Seismicity and Monitoring in the Vicinity of the Paducah Gaseous Diffusion Plant - Phase II (2009-2012)

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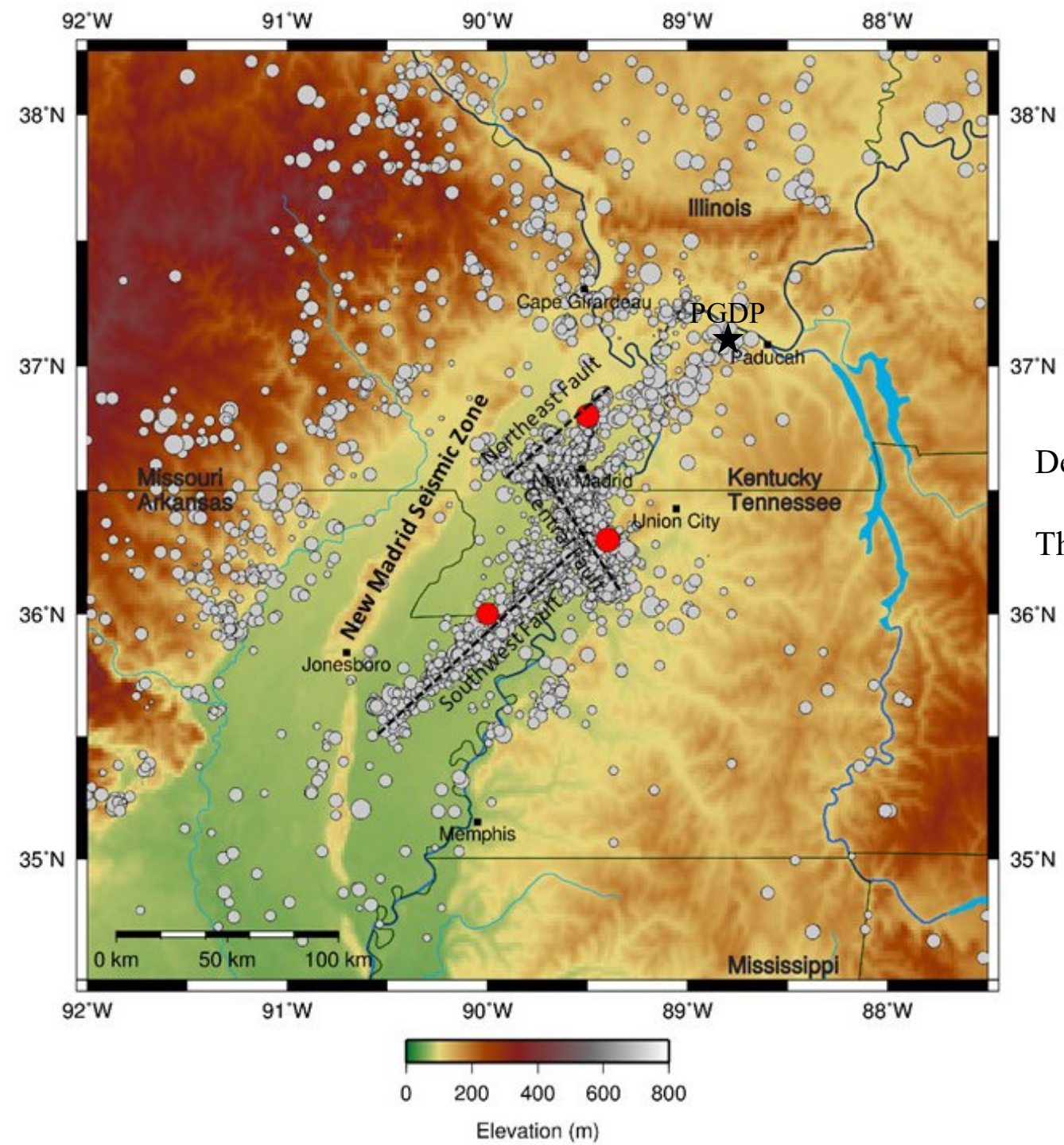
Outline

Objectives

Seismic Monitoring

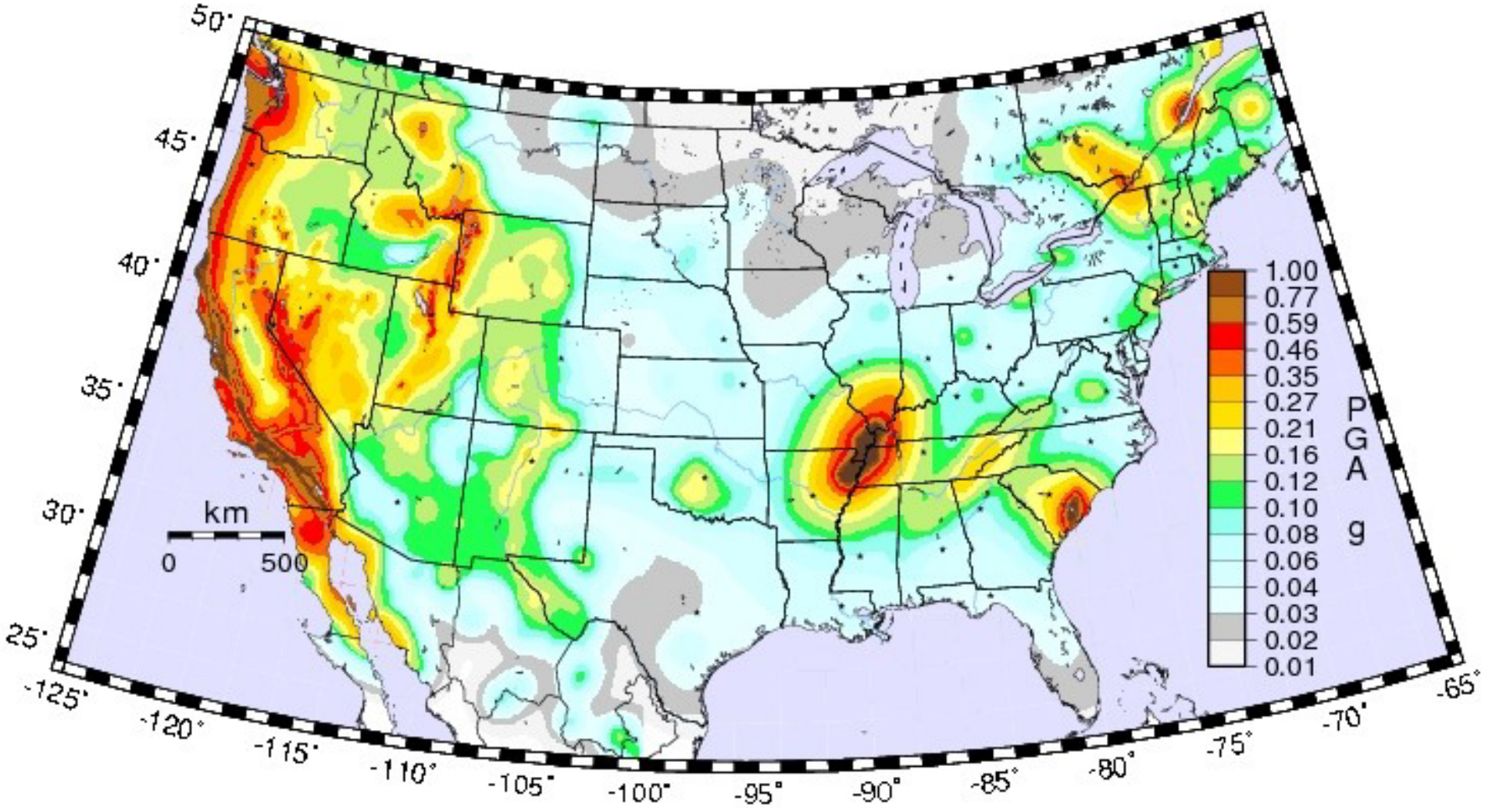
Central U.S. Seismic Observatory

Summary



December 1811-Febuary 1812

Three large earthquakes (>M 7.0)



Peak ground acceleration hazard map with a return period of 2,500 years (or 2 percent probability of exceedance in 50 years) for the continental United States (Petersen and others, 2008).

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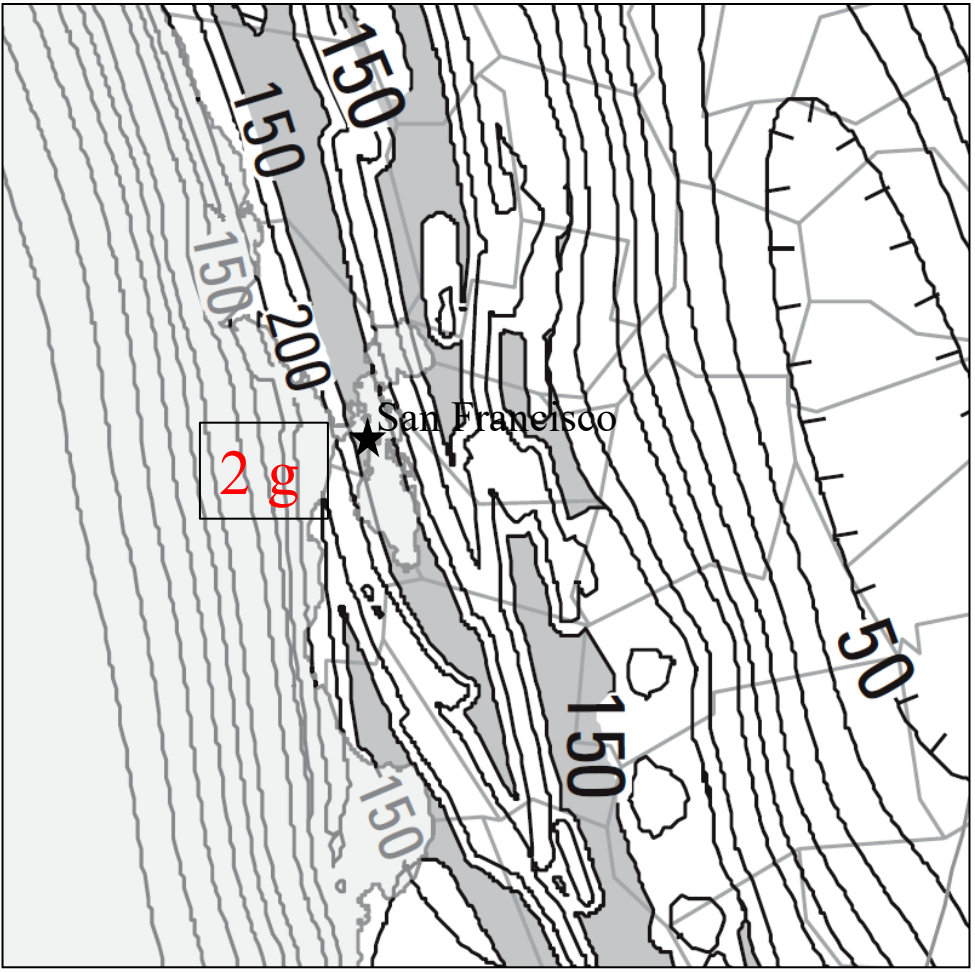
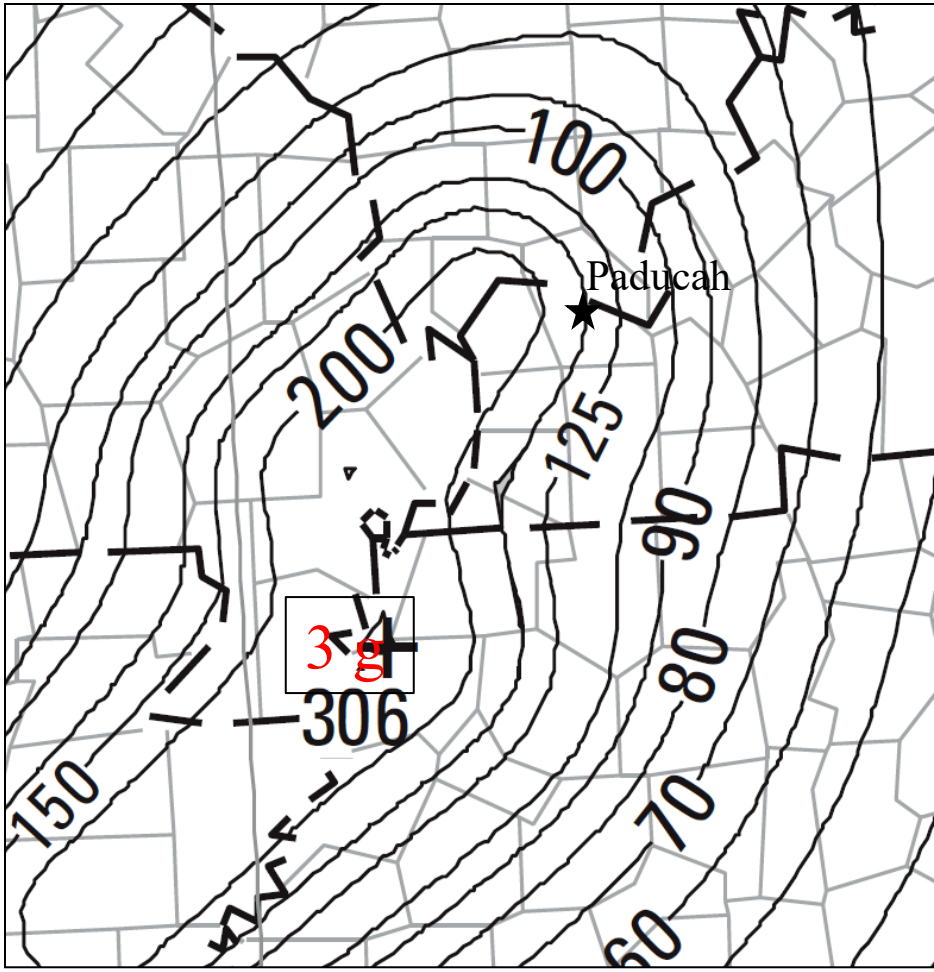
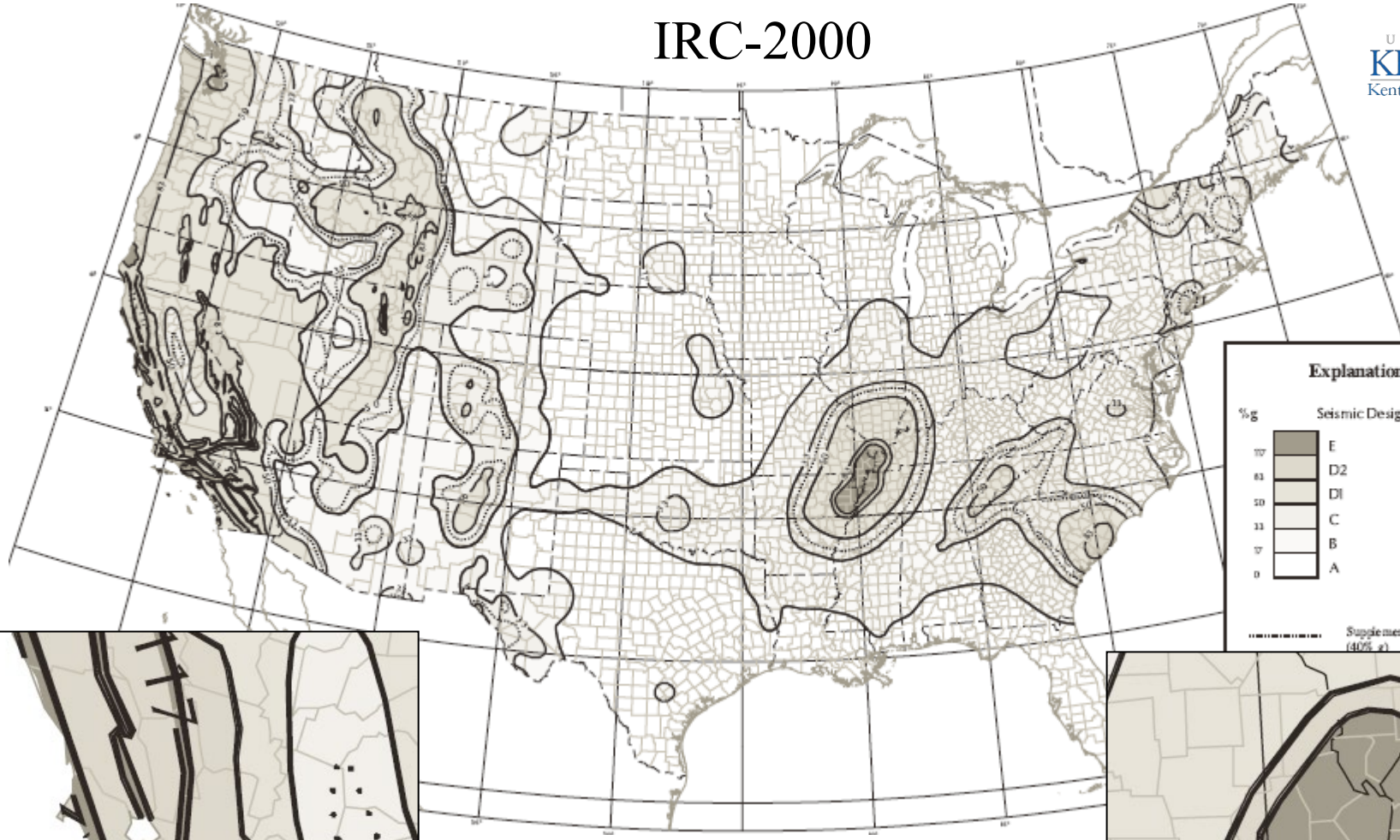
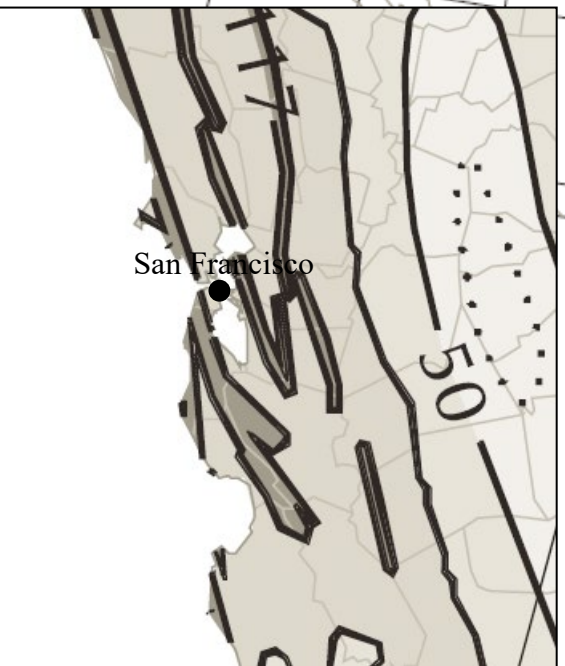
NEHRP-2009 (ASCE_7-10) Design Ground Motion

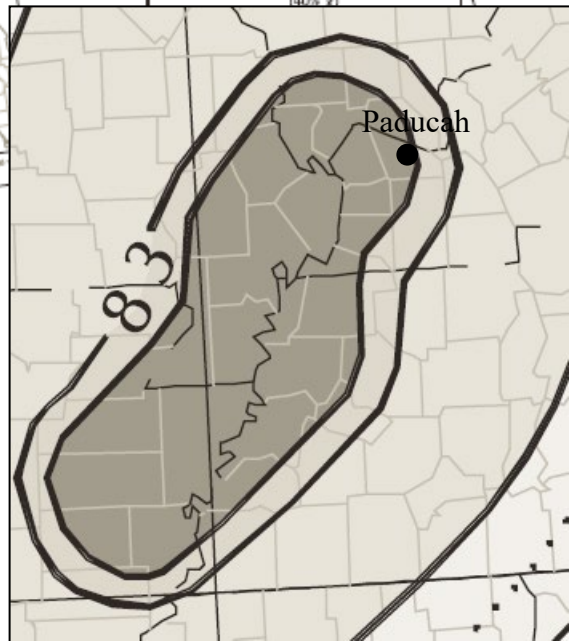




IRC-2000







Paducah: E (required a professional service)
San Francisco: D2

C-746-U Landfill Design Ground Motion

	Activity	Comments	Date
A	Site-specific seismic study conducted by REI, PGA of 0.40g	REI reported rock only ground motions in this study, 0.40g at 2,500 yrp [7 (Fig 5.18)].	1993
B	Seismic Design of the C-746-U Contained Landfill was performed using a PGA of 0.4g (Solid Waste Landfill Technical Application)	After applicant submitted the three phase application process, regulators approved operation of the landfill in November 1996 via Permit No. 073-00045.	1994 through 1995
C	REI updated 1993 study and calculated PGA of 0.51g	Report revision performed for USEC and driven by NRC.	1999
D	White Paper by Dr. Beavers evaluated existing landfill design	Determined that existing landfill design was adequate for PGA of 0.51g.	2/20/2001
E	C-746-U Contained Landfill Permit reissued with new seismic requirement identified in permit condition	Permit appeal filed by DOE; seismic technical submittals proposed following "Seismic Summit" conducted with DOE, KDWM, and USGS in Frankfort, KY.	New permit condition 2/1/2001 Seismic Summit held 5/29/2001
F	KDWM requested newly constructed cells to be designed to a PGA of 0.8g	DOE appeals request and KDWM agrees to consider a new study to determine the PGA value.	KDWM request 8/10/2001 and accepts new study concept 10/31/2001
G	DOE conducted new evaluation study to fulfill the ground motion assessment requirements of permit condition.	New study completed and submitted to KDWM.	3/7/2002
H	DOE conducted reevaluation of the seismic capacity of the landfill and associated support facilities to fulfill the remaining items of permit condition.	KDWM response that the submitted information does not meet requirements of landfill permit.	9/27/2002
I	DOE submitted proposal for seismic hazard reevaluation for landfill	No comments received from KDWM on proposal.	6/30/2010
J	DOE submitted Holocene Fault Study for landfill to KDWM	Notice of Deficiency received from KDWM.	10/27/2010

(Beavers, 2010)

Subtitle D (40 CFR) mandates: Minimum design ground motion of 2% PE in 50 years or 2,500 years return period.

USGS-1996 maps (2% in 50yrs)
PGA of 1.2g (B/C)
PGA of 0.8g (hard rock)

There is no landfill in US that has been designed for 0.7/0.8g PGA.

- The extreme high design ground motion (0.7/0.8g PGA) became a key issue affecting clean-up efforts at PGDP in 2001-2002

- Objectives for Phase I (2003-2006)
  - Seismic hazard research and assessment
  - Temporary network for monitoring seismicity
  - Drilling a deep borehole for the Central U.S. Seismic Observatory (CUSSO)
  - Report (Wang and Woolery, 2008)

- Key findings from Phase I (2003-2006)
  - Large uncertainties inherent in the hazard estimates
  - Compounding uncertainties makes the National Seismic Hazard Maps difficult, even impossible to understand
  - Using simple statistics, mean, median, or certain percentile, to quantify seismic hazards

C-746-U Landfill Design Ground Motion

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USGS-1996 maps (2% in 50yrs)
PGA of 1.2g (B/C)
PGA of 0.8g (hard rock)

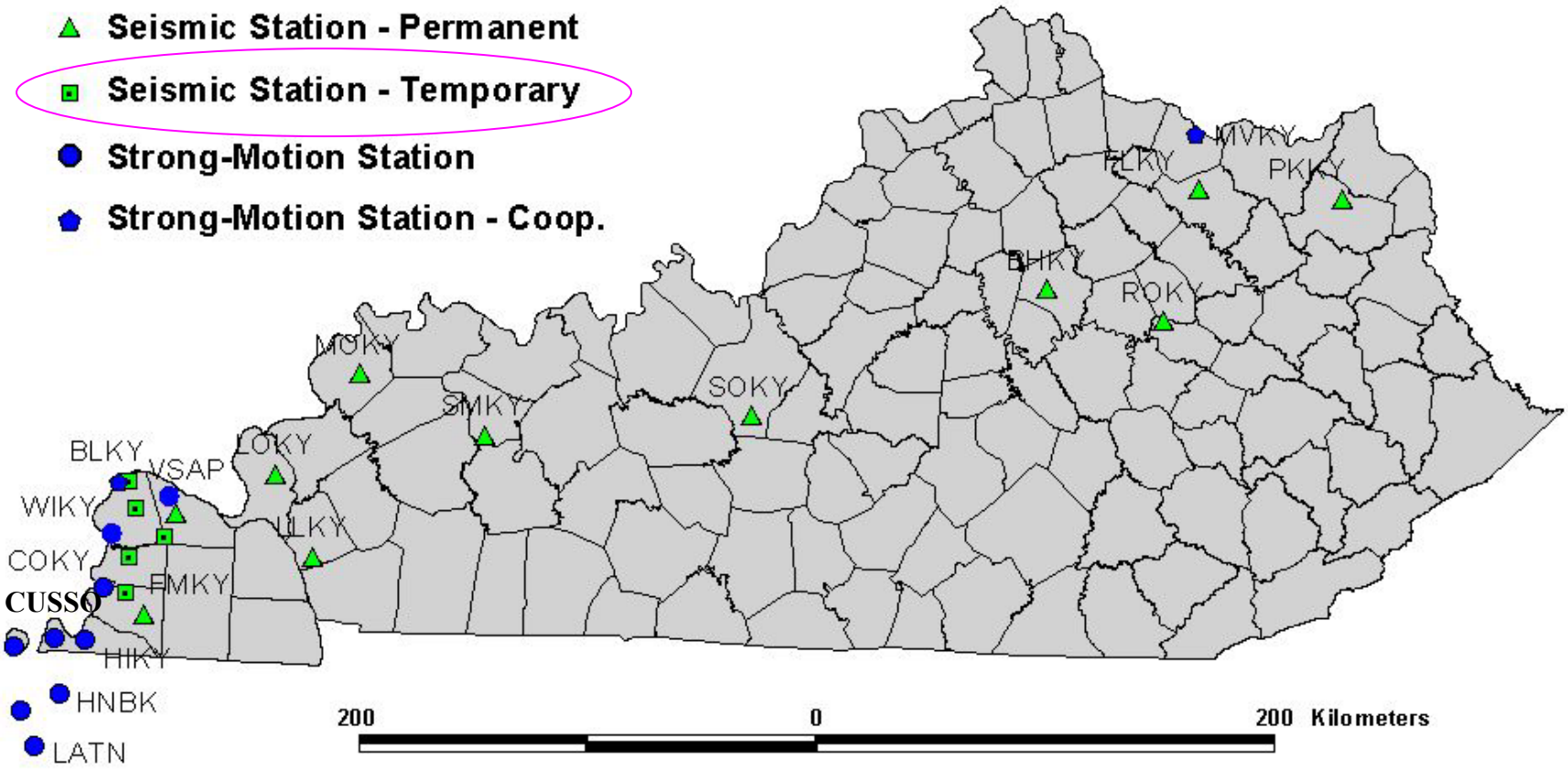
One of major results from Phase I:
Design PGA of *0.33g* (2011)

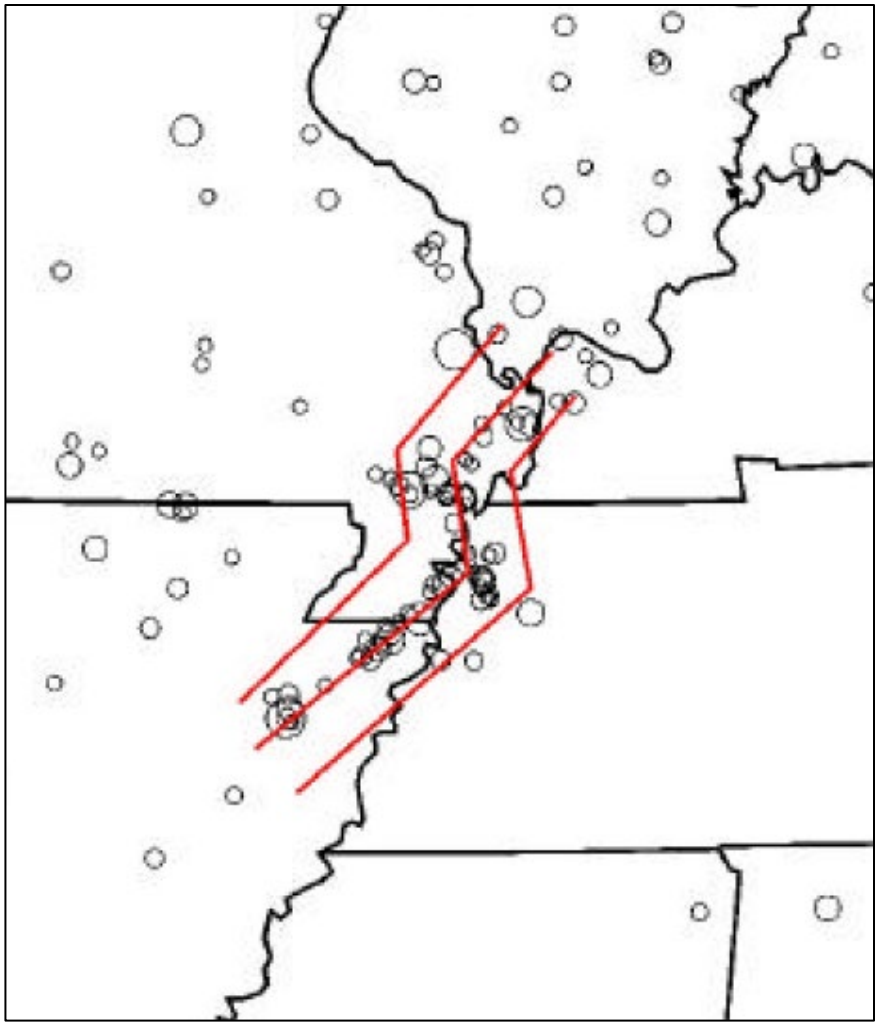
- The extreme high design ground motion (0.7/0.8g PGA) became a key issue affecting clean-up efforts at PGDP

- Objectives for Phase I (2003-2006)
  - Seismic hazard research and assessment
  - Temporary network for monitoring seismicity
  - Drilling a deep borehole for the Central U.S. Seismic Observatory (CUSSO)
  - Report (Wang and Woolery, 2008)

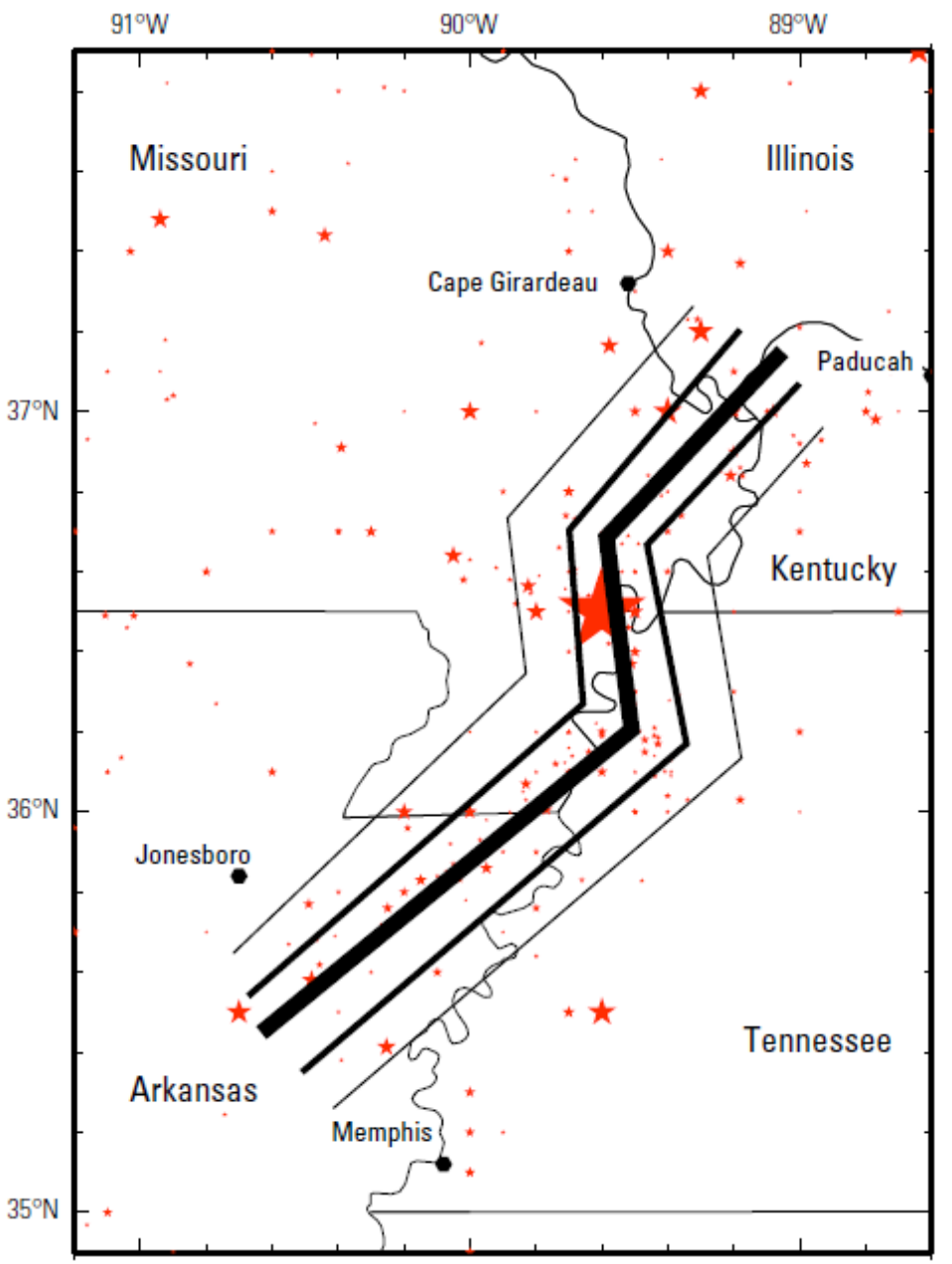
- Objectives for Phase II (2009-2012)
  - Continue monitoring seismicity
  - Complete the Central U.S. Seismic Observatory (CUSSO)

Kentucky Seismic and Strong Motion Network



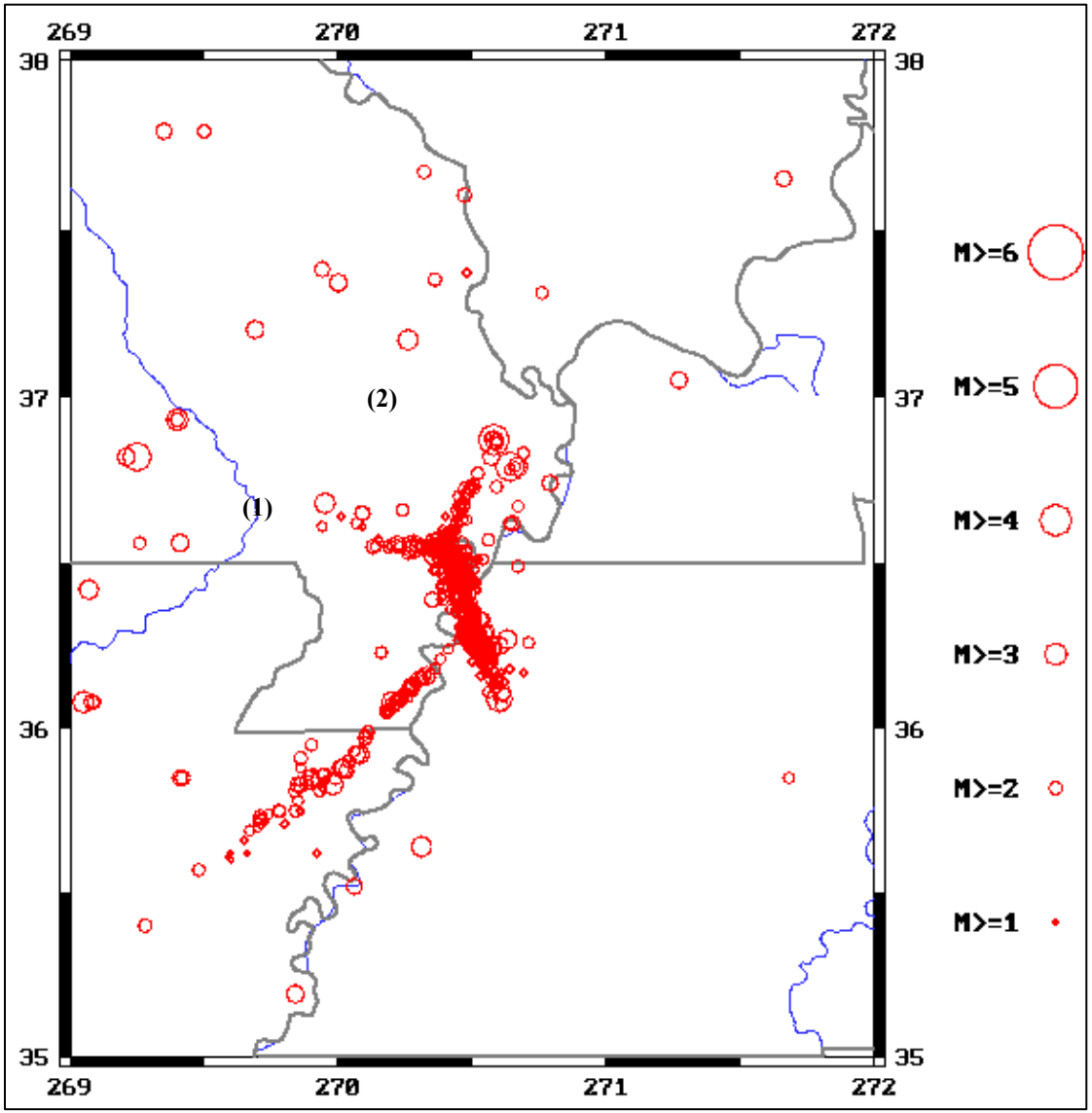


Fictitious faults (red) used to characterize the uncertainty in source location for New Madrid characteristic earthquakes (Frankel et al., 2002)

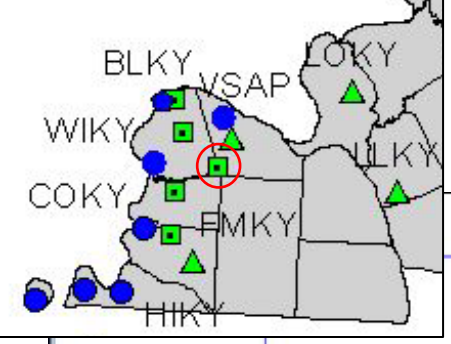


Locations of the modeled New Madrid hypothetical faults (Petersen et al., 2008)

Locations of earthquakes occurring in the New Madrid Seismic Zone between January 2009 and September 2012.



Magnitude	Date	Time (UTC)	Latitude	Longitude	Depth (km)	Location
1.9	06/29/09	04:06:15	36.490	89.330	12.8	Tyler, Ky.
2.4	03/25/11	03:12:04	37.046	88.733	6.0	Massac, Ky.



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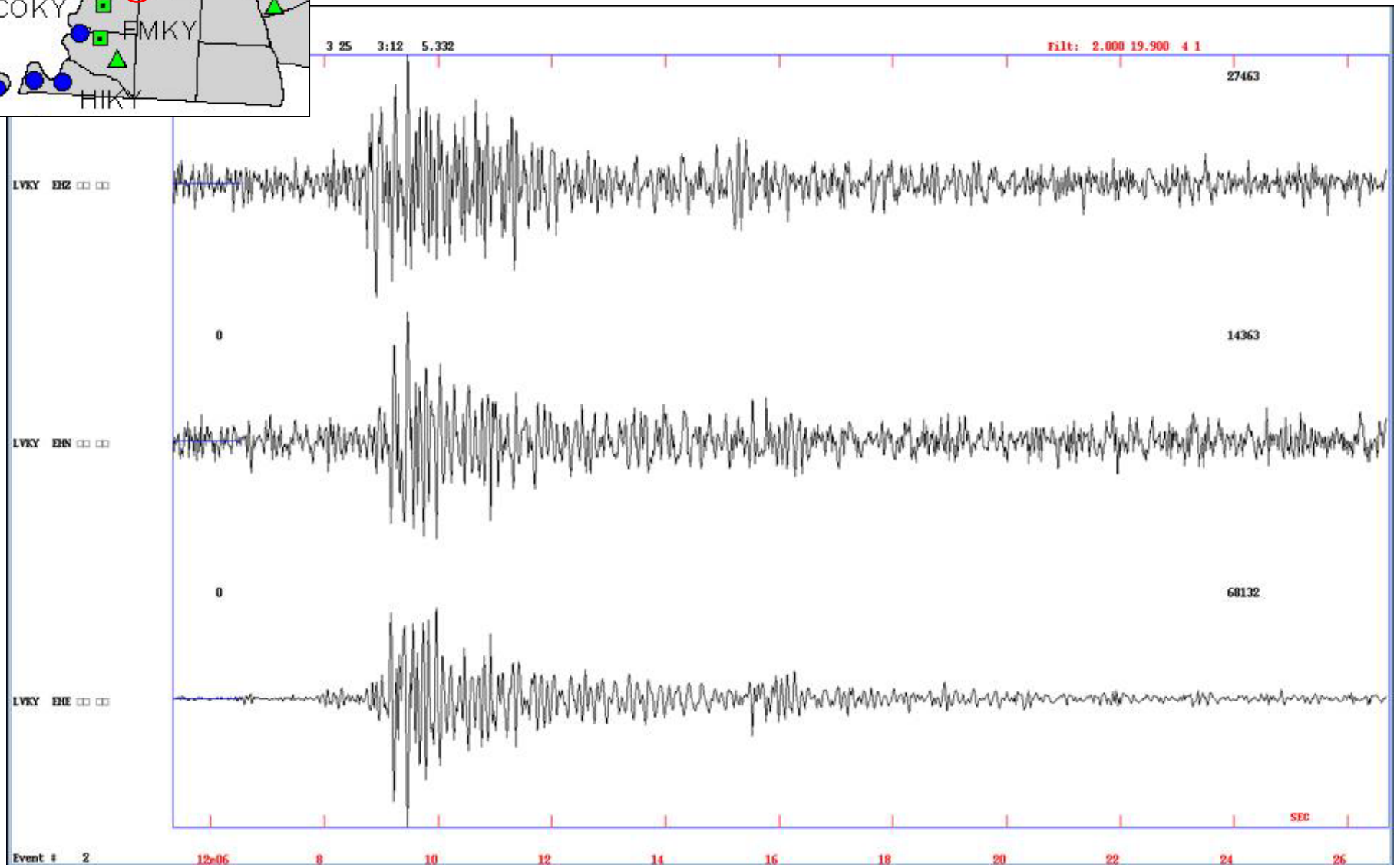
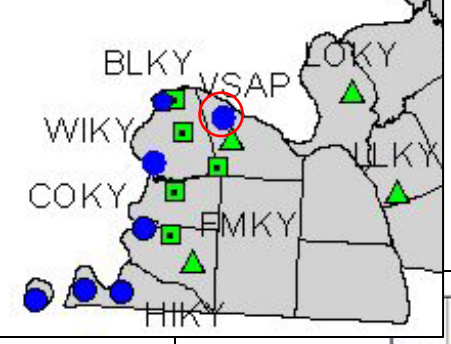


Velocity recordings at station LVKY from the March 25, 2011, earthquake.



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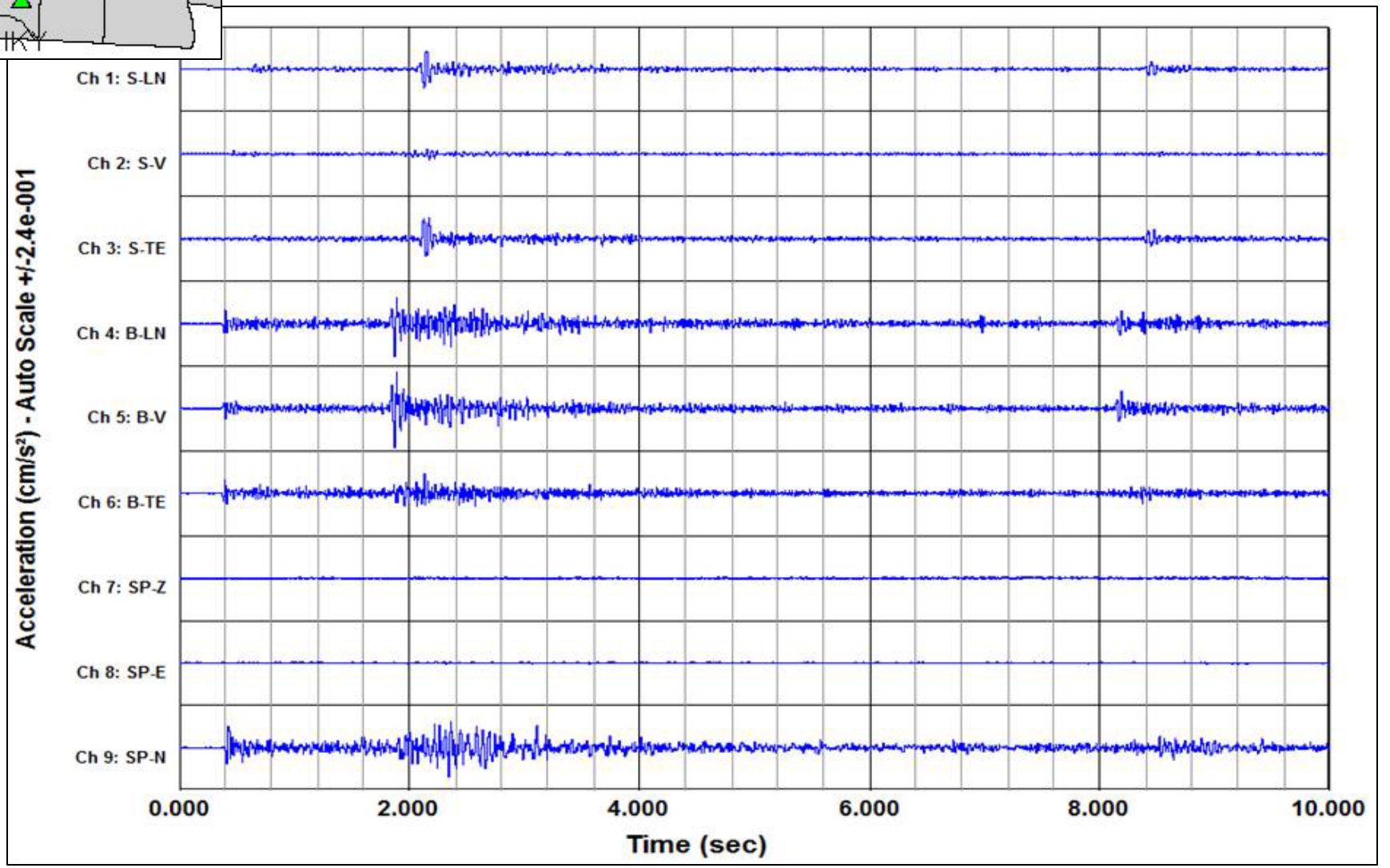
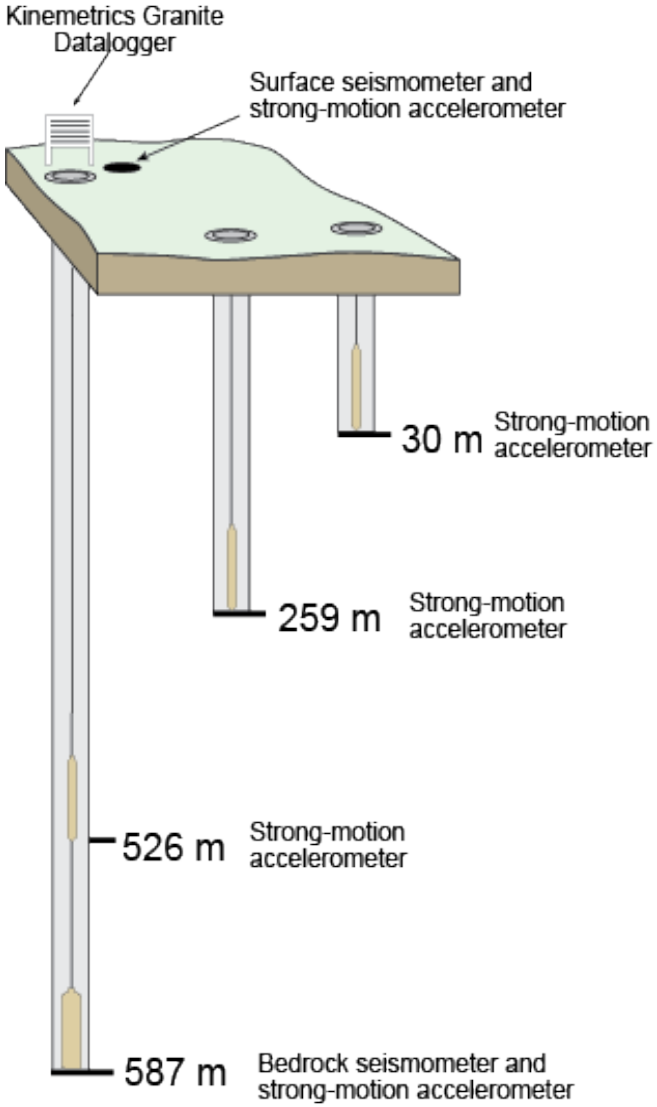


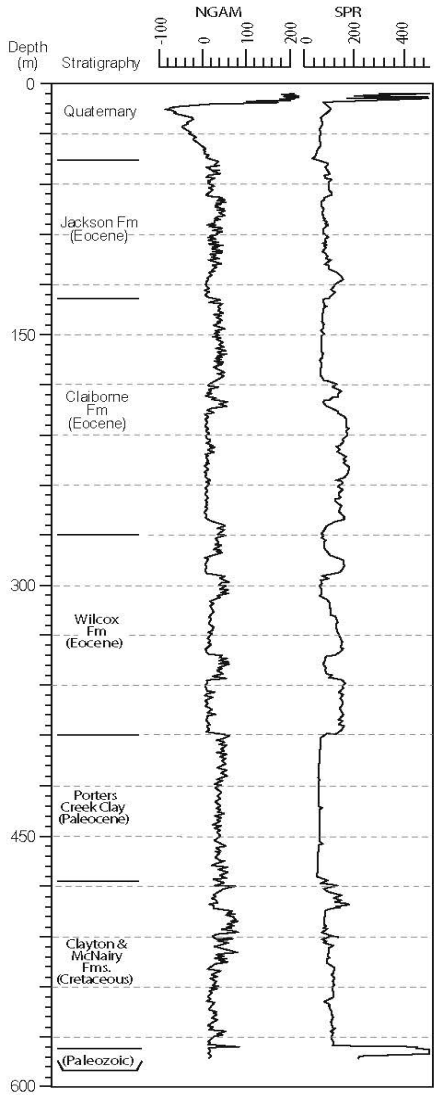
Acceleration recordings of the March 25, 2011, earthquake at station VSAP.

The Central U.S. Seismic Observatory (CUSSO) – *Unique in CEUS*

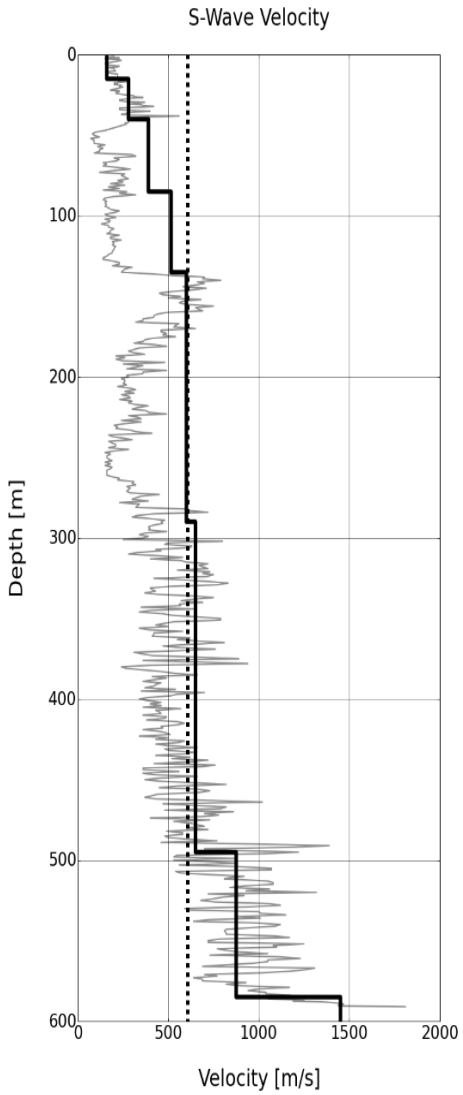
Instrumentation



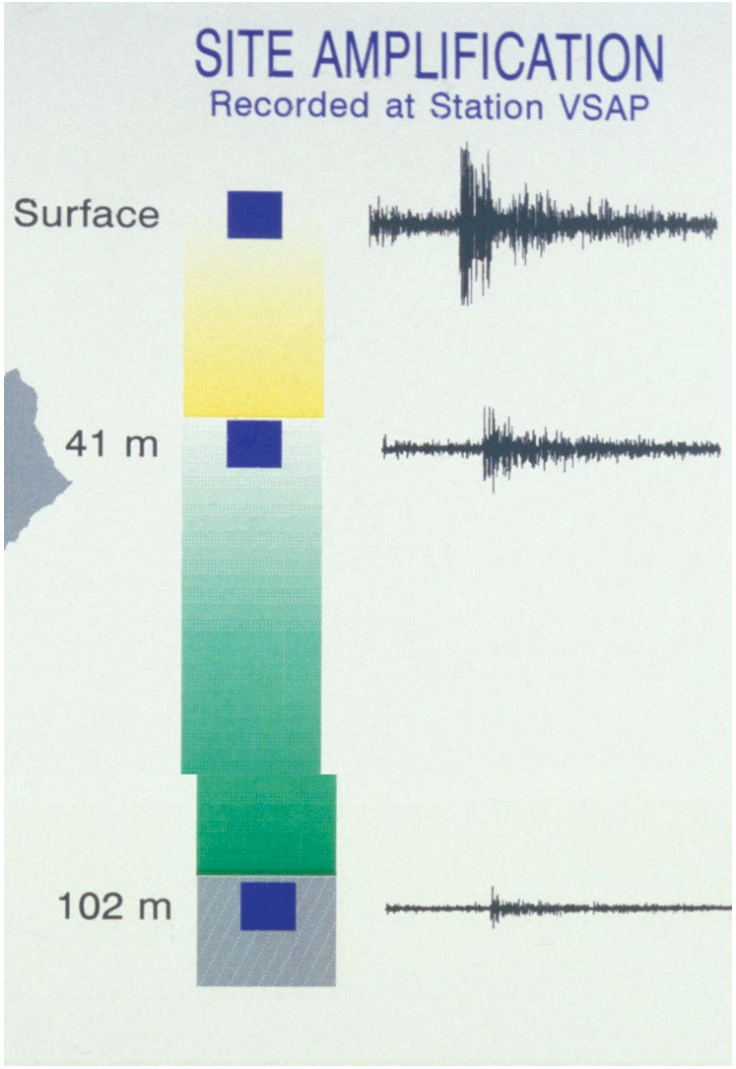
Geologic/geoph. Logs



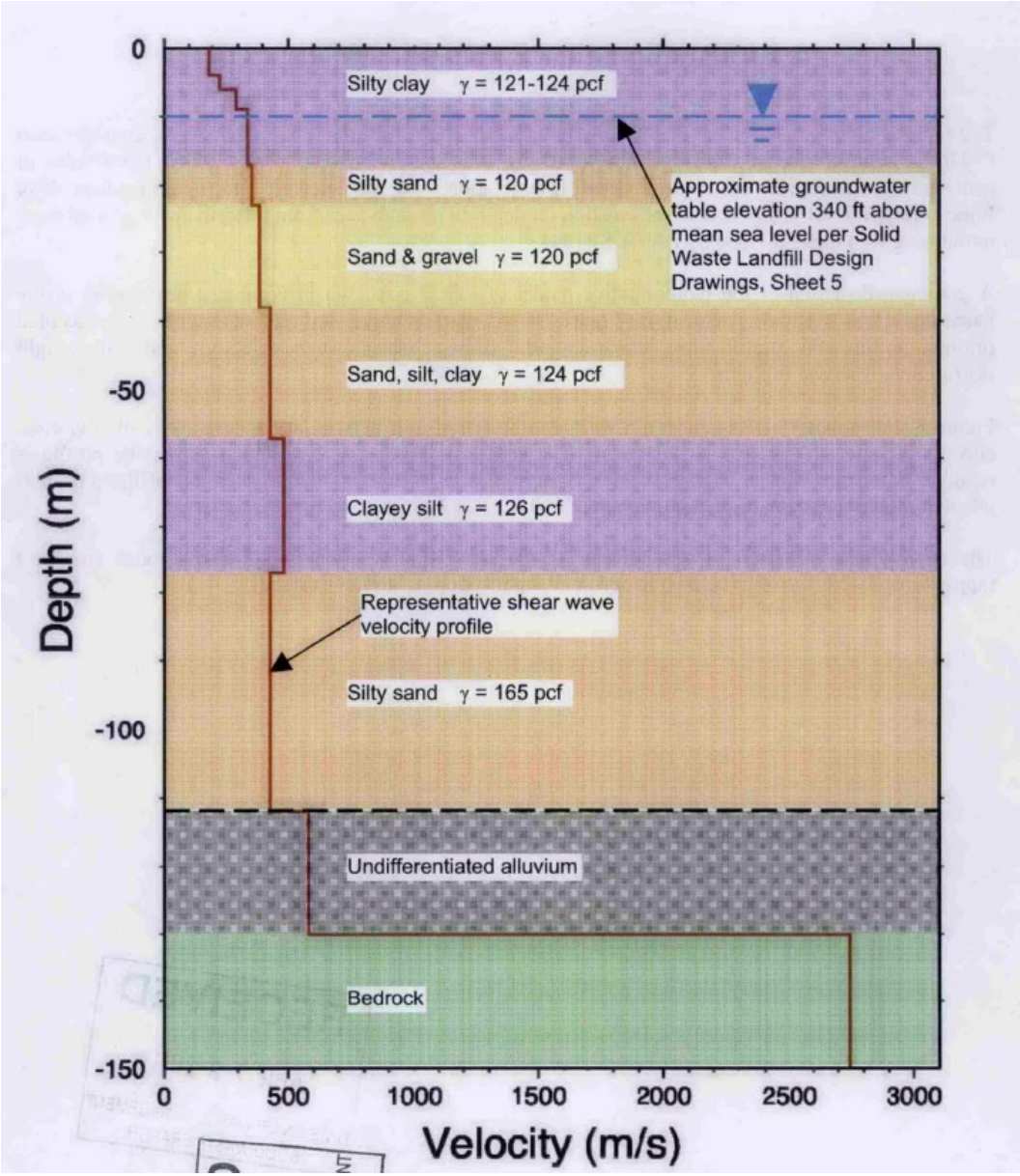
Shear-wave velocity



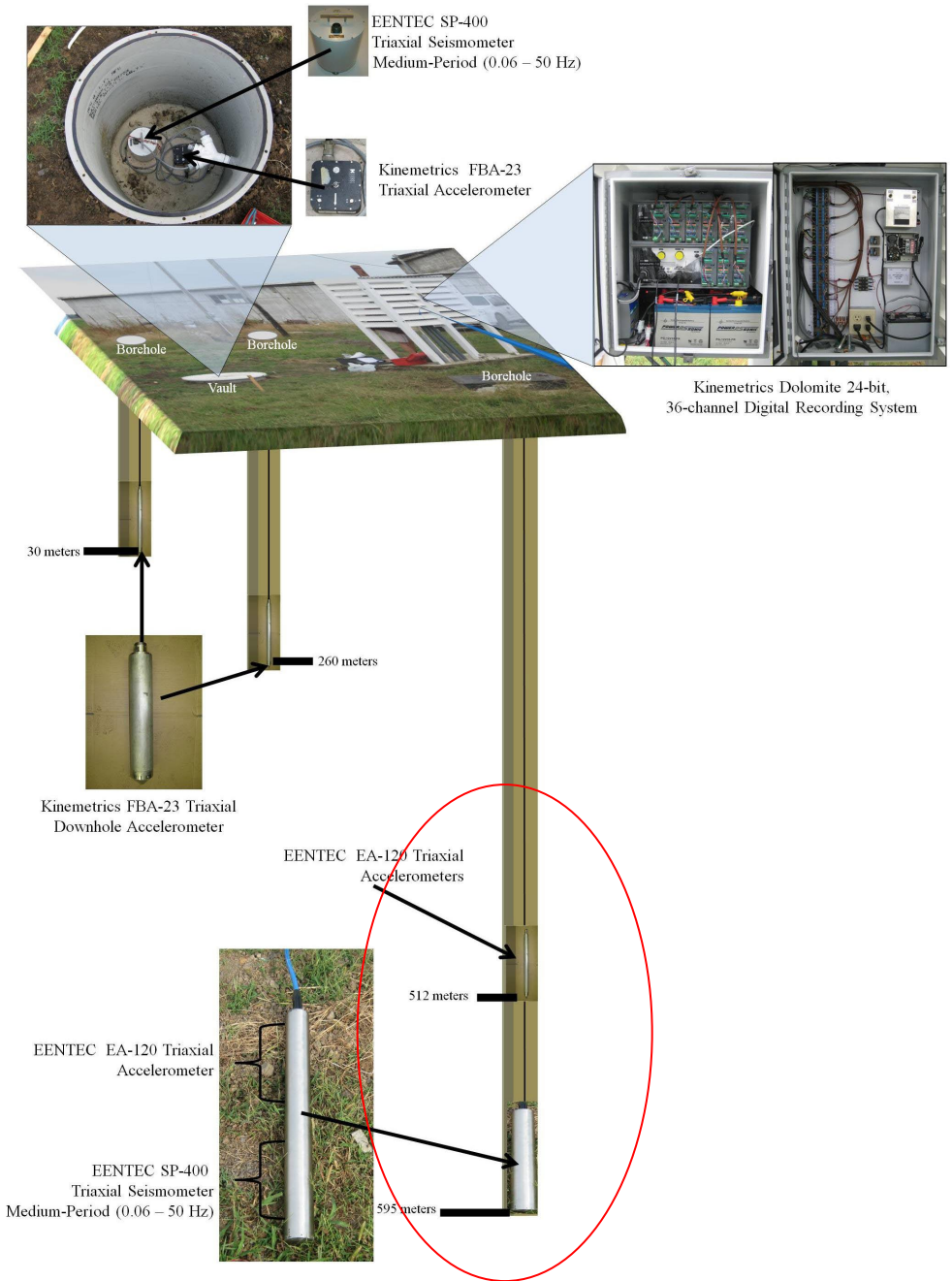
Main purpose of CUSSO: sediment effect on wave propagation, site effect in particular



Ground motion recordings from M 4.2 earthquake



CUSSO Installation and Operation



- First installation was completed in September 2009

- Operation from September 2009 to July 2010

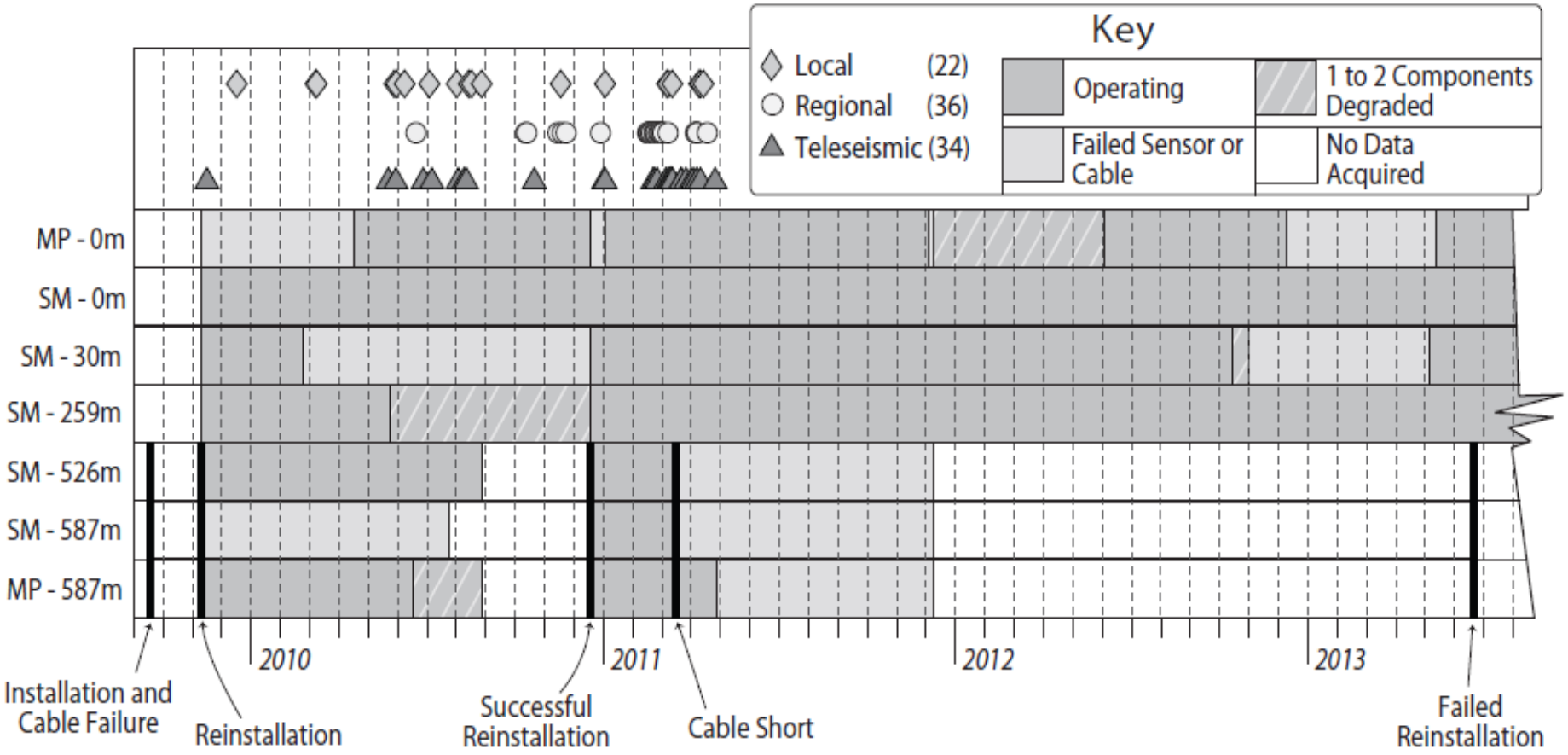
- Pulled out in August 2010 due to short circuit

- Reinstalled with new cable in December 2010

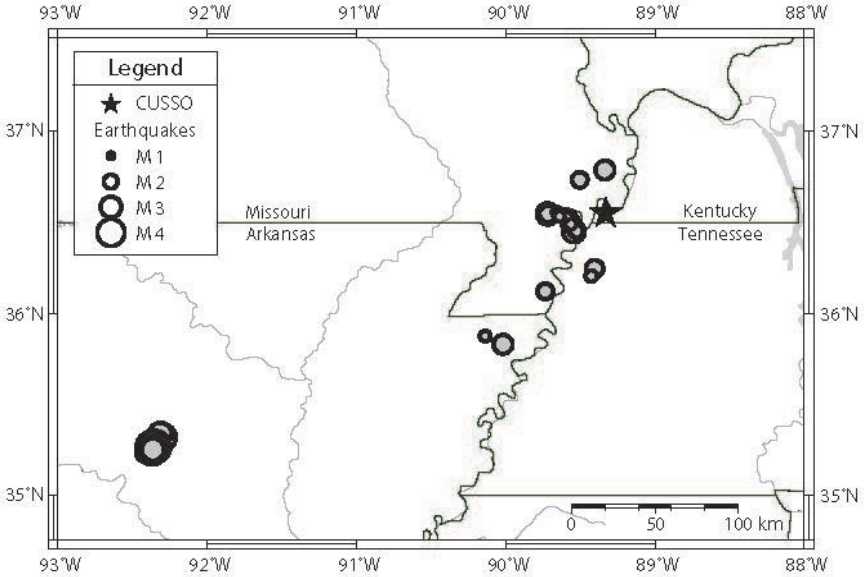
- Operation from December 2010 to July 2011

- Pulled out in August 2011

Graphical summary of CUSSO's history

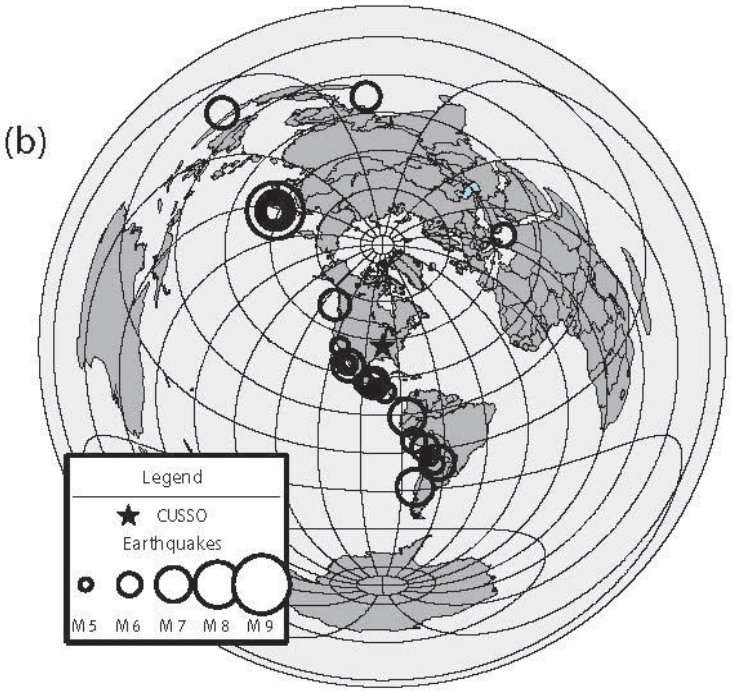


Total 95 earthquakes recorded: 24 local earthquakes; 37 regional earthquakes; 34 tele- earthquakes.



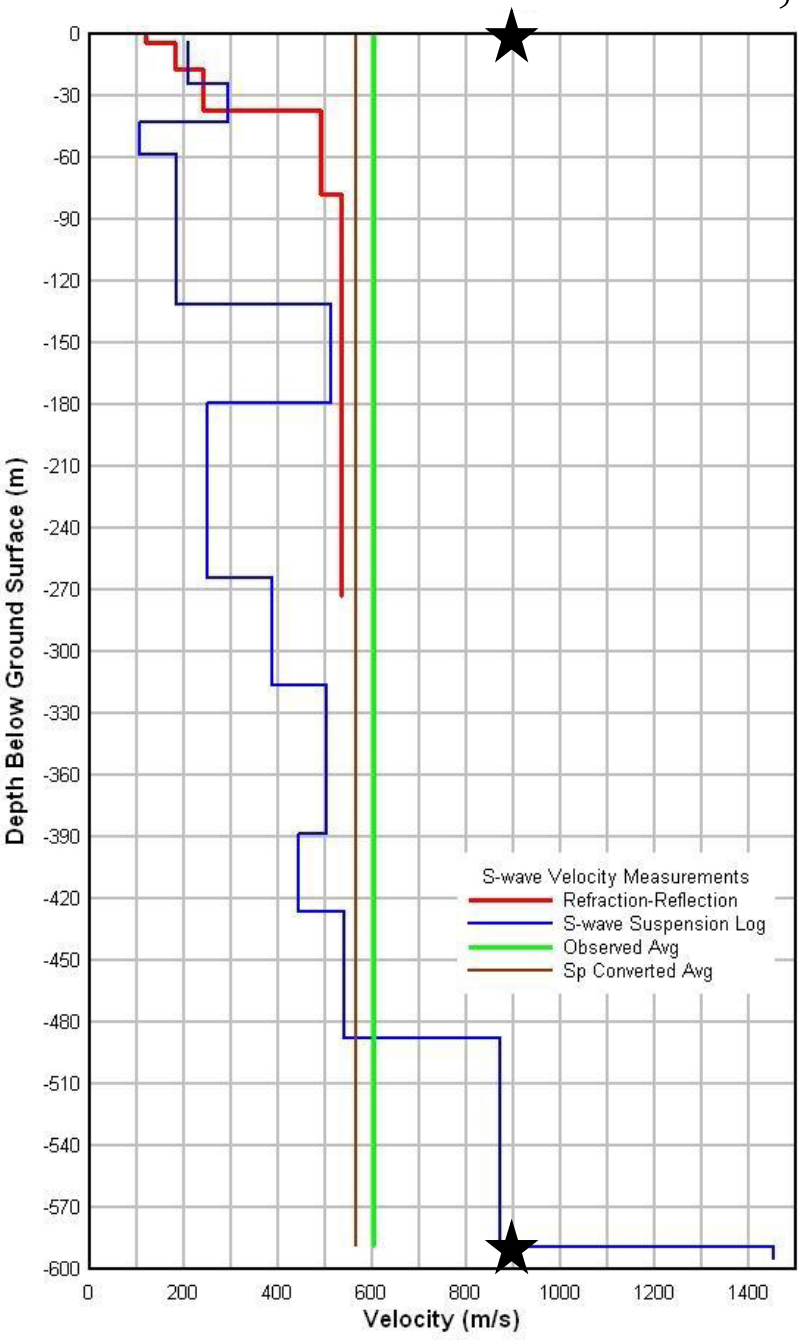
(a)

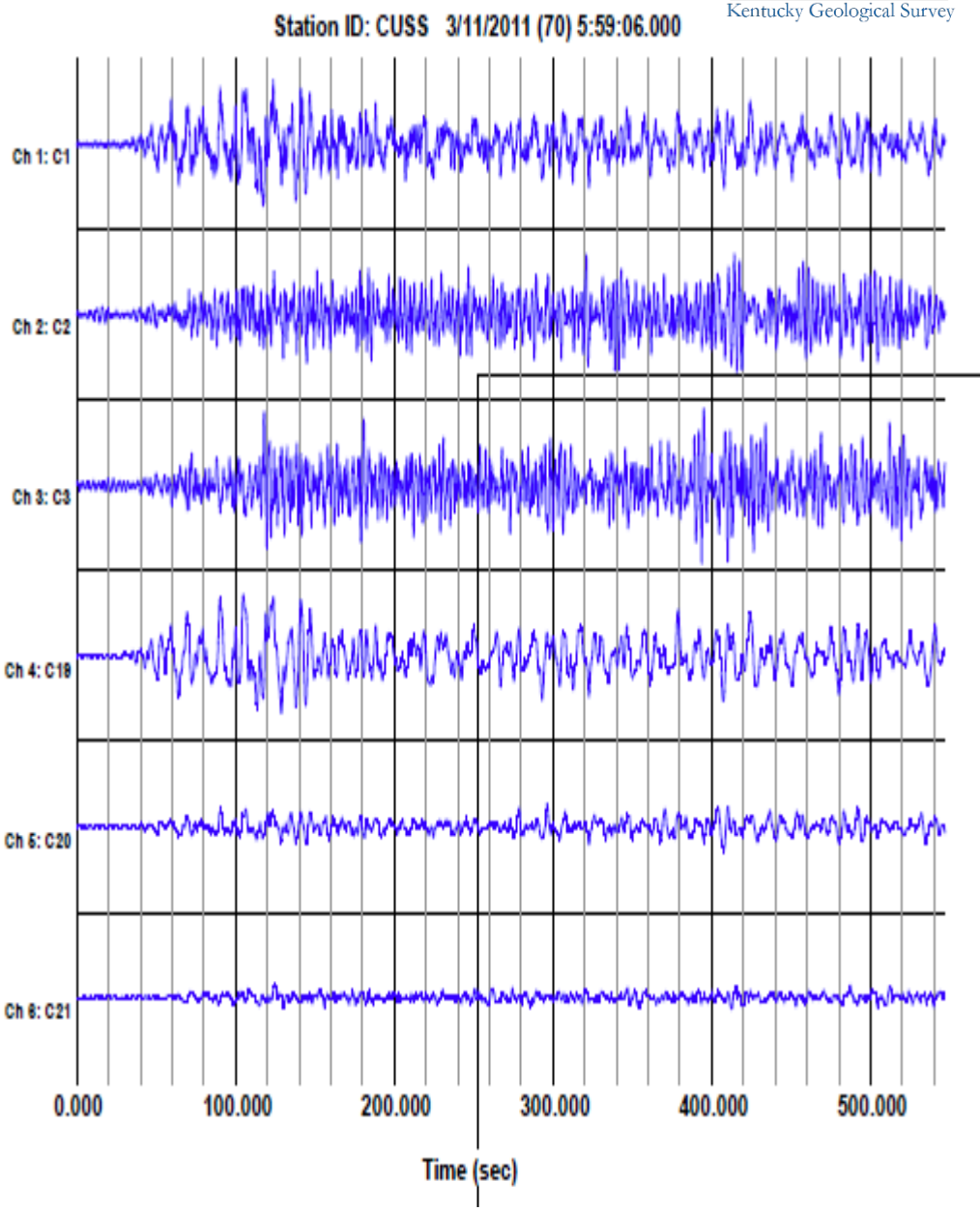
Local and regional earthquakes



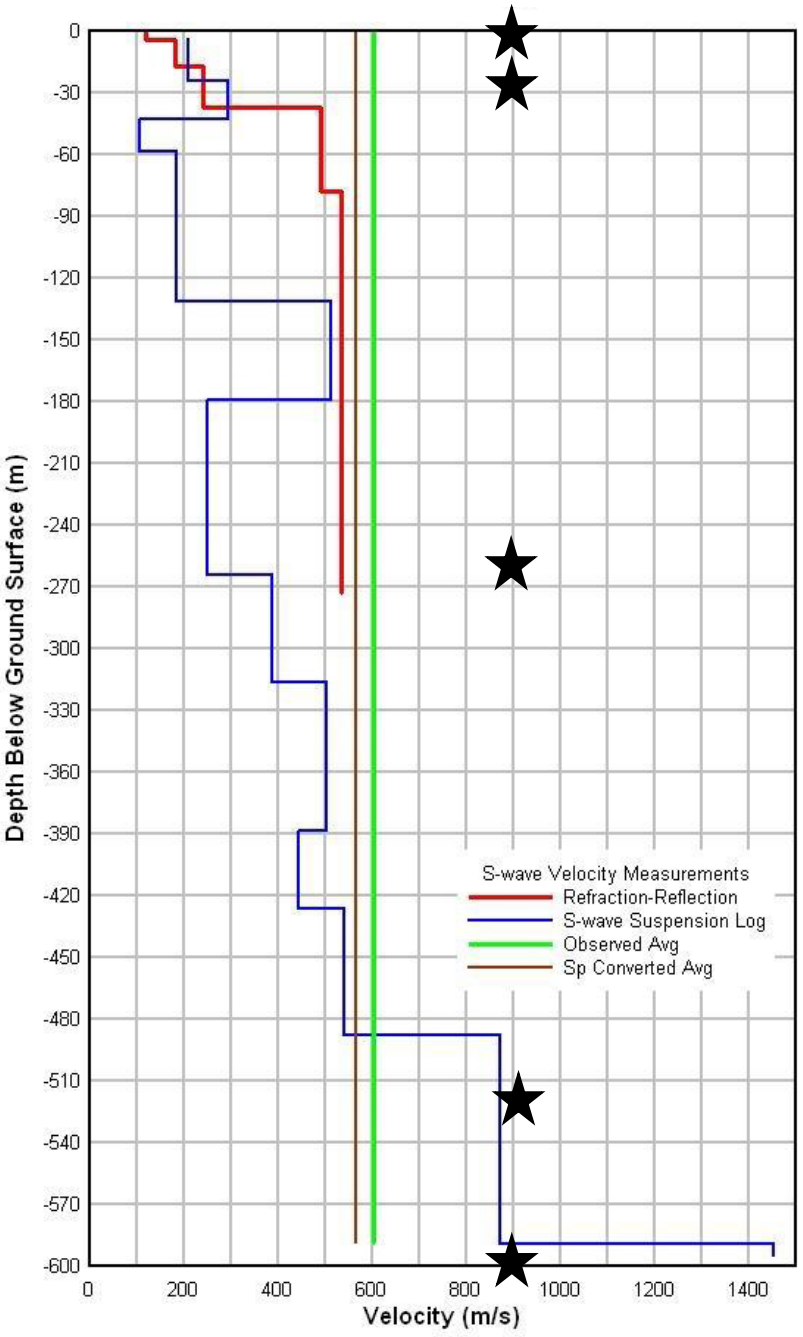
Tele- earthquakes

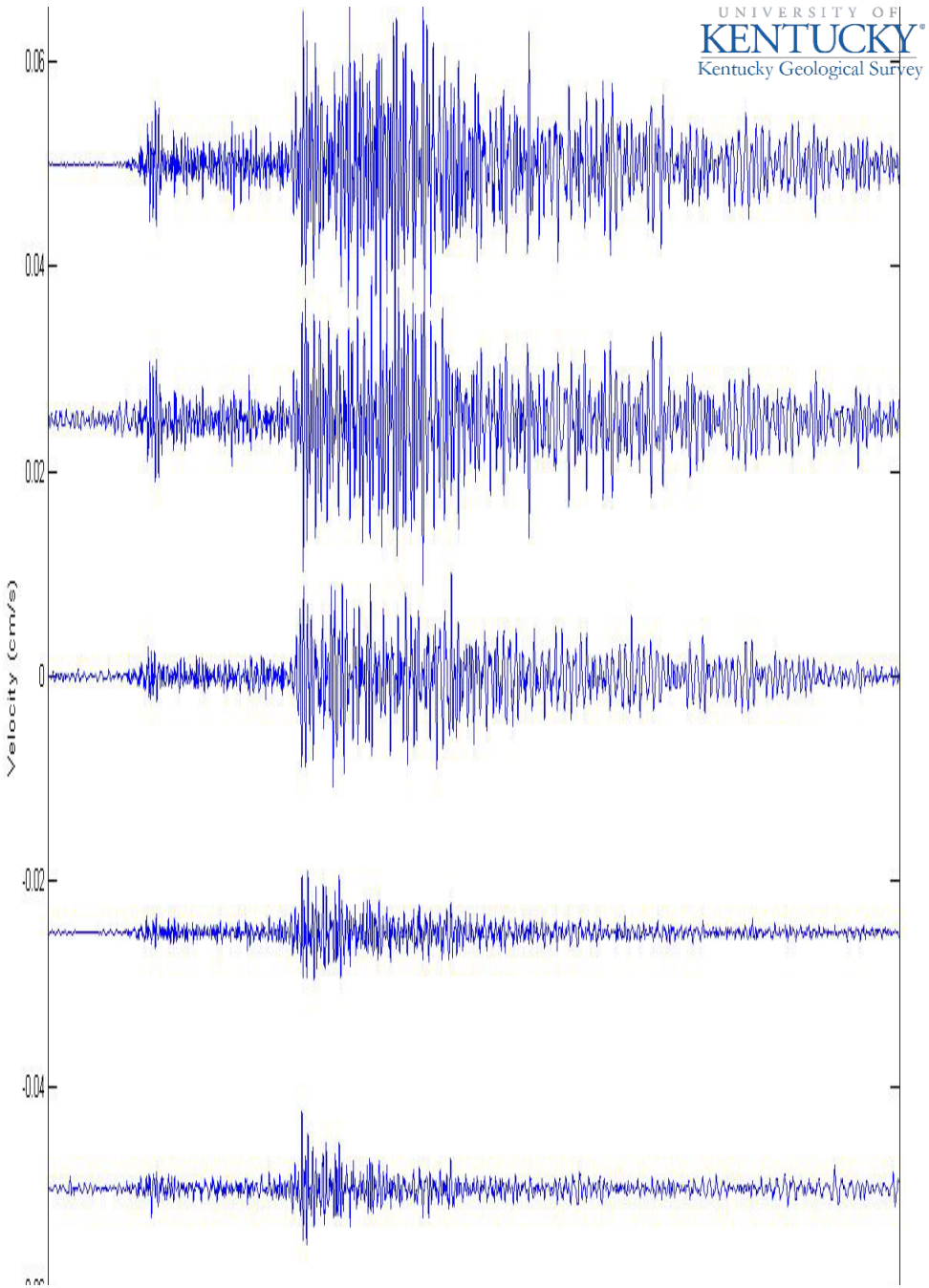
March 11, 2011 Japan earthquake (M9.0)



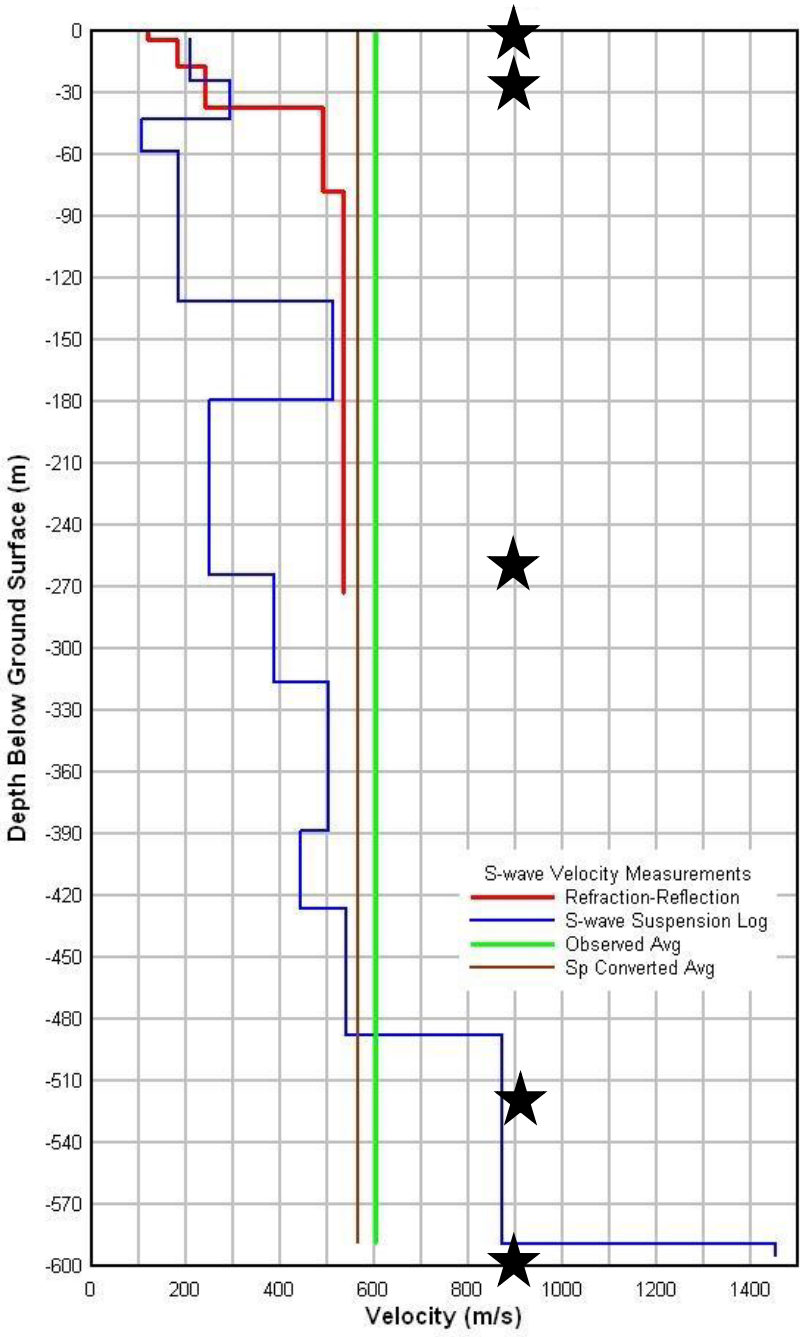


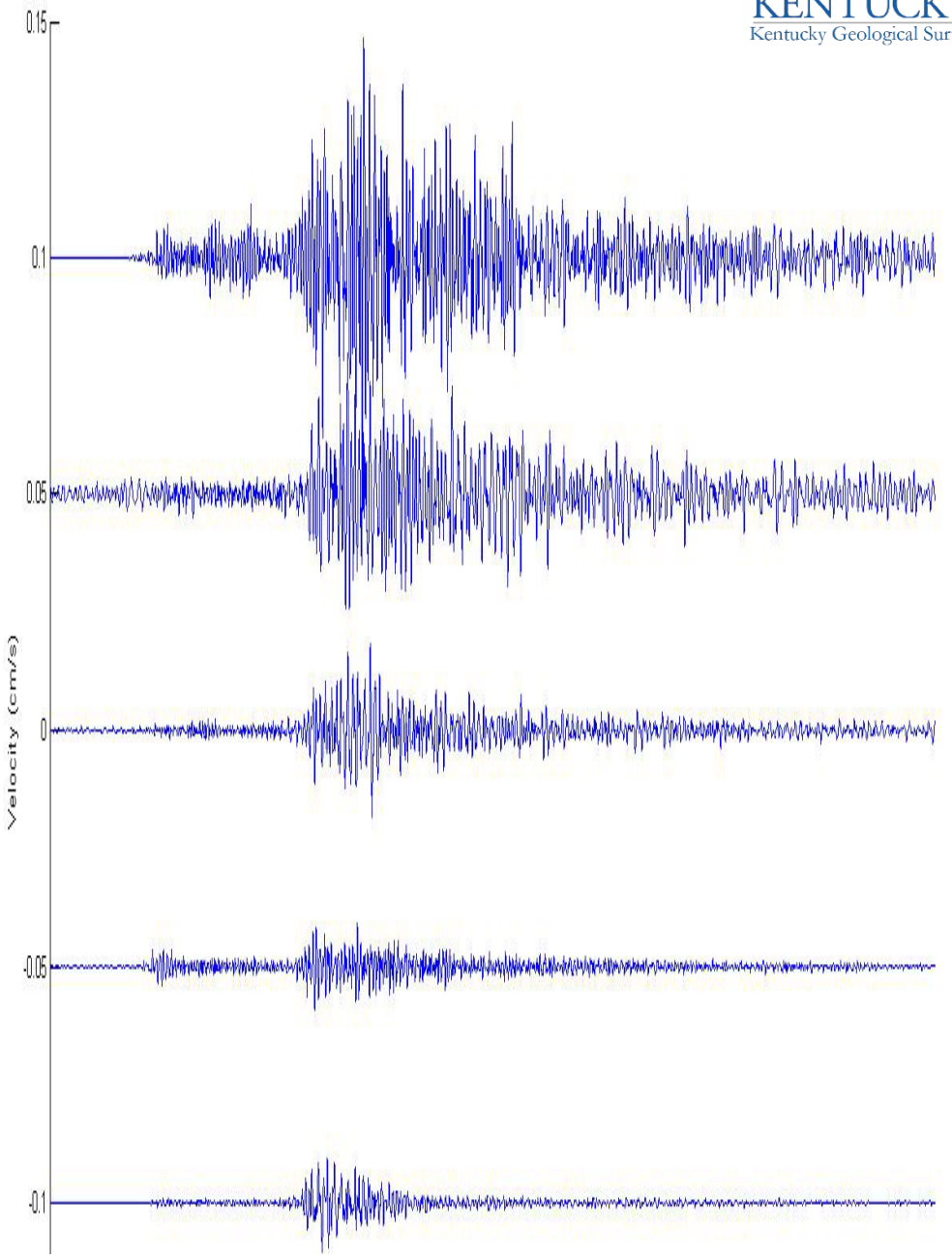
Feb. 28, 2011 AR EQ (M4.7) – Vertical



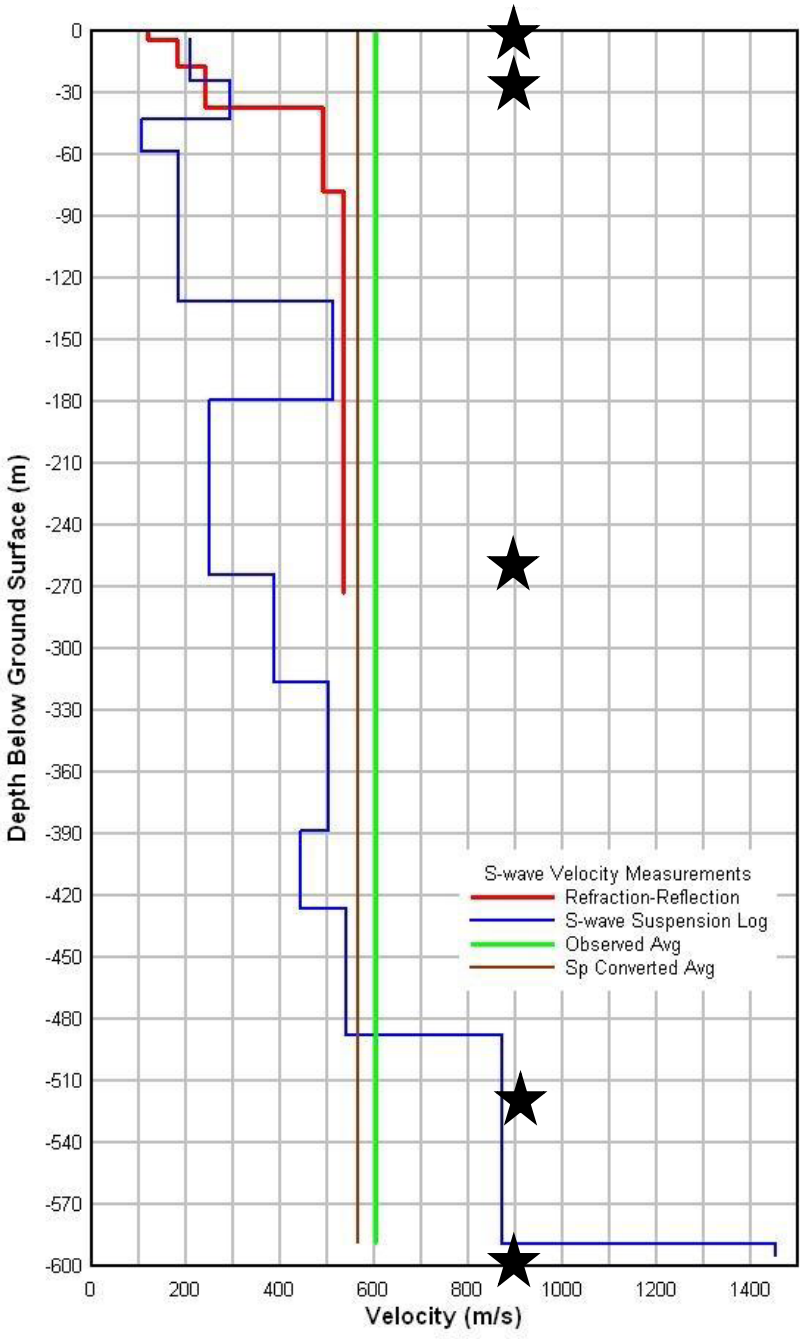


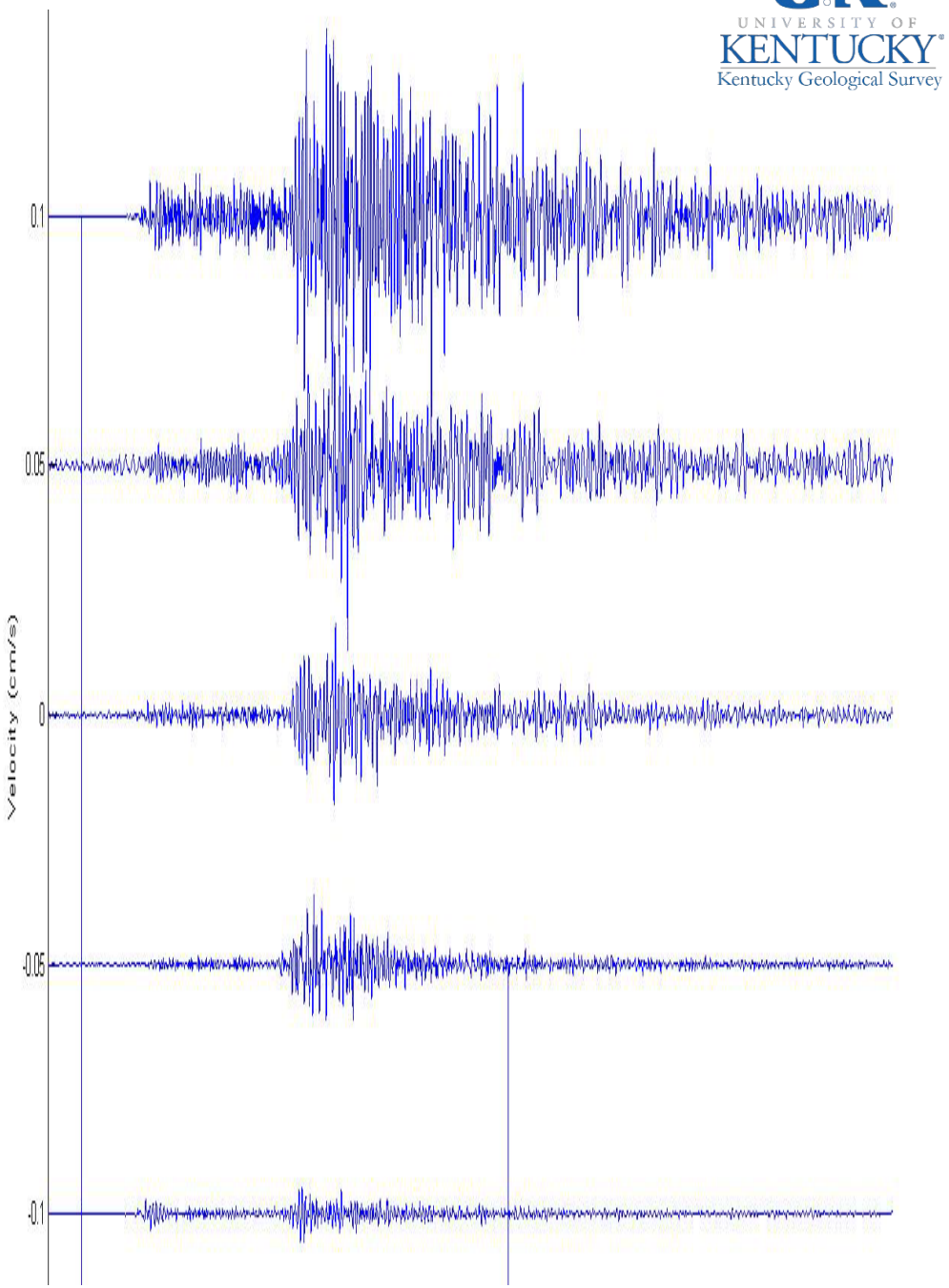
Feb. 28, 2011 AR EQ (M4.7) – Horizontal 1



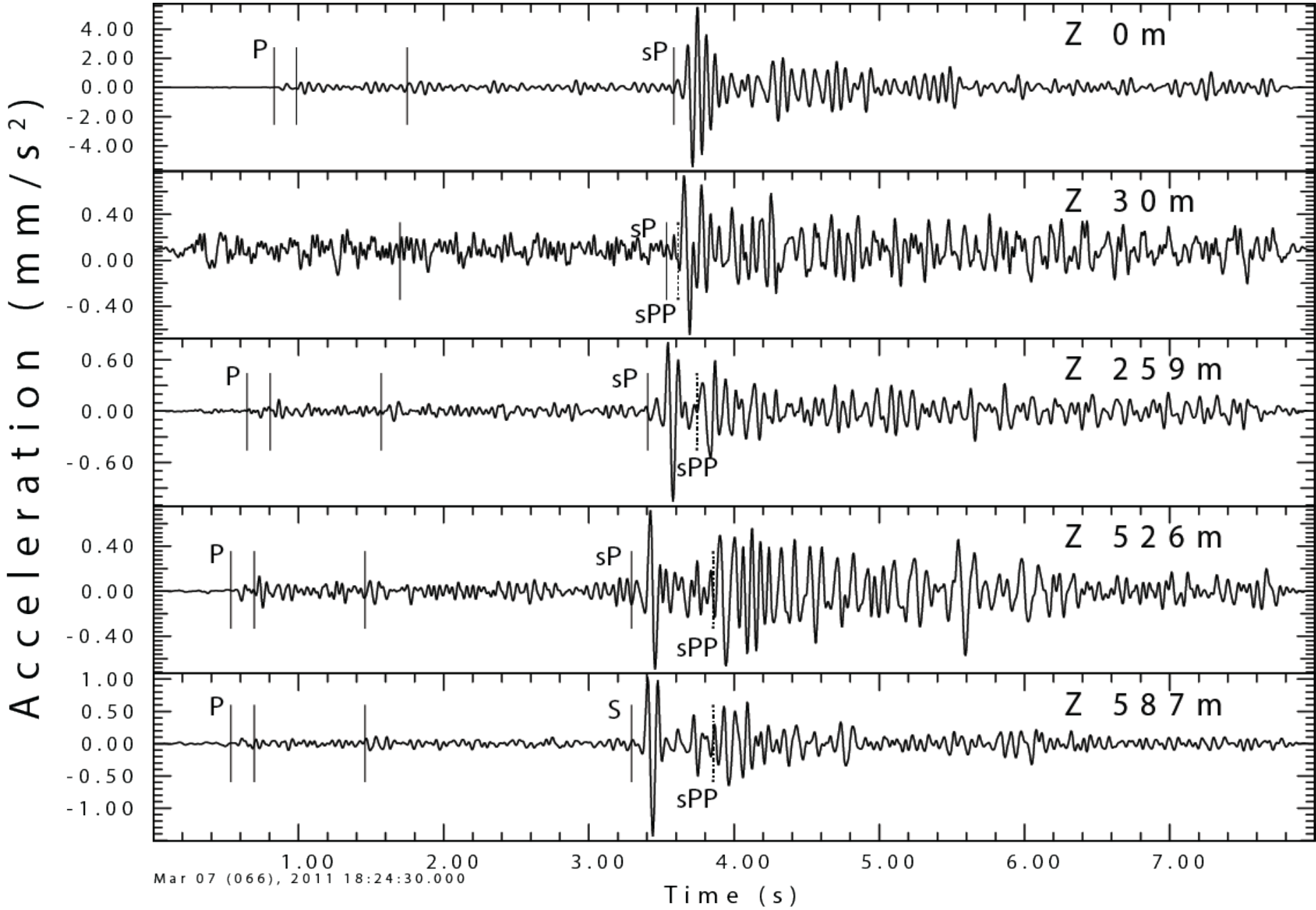


Feb. 28, 2011 AR EQ (M4.7) – Horizontal 2





Vertical-component recordings of an M 2.3 earthquake 22 km west of CUSSO.



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Summary

- The observed seismicity suggests that the active faults of the New Madrid Seismic Zone may not extend into the Jackson Purchase Region
- CUSSO provides a test site for verification and calibration of weak and strong motion propagations in thick sediments
- Our research has helped resolving the seismic design issue for PGDP, and has positive impact on the region