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# THE CHARACTERISTICS OF THE MODERATE-SMALL EARTHQUAKE CONCENTRATION BEFORE STRONG EARTHQUAKES IN AND AROUND NORTH CHINA

## 大华北地区强震前的中、小地震相对密集活动特点

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**摘 要**

本文利用七〇年至八二年的中、小地震活动资料，结合大华北区域快速破裂过程和特征，分析了该区十几年来强震发生前，中、小地震相对密集的活动特点。指出大华北地区存在一个近似扇形的快速破裂网络。这个网络（最少在目前）既控制着绝大多数的中、小地震活动带，又控制着强震的发震地区。探讨了该区自七〇年以来$M_S \geqslant 6.0$级地震前的中、小地震活动异常。强震主要发生在扇形破裂网络的交汇点附近，震前一至十年交汇点附近都有5级左右地震活动或出现相对密集现象，$M_L \geqslant 2.7$级的地震相对频率有较明显的增强。七〇年以来共发生8次$M_S \geqslant 6.0$级强震，其中6次有明显的地震活动异常（占75%），2次尚未发现异常活动（占25%）。所有这些对于判断大华北地区的未来强震危险地点及中、短期震情分析具有实用意义。

As the reliability of seismicity data is the highest in all "earthquake prediction data", more and more seismologists are thinking of finding the useful and practical precursors among the data of seismic activity which may be large or small and their centres may be near or far from the epicentre of the strong earthquake[1—5]. According to the present scientific and technical level, the work of this study is one of the principal ways to investigate earthquake prediction. Since 1970, the ability to observe the small earthquakes in and around north China is increasing gradually (5), so that the data observed in the different parts of north China are more comparable. In this paper, using the data of the seismicity we will discuss the anomalous phenomena appeared during the process of re-

gional quick fracture in north china and find the information of strong earthquake risk place (or area).

1. The Regional Seismic Activity in and around North China before Tangshan Earthquake ($M_S$=7.8)

It is pointed out that since a longer time there is a fanlike quick fracture network in and around north China (see Fig. 1 a and b)[6]. This network (at least at present) controls not only almost all the belts of moderate and small earthquakes but also the places of strong earthquakes in given area. Let's trace the bigger regional fracture process (since 1970) and its relationship with the strong earthquakes. From 1970 to 1973, the seismic activity increased evidently (see Fig. 2a) in the whole north China (almost along every belt of the fracture network) especially along the boundaries of Eerduosi block, except south one, and along the boundaries of the Southeast Shanxi block. But in 1972, the moderate-small earthquakes were clearly clustering in the area which is nearly bounded by the centers of the 1966 Xingtai earthquake, the 1969 Bohai earthquake, the 1976 Helingeer earthquake and the 1976 Tangshan earthquake (see Fig. 2b). During the period of 1973—1974, the moderate-small earthquakes tended to be clustered along the three radial belts, the belt of west boundary of the Eerduos block, the North-east belt passing through Tangshan-Haicheng and the North-east belt passing near by wuhai-Nanjing (see Fig. 3a). Among the the density of the moderate-small earthquakes was the highest along the Tangshan Haicheng belt (see Fig. 3b). In this background the Haicheng earthquake with a magnitude of 7.3 occurred on Feb. 4, 1975. As the density and intensity along this seismic belt were very high during the period of 1974—1975, Tangshan earthquake with a magnitude of 7.8 occurred on July 28, 1976 and at the same time several earthquakes with magnitude about 6 also occurred in north China. The characteristics of the seismic activity during the period of 1975—1979 are that the moderate-small earthquake tended to be clustered on the outskirts of the fan-like fracture network and that the strong earthquakes occurred almost at the intersections of seismic belts (6) (see Fig. 4 and Fig. 1b). During the period of 1980—1981, the density of the moderate-small earthquakes along Xingtai-Tangshan belt was the highest in north China too. As the result of it, the Xingtai earthquake of magnitude 6.0 occurred on November 9, 1981 (see Fig. 5).

According to the regional seismic activities for 13 years, it seems that the characteristics of the regional fracture process in and around north China are as follows.

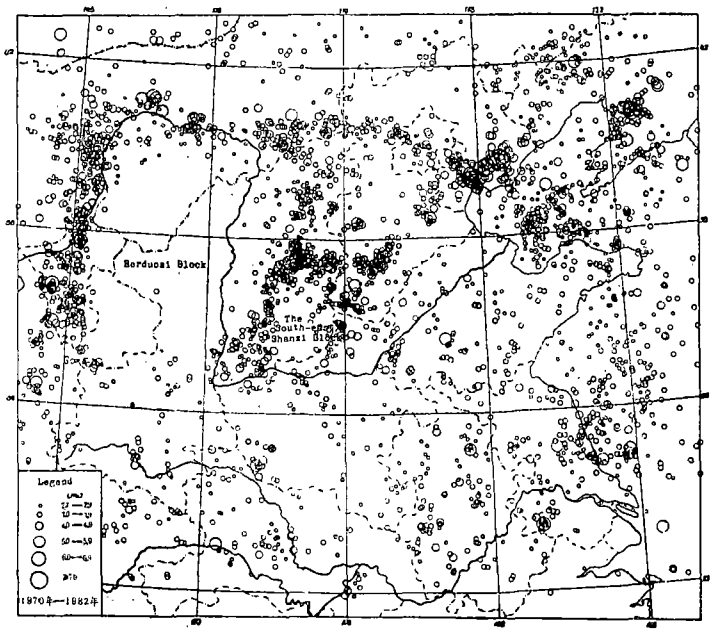
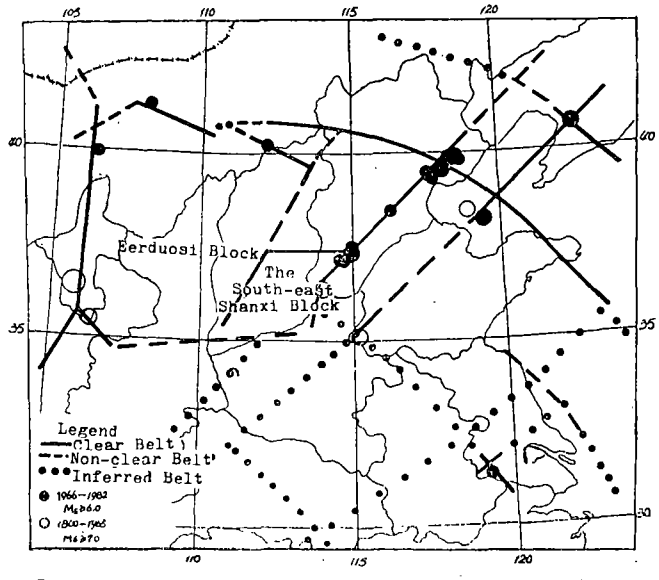



图 1 a　Fig. 1 a




The Fan-like Fracture Network in and around North China

图 1 b　Fig. 1 b

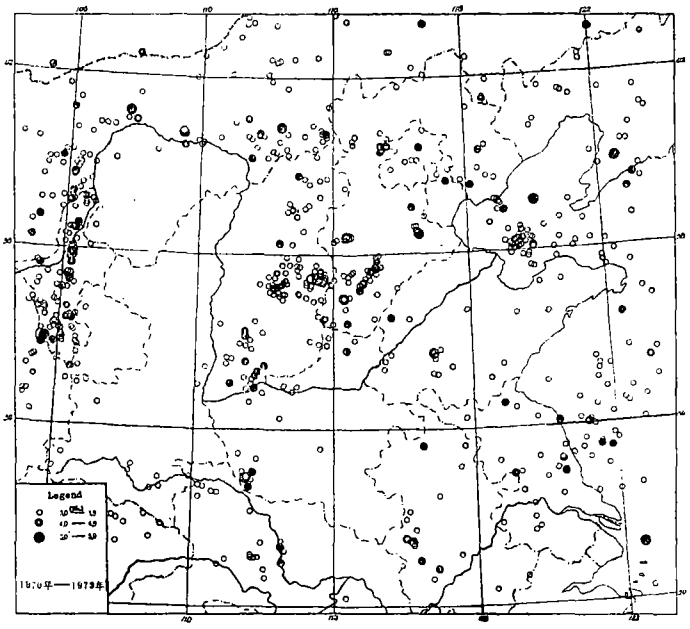



图2a Fig. 2a

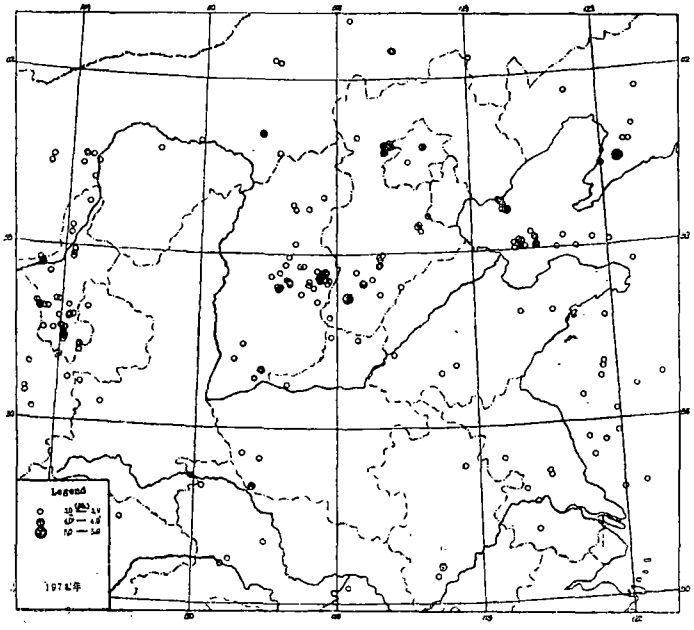



图2b Fig. 2b

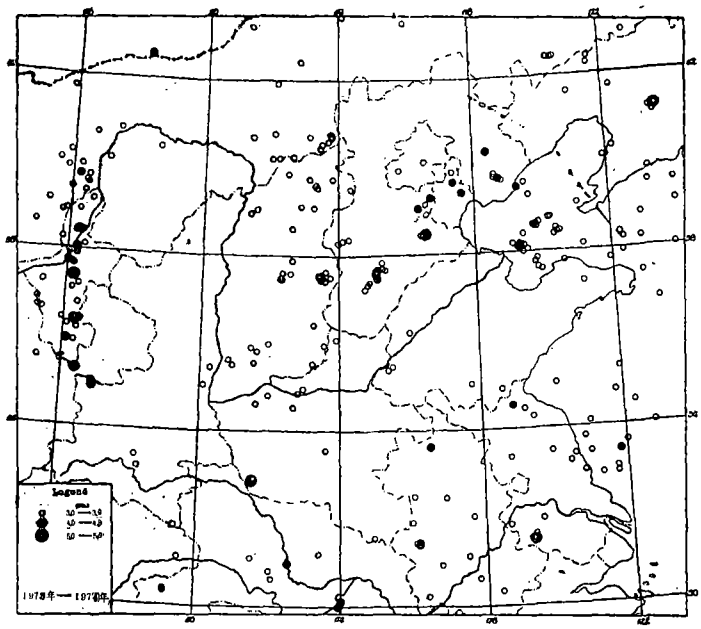


图 3 a　Fig. 3 a

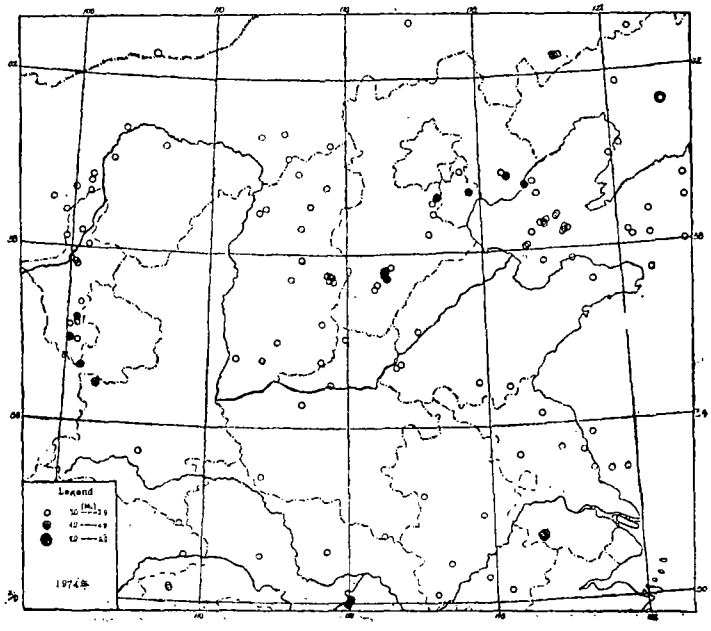


图 3 b　Fig. 3 b

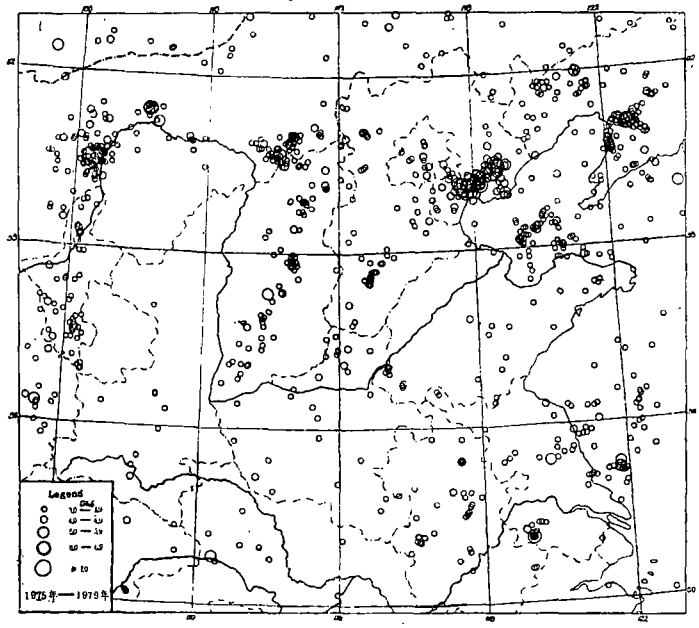



图4 Fig. 4

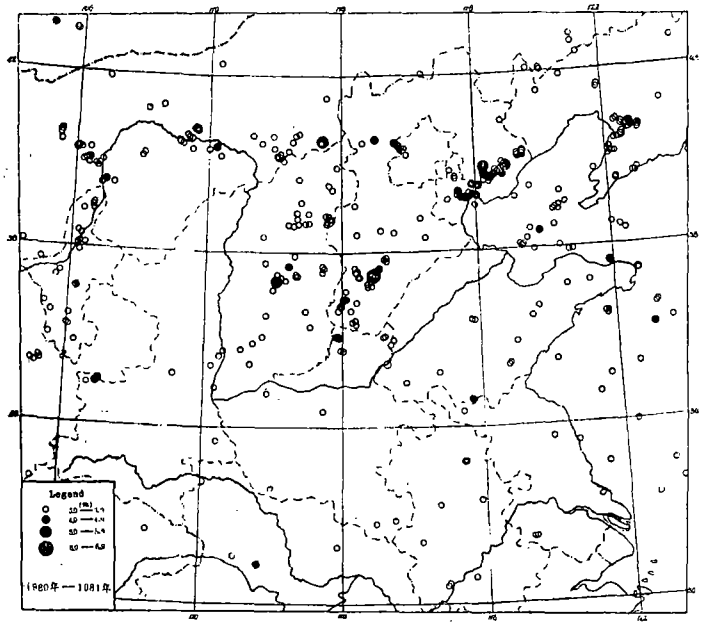



图5 Fig. 5

1 ) After the 1969 Bohai strong earthquake ($M_S=7.4$), the moderate-small seismic activities increased in the whole region. It is said that regional stress increased everywhere. During the period of 1973—1974, the moderate-small earthquakes were primarily clustered along the radial belts of the regional fracture network. It may be said that at that time the moderate-small fractures had begun to be concentrated along some belts, then they tended to be clustered primarily along the Tangshan-Haicheng seismic belt and finally the Haicheng and Tangshan strong earthquakes occurred. It may be said that the bigger regional quick fracture process is similar to that of the rock specimen in lab. ( 8 ).

2 ) Since 1982, the moderate-small earthquakes have clustered along radial seismic belts again ( see Fig. 6 ). It must be considered as a important phenomenon to be monitored.

3 ) When the moderate-small earthquakes concentrate along some belt, the intersections of fracture network which are located on the seismic clustered belt are danger places of strong earthquakes.

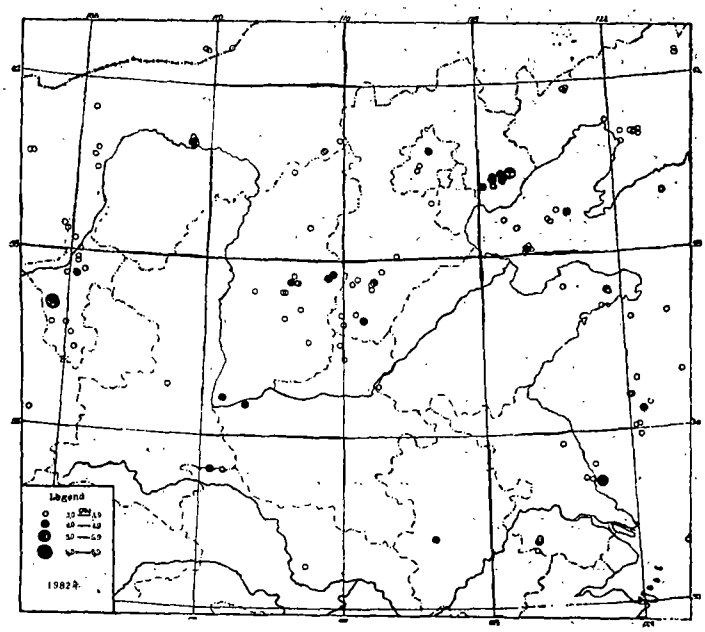



图 6　Fig. 6

2. The Characteristics of Moderate-small Seismic Activities before Strong Earthquake in and around Its Center

Before a strong earthquake, the moderate-small earthquakes tend to be usually clustered in and around the epicenter of the main shock. Fig. 7

shows that since 1970 there is a relative concentration of the moderate--small earthquakes ($M_L \approx 5.0$) before all the strong earthquake (from one till ten yeare) in and around north China. Because this is a common phenomenon, the areas (or belts) of earthquake ($M_L \approx 5.0$) clustering may be considered as a empirical criterion of strong earthquake risk.

In order to analyse the moderate-small seismic activities in and around a center of a strong earthquake, we divided the main belts of the fracture network into 18 parts (see Fig. 8). For every parts two curves of the seismic activities have been made. One is the curve of the monthly slip seismic frequency and another is the curve of monthly-average ratio-of frequency.

Comparing and analysing the curves mentioned above we find that there are three kinds of anomalous seismic activities before the earthquakes $M_S \geqslant 6.0$ (including strong aftershocks 3 years after).

1) The first is that which has clear anomalous seismic activities in and around the epicenters of the main shocks. For example, 6—12 months before the Dengkou earthquake ($M_S = 6.0$) of September 23, 1976 (see Fig. 9) and the Xingtai earthquake ($M_S = 6.0$) of November 9, 1981 (see Fig. 10), evident anomalous seismic activities had been found.

2) The second kind is that which possesses relative evident anomalous seismic activities. For instance, before the 1975 Haicheng earthquake ($M_S = 7.3$) and its aftershock ($M_S = 6.0$) of May 13, 1978 (see Fig. 11), the 1976 Tangshan earthquake ($M_S = 7.8$) (see Fig. 12) and the Wuyuan earthquake ($M_S = 6.0$) of August 25, 1979 (see Fig. 13), the relative anomalous seismic activities had appeared somewhat earlier. It is important to point out that during the 6 months before the 1976 Tangshan earthquake ($M_S = 7.8$), the evident anomalous seismic activities had been found in and around the epicenter of the 1969 Bohai earthquake with $M_S = 7.4$ (see Fig. 14).

3) The third is that the clear or relatively clear anomalous seismic activities had not been found before the strong earthquakes, such as Helingeer earthquake ($M_S = 6.3$) of April 6, 1976 and the Liyang earthquake ($M_S = 6.0$) of July 9, 1979.

According to the above discussion it can be said that, since 1970, 8 earthquakes ($M_S = 6.0$) occurred in and around north China. of them 6 strong earthquake had been preceded by anomalous seismic activities (about 75%), and 2 earthquakes had been not (about 25%). So it is clear that the method mentioned above is of some practical value for analysing and determining the danger places and times of strong earthquake ($M_S = 6.0$) occurrence in and around north China.

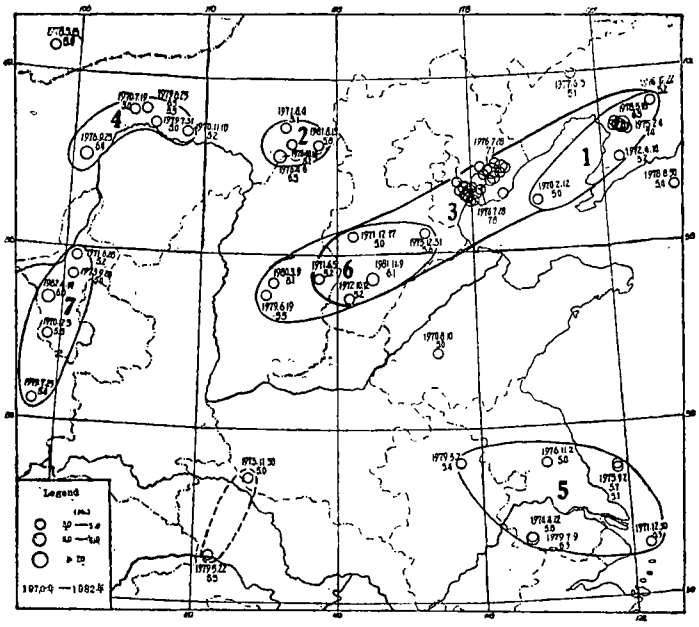



图 7　Fig. 7

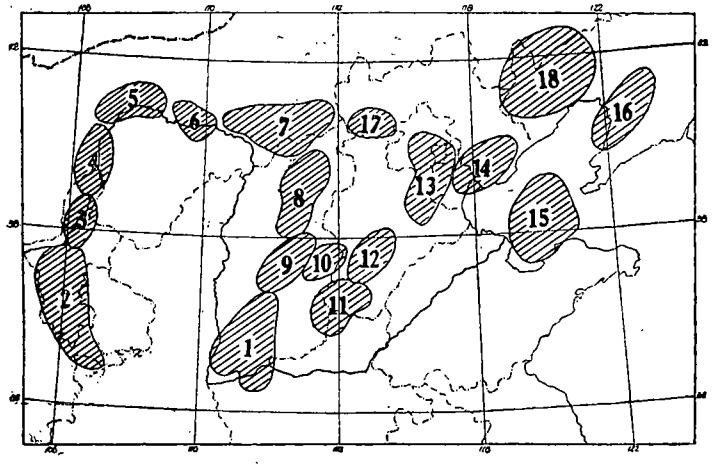



图 8　Fig. 8

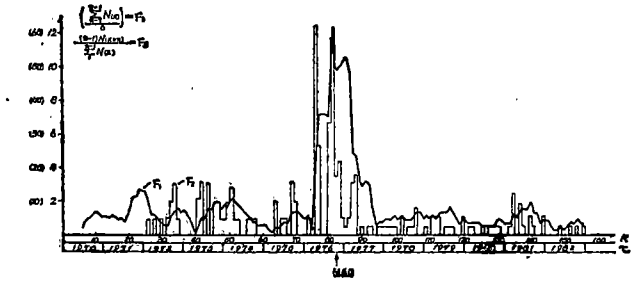


图 9　Fig. 9

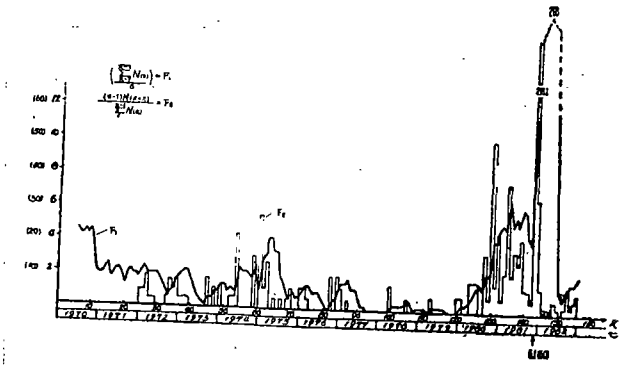


图10 Fig.10

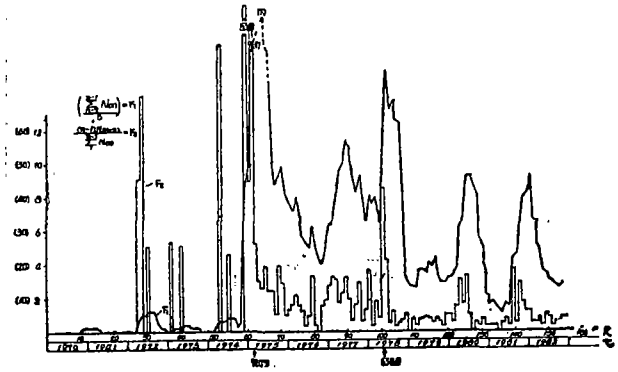


图11 Fig.11

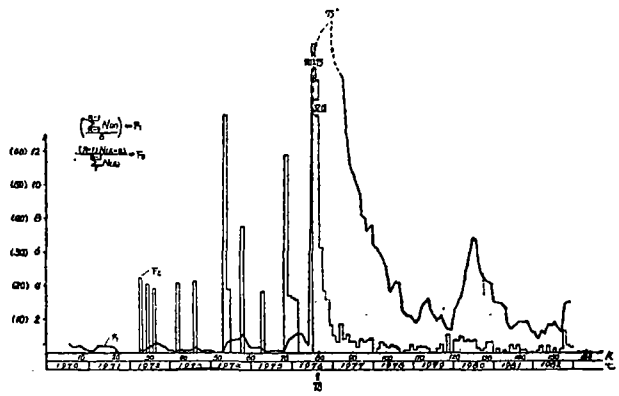


图12 Fig.12

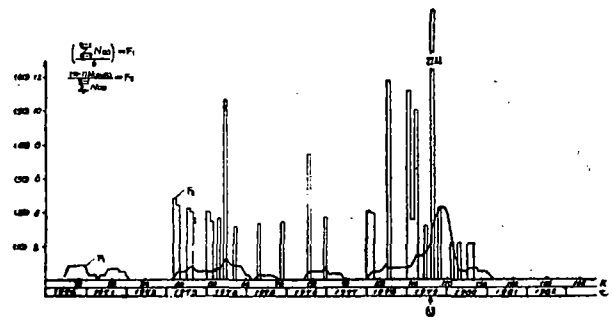


图13 Fig.13

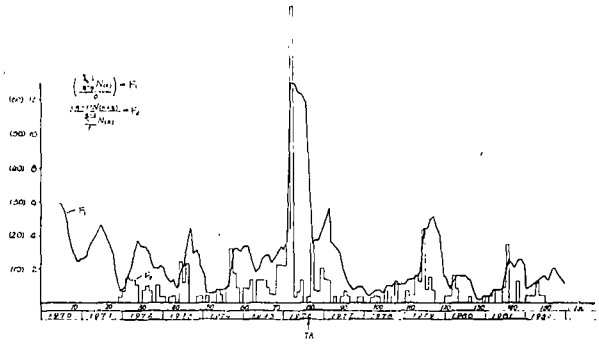


图14　Fig.14

3.Conclusions

According to the description in this paper the conclusions can be made as follows.

1 ) For a long period ( at least for last thirteen years ), there is a fan-like quick fracture network in and around north China. All the strong earthquakes ( $M_S = 6$ ) tend to be located around the "points" of seismic belt intersection of the network. When the moderate-small earthquakes are clearly clustering along a few seismic belts, the intersection "points" located on them are the dangerest areas in the fracture network.

2 ) Before the strong earthquakes with $M_S \geqslant 6.0$ ( from 1 to 10 years ) around the intersection "points" near which the epicenters of the earthquakes ( $M_S \geqslant 6$ ) are located, the earthquakes with $L_L \approx 5.0$ can be usually found or clustered.

3 ) Before about 75 per cent of strong earthquakes, an and around their epicenters the frequency and strength of moderate-small earthquakes ( $M_L \geqslant 2.7$ ) are clearly increasing.

The above three points have some practical value for determining the strong earthquake risk and for analysing the tendency of the mid-short range anomalous seismic activities in and around north China. But they are only the empirical ways which must be further developed.

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