Study on The Quantitative Relationship Between Active Fault and Seismicity in China

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1. Introduction

Both active tectonics and seismicity are the phenomena of crustal deformation. There is a close relationship between active tectonics and earthquake. Active tectonics plays an important role in the transfer and accumulation of strain energy during the earthquake preparation. Active tectonics controls not only the size and location of strong earthquakes, but also the activities of moderate and small earthquakes. Active fault is the most important active tectonics. Many scientists studied the relationship between the active fault and seismicity (Cluff 1972; Schwartz and Coppersmith 1984; Bonilla,Mark and Lienkaemper 1984; Lawson 1985; Howell 1986; Slemmons, Bodin and Zhang,1989). These studies are mainly concentrated on the static relationships between the strong earthquakes and faults in interplate region. This paper is different from them as fellows:

(1) GIS spatial analysis methods are applied.

(2) We study Intraplate active fault features rather than interplate ones.

(3) We study the quantitative relation between active fault and earthquakes which include not only strong events but also small and moderate ones.

(4) We emphasize the interaction of conjugate faults.

(5) We have interest in the relationship between seismicity and direction of active fault trend.

2. data

In this paper, we mainly analyzed active faults and seismicity data for north China (33° ~ 41°N, 105° ~124°E).

2.1 Active fault data

In north China, active fault has been systematically investigated since 1990. A series of quantitative data are collected during the active fault mapping and the site investigations. The active fault data include fault tectonic map and attribute data of each fault. The fault attribute data consists of fault length, age, trend, dip, mechanism, displacement, slip rate and seismicity history etc.. In the past years, these data are dispersed in many published papers or site investigation reports. This study began from gathering active fault data from various papers and research reports. Firstly the active faults were plotted on the tectonic map in the scale of 1:2,500,000. Then the fault tectonic

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map was digitized into map file on GIS. The fault in the map file is called object. The fault attribute data were inputted into the active fault database (table file) with 31 parameters. Finally the fault objects in the map file were linked with the attribute data in the table file. Each fault object in the map file relates to one record in the table file (i.e. fault attribute data file). Well organized database is necessary for data selections and spatial analyses.

2.2 Seismicity data

Seismicity data in north China is more complete than other regions in China. Since 1966, many seismological stations have been gradually established in North China. From 1970, earthquakes ($M_l \geq 2.0$) could be recorded. The data are sent to the data center everyday from each provincial seismological bureau in China. Each event include several kinds of parameters, for example, origin time, location, magnitude, depth, etc.. We converted seismic catalogue into GIS format.

3. Method

The study method in this paper is different from that before. We introduced GIS spatial analysis functions to study the relationship between active fault and seismicity, and temporal variation of seismicity in different tectonic conditions. Applied the GIS programming tool, the active fault selection and seismicity analysis functions were developed on the GIS. The following analyses were done by using these functions.

The active faults in North China are divided into 9 groups according to their trends. Each group include the faults which trends change within 30°. There is 10° overlap between two adjacent groups in order to have more groups and enough data in each group. The fault strikes of 9 groups are 0°~30°, 20°~50°, 40°~70°, 60°~90°, 260°~290°, 280°~310°, 300°~330°, 320°~350° and 340°~360°, respectively. Two groups of 320°~350° and 340°~360° were not studied in this paper because of few active faults with the strike in 330°~360° in study region. 20km buffer zones were generated around each fault groups. Earthquake ($M_l \geq 2.0$) data in each group buffer region were picked out from earthquake database. The seismicity features in each group region were analyzed. For examples, Fig.1 shows 300°~330° trend fault buffer zones (within 20km) and their seismicity in north China. The histograms of temporal variation of earthquake number in various direction fault zones were compared.

4. Results

Fig.2 is the comparative diagram of the temporal variation of earthquake number in different strike fault group buffer zones since 1970. Horizontal axis is the time. Vertical axis is the number of earthquakes in each fault group buffer zones. We can find from the diagram there are different seismic variation features in different direction fault group buffer zones. The most prominent feature is that there are only three times synchronous seismological activity anomalies in conjugate fault groups since 1970. These anomalies exactly related to three episode strong earthquake ($Ms \geq 6.0$) activities in north China. The anomaly began from 3 to half year before each episode mainshocks.

This phenomena is a significant feature in mid-short term earthquake prediction. Three anomalies are as fellows:

(1) The seismicity ($M_l \geq 2.0$) anomaly began from 1975 to 1976 before July 28 Tangshan strong earthquake (Ms=7.8; epicenter N39.4°, E118.0°). In Southwest-Northeast direction (40°~90°) and Southeast-Northwest direction (300°~330°) fault group buffer regions, earthquake number increased rapidly.

(2) Before October 18, 1989 Datong earthquake (Ms=6.1; epicenter N39.95°, E113.82°) , the earthquake ($M_l \geq 2.0$) number anomaly began from July 1986 in NEE trend (60°~90°) fault group buffer zones and their conjugate NW trend (300°~330°) fault group buffer zones.

(3) From July 1995 before May 3, 1996 Baotou earthquake (Ms=6.4; epicenter N40.78°, E109.68°) and January 10, 1998 Zhangbei earthquake (Ms=6.2, epicenter N41.1°, E113.3°), earthquake ($M_l \geq 2.0$) number anomaly evidently emerged in SSW-NNE direction (0°~30°) fault group buffer zones and WE direction (260°~290°) fault group buffer zones.

It is evident that the third earthquake number anomaly is different from the first and second ones in dominant active tectonic directions. It will be discussed in next part.

5. Discussion

Why will the dominant directions of active tectonics change in different time? One possible reason is due to the speed variation of earth rotation (Deng,Z.-H., Q.-Z.Chu. J.-H.Li. P.-X.Liu and X.-H.Liang, 1998). There are several times of earth rotation speed change in past 40 years (China Seismological Bureau, 1981, Inner Mongolia Seismological Bureau, 1997).

(1) From 1964 to 1977, earth rotation decelerated. The conjugate directions SW-NE and SE-NW are dominant active tectonic directions. Most strong earthquakes took place in the dominant direction tectonic belts during this period, such as 1966 Xingtai earthquake (Ms=7.2), 1975 Haicheng earthquake (Ms=7.3), 1976 Longling (Ms= 7.4), 1976 Tangshan earthquake (Ms=7.8), and 1976 Songpan earthquake (Ms=7.2), etc..

(2) From 1978 to 1987, earth rotation accelerated slowly. Seismicity weaken in this period. A few moderate earthquakes occurred in NS or WE directions tectonic belts, for example, 1979 Wuyuan earthquake (Ms=6.0). The conjugate directions NS and WE are dominant active tectonic directions.

(3) From 1988 to 1993, earthquake rotation decelerated again. The dominant active tectonic directions changed to SW-NE and SE-NW trend. There are 1988 Lancang-Gengma earthquake (Ms=7.2 and 7.6) which took place in the intersection of NE strike fault and NW one, and 1989 Datong earthquake (Ms=6.1 and 5.8) which occurred in SW-NE direction active fault.

(4) After 1994, earth rotation changes to accelerate. The dominant active tectonic directions became NS and WE conjugate ones. Most of strong earthquakes in China took place in NS or WE direction tectonic belts after 1994, for examples, 1996 Lijiang earthquake (Ms=7.0), 1996 Atushi earthquake (Ms=6.9) , 1996 Baotou earthquake (Ms=6.4), 1997 Mani earthquake (Ms=7.6), 1997 Jiashi strong earthquake swarm (Ms=6.1,6.4,6.3,6.5,6.6,6.8,6.5), and 1998 Zhangbei earthquake

(Ms=6.2), etc..

6. Conclusion

From above we can make conclusions as fellows:

(1) The GIS is a powerful tool to study the quantitative relationship of active faults and seismicity.

(2) The quantitative active fault data can be applied not only in the long term earthquake prediction and the identification of potential earthquake sources in the site evaluation, but also the study of the interaction of active faults and regional tectonic dynamic variation. Active tectonic controls not only the size and location of most strong earthquakes, but also moderate and small earthquake activities.

(3) The synchronous earthquake number anomalies in conjugate fault group region are the significant feature before strong earthquakes in north China.

(4) The dominant directions of active tectonics can be changed in different time. One possible reason is due to the speed change of earth rotation.

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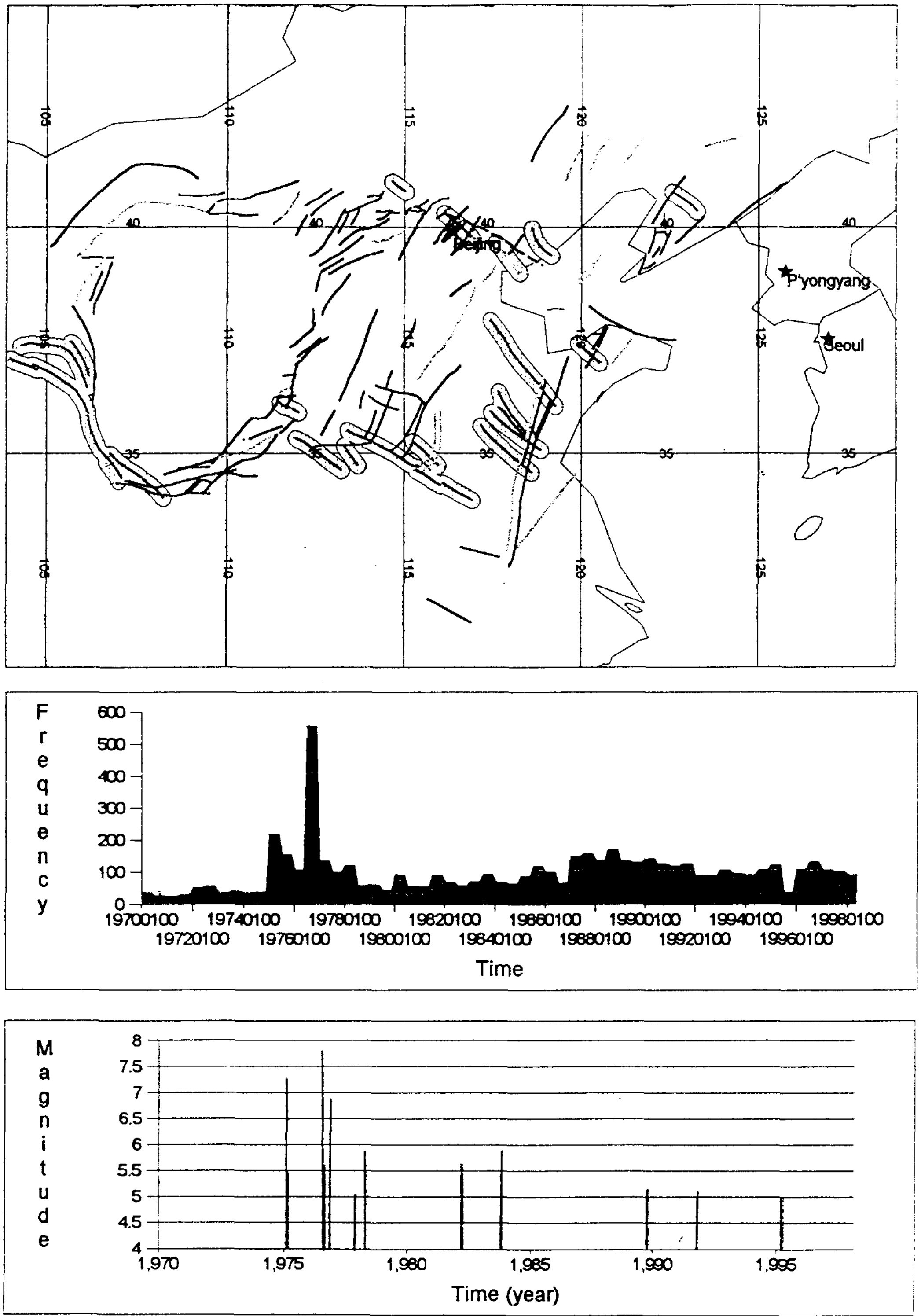

Fig.1 NW 300°~330° trend active faults and seismicity within their 20 km buffer zones in North China (1970~1998.2.28)

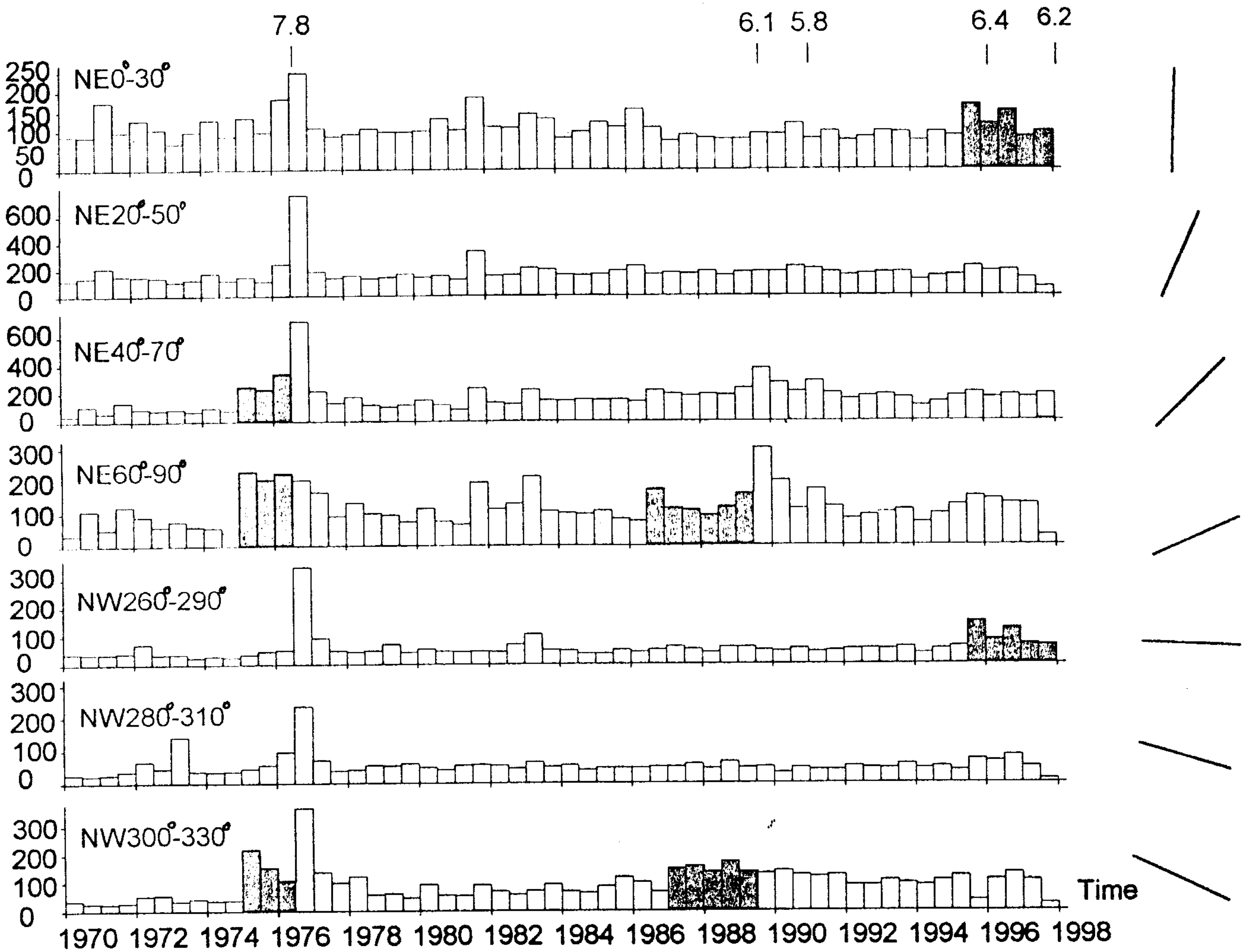

Fig.2 Seismic frequence (M>=2.0) in different trend active fault buffer zones (20km) in North China (1970~1997)