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THE STUDY ON SEISMICITY AND THE ESTIMATE OF THE EARTHQUAKE RISK RECENTLY IN NORTH CHINA

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INTRODUCTION

A Ms 6.1 earthquake took place in the district nearby the city of Datong, Shanxi Province, in North China in October 1989. As this earthquake is the strongest one in North China since the Ms7.8 Tangshan earthquake in July 1976, this earthquake has drawn much attention. Many scientists consider that a new seismically active episode in North China is in the offing and the degree of seismicity will be higher than that in the seismically quiet episode of the last decade. This point of view has been strengthened by the occurrence of the Ms 5.1 Xinzhou earthquake in January 1991 and the Ms5.8 Datong earthquake in March 1991. How strong will the seismicity be in North China in the coming seismically active episode? Where will be the principal seismically active area?

In this paper, based on the fairly detailed record data of the third and the fourth seismically active periods in North China, these questions are discussed by studying the characteristics of the time process of the seismicity, the distribution of earthquake magnitudes and the migration of principal seismically active area during each active period. Moreover, we point out the most dangerous area where a strong earthquake may take place and the estimated magnitude by studying the concentrated areas of moderate earthquakes in recent 10 odd-years in North China.

STUDY ON SEISMICITY IN NORTH CHINA

To study the seismic tendency of the coming 10-odd years in North China, we should study the seismic characteristics of the past periods in this region.

The North China seismic region extends over north Latitude 34°—41°, and east longitude 109°—123°. As the earthquke records before the year 1000 for this region are insufficient, only the relatively-concentrated earthquakes of Ms≥6 after 1000 A.D. are separated roughly into four seismically active periods. The first might range from a certain time before the year 1000 to 1068 A.D.. The second period is from 1209 to 1368 A.D.. As generally acknowledged, since the late fourteenth century, the record of Ms≥6 earthquakes in North China has been complete on the whole[1]. The third period from 1484 to 1730 and the fourth period from 1815 to the present seem to be documented more reliably. Fig. 1 shows the time series of earthquakes with Ms≥6 of the third and the fourth active periods in North China. It can be seen from Fig. 1 that

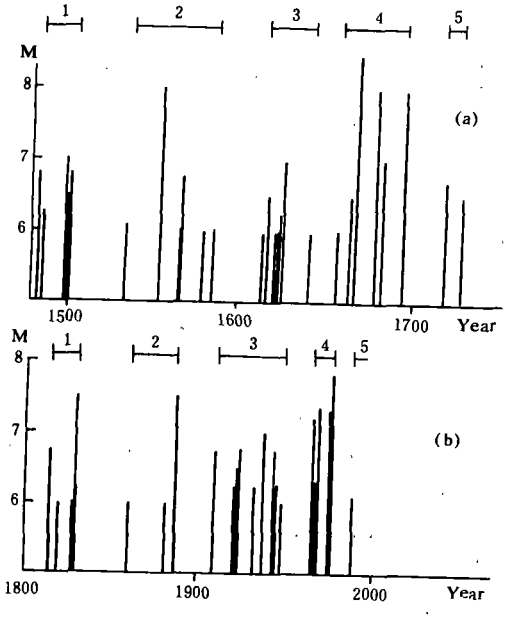

Fig. 1 The time series diagram of earthquakes with M≥6. 0 in the North China seismic region
a. the third activeperiod (1484—1730)
b. the fourth active period (1815—)

these two periods have very similar seismic process and both periods can be divided into five stages: 1. The initial stage of active periods; 2. The stage of relatively decreasing of seismic frequency; 3. The preparatory stage before great energy release; 4. The stage of great energy release; 5. The stage of residual energy release. In the first stage, several Ms≥6 earthquakes occurred within 20 years after 100 years or so seismically quiet period; in the second stage, the seismic frequency obviously decreased; in the third stage, the seismic frequency obviously increased again; in the fourth stage, great energy released. The energy release in the fourth stage accounts for 80 percent of the total released energy of the third period, and the released energy in the fourth stage accounts for more than 60 percent of released energy of the fourth active period. In the fifth stage, the seismicity was low. There were only two Ms>6 earthquakes in the fifth stage of the third active period. According to the similarity of seismic processes between the third and the fourth active periods, we can deducc that the stage of residual energy release of the fourth active period will come after the great energy release stage from 1966 to 1976, and the energy release will obviously decrease.

Table 1 Earthquake number of various magnitudes in the third and fourth active period in North China

Active period	Magnitude			Sum	Mmax
	6.0≤M_s≤6.4	6.5≤M_s≤6.9	M_s≥7.0		
3rd active period	11	8	7	26	8.5
4th active period	10	6	7	23	7.8

The frequency distribution of Ms≥6 earthquakes is listed in Table1. It can be seen from Table 1 that the frequency distribution of Ms≥6. 0 earthquakes in the fourth active period has been close to that in the third active period, and that there is a strong earthquake obviously larger than the others in each active period. Thus, we can deduce that almost all seismic energy of the

fourth active period in North China has been released and the peak stage of seismicity of the fourth active period has been over. Based on the similarity of the seismic process and the difference of seismic frequencies between the two active periods, one to three Ms≥6 earthquakes may take place[2].

According to the results of Refs. [3,4], the major seismotectonics in North China is NE to NNE tectonic zones, the zonation of epicenters of strong earthquakes along this direction is most obvious. In Ref. [3], NE to NNE seismic zones in North China was divided into four seismic zones from west to east (see Fig. 2). They are as follows:

1. The Shanxi seismic zone. Its range is Xi'an—Taiyuan—Datong—Huailai;

2. The North China Plain seismic zone. This zone embraces the western and the eastern branches, and ranges of which are Xinxiang—Xingtai—Sanhe and Heze—Cangzhou—Tangshan, respectively;

3. The Tan—Lu seismic zone. Its range is Linyi—Bohai—Haicheng;

4. The Yellow Sea seismic zone. The zone lays roughly in NS direction nearby 122°E.

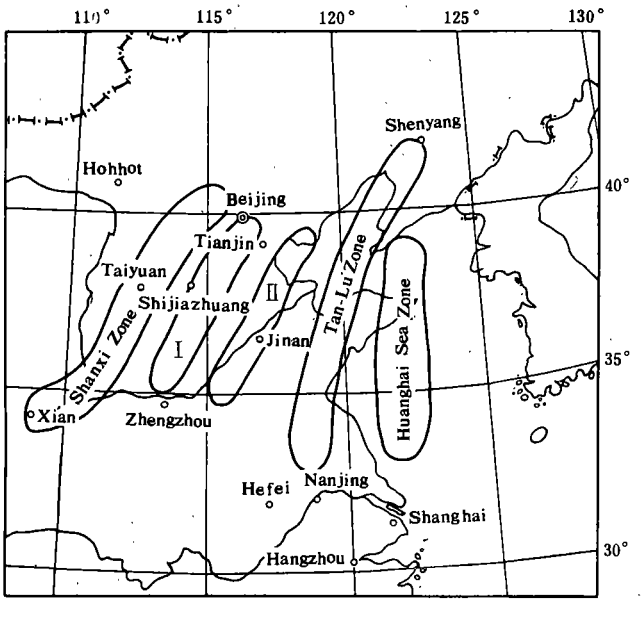

Fig. 2 Seismic zones in NE direction in North China
I. the west branch of North China plain zone
II. the east branch of North China plain zone

Arranging the earthquakes in Fig. 1 in seismic zone order, we can obtain the results shown in Fig. 3 and 4. It can be seen from Fig. 3 that the Ms≥6 earthquakes in the former three stages of the third active period mainly occurred in the Shanxi seismic zone and the North China Plain seismic zone, especially in the Shanxi seismic zone, the Ms≥6 earthquakes in the fourth stage occurred in the North China Plain seismic zone at first, then moved eastward to the Tan—Tu seismic zone then moved back to the North China Plain zone and the Shanxi zone, in the fifth stage there was a Ms≥6 earthquake occurred in the Shanxi zone and the North China Plain zone respectively, and the earthquake in the Shanxi zone was greater. It can be seen from Fig. 4 that the earthquakes in the first stage of the fourth active period moved from the Shanxi zone to the North China Plain zone and the Tan—Lu zone, the earthquakes mainly occurred in the Tan—Lu zone in the second stage, and in the Yellow sea zone in the third stage, in the fourth stage, the earthquakes mainly occurred in the Tan—Lu and the North China Plain zone, especially in the latter. The Ms6. 1

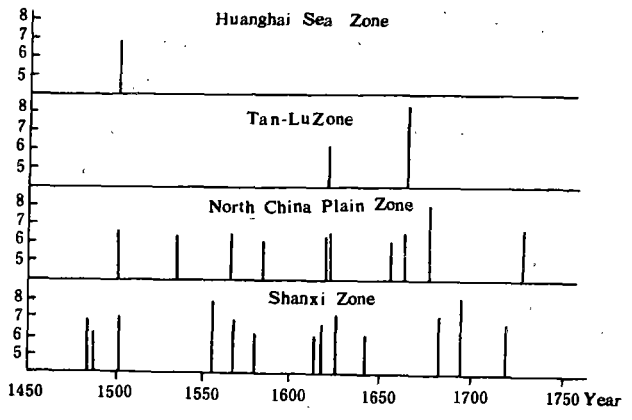

Fig. 3 The time series diagram of earthquakes with Ms≥6.0 in each seismic zone in North China in the 3rd active period

Datong earthquake occurred in the Shanxi zone in October 1989. Analyzing the above-mentioned seismic process, we can see that the Ms ≥ 6 earthquakes in the third and the fourth active periods moved eastward from the Shanxi zone to the Yellow Sea zone or the Tan—Lu zone, and then moved back to the shanxi zone. Based on the migration, in the remaining time of the fourth active period, the principal seismically active region where Ms ≥ 6 earthquakes will probably occur may be in the Shanxi seismic zone.

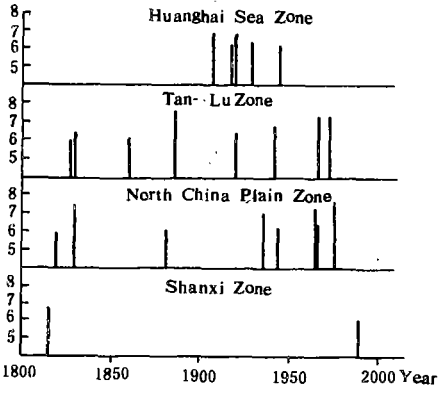

Fig. 4 The time series diagram of earthquakes with Ms≥6.0 in each seismic zone in North China in the 4th active period

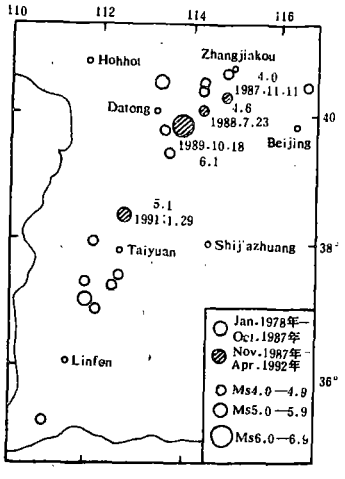

Fig. 5 Epicenter distribution of earthquakes with Ms≥4.0 in Shanxi zone from January 1978 to April 1992

ANALYSIS OF THE COMING SEISMIC RISK IN NORTH CHINA

As mentioned above, the principal seismically active region may be in the Shanxi zone where Ms≥6 earthquakes will occur. Which places in the Shanxi zone are the dangerous areas where great earthquakes may occur? Fig. 5 shows the epicenter distribution of Ms≥4.0 earthquakes in the Shanxi zone from January 1978 to April 1992. At first, we study the epicenter distribution from January 1978 to October 1987. We can see from Fig. 5 that earthquakes occurred in Hunyuan—Zhangjiakou and the southwest of Taiyuan in this period. In fact, the two regions were the most

seismically concentrated regions in North China in this period except the old seismic areas of Xingtai, Tangshan and Haicheng. According to the experiential law that great earthquakes often occurred in the concentrated areas of moderate earthquakes, these two regions should be the most dangerous areas where great earthquake will occur. In November 1987, a Ms 4.0 earthquake occurred again in the Hunyuan—Zhangjiakou region. This earthquake made the distribution of epicenters in this region have the form of gap, and after the Ms4.6 Yangyuan earthquake occurred in July 1988, the Ms 6.1 Datong earthquake took place in October 1989. In the southwest of Taiyuan, the M5.1 Xinzhou earthquake in January 1991 made the pattern of seismic gap more perfect. Because the M_s 6.1 Datong earthquake in 1989 and the Ms5.8 Datong earthquake occurred in Hunyuan—Zhangjiakou region, the most dangerous region at present is the seismic gap nearby Taiyuan, i.c. the region of Xinzhou, Dingxiang, Taiyuan, Jiaocheng, Taigu and Jiexiu, which has circumference of 70km around Taiyuan.

On the basis of 23 examples of strong and moderate earthquakes, Lu Yuanzhong obtained the following statistic magnitude formula of background seismicity gap[5]:

$$Ms = 3.3\lg L - 1.48 \pm 0.41 \quad ;$$

$$Ms = 1.23\lg L + 5.35 \pm 0.51 \quad 。$$

where L(km) is the major axis of seismic gap, T(year) is the duration of seismic gap. The calculated magnitude of seismic gap nearby Datong is 6.1—6.6 and consists with the actual magnitude. The calculated magnitude of seismic gap nearby Taiyuan is 6.0—6.7 and its median value is taken as Ms6.4±0.4.

SUMMARY

1. On the basis of the data of the third and the fourth seismically active periods in North China, we studied the characteristics of seismicity time process, the frequency distribution of earthquakes with different magnitudes and the migration of principal seismically active area in each active period, and concluded that one to three Ms≥6 earthquakes will probably occur in the remaining time of the fourth seismically active period in North China and the principal area of these earthquakes may be in the Shanxi seismic zone.

2. The study on the distribution of moderate earthquakes occurred since 1978 shows that the most dangerous region in North China where Ms≥6 earthquakes will occur mar be the region nearby Taiyuan.

3. If a strong earthquake occurs nearby Taiyuan, the magnitude may be Ms 6.4±0.4.

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中国华北地震活动性研究与近期地震危险性

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摘 要

本文综合研究了华北地区第三地震活动期和第四地震活动期地震活动时间进程、各级地震频次分布和活动期中地震活动主体地区的迁移,得出华北地区第四地震活动期可能还有1—3次6级多地震,其主体地区可能在山西地震带。本文还研究了近十几年来华北地区地震活动的集中区,指出目前华北发生6级多地震的最危险地区是太原附近地区,其震级可能为M.6.4±0.4。
