by Zheng Jiandong

Significance of the Altun Tagh fault of China

The Altun Tagh fault, a major left-lateral strike-slip fault in Asia, has been of interest to many scientists. On the basis of field investigations, the Altun Tagh fault is known to be very active as it not only exhibits strike-slip and compressional features but also has produced many historical seismic events. It bounds the Tibetan Plateau, separates the Tarim and Qaidam Basins, and plays an important role in the geodynamic evolution of that region.

Introduction

The Altun Tagh fault, a major left-lateral strike-slip fault in Asia, extends about 1,600 km from western Lanzhulong eastward to the Jinta Basin, where it becomes concealed in the Badian Jaran desert. Although earth scientists know few details about the fault's geologic settings because of its location at high altitudes and in sparsely populated to nonpopulated areas, many scientists are aware of its existence and significance. Zhang Wenyong suggested (Tectonic Map Compiling Group, 1974) that the Altun Tagh is a transform fault between the western Kunlun Shan (Mountains) and the Qilian Shan (fig. 1). Molnar and Tapponnier (1975) assumed from their interpretations of Landsat imagery that the total displacement on the Altun

Figure 1.—Geotectonic provinces of western China: I, North China platform; II, Yangtze platform; III, Northwest platform; IV, Middle-South Tibet continental block; V, Tianshan-Mongolian-Xing-ganling fold system; VI, Qinling-Qilian fold system; and VII, Kunlun-Shanjiang fold system (Shanjiang: Jinshajiang,

Lancangjiang, and Nujiang). The Altun Tagh fault is located in the Northwest platform (III, shown by ruled patterns), which contains: 1, Tarim depression; 2, Qaidam depression; 3, Altun fault uplift; and 4, Alxa platform uplift.

Figure 2.—Distribution of the Altun Tagh fault belt. Explanation: 1, fault; 2, buried or uncertain fault; 3, uplifted region; 4, basin.

Tagh fault was about 400 km. Zhao Zhiyun and Zhu Shida (1980) supported the idea that the Kuyake fault, part of the western Altun Tagh fault, is a rift valley that separates the Kunlun Shan into its western and eastern parts. Ren Jishun and others (1980) pointed out that the Altun Tagh fault, one of the most important shear faults in western China, extends from the Altun Shan east to Beishan. Ding Guoyu (1982), in comparing the active faults of China, pointed out that the Altun Tagh fault is the most active and that the slip rate is about 6 mm/yr based on the offset of stream channels. A regional geological survey was conducted in the 1980s by the Geological Bureau of the Xinjiang Uygur Autonomous Region, and geological reports on the Xorkol and Baxkorgan sheets (scale 1:200,000) were published in 1982. Molnar and Deng Qidong (1984) determined the approximate average rates of deformation in central and eastern Asia on the basis of large earthquake events. They estimated that left-lateral shear has been more than 10 mm/yr on easterly trending planes in northwestern Tibet and Gansu. Furthermore, they pointed out that slip on the Altun Tagh fault is poorly represented. The State Seismological Bureau of China organized a program to begin research on the active Altun Tagh fault in 1985. The author took part in the field investigations in the Tarim Basin, Qaidam Basin, and Altun Shan from 1985 to 1988, and some of the preliminary conclusions are included in this paper.

Basic characteristics of the Altun Tagh fault

Tectonically, the Altun region is referred to as a part of the North-western platform, which consists of four geologic units: the Tarim depression, the Qaidam depression, the Altun fault uplift, and the Alxa platform uplift (fig. 1) (Yang Weiran and others, 1984).

On the basis of field investigations, the structural styles in the Altun Tagh fault belt are very complex but, in general, consist of a series of left-lateral strike-slip faults. The total length of the fault belt is at least 1,600 km; some geologists assume that it extends to northeastern China and is, therefore, about 3,500 km long. The trend of the fault belt is about N. 70° E., and two main branches may be distinguished: the southern, named the Kuyake-Xorkol fault, and the

Figure 3.—The Xorkol pull-apart basin (interpreted from Landsat image). Explanation: 1, fault; 2, fault interpreted from Landsat image; 3, depositional basin; 4, compressional structure.

northern, named the Lapeiquan-Jinta fault (fig. 2). The dip of the faults is about 70°. Dips in the western and eastern parts of the fault belt are inclined southeast, whereas those in the central part are inclined northwest. The Altun Tagh fault has the features of a strike-slip fault, such as the Xorkol pull-apart basin (fig. 3) where the thickness of the Cenozoic rocks is about 4,500 m, as well as the thrust or overthrust features of a compressional fault. Figures 4 and 5 show examples of thrusting along the fault belt.

At the margins of the Tarim and Qaidam depressions are exposed Precambrian rocks, and the Altun Shan consist essentially of the Precambrian Dunhuang and Danghe Groups. Paleozoic rocks are located at the southern margins, and Mesozoic to Cenozoic terrestrial sediments are exposed mainly in the foredeeps and intermontane basins (figs. 2 and 6). Thus, I suggest that the Altun Shan are not part of a Caledonian or Variscan fold belt but, rather, are in a stable block. The active history of the Altun Tagh fault could be dated to the Variscan orogeny because many Variscan granites are intruded along it. I suggest, however, that the fault was localized by intensive action in the Cenozoic Era following the tensional tectonic environ-

ment in the Mesozoic Era, when many Jurassic and Cretaceous faulted depressive basins, including the Xorkol and Jinta Basins, were distributed along about 1,000 km of the fault and provided weaker lithosphere. These Jurassic and Cretaceous basins are easy to identify in the field: the Early and Middle Jurassic basins have coal-bearing formations and are called black basins, whereas the Late Jurassic and Cretaceous basins contain red rocks and are called red basins. Upper Triassic formations are exposed along the road from Mangya city to the region of Ruofang (fig. 2). According to the No. 6 Geological Team of Qinghai Province, this is the first discovery of Upper Triassic formations between the Tarim and Qiadam Basins and is important in the explanation of their evolution. The principal strike-slip movement of the Altun Tagh fault took place in the early Cenozoic Era contemporaneously with the collision between the Indian continent and Eurasian plate. After the collision, the total displacement on the Altun Tagh fault was 250 km according to the offset of Jurassic coal in the Qiemo and Gase mines (fig. 7) (Zheng Jiandong, 1989).

Figure 4.—Geologic section near Xorkol. The Altun Tagh fault actually consists of a series of faults. The main fault is located at the north end of the section where Precambrian rocks are thrust over younger rocks. Explanation: γ_3 , Variscan granite; σ , basic or ultrabasic rock; AnC, Precambrian; Pz, Paleozoic; J, Jurassic; K, Cretaceous; N, Neogene; Q, Quaternary.

The Altun Tagh is an active fault and has cut the Neogene and Pleistocene strata at many places. The Wuzunxiao dry salt lake is displaced about 400 m; gullies, rivers, and ridges are sinistrally offset by the fault; and a series of scarps has formed at the surface. The maximum offset on a stream channel is about 55 km in the Qarqan River in Xinjiang Uygur Autonomous Region (fig. 6). The average slip rate on the Altun Tagh fault has been about 7 mm/yr during the Cenozoic, an estimate obtained by the use of the velocities of retrogressive erosion, vertical erosion, and horizontal offsets. The Holocene slip rate varies in different parts of the fault belt and ranges from 4.5 to 10.3 mm/yr according to data from field investigations. The Altun Tagh fault belt is a seismically active zone that has produced 23 earthquakes of magnitude (M) ≥ 5 (table 1). The earthquakes of 3 and 12 July 1924 ($M=7 \frac{1}{4}$), which occurred in eastern Minfeng region, were the largest recorded in the seismic zone (fig. 8). Recently, a few ancient seismic deformation belts have been found along the zone.

Figure 5.—Geologic section east of Aksay (see fig. 2). The Altun Tagh fault consists of two planes. On the southern plane, Ordovician (O) limestone and shells are thrust over Neogene (N) sandstone; on the northern, the sandstone is, in turn, thrust over Quaternary (Q) conglomerate laterally.

Figure 6.—Simplified geologic map of the Altun Tagh fault belt. Explanation: 1, Cenozoic basin; 2, Jurassic-Cretaceous terrestrial basin; 3, Triassic formations; 4, Paleozoic rocks; 5, Precambrian rocks; 6, fault; 7, uncertain fault; 8, Quaternary volcano.

Table 1.—Earthquakes of $M \geq 5$ along the Altun Tagh fault belt

(Abbreviation: Do., Ditto)

Date	Epicenter location			Magnitude	Source of data
	Latitude (north)	Longitude (east)	Epicenter area		
1785.4.18	39.9	98.0	Yumer	(6)	Gu Gongxu (1982)
1832.8	39.9	96.8	Yumer	(5 1/2)	Do.
1922.10.17	39.5	91.0	Lop Nur	6 1/2	Do.
1924.7.3	36.8	83.6	Minfeng	7 1/4	Do.
	36.8	84.1			
1924.7.5	37.3	85.3	Qiemo	(5)	Do.
1924.7.12	37.4	83.6	Minfeng	7.2	Do.
	37.0	84.8			
1932.12.25	39.7	96.7	Changma	7.6	Do.
	39.7	97.0			
1933.1.17	40.0	97.0	Yumer	5 1/2	Do.
1933.7.11	40.5	96.0	Anxi	5 1/4	Do.
1933.9.26	38.3	86.9	Ruoqiang	6 3/4	Do.
1935.11.30	38.9	93.9	Sulan Lake	5 1/2	Do.
1951.12.27	39.6	95.7	Subei	6	Do.
1952.1.23	39.8	95.7	Subei	5 1/2	Do.
1952.2.6	39.9	95.2	Subei	5 1/4	Do.
1957.8.23	37.7	87.2	Qiemo	5	Do.
1960.11.17	38.5	89.4	Ruoqiang	5.2	Do.
	38.1	88.7	Ruoqiang	5 1/2	
1977.10.20	39.2	91.2	Lop Nur	5.1	Gu Gongxu (1983)
1978.7.31	35.4	82.0	Kerya Mt.	5.5	Do.
1979.12.2	38.7	89.8	Mangya	5.6	Predicting Center (1980)
1980.2.5	39.2	89.5	Ruoqiang	5.0	Seismological Bureau of the Xinjiang Uygur Autonomous Region (1985)
1980.10.7	35.6	82.1	Yutian	5.8	Do.
1982.11.1	36.2	82.8	Minfeng	5.0	Do.

* Macroscopic earthquake epicenter

Geodynamic history

The Altun Tagh fault is the active northwestern boundary of the Tibetan Plateau in the Asian continent, and the fault plays an important role in the geodynamic history of the plateau. The boundary is a sharp gravity gradient zone and a crustal differential zone, and it controls the distribution of continental basins such as the Qaidam, Xorkol, and Jiuquan (fig. 2). However, the Altun Tagh fault might be interpreted as a transform fault because it is very long and terminates in other features, for instance, the Qilian compressional belt to the east and the Kunlun shear-tensional belt to the west (fig. 1). As the Indian continent collided with Eurasia, the Altun Tagh fault intersected the maximum principal stress at a large angle and thereby produced the mechanism in transpression.

The Altun Tagh fault and the Karakoram fault form a conjugate shear couple (fig. 9). The first fault is sinistral and the second is dextral, which creates a tectonic escape for the Qiangton block, the northern part of the Tibetan Plateau. The rate of eastward tectonic escape of the Qiangton block is about 5–10 mm/yr (Zheng Jiandong, 1988). Consequently, the rate of northward movement of western Asia has decreased because part of the energy is consumed in the

continental crustal shortening and thickening and part is distributed in transcurrent movement. For instance, the Tibetan and Persian Plateaus are symmetrical to the Pamir Plateau collision corner, and their escape rates are about 5–10 mm/yr eastward and westward, respectively.

The tremendous uplift of the Tibetan Plateau is the consequence of continental crustal shortening, thickening, and folding. A series of thrust slabs and Precambrian blocks on the southern and northern margins of the plateau are another effect of the unified uplift process. Neotectonic characteristics on the northern and southern sides of the Altun Shan are quite different: on the north, the mountains seem to drop straight into the Tarim Basin, and on the south, the Altun Shan are being uplifted along with the Tibetan Plateau.

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Figure 9.—Schematic geodynamic map of the western part of the Asian continent. Explanation: 1, Cenozoic continental basin; 2, young plateau; 3, Precambrian shield; 4, strike-slip fault; 5, thrust fault; 6, collision zone; 7, uncertain fault; 8, rate and direction of movement of the continental block (mm/yr); 9, relative rate and direction of movement of the plate (mm/yr). Also, I, Tibetan Plateau; II, Pamir Plateau; III, Persian Plateau; K, Karkum Basin; Q, Qadum Basin; T, Tarim Basin; AF, Altun Tagh fault; CF, Chaman fault; HF, Herat fault; IS, Indus suture; KF, Karakoram fault; KOF, Kopet fault; LSF, Longmen-Shan fault; MBF, main boundary fault; QF, Qilian fault; RRF, Red River fault; TF, Tien Shan fault; XXF, Xianshuhe-Xiaojiang fault; YS, Yarlung Zangbo suture; ZS, Zagros suture.

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