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Characteristics of present-day active strain field of Chinese mainland*

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Abstract

On the basis of the GPS data obtained from repeated measurements carried out in 2004 and 2007, the horizontal principal strain of the Chinese mainland is calculated, which shows that the direction of principal compressive strain axis of each subplate is basically consistent with the *P*-axis of focal mechanism solution and the principal compressive stress axis acquired by geological method. It indicates that the crustal tectonic stress field is relatively stable in regions in a long time. The principal compressive stress axes of Qinghai-Tibet and Xinjiang subplates in the western part of Chinese mainland direct to NS and NNE-SSW, which are controlled by the force from the collision of the Eurasia Plate and India Plate. The principal compressive strain axes of Heilongjiang and North China subplates in the eastern part direct to ENE-WSW, which shows that they are subject to the force from the collision and underthrust of the Eurasia Plate to the North America and Pacific plates. At the same time, they are also affected by the lateral force from Qinghai-Tibet and Xinjiang subplates. The principal compressive strain axis of South China plate is WNW-ESE, which reflects that it is affected by the force from the collision of Philippine Sea Plate and Eurasia Plate and it is also subject to the lateral force from Qinghai-Tibet subplate. It is apparent from the comparison between the principal compressive strain axes in the periods of 2004~2007 and 2001~2004 that the acting directions of principal compressive stress of subplates in both periods are basically consistent. However, there is certain difference between their directional concentrations of principal compressive stress axes. The surface strain rates of different tectonic units in both periods indicate that the events predominating by compressive variation decrease, while the events predominating by tensile change increase.

Key words: GPS; strain field; compressive strain axis; stress; tectonic motion
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Introduction

In the 1980s, GPS (Global Positioning System) was first applied to the field of crustal motion measurement in the world and in the 1990s, GPS developed rapidly in China. In 1999, a network project, *i.e.*, a unified GPS monitoring network was established in the Chinese mainland. In the years of 1999, 2001, 2004 and 2007, the network was remeasured several times. We should say that the establishment and measurement of GPS network have greatly promoted the geoscientific research to a deep level. And GPS data has begun to play a more and more important role in the fields of geodynamics, present-day crustal tectonic activity, developing mechanism of earthquake and its prediction, volcanic activity monitoring, and so on. On the basis of the three epochs of GPS

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data (1999, 2001 and 2004) obtained from the network and the GPS data from the local networks established from 1980s to 1990s, a number of geoscientific specialists in China have carried out researches in the horizontal deformation strain field of the Chinese mainland (LI *et al*, 2003; WANG *et al*, 2001; HUANG and WANG, 2000; YANG *et al*, 2002; WANG *et al*, 2003; ZHU *et al*, 1999; ZHOU *et al*, 1998).

The data used in the paper are mainly from the measurements of GPS network carried out in 2001, 2004 and 2007, respectively. And the data processing of GPS baselines is conducted with the IGS precise ephemeris in the ITRF 2000 coordinate framework by using the GAMIT/GLOBK software (10.32 Version). The data from 15 international IGS tracing stations and 26 fiducial sites are used in the processing. The controlling files for baseline processing are sestbl. and autcln.cmd downloaded from the SIO website.

The controlling parameters for data processing are as follows.

Sampling interval:	30 s
Maximum epoch number:	2 880
Cut-off altitude angle:	10°
Baseline processing:	relaxation solution
Tropospheric error model:	Saastamoinen model and default meteorological parameters
Zenith delay parameters:	25
Ionospheric delay:	eliminating the LC observations of ionosphere
Satellite orbit parameters:	9 parameters (6 are Kepler′s radicals and 3 are solar radiation parameters)
Data elimination:	AUTCLN

In the data processing, a core site in the ITRF2000 framework is used, whose coordinate and coordinate motion rate are the parameters controlled by the coordinate system, *i.e.*, the coordinates in the EW and SN directions are tightly constrained as 3 mm and that in the longitudinal direction as 10 mm. As to the other GPS observation sites, a loose constraint is given to their coordinates and coordinate motion rates, which is 30 mm for the EW and SN directions and 100 mm for the vertical direction. By taking these measures in the calculation, the obtained GPS site velocities are accurate and reliable. Taking the calculated GPS site velocities (2004~2007) as an example, its mean displacement component in the east direction is 30.90 mm/a with an error of 0.41 mm/a, while its mean displacement component in the north direction is 12.66 mm/a with an error of 0.26 mm/a. The real error might be larger than the above values, but they are much smaller than the values of site velocity. Then on the basis of GPS site velocities in the epochs of 2001~2004 and 2004~2007, we have calculated their strain parameters respectively and studied the characteristics of strain field of the Chinese mainland with reference to the calculated results of these two epochs.

1 Ideas and methods

Strain is a kind of measurement to show the degree of physical change. Strain is related to stress and the strain of an object is resulted from the action of stress. In the analysis of the triaxial strain and stress ellipsoidal bodies of a micro-object unit, the three strain principal axes of the strain ellipsoidal body correspond to the three stress principal axes of the stress ellipsoidal body, respectively, and their locations are consistent with each other. The maximum principal strain axis of the strain ellipsoidal body corresponds to the minimum principal stress axis of the stress ellipsoidal body, its minimum principal strain axis corresponds to the maximum principal stress axis, and its maximum shear strain corresponds to the maximum shear stress (Geological Dictionary Editing Office, Ministry of Geology and Mineral Resources, 1983). In an isostatic body, the corresponding principal strain and principal stress are proportional to each other. In the analysis of ground strain and stress fields, if the geological body is assumed to be isostatic and isotropic, one can study the crustal stress status on the basis of strain. In the analysis of 2-D crustal plane strain and stress, the principal compressive strain axis of crustal block is consistent with the major axis of compressive stress, and its principal tensile strain axis is coincident to the major axis of tensile stress (vertical strain and stress are ignored here). In other words, the direction of horizontal crustal principal compressive strain axis is consistent with the acting direction of horizontal principal compressive stress, and the magnitude of strain is proportional to that of principal stress. The horizontal principal tensile strain axis and the horizontal principal tensile stress have the same relationship between them. As to the strain field calculated from the observed data of GPS sites on the ground, the direction of its principal compressive strain axis represents the main direction of crustal compressive stress, and the principal tensile strain axis represents the main direction of tensile stress. One can also derive the continuous strain field of crustal block by taking the crust as a continuous medium. In the calculation, the GPS site velocities in the global reference frame should be suitably interpolated in order to ensure their uniform distribution. Then each site can be taken as a group together with its surrounding adjacent sites to derive the strain rate (LI *et al*, 2001, 2007). The obtained result can represent the strain status of the local region where the GPS site is located.

2 Strain rate field

2.1 From year 2004 to 2007

On the basis of the results from neotectonic researches, the Chinese mainland can be divided into five first-order active units of Qinghai-Tibet, Xinjiang, South China, North China and Heilongjiang subblocks, and each of them can be divided into multiple secondary active blocks (MA, 1987; ZHANG *et al*, 2003). Figure 1 shows the minimum and the maximum principal strain rates of the Chinese mainland obtained by the above-mentioned method. And Table 1 provides the statistics of principal strain rates corresponding to their geological structural zones. Statistics is also made for the directions of principal compressive strain axes with an interval of 10° and the magnitude of each directional segment is shown by percentage (see Figure 2).

It is apparent from Figure 1 and Table 1 that the direction of principal compressive strain axis of Qinghai-Tibet subplate has changed gradually from NNW to N and NE from the western part to the eastern part. We can see that the direction of principal compressive strain axis is ENE in the north area (West Qingling) of the eastern Qinghai-Tibet subplate, about EW in the middle area, SE on the Sichuan-Yunnan block in the south area, and SSE on the southwest Yunnan block. The direction of principal compressive strain axis of Qinghai-Tibet subplate extends outwards (NW-N-NE-E-SE) in a radial orientation around the east segment of Himalaya tectonic zone and Arsam cape.

The mean principal compressive strain rate of Qinghai-Tibet subplate is -18.42×10^{-9}/a. The maximum value of -24.28×10^{-9}/a is in the middle area and the minimum value of -7.65×10^{-9}/a is in the Southwest Yunnan area with a difference of 3.17 times. While its maximum principal tensile strain rate is 25.89×10^{-9}/a in the Sichuan-Yunnan block and its minimum principal tensile strain

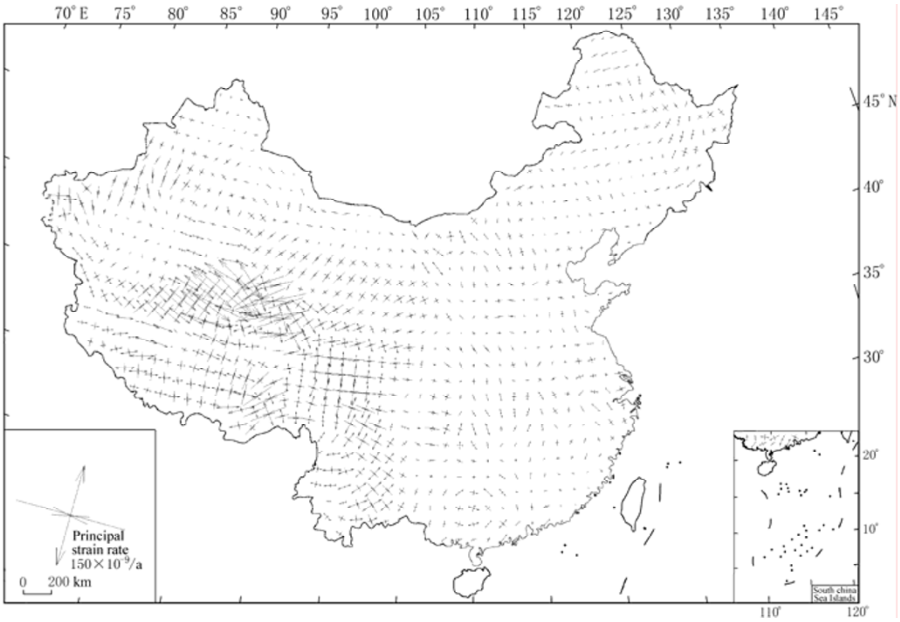

Figure 1 Principal strain rates of Chinese mainland in 2004~2007

Table 1 Zoning strain rates and errors in 2004~2007

Region	Principal compressive strain rate $\varepsilon_1/10^{-9}$ a^{-1}	ε_1 error /10^{-9} a^{-1}	Principal tensile strain rate $\varepsilon_2/10^{-9}$ a^{-1}	ε_2 error /10^{-9} a^{-1}	Surface strain rate /10^{-9} a^{-1}	Maximum shear strain rate $\gamma/10^{-9}$ a^{-1}	γerror /10^{-9} a^{-1}
Qinghai-Tibet subplate	−18.42	6.30	19.35	6.19	0.93	37.78	8.90
Qinghai-Tibet subplate (to the west of 90°E)	−12.73	5.02	21.63	5.98	8.90	34.36	7.90
Qinghai-Tibet subplate (from 90°E to Xining in the east)	−24.28	7.80	18.49	7.54	−5.79	42.77	10.86
Qinghai-Tibet subplate (West Qingling)	−14.03	3.92	9.32	3.62	−4.71	23.34	5.37
Qinghai-Tibet subplate (Longmenshan)	−17.67	4.98	15.30	4.24	−2.37	32.96	6.54
Qinghai-Tibet subplate (Sichuan-Yunnan block)	−17.28	5.45	25.89	5.23	8.62	43.17	7.56
Qinghai-Tibet subplate (Southwestern Yunnan)	−7.65	5.04	15.05	5.20	7.40	22.70	7.25
Xinjiang subplate	−8.79	3.12	5.32	3.43	−3.47	14.11	4.77
Tarim block	−9.07	3.27	5.70	3.66	−3.37	14.76	4.95
Tianshan belt	−15.50	3.41	5.34	3.78	−10.16	20.84	5.34
Juggar block	−4.31	2.17	5.10	2.66	0.78	9.41	3.32
Alax block	−5.38	3.29	4.30	3.18	−1.08	9.68	4.85
South China subplate	−3.54	3.54	7.92	3.40	4.38	11.45	4.91
North China subplate	−4.76	4.20	5.29	4.01	0.54	10.05	5.82
Ordos block	−3.05	4.08	6.94	3.86	3.88	9.99	5.63
Taihang block	−5.44	4.18	5.06	3.63	−3.08	10.50	5.55
Ji-Lu (Hebei-Shandong) block	−3.31	4.69	5.46	4.03	2.16	8.77	6.19
Yu-Wan (Henan-Anhui) block	−7.38	3.74	1.03	3.89	−6.35	8.41	5.41
Jiao-Su block	−5.23	4.17	5.29	4.37	0.06	10.52	6.06
Heilongjiang subplate	−3.44	4.11	5.81	3.70	2.37	9.26	5.55
Yinshan-Yanshan block	−3.97	4.42	5.26	3.63	1.29	9.22	5.73
Xing′an block	−2.03	3.50	5.44	3.29	3.41	7.47	4.82
Songliao block	−4.30	4.30	5.93	3.94	1.62	10.23	5.86
Changbai block	−4.73	5.15	7.21	4.61	2.49	11.94	6.93

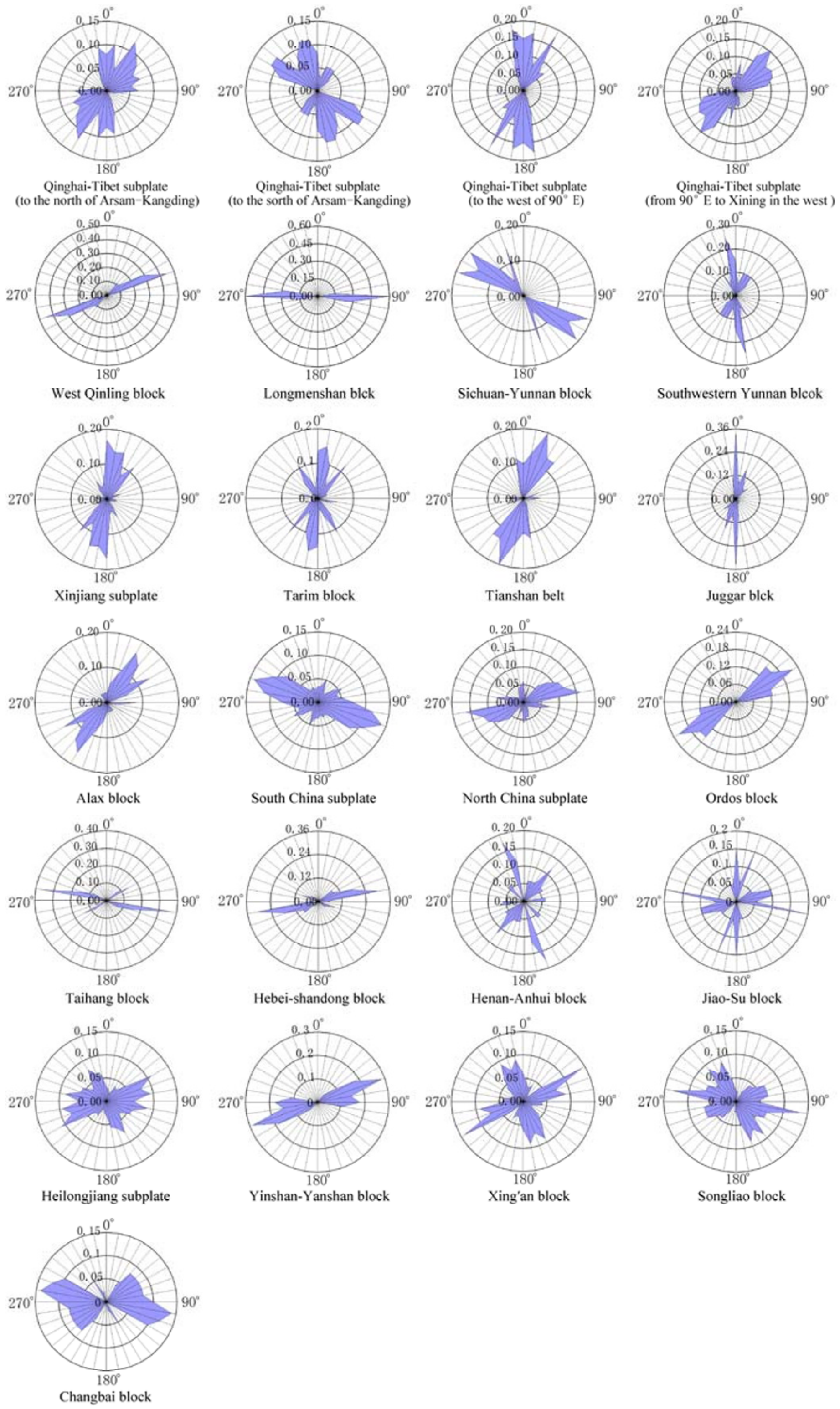

Figure 2 Statistics of principal compressive strain-axis directions (2004~2007)

rate is 9.32×10^{-9}/a in the north area of the eastern Qinghai-Tibet subplate with a difference of 2.77 times. The surface strain rate of Qinghai-Tibet subplate shows a value below zero in the middle area, north area of the eastern part, Longmenshan area and Southwest Yunnan, where compressive motion is predominant. While in the other areas and segments, tensile motion ranks the first. The mean maximum shear strain rate of Qinghai-Tibet subplate is 37.15×10^{-9}/a with the largest value of 43.17×10^{-9}/a in the Sichuan-Yunnan block and the smallest value of 22.70×10^{-9}/a in the Southwest Yunnan area.

Figure 2 shows the statistic results of principal compressive strain-axis directions of different tectonic units (the clockwise is positive and the counterclockwise is negative with the north as 0°). It indicates that the directions of principal compressive strain axes in the western area of Qinghai-Tibet subplate (to the west of 90°E) are mainly concentrated between ±10° with a predominant direction of −10°; The directions of principal compressive strain axes in the middle area (from the 90°E to Arsam cape-Xining zone in the east) are mainly concentrated between 30°~80° with a predominant direction of 40°; The directions of principal compressive strain axes in the north area of the eastern part (West Qingling and its north) are mainly concentrated between 60°~70° with a predominant direction of 70°; The directions of principal compressive strain axes in the middle area (Longmenshan) are mainly concentrated between 80°~100° with a predominant direction of 90°; The directions of principal compressive strain axes of Sichuan-Yunnan block in the south area are mainly concentrated between 290°~310° with two predominant directions of 310° and 290°. The predominant direction of principal compressive strain axis of the Southwest Yunnan block is 350°.

What mentioned above indicates that the principal compressive strain rates, surface strain rates and maximum shear strain rates are not the same in magnitude in different areas of Qinghai-Tibet subplate. Some areas are predominated by compressive motion, while some are controlled by tensile motion. The radiation of principal compressive strain axis in the directions of NNW-ESE around the east segment of Himalaya tectonic zone and Arsam cape displays the northward intensive collision and compression of India Plate to Qinghai-Tibet subplate at this location.

On Xinjiang subplate, the principal compressive strain axis changes from NNW to N and NE from the western part to the eastern part, while its general direction of principal compressive strain axis is NNE. The statistic result shows that the directions of principal compressive strain axes of Xinjiang subplate are concentrated between 0°~20° with a predominant direction of SN; The direction of principal compressive strain axis of Tarim block is 10°; The predominant direction of principal compressive strain axes of Tianshan tectonic belt is 20°; and the predominant direction of principal compressive strain axes of Juggar block is 0°.

On Xinjiang subplate, the compressive motion is intensive in the western part and the tensile motion is predominant in the eastern part with a mean principal compressive strain rate of -8.79×10^{-9}/a. Its maximum principal compressive strain rate of -15.50×10^{-9}/a is in a secondary structure of Tianshan tectonic belt, while its minimum value of -4.31×10^{-9}/a is on Juggar block. The surface strain rate of Xinjiang subplate is a negative value, indicating that compressive motion is predominant here in general. The compressive motion is also predominant on Tarim block and Tianshan tectonic belt, but there is a little bit tensile motion on Juggar block as a whole. The maximum shear strain rate is relatively the largest on Tianshan tectonic belt with a value of 20.84×10^{-9}/a, while it is the smallest on Juggar block with a value of 9.41×10^{-9}/a.

It is apparent from the above that the compressive variation weakens and the tensile change intensifies from the south to the north on Xinjiang subplate. The principal compressive strain rate, the surface strain rate or the maximum shear strain rate of Tianshan tectonic belt are the largest of the total.

The directions of principal compressive strain axes of Alax block are concentrated between 30°~60° with a predominant direction of 30°. Compared with Qinghai-Tibet and Xinjiang subplates, the strain rate of Alax block is relatively small and its two horizontal principal strain rates are within $\pm 5.38\times 10^{-9}$/a. Its surface strain rate has a weak compressive change and its maximum shear strain rate is roughly the same as Tarim block.

The general direction of principal compressive strain axis of South China subplate is WNW. Its statistic result indicates that the directions of principal compressive strain axes are concentrated between 280°~310° with a predominant direction of 290°. In the period of 2004~2007, the South China subplate mainly has a tensile change and its principal tensile strain rate is more than two times of its principal compressive strain rate. However, its strain rate is not large in general and the variation is small.

The directions of principal compressive strain axes of North China subplate in the period of 2004~2007 are concentrated between 50°~180° with a predominant direction of 80°. However, the principal compressive strain axes of its secondary tectonic blocks are different in directions. For example, Ordos block has a predominant direction of principal compressive strain axis of 60°, Taihang block has a predominant direction of 280°, Yu-Wan (Henan-Anhui) block has a predominant direction of 340°, Ji-Lu (Hebei-Shangdong) block has a predominant direction of 80°, and Jiao-Su block has a predominant direction of 280°. It reveals that the directions of principal compressive strain axes of North China subplate are characterized by an alternate distribution of ENE and WNW from the west to the east.

There is not large difference between the principal compressive and tensile strain rates of North China subplate, both are about 5×10^{-9}/a. Among the secondary blocks of North China subplate, Yu-Wan block has the largest principal compressive strain rate, while Ordos block has the smallest value. The surface strain rate shows that on Taihang and Yu-Wan blocks, compressive variations are predominant, while on other blocks, tensile motions are large. The maximum shear strain rates are relatively large on Taihang and Jiao-Su blocks.

The directions of principal compressive strain axes of Heilongjiang subplate are mainly concentrated in a wider interval of 60°~170° with a predominant direction of 60° and a number of peak values. Among the secondary blocks of Heilongjiang subplate, the principal compressive strain axes of Yinshan-Yanshan block mainly distribute in the zone of 60°~100° with a predominant direction of 70°; The directions of principal compressive strain axes of Xing′an block are concentrated in two interval zones, one is 60°~180° and the other is 150°~170° with a predominant direction of 60°. It is apparent from the principal strain rates shown in Figure 1 that the ENE-trending and the NNW-trending principal compressive strain axes of Xing′an block distribute in an alternate orientation from the south to the north, forming principal compressive strain axis zones and groups. This is the main reason for the two predominant directions of principal compressive strain axes of Xing′an block. The directions of principal compressive strain axes of Songliao block are concentrated between 40°~160° with a predominant direction of 100°. The directions of principal compressive strain axes of Changbai block distribute between 40°~120° with a predominant direction of 100°.

Among the secondary tectonic units of Heilongjiang subplate, the principal compressive strain rate of Changbai block is relatively the largest with a value of -4.73×10^{-9}/a and that of Xing′an block is the smallest with a value of -2.03×10^{-9}/a. The surface strain rate of Heilongjiang subplate is positive, which indicates that tensile activity is predominant here. The tensile motion of Xing′an block is relatively strong, while that of Yinshan-Yanshan and Songliao blocks is weak. The maximum shear strain rate is the largest on Changbai block and the smallest on Xing'an block.

Among the secondary structures of Heilongjiang subplate, the directions of principal compressive strain axes of Yinshan-Yanshan block are relatively concentrated, while those of Songliao block is dispersive. The principal compressive strain axes of Xing'an block display a grouping phenomenon of two major directions. Heilongjiang subplate and its secondary blocks are all predominated by tensile variation.

In summary, the horizontal principal strain axes of Chinese mainland are not the same in direction on different subplates and their strain rate parameters also differ greatly in magnitude, which might be related to the tectonic parts where they are located and the acting forces of the surrounding plates. However, in consideration as a whole, the principal compressive strain axis of the western part of Chinese mainland is about SN~NNE from the west to the east, while the principal compressive strain axis of the eastern part is predominated by ENE~E~ESE from the south to the north.

2.2 From year of 2001 to 2004

Figure 3 shows the statistic results of principal compressive strain-axis direction of each subplate in the period of 2001~2004, which is the same as Figure 2 in figure drawing. In comparison with Figure 2, the discrete level of principal compressive strain-axis directions of Qinghai-Tibet, Xinjiang, South China and North China subplates is larger; The directions of principal compressive strain axes of Alax block are basically the same in concentration in both periods of 2001~2004 and 2004~2007; The variation of principal compressive strain-axis directions of Heilongjiang subplate is different from them, which is relatively concentrated in the period of 2001~2004 (about 40% in the range of 330°±5°) and relatively discrete in the period of 2004~2007.

Among the subplates of Chinese mainland, the time period with relatively active seismic activity of Heilongjiang subplate is 2003~2006 and several moderate and strong earthquakes occurred in this period, indicating its relatively strong stress. The principal compressive strain-axis directions of Heilongjiang subplate is relatively concentrated in the period of 2001~2004, which might be resulted from a strong acting stress. Its principal compressive strain-axis directions in the period of 2004~2007 are relatively discrete, which might be due to stress release of earthquakes, as a result, the stress action is weakened and the crustal stress behavior is not active. The concentration of principal compressive strain-axis directions of other blocks is not obvious, which might be related to the inactive stress action. We therefore could say that strong stress may make the stress field unified, while weak stress may make the stress field relatively relaxed and the strain axes relatively scattered.

The directions of principal compressive strain axes of the blocks are roughly the same in both periods of 2001~2004 and 2004~2007, except Qinghai-Tibet subplate with a difference of 30°.

The variation of surface strain rate indicates that the blocks with compressive change in the period of 2001~2004 are more than those in the period of 2004~2007. Only Xinjiang subplate and partial zones of Qinghai-Tibet subplate maintain a compressive variation in both time periods (see Tables 1 and 2).

Considering as a whole, the principal compressive strain rate, principal tensile strain rate, and maximum shear strain rate of the subplates in the western part of Chinese mainland are all larger than those of the subplates in the eastern part.

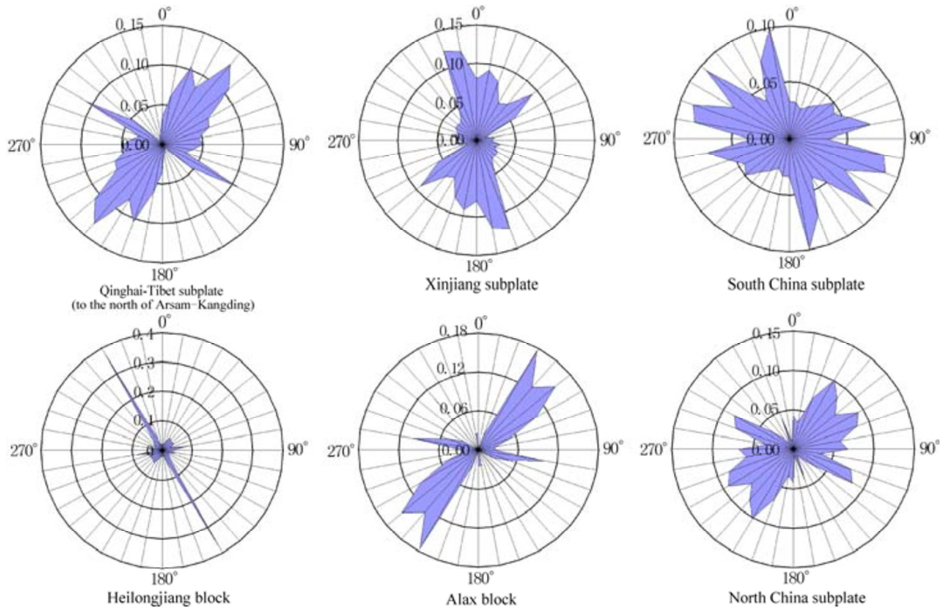

Figure 3 Statistics of principal compressive strain-axis directions (2001~2004)

3 Discussion and conclusions

1) The horizontal principal compressive strain axis obtained from the calculation of GPS data represents the crustal principal compressive stress axis, and the principal compressive strain axis reveals the distribution characteristics of principal compressive stress. The principal compressive strain-axis directions of subplates located within the range of Chinese mainland in the period of 2004~2007 reflect that the acting direction of principal compressive stress of Qinghai-Tibet subplate is NNE−SSW with a predominant direction of 30°; The acting direction of principal compressive stress of Xinjiang subplate is also NNE-SSW with a predominant direction of about SN; The acting direction of principal compressive stress of South China subplate is WNW−ESE with a predominant direction of 110°; The acting direction of principal compressive stress of North China subplate is ENE−WSW with a predominant direction of 80°; The acting direction of principal compressive stress of Heilongjiang subplate is also ENE−WSW with a predominant direction of 60°. The acting direction of principal compressive stress of subplates located in the western part of Chinese mainland is NNE−SSW, which is consistent with the compressive force resulted from the intensive collision of India Plate and Eurasia Plate in the Himalayan zone. It indicates that the present-day tectonic deformation of Qinghai-Tibet and Xinjiang subplates is mainly subject to the effect and control of the acting stress caused by the collision of India Plate and Eurasia Plates. The direction of principal compressive strain axis (*i.e.*, the major axis of compressive stress) obtained from GPS data is basically the same as the acting direction of neotectonic stress acquired by geo-

Table 2 Statistics of zoning strain rates in 2001~2004

Region	Direction of principal compressive strain axis/°	Principal compressive strain rate $/10^{-9}$ a^{-1}	Principal tensile strain rate $/10^{-9}$ a^{-1}	Surface strain rate $/10^{-9}$ a^{-1}	Maximum shear strain rate $/10^{-9}$ a^{-1}
Qinghai-Tibet subplate	13.32	−18.42	18.72	0.30	37.15
Qinghai-Tibet subplate (to the west of 90°E)	356.30	−15.17	14.44	−0.74	29.61
Qinghai-Tibet subplate (from 90°E to Xining in the east)	24.30	−21.15	23.29	2.14	44.44
Qinghai-Tibet subplate (West Qingling)	63.70	−15.35	10.95	−4.40	26.31
Qinghai-Tibet subplate (Longmenshan)	92.53	−21.07	17.95	−3.12	39.02
Qinghai-Tibet subplate (Sichuan-Yunnan block)	311.78	−20.87	23.80	2.93	44.68
Qinghai-Tibet subplate (Southwestern Yunnan)	345.74	−21.77	15.67	−6.09	37.44
Xinjiang subplate	3.46	−11.09	4.99	−6.10	16.08
Xinjiang subplate (Tarim block)	4.32	−11.45	7.04	−4.41	18.50
Xinjiang subplate (Tianshan belt)	357.42	−13.13	3.09	−10.04	16.22
Xinjiang subplate (Juggar block)	7.47	−8.44	3.52	−4.92	11.96
Alax block	14.42	−5.62	5.78	0.16	11.40
South China subplate	352.87	−9.95	8.87	−1.08	18.81
North China subplate	72.84	−4.12	6.08	1.96	10.20
Ordos block	68.37	−4.85	5.63	0.78	10.48
Taihang block	56.82	−4.24	6.13	1.89	10.37
Ji-Lu (Hebei-Shandong) block	84.81	−6.63	4.36	−2.28	10.99
Yu-Wan (Henan-Anhui) block	86.49	−4.42	9.28	4.86	13.71
Jiao-Su block	71.31	−1.71	5.02	3.32	6.73
Heilongjiang subplate	289.09	−3.22	2.72	−0.50	5.94
Yinshan-Yanshan block	273.64	−2.83	3.21	0.38	6.04
Xing′an block	294.26	−2.64	2.80	0.15	5.44
Songliao block	283.88	−4.28	2.07	−2.21	6.35
Changbai block	296.51	−3.91	3.10	−0.81	7.00

logical method and it is also approximately consistent with the *P*-axis of compressive stress from focal mechanism solution (MA, 1987; WANG *et al*, 1996; XIE *et al*, 2003). It proves that the strain and stress fields calculated from GPS data are reliable and practical.

The present-day strain and stress fields in the eastern part of Chinese mainland calculated from GPS data express that from Heilongjiang subplate in the north to South China subplate in the south, the acting direction of principal compressive stress has changed gradually from ENE−WSW to proximate EW and WNW-ESE and the major-axis direction of principal compressive stress has increased step by step from the north to the south. It indicates that the eastern crust of Chinese mainland is not only affected by the lateral acting force exerted by Qinghai-Tibet and Xinjiang subplates in the western part, but also influenced by the collision and underthrust of Eurasia plate to North America, Pacific and Philippine Sea plates. Under their joint acting force, the principal compressive stress axis of ENE-WSW to WNW-ESE is formed on the subplates in the eastern part of Chinese mainland. The distribution characteristics of principal compressive stress axis in this area are basically consistent with the P-axis of focal mechanism solution of strong earthquakes and they can be confirmed to each other.

The general strain and stress field of Chinese mainland obtained from GPS data is consistent with the results from focal mechanism solution and by geological method, which indicates that the stress field of Chinese mainland is basically stable in a relatively long time and it belongs to a kind of inherited continuity and development relative to the neotectonic movement.

2) The distribution of principal compressive strain axes of subplates and secondary blocks of Chinese mainland indicates that the directions of principal compressive strain axes of different secondary blocks are not the same. This is possibly because of the local stress caused by the mutual action of blocks with different geometrical shapes and in different tectonic locations. The principal compressive stress axis corresponding to the principal strain axis of secondary blocks and the general stress field act jointly on the block. The general stress field provides a seismogenic background, while the local stress field promotes the preparation and formation of strong earthquakes. Therefore, local strain and stress field is closely related to the development of strong earthquakes.

3) Considering the Chinese mainland as a whole, the principal compressive strain rate, principal tensile strain rate, and maximum shear strain rate of the subplates in the western part are larger than those of the subplates in the eastern part. Most subplates in the western part have a strain rate of 10^{-8}/a, while most subplates in the eastern part have a strain rate of 10^{-9}/a that is one order of magnitude smaller.

4) In both time periods of 2001~2004 and 2004~2007, the concentration of principal compressive strain axes of Heilongjiang subplate have a change from the high to the low. The principal compressive strain axis of Qinghai-Tibet subplate in the latter period has a clear deflection as compared with that in the former period. Obvious variation cannot be seen in other blocks.

Generally, the blocks with compressive variations decrease to a certain extent in the Chinese mainland. However, Qinghai-Tibet and Xinjiang subplates maintain a relatively evident compressive variation in both time periods, which indicates that the compressive stress is really large on the two subplates.

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