QUICK ML DETERMINATION FROM STRONG-MOTION RECORDS

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ABSTRACT

Determination of the local magnitude, ML, for earthquakes, using simulated Wood-Anderson seismograms from strong-motion accelerograms has become a common practice due to greater availability of digitized records.Usually this is done long after the earthquakes. With the advent of solid-state digital accelerograghs,the ML magnitude can be determined more quickly. However,if we continue to rely on the simulated Wood-Anderson trace amplitude,it will still take some time to wait for the end of recording before we can process the record. This would not be quick enough for an Earthquake Early Warning System to issue reliable information about the magnitude along with the origin time and epicenter location of an earthquake. In this study, we have analyzed over 300 digitized strong-motion records from three recent large earthquakes in California and Taiwan to determine their ML magnitudes and response spectral shapes. We further correlated the results from these two types of analyses with each other, as well as with the local site geology of the recording stations.

We first classified the records into three subsets by comparing their response spectral shapes with the Uniform Building Code (UBC) design spectral shapes.We have found that the records with response spectral shapes of the UBC S1 type have significantly smaller than average ML values, whereas those with response spectral shapes of the UBC S3 type resulted insignificantly larger than average ML values. The records with response spectral shapes of the UBC S2 type had ML values in the average range. The above findings are presented in an accompanying paper.

In this paper we present another finding which may serve as an empirical basis for quick ML determination even before the earthquake stops.This finding shows that there exists an apparent correlation between the Wood-Anderson (WA) amplitude and peak ground acceleration (PGA) for the three earthquakes. This apparent correlation will enable us to determine the ML magnitude usingthe PGA inlieu of WA amplitude.

Figure 1 shows a log-log plot of the WA amplitude as a function of the PGA

for the subset of records which have response spectral shapes of the UBC S1 type. The data points form an apparent linear trend which can be fitted with a straight line as follows:

$$\log A = 1.001*\log G + 1.646 \qquad (1)$$

where A is the WA in mm at static magnification of 1, G is the peak horizontal ground acceleration in g.

Similarly, Figure 2 shows a log-log plot of the WA amplitude as a function of the PGA for the subset of records which have response spectral shapes of the UBC S2 type.In this case the data points form an even tighter linear trend which can be fitted with a straight line as follows:

$$\log A = 0.8946*\log G + 1.724 \qquad (2)$$

where A is the WA in mm at static magnification of 1, G is the peak horizontal ground acceleration in g.

Finally,Figure 3 shows a log-log plot of the WA amplitude as a function of the PGA for the subset of records which have response spectral shapes of the U BC S3 type. In this case the data points also form a tight linear trend which can be fitted with a straight line as follows:

$$\log A = 0.8857*\log G + 1.859 \qquad (3)$$

where A is the WA in mm at static magnification of 1, G is the peak horizontal ground acceleration in g.

The straight lines defined by Equations 1,2, and 3 have similar slopes but have successively larger offsets of 1.646, 1.724, and 1.859, suggesting that for a given PGA, a record of the UBC S3 type would result in an ML value exceeding those of a UBC S2 and a UBC S1 types by 0.135 and 0.213, respectively.

For quick ML determination, if the recording station is known for its type of response spectral shape, then one of the above three equations with appropriate response spectral shape can be used to estimate the log A value from the log G value. If the type of response spectral shape is not known for the recording station, then the intermediate Equation 2 can be used for the same purpose.In the second case,the resulting ML value will have a larger variation than in the first case.

The next step for ML determination is to substitute the log A value, after incorporating the appropriate static magnification factor, in the well-known Richter formula,

$$ML = \log A - \log A0 \qquad (4)$$

where - log A0 is the distance correction function.

For quick ML determination, the hypocentral distance required for determining the - log A0 can be estimated from the S-P time on the acceleration record. Figure 4 shows a real example to demonstrate that an acceleration record can provide all the information needed for quick ML determination, with the help of Equation 1, 2, or 3.

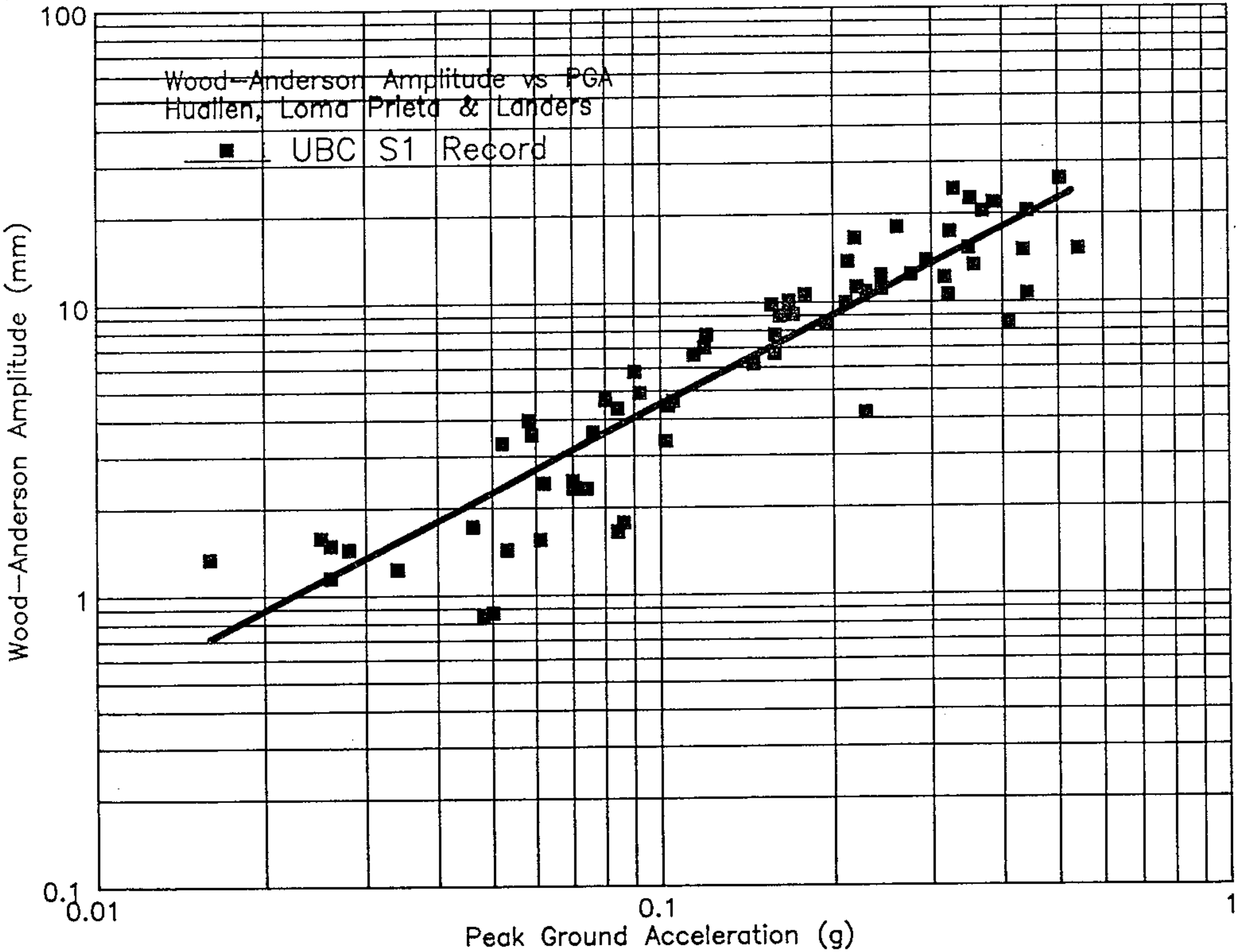

Figure 1. Simulated Wood-Anderson trace amplitude (at static magnification of 1) as a function of the peak ground acceleration for strong-motion records of the three large California and Taiwan earthquakes whose response spectral shapes are of the UBC S1 type.

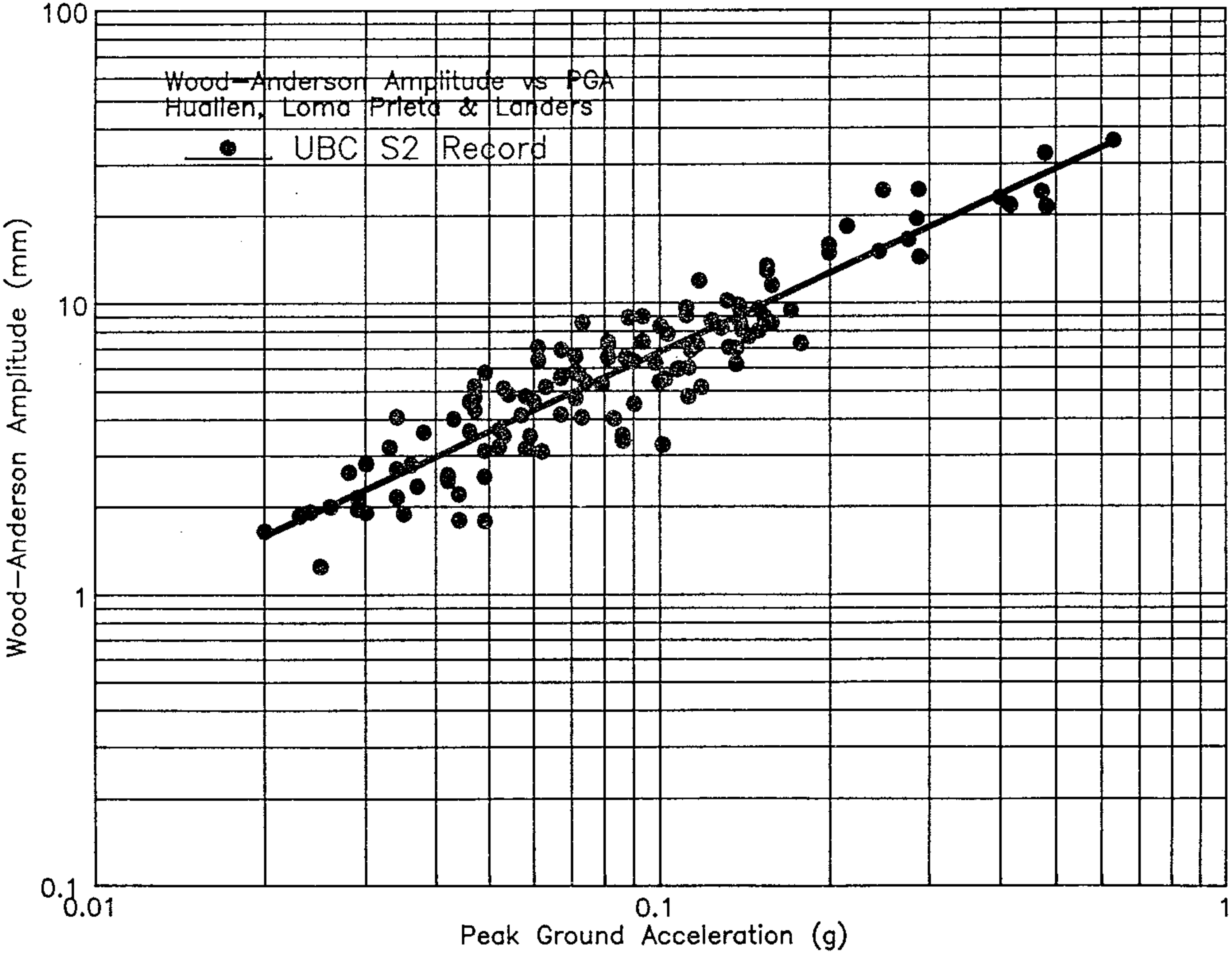

Figure 2. Simulated Wood-Anderson trace amplitude (at static magnification of 1) as a function of the peak ground acceleration for strong-motion records of the three large California and Taiwan earthquakes whose response spectral shapes are of the UBC S2 type.

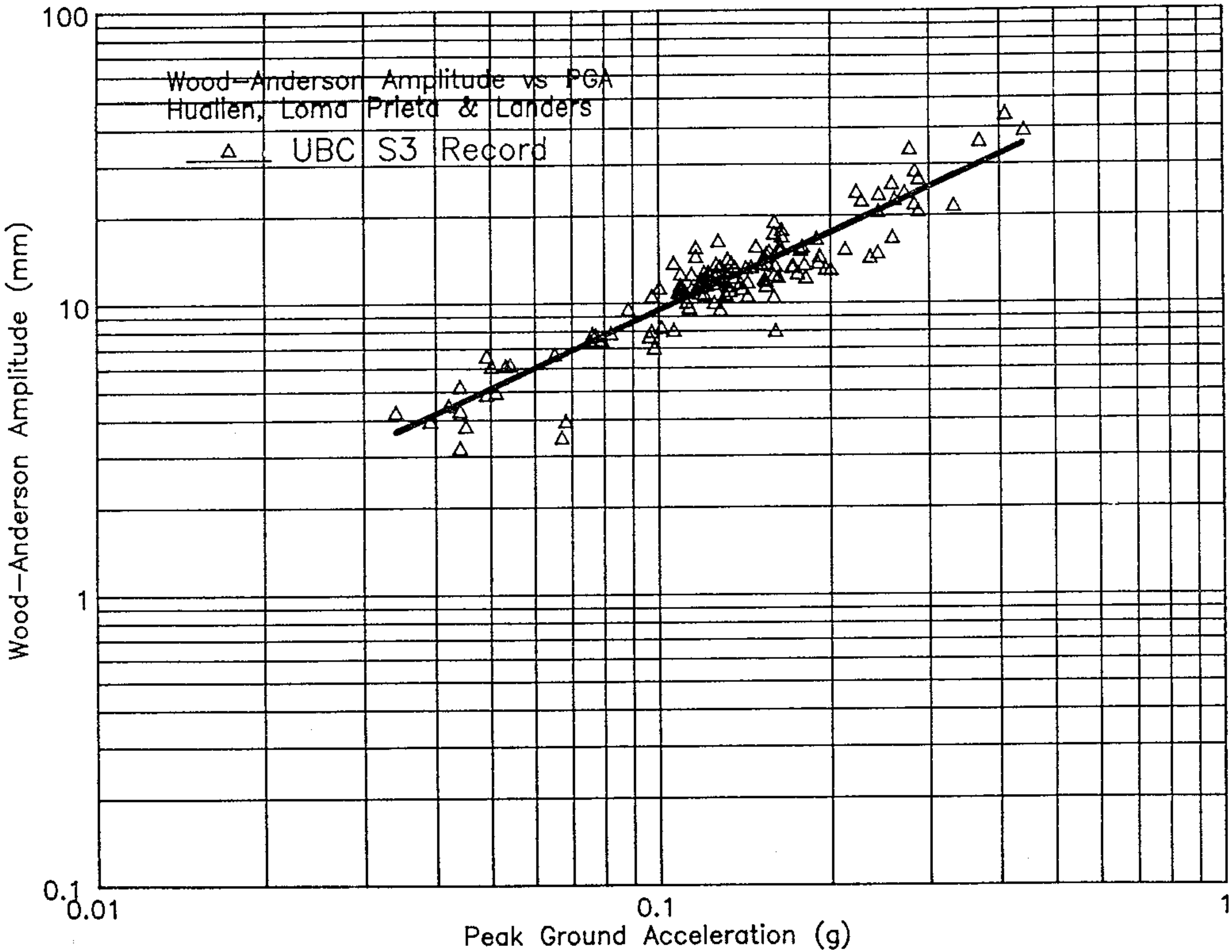

Figure 3. Simulated Wood-Anderson trace amplitude (at static magnification of 1) as a function of the peak ground acceleration for strong-motion records of the three large California and Taiwan earthquakes whose response spectral shapes are of the UBC S3 type.

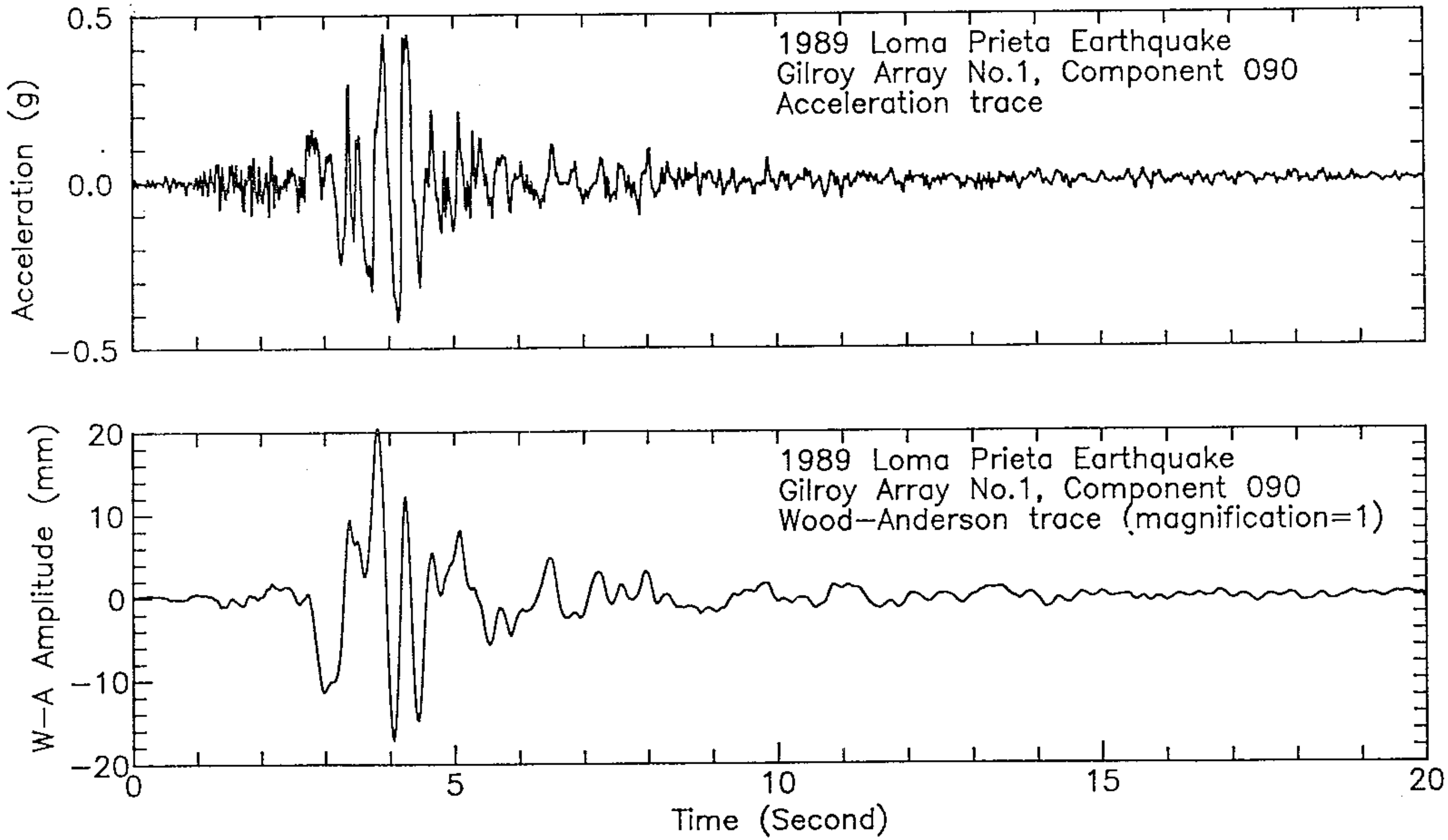

Figure 4. The E-W component acceleration record and its simulated Wood-Anderson seismogram recorded at the Gilroy Array Staion No.1 from the 1989 Loma Prieta, California earthquake. The acceleration record contains all the information needed for quick M_L detaermination, even before the earthquake stops.