mb vs Mw in the search for High Stress-Drop Earthquakes

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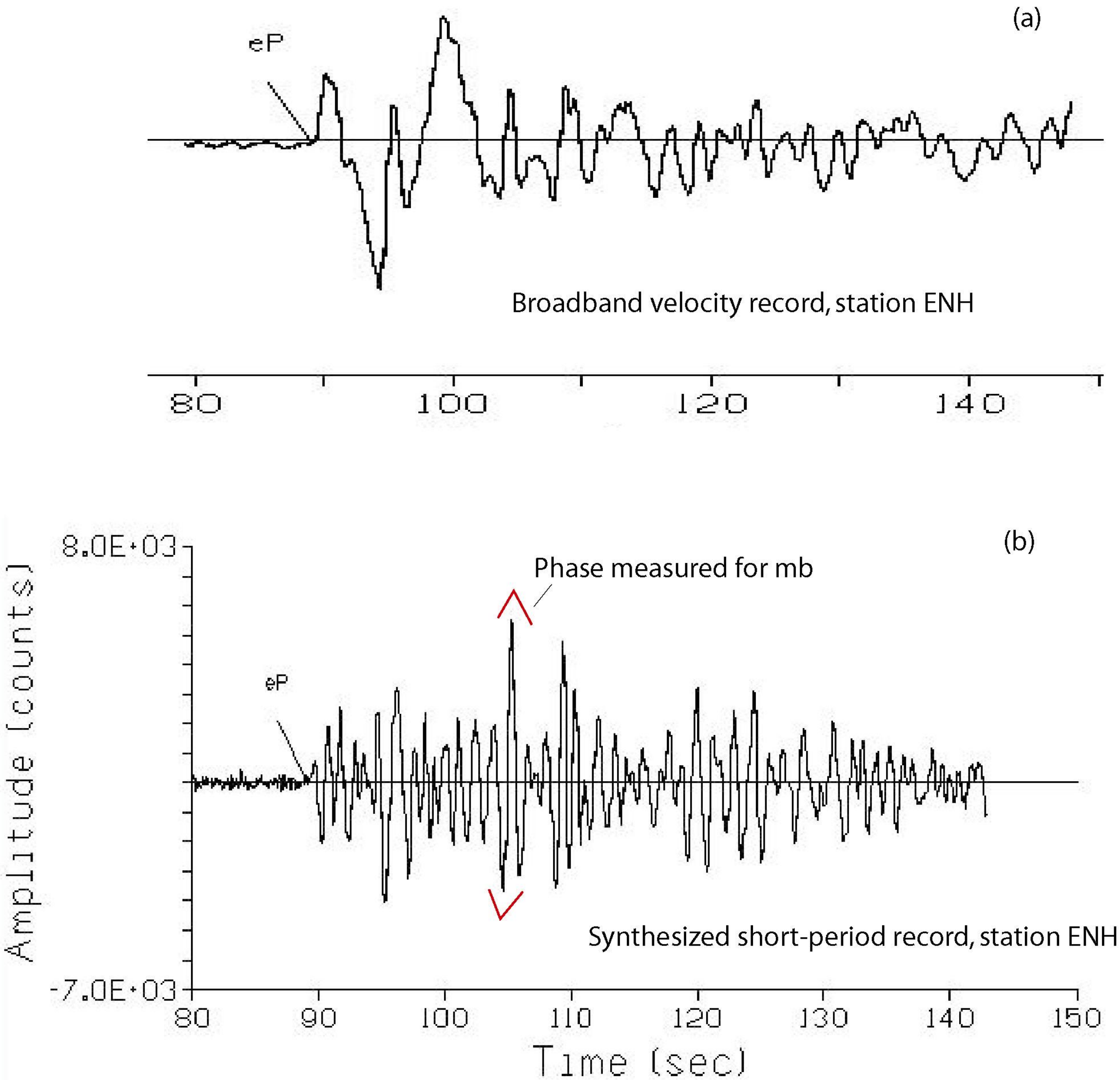
Theory predicts that high stress-drop earthquakes should tend to have high values of *mb* (a measure of the short-period energy of the earthquake) compared to *Mw* (a measure of the long-period energy of the earthquake. There are a number of factors in addition to stress drop that can influence mb. It is possible, nonetheless, that stress drop is important enough an influence on *mb* that *mb-Mw* values for cataloged earthquakes could be used to search for extremely high stress-drop earthquakes. Final identification of anomalously high stress-drop earthquakes would have to depend on detailed study of the candidate earthquakes.

At the USGS/NEIC, the *mb* measurement is made from a signal that is narrow-band filtered with a central frequency near 1 Hz (fig. 1b). The measurement is made from the largest amplitude phase in the entire P, pP, sP waveform. The current practice, in effect since the early 1970's, differs from the practice used in the 1960's and early 1970's, when amplitudes were measured in the first few cycles of the P-wave train. From comparison of the unfiltered broad-band velocity signal (fig. 1a) with the filtered signal from which *mb* is measured (fig 1b), it is clear that *mb* cannot reflect the source-process of the entire earthquake except in some statistical sense. The hope is that *mb* might reflect the source processes (breakage of high stress-drop asperities; stopping phases, etc.) that are most responsible for high-frequency ground-motions of engineering interest. "Stress drop" is used to characterize the efficiency of these processes.

Plotting *mb* vs. *Mw* for earthquakes world-wide (Fig. 2) shows large scatter. If this scatter were due entirely to changes in the stress droop, it would imply a variation in stress drop of over three orders of magnitude. It is clear that *mb* does depend on other factors besides stress-drop. For example (Fig. 2), a 500 bar *Mw* = 6.0 earthquake in a region of low upper-mantle attenuation (e.g. eastern U.S.) may produce a similar mb as a 5 kbar *Mw* = 6.0 earthquake in a region of high upper-mantle attenuation (e.g., western U.S.). Restricting attention to *mb* vs. *Mw* from earthquakes in geographically limited source-regions should remove scatter due to differences in upper-mantle attenuation.

Figures 3 and 4 show different perspectives on *mb* vs. *Mw* for the California-Nevada region. In any given *Mw* range there are some earthquakes that stand out as having high *mb* vs. *Mw*. The bottom-line question, which I have not yet been able to systematically investigate, is: are the shocks with high *mb* vs. *Mw* in Figures 3 and 4 characterized by unusually high stress-drops? If so, *mb* vs. *Mw* would appear to be a promising reconnaissance tool for searching for stress-drop extremes world-wide.

Example of mb amplitude measurement for Indonesian earthquake of 2004/07/28, 03:56 UTC



a. Earthquake has mb = 6.1, Mw = 6.5
b. Amplitude is measured anywhere in the P-wave train before PP
c Amplitude is measured through a filter that replicates the response of an analog, narrow-band, short-period seismograph.

Figure 1. Example of a measurement of *mb* for the New Guinea earthquake of 2004.07.28, 03:56 UTC, *mb* = 6.1, *Mw* = 6.5, made at station ENH.

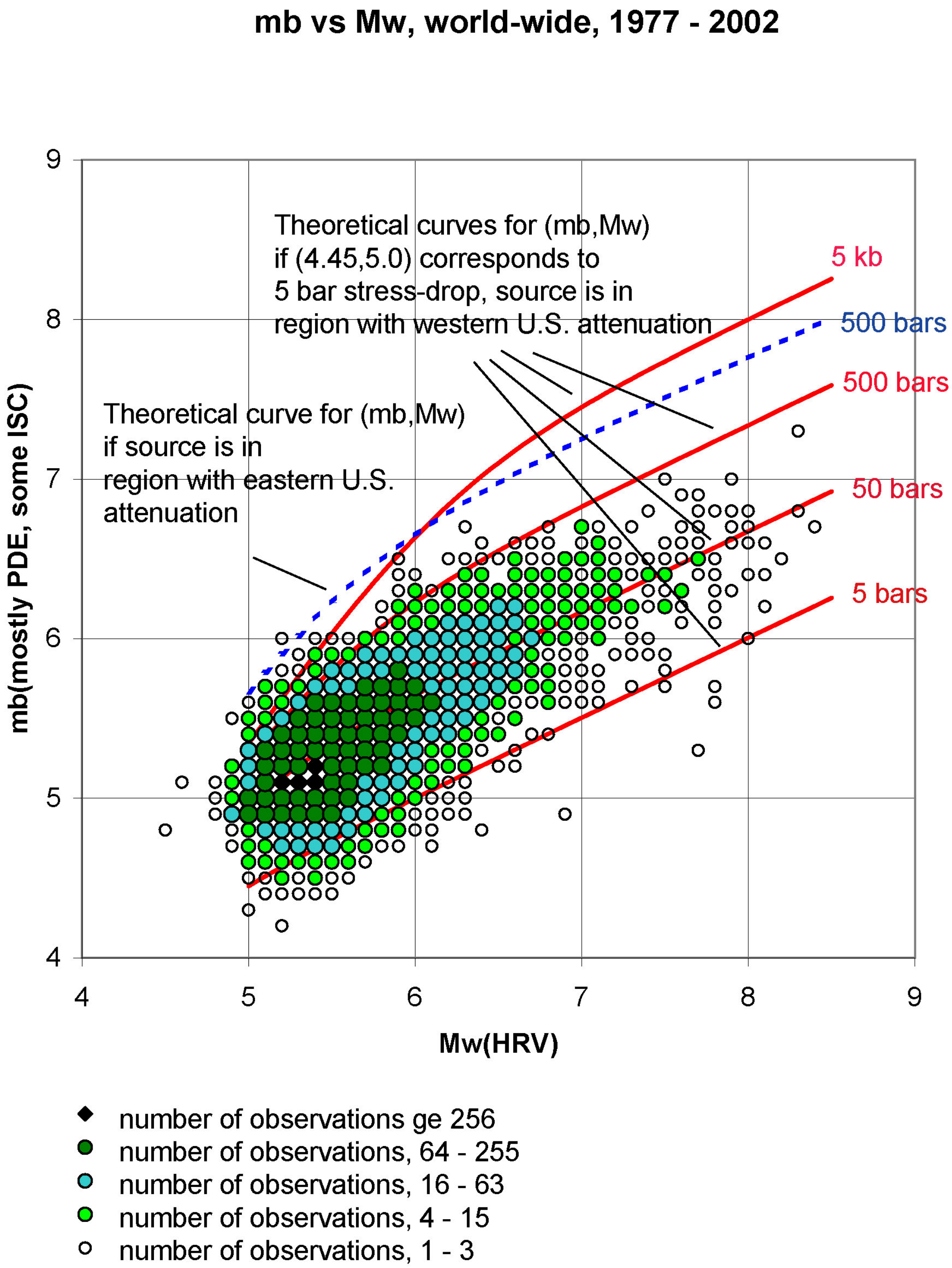


Figure 2. Summary of global *mb/Mw* observations for over 13,000 earthquakes, 1977-2002. Only *Mw* derived from Harvard CMT's are used here. All earthquakes had CMT depths of 50 km or less. The stress-drop curves are prepared assuming a simple "omega-squared" source-model and assuming that the P-wave amplitude at 1 sec is directly proportional to the displacement spectral amplitude at 1 sec. The baseline of the curves is established by assuming that (*mb,Mw*) = (4.45,5.0) corresponds to a 5 bar stress-drop in a region with attenuation characteristics similar to those of the western U.S.

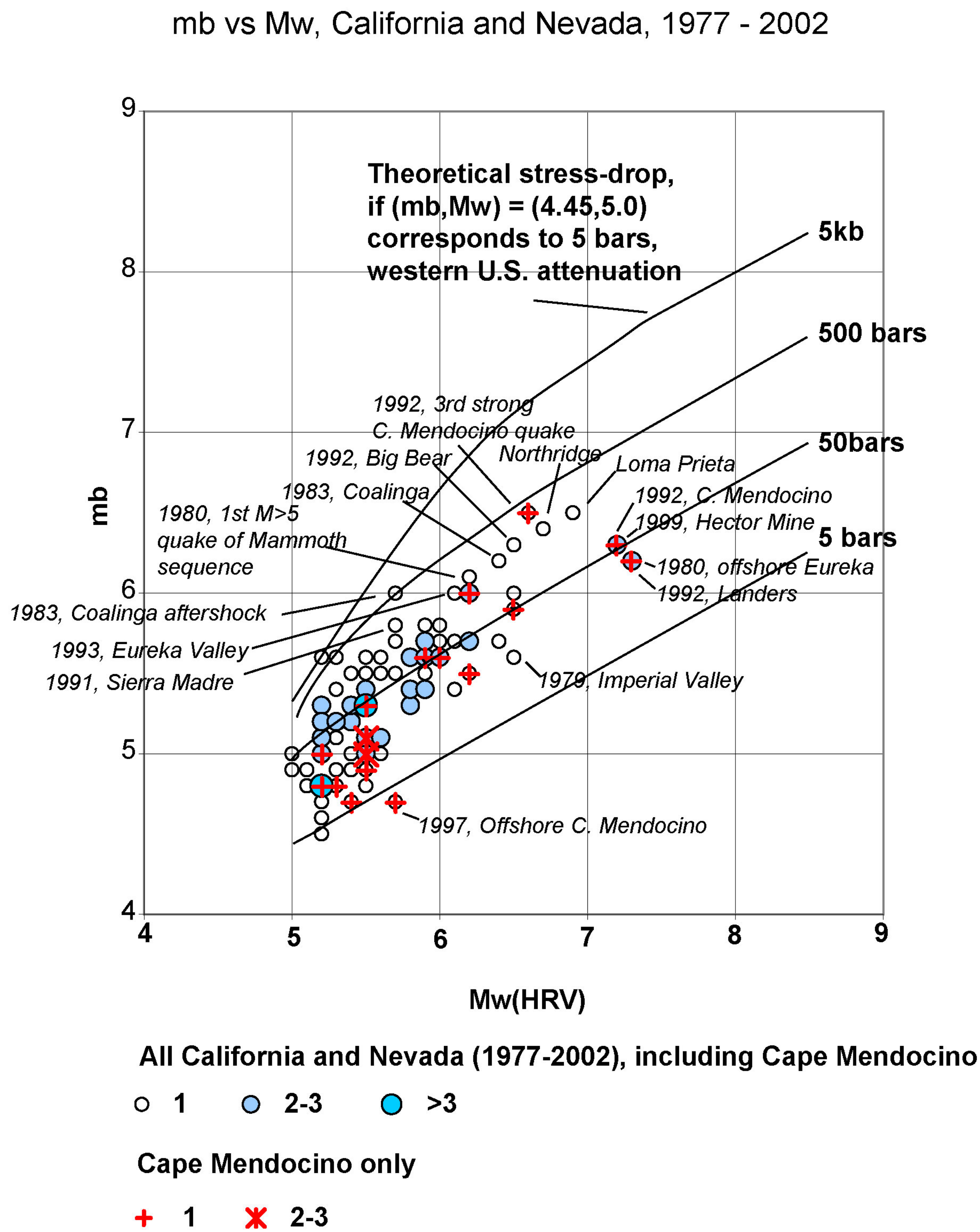


Figure 3. Summary of *mb/Mw* observations for 103 earthquakes in California and Nevada, 1977-2002. Considering earthquakes from different regions in California, those from Cape Mendocino (near shore or under land) seemed most anomalous with respect to earthquakes in California and Nevada as a whole. These shocks are therefore represented twice, once pooled with the other shocks and once separately, with different symbols.

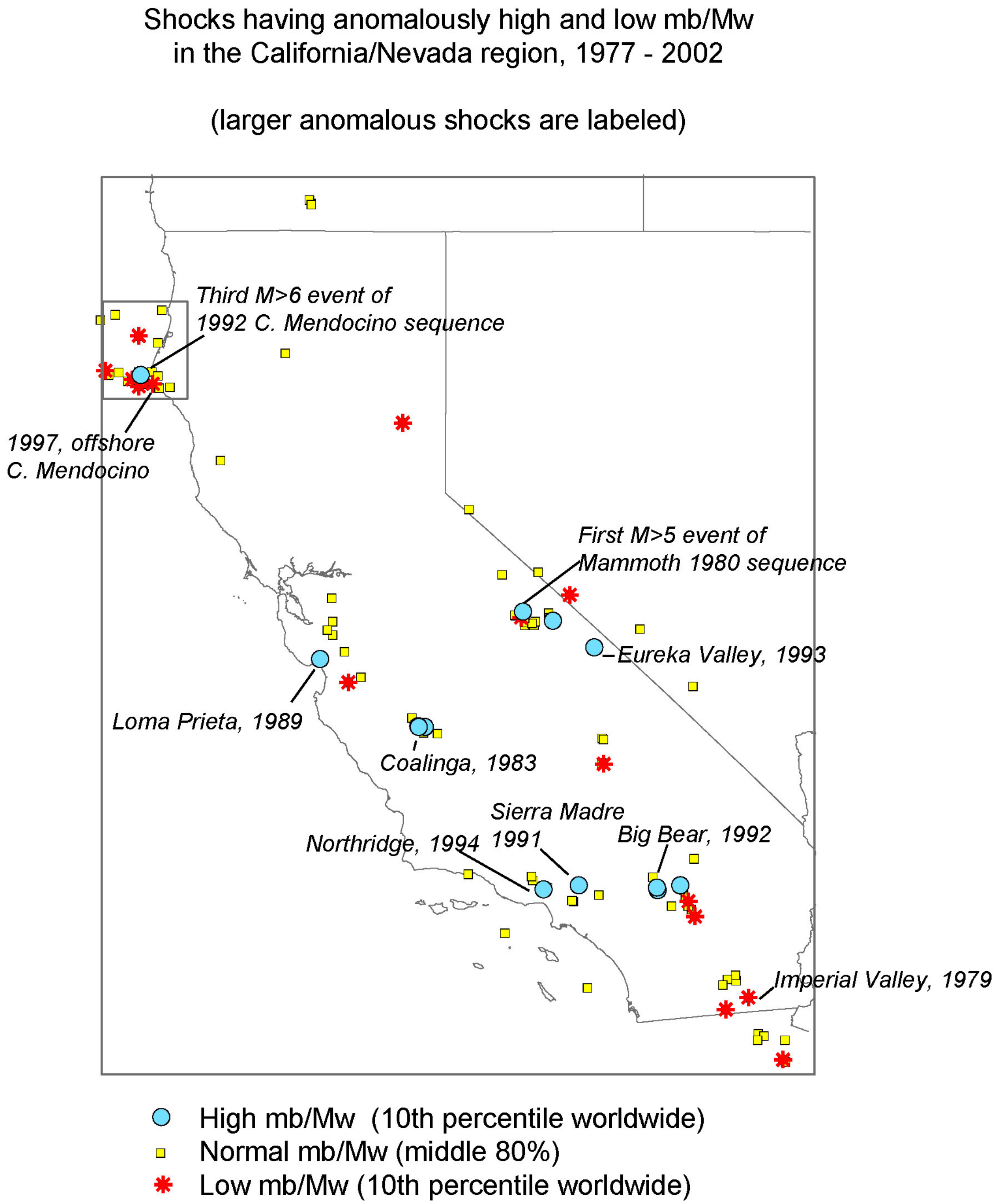


Figure 4. For a given pair of observations {*mb(I),Mw(I)*}, I calculate *mb(I)* – [mean *mb* for all *Mw(I)* worldwide].High *mb/Mw* are in the 10% upper percentile worldwide. For *Mw* > 6, and assuming the simple source-model used elsewhere in this study, these events will have stress drops higher by at least a factor of 2 than the global average. Low *mb/Mw* are in the 10% lower percentile worldwide. These events will have stress drops lower by at least a factor of 2 than the global average.