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Earthquake recurrence intervals of Quaternary faults in the USA: relationships with other fault parameters

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The average recurrence interval (T) between large, surface-rupturing, earthquakes in an active fault is one of the most important parameters to assess the seismic hazard that the fault poses. Here we present results regarding how this parameter relates to other fault parameters, such as the long-term (geological) slip rate (S), the average displacement-per-earthquake (D) in the fault, and the fault length (L). The goal is to identify new relationships which could be useful in estimating T from other parameters, or which might give clues about the process of faulting.

We focus our attention on faults of the conterminous USA, for which a considerable amount of paleoseismological results has been published throughout the past three decades. The United States Geological Survey (USGS) is currently compiling and reviewing this information, and maintains a Quaternary Fault and Fold Database of the United States. Currently (in January 2007), this database contains maps, information and references about 1885 structures. Most of these faults, fault sections, and associated folds have been active during the past 1.6 million years, and are the known (or sometimes believed) source of earthquakes with magnitude larger than 6.

We have reviewed this database, and made a shortened version which only includes information about faults or fault sections for which detailed paleoseismological data are available. Namely, a fault is included in our database only if there is an estimate of T based on the dated ages of past surface-rupturing earthquakes. If T has been estimated by other means (for example from D and S), we have not included it in our database. This high-quality information about past earthquakes is available only for a

minority of faults of the original USGS database. Most of the faults in our abridged dataset are located in the western (most tectonically active) geological provinces of the USA.

We have made an effort to arrive to consensus, averaged values for the fault parameters when there were disagreements between the published estimates. Also, we have taken into account all the uncertainties of the average recurrence interval: the uncertainties in the dating of the events, and the uncertainty caused by the small number of events recorded in each fault. That is, the more numerous and the better dated the past earthquakes in a fault are, the better is the resulting estimate of T. Note that, because the seismic vs. aseismic slip are difficult to distinguish in paleoseismological studies, the estimates of D and S may include unknown amounts of aseismic displacement and aseismic slip rate (creep rate), respectively.

We have checked that (for those faults for which T, S and D are available) the ratio D/S compares well with the estimation of T from the ages of the earthquakes themselves. This indicates that the data are consistent with each other.

The main results are the following:

1.- Very clearly, T is mainly dependent on S. There is an inverse proportion between both parameters, which could enable estimating T from S alone, even if D is unknown.

2.- Faults with higher S (and thus lower T) tend to have slightly higher values of D.

3.- Longer faults tend to have higher values of S and D, and lower values of T. This implies that large faults pose a double hazard: they tend to generate not only larger, but also more frequent earthquakes than short faults.

4.- There are differences between fault types: The strike-slip faults tend to have higher values of S, D and L, and lower values of T, than the dip-slip (normal and reverse) faults.