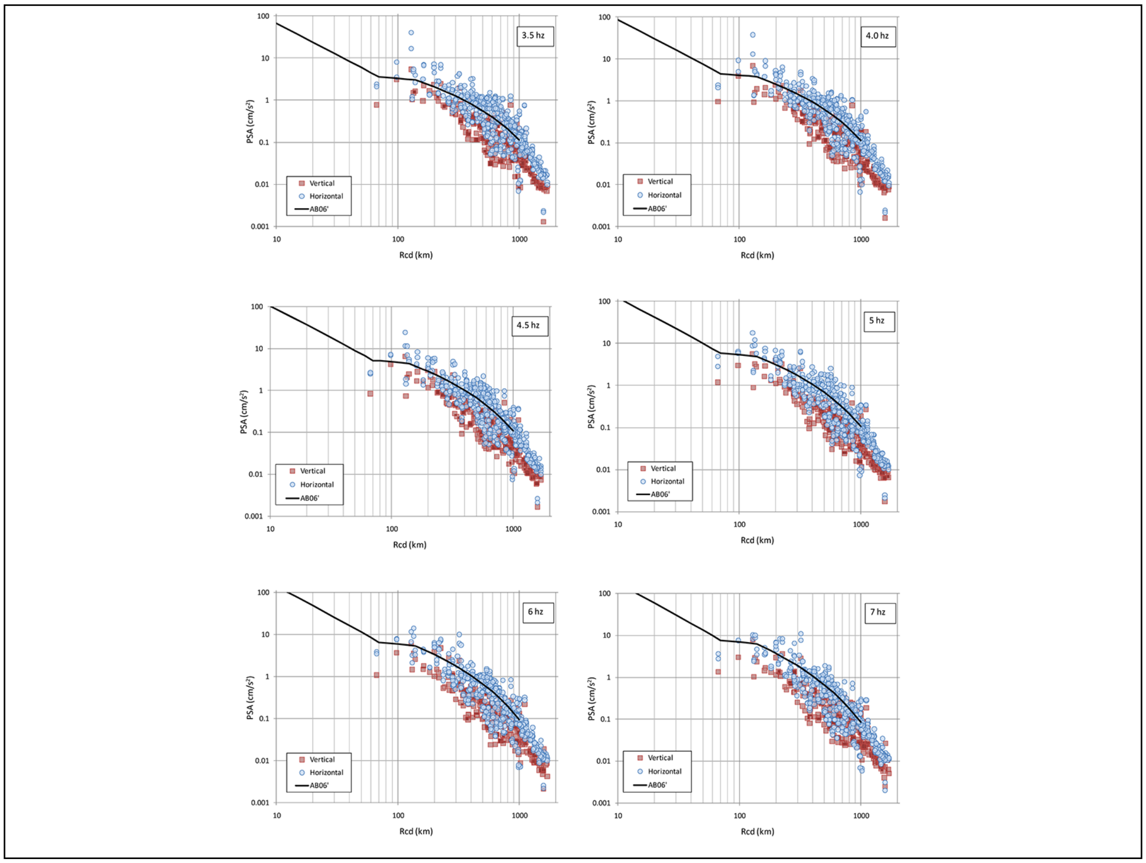
Tasks C.1 and C.2 of the working group are currently focusing on this issue, using new data.

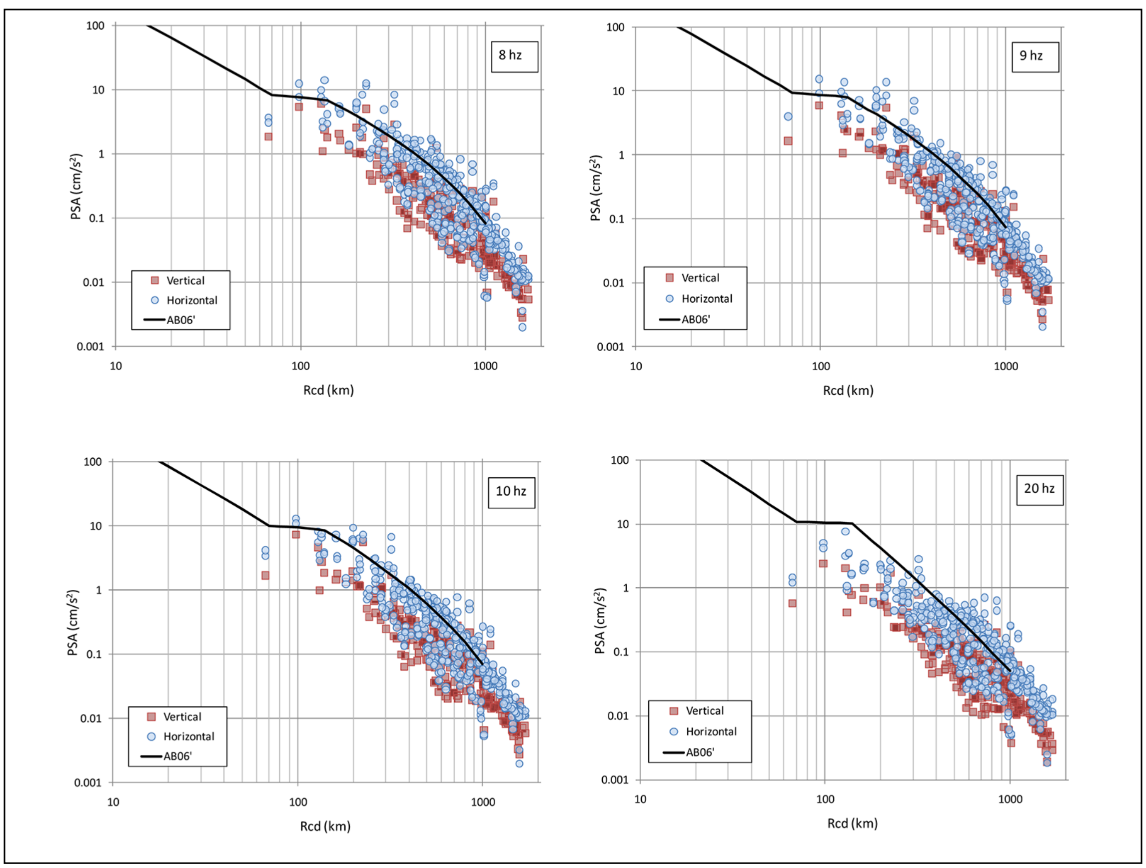
Broadband Station locations in the Eastern US as of April 30, 2011



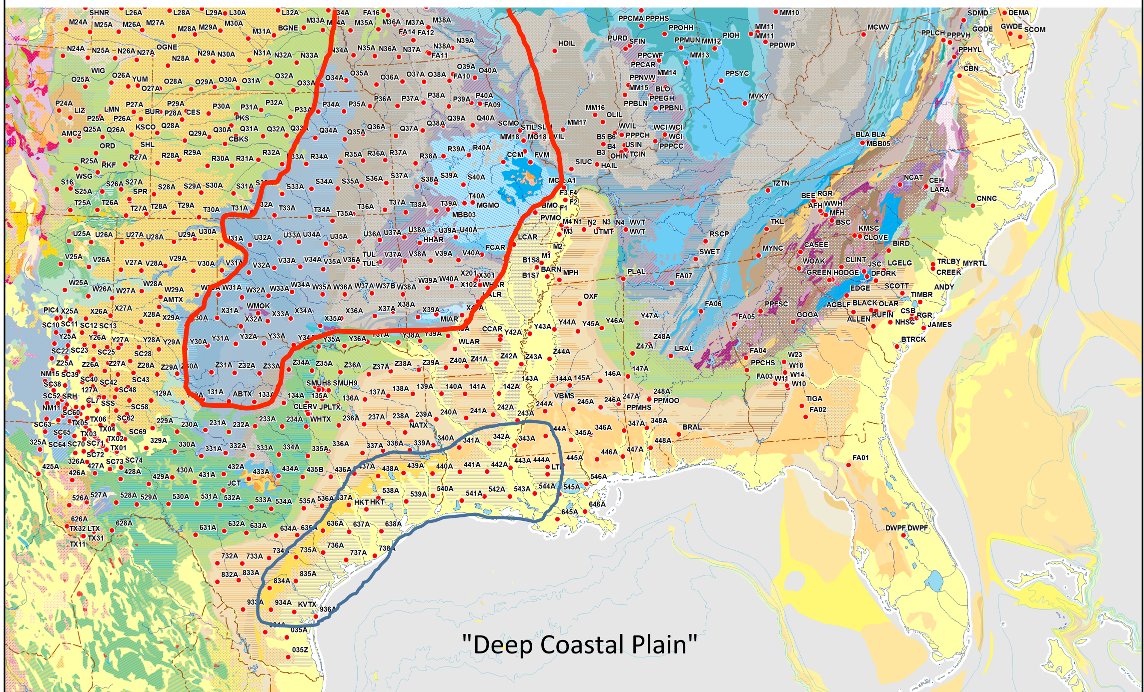
PSA values for the 2/28/2011 Arkansas earthquake
(prepared by Shahram Pezeshk)



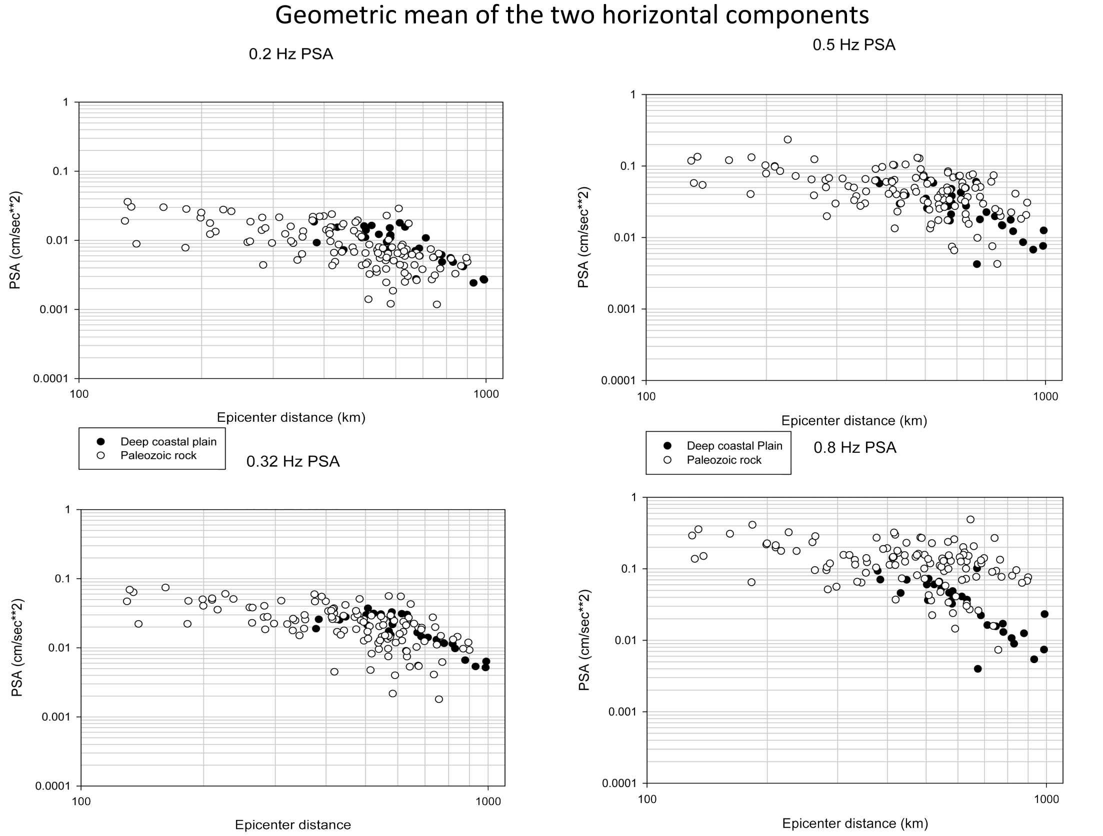

3.5 hz
4.0 hz
4.5 hz
5 hz
6 hz
7 hz
PSA (cm/s²)
Rcd (km)
Vertical
Horizontal
AB06'


8 hz
9 hz
10 hz
20 hz
PSA (cm/s²)
Rcd (km)
Vertical
Horizontal
AB06'

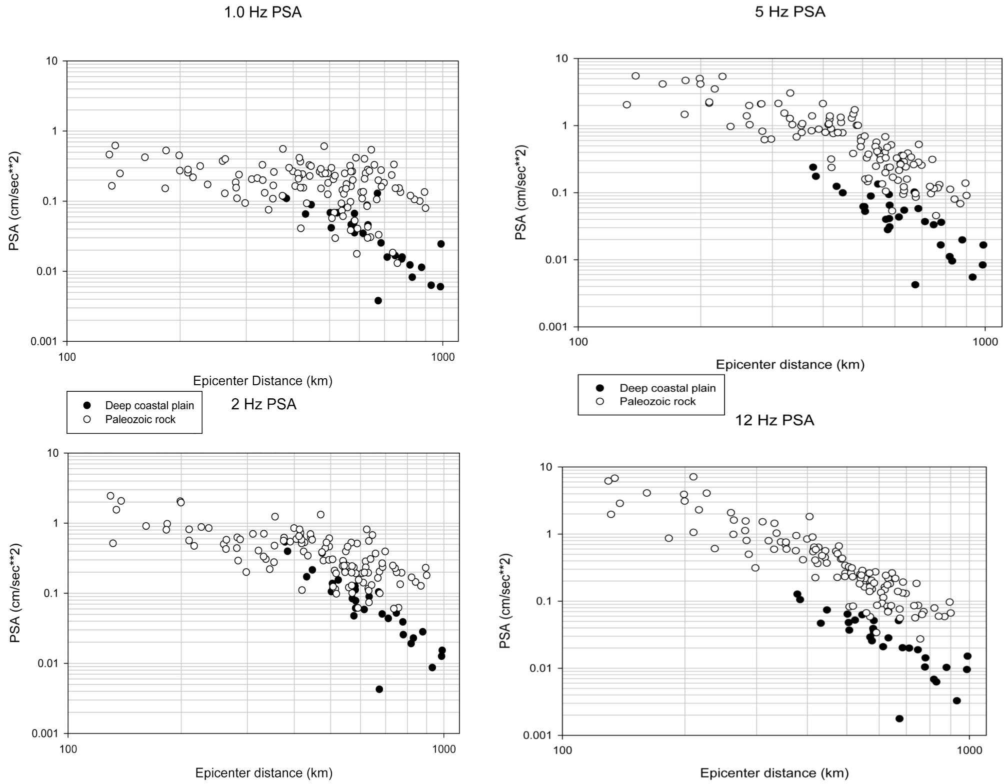
"Paleozoic Rock"



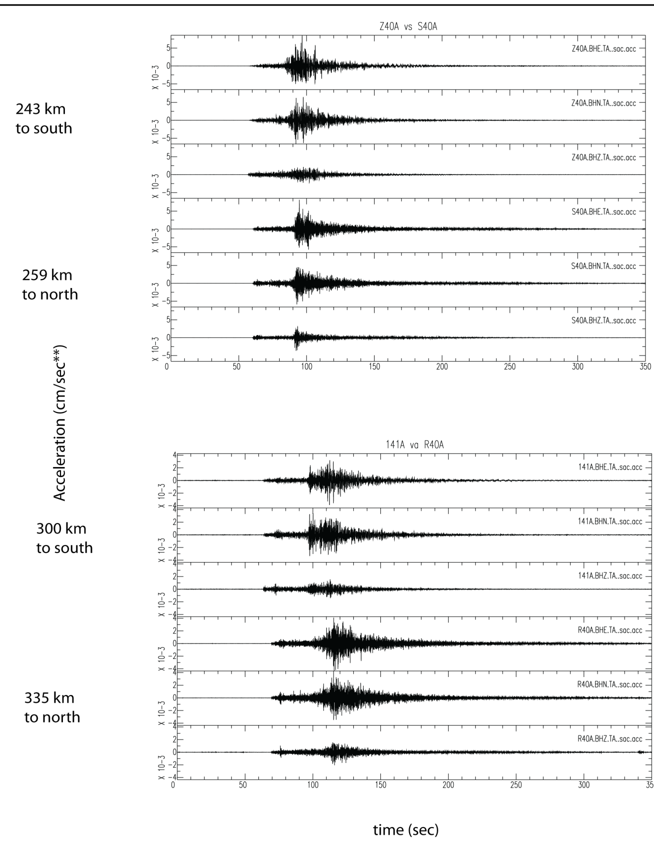
Geometric mean of the two horizontal components



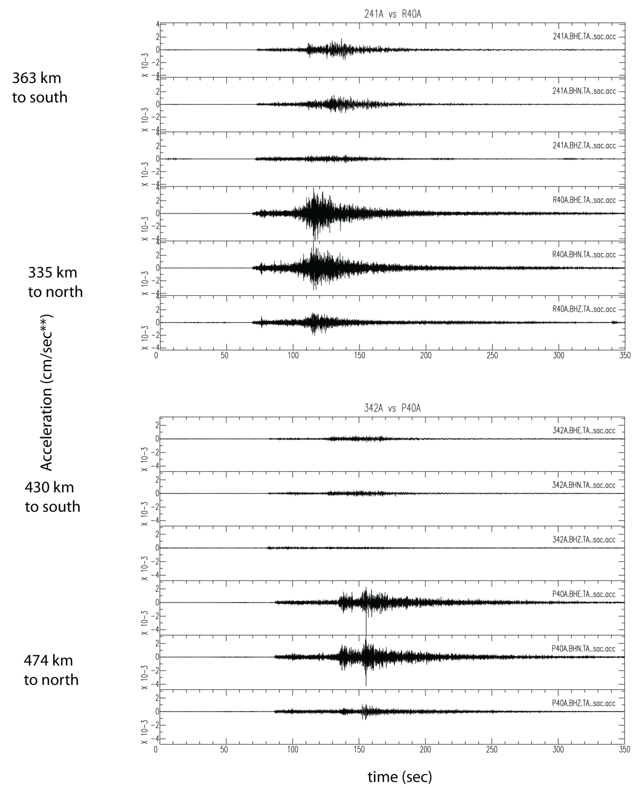
Geometric mean of the two horizontal components



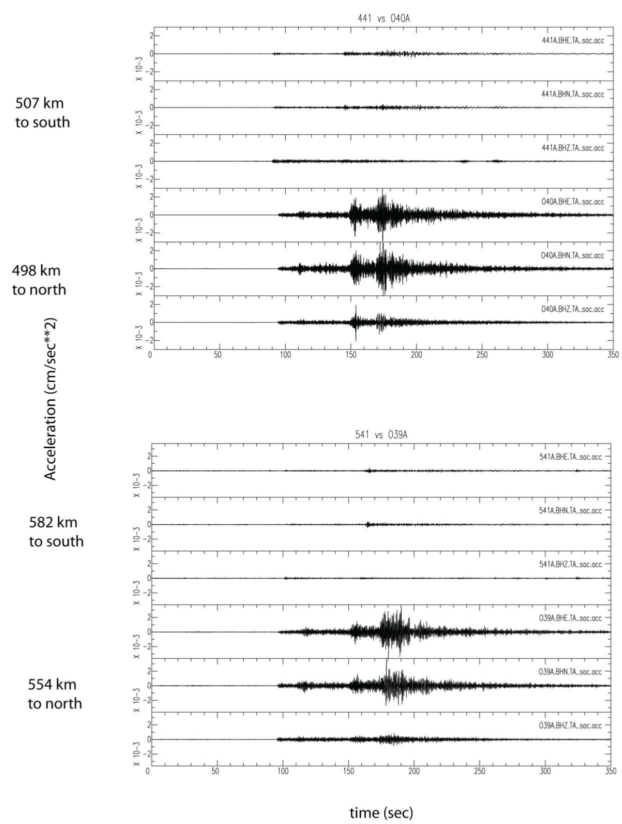
Comparison of seismograms to the north and south of the February 28, 2011 central Arkansas earthquake (M 4.7).



Comparison of seismograms to the north and south of the February 28, 2011 central Arkansas earthquake (M 4.7).



Comparison of seismograms to the north and south of the February 28, 2011 central Arkansas earthquake (M 4.7).



$$A(\omega) = S(\omega)g(r)\exp\left(-\frac{\omega r}{2q_p v_p}\right)\exp\left(-\frac{\omega h}{2q_s v_s}\right)$$

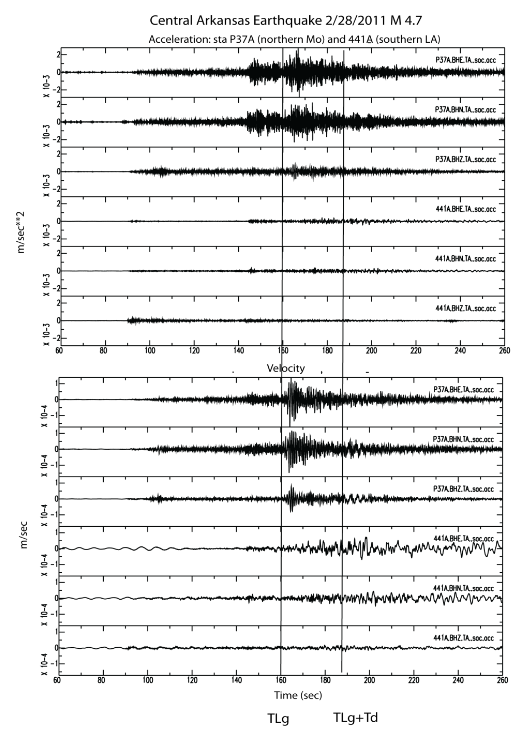
$$\ln\left[\frac{A(\omega)}{g(r)}\right] = \ln\,(S(w) - \frac{\omega r}{2q_p v_p} - \frac{\omega h}{2q_s v_s}$$

$$lnY = c_1 + \; c_2\omega r/2 + c_3\omega h/2$$

A (w) is the geometric mean Fourier amplitude of the two horizontal components at frequency w, r is epicenter distance, g(r) represents geometrical spreading and h is thickness of coastal plain sediments. It is assumed that $g(r) = r^{-1.3}$ for r < 100 km, $g(r) = r^{-0.5}$ for r > 100 km.

Using observations of A(w) at the TA stations, solve for C_1, the log source amplitude, C_2 (the inverse of the product of Q and velocity for the crustal path) and C_3, (the inverse of the product of sediment Q and velocity at the receiver end of the path).

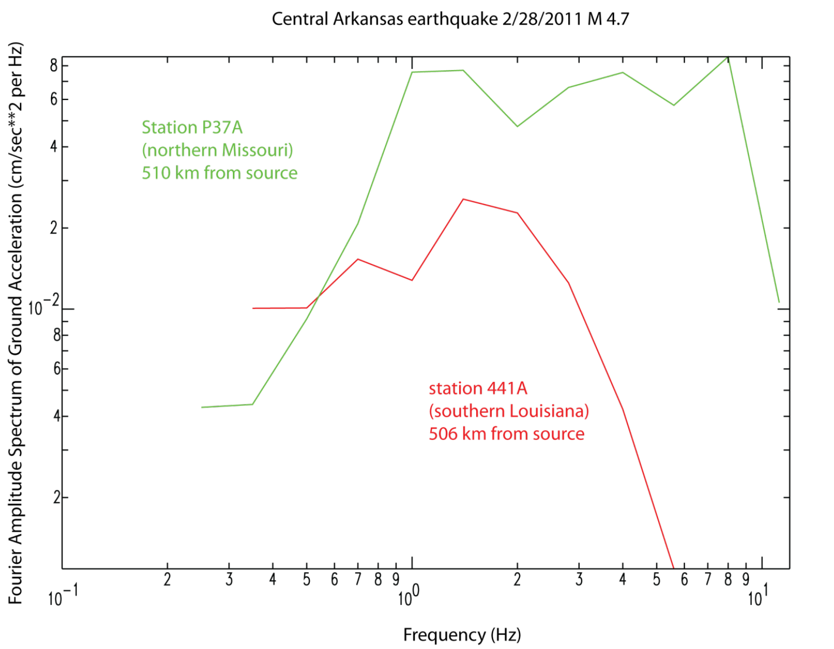
h is estimated from contour maps to the base of marine sediments: e.g. *Salvador, A., (1991). The Gulf of Mexico Basin, vol. J. The Geology of North America, Geological Society of America, Boulder, Colorado.*



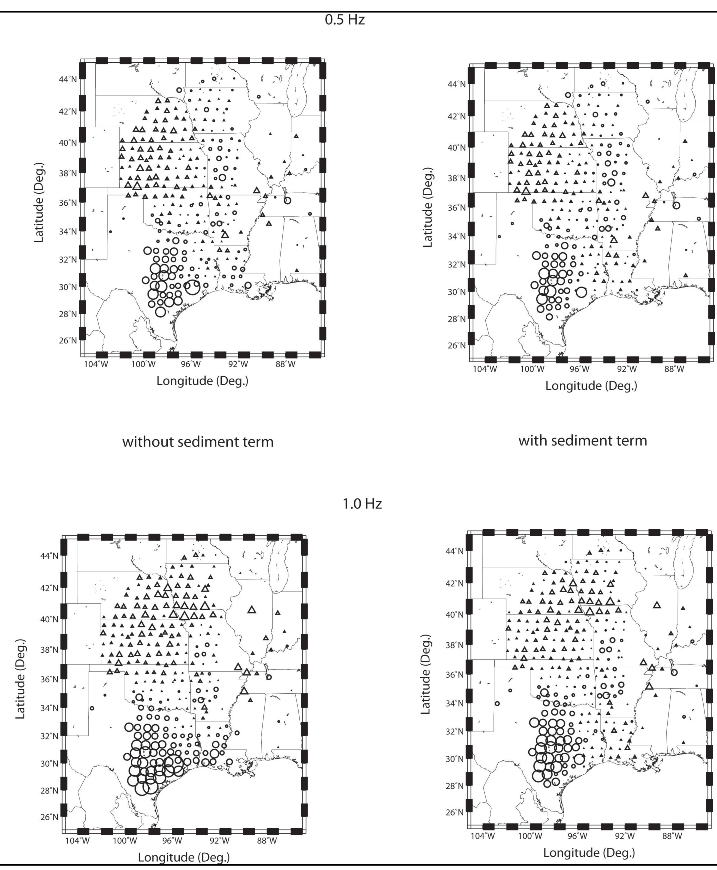
TLg = origin time + r / 3.53

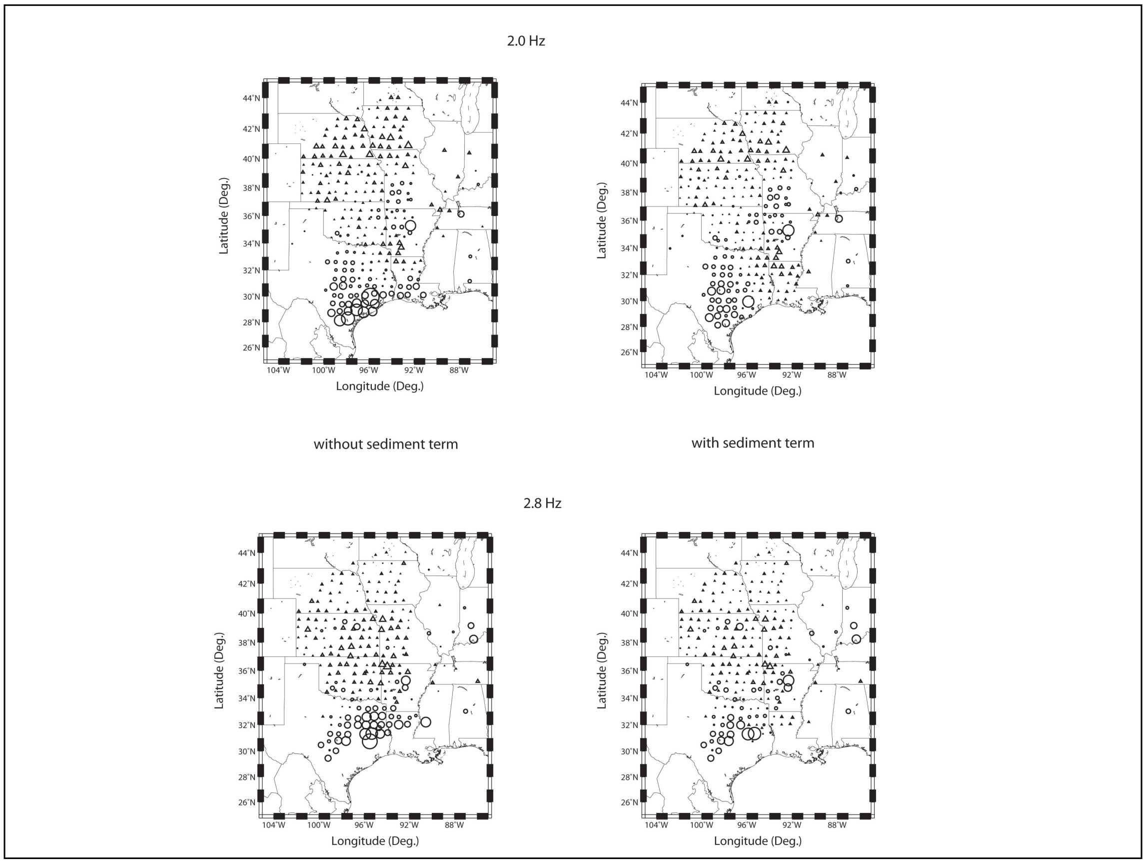
Td = 8.71 + 0.026 r

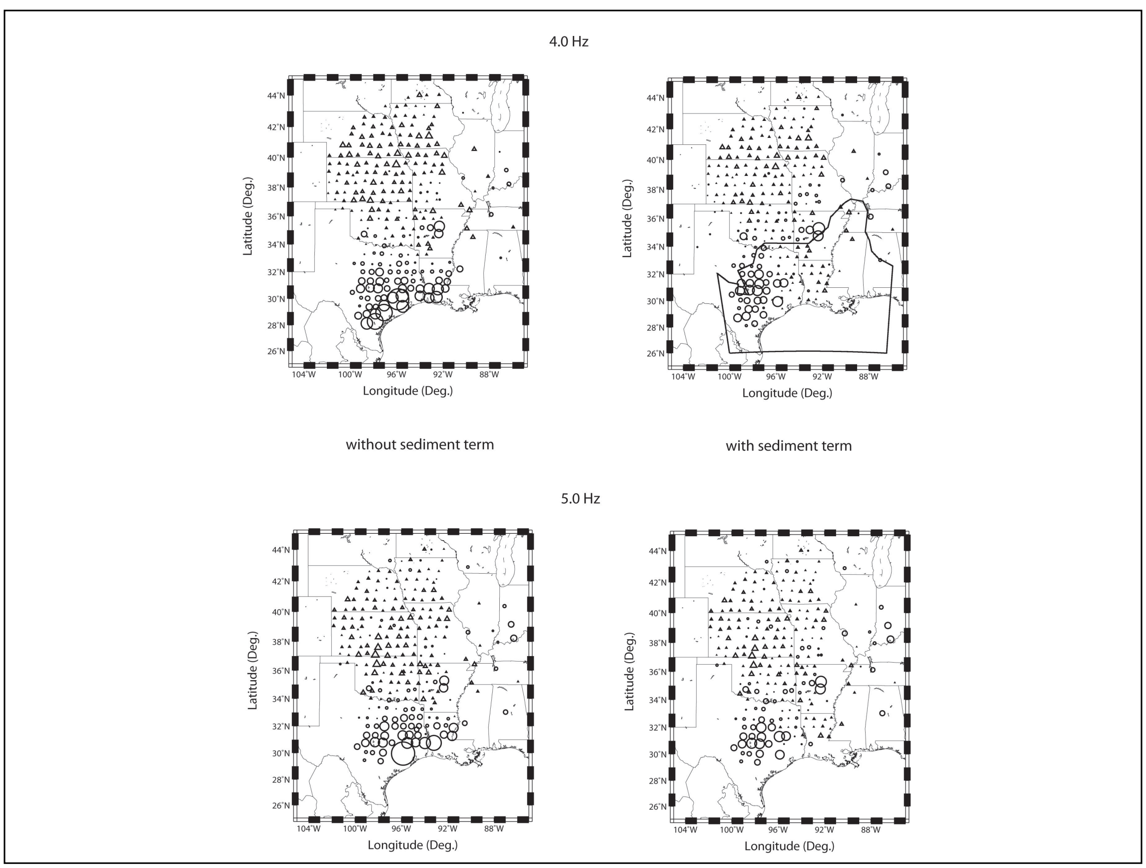
Td is the time at which the integral of acceleration squared between time TLg and TLg + 100 seconds reaches 70% of the maximum value.



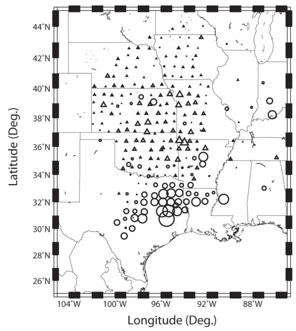
Lg signal amplitudes exceed noise amplitudes in equal-length time windows (Td) prior to the predicted P or Pn arrival time BY AT LEAST A FACTOR OF 5.



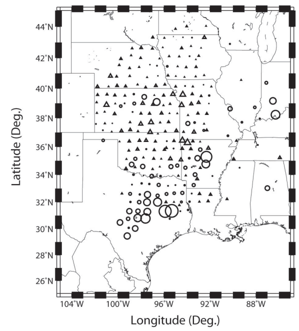

2.0 Hz
without sediment term
with sediment term
2.8 Hz
Latitude (Deg.)
Longitude (Deg.)
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
28°N
26°N
104°W
100°W
96°W
92°W
88°W


4.0 Hz
without sediment term
with sediment term
5.0 Hz
Latitude (Deg.)
Longitude (Deg.)
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
28°N
26°N
104°W
100°W
96°W
92°W
88°W

8.0 Hz

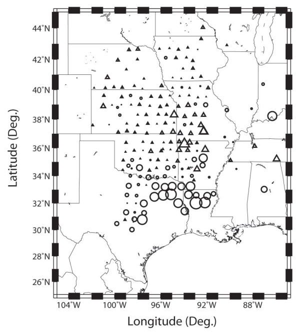


without sediment term

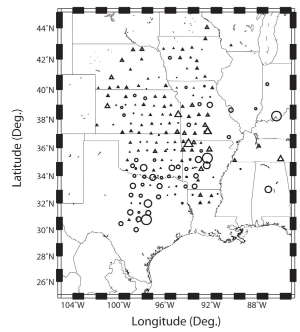


with sediment term

11.2 Hz



without sediment term



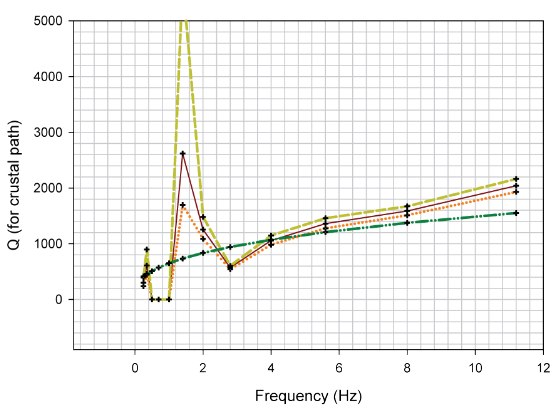
with sediment term

All Stations

Red and Yellow lines show the mean +/- standard error estimates for crustal path Q.
Green line shows results of Erickson et al., (2004), Bull. Seism. Soc. Am., 94, no. 5, 1630-1643.

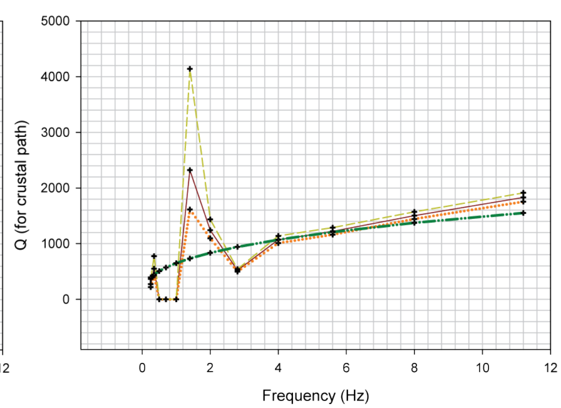
Crustal Attenuation only

Q for the crustal path
All stations, model using ONLY the crustal attenuation term
Arkansas 2/28/2011 M 4.7



Both Crustal and Sediment terms

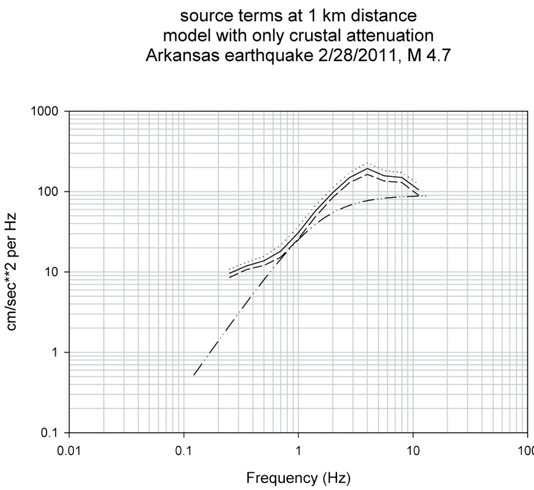
Q for the crustal path
All stations, model using both crustal and sediment attenuation terms
Arkansas 2/28/2011, M 4.7

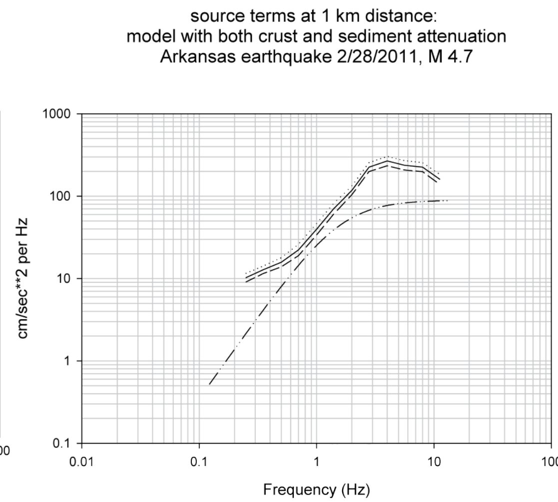


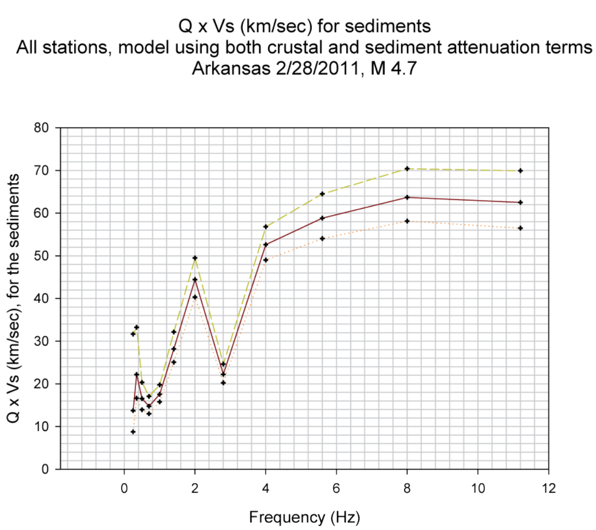
All Stations

Crustal Attenuation only

Both Crustal and Sediment terms

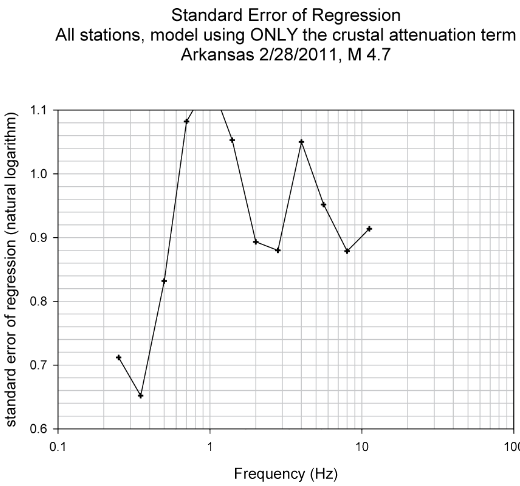




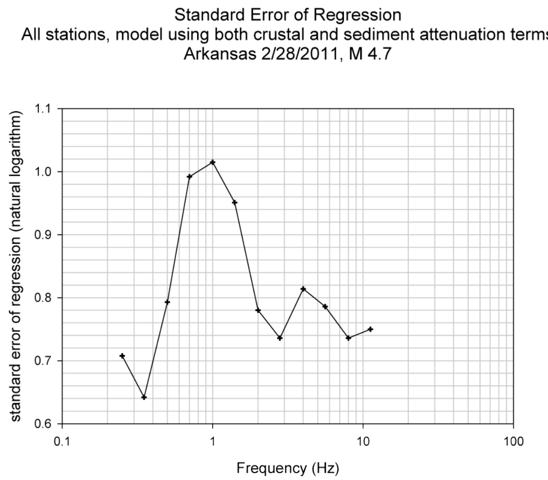


All Stations

Crustal Attenuation only

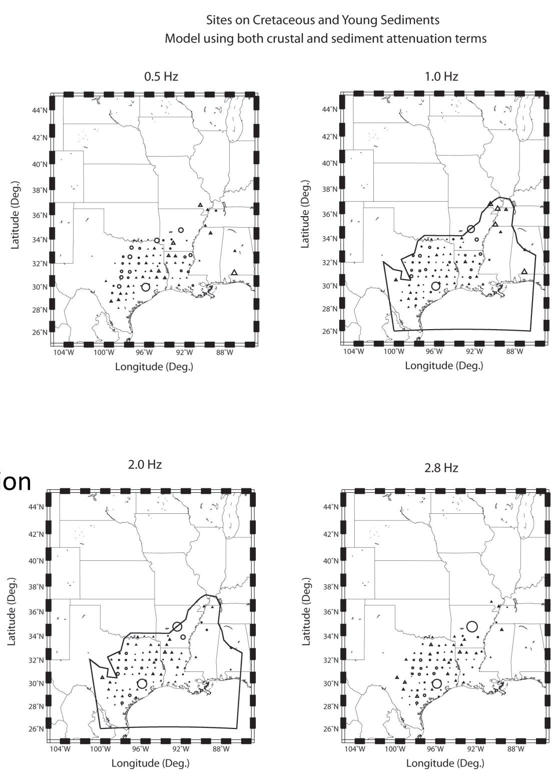


Both Crustal and Sediment terms

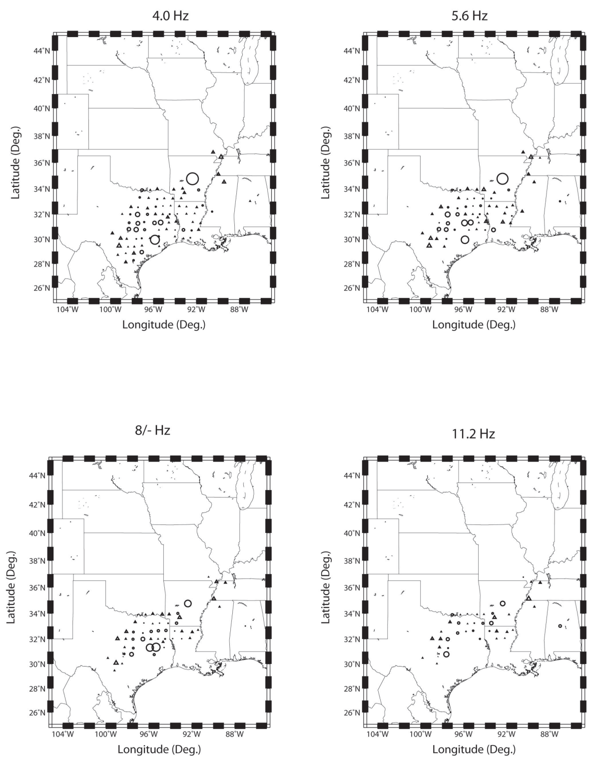


Residuals from fitting only the data from stations on Cretaceous and Younger sediments.

Note that both crustal and sediment attenuation terms were used.

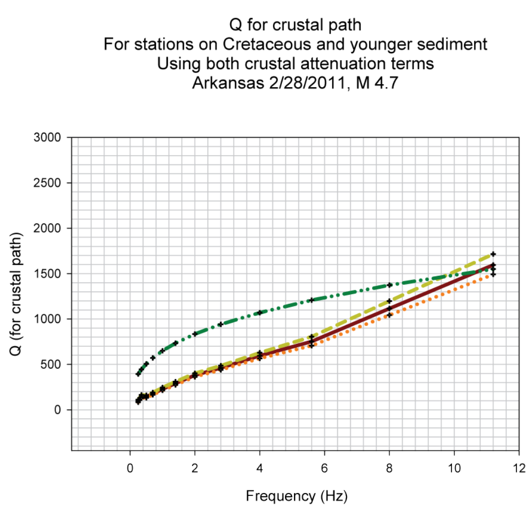


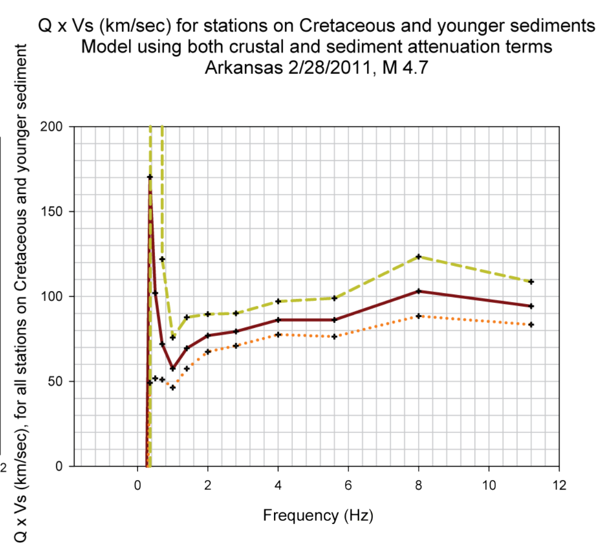
Sites on Cretaceous and Young Sediments
Model using both crustal and sediment attenuation terms



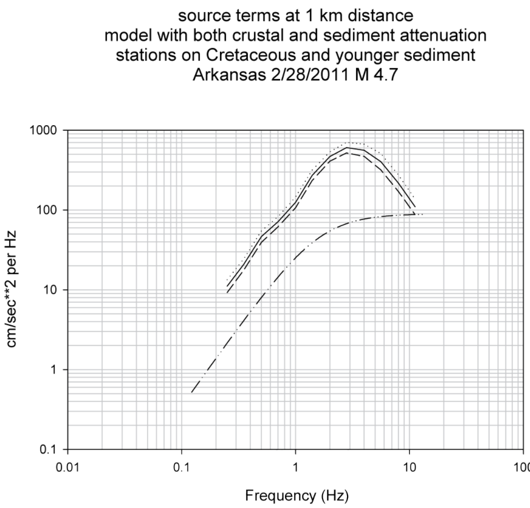
Stations on Cretaceous and Younger sediment, model using both crustal and sediment attenuation terms

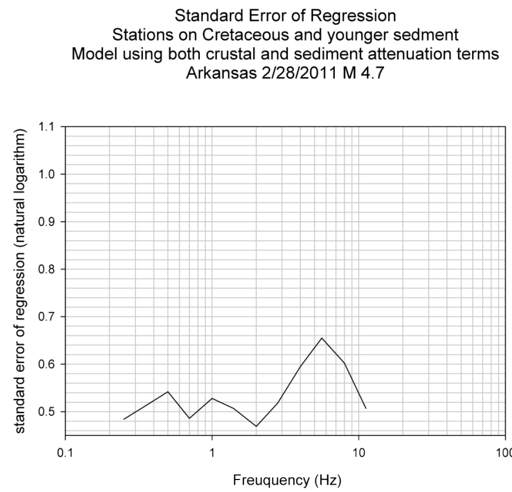
Yellow and Red dotted lines show mean +/- standard error estimates for crustal path Q (left), and sediment Q x Vs (right).
Green line shows results of Erickson et al., (2004), Bull. Seism. Soc. Am., 94, no. 5, 1630-1643.



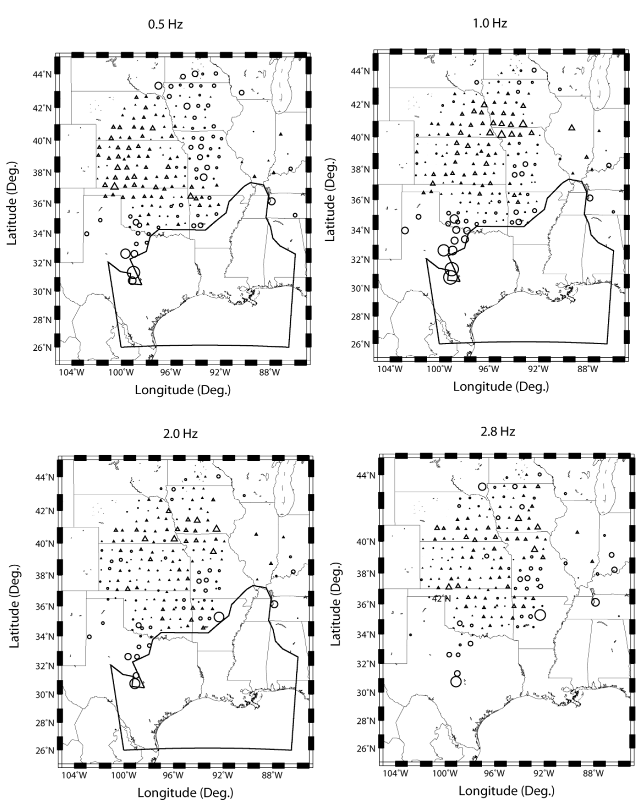


Stations on Cretaceous and Younger sediment, model using both crustal and sediment attenuation terms

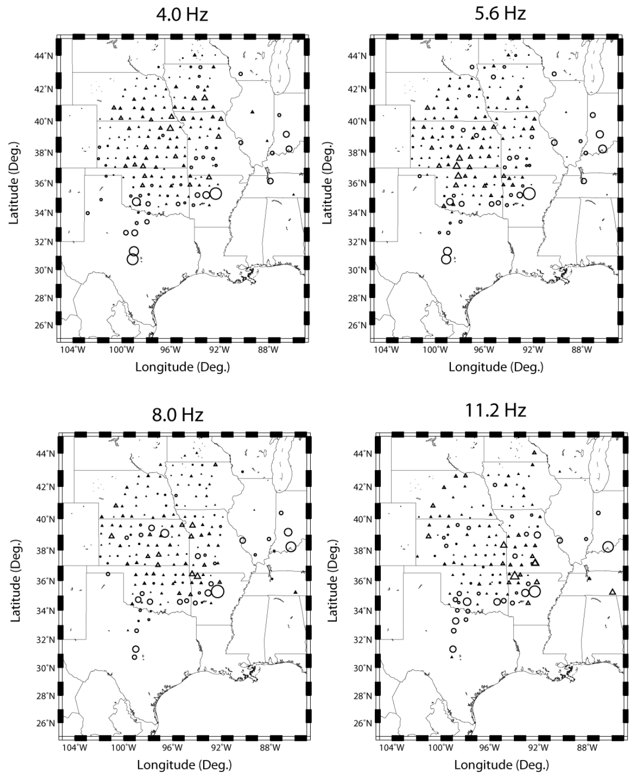




Stations on Paleozoic Rock

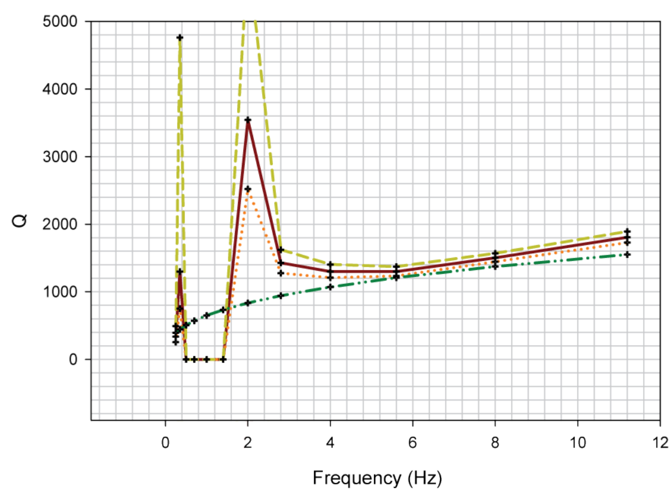


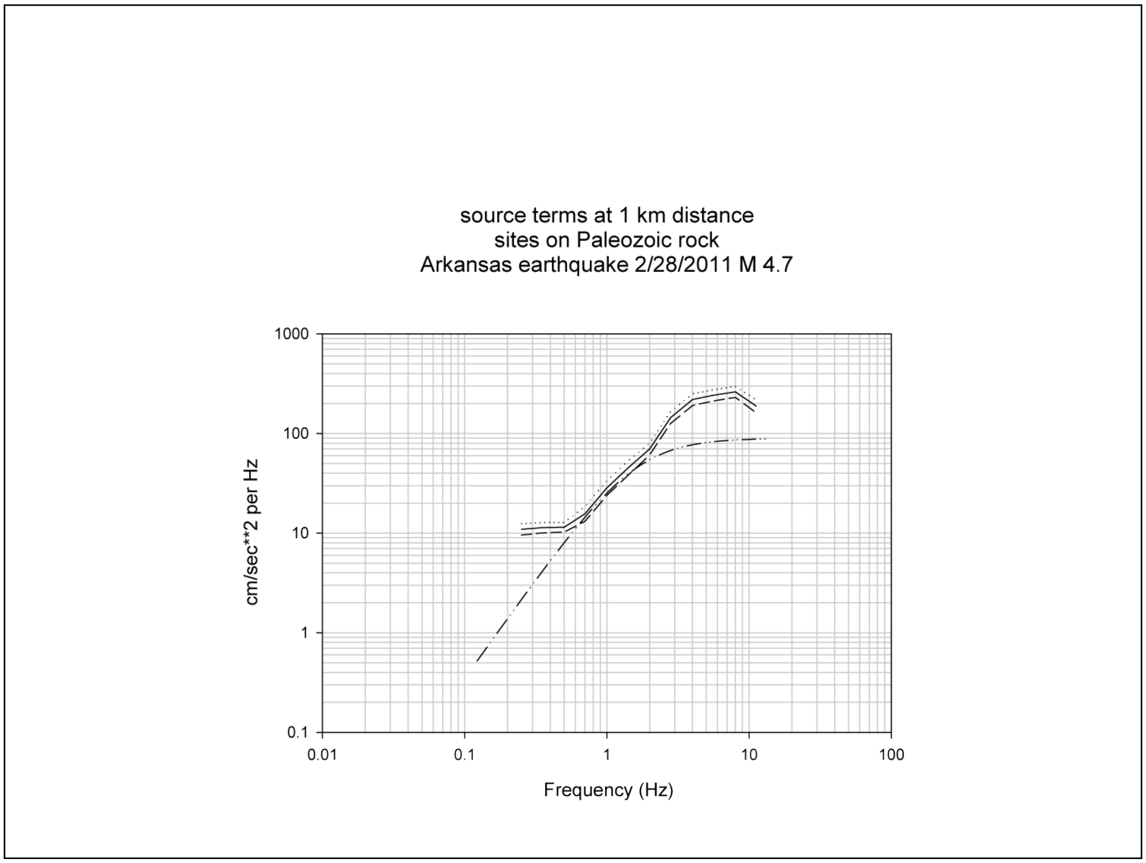
Stations on Paleozoic Rock

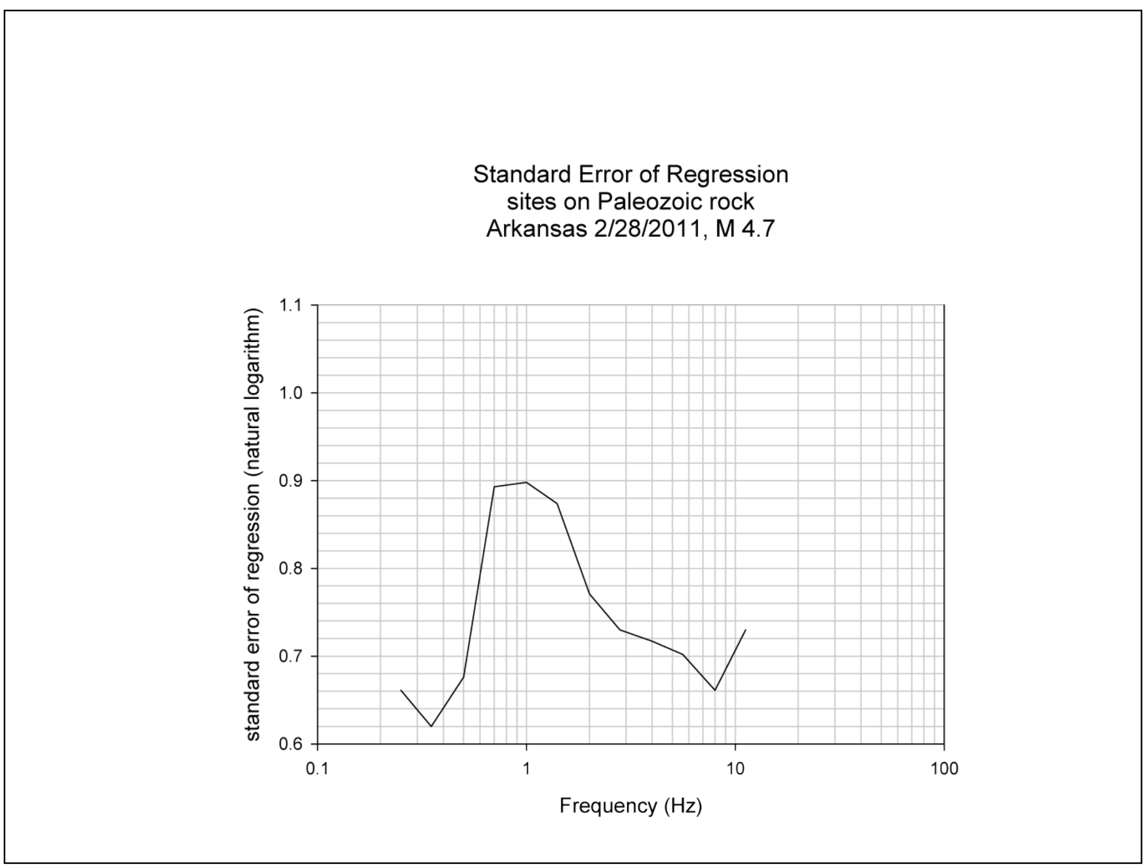


Yellow and Red dotted lines show mean +/- standard error estimates for crustal path Q.
Green line shows results of Erickson et al., (2004), Bull. Seism. Soc. Am., 94, no. 5, 1630-1643.

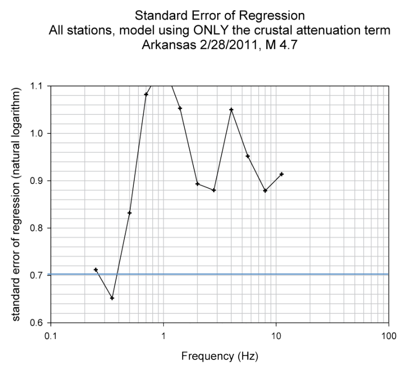
Q for sites on Paleozoic rock
Arkansas 2/28/2011 M 4.7

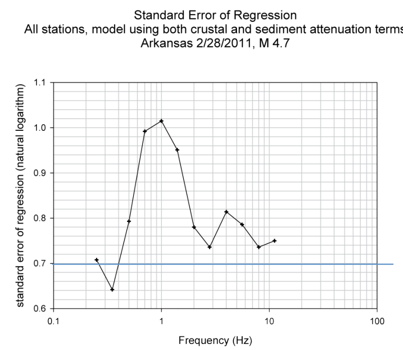



source terms at 1 km distance
sites on Paleozoic rock
Arkansas earthquake 2/28/2011 M 4.7
1000
100
10
1
0.1
cm/sec**2 per Hz
0.01
0.1
1
10
100
Frequency (Hz)

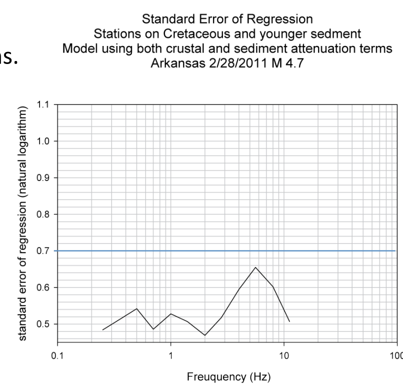

Standard Error of Regression
sites on Paleozoic rock
Arkansas 2/28/2011, M 4.7
1.1
1.0
0.9
0.8
0.7
0.6
standard error of regression (natural logarithm)
0.1
1
10
100
Frequency (Hz)

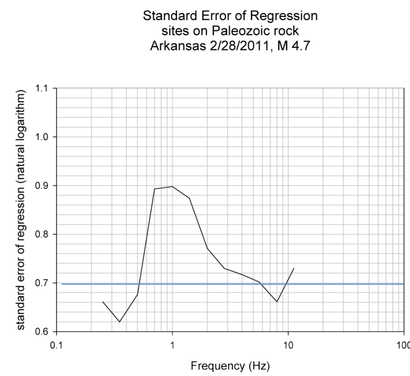
Comparison of Model Standard Errors



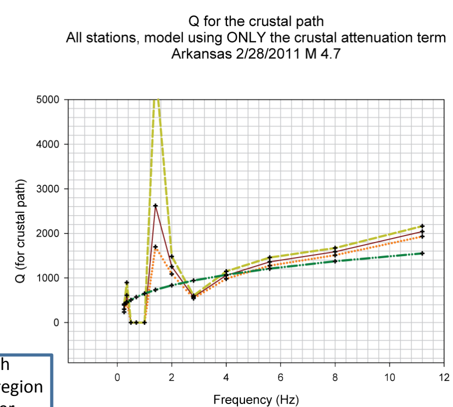


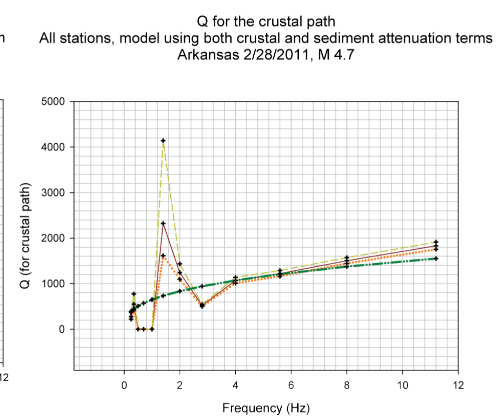
Regression standard error is greatly reduced by treating the Paleozoic rock sites and Coastal plain site as different regions.





Note that 0.7 - 1.5 Hz shows large error when rock sites are included.

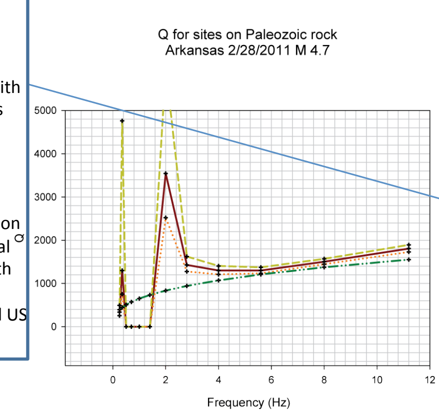


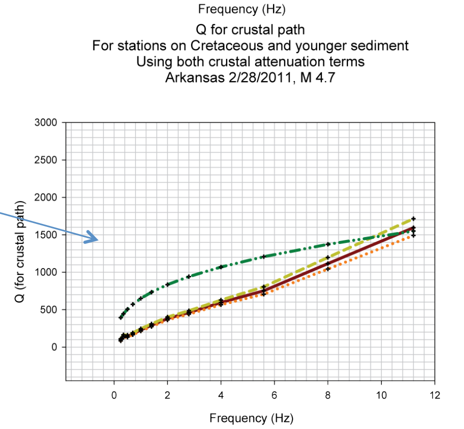


Q for the crustal path in the coastal plain region appears much smaller than for the Paleozoic rock sites.

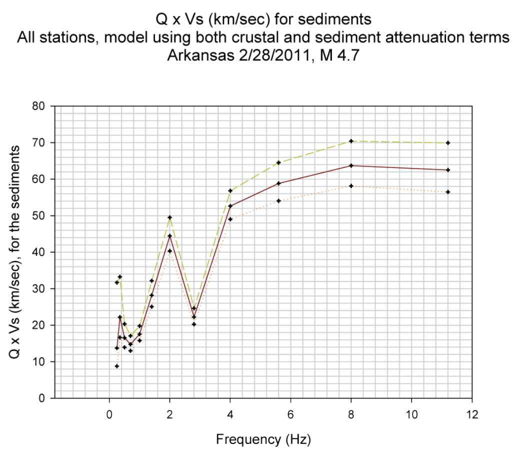
This is the case even with the sediment thickness term present in the regression model.

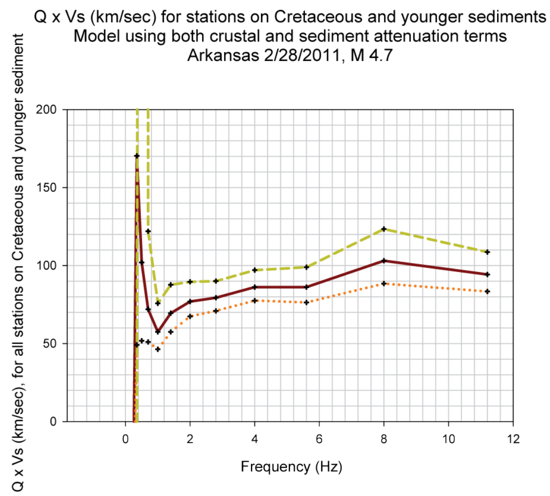
It appears that sub-sediment attenuation is much higher in central Texas in connection with the buried Ouachita belt, than in the central US region to the north.





It appears that the great thickness of post-Cretaceous sediments in Louisiana and eastern Texas, and along the Gulf coast, requires special treatment. The reduction of regression standard error when this effect was modeled was significant. Estimated Q x Vs values are less than 125 for frequencies above 2 Hz. Values at lower frequency are undetermined.





Summary

1) The Gulf coastal region requires special treatment for ground motion modeling.

2) The Feb. 28, 2011 Arkansas shock indicates large high-frequency attenuation to the south and southwest relative to stations in the central US sited on shallow Paleozoic sedimentary rock.

3) These effects may be due to

   a) attenuation near the receiver-end of the path in the East Texas basin, the northern Louisiana salt basin, and along the entire Gulf coastal margin, due to several kilometers of post Cretaceous sediment in those areas.

   b) Stations in central Texas on thin coastal plain sediments also show strong attenuation. This may be due to complex wave propagation effects through the buried Ouachita orogenic belt underlying this area.

4) In the frequency range from 0.5 to 2.0 Hz, Lg propagation within the cratonic platform of the central US also exhibits complex behavior. Paths that cross the region of the mid-continent rift show little or no attenuation.

All of these issues need to be further examined using additional TA data from other well-recorded events in the region.

On-going and future work on regionalization issues

Incorporate more TA data from several events in Oklahoma, Texas and Arkansas to better establish path dependent effects in the Gulf Coastal - Ouachita region.

Examine other areas in the central-eastern region now being monitored by the Earthscope Transportable array.

This will be necessary to quantitatively address the following NGA-East Path Working Group goals and objectives.

C.3 Select representative 1D crustal structure for each region

C.4 Evaluate the need for different regions, define different regions

C.5 Develop rules for treatment of region boundary crossing

D.1 Estimate regional source and path parameters for CENA earthquakes

D.2 Develop models for source and path parameters