Large amplitude PGA's and PGV's and arms stress drop variability

John Anderson
Nevada Seismological Laboratory
MS 174
University of Nevada
Reno, Nevada 89557
775-784-4265
jga@seismo.unr.edu

This paper reviewed and presented figures showing extreme accelerations and extreme velocities. Figure 1 shows the statistics of extreme accelerations, and Figure 2 shows the statistics of extreme recorded velocities. Figure 1 shows 35 records that have been identified with peak accelerations greater than 800 cm/s2. Figure 3 shows about 25 records for which one or more component exceeded 75 cm/s. These are roughly the thresholds of extreme motions that we will investigate.

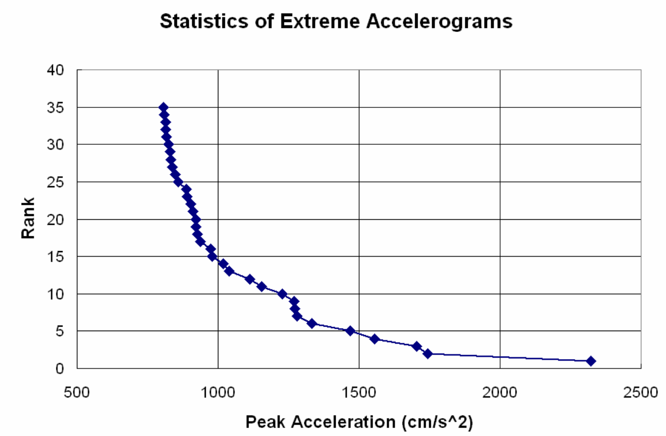

Figure 1. Extreme accelerations. The table with extreme records has been drawn from the COSMOS database.

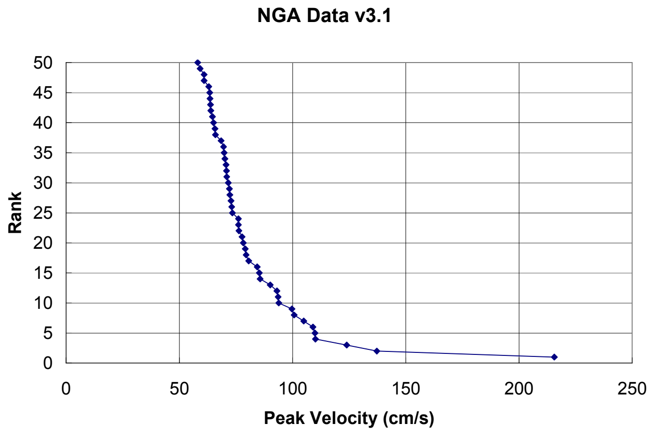

Figure 2. Extreme velocities. The table with extreme velocity records has been drawn from the PEER NGA database.

My presentation at the Workshop on Extreme Ground Motions at Yucca Mountain focused on the results of a preliminary review of some of these records. The very preliminary impression is that most of the extreme velocities are associated with near-fault pulses for earthquakes with M>6. However, that remains to be examined in more details.

Several of the extreme accelerations are shown in Figure 3. Figure 3 shows horizontal components of the records, even if the maximum acceleration occurred on the vertical component, thus explaining why some of these records appear to have peaks that are smaller than 80% of gravity. The 36 accelerograms identified so far with peak acceleration in excess of 800 cm/s2 come from 22 earthquakes, 1971-2003. Two earthquakes contribute six records each: Japan, 200, 3 May 26, MW=7.0 (HRV), Depth =61 km, and Northridge, 1994, MW=6.7, shallow. Of these records, 14 accelerograms from 12 earthquakes caused peak acceleration in excess of 1g. On 78% of the records, the horizontal component was the strongest.

A preliminary conclusion presented at the workshop is that all cases of extreme accelerations occur in one or more of the following limited set of conditions:

- Thrust faulting: 69%
  - Hanging wall: 47%
- Not sure if this percentage is different from the distribution of mechanisms in the overall data set. The fact that none of these are from normal faulting may merely represent the lack of normal faulting data.
- Forward directivity: ≥33%
- Dam abutments (Topographic amplification): 20%
- Site Condition
  - Soil site condition: ≥ 33%
  - Recognizable strong resonance: 6%
- Deep source (perhaps very high stress drop): 20%
- The parameter kappa is less than 30 ms on all but one of the records examined.

- Several of the peaks occur in isolated spikes that are much greater than the rest of the record.

There was no obvious tendency for the extreme peak accelerations to occur more frequently with higher magnitude events. The preliminary study found more points in the magnitude 6.5-7 range than at higher magnitudes. However, most of the overall data set is also in that range, so I did not come to any conclusions yet on the statistical significance if any of that observation. Spectral amplitudes at high frequencies and rms acceleration showed a similar lack of magnitude trend.

The preliminary conclusions also examined a few records from Japan, where the extreme ground motions were recorded on the Kiknet stations with a downhole accelerogram also available. Record accelerations at the surface correspond to accelerations of under 20% g at 100 m depth at 4/5 stations, and to accelerations of 300-600 cm/s2 at the last station.

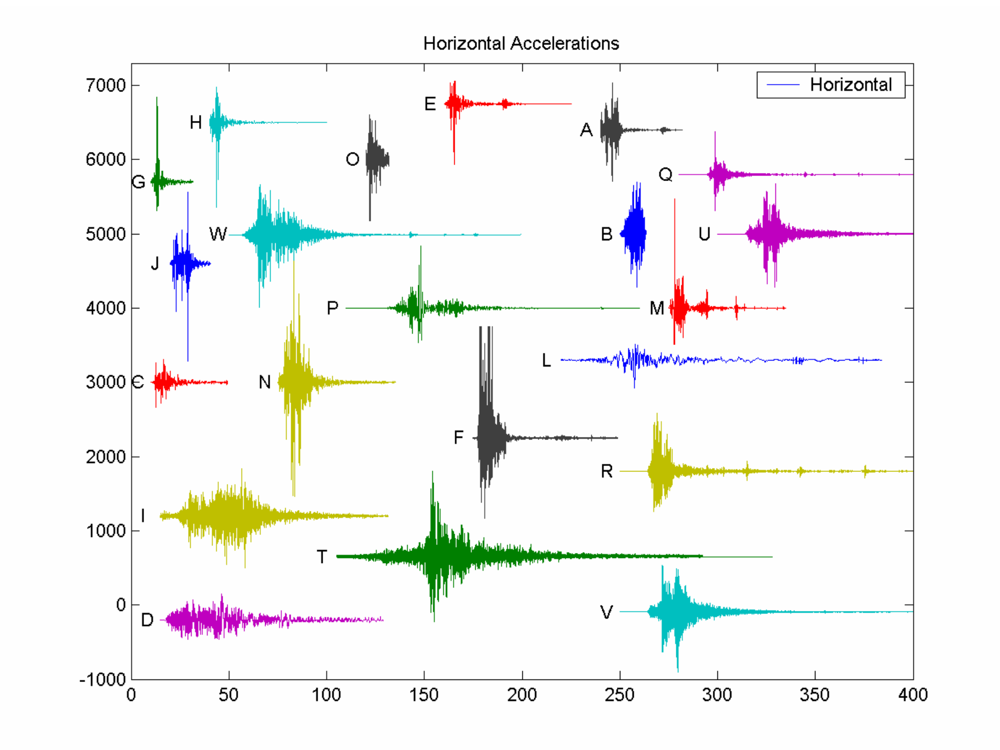

Figure 3. Several extreme accelerograms plotted on a common scale.

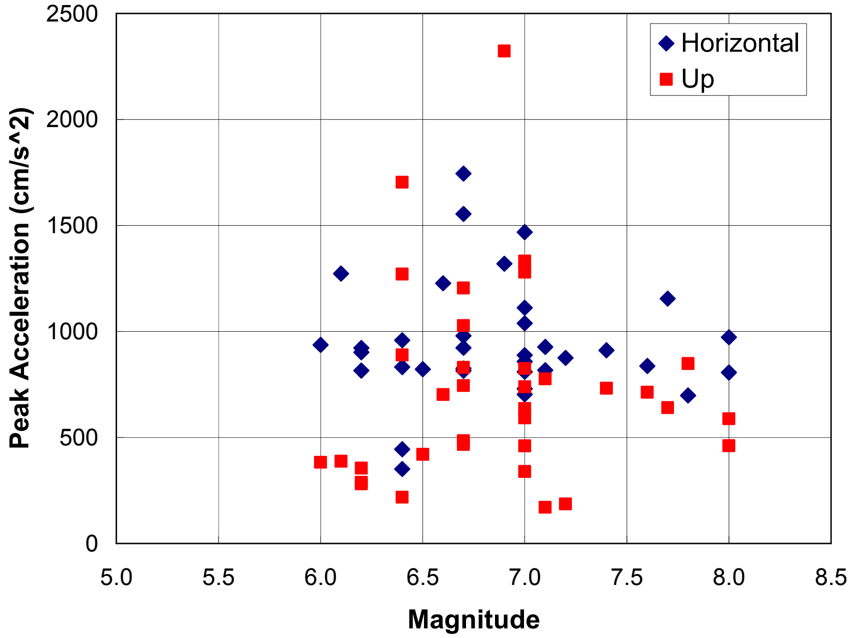

Figure 4. Peak accelerations as a function of the earthquake magnitude. The criteria for being included is that at least one of the components on the accelerogram exceeded 800 cm/s2.

Conclusions

- Extreme velocities appear to have forward directivity or large earthquakes
- Extreme accelerations examined all have one or more of the following:
  - Thrust,
  - Forward directivity
  - Soft site
  - Abutment (topography)
  - Deep source
- Caveat: : normal faulting is barely represented.
- Surface/downhole pairs for extreme accelerations are much stronger at the surface.

Proposal:

We suggest that completing this study is relevant for Yucca Mountain. All of thee preliminary results need to be carried out in a strict QA environment. A more detailed study would examine more thoroughly the conditions associated with all accelerograms that caused peak accelerations greater than 80% of gravity, and peak velocities greater than 75 cm/s. Based on these results, it will be possible to judge whether any of these conditions that contributed extreme ground motions exist at Yucca Mountain. The surface – downhole data from Kiknet can further inform the Yucca Mountain debate with data.

Specific tasks. For each extreme accelerogram and each extreme velocity:

- Map of fault and station location
- Identify epicenter / directivity
- Focal mechanism
- Site condition
- Kappa, spectral amplitudes, arms
- Is this an isolated spike?
- Topography of the station

For KiKnet data with extreme accelerograms

- All of above
- Compare surface and downhole records on all of above points

Overview:

- Examine statistics.
- Put into perspective of scope of all data
- Conclusions for how this may be relevant for Yucca Mountain, considering how representative the conditions are of those near Yucca Mountain.
- Discussion of what combinations of conditions might cause the most severe accelerations and velocities.

The cost of this project is about one man-year.