Earthquake Hazard from Basin Focusing, part 2

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INVESTIGATIONS UNDERTAKEN

The M_W=6.7 Northridge earthquake on January 17, 1994, caused unexpected excessive damage in Santa Monica and Sherman Oaks, CA. Previous work (Gao *et al*, 1996) has concluded that a small sub-basin lens structure beneath Santa Monica focused seismic energy into these areas. The goal of this project is to gather evidence supporting the possible presence of other focusing or of defocusing structures elsewhere in southern California. We search for focusing effects by studying the amplification factors of local seismic stations as a function of incidence and azimuth for small earthquakes in the Los Angeles basin and surrounding areas.

The earthquakes used were taken from the SCEC database and were limited to those events in southern California (32.5 - 36.5º N, 116 - 120º W) with $M_L \leq 2.5$ for which there was an available fault-plane solution (strike, dip, and rake of the fault plane). For each earthquake, we first band-pass filtered the data between 5-15 Hz and removed the instrument response. For a given event we used seismograms with signal-to-noise (S/N) ratios greater than 1.5. We calculated the radiation pattern in order to determine the location of the nodal planes and then removed the data from the stations near the nodal planes, where theoretical amplitudes are most uncertain. We picked the maximum P-wave amplitude at each station within a 3-second window centered on the expected P-wave arrival time. Using selected amplitudes near the maximum of the fault-plane solution we performed a least-squares regression using the equation

$$A_{Ti} = \frac{A_o}{r_i^m}$$

(where A_{Ti} is the theoretical amplitude, r_i is the distance from the hypocenter for the *i*th station, and A_o is a scaling factor) in order to determine the exponent (m) value for each earthquake. We calculated the theoretical amplitude for each station based on the individual A_o values, the average m value, and the radiation function. The ratios of the observed amplitude to the theoretical amplitude at each station, after removing outliers, were then averaged over all the events recorded by that station in order to determine that station's amplification factor.

RESULTS

P-wave amplitudes (5-15 Hz) from southern California earthquakes appear to follow the equation (Figure 1):

$$A_T = \frac{A_o * \text{the radiation pattern}}{r^{0.35}}$$

The m=0.35 exponent value is based on 20 events. For each individual event the fluctuations in the observed amplitude correspond quite well to the fault-plane solution (e.g., Figure 2).

We have calculated the amplification factor for each station of the Southern California Seismic Network that recorded more than four earthquakes and found they vary from 0.4 to 2.3 (Figure 3). We are using the data to search for azimuthal variation in amplification factors that are indicative of focusing. Preliminary indications are that some azimuthal variation occurs (Figure 4), but many more events will need to be processed.

Detailed analysis of the data reveals that maximum P wave amplitudes at short range are Pg. At intermediate and long range, where Pg and PmP merge, maximum amplitudes are a combination of both. PmP at critical and super-critical incidence rises in amplitude relative to Pg. This accounts for the low exponent m=0.35, significantly less than m=1 expected for infinite medium geometric spreading of body waves. We are currently using LARSE I explosion data to model PmP and Pg amplitudes through the critical point in order to improve our earthquake model.

REFERENCES

Gao, S., H. Liu, P.M. Davis, and L. Knopoff (1996). Localized amplification of seismic waves and correlation with damage due to the Northridge earthquake, *Bull. Seism. Soc. Am.* **86**, S209-S230.

NON-TECHNICAL SUMMARY

Earthquakes cause variable amounts of ground shaking depending on soil conditions (site effects) and geologic structural effects such as focusing and defocusing by underground formations or topographic features. We analyze amplitudes from the Southern California Seismic Network to estimate the relative contributions of site and structural effects. One diagnostic is azimuthal dependent variation in amplification against which we are comparing the local geology. The ultimate objective is to predict hazardous shaking from future earthquakes.

REPORTS PUBLISHED

None at this time.

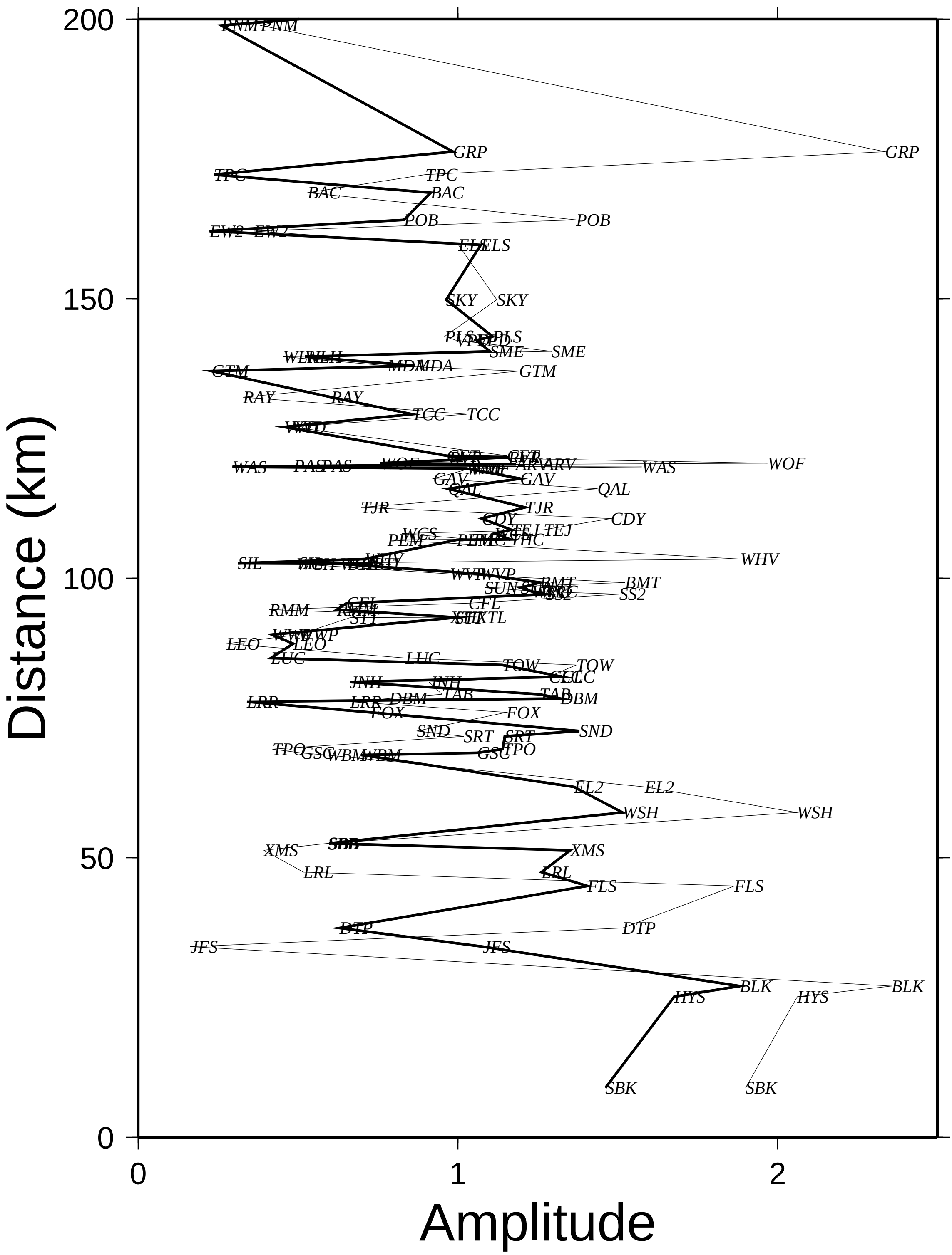

Figure 1. Observed (thick line) and theoretical (thin line) P-wave amplitude vs. distance from the hypocenter for one event.

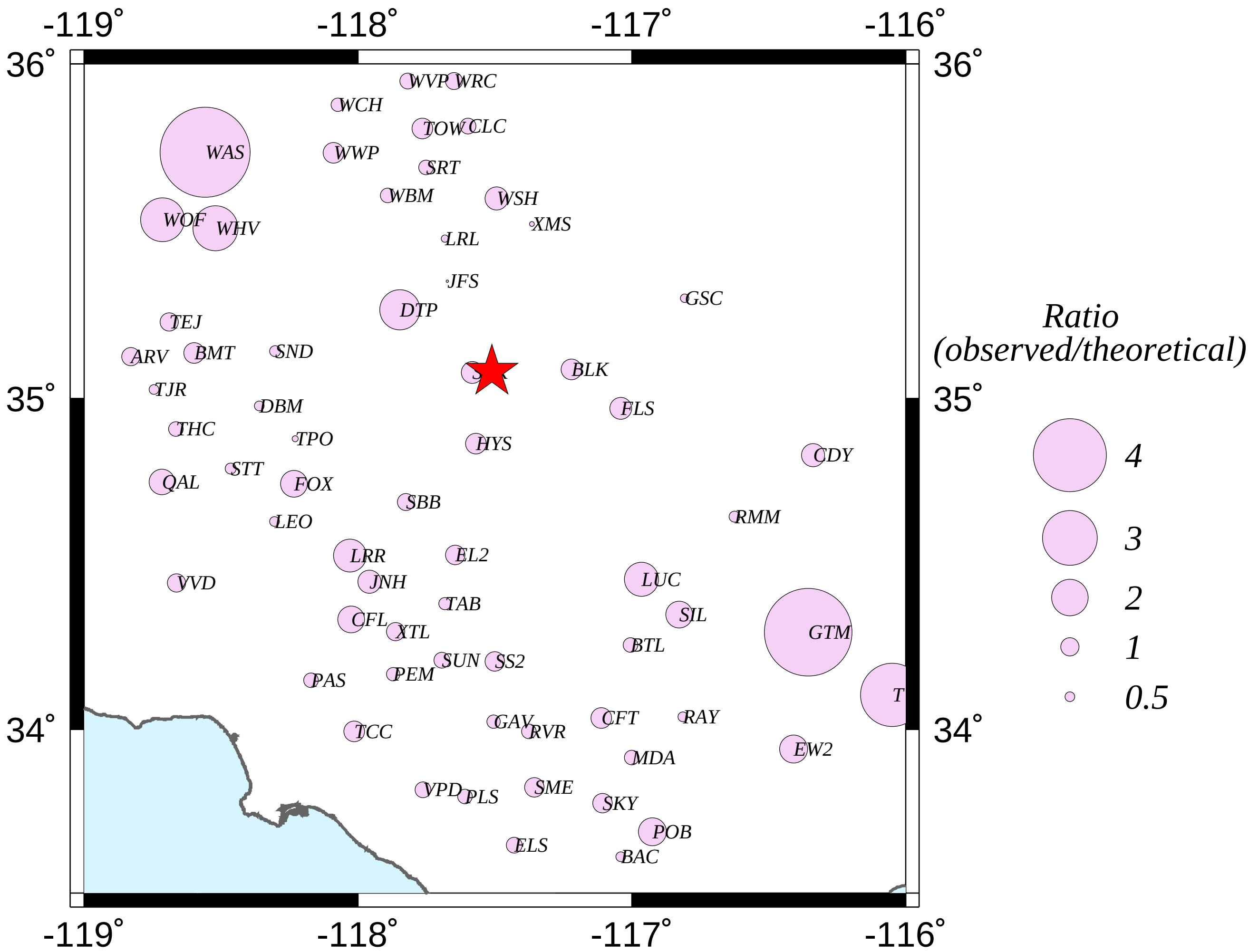

Figure 2. Map of the seismic stations that recorded a single event (star), where the size of the circle is proportional to the amplification factor, the ratio of the observed amplitude to the theoretical amplitude.

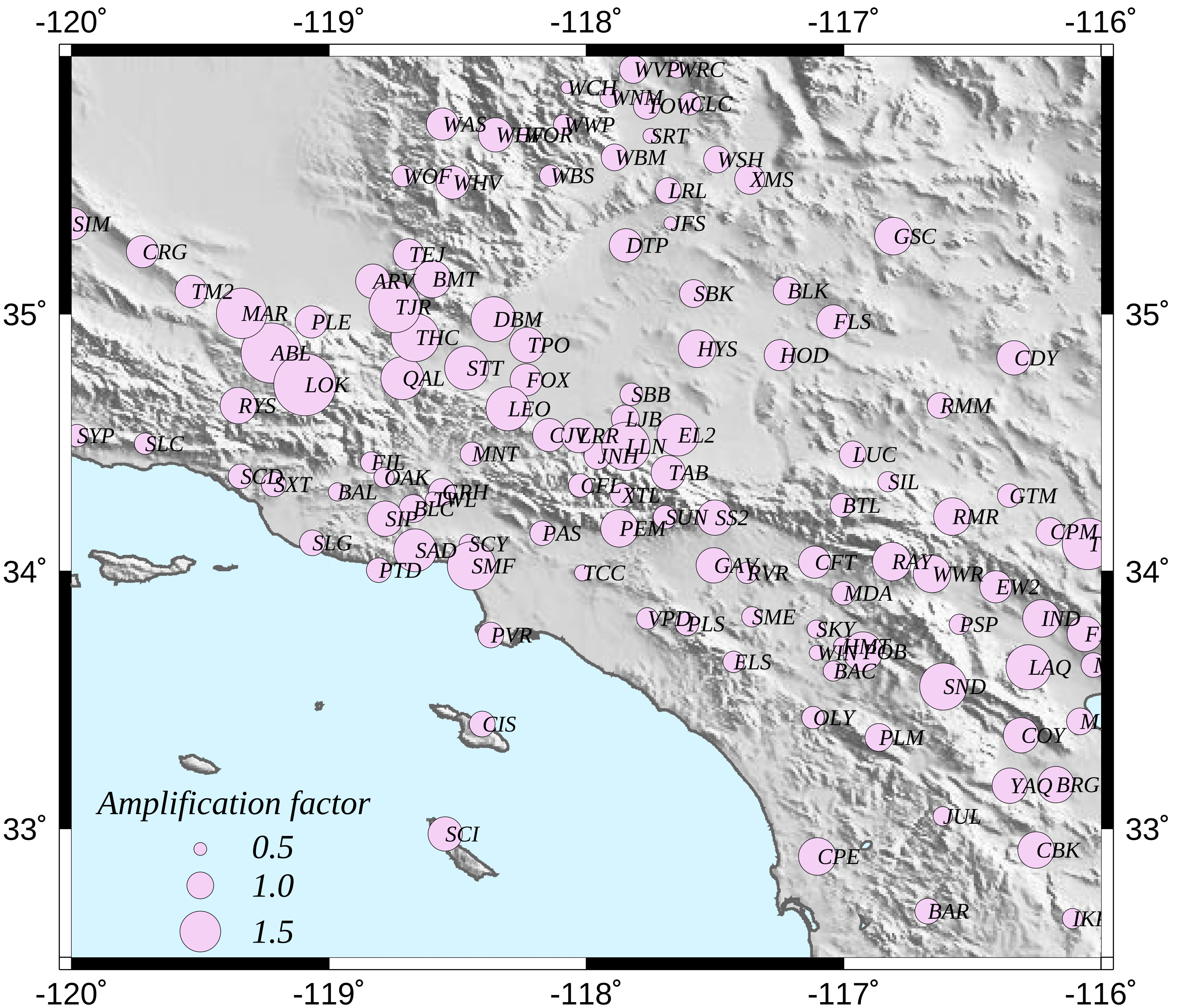

Figure 3. Map of the amplification factor (ratio of observed amplitude to theoretical amplitude) at each of the seismic stations, based on 20 earthquakes.

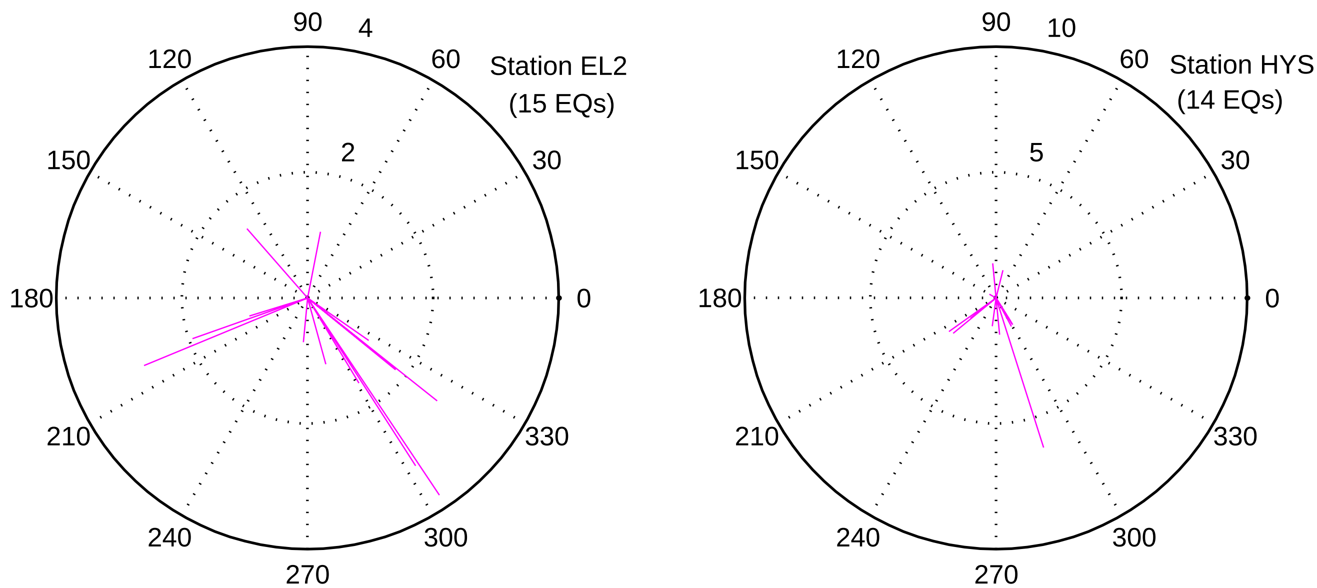

Figure 4. Lines correspond to ratio of observed to theoretical amplitude for centrally−located stations EL2 and HYS. The line directions as plotted correspond to back azimuths to the earthquakes.