Long- and intermediate-term seismic potential of Fen-Wei seismic belt: active fault data application

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Abstract
Recurrence model for strong earthquakes on Fen-Wei seismic belt is proposed on the basis of the collection and analysis of fault slip rate, paleoearthquake sequence, maximum displacement of each event etc. on 21 fault segments of the belt, which are active since late Late Pleistocene. And the long and intermediate term seismic potential of the belt has been evaluated through four approaches.

Key words: Fen-Wei seismic belt, strong earthquake recurrence model, seismic potential, conditional probability.

Introduction
Fen-Wen seismic belt is one of the highly seismic regions in history, with 144 events of $M \geq 5.0$ since the beginning of earthquake record in this area, including 2 great earthquakes of $M = 8.6$, 6 events of magnitude $7 \sim 7.9$, and 19 of magnitude $6 \sim 6.9$. There are plenty of literature concerning the future earthquake potential of the belt, most of which are based on the analysis of historical seismicity. However, it is becoming possible to evaluate seismic hazard by using active fault data, since a large number of active fault parameters is accumulated and paleoearthquakes has been excavated as a result of $1 \sim 50$ 000 active fault mapping, trenching and comprehensive studies on major active faults in Fen-Wei seismic belt such as the north margin fault of Yanqing-Huai'ai basin, the north piedmont fault of Wutaishan, and the north piedmont fault of Qinling.

Quantitative description of long and intermediate term earthquake prediction often takes the form of probability of earthquake occurrence in the near future. That is, under the assumption of certain recurrence interval model $f(\tau)$, if the average recurrence interval, time and magnitude of the most recent event are known, the conditional probability of earthquake recurrence in a future time window is calculated based on model $f(\tau)$. Several distribution functions of $f(\tau)$ are used frequently in literature, for example, normal distribution, lognormal distribution, Weibull distribution and Gaussian distribution (McCann et al., 1984; Working group on California earthquake probabilities, 1988; 1990). In China, Xue-Ze Wen (1990) used the lognormal distribution proposed by Nishenko et al. (1987) in evaluation of Xianshuihe fault zone.

In this paper, we try to investigate the distribution characteristics of paleoearthquakes and large historical events of Fen-Wei seismic belt, of which paleoearthquake trenching and active fault study are relatively concentrated, and we apply them in the overall evaluation of seismic potential by combining qualitative with quantitative approaches in consideration of the uncertainty in...
paleoearthquake data and active fault parameters.

1 Active fault data analysis

Each of the 18 major faults that are active since Late Pleistocene has been divided into two or three segments using geomorphic features such as step, gap, salient, etc. as segment boundaries according to discontinuity in activity such as age of faulting, magnitude (fault slip rates) and independence or difference of paleoearthquake sequence, then 21 segments active since late Late Pleistocene have been chosen as the probable location of large events in the near future to be analyzed from the seismic hazard by using available examined fault slip rate, paleoearthquake and historical event sequence, maximum average displacement in one event (Table 1, Figure 1). The examination steps of fault slip rates are as follows:

1. Find the source of every slip rate data. Compare the reliability of all slip rates of the same segment, and discard the less reliable data.

2. Analyze the effect of time span on slip rates, choose the fault slip rates since 2~3 Ma or 1 Ma on some segments. The examination of paleoearthquakes includes: 1. Abandon those events too old from present; 2. Compare and analyze the paleoearthquake events exposed in different trench logs on some segments, discard repetitive events and minimize the age range of events by gradual limitation; 3. The occurrence time of event is considered to be the mean value of the range of paleoearthquake dating using half of the range value as error bar or a value inclined to one side of the range with errors referred to trench log; 4. Only the relatively complete and clearly presented paleoearthquake sequences are used in the following quantitative analysis*.

\[
T_{av,k} = \frac{1}{N_k} \sum_{i=1}^{N_k} T_{ik}
\]

\[
\sigma_{av,k} = \left\{ \frac{1}{N_k - 1} \sum_{i=1}^{N_k} (T_{ik} - T_{av,k})^2 \right\}^{1/2}
\]

Although the recurrence intervals cover a wide temporal range, the normalized values exhibit relatively little scatter, with the majority of the data falling within 0.5 of \( T/T_{av} = 1 \). Like figure 2 b and c, Figure 2 a resembles the form of normal distribution, which implies that there may exist a natural recurrence interval for the large events on a specific fault segment, but the intervals deviate from the natural interval under the effect of other less understood factors, therefore the overall distribution of \( T/T_{av} \) values roughly takes the form of normal distribution.

However, the structures in Figure 2 differ from normal distribution, and the difference varies for different data sample and tectonic settings as we can see in figure 2. The empirical distribution of Figure 2 a is asymmetric, with a heavy tail for recurrence intervals larger than the average, which may imply that the probability of earthquakes having a longer interval than average is larger than normal. This trend of favoring events with longer than average recurrence intervals in Figure 2 a is more significant than that in Figure 2 b with similar characteristics, which suggests that changes in stress tend to retard rather than accelerate earthquake recurrence (Nishenko and Buland, 1987), and this feature is more prominent in intraplate large earthquakes.