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The Constraints of the Neotectonic Movement of the Northwest Region of China on Earthquake Activity in Qinghai Province

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Abstract. Indian Plate on the south, Eurasian Plate on the north, and the Northwest region of China have been squeezed together since the Himalayan tectonic movement, while many faults have been formed. The research was based on the study of direction of active faults lied at the Qinghai-Tibet Plateau, which were formed in the Neotectonics since the Late Pleistocene epoch, the distribution characteristic of the stress release in the crustal deformation and epicenter of the earthquake on the both side of the Aejin fault, Qilian Orogenic Belt and Eastern Kunlun. The intersection region of NNW-striking faults and the NWW-striking faults was under the maximum tectonic compression, it showed the most complicated geometric configuration and the stressed concentration site, so it can easily result in an earthquake, and precautionary measures must be made in this region.

1. Introduction

The “Neotectonics” was proposed by Former Soviet Union scholars in the 1940s, which temporally refers to the tectonic movements since the late Tertiary^[1]. Currently, scholars hold different opinions on the definition of Neotectonics and time. However, in terms of the degree that is related to the earthquake formation, tectonic movement since the late Miocene is closely related to the seismic activities. Under this structural geology background, the present study mainly discussed the features of Neotectonics and its active faults. Its constraints and influences on seismic activities in Qinghai province was also explored in this paper. Neotectonism fracture characteristics of their activities, explore the control and influence of the Qinghai earthquake.

2. The relationship between neotectonics and the present tectonic framework in Qinghai

The active faults in lands of China are significantly affected by the continental collision between Ancient Eurasian Plate and Ancient Indian Plate. Compared with the pushing dislocation of Pacific Plate, this influence had a greater impact and larger range, and the changing Cenozoic is shown during this period in Tibetan Plateau^[2, 3].



2.1. Paleocene-Eocene

Songpan-Garze and Gangdise belt are large original provenance areas of tectonic uplift. And Eastern Tarim, Tsaidam, Changtang and Hoh Xil mainly are large areas of tectonic lake basin-floodplain sediments. On the west and south of Tibetan Plateau is the new Tethys.

2.2. Oligocene

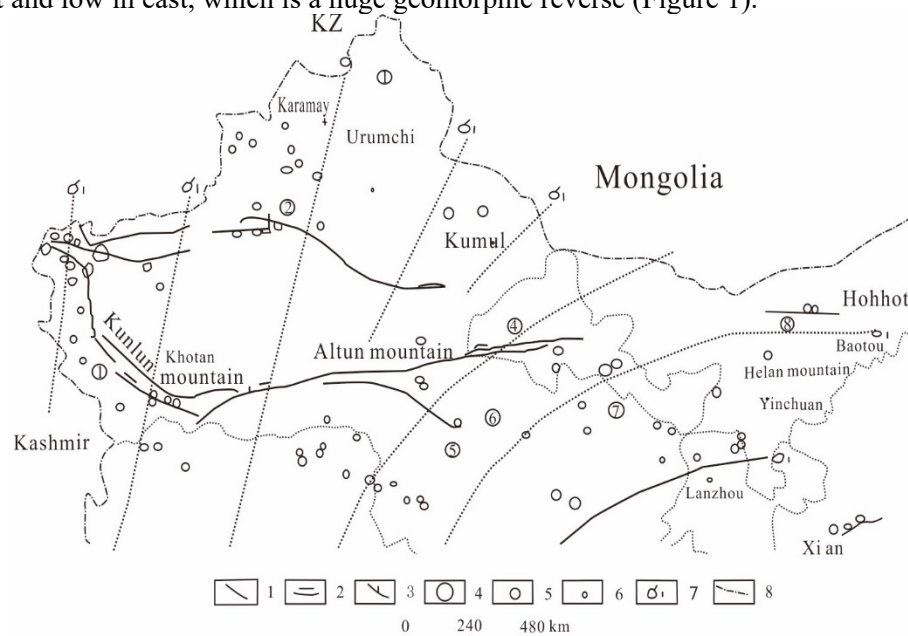
The Large areas of Gangdise-Himalayan and Karakorum are causing regional uplift and lack of sedimentation. Along the Nyagchu, an ancient river (Dazhuka conglomerate) were formed from east to west. Western Kunlun and Songpan-Garze are still original provenance areas of uplifting. Tarim, Tsaidam, Changtang and Hoh Xil mainly are large sedimentation areas of tectonic lake basin, Southwestern Tarim is shallow sea sedimentation of pressure basin, Tarim ended with the marine deposit in the late Oligocene.

2.3. Miocene

At about 23Ma, the Tibetan Plateau and its surroundings have various unconformity, which marks the overall uplift of the plateau. Tarim, Tsaidam and Xining-Lanzhou, Changtang and Hoh Xil mainly are sedimentation areas of tectonic lake basin. At 18-13Ma, the plateau and its surroundings appear the largest lake expansion in Miocene. About 13-10Ma, south-north-going fault basins were formed in Tibetan, which marked the beginning of the collapse when a plateau uplifted enough.

2.4. Pliocene

Except several large lake basins, such as Hoh Xil, Changtang, Tarim and Tsaidam, most regions are uplift and erosion areas. Due to the ongoing uplift and intense faulting in pliocene, large basins' basement are uplifted and divided into small basins. Lacustrine deposits significantly shrink and enter into the period of giant conglomerate accumulation. The original pattern of Tibetan Plateau, high in east and low in west, has experienced uneven uplift and depression, and ultimately created a new landscape, high in west and low in east, which is a huge geomorphic reverse (Figure 1).



1-Large active fault; 2-Torsion fault; 3-Large compression thrust; 4-The earthquake magnitude $M > 8.0$;

5-The earthquake magnitude $M = 6.0-8$; 6-The earthquake magnitude $M = 5.0-6$;

7-Axial direction of maximal principal pressure stress since middle Pleistocene; 8-Border;

Figure 1. Direction of active fault and seismic activity in northwest China^[4]

3. Neotectonics and distribution features of active faults

3.1. The main stages

Qinghai province locates in the west of China, the northeast of Tibetan Plateau. The main stages about active faults include: (1) Surface development of original Tibetan Plateau in Pliocene; (2) Overall uplift of Tibetan Plateau and sinkage of Tsaidam basin in early Pleistocene Ice age and intermontane fault valley development in mid- Pleistocene; (3) Sharp uplift of Tibetan Plateau and intermontane fault valley development in late Pleistocene; (4) Continual uplift and permanent permafrost evolution in Holocene^[4,5,6,7].

3.2. The main features

The distribution of fracture zones are mainly NW and NWW. Its formation, development and evolution are closely related to NNE horizontal pushing of Indian plate. During this pushing process, obstructed by the NNW-SN strike-slip fault zone in mid-eastern and northeastern Qinghai, the backlog in the region are made out to the east. Holocene is the major period in which the active faults formed. Southeastern Kunlun faults are stronger than the overall activity of the central and northern regions in Qinghai. Since the late Pleistocene, Neotectonics in Qinghai was active. The fracture zones are more than twenty-four, four of which are only active in late Pleistocene but immobile in Holocene, namely, Shule Nanshan-Datong mountain fault, Lajishan fault, north of Qinghai Nanshan mountain-Daotang River-Xunhua Nanshan fault, Xijirulan Lake-Xiewu fault, while the other twenty are all active fracture zones in Holocene in Qinghai (Figure 2).

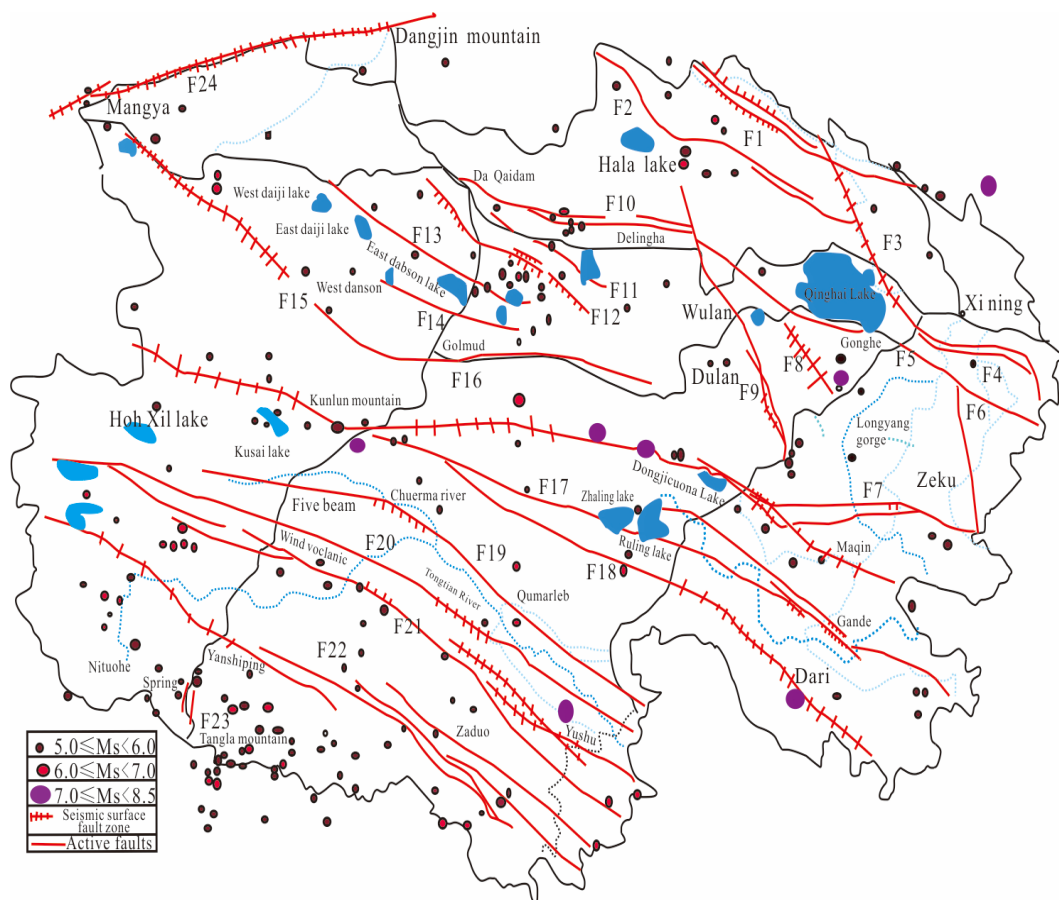


Figure 2. Direction diagram of active fault zone and earthquake epicenter in Qinghai province (From Zhou Bao, 2002 revision)

4. The relationship of earthquake active fault the distribution of earthquake

The general characteristics of earthquake in Qinghai province are defined as more times, higher frequency and greater intensity. Since the earthquake was recorded first from 1900, there are as many as 17 times strong earthquakes over a 6.5 magnitude tremor, including 5 times over a 7 magnitude tremor. Among these quakes, the strongest was ranked as an 8.1 magnitude tremor in the west pass of Kunlun Mountains. Earthquake distribution has been characterized as obvious zonality and appears as cluster. In the massif of northern Qiangtang and Baryan Har Mountain, earthquakes are presented as NWW-striking zonal distribution, and however presented obviously as cluster in the Qaidam Basin and its north margin, Ela Mountain, and the south margin of Gonghe Basin. Such as the earthquake of a 7 magnitude tremor occurred in Karakorum Mountain in 1996, the earthquake ranked as an 8.1 magnitude tremor in the west pass of Kunlun Mountains, Yushu earthquake in Qinghai province in April 2010, which all took place and distributed around the active fault in Qinghai province.

5. The constraints and influences of the active fault zone on earthquake

According to the existing researches and earthquake records, there are 3 paleo-seismic events along the Aejin thrust left-lateral strike-slip fault zone, and mid-strong earthquakes of 6-7 magnitude happened many times in history, but recently the seismicity has been weakened. In the north margin of Qilian Mountain thrust left-lateral strike-slip fault zone, there have been ever 7 times of strong earthquakes over 7 magnitude tremor, while existed simply in 20th century the earthquake of 8.6 magnitude in Haiyuan county (Dec. 16, 1920) and 8 magnitude in Gulang county (May 23, 1927), etc. And, a strong earthquake of 7-7.5 magnitude once happened in Holocene Age along the southern active fault of Hoh Xil Mountain. The quake of 8.1 magnitudes (Nov. 14, 2001) in the Qusay Lake section of the eastern Kunlun thrust left-lateral strike-slip fault zone is a stronger quake occurred in Qinghai district since the Dangxiong earthquake of 8.0 magnitude in 1981. Moreover, there are another 9 paleo-seismic events in the same district. Among these quakes, the age of the earliest ancient earthquake can be dated back to 31900 ± 1923 aBP, and the latest ancient earthquake was at the age of 3100 ± 201 aBP. It is a matter of fact that the quake activity has a quasi-periodicity and its average recurrence interval is 3544 ± 416 a, which shows the great quake of 8.1 magnitudes took place in Nov. 14, 2001 in the Qusay Lake section is a kind of reoccurrence of the earthquake activity in this fault zone during quasi periodicity. Yushu earthquake (April 14, 2010) in Qinghai province took place in the Ganzi-Yushu-Fenghuishan fault zone which is located in the southern boundary of Baryan Har Mountain massif. Since 1900, in this area, there have been 5 or 6 earthquake records within the range of 200 km. It is thus clearly seen that Yushu earthquake was also constrained by active faults.

To sum up, the epicenter of earthquakes in Qinghai province distributed mostly along the active fault or areas nearby, or located in the inter-sect composite parts of the active faults, such as the position nearby the Kunlun Mountain pass between the east Kunlun fault zone and Kunlun mountain pass-Dari fault zone, where the earthquake distributes intensively; Or located in the relatively compact areas of the branch distribution of active fault zones, such as the places nearby the two branches in the Wulangdong-E la Mountain-Hot spring fault zone, Wulanwula Lake-Yushu fault zone in the southern Qinghai province and the relatively compact areas of the branch distribution of Wulanwula Lake-Angqian fault zone, are all zones of high earthquake incidence; or located in the endpoint of active fault zone, such as the southern concealed fault zones in the south margin of Gonghe Basin and the southern Wulangdong-E la Mountain-Hot spring fault zone; or located in the area of high curvature in fault zone, such as the north margin of Qaidam Basin fault zone and the compact area in the inflection point of Da Qaidam-Zong Wulong Mountain fault zone; or located in the piedmont active fault zone, such as the northern piedmont of Tanggula Mountain, the southern piedmont of Kunlun Mountain, the southern piedmont of Xi Tianshan Mountain, and the southern piedmont of Qilian Mountain, etc. And, the regional suture zone and deep fault zone are the places to produce strong earthquakes over 7 magnitude tremor, such as the eastern Kunlun fault zone and the Aejin-Qilian suture zone, etc. Visibly, active faults have an obvious effect on the distribution of epicenter in Qinghai district.

6. Conclusion

(1) From the perspective of geotectonic setting, since the Himalayan tectonic movement, it is the main place for the adjustment and the stress release in the crustal deformation in the both side of the Aierjin fault, Qilian Orogenic Belt and Eastern Kunlun and also the main position for large-scale active fault development, which have obvious constraints for the earthquake movement in Qinghai province.

(2) Neo-tectonic movement in Qinghai district is very active; there are as many as 24 active fault zones since the Late Pleistocene epoch that the predominant directions of these active faults are mostly towards NNW and NWW. NNW-striking faults play a significant role in the evolution process of the tectonic framework formation of the whole northern Qinghai region, which restricts together with the NWW-striking faults the morphology and the sedimentary environment of the tectonic basin and the spatial distribution pattern of strong earthquake occurrence developed in the depression zone.

(3) The intersection region of NNW-striking faults and the NWW-striking faults was under the maximum tectonic compression, and it showed the most complicated geometric configuration and formed a site that easily concentrated tectonic stress, so it can consequently result in earthquakes. Therefore, precautionary measures must be paid high attention in regions like Qinghai province.

Acknowledgments

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