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Junction and Evolution of the Qinling, Qilian and Kunlun Orogenic Belts

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Abstract As the main part of the "central mountain system" in the continent of China, the Qinling, Qilian and Kunlun orogenic belts have been comprehensively and deeply studied since the 1970s and rich fruits have been reaped. However, these achievements were mostly confined to an individual orogenic belt and the study of the mutual relationship among the three orogenic belts was obliged to depend on comparative studies. Different views were produced therefrom. The material composition and structural features of the junction region show that there are several epicontinental and intracontinental transform faults developed in different periods. Restricted by these transform faults, the large-scale lateral movements and, as a consequence, complicated magmatism and tectonic deformation took place in the orogenic belts. According to these features, the authors put forward a three-stage junction and evolution model and point out that there is not a single junction zone traversing from west to east but that the three orogenic belts have been joined progressively by the epicontinental and intracontinental transform faults.

Key words: central mountains, Qinling, Qilian and Kunlun orogenic belts, junction and evolution, intracontinental transform fault

1 Introduction

The Qiling, Qilian and Kunlun orogenic belts have constituted the main part of the "central mountains" in Chinese continent. Then, such problems as whether the three orogenic belts belong to a united orogenic belt (Zhang Guowei and Liu, 1998) were brought to the attention of many geologists. At present, fruitful achievements have been made in the studies of the different sections of each orogenic belt (Jiang Chunfa et al., 1992; Feng, 1997; Zhang Guowei et al., 1997), and the knowledge about its material composition, tectonic property, evolution and geodynamic basis has been deepened. But the study of the relationship among these orogenic belts was obliged to depend on contrastive analyses (Cheng, 1994; Li Chunyu et al., 1978; Gao et al., 1990; Yin and Zhang Keqin, 1998). Some researches have conducted geological and tectonic surveys in the junction region and made significant exploration into their relationship (Zhang Weiji et al., 1994; Xu et al., 1996).

Up to now, there have been three viewpoints to the relationship among the three orogenic belts. The first view suggests that North Qilian and East Qinling belong to a united orogenic belt because they have evolved unanimously in time and space (Li Chunyu 1978; Cheng, 1994; Zhang Weiji 1994). The second view stresses on the Kunlun-Qinling suture zone, i.e., the Qingshuiquan ophiolite zone of East Kunlun and the Gaodan ophiolite zone of East Qinling are all the residues of the Qinling-Kunlun ocean between the North China and South China plates. The development and evolution of the ocean is the basis for the formation of the Qinling-Kunlun orogenic belt (Gao, 1990; Cheng, 1994). In the third viewpoint, Yin Hongfu and Zhang Kexin (1997) describe the three orogenic belts as a whole with the view of a "multi-island ocean". Obviously, these studies and different thoughts have laid a solid foundation for the deep probe into the formation mechanism of the "central mountains". However, little study has been done concerning the epicontinental and intracontinental transform faults and their large-scale lateral movement, magmatism and tectonic deformation, although these are all very impotent in the joining process of the three orogenic belts.

From the beginning of the 1990s, a number of 1:50 000 and 1:250 000 regional geological surveys have been launched in the junction region of the Qinling, Qilian and Kunlun orogenic belts, e.g. Qinghaihunanshan (South Mountain of the Qinghai Lake), Ngolashan (the Ngola Mountain), east section of East Kunlun Mountains, and the A'nyêmaqên Mountain. These investigations reveal that all the faults, except the Ordos southwest margin epicontinental transform fault which links up the North Qilian and East Qinling suture zones, the north margin of West Qinling, north margin of A'nyêmaqên, and Ngolashan fault, are intracontinental transform faults which play an important role in the junction and evolution of the three orogenic belts, with a peculiar material composition and structure.

2 Material Composition and Structure of the Junction Part

Most of the West Qinling orogenic belt is located at the junction part of the three orogenic belts (Fig. 1). To the west it was cut off by the approximately N-S trending Ngolashan tectonomagmatic zone developed at the east margin of the Qaidam basin and east end of the Kunlun orogenic belt; to the east there widely developed the Early to Middle Triassic Longwuhe Group composed of turbidities (Qinghai Bureau of Geology and Mineral Resources, 1997); further to Xiqingshan it was transformed into a carbonate platform (Yin et al., 1992). The Ngola Mountain shows a clear E-W zoning: in the west zone, Late Triassic epicontinental granites and terrestrial volcanic rocks are developed (Cao et al., 1999; Jiang et al., 1999), which constitute an approximately N-S trending magmatic zone (Xing and An, 1996); the east zone is composed of Triassic Olenekian-Carnian sediments of continental shelf-neritic and littoral-molasse facies (Zhou Guangdi et al., 1998). On the east margin of the Ngola Mountain, Late Carboniferous to Early Permian ophiolite mélange and island-arc volcanic rocks are preserved, which are an important mark for the early joining of the Qaidam massif, East Kunlun belt and West Qinling orogenic belt in the Early Palaeozoic Era. The zone outcrops discontinuously in N-S direction and is limited to the range between the sinistral strike-slip fault on the north margin of A'nyêmaqên and the dextral strike-slip fault on the north margin of West Qinling. Although, just as other geological bodies in West Qinling, it has been subjected to deformation and destruction similar to the strike-slip faults and thrust-nappe faults in Lucanian Apenines, Italy, found

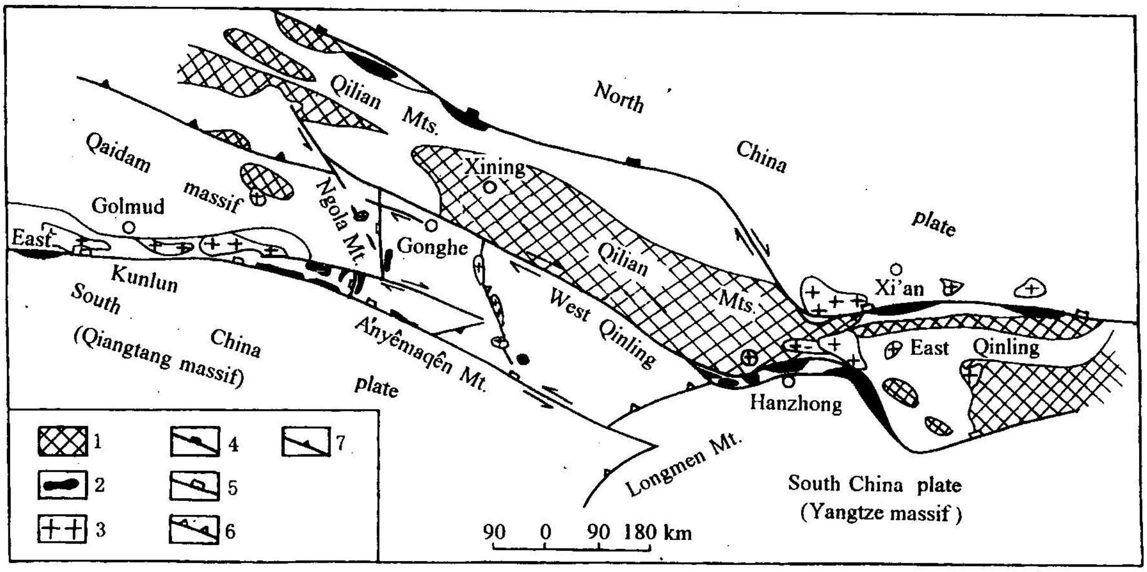

Fig. 1. Tectonic sketch of the junction part of the Qinling, Qilian and Kunlun orogenic belts.
1. Precambrian crystalline base; 2. ophiolite mélange; 3. epicontinental granite; 4. North Qilian-Shangdan suture zone; 5. East Kunlun-Mianlüe suture zone; 6. intracontinental transform fault; 7. nappe structure.

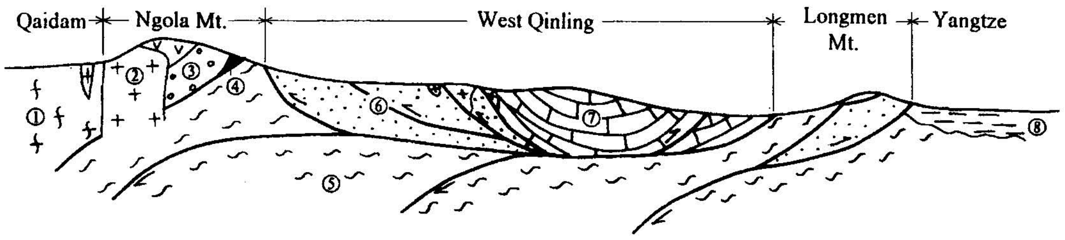

Fig. 2. Structural section between the Qaidam and Yangtze massifs.
① Early Proterozoic gneiss; ② Late Triassic granite; ③ Early-Middle Triassic neritic-molasse sediment; ④ Permian ophiolite mélange; ⑤ Middle-Late Proterozoic tectonic schist; ⑥ Early-Middle Triassic turbidite; ⑦ Early-Middle Triassic neritic sediment; ⑧ Jurassic lacustrine sediment.

by Stefano Catalano et al. (1993), the E-W zoning in the Ngola Mountain and the E-W lithofacies variation in West Qinling are clearly shown (Fig. 2).

The fault on the north margin of West Qinling (also named the Qinghaihu Nanshan fault), which is a boundary between Qilian and West Qiling, is generally regarded as the same fault on the north margin of the Qaidam basin. A detailed survey found, however, that their kinematic features and geodynamic significance are quite different. To the west of the Ngola Mountain, the Qilian orogenic belt was pushed toward the Qaidam basin, forming a typical basin-marginal nappe zone (Yang Minghui, 1988); whereas in the east, a peculiar dextral shear-strike slip fault steadily extended to the east and linked the Mianlüe zone of East Qinling, constituting an intracontinental transform fault joining the Mianlüe zone and the east margin of Ngolashan suture zone, which are represented by Late Palaeozoic ophiolite mélange. The fault is similar to the epicontinental transform fault on the southwest margin of the Ordos massif. The latter is linked up with the Shangdan zone of East Qinling and the North Qilian suture zone represented by Early Palaeozoic ophiolite mélange. They not only adjusted the various divergences occurring in the evolution of the suture zones on both sides, but were also the important mark and main cause for the large-scale lateral movement.

With the deepening of the study, the material composition and structure of the A'nyêmaqên tectonic belt have revealed more clearly that it is not entirely a junction zone resulting from subduction and consumption of the oceanic crust of the A'nyêmaqên Ocean (Jiang Chunfa, 1992) from south to north in the Late Palaeozoic Era, but probably the eastern extension of the south zone of the East Kunlun orogenic belt. Its main part is composed of Permian slip-collapse accumulations of carbonatites, epicontinental clasolites and argillaceous-carbonaceous slates, reflecting a palaeogeographic sedimentary environment with the depth of water gradually increasing from northwest to southeast. It was probably a cape on the southeast margin of the Qaidam massif. So, it is very difficult to find in this tectonic belt the various tectonic properties caused by subduction. The cape was bound to vanish gradually in its extension towards the southeast. A sinistral strike slip fault developed to its north pieced together the different rock-blocks of West Qinling into this tectonic belt and caused partial materials to be inserted into the East Kunlun orogenic belt in the Kuhai area, which formed another boundary of intracontinental transform faults between Qinling-Kunlun and the southern mountains.

In a word, it is clear that there is not a single suture zone traversing from west to east in the three orogenic belts. Under a united tectonic background, the transform faults served as an important tie to the orogenic belts and caused the large-scale lateral movement of inner materials and complicated relationship of junction in the orogenic belts.

3 Evolution of Junction of the Qinling, Qilian and Kunlun Orogenic Belts

Despite the different opinions on the relationship among the three orogenic belts, the view that they are products of long-term activities between the North China and South China continents has been approved by a majority of researchers. The authors agree with this view and hereby put forward an evolution model of three stages as follows:

3.1 Evolution stage of the North Qilian-East Qinling Ocean

The Early Palaeozoic ocean between the North China and South China plates has been affirmed by the North Qilian ophiolite zone (Zhang et al., 1997) and the Gaodan ophiolite mélange zone of East Qinling, but its embryonic stage can be traced back to the Late Proterozoic Era, when North Qilian and East Qinling all began as rift valleys (Feng, 1997, 1998) and later a small oceanic basin represented by the Songshugou ophiolite emerged (Pei, 1997). But East Kunlun remained in a state of intracontinental rift throughout this stage (Fig. 3a). Even in the climax of spreading of the North Qilian-East Qinling Ocean at the beginning of the Early Palaeozoic (Xia et al., 1998), there was no formation of typical oceanic crust matter in East Kunlun and the numerous rifts between it and the North Qilian Ocean (e.g. the north margin of the Qaidam basin and Danghenanshan). At the end of the Early Palaeozoic, the North Qilian-East Qinling Ocean subducted under the North China plate, and by the Late Palaeozoic, with the collision and piecing together of a series of blocks split from the north passive margin of the South China plate, such as the Qinling microplate (Zhang Guowei, 1997) and the Qaidam mircroplate (including the Middle-South Qinling massif and Qaidam massif) (Zhang Qi, 1997), the history of the ocean's evolution came to an end. The subduction and collision in this stage were influenced by the south margin of the North China continent. North Qilian and East Qinling were joined by the epicontinental transform fault on the southwest margin of Ordos. The fault not only served as an important adjustment in the subduction and collision of the North Qilian- East Qinling Ocean but also led to a lateral displacement of the materials in the collision from east to west (Fig. 3b), and a subduction from the margin to the centre of the land in west sector. We have found an approximately N-S trending Devonian muscovite-two mica granite zone (Rb-Sr isochron age 380 Ma) in middle Qilian sector, north of Qinghai Lake. It is probably a typical indicator of the lateral subduction if the dynamic environment this type of granite reflects is an intracontinental subduction (Deng et al., 1999).

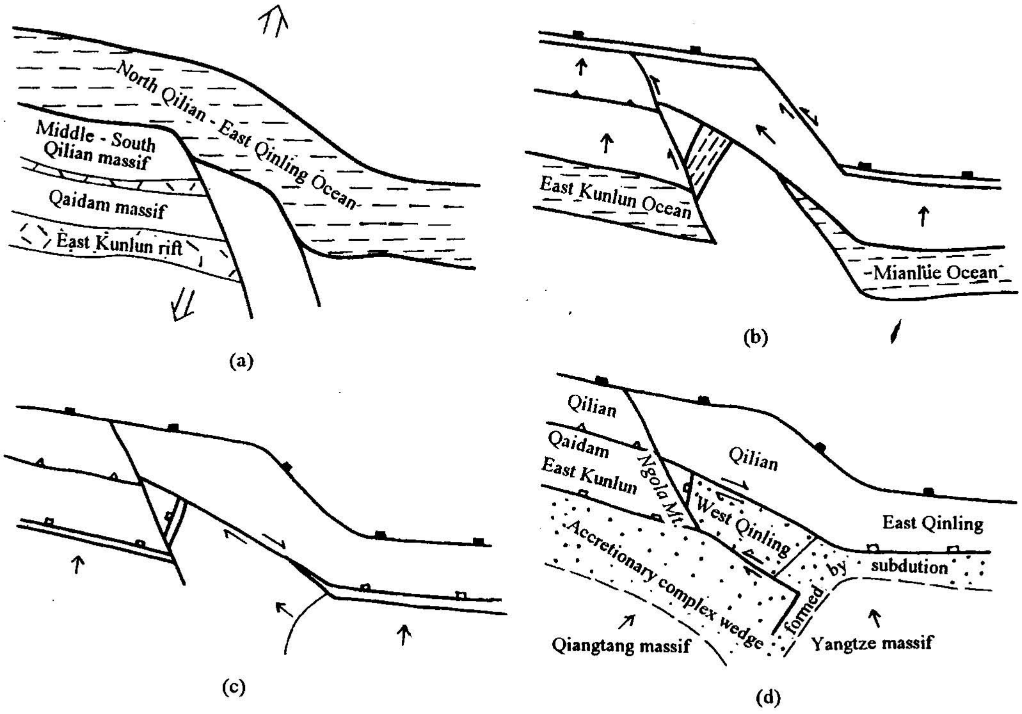

Fig. 3. Model of the junction and evolution of the Qinling, Qilian and Kunlun orogenic belts.
Legends same as in Fig. 1.

3.2 Evolution stage of the East Kunlun-east margin of Ngola Mountain-Mianlüe of East Qinling Ocean

North Qilian and East Qinling completed their first junction after going through the evolution mentioned above. Following the Late Proterozoic rifting (small oceanic basins may have occurred in some places), East Kunlun had remained in a state that the south part expanded slowly while the north part subducted and collided continuously toward the Qaidam microplate (Zheng, 1992; Gu, 1994). The huge magmatic arc composed chiefly of Variscan and Indosinian magmatites in the north of East Kunlun (Gu, 1996) revealed that the subduction was intensifying by the Late Palaeozoic while oceans appeared in the south. However, the situation was quite different in the area around east margin of the Ngola Mountain and East Qinling compared with East Kunlun. Based on the Devonian basic dike swarm (Ar-Ar plateau age 394 Ma) developed in the Middle-Late Proterozoic metamorphic blocks and the numerous ductile deformation structures of extention and décollement in the east margin of the Ngola Mountain, we can infer that the oceanic basin of West Qinling began to open in the Early Devonian and the oceanic crust formed in the Permian, which coincides the palaeotectonic background of the Mianlüe zone (Zhang Guowei, 1997; Lai et al., 1999). The discontinuous closure of oceanic basins is similar to that for East Kunlun and East Qinling, but in West Qinling, the main body between blocks was compressed and impacted from east to west (Fig. 3c) controlled by the north intracontinental transform fault. By the end of Permian Period, the second junction was completed.

3.3 Evolution stage of "accretionary complex wedge by subduction" on the south margin of Qinling-Qilian-Kunlun

Sengor (1992) summarized the formation mechanism of the Tethys in Triassic Period with the concept "accretionary complex wedge by subduction". As the north margin of the East Tethys, East Kunlun, the Ngola Mountain and East Qinling were all controlled by this rule. The movement in the end of Late Palaeozoic Era continued and an intense intracontinental subduction took place. Magmatic intrusion was widespread in the front of the obduction massif and enormous epicontinental fragments accumulated in the foreland basin. In the later period, the "accretionary complex wedge by subduction" composed of thick accumulation prevented the convergence of blocks and brought about large nappes, transverse and strike-slip faults, e.g., the dextral strike-slip fault in the Ngola Mountain (Sun, 1999), dextral transverse fault on the north margin of West Qinling, sinistral strike-slip fault on the north margin of A'nyêmaqên, a series of approximately N-S trending nappes and the Longmenshan nappe zone (Liu, 1993). These are also the last structures in the junction of the three orogenic belts.

4 Conclusion

To sum up, there is not a single junction zone traversing from west to east in the three orogenic belts. It is the epicontinental and intracontinental transform faults that caused different evolution features in various orogenic belts under a united tectonic background and led to large-scale lateral movements and the magmatism and complicated tectonic deformation thereby induced. And finally, a united orogenic belt, which is based on two junction zones linked by continental transform faults, formed after having undergone three complicated evolution stages.

Manuscript received Nov. 1999
accepted March 2000
edited by Ren Xifei and Zhu Xiling

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