USING GPS AND OTHER CRUST DEFORMATION DATA FOR RESEARCH THE SOME COMMON CHARACTERISTICS OF TECTONIC DEFORMATION ABNORMITY BEFORE THE STRONG EARTHQUAKE

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ABSTRACT

By the high-precision GPS and repetition leveling data observed from the northeast margin of the northeast margin of Qinghai-Tibet plateau and by comparing them with geological structures and strong earthquakes activities in this area, the some common characteristics of regional tectonic deformation abnormity before the strong earthquake are studied. The results show that: a).For horizontal movement-deformation , it shows features of centralized high strain area (or zone) of dominating shear deformation related to active block and faults; b).For regional vertical deformation, it shows distribution features of abnormal apophysis area and dense belt-high gradient belt of vertical difference deformation (some of them reflect distribution of four quadrants) related to tectonics; c).Common features of regional vertical deformation abnormity area and high strain distribution area of horizontal deformation. Having analyzed preliminarily formation mechanism of these common characteristics of abnormity, it concludes that: these are results, controlled by basic united tectonic stress field of large-range, caused by stress-strain accumulation and certain phase strong earthquake, according to deformation difference brought about on tectonic position in the boundary zone and inner second-order faults of active blocks by unstable and inharmonious features for movement of block system of different levels and deformation of boundary. Based on above, the meaning of medium-term prediction of strong earthquakes is discussed, grounding on common features of regional deformation abnormity, and combining with background of geological tectonic activities.

KEYWORDS

Northeast margin of Qinghai-Tibet plateau, GPS and leveling, Geodetic deformation abnormity characteristics before earthquake, Meaning of prediction

1.INTRODUCTION

Geodetic deformation is the image on earth surface reflected by crust tectonic movement[1]. The regional deformation abnormity related to structure obtained by geodetic measurement of regional leveling and GPS, is the exterior features after certain phase of development of strong earthquake. It is quantitative and intuitive, and has clear physics meaning[2]. However, due to the long interval of repetition of regional leveling observation (several years or more), short-time data accumulation of GPS and a lack of earthquake examples, the application of regional deformation abnormity for medium-short-term prediction of earthquakes is limited. Considering that most areas where earthquakes took place before the middle 1990s only had vertical deformation data， the areas where earthquakes took place after the late 1990s just have at least two-phase GPS data. Therefore, in our study

process, according to support degree of data，majored in the northeastern of Qinghai-Tibet plateau(Figure 1), compared with earthquakes examples of other areas, the common characteristics and its mechanism of regional deformation abnormity before many strong earthquakes with accumulation of geodetic deformation data are analyzed and discussed，so is the meaning of prediction of strong earthquake position combined with the study of background of new tectonic movement.Taking lots of earthquakes (around or more than magnitude of 6) with at least two-phase accumulation of deformation data from the 1980s in the monitoring area and its margins (In Qinghai province, the Menyuan Ms6,4 in 1986 and the Gonghe Ms7.0 in 1990; In Gansu province, the Jingtai Ms6.2 in 1990, the Yongdeng Ms5.8 in 1995, the Jingtai Ms5.9 in 2000 and the Yumen Ms5.9 in 2002; the Delingha Ms 6.6 of Qinghai province and the Minle Ms6.1 and Ms5.8 of Gansu province in 2003, etc.)as main study objects；Meanwhile, we compare these results with earthquake examples such as the Tangshan Ms7.8 in 1976, the Datong Ms6.1 in 1989 of North China and the Lijiang Ms7.0 in 1996 of Sichuan-Yunnan area.

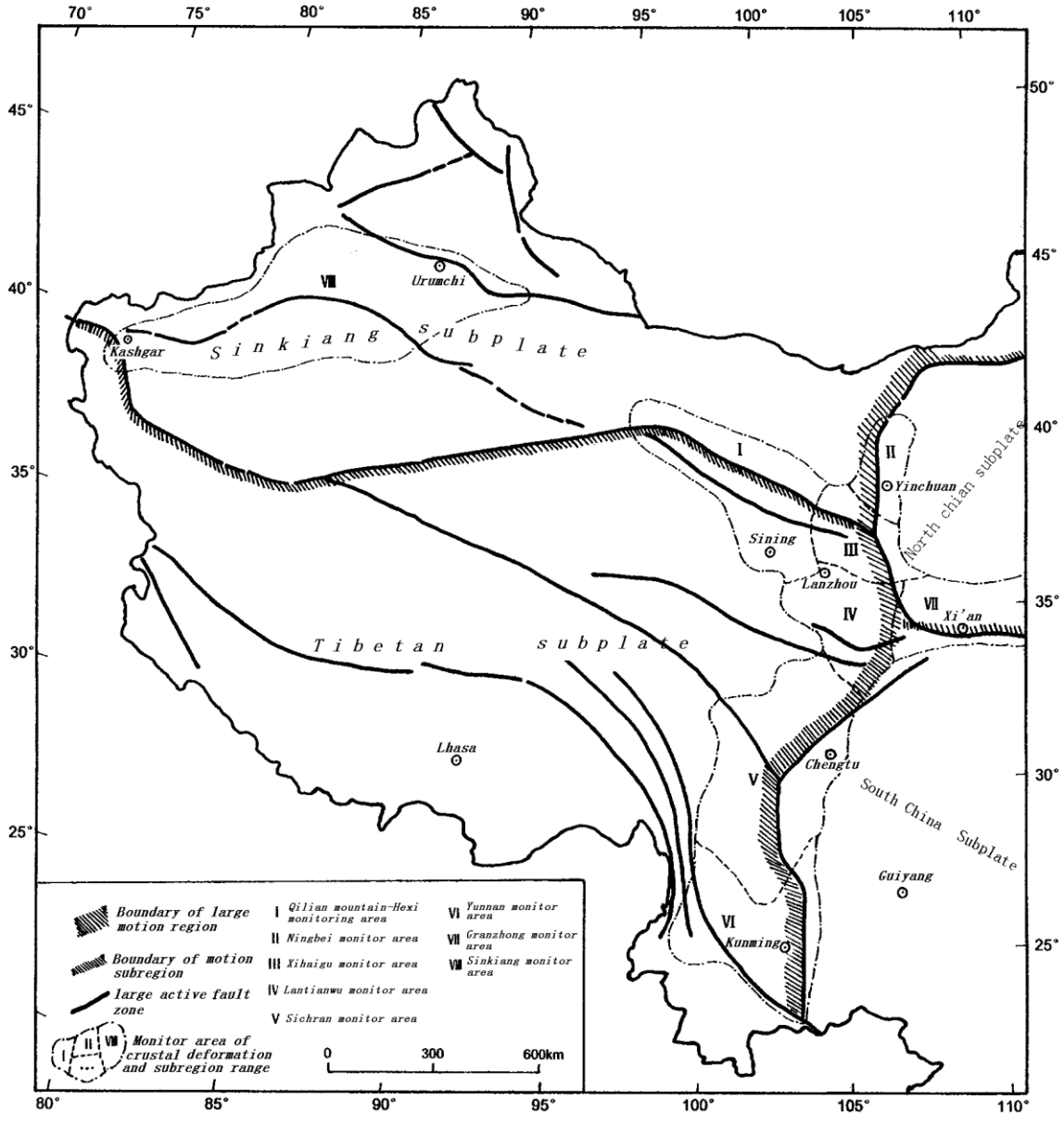

Figure 1 Distribution of main tectonics and crustal deformation monitoring area in the west of China

2. GENERAL CONDITION AND PROCESSING OF REGIONAL DATA

The large-range crust deformation observation in the northeastern margin of Qinghai-Tibet plateau (Gansu, Qinghai and Ningxia areas) started in the 1970s, among these observations, the first 10 year is the beginning phase of data accumulation. The precise leveling monitoring network along the northeast margin of Qinghai-Tibet plateau (95° ~107° E, 32° ~40° N)consists of some linked nets of Qilianshan-Hexi corridor, Lan(zhou)-Tian(shui)-Wu(du), Xi(ji)-Hai(yuan)-Gu(yuan) and Ningbei (North Ningxia) arranged along the boundaries of tectonic blocks(see Fig. 1). Since the establishment of the leveling network in 1970s, the interval for repeated measurements in each area is generally about 5 years (sometimes about 7 or 8 years), such as the area of Qilianshan-Hexi corridor, rather completed remeasurements were made in 1971,1979,1983,1989,1995 and 2000. By dynamic adjustment of data from multiple repeated measurements for each area, the vertical deformation velocities in different time intervals are obtained. After error estimation (the velocity r.m.s. error for each data time period in each area is smaller than one thirds of averaged absolute value of the corresponding deformation velocity) and uniform processing by the least square collocation, the grid values of velocity are formed. Then, the dynamic images of vertical deformation velocity are plotted (limited by space, only the deformation images of 4 data time periods of ,1979~1983, 1983~1989, 1989~1995 and 1995~2000 of the measuring region from Qilianshan to Hexi corridor which is located in the major segment of the studied area is given in the paper, see Figure 2).The GPS monitoring network along the northeast margin of Qinghai-Tibet plateau (94° ~107° E, 33° ~42° N) established in the 1990s, The measurements were carried out in this network in 1993, 1999, 2001 and 2003. While processing GPS data, first, the observation result of any period data was computed accurately by using GAMIT software; The second, the horizontal velocity fields of the three time-periods (1993-1999,1999-2001 and 2001-2003) were obtained by adjustment solution of GLOBK software; Lastly, according to the relation between displacement and strain, the appearing strain parameters (the principal strain, the maximal shearing strain and the surface expanding, and so on. In this paper, duo to the limit of the paper's length, we only gave the distribution figure of the maximal shearing strain, see Figure 3) of the horizontal deformation field are calculated[3].

3.THE SOME COMMON CHARACTERISTICS OF REGIONAL DEFORMATION ABNORMITY BEFORE STRONG EARTHQUAKE

3.1. For Regional Vertical Deformation

Before strong earthquake, the regional vertical deformation shows distribution features of abnormal apophysis area and dense belt-high gradient belt of vertical difference deformation (some of them reflect distribution of four quadrants) related to tectonics. It can be seen from the dynamic images of vertical deformation field in the measuring region of Qilianshan-Hexi corridor located along the principal boundary zones of northeast margin of Qinghai-Tibet plateau and the distribution of several M≈6 and M≥6 earthquakes that the M=6.4 Menyuan earthquake in 1986 and M=6.2 Jingtai earthquake in 1990 just occurred in the deformation gradient zones located near Qilianshan principal fault which was generated by the regional intensive vertical differential movement in 1980s (Figure 2a~b). Consistent with strike of the fault, the deformation gradient zones have large

areas of uplift. Although the M=5.8 Yongdeng earthquake in 1995 and M=5.9 Jingtai earthquake in 2000 and M=6.1 Minle earthquake in 2003 did not occur in the time period with larger regional vertical differential movement, these epicenters of earthquakes were located at the deformation gradient zones near the region with locally significant uplift in the eastern part of the measuring region (Figure 2c~d). In addition, the M=7.0 Gonghe earthquake occurred in April of 1990 was not covered by the monitoring network, but it has been reflected by the limited data that this earthquake is still included in the NW-trending huge uplifted zone[4].

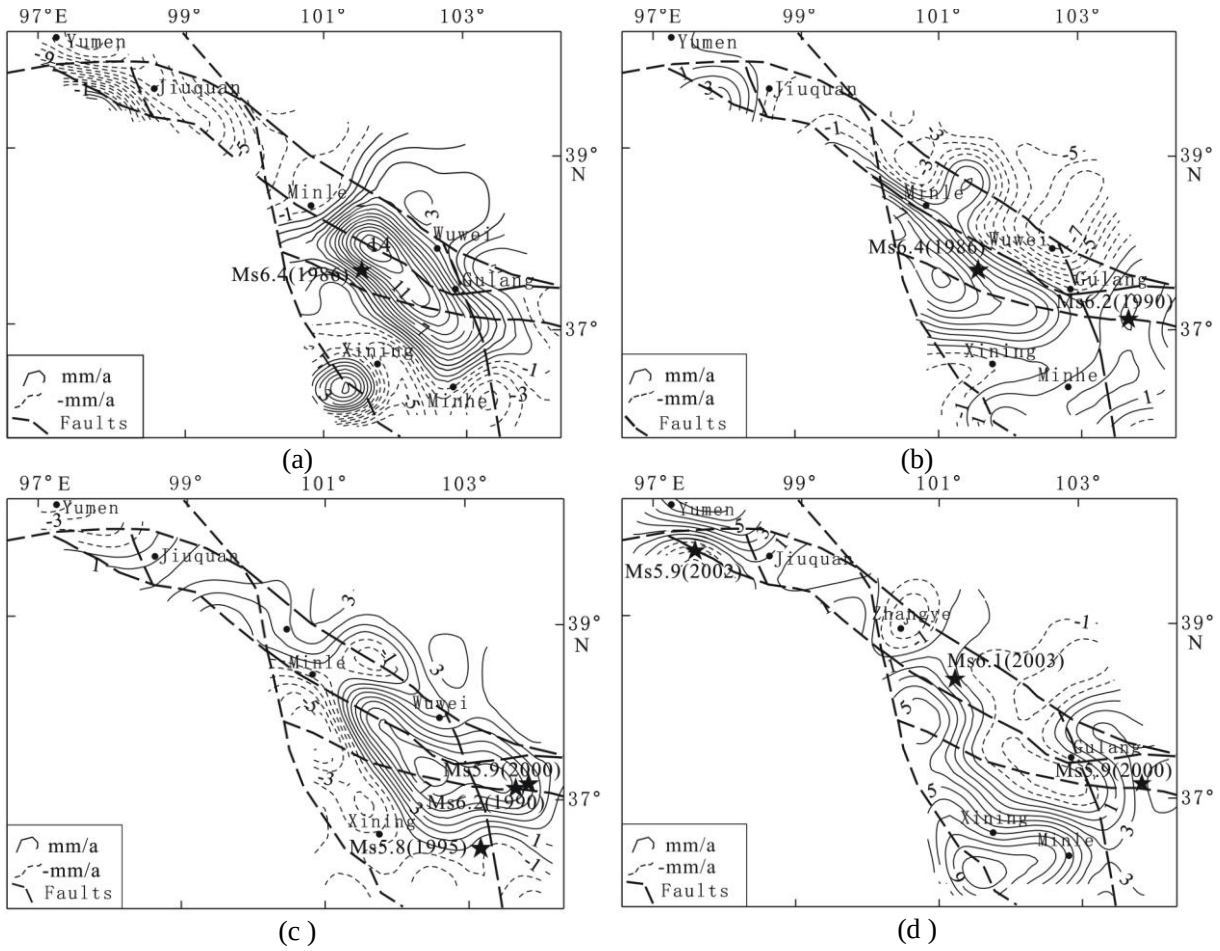

Figure 2 Contour map of vertical deformation velocity in Qilianshan-Hexi area by levering
(a)1979~1983; (b)1983~1989; (c)1989~1995; (d)1995~2000

3.2. For Regional Horizontal Movement And Deformation

Characteristics of current horizontal movement and deformation obtained in the northeast margin of Qinhai-Tibet plateau by GPS measurements for 1993~2003 : a).The distribution of relative horizontal movement velocity in the interior of the area relative to the barycenter of the GPS network shows that the block movements differ greatly on both flanks of Qilian-Haiyuan fault zone located along the northeast boundary of Qinghai-Tibet block; The left-lateral movement between Gansu-Qinghai block and Alxa block is about 6 mm/a, the movement along the boundary zone of 2 blocks is compression-torsion with left-lateral strike-slip and compression on the whole, and the approximate EW-trending relative tensile movement (deformation)exists in the interior of the block. b).The direction of predominant distribution is

NE for the principal compressive strain of apparent strain field in the area. The region with the maximum shear strain distributes in the area of Wuwei and Qilian, which is the joint zone of Qinghai-Tibet block and Alxa block and the region with the extreme maximum shear strain is located on the north flank of principal boundary fault zone with the magnitude of 7×10^{-8}. The region with high surface expansion and compression is situated on the south flank of Wuwei and the strain in the extreme region is more than -3×10^{-8}. In addition, in the vicinity of Jiuquan and along the west margin of Ordos block, there are regional surface expansion and compression with the value of more than -2×10^{-8}. The above-mentioned reflects that the horizontal movement and deformation are inhomogeneous in space distribution both along the boundary and in the interior of the block..c).In this area ,the horizontal movement shows features of centralized high strain area (or zone) of dominating shear deformation related to active block and faults. The M=5.8 Yongdeng earthquake in 1995 and M=5.9 Jingtai earthquake in 2000 and M=5.9 Yumen earthquake in 2002 and M=6.6 Delinha earthquake in 2003 and M=6.1 Minle earthquake in 2003 are located in the high-strain zones near the block boundaries reflected by the GPS horizontal movement measurements carried out from 1993 to 2003 in this area[5] (Figure 3a~c).

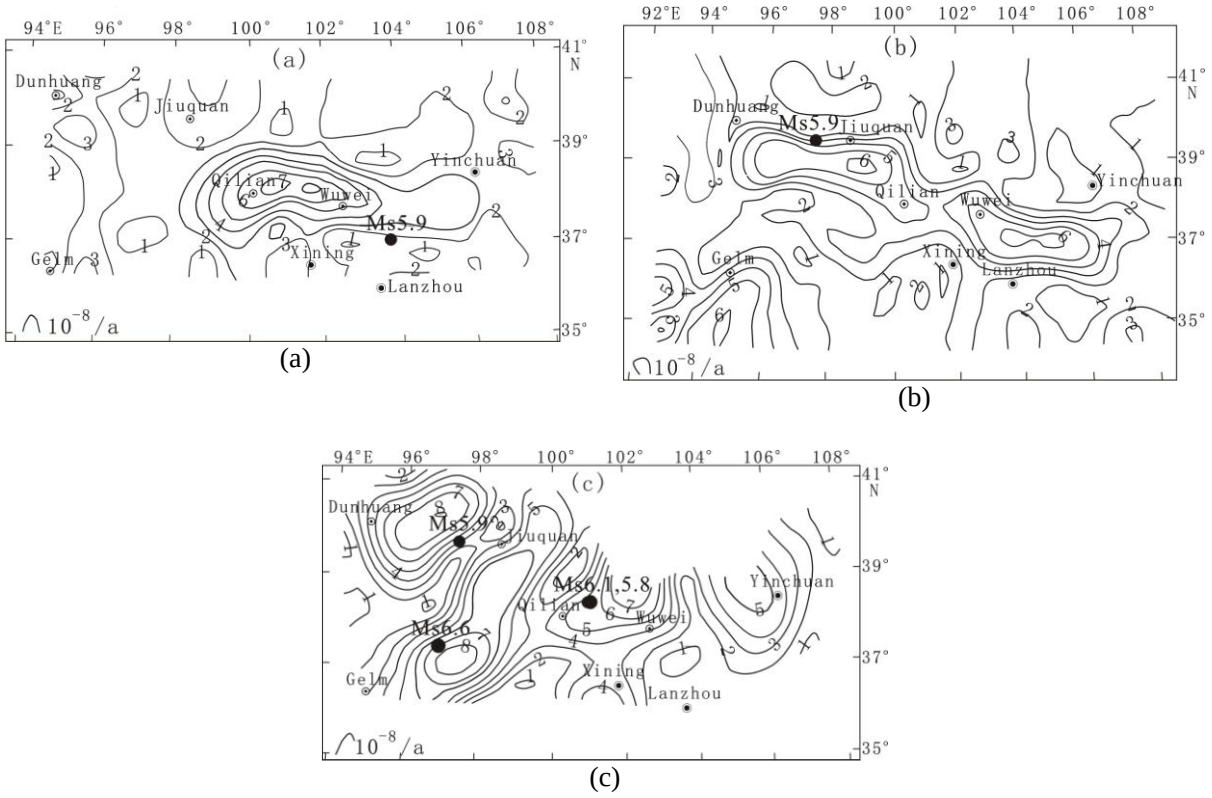

Figure 3 Map of relative horizontal movement marimum strain distribution in the northeast margin of Qinhai-Tibet plateau by GPS
(a)1993~1999; (b)1999~2001; (c)2001~2003

3.3. The Some Commensal Features of Regional Deformation Abnormity Before Strong Earthquake

Commensal features of regional vertical deformation abnormity area and high strain distribution area of horizontal deformation . Such as M=5.9 Jintai earthquake in 2000 and M=5.9 Yumen earthquake in 2002 and

M=6.1 Minle earthquake in 2003 are located in the high-strain zones near the block boundaries and the places near the uplifted area and high-gradient zone of vertical deformation(Figure 2d and Figure 3a~c).Therefore, the regional deformation abnormity before earthquake usually appears three aspects of common characteristics: a) For regional vertical deformation, it shows distribution features of abnormal apophysis area and dense belt-high gradient belt of vertical difference deformation (some of them reflect distribution of four quadrants) related to tectonics; b)For horizontal movement, it shows features of centralized high strain area (or zone) of dominating shear deformation related to active block and faults； c) Common features of regional vertical deformation abnormity area and high strain distribution area of horizontal deformation.

4.THE MECHANISM OF COMMON CHARACTERISTICS OF REGIONAL DEFORMATION ABNORMITY AND PREDICTION MEANING OF STRONG EARTHQUAKE

In geological structure, the main strike of principal fault system along the northeast margin of Qinghai-Tibet plateau is NWW in the westem segment and turns gradually to NNW to Haiyuan area[6] (Figure 4).

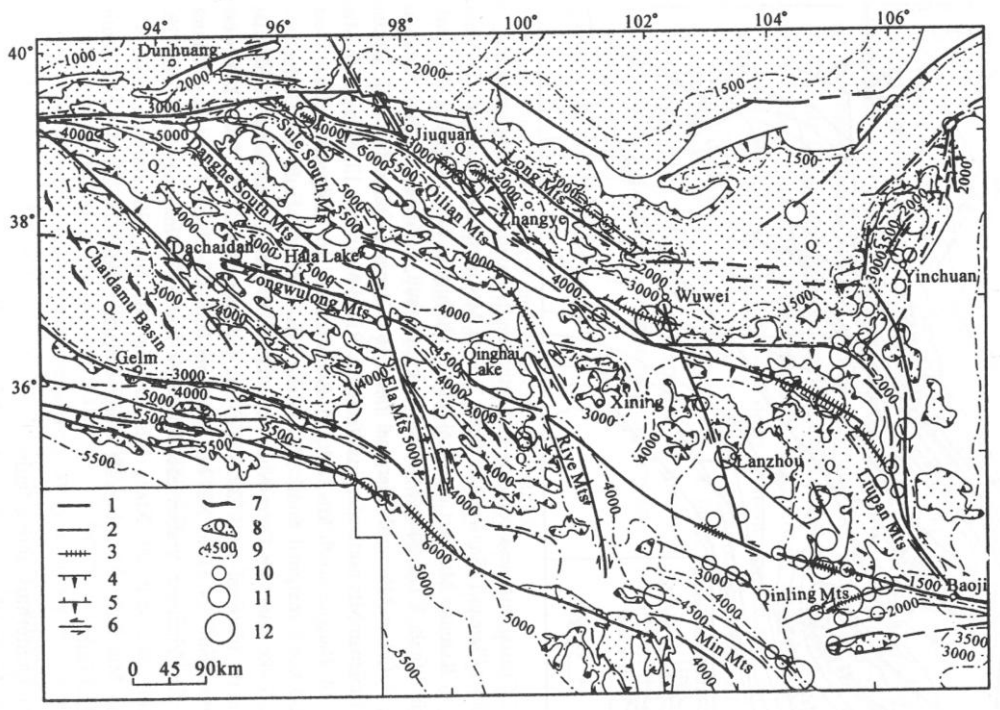

Figure 4 Distribution of main tectonics in the northeast margin of Qinghai-Tibet plateau(by Guo.2000)

The results obtained from both geological research and GPS measurements indicate that the basic activity characteristics of this principal boundary zone are sinistral torsion and obduction, and the sinistral activity is quite significant recently. Under the action of source motive of the northwad push-collision of Indian plate, the Qinghai-Tibet plateau compresses northward. The crustal movement is predominant by horizontal motion and the relative movement between the blocks has its inherent tendency. That is why the data from GPS measurements with a scale of several years, the data of vertical deformation with a scale of several tens years and the general trend of crustal movement with a scale of thousands and thousands years are consistent with each other. Analyzed logically, when the relative horizontal movement along the boundary fault of the block is

rather stable and smooth, obvious vertical movement with a tendentious accumulation is not easy to occur, while when the horizontal movement along the block boundary is hindered, obvious vertical movement (anomalous uplift and high-gradient zone) with a tendentious accumulation might possibly occur.Although the data obtained at present indicate that the activities along the boundary zones of the block are different, the earthquake might only develop in the place with the hindered boundary activity and relatively concentrated stress, because the block (active block) is relatively independent and the movement and deformation can be considered as the activity of the whole block. Therefore, the tendentious accumulation of vertical movement generated under the higher crustal stress is a natural phenomenon (It cannot be supposed that the movement generated under higher stress would appear in the form of abrupt variation and quick recovery).

Therefore, having analyzed formation mechanism of these common characteristics of abnormity, it concludes that: these are results, controlled by basic united tectonic stress field of large-range, caused by stress-strain accumulation and certain phase development of strong earthquake, according to deformation difference brought about on tectonic position in the boundary zone and inner second-order faults of active blocks by unstable and inharmonious features for movement of block system of different levels and deformation of boundary.

According to support degree of regional crust deformation data, it has practice meaning of medium-term predicting especially earthquake position to understand, grasp and apply above common features of deformation abnormity. First, if the high strain distribution situation of horizontal movement and deformation of active blocks and their boundaries, especially high strain region related to activity difference of tectonic fracture of block boundary is analyzed, it is helpful to determine tectonic region where earthquake will take place. Second, time-space scale and trend transformation of abnormal apophysis area and high gradient belt of vertical difference deformation (or distribution of four quadrants) under the background of strengthened inherit vertical difference movement related to tectonics with long-time data accumulation are helpful to determine stress-strain status of medium-term phase of strong earthquake and earthquake tectonic region. Third, according to the commensal features (needing the support of two kinds of data) of regional vertical deformation abnormity area and centralized high strain distribution area of horizontal deformation, especially laying attention to the relationship between shear dislocation status reflected by regional deformation abnormity and background of activity of tectonic fractures, it is helpful to determine the place where strong earthquake will take place.

5. CONCLUSION

(1) The regional deformation abnormity of medium-term phase (1-3 year or more) before earthquake usually appears three aspects of common characteristics: a).For regional vertical deformation, it shows distribution features of abnormal apophysis area and dense belt-high gradient belt of vertical difference deformation (some of them reflect distribution of four quadrants) related to tectonics; b).For horizontal movement, it shows features of centralized high strain area (or zone) of dominating shear deformation related to active block and faults； c).Commensal features of regional vertical deformation abnormity area and high strain distribution area of horizontal deformation.

(2) The common characteristics of regional deformation abnormity before many strong earthquakes it concludes that: these are results, controlled by basic united tectonic stress field of large-range, caused by stress-strain accumulation and certain phase development of strong earthquake, according to deformation difference brought

about on tectonic position in the boundary zone and inner second-order faults of active blocks by unstable and inharmonious features for movement of block system of different levels and deformation of boundary.

(3) According to support degree of regional crust deformation data, it has practice meaning of medium-term predicting especially earthquake position to understand, grasp and apply above common features of deformation abnormity.

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